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Welcome to ACES 2016!

On 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 2016 Conference! We have organized an assortment of workshops, plenary sessions, presentations, and field tours - but hope that you find ACES to be more than a series of meetings and presentations. Instead, as information is being shared, please make a concentrated effort to 'step out of your silo' or 'move away from your comfort zone' and attend presentations and participate in sessions you might not normally select. We are confident that if you do so, you will gain important understanding and interact with valuable new contacts to help further the discussion on, and science of, ecosystem services.

The ACES 2016 conference features a focus on implementation advances and challenges, a track on conservation finance, and sessions addressing a broad range of topics, methods, and practices such as human well-being, monetary and non-monetary valuation, urban ecosystem services, the impacts of climate change on terrestrial and coastal ecosystems and services, and the role of Traditional Ecological Knowledge. Also of note will be presentations and posters from around the world including developing countries. There will be nearly 500 participants at ACES 2016 from 24 nations, including leaders from all levels of government, NGO's, non-profits, academia, and the private sector.

We wish to thank the supporting and partnering organizations and the Planning, Program, and Steering Committee members for their exceptional efforts to make ACES 2016 a success. Their insights and support are greatly appreciated, and this conference could not have happened without them. In particular, we are grateful for the continued outstanding efforts of the staff of the University of Florida, IFAS Office of Conferences and Institutes in organizing the logistics and making this conference possible, and the strong leadership of Kristin Zupancic and Jasmine Garcia in this endeavor.

We anticipate that ACES 2016 will provide many opportunities to share science advances and state-of-the-art practices and continue the dialogue and information sharing within the ecosystem services community. 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 2016!

Dianna M. Hogan, Ph.D.
Planning Committee Chair
Supervisory Physical Scientist
Eastern Geographic Science Center and
Science and Decisions Center Affiliate
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ABSTRACTS

Listed alphabetically by presenting author last name.
Presenting author names appear in **bold**.

HEALTH ASSESSMENT OF *CHRYSICHTHYS NIGRODIGITATUS* IN LAGOS LAGOON, NIGERIA

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Environmental health is paramount to overall functioning and survival of fish. Complex dynamics of eosystem relationships with anthropogenic stressors influence state of well-being of fish. Impact of pollution and environmental degradation on ecology and health status of *Chrysichthys nigrodigitatus* in Lagos Lagoon ecosystem is in relation to environmental contaminant from varying sources, and around the coastal line resulted in depleted state of the desired economically important fish stock.

Health status of *C. nigrodigitatus* was investigated using some ecological and health indices, over 24 months in Lagos Lagoon to assess fish normal functioning (health) ad mist contaminants in the ecosystem to know the state of well-being of the fish; for stock management, public (human) health awareness, and for food security. Some water analysis: temperature (^{0}C), pH, Dissolved Oxygen (mg/l), conductivity (µScm), depth (m), turbidity (m), and salinity (‰) of Lagos Lagoon were carried out at selected locations. Fish with mean standard length 18.90 ± 1.35 (cm) and mean weight range (201.59 ± 38.29) (g) were randomly collected by assistance of fishermen using fishing nets and separated into sexes; growth pattern, condition factor and regression analysis of fish were determined. Some heamatology (Packed Cell Volume, Haemoglobin, Red Blood Cell, White Blood Cell, Neutrocyte, Monocytes, Lymphocyte, Eosinophil, Mean Cell Volume, Mean Cell Haemoglobin, Mean Cell Haemoglobin Concentration) profile determined revealed state of infection due to deviation from normal limits; and some heavy metal concentrations (Lead, Iron, Zinc Copper, and Chromium) levels determined in fish tissue revealed slight accumulations.

Using two-ways analysis of variance, results obtained revealed no significant difference ($P \geq 0.05$) in water parameters from normal range. Sex ratio indicated higher male to female (36: 27) which is nature specific. Morphometric measurement indicated isometric (b) factor that female samples revealed negative allometric, but better condition factor (K) (2.86); while male revealed positive allometric and a lower condition factor (K) (0.44) which is sex, reproduction and food availability as robustness indicate state of well-being of the fish. Heamatology values revealed slight deviation from normal range which prone fish to infection as it indicated pollution influence; and heavy metal presence indicated stress prevailing environment.

Hence, information is important for environmental safety and security. Diverse other aquatic resources will none-the-less be experiencing challenged condition which can be threatening to existence. Policy-makers alert for save aquatic environment to sensitize people (stakeholders) and mitigate causes of pollutants is paramount to fish continual existence, safe human health and food security for economic viability, poverty eradication and promotion of national wealth.

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PELAGIC ECOSYSTEM SERVICE ASSESSMENTS CAN REVEAL AN UNDERAPPRECIATED SOURCE OF OCEAN WEALTH

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Economic development in the ocean is increasing rapidly to meet global demands for ocean-generated protein, energy, shipping and tourism. With the majority of people living within 50km of the world's coasts, these increasing demands for use of ocean space are often leading to conflict among users and between users and the habitats and ecosystems that drive much of the ocean's productivity. Maintaining the multitude of environmental benefits – derived from ocean ecosystems will require additional spatially-explicit knowledge of how and where benefits are produced, and national and regional ocean-use policies that integrate sectorial regulatory frameworks (e.g., on shipping, oil and gas exploration, fishing, conservation, etc.) under singular national comprehensive management systems. As with nearshore ecosystems like coral reefs and mangroves, pelagic ecosystems produce tremendous benefits that are subject to change from both management and environmental forces. Increasing our understanding of where and how pelagic ecosystem service flows are generated will inspire the development of integrative ocean policy, both within and beyond nations' exclusive economic zones (EEZs). When shaped by ocean policy frameworks and anticipated ocean use, mapping of pelagic services and values, along with natural capital accounting and ocean health assessments, will: 1) strengthen on-going national and international ocean management efforts; 2) help avert future conflict through more informed planning; 3) secure positive outcomes for human well-being as well as conservation targets, potentially helping to meet both societal and environmental goals as framed in SDG #14. This paper presents new perspectives and pathways for using pelagic ecosystem services for improved ocean governance.

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EXPERIMENTAL ECOSYSTEM ACCOUNTING: RECENT DEVELOPMENTS AND RESEARCH GAPS

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Ecosystem accounting approach addresses gaps in the current System of Environmental-Economic Accounting (SEEA) framework to describe interactions between the ecosystems and the economy by linking the ecosystem service flows to different parts of the economy. Experimental approaches were piloted to trial ecosystem accounting in Peru. The goal of this pilot was to field-test state-of-the-art theories and methods on quantification and monetary valuation of service flows from natural ecosystems, including forests. Within a larger set of accounts we used the "ecosystem services supply and use account" to record ecosystem services flows from the ecosystem (i.e., its supply) to beneficiaries (i.e., its use). In particular, we present results of monetary valuation of key ecosystem services in the region: provision of timber, water, firewood, bush meat, ecotourism, regulation of sediment and climate (carbon stock). Consistent with national accounting frameworks, we employed a multitude of methods for monetary valuation depending on type of ecosystem services and type of beneficiary. We discuss how monetary accounts can be integrated in combination with biophysical accounts within the broader ecosystem accounting framework and what are the limitations, challenges and opportunities for future research and development.

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SUSTAINABLE LANDSCAPES: THE FUTURE WE WANT

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A number of indicators exist to measure sustainability of landscapes, across socio-economic and ecological dimensions. However, those indicators are usually designed to assess sustainability in a static time frame and not under future conditions. In order to develop forward-looking indicators we need dynamic models capable of predicting evolution of landscapes into the future by integrating interactions between human systems and the environment, and how those change through time in response to internal and external drivers and pressures such as climate change, new technologies, investments, policies, population dynamics, consumption patterns and market forces.

This study is being conducted in San Martin region, Peru – a diverse landscape characterized by high biodiversity in forested ecosystems, population growth, population migration, deforestation and rapid growth in commercial agricultural systems such as coffee, cacao and oil palm. The project develops forecast models for major agricultural crops in San Martin – through the interactions between food production, deforestation and carbon emission for the year 2030. This ultimately leads to development of alternative pathways to maintain food production, earning revenues while minimizing deforestation and emission. The project also develops policy and business investment proposals required to achieve long-term sustainability at scale.

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ADAPTIVE MANAGEMENT FOR ECOSYSTEM SERVICES

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Management of natural resources is necessary even when there is basic uncertainty regarding system response to management actions, and is complicated by uncertainty, competing stakeholder goals, and non-linear responses and interactions among variables of the managed systems. Resource managers must balance competing needs of stakeholders, and tradeoffs inherent in all management decisions. An adaptive management framework is ideal for managing complex systems of people and nature in many circumstances, including when explicit outputs and tradeoffs of interest are ecosystem services. The flexibility inherent in adaptive management can accommodate tradeoffs among the multiple scales of ecological structure and process that inform stakeholder objectives and the production of suites of ecosystem services. If tradeoffs between ecosystem services are ignored, future problems may be created that can result in expensive remedial actions to restore previously available services. Further, humans interact with natural systems within a consistent but narrow range relative to the scales at which ecological structures and processes occur. It is important to consider and balance the temporal and spatial scales at which adaptive management will be applied because the temporal and spatial scales dictate to a great extent the potential tradeoffs in ecosystem services and the extent to which desired ecosystem services can be managed.

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INCORPORATING ECOSYSTEM SERVICES INTO MONARCH HABITAT RESTORATION PLANNING AT A REGIONAL SCALE

Zach H. Ancona and *Darius J. Semmens*
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Monarch butterflies (*Danaus plexippus)* are an iconic species that provides important cultural ecosystem services throughout eastern North America. The White House released the 2015 Pollinator Research Action Plan outlining the need to "restore or enhance 7 million acres of land for pollinators over the next 5 years" and "increase the Eastern population of the monarch butterfly to 225 million (individuals) occupying an area of approximately 15 acres in the overwintering grounds in Mexico by 2020." The most effective means of reaching this goal is to restore the monarch's host plant, milkweed (*Asclepias spp.)*, which has been greatly reduced in the northern part of the monarch's breeding range. However, recent work has shown that it is not possible to restore sufficient milkweed without involving agricultural land.

In this study, we consider whether targeting restoration sites for milkweed and other native vegetation that provides multiple ecosystem services could yield sufficient habitat while also increasing value from crop pollination and sediment/nutrient retention. We factor into our analysis that non-agricultural lands are contributing their maximum potential of milkweed, about 800 million milkweed stems. This leaves roughly 600 million milkweed stems needed on agricultural land in order to meet restoration goals set by the White House. We used the National Hydrography Dataset alongside cropland data to identify riparian areas adjacent to crops that could benefit from an increased presence of pollinator habitat in the Upper Midwest. We also used the NRCS cropland data layer to identify areas with the greatest potential to benefit from the sediment and nutrient retention services provided by riparian buffer strips. Our analysis focused on two scenarios for milkweed habitat restoration while considering the ecosystem services that would benefit from habitat restoration along riparian corridors.

Our first scenario targeted riparian corridors adjacent to non-corn/soybean crops as well as in corn/soybean cropland on marginal soils, which require greater treatment with fertilizers. In the first scenario, we used 30 meter buffers on both sides of riparian corridors, which have been shown to remove substantial quantities of nitrogen, phosphorus, sediment and pesticide pollutants from drainage areas, making our analysis ideal to examine the co-benefits of habitat and ecosystem service restoration. The first scenario could add approximately 67.2 million stems of milkweed on approximately 600,000 acres adjacent to riparian areas. Our second scenario used the same subset of cropland data, but increased the riparian buffers to 100 meters. This increase in buffer width could accommodate approximately 349 million milkweed stems in an area of 3.1 million acres. Future work should consider buffer strips on other agricultural lands like pasture and hay to further the progress towards restoration goals. Our results suggest that riparian buffers can be used to meet monarch habitat restoration goals while also restoring degraded ecosystem services like pollination and sediment/nutrient retention, thus giving taxpayers and farmers a bigger return on investments in monarch conservation.

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DESIGNING ENVIRONMENTAL METRICS TO SCALE: LESSONS FROM THE MONARCH BUTTERFLY

Erik Anderson
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So many of the environmental problems we face share a central problem: scale. How do we motivate and organize conservation at the pace and scale necessary to achieve meaningful outcomes? For species like the monarch butterfly, Greater sage-grouse, and a multitude of species in the Central Valley of California, the scale of action required can seem overwhelming.

Well-designed environmental metrics—and the tools necessary to measure, track and report them—hold the promise of making these unsolvable problems solvable. These tools provide science-based, objective and transparent assessments of habitat function or ecosystem service outputs. They allow for regulators, regulated entities, conservationists, and landowners to understand a problem in the same way, communicate with a shared language, and work towards a common goal. Using these tools, the contribution of every action can be understood in a quantified way, fostering innovation and creativity to achieve outcomes efficiently and with limited resources.

This presentation will provide an example, using the recently-developed Monarch Butterfly Habitat Quantification Tool, of how environmental metrics and associated tools can be designed to meet the needs of the diverse stakeholders who use them. This design approach, which balances the information needs of each stakeholder with reasonable constraints of data collection, allows for wide-scale adoption and use of the Monarch Butterfly Habitat Quantification Tool.

Preservation of the monarch butterfly's annual migration will require multi-national collaboration at an almost unprecedented scale. Well-designed environmental metrics can serve as the backbone of this collective effort, and can support restoration and recovery efforts for other imperiled resources and species as well.

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THE EFFECT OF LANDSCAPE CHARACTERISTICS AND ATTRIBUTES ON THE DEVELOPMENT OF BUMBLE BEE COLONIES (*BOMBUS IMPATIENS*) IN LOWBUSH BLUEBERRY (*VACCINIUM ANGUSTIFOLIUM*) FIELDS ON PRINCE EDWARD ISLAND.

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Bees provide an essential ecosystem service to many agroecosystems. The diversity and abundance of their communities, and the size of these populations in agricultural systems is weakly influenced by the size and shape of the patches (mean patch size, number of patches, interpatch connectivity) and their configuration in the landscape (Winfree et al, 2013)(Kennedy et al, 2013). Our observational study tests for a relationship between similar metrics and the development of bumblebee (*Bombus impatiens*) colonies. Colonies (6 per field) were placed near lowbush blueberry (*Vaccinium angustifolium*) fields (6 fields) on Prince Edward Island for a month (~30 days) both during and soon after the blueberry bloom period. Selection of each field site was based on our gradient of available floral resource. We modeled the effects of landscape composition (space occupied by each distinct landscape, length of roadways, length of coastline) & configuration (mean patch size, number of patches, patch evenness, and patch diversity), against colony development metrics (number of workers, number of queens, number of pollen pots, number of honey pots, & total hive weight) produced by each colony. Each of the landscape metrics was measured on two scales, within 500 m & 2 km of the field sites. Both linear and nonlinear regression techniques were considered. Our results indicate that the relationships between bumblebee development on blueberry fields and habitat quality around said fields are non-existent. These results are interesting and contribute to the growing body of research about landscape ecology and its effects on community dynamics.

We also compared indices of diversity and abundance counts to the aforementioned landscape characteristics. The only emergent trend was a linear correlation between native abundance and patch diversity. This relationship was modeled using simple linear regression.

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APPLICATION OF ECONOMIC TOOLS FOR WILDLIFE CONSERVATION: CASE STUDIES FROM PROTECTED AREAS OF INDIA

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The establishment of Protected Areas (PAs) forms the cornerstone of the strategy for wildlife conservation. The underlying goal of PAs is to maintain the ability of ecosystems to provide goods and services to sustain human wellbeing. However, in economic and development terms it is difficult to justify the costs involved in creation and maintenance of PAs. Given society's increasing demands for employment, income and infrastructure, development decisions tend to maximize short-term economic gains at the expense of life-sustaining ecological processes and functions. The significant economic, environmental and social benefits provided by PAs are usually not captured in market prices, thus providing inadequate incentives for conservation. When PAs are undervalued, their conservation appears to be less desirable in development terms. Though benefits derived from PAs are realized at local, national and global levels, the people living in and around PAs while deriving little benefits from conservation pay enormous costs in terms of lost access to their life support system, as well as damage to their crops, livestock and lives from wild animals. Hence, measures devised to conserve wildlife and their habitats must provide incentives to make conservation an economically viable and acceptable land use option for the local people by compensating them for the impoverishment caused by wild animals and providing incentives for better conservation practices. For this, it is important to understand who has been affected and who is paying the cost of conservation.

In order to ensure the sustained flow of benefits from conserved ecosystems for human wellbeing, valuation of the ecosystem services provided by PAs is essential. This can help resource managers deal with the effects of market failures, by measuring the benefits provided by PAs to society, which otherwise are generally hidden from traditional economic accounting. Addressing the value of ecosystem services helps society to make informed choices about the trade-offs involved in competeing uses of natural resources. Such analyses can identify marginalized stakeholders who pay the higher costs of conservation as well as the beneficiaries. This session aims to familiarize participants with the economic tools that canbe applied under differeing circumstances of time and resources for the assessment of costs and benefits of conservation. Based on case studies from various PAs of India, the session demonstrates that the economic valuation of services provided by conserved ecosystems can make a convincing case for wildlife conservation.

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PROVISIONING SERVICES AND STATUS OF HUMAN WELLBEING IN WESTREN HIMALAYAS

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The wellbeing of rural human societies is determined by the availability and accessibility of goods and services. We assessed the impact of different accessibility conditions and quality of provisioning services provided by the forest resources on the human wellbeing of user communities of Nanda Devi Biosphere Reserve, western Himalaya, India. Data regarding status of wellbeing was collected in 22 villages selected on the basis of secondary demographic information, distance and state of the forest resources i.e. degraded and less-degraded. Semi-structured questionnaire based interviews were conducted in randomly selected households (n=764). To assess the status of wellbeing first seven Millennium Development Goals of United Nations were used as indicators. To assess the quality and quantity of forest resource, transects (n=22) were laid in the forests frequented by the sampled households. It was found that the status of wellbeing of the household located close to forest was better than the households located away from forest. The wellbeing of households using less-degraded forest resources was significantly better than those using degraded resources. Households with access to less-degraded resources also consume wild fruits and vegetables which add to the food security of the user group. Other then quality of forest resources, access to education facilities and availability of alternative livelihoods were also found to be positively associated with the wellbeing of the respondents. Results highlight the importance of forests in human wellbeing. Hence, contribution of natural resources to wellbeing of rural communities should be considered by policy makers and linkages between wellbeing and forest health need to be incorporated in management and conservation of forest resources.

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ECOSYSTEM ACCOUNTING: APPLYING INTERNATIONAL LESSONS LEARNED TO THE UNITED STATES

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Natural capital accounting (NCA) tracks changes in ecosystem services and directly ties these changes to costs and benefits across different economic sectors. NCA has evolved to address a major shortcoming of conventional economic measures like gross domestic product (GDP) – that GDP ignores the economic contributions of nature and fails to indicate how the loss of ecosystem services can undermine economic prosperity. NCA is being used in dozens of countries globally, and similar approaches, such as those outlined by the Natural Capital Coalition, are being adopted by the private sector to measure and value their risks and dependencies on natural capital. Yet, until recently, the compilation of a data, modeling, and valuation infrastructure to support NCA in the U.S. had not yet occurred. This changed with the establishement in fall 2016 of a working group funded by the USGS' Powell Center for Analysis and Synthesis that brings together Federal agencies, academics, and the private sector to build a foundation for a national NCA system, building on these international standards. We are first compiling existing NCA-relevant data nationwide, linking and quantifying environmental-economic trends over time. We next are developing national-scale biophysical models of ecosystem services that can be applied using a cloud-based modeling system linked to national spatial datasets hosted by USGS and others. Finally, we will apply NCA at the subnational scale, within a landscape managed by multiple Federal agencies and where businesses are impacting and benefitting from natural capital, and for which economic data to value ecosystem services are available and policy applications are apparent. We will also identify uncertainties, data and methodological gaps, and next steps needed to advance NCA science and policy applications in the U.S. and beyond. Our approach aspires to provide a rigorous and replicable assessment process to support more sustainable natural resource management for Federal agencies and the private sector. This emerging work in the U.S. draws on a wealth of experiences in developing NCA and applying it to decision making around the world, including work by the World Bank-led Wealth Accounting and Valuation of Ecosystem Services (WAVES) Program and by the Natural Capital Coalition. In this presentation, we will briefly highlight international experiences in NCA, then describe the state-of-the-art and -science of emerging NCA in the United States, and how international experiences can inform U.S. efforts and vice versa.

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CLIMATE CHANGE, VEGETATION CHANGE, AND RECREATION IN MINNESOTA

Baishali Bakshi
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Climate change is causing a significant shift in forest tree species composition in the boreal forests of northern Minnesota. These changes will affect forest-based recreation, a valuable ecosystem service to Minnesota's economy. While research shows that people prefer forested areas to barren areas as locations for recreation, a gap exists in the literature connecting forest composition and recreation and their links with climate change. In this paper we use an econometric model to link county-level data on forest composition and a variety of forest-based recreation activities including fishing, hunting, hiking and wildlife watching, to quantify and predict the impacts of climate-induced vegetation change on recreation. The data for this research is sourced from the Forest Inventory Analysis (FIA) program of the US Forest Service, the Minnesota DNR, and the Forest Ecosystem Vulnerability Assessment for Minnesota (MN-FEVAS) research project. We present results in terms of a range of current and future climate scenarios. Our results inform policies on climate-adaptation and recreation potential of Minnesota's forests, while contributing to the valuation literature on cultural ecosystem services.

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MONITORING INDICATORS FOR EVALUATING RESTORATION PROGRAM SUCCESS FOR THE GULF OF MEXICO

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A number of restoration processes and decision-making bodies, such as the RESTORE Council, the National Fish and Wildlife Foundation and the Deepwater Horizon NRDA Trustee Council, will oversee the restoration activities associated with damage settlements of the Deepwater Horizon oil disaster. Monitoring will be an integral part of restoration planning, design, and assessment at the individual project level. The scope and scale of restoration efforts and the complex nature of the Gulf ecosystem, however, make quantifying the cumulative benefits of restoration activities extremely difficult. Our project goal was to determine if a set of monitoring indicators could be identified that could be used across monitoring efforts at the project level to provide information as to the overall ecosystem services and restoration impacts provided across restoration programs.

We evaluated potential monitoring indicators using two approaches, a top-down and a bottom-up screening. The top-down approach reviewed programmatic evaluation approaches for other major restoration programs (e.g., Puget Sound, Chesapeake Bay, Great Lakes, etc.) and selected seven evaluation criteria (e.g., cost-effectiveness, scientific validity, scalability, etc.). These criteria were then applied to an original set of almost 200 monitoring indicators to develop a short-list of system wide, ecosystem service indicators. The bottom-up approach looked at the types of restoration projects being proposed, and their associated goals and objectives, and developed a conceptual restoration model (CRM) for 14 types of restoration and targets. For each of these CRMs, the key relationships between system stressors, habitats, habitat conditions, and ecological community response was identified. Common system stressors across the varied environmental conditions were identified and an overall system-wide CRM was developed. Based on both individual and system CRMs, a set of monitoring indicators were identified. Results from the top-down and bottom-up approaches were compared and a suite of indicators was selected based on the convergence of the two approaches. We will present the results of our analysis and our list of indicators for tracking restoration program success.

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TELE-CONNECTED ECOSYSTEM GOODS AND SERVICES: ADDING CONTEXT TO COMMUNITY DECISION-MAKING USING AN EXPANDED FEGS APPROACH

Stephen B. Balogh
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The ecosystem goods and services approach has become an important means of evaluating trade-offs among diverse stakeholders in decision support processes. The final ecosystem goods and services (FEGS) conceptualization places the focus of the analysis squarely on the beneficiary of the good or service and defines services in terms that can be understood by the public without a need for interpretation. However, in FEGS analyses done to inform community decision-making, the scope is limited to a defined local or regional ecosystem and its inhabitants, and these analyses tend to focus on marginal changes in FEGS, i.e. the difference between a business as usual trajectory and various intervention options. This approach lacks context for the quantity or quality of FEGS delivered versus the demand for those goods and services, and also can fail to capture FEGS delivered to beneficiaries in the broader “servicescape.”

For many communities, especially those living in urban areas, the capacity of the local ecosystem to provide FEGS is inadequate relative to the population. In many cases the community may rely on ecosystems “upstream” or “downstream” of their immediate location to meet local demands for material and energy as well as waste assimilation. Communities also rely on regional, and sometimes distant ecosystems to provide supporting, regulating, and cultural services. In turn, FEGS are provided from local natural resources to communities elsewhere. Thus, urban lands have become increasingly “tele-connected” to local and distant areas, and changes in population or the patterns of consumption in urban communities can affect nonurban places and vice versa.

This paper synthesizes conceptual models and theory from social metabolism, systems ecology, and sustainability science into a framework for an expanded FEGS approach. I propose methods for evaluating FEGS in this broader spatial and temporal context. Using the San Juan Bay Estuary watershed as a case study, I quantify the teleconnections to distant ecosystems and compare production of FEGS with an estimate of demand. On the production side, ecoservice production rates from the literature and spatial datasets are used to calculate key FEGS or proxy goods and services. I also identify FEGS provided to the broader servicescape. For demand, food and energy consumption data are used to determine important metabolic inputs and outputs. From these material and energy flows, I estimate resource-sheds for the population within the watershed. I conclude with a discussion of the implications of the framework for research, evaluation, and practice. The results from expanded FEGS analysis provide valuable information for the community decision-making process by providing context for the quantity or quality of FEGS delivered, and local and distant, as well as short- and long-term benefits. Through this approach, communities can maximize benefits derived from the local ecosystem, while minimizing impacts on communities outside of their jurisdiction.

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BEYOND PLANNING AND RESTORATION: USING STRATEGIC PARTNERSHIPS TO SUPPORT, ENHANCE, AND EXPAND COASTAL RESTORATION PROJECTS IN URBAN AREAS

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When the Maryland Port Administration (MPA) created a new Dredged Material Containment Facility (DMCF) at the Masonville Marine Terminal within Baltimore City limits, it designed its mitigation efforts to focus not only the natural environment, but also the residents of the surrounding communities. MPA agreed to provide a package of community enhancements that included environmental remediation, an education center, habitat restoration and a site for nature-based recreational activities. Original plans called for MPA to restore 54 acres of upland and wetland habitat as well as the cove's 70 acres of shallow water habitat.

Early on, MPA engaged three local partners to help support those community enhancements and restoration efforts. The National Aquarium, The Living Classrooms Foundation and the BayBrook Coalition were asked to develop opportunities for community stewardship, on-site environmental education and to support green jobs for local community members. Soon after groundbreaking for the education center in 2009 other partners were brought on board to provide additional resources for the overall environmental restoration project. Most notably, the City of Baltimore and the U.S. Fish and Wildlife Service (FWS) were instrumental in lending their expertise in wildlife management, park management, neighborhood and community resources and access to larger scale planning efforts underway in the region.

The list of partners grew steadily and restoration and education efforts moved into the neighborhoods than included the Masonville Cove watershed. Funding efforts to increase stewardship and educational activities upstream were successful and eventually a Small Watershed Action Plan (SWAP) was developed with community input, additional restoration work has commenced in large green spaces within the communities and all 10 local schools in the watershed received dedicated environmental education programming by one or more of the project partners.

At the cove, partners are using the restored site for ongoing stewardship and engagement programs. These include but are not limited to the development of a Masonville Stewards group, annual Bioblitz, regular community-based restoration events, year-long environmental education programming, community nature-based programming, regular birding activities, installation of an osprey cam, citizen science programs, and workshops, etc. In the neighborhoods, partners are involved in facilitating green infrastructure BMPs, litter prevention initiatives, habitat gardening, and additional programs targeting issues of environmental justice and diverse stakeholders.

In 2013, the FWS designated the Masonville Cove project site as the first Urban Wildlife Refuge Partnership in the United States. Since a majority of FWS refuges are in remote locations but 80 percent of Americans live in urban areas, FWS identified the need to find innovative ways to share their mission with an expanded audience. The Urban Wildlife Refuge Initiative aims to forge connections between the National Wildlife Refuge System, natural resource conservation, and people living in urban areas.

Last year, the Masonville Cove Urban Wildlife Refuge Partnership became the cornerstone of a larger initiative, the Greater Baltimore Wilderness Coalition (GBWC). GBWC is engaging additional partners to create a network of protected outdoor spaces and connecting area residents to Baltimore's rich natural and cultural resources.

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TOOLS AND METHODS TO MANAGE CARBON SEQUESTRATION IN AGRICULTURE AND FORESTRY

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In this session I will discuss the policy context, methods, and tools for greenhouse gas and carbon estimation in agriculture and forestry. The Intergovernmental Panel on Climate Change (IPCC) provides guidelines for carbon estimation for agriculture, forestry, and other land use (AFOLU). This methodological guidance is applied in the annual *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, and the process-based biogeochemical model DayCent is used to model carbon and nitrogen fluxes in most agricultural and grazing land. The *Inventory* covers 1990 to present and utilizes AFOLU data primarily from USDA statistical samples and producer surveys. The entire time series of the *Inventory* is recalculated each year based on data and methodological improvements. This report is used by national policy makers to set and monitor greenhouse gas reduction goals. The national scale of the *Inventory* and IPCC methods, however, are not very useful at the local or entity scale in AFOLU due to variations in climate, soil, and management practices at the local scale. USDA recently developed the report *Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory*, which provides guidance for greenhouse gas estimation at the entity scale. Methods from *Quantifying Greenhouse Gas Fluxes*, along with the DayCent model, are implemented in the online tool COMET-Farm (cometfarm.nrel.colostate.edu/). COMET-Farm estimates greenhouse gas fluxes and carbon sequestration at the farm level and requires detailed producer input. A similar tool is being developed for forest managers. These tools can be used by individual producers, offset registries, and supply chain initiatives to estimate the effect of management changes on greenhouse gas fluxes and carbon sequestration.

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USDA'S CLIMATE CHANGE PLAN AND BENCHMARKING PROGRESS

Marci Baranski
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In 2015, the United States announced our intended nationally determined contribution (INDC) to greenhouse gas reduction for 2025: a 26 to 28 percent reduction in annual greenhouse gases (GHG) below 2005 levels. The United States is also considering a long-term goal of reducing emissions by 80 percent below 2005 levels by 2050. While agriculture and forestry are not explicitly mentioned in the INDC, these sectors are included as part of the country's "economy-wide" approach and have both GHG reduction and carbon sequestration potential. In an effort to strategically target this potential, the U.S. Department of Agriculture (USDA) is advancing the Building Blocks for Climate Smart Agriculture and Forestry, which aim to mitigate 120 to 135 million metric tons of carbon dioxide equivalent annually by 2025 through USDA and partner programs. This amount is approximately 6.5 to 7.5 percent of the national reduction goal for 2025. Activities are considered GHG reductions if they result in net emissions lower than baseline and carbon sequestration when they sequester additional carbon (e.g., existing forest stocks are not considered a sequestration). The Building Blocks are based on a set of five principles: (1) voluntary and incentive based, (2) focused on multiple economic and environmental benefits (e.g., ecosystem services), (3) designed to meet the needs of producers, (4) cooperative and focused on building partnerships, and (5) measured to evaluate progress. USDA GHG mitigation efforts will be quantified by agencies and should be reflected in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*.

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EVALUATING ECOLOGICAL AND COMMUNITY RESILIENCE BENEFITS RESULTING FROM DEPARTMENT OF THE INTERIOR HURRICANE SANDY PROJECTS

Amanda Bassow
Northeastern Regional Office, National Fish and Wildlife Foundation, Washington, DC, USA

In 2014, the Department of Interior partnered with the National Fish and Wildlife Foundation (NFWF) to administer an external funding competition to support coastal resilience projects in the region affected by Hurricane Sandy. The projects complement the DOI Bureau-led projects, but are led by state and local governments, universities, non-profits, community groups, tribes, and other non-Federal entities. Through a competitive grant process, NFWF awarded $102.7 million to 54 projects. Following an extensive effort led by DOI and Abt Associates to identify a set of ecological and socio-economic metrics needed to measure the combined impact of the DOI and NFWF projects, NFWF launched a third-party program evaluation to use these metrics to assess the impact of this unique body of resilience work.

This presentation will discuss plans for the evaluation, which kicked off in June 2016, and will run through 2018, seeking to answer the following questions:

1. Ecological Impacts: What fish, wildlife and other ecological/environmental outcomes have been observed in the project area? To what extent are they believed to be a result of Hurricane Sandy project activities, either individually and/or collectively? If more time is needed to observe the anticipated benefits, do the mitigation or restoration outcomes match the modeled projections for resilience improvements?
2. Social Impacts: To what extent did projects individually and/or collectively reduce estimated storm risk to coastal and inland communities and/or fish and wildlife and their habitats? To what extent did projects individually and/or collectively mitigate actual storm damage?
3. Cost-effectiveness: What is the relative cost-effectiveness of resilience activities (e.g., dune restoration, living shorelines, vulnerability assessments, early warning systems) for achieving ecological and social outcomes? In the long-term, how cost-effective are projects' green infrastructure approaches in achieving resilience outcomes when compared to gray infrastructure approaches?
4. Improved Understanding: Did/will the knowledge gained from the projects support improved decisions on implementing resilience strategies, and thus more cost-effective management of the coast in a changing climate?
5. What lessons have we learned regarding what is needed to achieve the program's coastal resilience goal?
6. What knowledge gaps would we need to fill to better understand the benefits of project activities and to inform planning and prioritization for green infrastructure implementation or restoration?

Recognizing the unique opportunity afforded by the scale and distribution of Hurricane Sandy projects, NFWF and DOI also are investing in longer-term monitoring through 2024 to better understand how these projects perform over time.

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MANAGING SPATIALLY DISTRIBUTED SMALL NATURAL FEATURES THAT PROVIDE LARGE-SCALE ECOSYSTEM SERVICES

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Many places have small natural features that are far more important for maintaining providing ecosystem services than their size would indicate. Examples include desert springs, rocky outcrops, coral heads, and vernal pools. Even single large, old trees embedded in an early successional landscape may have disproportionate ecosystem value. These landscape elements are arguably too small and scattered to be effectively managed using traditional ecosystem management. Because of their small size, conservation strategies are complicated by: (1) a lack of widespread understanding of their ecosystem service contributions among the scientific, regulatory, and public communities leading to perceptions of insignificance, (2) uncertainties over their physical location within a given landscape, (3) uncertainties regarding their legal status, and (4) a spatial scale mismatch between the broad, regional accrual of beneficial services and the concentrated, local costs of protection.

A diverse set of conservation tools has emerged to manage small natural features, but these tools often lack strategic coordination and ecological coherence. Nevertheless, these features present novel opportunities because they require less total conservation area, less intensive forms of protection, and, in some instances, shorter durations of protection than their larger counterparts. They can often be protected while allowing traditional activities such as forestry, fishing, and grazing to continue nearby, and even new residential development may be designed with ecological benefits in mind. Individual small natural features are often owned by a single landowner, thus avoiding difficult multi-landowner coordination. Lastly, they create interesting opportunities for diverse governance structures (e.g., state and local; top-down and bottom-up) that involve collaborations of multiple stakeholders targeted towards adaptive and flexible solutions.

This paper investigates the challenges and policy alternatives associated with conserving the ecosystem services provided by spatially distributed but ecologically connected small natural features. Using a spatial simulation model of town and landowner decision-making, we examine what types of policies are best able to provide eciosystem service protection given heterogeneity among local community and individual landowner attitudes towards conservation, the intensity of current and future land uses in the surrounding matrix, and the spatial dimensions of these features across the landscape. By simulating our behavioral model over numerous potential landscapes and community and landowner objectives, we predict how different policy alternatives will manifest in terms of ecosystem service production in various communities offering policy decision-making guidance to interested stakeholders.

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STATE OF PRIVATE INVESTMENT IN NATURAL CAPITAL

Description:
This interactive panel discussion will review the findings of a new report – State of Private Investment in Conservation – and will reflect both on the evolution of conservation finance and investment in natural capital in the last decade and on trends and opportunities for the immediate future.

In 2016, Forest Trends' Ecosystem Marketplace, Encourage Capital, JP Morgan Chase, the Gordon and Betty Moore Foundation, the David and Lucile Packard Foundation, the Nature Conservancy NatureVest program, Credit Suisse and Cornell University all partnered on a major new survey of private investment in conservation. The survey was carried out to better understand the size and scope of impact investments in conservation and the environment, and to help guide the investment community on developments and emerging trends or opportunities in the area of conservation investment.

While there has been much research done on impact investments, particularly as these related to social issues and bottom-of-the-pyramid (BOP) investments, the field of conservation impact investment has been less well studied. This report is a follow up survey and report to the Investing in Conservation Survey report published in 2014.

Panel Discussion Topics:
The panel discussion will explore a number of questions relating to the intersection of natural capital and conservation finance:

1. What are the key findings of the private investment survey?
2. What key areas of conservation – habitat, water, forests, agriculture, fisheries – are private investment moving to?
3. What are some of the risk and reward attributes of these investments? What are private investors looking for in conservation-related investments?
4. How are the conservation impacts or results of these investments being measured, and what are some of the results of these investments?
5. What are some of the challenges and barriers to scaling conservation finance?
6. What emerging trends are worth paying attention to?

S**ession Agenda:**
10 minute overview of survey findings, and 10 minutes each for panelists
60 minute facilitated audience Q&A and discussion

Speakers
Organizer and Moderator: **Ricardo Bayon**,
Partner, Encourage Capital

Panelists:

Kari Cohen
Deputy Chief for Science and Technology, USDA NRCS, and head of NRCS' Environmental Markets program

Eric Hallstein
Chief Economist and Director of Conservation Investments for TNC California

George Kelly
Chief Markets Officer, Resource Environmental Solutions (RES) and former President, Environmental Banc and Exchange

Roger Williams
President, Blue Source and manager of corporate strategy, sourcing and development of verified emission reduction projects for Blue Source's aggregated offset portfolio

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DEVELOPING ECOLOGICAL PRODUCTION FUNCTIONS: A PROCESS FOR LINKING ENVIRONMENTAL STRESSORS TO ECOSYSTEM SERVICES VIA THE STEPS FRAMEWORK

***Michael D. Bell*[1]*, Jennifer Phelan*[2]*, and Tamara F. Blett*[1]
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Anthropogenic stressors such as climate change, fire, and pollution are driving shifts in ecosystem function and resilience. Scientists generally rely on biological indicators of these stressors to signal that ecosystem conditions have been altered beyond an acceptable amount. However, these biological indicators are not always capable of being directly related to ecosystem services that allow scientists to communicate the importance of the change to land managers and policy makers. Therefore, we developed the STEPS (**ST**ressor – **E**cological **P**roduction function – final ecosystem goods and **S**ervices) Framework to link changes in a biological indicator of a stressor to Final Ecosystem Goods and Services (FEGS). The STEPS Framework produces “chains” of ecological components that connect the change in a biological indicator to the Final Ecosystem Goods and Services Classification System (FEGS-CS). The series of ecological components is an ecological production functions (EPF) which links a biological indicator of a stressor to an ecological endpoint that is directly used, appreciated, or valued by humans (i.e., FEGS). The framework uses a qualitative score (High, Medium, Low) for the Strength of Science (SOS) for the relationship between each of the components in the EPF to identify research gaps and prioritize decision making based on what research has been completed. The ecological endpoint of the EPF is a FEGS to which discrete Beneficiaries, or direct users of the ecological endpoint, are identified to evaluate who is being impacted by the change.

The STEPS Framework should be able to be adapted to any system in which a stressor is modifying a biological component. Linking biological indicators to ecological endpoints identifies the multiple pathways that a stressor can influence the ecosystem and highlight which changes are most expansive and where changes congregate downstream. We developed an equation to characterize the SOS for the EPF that takes into account the strength of each link in the chain and the number of links in each chain. This equation ranks the chains based on knowledge, not the relative impact of a stressor on each FEGS. Managers and policy makers may use this information to understand uncertainty imbedded in the chains, or select chains with strong scientific foundations for further assessment and subsequent valuation. The clarity and quality of the chains are also being used to tell compelling stories to efficiently and effectively relate the importance of the changes to focused audiences. The results of the analysis are be transferred to the social science community enabling them to apply valuation measures to multiple or selected chains, providing a more comprehensive analysis of the effects of anthropogenic stressors on measures of human well-being.

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MANAGING WETLANDS FOR CLIMATE CHANGE ADAPTATION AND DISASTER RISK REDUCTION: A CASE STUDY OF THE EASTERN FREE STATE; SOUTH AFRICA

Johanes Amate Belle
Disaster Management Training and Education Centre for Africa, University of the Free State, Bloemfontein, South Africa

Wetlands play a critical role in CCA and DRR. Using a combination of frameworks, this study explored the integration of DRR and CCA into wetlands management. The overall aim was to develop a holistic and integrated management framework for wetlands that will be resilient to disaster risks and climate change impacts in the eastern Free State Province. Such a framework will also be replicable elsewhere.

A mixed research method was followed and 95 wetlands were randomly selected. Four tools were used to collect primary data which was analyzed using SPSS for quantitative and into themes for qualitative data.

Communal wetlands were more degraded partly due to a problematic legal and institutional arrangement for wetland management in South Africa, poor land use systems and poor wetlands management. Wetlands in protected areas and in private commercial farms were in good ecological state but needed constant monitoring. Though the later wetlands could mitigate the recurrent risks of drought and wild fires; that was not the case with communal wetlands. Proper legal and institutional arrangement, education and awareness on wetland functions especially those on DRR and CCA were key to ensuring the wise and sustainable management of wetlands in the area. To build wetland resilience in the area especially for DRR and CCA, an IWMF was proposed that was to be boosted with further research. Quantifying the peat content of wetlands in the study area was needed in order to exploit the possibility of carbon trading as a way of reducing GHG emission and conserving these wetlands.

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USING CLASSIFICATION AND CAUSAL CHAINS TO CONSIDER AIR QUALITY IMPACTS TO FEDERAL LANDS

Tamara Blett *and Michael D. Bell*
National Park Service, Lakewood, CO, USA

Federal agencies are increasingly using ecosystem services constructs to characterize how changes to the environment affect human welfare. However, few of these efforts to date have focused on developing the the "supply side" of ecosystem services. Using classification systems to provide a comprehensive ecosystem map that describes potential impacts to natural resources from an ecosystem stressor can provide links between how changing environmental inputs are impacting the end products humans value. Developing causal chains for multiple impact pathways that end at an Ecosystem Services classification, allows for an examination of possible tradeoffs, identification of synergistic effects, and highlighting of concern areas.

One such stressor is the deposition of air pollututants to ecosystems. To better explore the rich landscape of multiple and varied links between biological indicators of air pollution and potential users of ecosystem services, we assembled a group of 27 ecologists, air quality specialists, and economists from multiple federal science and land management agencies, in a 2015 workshop. Participants were divided into four teams and tasked with using a framework to assess the impacts of four categories of pollutant deposition: aquatic acidification, aquatic eutrophication, terrestrial acidification, and terrestrial eutrophication on federally managed lands.

Air quality impacts were selected as a case study for our workshop, because the impacts of air pollution on natural resources are well documented and critical loads (impact thresholds) have been developed for many biological indicators. The exceedance of a critical load leads to a change in a sensitive component of the ecosystem, but without the causal chain to an ecosystem service, would not tell the land manager that air pollution may be diminishing the ecosystem services provided by aquatic or terrestrial systems. Understanding potential ecosystem services losses, and identifying the beneficiary groups that care about them, can help land managers implement effective policy or management actions, and assist air regulators in illustrating the potential benefits to the public of emissions reductions of nitrogen and sulful pollutants which contribute to eutrophication and acidification of ecosystems.

The four workshop teams identified 169 unique environmental pathways linking an air pollution induced change in a biological indicator to Final Ecosystem Goods and Services, resulting in a total of 1073 unique links between a critical loads exceedance and a beneficiary; identified as chains. Lessons learned about how to effectively utilize multidisciplinary groups to develop causal chains included: (1) clearly identify workshop purpose and objectives, (2) provide context and background for participants (3) pre-select a process for chain development (4) select a discrete stressor or action where impacts and indicators are well-founded, (5) focus on an established classification system with defined endpoints (6) use small working groups of subject matter experts to develop products, (7) follow up with publication of results, and (8) that developing a narrative between the stressor and the human component can better engage the end user.

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LIVING SHORELINES: SYNTHESIZING RESULTS OF A DECADE OF IMPLEMENTATION IN COASTAL ALABAMA

Brittany Blomberg[1], *Kenneth Heck*[1], *Judy Haner*[2], *Dorothy Byron*[1], *Steven Scyphers*[3], *Jonathan Grabowski*[3], *Mary Kate Brown*[2], *and Matthias Ruth*[3]
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Substantial funds have been invested in living shoreline projects across the U.S. to restore critical coastal habitats (i.e., oyster reef, salt marsh), protect shorelines and enhance resiliency of coastal communities. A variety of techniques have been implemented, and new technologies continue to be developed. However, we don’t have a firm understanding of the degree of success of different technologies and designs of living shoreline projects. In this study, we synthesized physical, biological, and socioeconomic data from 12 living shoreline projects implemented in coastal Alabama over the past decade to evaluate project success and quantify the ecosystem services provided. Projects included in this synthesis span a wide range of reef technologies (e.g., loose oyster shell, bagged shell, reef balls, reefBLKs, etc.) and spatial scales (e.g., meters to miles). We aimed to determine which methods are most effective in providing a suite of ecosystem services, such as shoreline stabilization, habitat enhancement and potential water quality benefits. All monitoring data collected for each project were compiled and analyzed to evaluate the performance and efficacy of each reef technology. Market and non-market valuation techniques were used to estimate the value and benefits of several ecosystem services, and service delivery was compared among project techniques and expected reef lifetimes. Quantifying ecosystem services consistently across projects can elucidate how the provisioning of services varies among techniques. Here, we present lessons learned from these past projects and identify the most promising strategies to ensure that future large-scale investments maximize ecological and societal benefits. Our results are widely applicable to other areas across the Gulf of Mexico and elsewhere, and will help inform decision-making by allowing more accurate and comprehensive prediction of the environmental benefits and societal values derived from living shoreline projects.

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FIELD STEWARDS: GROWING A MARKET FOR CLEAN WATER

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Consumers are demanding more from companies – especially in the food industry. They want more transparency, accountability, and social and environmental responsibility from the brands they support.

Food companies know they have sustainability challenges, but a complex agricultural commodity system make it both expensive and extraordinarily difficult to track inputs like corn and soybeans from the field to the consumer.

To address these issues, the Field Stewards program, supported by grants from the Natural Resources Conservation Service and the McKnight Foundation, is building a certification and offset market for water quality protection in row crop agriculture in the Upper Midwest.

Certified farms meet a high standard of water quality protection on all fields and farmers are eligible to sell certificates associated with their corn and soybeans acres. Food companies purchase these certificates through the Field Stewards program to offset the environmental impact of their corn and soybean supply chains.

Through the selling of certificates, farmers receive a direct financial benefit for their stewardship efforts, food brands address supply chain sustainability challenges, and consumers have the opportunity to support a water quality friendly product. A triple win.

In 2016, GNP Company, the largest integrated chicken producer in the Upper Midwest, will be the first brand to purchase certificates from certified farmers.

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MATRIXGREEN AS AN APPLICATION TO IDENTIFY THE CONNECTIONS OF LIVEABILITY IN UDAIPUR, INDIA

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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 increasing evident among urban planners that cities become fragmented, losing social and natural connections to their surroundings as they lose more and more nature to hard surface development. Fragmentation is a significant challenge for urban planning when preserving ecosystem services, and especially when striving to preserve biodiversity.

This presentation describes the use of MatrixGreen, a toolbox to ArcMAP providing urban landscape connectivity analysis. The toolbox was used in the city of Udaipur, India, to help urban planners to identify opportunities for green space important for social and ecological connectivity and where urban development should be curtailed or re-imagined to promote the social and ecological connectivity in the most effective way possible. Udiapur is an ancient walled city surrounded by lakes in the southwestern state of Rajasthan. MatrixGreen identifies patches (e.g., social and natural open space) in the urban landscape and the connectivity (e.g., transport, communication and migration) links between patches. By analyzing network connectivity, urban planners can identify patches in the city landscape that lack sufficient connectivity to other patches and the natural environment (Component Analysis). Urban planners also can identify patches centrally situated within the network (Betweenness Centrality), a metric useful to measuring the stepping-stone importance of individual patches.

The Udaipur project was conducted in 2015/ 2016. Udaipur contains thousands of religious shrines, holy or sacred places, often accompanied by large sacred trees. The walled city in Udaipur could be viewed in the context of shrines and sacred places representing patches in the urban network. Local avifauna expertise could define a connectivity framework for ecological species using the big trees as stepping stones between these patches. The initial MatrixGreen analysis indicated that the existing network was poor; many shrines are badly maintained and the associated ecological and cultural values of these places significantly degraded. MatrixGreen was then used to re-imagine the urban network where shrines and sacred places in the walled city functioned as hotspots for ecosystem services. The comparison showed that by focusing on changes to urban development plans the city could improve the health, safety and cultural conditions of patches within the urban network and reconnect the walled city to the surrounding natural environment. The work demonstrated how focusing resources on creating ecosystem service hotspots in the current ecological and cultural structure of the city can increase the potential for biodiversity and social connectivity, thereby supporting a more liveable and resilient urban environment.

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ESTIMATING THE COST OF WETLAND LOSS IN LOUISIANA IN TERMS OF VULNERABILITY TO HURRICANE DAMAGES

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Coastal storms have the potential to cause significant damage to communities. Projections of future hurricane regimes, population growth, and sea level rise suggest that coastal communities will be increasingly vulnerable to damage from coastal flooding in the future. Sea level rise associated with climate change also threatens ecosystems that are known to be beneficial for reducing the impact of coastal storms, such as reefs, dunes, forests, and marsh. These protective ecosystem services provided by coastal wetlands are the focus of much research and management effort. The coast of Louisiana is suffering from severe wetland loss as the result of decreased sediment flows and increased saltwater intrusion. Billions of dollars in restoration projects are planned for the next 50 years, but very little is known about the economic value of the damage mitigating ecosystem services provided by natural coastal features. This presentation describes an application of the expected damage function (EDF) approach to valuing natural features for the damage mitigation services provided. The EDF approach uses economic damage data to model damages as a function of explanatory variables (e.g. storm intensity, population characteristics) including some measurable and valuable component of the natural feature of interest. The value of the natural feature can derived according to the model parameters because the dependent variable is already in monetary terms. This method is considered an alternative to conventional ecosystem service valuation techniques because there is no direct elicitation of consumer preference or willingness-to-pay (WTP), but provides a useful lower-bound estimate for the value of protective ecosystem services. The results of the valuation show that coastal wetlands are highly valuable for the mitigation of storm damages. Additionally, the geographic location of the wetland has a significant impact on the value of protection it provides. For example, wetlands display decreasing marginal product, implying that the value of a given wetland increases with size, but at a decreasing rate. We demonstrate that, as Louisiana's coastline recedes, the cost of future wetland loss (in terms of increased vulnerability of economic damages) will be significantly greater than the costs incurred due to past wetland loss. The results also explore how the value of this ecosystem service varies with population size and hurricane intensity, and highlight why this information is useful for project prioritization and planning. Given the potential for hurricane damages to reach well into the billions of dollars, small reductions in damage can be highly valuable relative to other ecosystem services. Because of the importance of this ecosystem service and the relative lack of development in the EDF approach, there is a potential for significant progress in this line of methodology. The method is also valid in other instances where the damages resulting from a disaster are affected by environmental features, and some general guidelines for the method are discussed.

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MISSISSIPPI RIVER DIVERSIONS: COMMUNITY IMPACTS AND ECOLOGICAL RESTORATION

James Boyd

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Billions of restoration dollars from the Deepwater Horizon Settlement have become available to Louisiana and other Gulf Coast states. The talk will describe one proposed use of that funding: large-scale diversions of the Mississippi River to deliver sediment and build land along Louisiana's coast. Dozens of state, federal, and other institutions are involved in the planning, financing, and possible approval of these investments. A variety of political, legal, economic, and environmental disputes have emerged as this restoration option is debated. The talk will describe how environmental and social science is contributing to the identification, assessment, and resolution of those conflicts. The talk will be of most interest to those interested in how ecosystem services analysis is used (or not) in a contentious "real world" context.

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REPRESENTATION OF REPTILE BIODIVERSITY AND ECOSYSTEM SERVICES WITHIN THE PROTECTED AREAS OF THE CONTERMINOUS UNITED STATES

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A focus for resource management, conservation planning, and environmental decision analysis has been mapping and quantifying biodiversity and ecosystem services. The challange has been to integrate ecology with economics to better understand the effects of human policies and actions and their subsequent impacts on human well-being and ecosystem function. Biodiversity is valued by humans in varied ways, and thus is an important input to include in assessing the benefits of ecosystems to humans. Some biodiversity metrics more clearly reflect ecosystem services (e.g., game species, Federally theatened and endangered species), whereas others may indicate indirect and difficult to quantify relationships to services (e.g., taxa richness and cultural value). Recently, species distribution models have been developed at broad spatial scales and can be used to map biodiversity metrics. The importance of reptiles to biodiversity and ecosystems services is not often described and only recently have there been attempts to identify these ecosystem services. Provisioning services provided by reptiles include food (e.g. turtles, alligators) and medicine (e.g. anti-venom). Regulating services include disease transmission and pest outbreaks (e.g. rodent populations). Cultural services include awareness of venomous species and regulatory frameworks (Federally and state listed species). Supporting services include food web dynamics, altering physical habitats, and cycling nutrients. In the present study, we identify and map reptile biodiversity and ecosystem services metrics. We used recently completed species distribution models for reptiles in the conterminous United States from the U.S. Geological Survey's Gap Analysis Program. We focus on species richness metrics including all reptile species richness (322 reptiles), taxa groupings of lizards (116), snakes (146) and turtles (58), NatureServe conservation status (G1, G2, G3) species (61), IUCN listed reptiles (39), threatened and endangered species (22), Partners in Amphibian and Reptile Conservation listed reptiles (63), venomous reptiles (21) and rare species (80). These metrics were then analyzed based on the Protected Areas Database of the United States (PAD-US) to provide insight into current conservation lands and reptile biodiversity and ecosystem services. We present results of these various biodiversity and ecosystem services metrics focusing on current distributions and overlap with conservation lands. The project has been conducted at multiple scales, starting at watersheds, then multi-state regional areas, and currently at the national-level EnviroAtlas. As an example of the plasticity of this approach, we provide results for one taxa (reptiles) for the conterminous United States. We provide a method to map and quantify ecosystems services at broad scales using documented agency or organization lists and USGS Gap Analysis Program datasets to look at various aspects of reptile biodiversity and ecosystem services. These datasets are not available globally but other models at the county, state/province, nation, continental, and global scale can be used to conduct similar analysis.

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A POLLINATOR HABITAT CREDIT PROGRAM ON PERMANENTLY PROTECTED FARMS IN MICHIGAN

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The loss of more than 30% of managed honeybee colonies during the last several years is a threat to U.S. agriculture because one third of our food supply relies primarily on honeybees for pollination and insect-pollinated crops were valued at $20 billion in 2000. Also, the U.S. Fish and Wildlife Service lists more than 50 pollinator species as being threatened or endangered and wild honeybee populations have dropped 25% since 1990.

Pollinator habitat is one of many ecosystem services that well-managed farmland can provide and AFT is initiating an effort through funding from an NRCS Conservation Innovation Grant to explore its market opportunities. This project will test the use of an adapted Pollinator Habitat Credit guidance protocol to enhance long-term agricultural productivity and environmental sustainability, stimulate development of environmental markets and leverage additional private sector funds for farmers participating in the Agricultural Land Easement (ALE) program. More specifically, this project will: 1) establish at least 40 acres of pollinator habitat (80 pollinator credits) on 20 new or existing permanently protected sites; 2) provide training on proven implementation techniques to local conservationists; 3) engage at least 15 private businesses in helping to fund establishment of pollinator habitat on selected sites through Payment for Ecosystem Services (PES); 4) learn how to efficiently blend the rules and requirements of local farmland protection programs, farmer contracts and PES programs; and, 5) use the resulting market framework and guidance to expand this effort to other states with active farmland protection programs.

A significant innovation of this project will be the opportunity to test the integration of public and private programs and funding sources for voluntary farmland protection and conservation efforts. In particular, the project intends to incentivize additional farmland protection by combining conservation easements with pollinator habitat creation, stimulating PES markets and exploring and testing integrated projects using different NRCS programs such as ACEP.

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THE NET RESOURCES ASSESSMENT: ASSESSING THE TRADEOFF BETWEEN ECONOMIC DEVELOPMENT AND CONSERVATION OF ECOSYSTEM SERVICES

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The Net Resource Assessment (NetRA) is a policy relevant analytical model to assess multiple natural resource availability and to examine the interrelationship between energy, mineral development and its impact on natural ecosystem services. The approach emphasizes the interdependence of natural resource development and its effect on collocated ecosystem services in a spatiotemporal model. This interdependence is a crucial consideration in land management and land use decisions. The NetRA has been developed as an integral component of the USGS Multi-Resources Analysis (MRA).

The NetRA contains an analytical decision support tool (DST) to address the needs and direction of resource managers. The current NetRA is in the Proof of Concept phase that is defined as a realization of a method to demonstrate its feasibility to inform resource management decisions. The Proof of Concept establishes functionality to simulate complex domains or systems over space and time and the capacity to be propagated to alternative locations where desired. Currently, a limited version of the NetRA operates at multiple map scales, contains a set of integrated, compatible sub-models with specific data requirements for natural resource stocks, engineering economics, biophysical and ecological data for ecosystem services stocks, market prices, regulations, and nonmarket values.

The NetRA is applied in a hypothetical example in USGS Assessment Unit (AU) 200263 in the Piceance Basin, Colorado. The example was undertaken to estimate revenues from hydraulic fracturing of natural gas reserves and the impacts on ecosystem services in the region including Mule Deer species, aquatic species and consumptive uses of water supplies.

The design and application of the NetRA Proof of Concept are discussed and a demonstration of outputs are presented to show how the DST is used to integrate natural and ecological resource assessment. At the Proof of Concept stage there are several assumptions, however, the model outputs establish that USGS science information can provide critical support in the evaluation of the impact of continuous natural gas production activities can have on ecosystem services at a regional scale. Variation of net social benefits from development demonstrates that there is an impact on the region due to the distribution of geophysical characteristics. The hypothetical example demonstrates that social costs imposed on ecological and water resources could be significant as the area for gas production expands across the assessment unit. Finally, 3D maps are produced to rank land in terms of net social benefits.

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VALUING CHANGES TO ECOSYSTEM SERVICES FROM GAS AND MINERAL DEVELOPMENT

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Gas and mineral development impacts local ecosystem services through land disturbance. This disturbance typically results in a loss to ecosystem services, which could be viewed as a perpetual loss (i.e. economic loss in one period results in economic losses in future periods as well). Using the results of a meta-analysis, economic consumer surplus values are calculated for two ecosystem services (Mule Deer and Aquatic Species) in the Piceance Basin of western Colorado. A meta-analysis uses the results of multiple studies to estimate a value, in this case consumer surplus estimates from over 1,000 studies were employed to estimate consumer surplus for the two ecosystem services. Consumer surplus is an economic valuation concept that is used to derive the benefits of ecosystem services to society. The meta-analysis provides the vehicle for estimating the benefits of these ecosystem services, viewed as a perpetual loss. We integrate these discounted consumer surplus estimates into the Net Resource Assessment (NetRA) policy tool that has been developed to demonstrate how the inclusion of social costs can impact resource development plans.

The NetRA has been applied through a series of hypothetical examples to demonstrate how differing development plans can impact two of the ecosystem services found in the Piceance Basin. In deciding which development strategy in a specific location should be implemented, a resource manager would calculate the social net benefits of development rather than only the traditional private economic benefits of natural resources development. Through the incorporation of consumer surplus into the NetRA we are able to calculate total social benefits in a spatial frame. Understanding social values for ecosystem services is an important step to ensure their long term existence to provide perpetual social benefits. Preliminary findings indicate that while a loss in ecosystem services occur, when discounting this loss using the Net Present Value (NPV) formula these losses are not as large in magnitude.

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THE POWER OF PUBLIC-PRIVATE PARTNERSHIPS

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While drivers for GI clearly exist (regulations, resilience, New Urabanism), the current approach to implementing green infrastructure (GI) has led to limited deployment of this valuable potential asset. Several factors can be attributed to this result. First, the cost of GI (especially for urban retrofits) has been seen as prohibitively high. Second, public procurement processes that govern the pace and scale of GI implementation are cumbersome and inefficient. Third, concerns regarding the performance of GI, particularly long-term, are common and the costs associated with maintenance are uncertain. The result of these barriers are GI plans that are often stuck at the "pilot" stage, at best, or simply aspirational, at worst.

In the context of ecosystem services, it is clear that piecemeal, small-scale implementations of GI limits overall environmental and social impact. For instance, large-scale green infrastructure and green spaces, such as parks and urban forested areas, can help to facilitate the movement of wildlife through enhanced habitat connectivity. The United Nations' "Green City Metric" proposes a minimum amount of green space per inhabitate (9 square meters) for "proper urban sustainability", which suggests that the scale of GI and sustainability are linked and Singh et al (2010) found that cities with adequate greenspace are those who provide between 20 and 30 percent green coverage. Jarden et al (2016) found that when GI is applied at the catchment-level, peak runoff can be reduced by 33% and total volume reduction can reach 40%. Clearly, the dimension of scale is critical to the impact of GI in urban areas.

One method to be considered when attempting to overcome barriers to scale is the use of public-private partnerships (P3s). The use of P3s is on the rise in the U.S. in transportation and other sectors due to the ability to reduce project costs as well as the pace of project implementation by utilizing private procurement processes and integrating project delivery services (design-build-maintain). Additionally, P3s can provide a unique platform for private investment when public funding is not adequate.

A P3 approach tailored to GI, the Community-Based Public-Private Partnership (CBP3) model, which was developed by EPA Region 3 (Mid-Atlantic), had been adopted by Prince George's County, Maryland, to retrofit 2,000 impervious acres within three years, and potentially an additional 13,000 acres within the next ten years. It is expected that the CBP3 approach can reduce costs by 40-50 percent while greatly accelerating project delivery. Additionally, a stringent inspection program ensures that payment is not made to the private party if performance is not provided. Lastly, the CBP3 allows for low-cost blended financing that, along with enhanced project delivery, results in a framework that promotes large-scale GI investment, which enhances social and environmental benefits as well as drives local jobs and economic benefits.

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SYNERGIZING SOCIAL JUSTICE AND AGRICULTURAL SUSTAINABILITY OBJECTIVES IN THE IMPLEMENTATION OF THE ENVIRONMENTAL QUALITY INCENTIVES PROGRAM IN THE FLINT RIVER BASIN, GEORGIA

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The combined impacts of climate change and increased demand for water resulting from population growth and the expansion of irrigated agriculture are likely to decrease the overall water supply in the Flint River Basin (FRB) of southwest Georgia. Historically, African-American farmers in the FRB have been especially vulnerable to the impacts of drought due to widespread discrimination within the USDA limiting access to federal farm funding. In recent years, the USDA has worked to improve access to federal funds among "socially disadvantaged farmers" through several Farm Bill Provisions, including provisions in the 2014 Farm Bill that provide higher cost-share payments under the Environmental Quality Incentives Program (EQIP) for this group . While the EQIP program was ostensibly designed to incentivize the adoption of agricultural conservation practices, it also provides cost-shares for the expansion of irrigated agriculture, potentially imposing additional stress on local water supplies.

In this presentation, I assess the potential role of the EQIP program in improving water efficiency and promoting social justice using quantitative and qualitative methods, with the FRB serving as a case study. Using semi-structured interviews and analysis of EQIP spending data, we evaluate how the Natural Resource Conservation Service (NRCS) has navigated trade-offs between social justice and agricultural sustainability objectives in the implementation of the EQIP program in the FRB. Specifically, we assess how effectively the EQIP program has engaged African American farmers in the region and how the program has impacted irrigation practices and agricultural water use. This research will help contribute to efforts to identify mechanisms that can be used to help synergize these potentially competing objectives to maximize the social and environmental benefits of the Environmental Quality Incentives Program.

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KEY ATTRIBUTES OF ECOLOGICAL PRODUCTION FUNCTIONS

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Ecological production functions (EPFs) link ecosystems, stressors, and management actions to ecosystem service (ES) production. Though essential for improving environmental management, relatively little attention has been directed toward the characteristics of EPFs. EPFs may be defined as *usable expressions (i.e., models) of the processes by which ecosystems produce ecosystem services, often including external influences on those processes*. We identify key attributes of EPFs and discuss both actual and idealized examples of their use to inform decision-making. Whenever possible, EPFs should estimate final, rather than intermediate, ESs. Although various types of EPFs have been developed, we suggest that EPFs are more useful for decision-making if they quantify ES outcomes, respond to ecosystem condition, respond to stressor levels or management scenarios, reflect ecological complexity, rely on data with broad coverage, have been shown to perform well, are practical to use, and are open and transparent with regard to code and documentation. We illustrate how conceptual and quantitative EPFs, representing the links between stressors and multiple ES endpoints, could be used to improve ES inclusion in risk assessment. The biggest challenges to implementing ES inclusion are the limited degree of detail in available datasets and generally poor understanding of linkages among ecological components and the processes that ultimately deliver the ESs. We conclude by advocating for the incorporation into EPFs of added ecological complexity and greater ability to represent the trade-offs among ESs.

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FOREST COMMUNITY, THE CAMBODIA PERSPECTIVE

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Cambodia 2016

The Kingdom of Cambodia is one of the smallest countries in Southeast Asia, located in the southwestern part of the Indochina peninsula. The Kingdom lies between 10°-15°N and 102°-108°E. Cambodia shares borders with Thailand, Laos and Vietnam. The area of Cambodia is approximately 181, 035 km2. In 2014, the population was approximately 11 million, 85 percent of whom lived in rural areas.

Cambodia is rich in natural resources, especially forest resources. Forest resources are one of the most important natural resources for national socio-economic development. Before 1970, a forest inventory implemented by the Forest Research and Education Institute (FREI) reported that the forest cover was 13, 227, 100 ha or 73 percent of the total territory.

Over the last 30 years, few forest inventories have been conducted in Cambodia. From 1993 to 1998, the rate of deforestation escalated to approximately 2 million ha per year-the highest rate of deforestation ever recorded in Cambodia’s history. According to the interpretation of LANSAT satellite imagery (1996/97-UNDP/ FAO), the forest cover of Cambodia is now estimated to be approximately 58 percent.

The principal direct causes of deforestation in Cambodia are extensive commercial forest exploitation and agriculture expansion. Inappropriate resource use, uncertain resource tenure and rapid population growth also contribute to the destruction of forest resources. Economic, social, and political forces, manifested in policy failures such as poor land-use planning, population pressure and poverty drive these factors

Scope and main objectives

At present, rural people need forest resources to maintain and improve their living standards and to meet their cultural needs. The Forestry Administration (FA) has responsibility for forest management and recognizes the importance of working with communities to meet the needs of rural Cambodians and to achieve sustainable management of forest resources.

Back ground of Community Forest

- The CF concept was initially introduced and piloted in Cambodia in the early 1990s, with a pilot area of 500 ha approved in Takeo Province in 1994
- It remained the only approved CF until the next CFs were legalized in Siem Reap in late 2007/2008 and in Kampong Thom and Oddor Meanchey provinces in 2009.
- NGOs supported and assisted communities’ to set about establishing and forming community based organizations, to manage areas for CF.
- The drafting of a sub-decree for CF by Ministry of Agriculture Forestry and Fishery in 1996, and was then adopted in Dec 2003.

Major Milestones of CF Evolution

- 1994: CF development with support from INGOs/donors.
- 1990s- 2000s: Different approaches developed and about 100 sites identified by 2002.
- 1996 CF Sub-Decree drafted with supported from NGOs

- 1998 Community Forestry Working Group established
- 2000: CF Guideline (Prakas) drafted by CF Working Group
- 2002: Forestry Law passed, and under the Law, CF recognized as a valid community based forest management modality.
- Late 2003: The Council of Ministers approved the Sub-decree
- 2004: FA organized a National CF Program Taskforce supported by NGOs
- Dec 2006: Guidelines (prakas) on CF approved by MAFF

Major lessons learnt

CF plays the following important roles:

- Contribute to the conservation and sustainable management of tropical forests, so as to meet the economic, social and environmental demands
- Empowerment of local communities and encourages the development of voice and encouraging dialogue between stakeholders and building capacity of community representatives.
- Promoting CF help increase local tenure rights and reduces the risk that forests and forested land will be illegally grabbed by individual and powerful interests undermining local needs
- CF legalisation have resulted in more effective enforcement of law and patrolling and thus, a reduction in illegal and destructive activities, increased supplies of NTFPs, and help to increase forest recovery and regeneration and increased local wildlife numbers and diversity.
- Provided important benefits to preserve cultural sites, spiritual / customary values for the ethnic monitories, collective action such as training, social capital, and increased networking and dialogues.

Major gaps and challenges

- It is often very time consuming and complex process for getting approval and formalisation of CF process, particularly at the national level.
- Many communities appear to risk losing access to CF sites approved by MAFF because of granting economic land concessions in their area.
- Support to Strengthen local authorities capacity to enforce bylaws and support legalisation process of CF in terms of supporting forest recovery since many applications, seeking to secure legalisation are pending at the MAFF, have been facing serious problems and risks of losing their land and forests resource before prior to approval from MAFF.

Next steps forward

We strongly believe the following measures need to be taken:

- Support legalisation and securing access to forested land and rights over forest use
- Increase support the establishment of provincial and national networks / forums of CF groups to create platforms for policy debate and exchange of lessons learned.
- Continue to work collaboratively with other development partners and CSOs organisations to find tune of our strategy.
- Continue to work to the best of our capacity with other partners to increase funding support to Forestry Cantonment to support registration/legalization process and effective law enforcement.
- Continue to support NTFPs market access and value chain.

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INCREASING RANGELAND SOIL ORGANIC CARBON TO MITIGATE GREENHOUSE GASES AND INCREASE CLIMATE RESILIENCY FOR CALIFORNIA

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As part of California's 4th Climate Change Assessment, we plan to assess and quantify maximum potential benefits and limitations to increasing soil organic carbon in California's rangelands under current and future climates. Rangelands, including publicly and privately managed lands, comprise a majority of the land base in California. Climate change poses severe risks to working landscapes in the state, including rangelands, and the ecosystem services they provide. These services include food, habitat, carbon storage, and water supply for urban and rural communities, agriculture, and wildlife. A healthy landscape can increase resilience to climate change, increase water quality and net primary productivity, and buffer the impacts of climate-driven environmental stress including forest die-off, wildfire, flood, and drought. Increasing soil carbon can serve as a climate adaptation strategy due to its documented beneficial effects on soil erodibility, soil water holding capacity, soil temperature, and net primary productivity. We are currently using data generated from published and ongoing field and lab trials to constrain water balance model estimates of soil moisture and evapotranspiration in order to quantify the potential changes in soil water holding capacity and carbon sequestration for rangelands statewide in response to increases in soil organic matter. Results will be used to quantify the potential benefits in ecosystem services—specifically water (surface water, soil water, and groundwater) and greenhouse gas benefits—under current and future climate scenarios. Additionally, results will be used to estimate the economic value of both no-action and management actions leading to soil organic matter increases, with respect to system hydrology and carbon sequestration for a representative sample of rangeland types. Finally, we will identify barriers to and incentives for rangeland carbon storage enhancement within a climate smart land use planning framework statewide under current and projected climate and land use scenarios. A spatially explicit Business-as-Usual scenario and a high conservation scenario developed through the USGS Land Use and Carbon Simulation (LUCAS) State and Transition Simulation Model (STSM) will be used to identify differences in economic and climate benefits of management activities with land use patterns. Results will identify regions where high C sequestration potential and high climate resilience overlap with regions of high development risk. By comparing scenarios we will identify the influence of land use strategies on opportunities for land management-based climate benefits.

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SPONSORSHIP PROGRAMS – NEW APPROACHES FOR CLEAN WATER STATE REVOLVING FUND FINANCING

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In 2009, the Iowa Legislature authorized the use of sewer utility revenues to finance a new category of projects, called “Water Resource Restoration Sponsored Projects.” Sponsored projects were defined as locally directed, watershed-based efforts to address water quality problems, inside or outside the corporate limits. Iowa has implemented the sponsored projects effort through the Clean Water State Revolving Fund (CWSRF). On a typical CWSRF loan, the utility borrows principal and repays principal plus interest and fees. On a CWSRF loan with a sponsored project, the utility borrows for both the wastewater improvement project and the sponsored project. Through an interest rate reduction, the utility’s ratepayers do not pay any more than they would have for just the wastewater improvements. Instead, two water quality projects are completed for the cost of one. Sponsored projects can be located within a sub-watershed entirely inside municipal boundaries, or in an upstream area. Applicants are required to work with local water quality organizations, such as Watershed Management Authorities, Soil and Water Conservation Districts, County Conservation Boards, or others. Project plans must include an assessment of the impacted waterbody and its watershed with data that supports the identification of the water quality problems to be addressed. Practices being funded under Iowa’s sponsored project program are primarily focused on restoring the natural hydrology of the watershed in which they’re located. Included are bioswales and biocells, permeable paving, rain gardens, wetland restoration, and other retention and infiltration practices that address nonpoint source runoff issues. While other benefits, such as flood control, stormwater management, or habitat restoration, may also be achieved, the practices must result in improved water quality. The first sponsored project in Iowa is with the City of Dubuque, initiated in 2013 as a pilot to test the financing mechanism. Dubuque executed a $64 million CWSRF loan to upgrade its wastewater treatment plant. Dubuque is also financing through the CWSRF a $29 million urban watershed plan for daylighting and restoration of the Bee Branch Creek. The sponsored project allowed Dubuque to borrow an additional $9.4 million for installation of permeable pavers in 73 alleys in the Bee Branch watershed, and repay the same amount as they would have for the watershed project alone. The permeable alleys will allow stormwater to infiltrate, providing water quality benefits and protecting the restored stream corridor from erosion. After the pilot project, the program was opened up to other communities. Since 2014, applications have been taken twice each year and a total of $37 million in additional commitments for 57 more projects have been made. The sponsored projects effort provides an incentive for communities to look beyond what is required under wastewater permits and to explore other water quality issues in their areas. While many applicants are focusing on urban stormwater, others are partnering with groups outside the city limits to address agricultural best management practices and lend support to watershed protection for regional lakes. Going through the process encourages community leaders to consider the value of local water resources and how they can contribute to protection or restoration. The program is promoting improved relationships between urban and rural interests, cities and watershed organizations, and local, state, and federal resources. The program is also helping build the technical expertise of Iowa’s engineering and design community to address nonpoint source issues. The Iowa Department of Natural Resources and the Iowa Finance Authority operate the Clean Water SRF programs, with assistance on green infrastructure projects from the Iowa Department of Agriculture and Land Stewardship.

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HOW DOES SPATIAL PATTERNING OF THE USDA'S CONSERVATION RESERVE PROGRAM IMPACT WATER QUALITY IN IOWA'S LAKES?

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Purpose

Obtain a better understanding of the role played by the spatial patterning of farmer participation in the United States Department of Agriculture's (USDA) Conservation Reserve Program (CRP) in the delivery of spatially configured ecosystem services for water quality.

Scope

This initial analysis looks at three lakes in Iowa that have varying degrees of CRP enrollment: 1) No CRP in a lake watershed, 2) Clustered CRP around a lake, and 3) Heterogenous CRP within a lake watershed.

Methods

This investigation sought to recover a partial ecological production function through quasi-experimental methods. It looked at the average treatment conditional on spatial interaction effects, otherwise know as difference-in-difference (DID). In this analysis the output is water quality in a lake while the inputs are addressing vegetation types, both for conservation and for agriculture, across space and time.

Results

Results of the three lakes sample will demonstrate how different spatial patterns of land enrolled for conservation through the USDA's CRP impacted water quality, particularly sedimentation and eutrophication. It will attempt to answer the question of whether land enrolled in CRP is having an impact on lake water quality in Iowa.

Conclusions

Conclusions will address how to expand this analysis to all of the 140 lakes throughout Iowa as well as what further data and analysis may be necessary to strengthen the results.

Recommendations

Recommendations will be provided on spatial distribution and quantity of vegetation types (crops vs. CRP land) in order to ultimately improve lake characteristics such as sedimentation and eutrophication.

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COMPARATIVE COMMUNITY CASE STUDIES AS RESEARCH TOOLS: A NATIONAL EFFORT TO SUPPORT LOCAL SUSTAINABILITY PLANNING

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The provisioning of ecosystem goods and services (EGS) is a key concept in USEPA Office of Research and Development research programs. This is a national issue, yet many decisions affecting EGS sustainability are made at the local level where decisions can have substantial influence on EGS. The Sustainable and Healthy Communities research program develops tools and approaches to help local decision making. Here we describe a coordinated case study approach that focuses on the transferability, scalability, and utility of selected tools and approaches across communities of different types. Transferability refers to how well tools can be applied in different systems, scalability refers to how well tools are applied across issues at different spatial and temporal scales, and utility refers to how well tools and approaches are adopted and used by local decision makers. The objective is to explore how communities approach decision making associated with resource sustainability and how this information can be used to structure decision support. A common case study thread is water resources, with a number of locations in coastal and estuarine settings. The output will be approaches to link environmental data and tools that predict the impact of human-induced change on EGS with community characteristics and priorities that drive decisions. The desired outcome is for communities to have a suite of tools and approaches for decision support available for local level decisions, while also having flexibility to consider and incorporate unique community characteristics when necessary to facilitate broad stakeholder engagement.

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INTEGRATING BIOPHYSICAL AND ECONOMIC VALUATION OF ECOSYSTEM SERVICES FOR THE CONSERVATION OF A BIOSPHERE RESERVE (THE BASQUE COUNTRY, SPAIN)

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The land use changes that have occurred over the last six decades in the Urdaibai Biosphere Reserve have led to increased conflicts between conservation and economic development. Therefore, it seems necessary not only to quantify the ecosystem services, but combine biophysical and economic valuation in order to provide more understandable values to policy makers and improve the sustainability of the territory. We assessed the land use changes in 1965, 1983 and 2009, and estimated the economic value of the ecosystem services based on the existing literature. Moreover, we identified some priority areas by comparing the biophysical and economic values of the land uses so as to analyse the effectiveness of the Biosphere Reserve since its establishment as a protected area to the present. The results showed that the recognition of the area as a Biosphere Reserve contributed to the conservation of core areas, but the total value of the ecosystem services decreased by nearly 25% outside them. Taking into account that the ecosystem services contribute to human well-being, we suggest that management policies should emphasise ecosystems with the highest variety and value and should recommend actions with the aim of enhancing ecosystem services.

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A PATH TO INNOVATIVE FINANCE FOR STORMWATER MANAGEMENT – A CASE STUDY IN THE UPSTREAM SUBURBAN PHILADELPHIA AREA

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Urban and suburban stormwater (SW) runoff is one of the few pollution sources whose negative impacts on water and habitat quality are increasing over the past few decades. At the same time, the cost of treating SW runoff is tremendous. The public sector often does not have the sufficient funding or manpower to cover all the cost. Therefore, leveraging the private sector's funding, expertise, and manpower can be an important way to supplement the public sector's effort.

In the past two years, the Environmental Finance Center at the University of Maryland in partnership with The Nature Conservancy (TNC) in New Jersey, the Pinchot Institute, and the Partnership for the Delaware Estuary worked on behalf of the William Penn Foundation to develop strategies to best utilize the foundation's philanthropic capital to incentivize the private sector in conservation for the Delaware River basin. Although TNC's focus is on SW runoff in the suburban Philadelphia area, the lessons learned are applicable to broad geographic areas, especially areas where there are not sufficiently sized, dedicated, and stable funding sources for SW management (SWM), such as many parts of Pennslyvnia, New York, and New Jersey.

During the research period, we conducted literature reviews, interviews, and in-person forums with practitioners and experts on SWM and conservation finance in the Philadelphia area and nationwide. We separated the private sector's involvement in SWM into two forms: private capital investment and private businesses spending. The presentation discusses the enabling conditions for private capital investments into a new environmental market such as SWM and why the conditions in the suburban Philadelphia area are not ready for it. However, there are private businesses that have either gone above and beyond what is required by SW regulations and/or used green stormwater infrastructure for SWM. These voluntary spendings are additional to the public and mandatory spending, and therefore should be encouraged. The presentation will discuss the practices, motivations, barriers, and wishes of these private businesses, what funders such as foundations or public agnecies could do to further this kind of behavior and ultimately create the enabling conditions for private capital investments.

We recommend approaching the issue through a behavior change persepective. If we consider the voluntary spending on good SWM as an innovation, we can apply the Diffusion of Innovation Theory to understand its adoption by society and speed up this adoption. The presentation will discuss strategies that funders could do to address all four components of creating behavior change: knowledge, attitude, inter-personal communication, and barrier removal.

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SOIL HEALTH: THE FOUNDATION FOR SUSTAINABLE PROVISION OF ECOSYSTEM GOODS AND SERVICES

*Presented by: **Kristie Maczko***

Dennis Chessman
Southeast Regional Team Leader, NRCS Soil Health Division, USDA, Lexington, KY, USA

Post-Industrial Revolution agriculture has experienced tremendous gains in productivity, which were particularly pronounced beginning in the first half of the 20th Century with the advent of hybrid crops, organic pesticides, synthetic fertilizers and large scale equipment. In the midst of the increased efficiency and productivity, soil function was often diminished in many areas through frequent tillage, seasonal fallow, reduced crop diversity and over-dependence on chemical inputs. The effect of this approach to agroecosystem management is typically manifest in decreased soil hydrologic function, poor nutrient cycling capacity and generally reduced system resistance and resilience to environmental perturbation. Soil function is inextricably linked to agroecosystem function, and therefore is an important consideration when assessing a landscape's overall ability to provide beneficial ecosystem goods and services. Management affects soil health. Changes in management that lead to increased soil organic carbon and improved soil structure have high potential to contribute to greater system resistance and resilience. Crop and livestock producers in many parts of the US have modified their management with the goal of improving soil health. An outcome of these changes has been a reversal of the degrading trends often associated with high-disturbance, low-diversity agricultural systems. The newly-formed Natural Resource Conservation Service, Soil Health Division seeks to work cooperatively with producers and conservation partners to identify locally-adapted agricultural systems that can lead to improved soil health, and to help increase adoption of these systems on working lands throughout the US.

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ADVANCING THE SEEA EXPERIMENTAL ECOSYSTEM ACCOUNTING: EXPERIENCE FORM THE UN PILOT PROJECT

Julian Chow
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Ecosystem accounting is an emerging field dealing with integrated biophysical data, monitoring changes in ecosystem assets and linking those changes to economic and human activity. The development of ecosystem accounting is in response to a wide range of demands for integrated information that can link analytical and policy frameworks on environmental sustainability, human well-being, and economic growth and development.

The System of Environmental-Economic Accounting (SEEA) Experimental Ecosystem Accounting (EEA), considered by the United Nations Statistical Commission at its 44th session in 2013 as an important step in the development of a statistical framework for ecosystem accounting. It provides a synthesis of the current knowledge in this area and represents a strong and clear convergence across disciplines of ecology, economics and statistics on many core aspects related to the measurement of ecosystems. Increasing the application of SEEA Experimental Ecosystem Accounting can provide an integrated measurement framework to inform the the Sustainable Development Goals monitoring process.

In order to assist countries in testing the SEEA Experimental Ecosystem Accounting, the United Nations Statistics Division, under the auspices of the United Nations Committee of Experts on Enviornmental-Economic Accounting, is implementing a project on advancing the SEEA Experimental Ecosystem Accounting in pilot countries in collaboration with UNEP and the secretariat of Convention on Biological Diversity. Financial assistance is being provided by the Government of Norway

The project work conducted in the pilot countries has demonstrated that SEEA helps in organizing and bringing together a number of uncoordinated monitoring initiatives that are ongoing, by using a common framework towards the development of an information system for sustainable development. Efforts have been made to bring together different stakeholders involved with the use of the accounts and the generation of data. Stakeholders include, but are not limited to, national statistics offices, ministries of planning and finance or their counterparts, ministries of environment and sustainable development or their counterparts, mapping agencies or their counterparts, and United Nations country offices. The objective of the project is to develop a national assessment in the seven pilot countries, namely, Bhutan, Chile, Indonesia, Mauritius, Mexico, Viet Nam and South Africa.

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FROM HEADWATERS TO DOWNTOWN: INFORMING CONSERVATION AND RESTORATION PRIORITIES WITH SPATIAL ANALYTICS AND ECOSYSTEM SERVICE VALUATION

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Urbanization, drought, wildfire, and flooding contribute to degradation of natural resources and the loss of ecological resilience in the State of Colorado. Wildfire compounded by prolonged drought incurs post-fire erosion and sedimentation of drinking water reservoirs, resulting in expensive mitigation to reduce current effects and future risks. The 2013 Colorado floods incurred property damage, loss of life, and sedimentation of major rivers and their tributaries. Meanwhile, the State's urban areas contribute point and nonpoint source pollution to rivers and tributaries causing serious water quality issues (e.g. Bacteria, TSS, TP). Compounding these problems are the impacts of climate change.

The complexity of challenges facing Colorado requires an intricate and comprehensive approach to managing solutions. State land-use managers, water utilities, government entities, and NGOs are in need of an approach to prioritizing conservation, restoration, and treatment of sensitive and threatened natural infrastructure. This collaborative effort brings together more than 40 organizations from public, academic, nonprofit, and private sectors to inform a framework that addresses these challenges.

In this presentation, we showcase a framework that enables the stakeholder community of the South Platte River Watershed (SPR) to prioritize restoration and conservation of highly valuable and threatened ecosystems. The SPR is a primary source of drinking water for the Denver Metro Area, serving 1.3 million people, or 25 percent of Colorado's population. Half of the water supply to these 1.3 million customers originates in the SPR Basin.

By leveraging more than three dozen local tools and data repositories, and working within three distinct project areas (Upper Watershed, Denver Metro, and Plains), our research represents the aggregation of work completed in the region. More than two dozen spatial datasets were used and combined to identify priority areas related to fire risk, disease and pest mitigation, sensitive habitat, valuable recreation, water quality, and vulnerable areas threatened by development. Finally, our analysis incorporated a robust economic analysis that identifies ecosystem service value across the map identifying the highest priority conservation and restoration opportunities.

Our results indicate that threats to the upper watershed include insect infestation, wildfire, and development, requiring extensive forest treatment in priority areas. The location of recreation areas and sensitive habitat show where restoration will be most effective, particularly in an effort to reconnect currently fragmented forest plots. Within the Denver Metro area the protection of water resources is of highest priority. In all project areas we demonstrate the threat to these natural assets from a changing climate.

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LIFE AFTER THE MEMO: A LOOK AT HOW FEDERAL AGENCIES INCORPORATE ECOSYSTEM SERVICES INTO FLOODPLAIN MANAGEMENT POLICY

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On October 7th 2015, the White House issued a memorandum directing all federal agencies to incorporate the value of natural infrastructure, or ecosystem services, into federal planning and decision making. This announcement marks the first time the Administration formally recognized the concept of ecosystem services, which represents a turning point for the integration of this concept at the federal level. While the announcement calls for the adoption of ecosystem services under “general planning and decision making,” in reality guidelines and standards vary widely between each federal agency. The memorandum reflects national recognition of the costs to floodplains in the face of human development and effects of climate change. This is evident in states like Vermont, where over 75% of river miles have been modified.

The monetary value of ecosystem services is recognized in very few federal processes. The Federal Emergency Management Agency (FEMA) was the first federal agency to adopt ecosystem service values in formal Benefit Cost Analysis (BCA); however, the agency is limited to buyout acquisition programs related to flood when implementing the methodology. FEMA’s BCA Tool has the ability to demonstrate the ecosystem service value of mitigation activities related to wildfire, drought, and land subsidence. In 2015, The Department of Housing and Urban Development (HUD) integrated ecosystem service concepts into the BCA, which was ultimately used to allocate $1 billion in the Natural Disaster Resiliency Competition (NDRC). For the first time, HUD also allowed applicants to submit socioeconomic data and narrative descriptions of environmental inequality to further inform project feasibility.

In this presentation, Earth Economics will discuss opportunities available to federal agencies to introduce new policy or address existing policy to incorporate ecosystem service standards. This presentation will focus on floodplain management and policy, highlighting those agencies that have incentivized floodplain development over the last several decades. We will introduce how current floodplain maps and guidelines have provided a false sense of security behind built structures such as levees and dams. We will then show how the maintenance of these water control systems are economically infeasible as natural systems degrade and place further costs on society. Finally, we will highlight opportunities for improved policy nationally with multiple case studies.

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OREGON HEALTH AND OUTDOORS ACTION FRAMEWORK

Bobby Cochran
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What if Medicaid could pay for trees? When the Oregon Health and Outdoors Action Framework (oregon.healthandoutdoors.org) was launched by public health, business, and conservation partners last Fall, actions were begun to answer that question. The Health and Outdoors Action Framework outlines strategies for accelerating positive health and conservation outcomes for all Oregonians by increasing the presence of, access to, and use of parks, nature, and the outdoors in communities facing inequities.

Those strategies include:
Community-led pilots to increase greenspace, access to greenspace, and culturally-relevant programming to link people to the outdoors;
Research to build a base of evidence linking health and the outdoors;
Communication tools to talk about that linkage; and
Policy options to improve the connections between health and the outdoors.

The presentation will discuss some of the early results from pilots in Hood River, concepts around a research agenda for health and nature, and policy options communities around the country can use to promote the link between health and the outdoors.

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RESEARCH TO ENHANCE ECOSYSTEM SERVICES IN SOUTHEASTERN US AGRICULTURE THROUGH LANDSCAPE PLANNING AND DESIGN

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The southeastern USA is noted for high levels of biodiversity and an ancient history of anthropogenic land use exploiting the full range of terrestrial to aquatic ecosystems. Over the last two centuries, this region experienced drastic reductions in native plant and animal communities concomitant with the expansion of agriculture, pastoralism and plantation forestry, along with one of the highest rates of urban expansion in North America. Despite severe reductions of highly-biodiverse landscapes in the Coastal Plain, this region is still known as one of the world's biodiversity "hotspots." Climate, soils and topography of the southeast will continue to favor the use of southeastern lands for food, fiber and fuel production into the foreseeable future. Indeed, agricultural production from southeastern farms is expected to increase in the coming decade, including, for example, increased production of "second-generation" biofuels. Researchers working in this region are currently grappling with issues of how to plan and design agricultural landscapes of the future that will enhance, on the one hand, crop and livestock yields that have long supported human populations, and on the other hand, ecosystem services, such as biodiversity, pollination, soil fertility, and water filtration, that are critical to the long-term resilience of the region. Panelists in this session will present perspectives on the future of agricultural landscapes of the southeastern USA, discussing current research activities and knowledge gaps related to agricultural ecosystem services. They will address the basis of accounting for ecosystem services in agricultural landscapes, and the research requirements to measure, monitor and evaluate agricultural systems vis á vis an ecosystem services framework. They will also address questions about designing and creating Southeastern agricultural landscapes of the future that provide for continued or enhanced yields, on the one hand, while managing for the resiliency of critical supporting and regulating ecosystem services on the other.

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INCORPORATING ECOSYSTEM SERVICES INTO PRIVATE LANDS CONSERVATION

Kari Cohen
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Over the past decade, Federal land management agencies (e.g., US Fish and Wildlife Service, US Forest Service, Bureau of Land Management) have incorporated, to varying degrees, ecosystem services analyses into their planning and decision making processes on Federal lands. As Federal land managers, these agencies have a direct impact on the ecosystem services generated on these lands.

Much of the academic and theoretical research, and applied agency efforts, on incorporating ecosystem services in Federal agency decision-making has focused on public lands. USDA's Natural Resources Conservation Service (NRCS), in contrast, works almost exclusively on private lands and provides planning and technical support to landowners and land managers who ultimately make resource management decisions. With an annual budget that exceeds those of the USFWS, BLM, and the Forest Service's National Forest System, NRCS's footprint on the landscape is immense—since 2009, the agency has helped more than 500,000 farmers, ranchers and forest landowners address natural resources on more than 400 million acres nationwide.

Given the scale and scope of NRCS's work, it is important to consider how ecosystem services can be incorporated into decision making on private lands. Most NRCS customers are operating a business on their land. The extent to which these customers consider ecosystem services (explicitly or not) in their decision making varies along a wide spectrum. In general, NRCS field staff help producers work toward ecological change rather than the generation of Final Ecosystem Goods and Services. Analyzing and communicating the benefits of site-specific ecological change and natural resource condition improvement is a productive approach--practices and systems that both improve yield and natural resource condition are those most likely to be adopted.

This presentation will explore the challenges and opportunities of incorporating ecosystem services into decision making on private lands. It will include agency examples and a discussion of how NRCS attempts to strike a balance between helping individual customers with on-site environmental objectives while ensuring that taxpayer dollars are generating public goods that contribute to resolving significant regional and national environmental challenges.

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PAY-FOR-SUCCESS—OPPORTUNITIES FOR FEDERAL AGENCIES AND WORKING LANDS CONSERVATION

Kari Cohen
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USDA's Natural Resources Conservation Service has been a leader in supporting the development of market-based approaches, such as environmental markets and conservation finance vehicles. These market-based approaches can attract private funding to working lands conservation, complementing and amplifying NRCS's work with farmers, ranchers and private landowners. These approaches can also help NRCS improve its understanding of how to pay for environmental outcomes, or ecosystem services. Pay-for-success is a strategy that has attracted recent interest for its promise of helping Federal agencies pay for environmental outcomes. Through a pay-for success approach on working lands, the Federal government could potentially increase the efficiency and efficacy of its financial assistance to private landowners. As they are currently structured, NRCS Farm Bill programs provide financial assistance to farmers, ranchers and forest landowners to implement and maintain conservation practices. Pay-for-success models can instead provide retrospective payments once some metric of ecosystem performance has been achieved.

There are substantial challenges to incorporation of pay-for-success approaches into Federal conservation programs. Legislative and regulatory hurdles, contracting and procurement obstacles and development of appropriate metrics for success are examples of these challenges. In addition, there must be a compelling argument for developing pay-for-success models—will they save the Federal government money? Attract private capital to working lands conservation? Without a compelling need, the development and transaction costs associated with pay-for-success models may render the benefits moot.

NRCS is experimenting with pay-for-success models, largely through its Conservation Innovation Grants program. Time and experience will tell if the promise and hope of pay-for-success approaches are realized.

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WORKING LANDS CARBON SEQUESTRATION AND GHG REDUCTIONS: THE IMPORTANCE OF QUANTIFYING GREENHOUSE GAS FLOWS ON FARMS AND RANCHES

Presented by: ***Kari Cohen***

Prepared by *Adam Chambers*
USDA NRCS Co-Leader Environmental Markets Team, Portland, OR, USA

Quantification tools are a critical underpinning component of all ecosystem service market transactions. In order to develop a scalable carbon market in the United States, the markets require sufficient supply and demand signals along with streamlined methods of connecting carbon credit supply with market demand. Project-level transaction costs must be minimized and contained, to avoid overburdening individual carbon market transactions. In an effort to provide carbon markets with a consistent and government-endorsed quantification tool, USDA has unified greenhouse gas and carbon sequestration quantification efforts behind the COMET-Farm^{TM} tool. COMET-Farm^{TM} is a whole-farm quantification tool supported by a comprehensive set of documented quantification methods and models that also support the U.S. National Greenhouse Gas Inventory.

COMET-Farm^{TM} is intended to provide farmers, ranchers, and forest land owners with a transparent, free, and publicly available quantification tool that can be used to evaluate all sources of GHG emissions and carbon sinks within the farm gate. The tool can be used for individual entity (farm, ranch, forest) carbon footprinting purposes and the tool can also be leveraged by carbon markets to reduce transaction costs, enable market transaction, and enable markets function efficiently by achieving a scalable volume of transactions.

Transparent and dependable quantification tools like COMET-Farm^{TM} can be leveraged to form the basis of market transactions. This USDA-supported tool can also be used to help farmers and ranchers meet corporate sustainable supply chain requirements and evaluate the carbon footprint of food, fiber and fuel produced on U.S. farms and ranches. COMET-Farm^{TM} and the other COMET tools are designed to enable farmers and ranchers to evaluate various conservation scenarios. The decision to voluntarily adopt atmospheric-beneficial conservation practices remains an economic decision based on the desires of the individual producer and the value of carbon credits in the market. This session will focus on the critical role of quantification tools within the construct of the U.S. voluntary and regulatory carbon markets.

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GUIDANCE FOR USERS ON ECOSYSTEM SERVICE ASSESSMENT

Presented by: ***Jack Cosby***[1]

Paula A. Harrison[1]*, Mark D.A. Rounsevell and OpenNESS*[3] *and OPERAs partners*[4]

[1]Centre for Ecology and Hydrology, Lancaster Environment Centre, Lancaster, UK
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A range of methods are available for mapping and modelling the supply and demand of ecosystem services as well as their economic and non-economic valuation. All types of methods have their role. The challenge is to understand the requirements of different decision-making contexts and what is gained in moving from simple to more complex approaches. This presentation addresses this challenge using the experience from 40 case studies from the European OpenNESS and OPERAs projects which applied a wide range of different biophysical, economic and socio-cultural approaches to operationalise the ecosystem service concept for sustainable land, water and urban management. A survey of the reasons why the case study teams selected particular methods was undertaken supplemented by a workshop where case studies reviewed and discussed their considerations in choosing particular methods in certain decision contexts and in relation to the applicability, benefits and limitations of each method. This information was used to explore different guidance tools for researchers and practitioners which support the selection of ecosystem service assessment methods. This presentation will provide an overview of the different considerations for method selection and how they relate to problem type or decision context. It will also illustrate how this information was used to iteratively develop, test and refine different types of guidance tools designed to help users from different backgrounds find relevant information on natural capital and ecosystem services that serves their needs.

The guidance tools are being operationalised within the Oppla online platform (www.oppla.eu). Oppla is an online web portal to support science, policy and practice in operationalising the natural capital and ecosystem services concepts. It is synthetising knowledge from a wide range of European projects, as well as the broader scientific community. It will also create an active community of interest among researchers, policy-makers and practitioners that are interested in sharing tools, experiences and learning between each other. The guidance tools within Oppla include a case study finder, an ecosystem service assessment support tool, simple filtering matrices, Bayesian belief networks for method selection, decision trees, and the 'Ask Oppla' crowd-sourced question and answer service.

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GUIDANCE FOR USERS ON ECOSYSTEM SERVICE ASSESSMENT

Presented by: ***Jack Cosby***[1]

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SPATIALLY EXPLICIT MODELLING AND GAMEIFICATION OF ECOSYSTEM SERVICES

Robert Costanza
Crawford School of Public Policy, Australian National University, Canberra, Australia

Ecosystems are connected to human well-being in a number of complex ways at multiple time and space scales. The challenge of ecosystem services science (ESS) is understanding and modeling these connections, with a range of purposes including raising awareness and providing information to decision-makers to allow them to better manage our natural capital assets. In order for ecosystem services to occur, natural capital must be combined with built, human and social capital. Thus ESS is inherently an integrated, transdisciplinary science that is concerned with the way these four forms of capital contribute to human well-being and the synergies and trade-offs among them. The process of valuation of ecosystem services is about quantifying and modeling these synergies and trade-offs. It requires a deeper understanding of the spatially explicit interconnections among ecosystem processes and functions, economic production and consumption processes at multiple time and space scales, and human psychology and decision processes. This talk will summarize progress on spatially explicit modeling of regional landscapes and new approaches to integrating these models with sophisticated game interfaces to both inform players about system dynamics and to elicit valuation information based on player choices.

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FIXING THE LAW TO ALLOW FOR AGENCY ADAPTIVE MANAGEMENT FOR ECOSYSTEM SERVICES

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[2] Vanderbilt University Law School, Nashville, TN, USA

Ecosystem services are becoming increasingly important in a number of agency and regulatory contexts, but current administrative law does not readily allow for scientifically valid adaptive management to promote those ecosystem services. This talk will highlight some of the major impediments in administrative law requirements to true adaptive management and propose a solution that would allow agencies to engage in true adaptive management to promote ecosystem services.

Administrative law seeks to promote values of transparency, public participation, agency accountability, and finality. The results, however, are legal processes that promote one-time, front-loaded decisionmaking, making it very difficult for agencies to engage in true adaptive management of any kind.

We promote instead an alternative legal approach that commits agencies to cycles of constrained experimentation, monitoring, and review. Our proposal insulates agencies from legal interference during most of the adaptive management cycle while still allowing for transparency and punctuated public participation and judicial review.

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CONNECTING ECONOMIC, SOCIAL, AND ECOLOGICAL INFORMATION FOR FOREST-LOCATED RURAL COMMUNITIES

Mindy S. Crandall[1]*, Kirsten Winters*[2]*, and Kim Hall*[2]
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Across the US, forest-dependent communities are facing significant challenges resulting from the decline in manufacturing, global competition, and changes in technology that have all reduced the demand for labor in traditional forest industries. At the same time, society is demanding greater provision of non-market ecosystem services (such as recreation, biodiversity protection, water protection, and aesthetic value) from forests, shifting the economic base in forest-dependent communities from traditional uses to more amenity-based. While amenity development has provided opportunities for some communities to diversify or expand their local economies, the changes in local labor markets along with in-migration bring social challenges to other places in transition. The costs and benefits associated with ecosystem services provision are thus not distributed equally across the landscape.

This study presents initial results of a typology of forest-located communities based on economic dependence across a gradient from traditional (e.g., timber) to amenity-based (e.g., tourism) uses at a sub-county geography. The typology can be used to compare outcomes by community type with respect to a wide variety of metrics. We use the typology to explore the extent to which each community type is related to socio-economic and ecological characteristics of interest, including measures of ecosystem service provisions. This information can illuminate patterns in costs and benefits and help guide policy.

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THE CLEAN WATER STATE REVOLVING FUND (CWSRF)

Michael Curley
Environmental Law Institute, Washington, DC, USA

When the Clean Water Act ("CWA" or, the "Act"), was passed in 1972, municipal sewage was the #1 source of pollution in the country. Not so any more. Now it's agricultural runoff and stormwater. Title VI of the Act and its predecessor, the construction grant program, were good at getting money to Publically Owned Treatment Works (POTWs) for municipal sewage.

In the last 28 years, the CWSRF has made financial assistance totaling over $115 billion to over 36,000 individual projects. That's an average project size of about $3 million. Over 96% of these funds have gone to POTWs as direct loans. The CWSRF the single most successful environmental finance program in the world.

But, since municipal sewage is no longer the #1 source of water pollution, it's no longer enough just to make $3 million loans to sewer plants. The CWSRFs need to change what they do and get into the 21st Century water pollution game.

Section 601 of the Act created three classes of projects eligible for funding: 1) to POTWs pursuant to Section 212 of the Act, 2) non-point source projects pursuant to a "319 Program", which the states were required to create under Section 319 of the Act, and, 3) projects in the 28 estuaries that were part of the National Estuary Program, created by Section 320 of the Act. These "320 projects" had to be included in the estuary's Comprehensive Conservation and Management Plan (CCMP), which the administrators of each estuary were required to create.

In 2014, Congress added eight more eligibilities for CWSRF funding in the Water Resources Reform and Development Act (WRRDA) of 2014. Among the more innovative additions are eligibility for: 1) decentralized (publically or privately owned) sewage treatment works; 2) (public or private) measures to manage, reduce, treat, or recapture stormwater or subsurface drainage water; 3) watershed projects; and, 4) reuse or recycling of wastewater, stormwater or subsurface drainage water.

So, now instead of just POTWs, the CWSRF must focus on agricultural runoff, watershed protection, and stormwater as the three biggest issues in dealing with 21st Century water quality problems.

In response, states are developing highly innovative approaches to dealing with these issues. The State of Maryland's CWSRF has used a linked deposit program to preserve 110 acres of undeveloped woodlands. The tiny city of Whitefish, Montana, has used Montana's CWSRF plus several other sources of funds to purchase 3,020 acres of upstream woodlands to protect it from becoming part of a ski resort development, which would have devastated their water quality.

The Commonwealth of Pennsylvania's CWSRF has also launched a nutrient trading program for both point-source and non-point sources of pollution. This is especially important because many non-point sources of pollution, like agricultural runoff are on private land. Abating the pollution means that farmers have to pay for these projects out of their own pockets. But, if states have nutrient credit trading programs, the farmers can undertake nutrient reduction projects and be reimbursed for the cost when they sell the nutrient credits through a CWSRF nutrient credit trading program.

So, the 21st Century has brought a new set of water quality challenges. But, slowly but surely, the states are stepping up with innovative programs to deal with them.

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FRAMING CLIMATE CHANGE SCIENCE AND ADAPTATION IN THE CONTEXT OF ECOSYSTEM SERVICES – MOVING THE BALL FORWARD

Organizers/Moderators: ***Janet A. Cushing***[1], *and* ***Gerard McMahon***[2]

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[2]DOI Southeast Climate Science Center, Dept. of Applied Ecology, North Carolina State University, Raleigh, NC, USA

While there have been various briefing papers and reports describing the ways that climate change can lead to permanent degradation of wildlife habitat and ecological services upon which humans depend, there is considerably more work to be done to fully understand the relationship between climate change and ecosystem services. Many of the studies that have occurred on this topic to date have been broad in scale, and lack the details concerning how climate change effects manifest themselves for specific ecosystem services. There is uncertainty about how the demands for certain services might change in response to a changing climate. Also, if one wishes to consider ecosystem services in the context of an uncertain future (e.g., climate change), what information does one need? This panel session brings together experts in the fields of socio-economics, engineering, and climate change science fields to address these overarching questions: What can an ecosystem services concept or framework bring to the dialogue of climate change research? Moreover, how can we be better informed about climate change impacts and adaptation strategies by looking at them through an ecosystem services lens?

The purpose of this session would be to take a step back, consider what we know and don't know both in terms of climate change research and ecosystem services assessments, and lay out a way forward to focus research efforts on how climate change scientists and social scientists can work together to help planners and decision-makers consider ecosystem services in the context of climate change. There are few opportunities where members of the ecosystem services community come into contact with members of the climate change science community to discuss future collaborative research pathways, and this session provides one such opportunity, with a moderated discussion and engaging the audience in the dialogue of how ecosystem services does or does not help society deal with questions of change and risk. The panelists will provide a brief overview of their experiences in climate change science and/or ecosystem services, as well as their perspective on where focused efforts are needed to help planners and decision-makers adapt to climate change impacts. Examples of current efforts where this applies most directly include the design of coastal reserves, and issues related to sea level rise and land loss.

Panelists:

James Boyd
Resources for the Future

Mitchell Eaton
DOI Southeast Climate Science Center, North Carolina State University

Robert Johnston
George Perkins Marsh Institute, Department of Economics, Clark University

Elizabeth Murray
Engineering Research and Development Center, US Army Corps of Engineers

Richard Palmer
Northeast Climate Science Center and Department of Civil & Environmental Engineering, University of Massachusetts

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DEFINING THE BEST NATURAL ENHANCEMENTS AND INNOVATIVE TECHNOLOGIES TO DELIVER ECOSYSTEM SERVICES TO HIGHLY URBANIZED WATERFRONTS

***Charmaine Dahlenburg*[1]**, *Eric Schott*[2], *Adam Frederick*[3], *Tsvetan Bachvaroff*[2], *and Brian Smith*[4]
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[2]Institute of Marine and Environmental Technology, University of Maryland Center for Environmental Science, Baltimore, MD, USA
[3]Maryland Sea Grant, Baltimore, MD, USA
[4]Maryland Department of Natural Resources, Annapolis, MD, USA

Worldwide, the development of waterfront cities has often resulted in the loss of ecosystem services and a decline in water quality and the health of aquatic communities. With two-thirds of the human population concentrated along shorelines, modification of natural coastlines is inevitable – crucial fish nurseries, and areas of refuge and food sources have been lost, limiting the availability of the necessary resources for aquatic organisms to flourish. Baltimore's Inner Harbor is no exception to these modified critical habitats.

The 300-year-old city is located within the 64,000-square-mile Chesapeake Bay watershed- the world's second largest estuary. Port operations and shoreline industry led the way for Baltimore to develop into a major US city. To create needed infrastructure for those purposes, the entire harbor shoreline has been hardened, with limited opportunity for the restoration of a natural "living" shoreline. Eighteen million people occupy the Chesapeake Bay watershed, causing further pressure on the already challenged environment.

Today, it is essential that a healthy harbor be restored and maintained in order to promote recreation, visitor appeal, healthy human communities and aquatic life within and adjacent to the harbor waters. Moreover, a restored waterfront provides an opportunity to enlighten millions of downtown visitors to the benefits of a healthy (functioning) habitat for aquatic life, highlighting the interconnectedness of humans and their environment and promoting the understanding of biodiversity in this urban estuary.

The National Aquarium is committed to creating a waterside campus that models and interprets best practices for redeveloping urban waterfronts worldwide. Waterfront Campus Plan (WCP) is a comprehensive, campus-wide strategy that will demonstrate not only how urban waterfronts can improve water quality and aquatic habitat for wildlife and people, but also how green gathering spaces can foster a sense of community and advance aquatic stewardship.

An urban wetland, an aquatic-focused component of WCP will exhibit a working ecosystem and demonstrate working ecosystem services in the middle of a central downtown location. This major outdoor exhibit will bring native wetland plants back to the Inner Harbor and use their naturally restorative power together with pioneering technologies to improve water quality. Innovative technologies, or "interventions," will deliver multiple microhabitats to the urban waters for people and species living there or visiting seasonally.

This presentation will focus on the proposed ecosystem applications and the long-term monitoring plan developed to measure success of the urban ecosystem as it is designed and installed.

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ECO-HEALTH LINKAGES: EVIDENCE BASE AND SOCIO-ECONOMIC CONSIDERATIONS FOR LINKING ECOSYSTEM GOODS AND SERVICES TO HUMAN HEALTH

***R. de Jesus-Crespo**, and R. Fulford*
USEPA, Gulf Breeze, FL, USA

Ecosystem goods and services (EGS) are thought to play a role in protecting human health, but the empirical evidence directly linking EGS to human health outcomes is limited, and our ability to detect Eco-Health linkages is confounded by socio-economic factors. These limitations hinder opportunities to develop greening and restoration strategies to complement existing health promoting efforts at the community level. In order to better inform Eco-Health conservation initiatives we seek to answer the following questions: i) which Eco-Health linkages are empirically supported and should be considered for management, ii) which are theoretically plausible but need further research, and iii) which socio-economic confounders should be accounted for when designing management plans.

To address these questions we review the evidence base linking “buffering” ecosystem services (water and air quality regulation, heat and water hazard mitigation) to physical health (respiratory illness, cardiac disease, gastro-intestinal disease, cancer and mortality) by applying the Eco-Evidence software, a tool to quantify weight of evidence and causality. We also model the relative influence of environmental, socio-economic and behavioral factors on select health outcomes based on a review of existing literature and a Bayesian Belief Network (BBN) approach.

Through our “weight of evidence” analysis we wish to define research gaps and focal areas that should be prioritized for management. Through the BBN model, we illustrate the importance of setting management expectations that correspond to the complex socio-economic dynamics that moderate the human health benefits provided by EGS. Our study informs the design of accurate predictive models that promote public health and wellbeing, and community-based decision making.

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INTEGRATING ECOSYSTEM SERVICES INTO USFS POLICY AND OPERATIONS

***Robert Deal**[1], Mary Snieckus[2], and Jonas Epstein[3]*
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[2]USDA Forest Service, Ecosystem Services & Markets Program Area, Washington, DC, USA
[3] USDA Forest Service, Watershed, Fish, Wildlife, Air & Rare Plants, Washington, DC, USA

The ecosystem services concept describes the many benefits that people receive from nature. In response to growing interest in ecosystem services, the USFS is identifying needs and opportunities to incorporate ecosystem services approaches into its programs and activities. Furthermore, the National Ecosystem Services Strategy Team (NESST) was chartered in 2013 to collaboratively develop national strategy and policy around ecosystem services and integrate it into Forest Service programs and operations. The concept provides additional value to the USFS in several ways including highlighting the broad suite of benefits that national forests and grasslands provide to the public and expands upon multiple-use management by including values often overlooked in traditional forest management decisions. In addition an ecosystem service approach can help the agency identify why particular management actions are needed and clarify relationships between the condition of forest ecosystems and the quantity or quality of services they provide.

In this paper, we identify several focus areas for including ecosystem services in Forest Service programs, explore opportunities and needs across programs and regions, and summarize some of the ongoing efforts to integrate ecosystem services into USFS policy and operations. We examine efforts in decision making, priority setting, measuring, reporting, communicating, and investing in ecosystem services. Highlights include the recent efforts to facilitate implementation of the ecosystem service components of the USFS 2012 National Forest System land management planning rule at the forest level and in collaborations at the project level; efforts to evaluate transitions towards outcome based national performance measures; and innovation in the development of environmental markets to leverage resources across private and public lands. Advantages of operationalizing ecosystem services across programs includes the ability to leverage partnerships with non-governmental organizations and private landowners and managers; support private forest conservation and restoration through payments for ecosystem services and markets; enhance connections with the public through a more open discussion on the benefits natures provides; inform more effective decision-making; and increase relevancy of the national forests and grasslands to the public. NESST provides broad national-scale direction for the USFS, but further successes will depend on lessons learned at the local, project and forest levels.

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COMMUNITY MAPPING OF ECOSYSTEM SERVICES IN TROPICAL RAIN FOREST OF ECUADOR

Ma. Jeaneth Delgado-Aguilar[1], *Werner Konold*[1] *and Christine B. Schmitt*[1, 2]
[1]Chair for Nature Conservation and Landscape Ecology, Albert-Ludwigs-Universität Freiburg, Freiburg, Germany
[2]Center for Development Research (ZEF), University of Bonn, Bonn, Germany

Tropical forests provide a wide range of ecosystem services (ES), and their continuous supply depends on efficient and effective management against deforestation and forest degradation. In Ecuador, indigenous communities are highly dependent on the forest and therefore on forest ES; however, there is a lack of knowledge about how the local communities use these services. In order to better understand how local and indigenous people interact with the forest and to facilitate its management, this study completed a spatially explicit assessment of ES in the Sumaco Biosphere Reserve (Napo province, Central-Northern Ecuador). The Biosphere Reserve was selected as a case study because it is a protected area where there is high land use and population pressure; thus making it essential to develop and monitor management plans. First, semi-structured interviews were conducted with experts (n=16) in order to identify the most important ES used by communities in the study area. In a second step, members (n=208) of 24 communities were asked to indicate on a 3-D map where they utilize the different ecosystem services (food, wood, water, tourism, hunting). The highlighted localities were digitized and then analyzed with statistical and GIS techniques. The results showed that the mapping of ES was dependent on age and gender of the respondents, especially for hunting. Ecosystem service locations were not randomly distributed, but were most abundant four kilometers or less from roads. Spatial pattern analysis identified hotspots of ES provision, and the evaluation by administrative units allowed us to identify five municipalities with high demand of all assessed ES. In conclusion, the combination of participatory mapping of ES-and GIS-based analysis can facilitate the identification of primary forest areas, provide guidance for developing specific forest management strategies, and can also support monitoring systems to detect forest degradation.

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AN ASSESSMENT OF CROP YIELD DEPENDENCE ON INSECT POLLINATION SERVICES IN THE NEOTROPICS

***Lena Dempewolf**, Azad Mohammed, John Agard, Anupa Mooneeram, and Brent Daniel*
Department of Life Sciences, University of the West Indies, St. Augustine, Trinidad and Tobago

Pollination services in many Small Island Developing States, particularly the Caribbean region, remain unassessed and unaccounted for. As a consequence, agricultural losses due to increasing threats to the service remain unnoticed and unchecked. This study highlights the relative contributions made by various size classes of pollinators primarily in two crop species of local economic importance and the subsequent potential effects on farmer livelihoods. The need for an increased understanding of how pollination services function in the Caribbean region, particularly in the context of sustainability challenges faced by Small Island Developing States, is underscored by the near total lack of data on Caribbean pollinators and their contributions to crop production. No studies have thus far been produced on pollination services in Trinidad and Tobago and, by extension, the wider region.

By limiting pollinator access, it was found that those able to access enclosures with the smallest mesh size provided the largest contribution to cucumber (*Cucumis sativus)* pollination, whereas this contribution was shared by insects able to access small and medium mesh-covered enclosures in hot pepper (*Capsicum chinense*) pollination. Complete exclusion yielded higher dependency ratios than was cited in previous literature, with dependency ratios for cucumbers, hot peppers, and okra (*Abelmoschus esculentus*) at 96.5%, 88.1% and 86.2% respectively. Therefore, in the complete absence of pollinators, potential national losses for the years during which experiments were conducted were estimated at US$1,252,725 for cucumbers (2012) and US$5,869,396 for hot peppers (2013). Given the high dependency on insect pollinators, national initiatives should focus on the education of farmers, including the need for pollinator conservation and the use of sustainable farming practices, and the formulation of policies to protect and manage pollination services.

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TECHNOLOGY TOOLS TO SCALE CONSERVATION AND MITIGATION PROGRAMS

Matt Deniston
Founder and Managing Partner, Sitka Technology Group, Portland, Oregon USA

Collecting data is easy. Sticking it in a spreadsheet or database doesn't take too much time. Way tougher and more time consuming: analyzing, quality checking, and synthesizing data at scale so that you, your organization, and the market in general can confidently use it to back credit or debit transactions.
In this talk, I'll share examples and lessons learned from 15+ years of first-hand experience building scalable knowledge infrastructures to support ecosystem management programs in the Pacific Northwest's Columbia Basin and Nevada's sagebrush country.

You will learn how mobile technology paired with a fully automated back-office metrics generator – things like pool volume or percent off-channel habitat for rearing salmonids – can save both time and money while also ensuring data quality. I will also address how drone technology, coupled with image processing technologies, can auto-generate key habitat metrics that feed habitat quantification tools. For example, it's now possible to calculate area of vegetation cover by habitat class or the extent of invasive species.

Finally, you will see an example of how to effectively share performance and results of your program with a variety of audiences: from colleagues to Congress.

And while it's fun to geek out on the tech, I'll wrap up with some thoughts on how to make your ecosystem service tools handy and easy to use by, well, us humans.

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ESTIMATING THE DISTRIBUTION OF HARVESTED ESTUARINE BIVALVES WITH NATURAL HISTORY-BASED HABITAT SUITABILITY MODELS

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Habitat suitability models are used to forecast how environmental change may affect the abundance or distribution of species of interest. The development of habitat suitability models may be used to estimate the vulnerability of this valued ecosystem good to natural or anthropogenic stressors. Using natural history information, rule-based habitat suitability models were constructed in a GIS for two recreationally harvested bivalve species (cockles, *Clinocardium nuttallii*; softshells, *Mya arenaria*) common to NE Pacific estuaries (N. California to British Columbia). Tolerance limits of each species were evaluated with respect to four parameters that are easy to sample: salinity, depth, sediment grain size, and the presence of bioturbating burrowing shrimp and were determined through literature review. Spatially-explicit habitat maps were produced for Yaquina and Tillamook estuaries (Oregon) using environmental data from multiple studies ranging from 1960 to 2012. Suitability of a given location was ranked on a scale of 1-4 (lowest to highest) depending on the number of variables that fell within a bivalve's tolerance limits. The models were tested by comparison of the distribution of each suitability class to the observed distribution of bivalves reported in benthic community studies (1996-2012). Results showed that the areas of highest habitat suitability (value=4) within our model contained the greatest proportion of bivalve observations and highest population densities, for both species. Our model was further supported by logistic regression analyses that showed correspondence between predicted habitat suitability values and logistic model probabilities. We demonstrate how these models can be used to forecast changes in the availability of suitable habitat for these species using projected changes in salinity and depth associated with climate scenarios for each estuary. The principle advantage of this approach is that disparate, independent sets of existing data were sufficient to parameterize the models, and to produce and validate maps of habitat suitability; however, not all estuaries have those data. Our next steps will be to test these models in other Pacific coast estuaries, and to apply this modeling approach for other harvested bivalve species. If these models are robust for multiple estuaries and bivalve species, fisheries resource managers will be able to transfer out approach to data-poor systems. Our habitat suitability models will be valuable tool to manage target species and require a relatively modest investment of time and money to collect the four rapidly-sampled environmental parameters.

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MARKET-BASED CONSERVATION FOR WORKING LANDS, NATURAL RESOURCES AND MILITARY TRAINING: LESSONS LEARNED FROM THE MARKET BASED CONSERVATION INITIATIVE PILOT

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In many states, military training tracks are a part of the rural landscape resulting in significant interest from the military in the maintenance and enhancement of land uses that are compatible with military training requirements. In the southeastern United States, a vast majority of the land is under private ownership increasing the need for policies that incentive landowners to maintain compatible land uses to mitigate the threat of conversion to land uses deemed incompatible. The belief is that market based conservation provides an effective means for achieving conservation goals due to its financial flexibility to undertake actions at the lowest cost. In North Carolina, a unique coalition of partners came together to develop a Market-Based Conservation Initiative pilot to test the economically driven policy for the conservation of working lands, natural resources and military training. While the evaluation of market-based conservation policies exists within the literature, there has been no formal evaluation within a context that includes military interests and involvement. To better understand how to develop effective market-based policies in the aforementioned paradigm, a qualitative case study was conducted to derive lessons learned based on the experience of program leadership that can be used to inform the development of similar initiatives.

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PAY FOR SUCCESS CONTRACTING STRATEGIES, AND CONSIDERATIONS FOR SELECTING THE RIGHT STRATEGY FOR YOUR SCENARIO

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Pay for success contract mechanisms link payment to the delivery of verified conservation outcomes. Paying for conservation outcomes creates financial incentives for landowners and conservation professionals to determine the most cost-effective ways to achieve and maintain desired conservation outcomes, while reducing the risk of taxpayer dollars funding projects that do not produce desired results. Furthermore, by focusing on outcomes, pay for success contracts create opportunities for investors to finance conservation projects with potential to achieve a return on investment if conservation outcomes are cost-effectively produced.

Environmental Incentives has designed and supported implementation of a range pay for success conservation procurement strategies. Examples include seed-funding conservation credit projects for a state-administrated prelisted species mitigation program, full credit delivery to fulfill mitigation obligations defined by a Habitat Conservation Plan, and reverse auction to maximize the retirement of impervious coverage using mitigation funds.

Pay for success strategies vary in terms of the potential risk to buyers of spending funds without the intended conservation outcomes, and the potential financial reward for producers from cost-effectively producing conservation outcomes. And the specific strategy appropriate for a given investor (governmental or non-governmental) and scenario depends on the unique context of the scenario. During this session, a range of pay for success strategies will be presented, as well as the contextual factors that should be considered when selecting a pay for success strategy for your scenario.

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USING SOCIAL MEDIA TO ASSESS URBAN PARK VISITATION AND RECREATION SERVICES

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While green space and parks in urban environments are known to provide a range of ecosystem services and public benefits, local planners and park managers often lack local, readily available information on how parks are used and what makes them desirable places for recreation because standard methods to survey and monitor park use and user preferences can be too costly. In our study, we overcome this limitation by using geotagged social media data from the websites Flickr and Twitter, along with spatial analysis and methods developed by our team at The Natural Capital Project, to assess patterns of visitation across city and regional park systems in the metropolitan area of the Twin Cities, Minnesota, USA. Preliminary results from this pilot study reveal which recreational amenities and other characteristics influence park use patterns. We find that larger parks located in higher density areas with more amenities and greater accessibility are associated with higher visitation. Furthermore, we evaluate how well these novel data perform relative to existing park survey data and determine that they are a valid proxy for assessing relative demand for public green space across a metropolitan area, in place of or in addition to data from traditional survey methods. As cities grow and shifts in demographics and preferences occur, adaptive management of public green space will become increasingly important for maintaining urban parks that provide ecosystem services and meet residents' needs. We demonstrate that applying novel big data sources like social media to rapidly assess recreational services provided by urban green space and parks systems—at a lower cost than traditional surveys—has the potential to inform such management.

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PROBABILISTIC INTEGRATED RESOURCES ASSESSMENT TOOL WITH ECOSYSTEM SERVICES (PIRATES)

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To make fully-informed land management decisions, regional planners need information about how different land-use and land-cover configurations may influence biodiversity and ecosystem service provision. Integrating probabilistic models of land-use change and other ecosystem processes can provide unique insights and information to help decision-makers weigh different land-use alternatives while considering uncertainty. We are applying a spatially-explicit probabilistic modeling approach to assess the landscape-scale impacts of energy development (building oil and gas wells) on wildlife habitat and ecosystem services in sagebrush ecosystems of Southwest Wyoming. In this approach, a stochastic energy footprint model is used to simulate future well pad development and the accompanying expansion of road networks under alternative resource extraction scenarios. Simulation outputs are then coupled with models of wildlife habitat and ecosystem services to evaluate the potential impacts of each scenario. Here we present an application of this framework for assessing how conservation policies aimed at protecting a single wildlife species may influence other species of conservation concern. We also discuss progress and challenges for fully connecting this framework to ecosystem service endpoints in the study region, using big-game hunting as an additional example. At the landscape scale, we have found that appropriate data and empirical analyses of the relationships between energy development and ecosystem service provision are lacking. As integrated frameworks for assessing the impacts of ecosystem change on wildlife and ecosystem services become increasingly common, challenges remain in applying these frameworks to decision making at regional scales and across diverse landscapes. Ultimately we aim to improve integration of probabilistic models of land change and ecosystem services to enable deeper investigation of tradeoffs and feedbacks between energy development strategies and ecosystem service provision.

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VALUING SOIL HEALTH BENEFITS FOR WYOMING RANCHERS

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Healthy soils provide many benefits at many scales. We aim to evaluate the benefits that accrue to private producers and to determine if practices aimed at improving soil health are more beneficial than costly for them. Further, the case study includes policy implications such as whether additional incentives are necessary for producers to adopt practices promoting soil health.

We use a hypothetical ranch based on typical characteristics of operations found in central Wyoming to assess the impacts of soil health on profitability over time. Our model is a multi-period linear programing model in order to account for the time dependency of livestock management decisions. By using a multi-period linear profit maximization model, we evaluate how profit-maximization management varies with or without participating in practices aimed at improving soil health. The model includes 100 iterations of price cycles in order to examine the impact market forces have on the outcomes of managerial decisions.

We examine a suite of generic practices that improve soil health over time. We also study how the initial level of soil health impacts the model outcomes. The response of soil health to varying practices over time is generally non-linear, so initial status of soil health – in tandem with practice implemented – greatly impacts the timing of both costs and benefits. In all cases, it is assumed that increases in soil health translate to increased forage production, whether through increased forage quality, quantity, or seasonal forage availability. This enhanced productivity is one ecosystem service, but it is also tied closely to other beneficial services including wildlife habitat, water quality, carbon sequestration, etc.

Although valuing these associated services is beyond the scope of this project, we track optimal responses to changes in forage over time, and calculate the Net Present Value (NPV) associated with each practice for various initial values of soil health. If the NPV is positive, the results suggest that a ranch should voluntarily undertake a specific practice. However, preliminary results suggest many practices must be implemented over a sufficiently long time period before benefits are seen, resulting in negative NPV and suggesting additional incentives may be needed to persuade private producers to implement practices that support aforementioned ecosystem services and provide public goods. Unless soil health on rangelands provides immediate, short-term boosts in forage production, then the rancher's costs of implementing conservation practices may outweigh his/her benefits and further financial support from public agencies may be necessary.

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ECOSYSTEM SERVICES AS PART OF THE SOUTHEAST CONSERVATION ADAPTATION STRATEGY (SECAS)

Cynthia Kallio Edwards
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This is the opening talk in the organized session entitled, *Using Ecosystem Services to inform Conservation Decisions at a Landscape Scale*. The dramatic changes sweeping the Southeastern United States — such as urbanization, competition for water resources, extreme weather events, sea-level rise, and climate change — pose unprecedented challenges for sustaining our natural and cultural resources. The purpose of this talk is to illustrate how ecosystem service valuation is helping the conservation community define a shared, long- term vision for the future through the Southeast Conservation Adaptation Strategy (SECAS).

The scope of SECAS is the fifteen southeastern states that are included in the Southeast Association of Fish and Wildlife Agencies plus Puerto Rico and the United States Virgin Islands. SECAS was initiated by the states of the Southeastern Association of Fish & Wildlife Agencies (SEAFWA) and the federal Southeast Natural Resource Leaders Group (SENRLG) with support from Southeast and Caribbean Landscape Conservation Cooperatives (LCCs), the Southeast Climate Science Center (SECSC), and the Southeast Aquatic Resources Partnership (SARP).

Defining the conservation landscape of the future requires a new model of working together across entities, factions, and political boundaries through a collaborative process. The process needs to result in the development and pursuit of desired future conditions that are needed to sustain fish and wildlife populations. It is not sufficient to have fish and wildlife resources subsist on what is 'left over' after infrastructure development, instead we need to define what the future needs to look to sustain fish and wildlife populations.

Current efforts are focused on a series of conservation 'blueprints' across the LCCs that depict shared conservation and restoration priorities across the Southeast and the Caribbean. One of the products of SECAS is a region wide blueprint that will stitch together these efforts. The blueprints combine multiple datasets, tooks and resources into cohesive maps that can be shared by regional plnners, highway departments, developers, and conservation professionals. The blueprints are continually being improved and much of the ongoing ecosystem services work work highlighted in this organized session will be incorporated into subsequent versions as data and information becomes available.

The recommendations from this effort include the concept of continued improvement given new information and embracing the need to include ecosystem services valuation into decision processes that focus primarily on the conservation and restoration of fish and wildlife resources. By understanding the values humans derived from these decisions, the conservation community can broaden its sphere of influence and garner additional support for conservation actions.

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INTEGRATING WETLAND CONSERVATION PRACTICES INTO CEAP CROPLAND ASSESSMENT

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The USDA Natural Resources Conservation Service (NRCS) has worked with farmers to incentivize them to voluntarily enroll 2.3 million acres of wetlands and wetland associated habitat in the Wetland Reserve Program (WRP) since 1990. Wetland conservation practices are designed to help restore wetland hydrology, vegetation, and biodiversity. The process-based Agricultural Policy Environmental eXtender (APEX) model can be used to quantify the benefits of land conversion to wetlands and wetland habitat due to the enrollment in the WRP in terms of nutrient retention, floodwater storage, and soil organic carbon. Further, using optimization scenarios in the APEX model allows identification of optimal upland management practices to best restore and maintain wetland functionality. First, we highlight recent improvements to the APEX model necessary to accurately simulate wetland hydrology and nutrient cycling. Second, we demonstrate how an agricultural landscape can be simulated with and without wetland restoration to quantify environmental benefits. Third, we present a case study in Des Moines River watershed. Upland cropland management simulated in the APEX model is determined by the CEAP-Cropland survey, which was designed to quantify the impacts of agricultural conservation practices on water, soil, and air quality.

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SIMULATING SUBSTITUTABLE WATER QUALITY POLICIES: PAYMENTS FOR OUTCOMES VERSUS PAYMENTS FOR PRACTICES

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Payments for ecological services, such as cover crops, and water quality trading are two incentive based, non-regulatory instruments that have potential to cost-effectively reduce nitrogen and phosphorous (nutrients) from agricultural nonpoint sources. However, it is important to understand the possible economic interactions of offering the instruments concurrently. Two supply curves were generated using data on payment for cover crops in Queen Anne's county, Maryland and modeled nutrient reductions of twelve cover crop treatments for a simulated population of corn fields on the Delmarva Peninsula near the Chesapeake Bay. A nutrient index combined PES for nitrogen and phosphorous reduction and a sensitivity analysis into a single payment to elicit potential costs of supply in the nutrient market. This nutrient index is the first of its kind to distinguish payments made for multiple ecological services and to explore the impact on policy effectiveness with overlapping nutrient reduction policies. PES and nutrient trading policies pay for the same service yet PES, as demonstrated in the results of this study, has potential to increase prices of nutrient credits (establish a price floor) or collapse the nutrient trading market altogether. In addition, the existence of the trading market has potential to reduce the effectiveness of existing PES, which already suffers from ineffective payment for nutrient services. Recognition of policy interaction and overlap is imperative for policy makers to recognize and address in development of nutrient abatement programs.

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EVALUATING FOREST SERVICE PERFORMANCE METRICS FOR FISHERIES & AQUATIC RESOURCES: SHIFTING FROM OUTPUTS TO INTEGRATED OUTCOMES

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For years the U.S. Forest Service has discussed the need to transition towards more effective, outcome-oriented performance metrics that better reflect the benefits provided to the American people as a result of federal management of public lands. In an era of increased wildfire suppression borrowing and political scrutiny of western lands, this need is becoming increasingly urgent. The focus on performance metrics would serve to 1) direct programmatic focus on key integrated priorities; 2) quantify success and track how national forest unit activities contribute to fisheries program priorities; and 3) establish accountability towards agency objectives articulated in the Chief's 2015-2020 Strategic Plan.

After vetting with leadership and regional program managers, a working group was established to evaluate existing performance metrics and identify how Fisheries & Aquatic Resources objectives could be quantified nationally as both five-year outcomes as well as annual outputs. This group was integrated horizontally and vertically, with representation from forest fish biologists, regional programs, regional directors, and Washington Office managers, planners and information specialists. The group had eight months to identify and recommend outcomes and outputs for formal incorporation as national performance metrics, and worked in phases to: 1) Highlight program objectives and develop narratives; 2) Identify broad national outcomes; 3) Identify quantitative outputs that would feed these medium- to long-term outcomes; 4) Solicit feedback from various staffs, budget specialists, and external partners; and 5) Provide recommendations on metrics which could be piloted in FY17 prior to formal incorporation in FY18. To this end, the working group met bi-weekly to monthly to address important issues and progress towards final recommendations which new performance metrics should be elevated at a national level.

Recognizing that the components of the program had ecological, economic and social objectives, these narratives were used as a template for structuring new metrics. From a comprehensive list of quantitative indicators and metrics, the working group selected and recommended three new outcomes and six new annual outputs for immediate piloting. Criteria used to evaluate proposed metrics included strength of the linkage between action and resource, effectiveness of quantification at a national scale, data quality and feasibility in reporting, and time or resource burden. While this effort has helped catalyze a larger movement to reevaluate national metrics at a broader agency scale, the working group is now focused on determining how identified metrics could be quantified and analyzed given existing reporting mechanisms and databases. Additionally, several of the proposed metrics require additional modeling and research to ensure that the data is robust enough to support outcomes.

This presentation will focus on the challenges of incorporating outcome-based performance metrics into national reporting for the purpose of agency accountability. It also could serve to highlight a potential path forward for other natural resource programs or agencies to consider how they quantify success, maintain relevancy, and claim accountability for their decisions and goals in an uncertain future.

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LESSONS AND IMPLICATIONS FOR ECOSYSTEM SERVICE VALUATION BEYOND USDA

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Increasing recognition of the myriad benefits that nature provides to humans has built significant momentum for estimating credible values for ecosystem services. Indeed, the Millennium Ecosystem Assessment pinpointed the lack of systematic valuation and pricing of ecosystem services as a principal cause of the degradation of natural systems around the globe. This central finding no doubt boosted interest in advancing the scientific theory and methods to improve valuation. However, implementation of ecosystem service valuation in the federal policy arena still lags the impressive advances in science. Several barriers have proven difficult to surmount in the existing institutional setting. Some agencies may turn to the private sector for ecosystem valuation but those organizations often lack the scientific capacity to rigorously assess all salient services. Such efforts, although well intentioned, may jeopardize the long-run potential of ecosystem service valuation to improve federal conservation and environmental programs. To address this risk, multiple public and non-profit organizations are engaged in developing best practices for ecosystem service valuation by federal agencies. This presentation offers key principles distilled from those efforts and the latest science to inform a rigorous and comprehensive ecosystem services valuation process. The principles cover stakeholder engagement, causal chains, interdisciplinary approaches, appropriate scale, monetary and non-monetary benefit metrics, characterizing uncertainty and missing theory, methods and data. Overarching lessons from USDA-CFARE project and implications for other federal agencies will be articulated.

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LEVERAGING THE STORMWATER DATABASE TO IMPLEMENT AND REPORT ON THE DISTRICT OF COLUMBIA'S STORMWATER PROGRAMS

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In urban areas, stormwater runoff carries large volumes of pollution into waterbodies and erodes stream channels. The District of Columbia Department of Energy and Environment (DOEE) implements several programs to reduce stormwater pollution, including its innovative Stormwater Retention Credit (SRC) trading program. In 2014, DOEE launched a new tool called the Stormwater Database, which improves DOEE's tracking of green infrastructure practices managing stormwater runoff in the District, strengthens DOEE's ability to plan strategically and achieve the highest water-quality improvements, and enhances DOEE's customer service as the agency implements complex and interrelated programs.

The Stormwater Database tracks projects during every stage of DOEE's regulatory process for new construction and redevelopment. DOEE's reviewers make permit approval determinations based on green infrastructure information in the Stormwater Database, and DOEE's inspectors can verify plan information in the field and conduct site inspections using tablets. The Stormwater Database calculates the volume of stormwater management that is required, the volume that is provided, and the volume that is achieved through the use of privately-traded SRCs. DOEE also uses the Stormwater Database to calculate eligibility for discounts on the District's stormwater fee.

Through the Stormwater Database, DOEE improves its reporting capabilities by collecting detailed information about the overall trend in green infrastructure installation in the District. This information is provided to District government leaders, EPA and environmental stakeholders, and to the general public. Data about green infrastructure supports DOEE's TMDL modeling and is also made publicly available in a GIS layer. By referencing green infrastructure data, DOEE can anticipate the impact of its programs on District waterbodies and plan strategically for program improvements.

By integrating several programs and processes, DOEE has made it easier for the public to receive financial incentives for green infrastructure, and DOEE is able to implement these programs in a simplified way. Several programs that would otherwise function independently of each other (including SRC trading and the District's stormwater fee discount) are now coordinated and more effective. Program managers can also use the Stormwater Database to evaluate bottlenecks or identify process improvements.

DOEE took an unconventional approach for development of the Stormwater Database. After working unsuccessfully with IT consultants who did not understand DOEE's programs, DOEE decided to build the Stormwater Database in-house using the staff responsible for program management. This has allowed DOEE to dynamically adapt the Stormwater Database as necessary to meet new data needs as they arise. Thus, DOEE has continually improved both its data-tracking system and the implementation of its programs to promote green infrastructure in the District. Through use of the Stormwater Database, DOEE's innovative programs prevent harmful stormwater runoff and help to restore the waterbodies of the nation's capital.

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DEVELOPING EVIDENCE-BASED ECOSYSTEM SERVICE POLICY USING BEHAVIORAL SCIENCE AND EXPERIMENTAL DESIGN

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Environmental problems are largely human behavior problems. Yet environmental programs, like those aimed at supplying ecosystem services, are typically designed by natural and physical scientists, engineers and lawyers, rather than behavioral scientists. Program designs thus end up being based on incomplete theories of human behavior. A growing body of empirical evidence demonstrates that insights from the behavioral sciences can be used to design better public programs. Most of this evidence comes from non-environmental contexts, but the early evidence in the environmental field is promising. Moreover, theory and methodological insights from the behavioral sciences are leading to advances in the evaluation of environmental programs, which is moving us in the direction of evidence-based environmental policy.

This presentation will address the knowns and unknowns of applying insights from the behavioral sciences to improve ecosystem service programs, and will discuss the ways in which the applications of these insights are contributing to the development of evidence-based environmental programs more broadly. The presentation will also describe the activities of the USDA-funded Center for Behavioral and Experimental Agri-environmental Research (CBEAR). CBEAR engages an active and growing coalition of internationally recognized researchers in behavioral and experimental policy research to improve agri-environmental programs that deliver ecosystem services.

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DEPARTMENT OF THE INTERIOR'S APPROACH TO ACHIEVING COASTAL RESILIENCE IN THE WAKE OF HURRICANE SANDY

Olivia Barton Ferriter

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Hurricane Sandy made landfall on Oct. 29, 2012, wreaking havoc on communities along the Atlantic Coast, impacting twelve states and the District of Columbia. The Department of the Interior (DOI) invested $787 million for Hurricane Sandy recovery to clean up and repair damaged national parks and wildlife refuges; restore and strengthen coastal marshes, wetlands and beaches; connect and open waterways to increase fish passage, eliminate water control structures and improve flood resilience; while bolstering local efforts to protect communities from future storms. In the aftermath of that destruction, DOI provided funding to local governments, non-profits, environmental agencies, and tribes across twelve states along the Atlantic Coast from Maine to Virginia, and west to Ohio. Over 160 restoration, mitigation, and science projects were funded to develop and implement best practices for enhancing coastal resilience to sea level rise, storm surge, and wave erosion for both ecosystems and coastal infrastructure (e.g. communities, and commercial and public installations). This approach has incorporated the consideration of ecosystem services to better understand the dynamics and resilience of coastal ecosystems. To assess the benefits of these projects, DOI led a coordinated effort to identify science needs, develop ecological and socio-economic metrics, and evaluate how these projects contribute to reducing communities' vulnerability and strengthening coastal resilience. A resilience assessment process has been initiated for determining project success using metrics to quantify changes in resilience resulting from project actions at multiple scales. These efforts will enhance our understanding of storm impacts and sea level rise on coastal ecosystems, and help managers respond and adapt to changing environmental conditions. This session will describe efforts to build ecosystem and community resilience in areas impacted by Hurricane Sandy along the Atlantic Coast. We will discuss various ecosystem services important to coastal landscapes and how our understanding has grown over time. We will highlight the science used to increase knowledge of coastal impacts and to help communities enhance preparation efforts against future storms and hazards. Additionally, we will discuss the ecological and socio-economic metrics' role during the DOI Hurricane Sandy program evaluation.

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CATALYZING IMPACT INVESTMENT IN SUSTAINABLE AGRICULTURAL LANDS AND PRACTICES

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In a new effort to spark investment in sustainable agriculture, Earth Economics is embarking on an agriculture-focused valuation project in partnership with Delta Institute and Farmland LP. The goal of this project is to assess the economic impact of sustainable management practices on ecosystem services.

Innovators, investment firms, and farmland trusts are seeking to spur a transition from the U.S.'s predominantly conventional mono-cropping system back to more sustainable systems and practices. Investors are beginning to purchase conventionally-managed farmland to convert to organic, sustainably-managed crop and livestock rotations. By investing in farmland, many see an important opportunity to support the transition to sustainable practices while also making a solid return on their investments.

With more and more investors looking to farmland, there is a growing need for consistent, transparent metrics to monitor farmland's environmental performance. This project aims to satisfy this need by quantifying the financial impacts of farm-scale and field-level sustainable management practices on ecosystem services. As part of the project, the team is developing a tool for agricultural producers, landowners, and other stakeholders. Earth Economics' Ecosystem Valuation Toolkit (EVT) will be used as a platform to quantify and report on the suite of environmental benefits associated with various management practices. The EVT contains a database of thousands of economic values for ecosystem services that generate per-acre benefit transfer values across a wide range of ecosystem services. Once this project is implemented, the EVT can report on ecosystem service benefits arising from different management practices, both sustainable and conventional, within a variety of agricultural landscapes.

The initial project will focus on case studies in select Farmland LP agricultural properties in California's Sacramento Delta region and Oregon's Willamette Valley. As the project continues into 2017, these results will be applicable nationwide.

This new analysis will provide invaluable data for investors – with a clear picture of the financial impacts of sustainable agriculture practices, they will be able to gauge the environmental and financial impacts of their investments and compare investment options. Additional parnerships with farm owners and investors should be pursued to test the completed tool and to begin including ecosystem service benefits into farmland accounting.

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APPLYING ECO-HEALTH SCIENCE IN ENVIRONMENTAL GOVERNANCE

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Human well-being is inextricably connected to the sustainable use of natural and built resources. The ecosystem goods and services (EGS) concept has become increasingly valuable for identifying and evaluating important trade-offs and by extension has become a central element of decision support for both public and private institutions. A research priority for the United States Environmental Protection Agency (EPA), has been to develop methods for incorporation of EGS into decision making to protect human health.

Ecosystem services have been linked to human health endpoints ("Eco-Health") by a variety of studies, but many of these rely on conceptual assumptions without empirical evidence, or present correlations lacking a clear theoretical foundation. To better inform decision making, Eco-Health research may benefit from standard criteria to more clearly link management decisions to health outcomes. The most effective use of the resulting data will be in a decisional framework that effectively operationalizes the science for decision making.

Based on examples from EPA research, as well as the literature, we will explore how Eco-Health data can be incorporated into decision frameworks and effectively translated into decision evaluation criteria. The result is a roadmap for use of scientific data in structured decision support that can be applied across a wide array of issues and communities.

Decision makers are often challenged to effectively deal with complex decisions affecting multiple stakeholder groups and involving significant tradeoffs among decision options. Structured decision support tools offer a lot of promise for filling this need. The goal is translating decisions into changes in EGS and then translating change in EGS into measures of human benefit such as health.

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EARLY ACTION INCENTIVES IN U.S. ENVIRONMENTAL MARKETS

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Early action can mean different things depending on the particular context in which it is used. In some situations, early action refers to activities undertaken prior to the implementation of a particular regulatory program, for example prior to set compliance periods under greenhouse gas (GHG) reduction regimes or prior to implementation of total maximum daily load (TMDL) requirements to improve water quality. In other situations, early action refers simply to the generation of a particular service prior to it being needed to mitigate an impact elsewhere.

In the specific case of U.S. environmental markets, early action can result in two distinct benefits. The first is a market efficiency benefit. Early action can help to generate sufficient credit supply to provide viable, low cost option to buyers and gain market momentum at the outset of a new market. The second benefit is the facilitation of advanced mitigation. At the outset of new markets, and even continuing into mature markets, early action can help to generate increased environmental and other benefits by reducing lags in outcomes.

The presentation will introduce the mechanisms that have been proposed for encouraging early action in ecosystem service markets and the theory behind their use. To a varying extent, these mechanisms have also been deployed in markets themselves, lending valuable insight into how they function in the real world. This experience will be related through a series of short case studies, with an emphasis on wetlands mitigation and banking, species and habitat banking, GHG emission reduction and sequestration, and water quality trading. For each market, this presentation will discuss both the tools employed as well as the lessons learned from its implementation. Implementation examples are themselves identified from the academic literature and individual program or market documentation.

The literature and case study analysis generally find that the incentives needed to drive early action will differ between parties, and interventions will need to be responsive to and balance these differences. The tool or approach best suited to encourage early action may also change as conditions change and new barriers arise. Finally, it is important to recognize that market structure can itself influence the efficiency of any eventual trading activity, further implying that any effort to address market thinness, including efforts to encourage early action, will also be a function of market structure. Accordingly, the presentation will conclude with an assessment of the tools best suited to particular resource and market attributes, and recommendations for how these mechanisms can be better deployed to facilitate broader market and environmental objectives.

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WHAT CONSTITUTES “EVIDENCE” AND HOW SHOULD WE ASSESS IT?

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Evidence chains provide a clear frame to look at the level of support (the evidence) for the hypothesised causal pathways linking interventions to outcomes. In the case of ecosystem services, these causal pathways increasingly link environmental changes to human health and development outcomes, and therefore require a shared understanding of appropriate evidence assessment across these disciplines. Although there are widely used standards for strength of evidence assessment, particularly in clinical sciences, these standards are often challenging to apply in natural resource management and no consensus exists amongst the environmental community about how to assess evidence. Here we present the results of an interdisciplinary collaboration established to provide guidance on assessing evidence associated with ecosystem service evidence chains. We propose a set of key considerations that should be applied to the process of gathering and synthesizing evidence, both for links within an evidence chain and for entire causal pathways. These considerations include whether there is support from multiple types of evidence, the consistency of effect size, the reliability and applicability of the information, and which links in an evidence chain are most critical to focus evidence assessment on. Being able to assess evidence is important for understanding the pathways through which natural resource management and conservation decisions alter the environment and human well-being, and with alignment of research agendas across different fields.

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IMPACT OF INCREASED CORN PRODUCTION ON GROUND WATER QUALITY AND HUMAN HEALTH

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Attributing nitrogen (N) in the environment to emissions from agricultural management practices is difficult because of the complex and inter-related chemical and biological reactions associated with N and its cascading effects across land, air and water. Such analyses are critical, however, in understanding the benefits and disbenefits associated with environmental management options, such as the use of corn to produce biofuels. Coupled physical models present new opportunities to understand relationships among environmental variables across multiple sources, pathways and scenarios. Because they link emission sources with meteorology and the pollutant concentration found in the environment, they shed new light on these complex interactions and how they will respond under various management scenarios. In this study, we use a coupled modeling system to assess the impacts of increased corn production on groundwater. In particular, we show how the models provide new information on the drivers for contamination in groundwater, and then relate pollutant concentration changes attributed to increased corn production between 2002 and 2022 to health and cost outcomes.

To accomplish this, we applied a coupled meteorology, agricultural and air quality modelling system to examine the impact of N inputs from corn production on ecosystem and human health. The coupled system accounts for N deposited or emitted to and from the land surface, providing a unique opportunity to examine the effect of management practices such as type of fertilization, tilling and irrigation on groundwater quality. We performed extensive multivariate regression modelling to investigate the rich dataset of model variables for associations between agricultural management practices and nitrogen contamination in groundwater. We then applied the regression model to predict and contrast pollution levels between two corn production scenarios. Finally, we applied a published health impact function to assess increased vulnerability to spina bifida birth defects resulting from exposure to groundwater nitrate from increased corn production.

The regression modeling revealed that aquifer type, percent land use, number of animal feeding operations, N fertilizer and soil properties were all important predictors of nitrate in groundwater. Of particular note, no association was seen with total N fertilizer placed on all crops, but a very strong association ($P < 0.0001$) was seen when the variable was refined to represent irrigated (as opposed to rainfed) crops placed on grain corn (as opposed to other crops). We also found that high groundwater nitrate (≥ 5 mg/L) occurred in areas with a minimum soil hydraulic conductivity value that was 12 times higher than areas with lower groundwater nitrate concentrations (< 5 mg/L). In addition, high groundwater nitrate concentrations occurred in areas with an average animal feeding operation count that was 4.4 times higher and an average N fertilizer rate that was 2 times higher than areas with lower groundwater nitrate concentrations. To calculate health impacts, we identified a health impact function for excess spina bifida cases resulting from exposure to drinking water with > 5 mg/L groundwater nitrate. Nitrate in groundwater was predicted to increase above the drinking water threshold of 5 mg/L in some areas as a result of our increased corn production scenario, resulting in a slightly increased risk of spina bifida birth defects.

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ADAPTIVE GOVERNANCE OF URBAN SOCIAL-ECOLOGICAL SYSTEMS

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A central tenet of adaptive management is that management involves a learning process that can help regulated communities achieve environmental quality objectives. Adaptive management is a framework for managing social-ecological systems, and is a critical aspect of adaptive governance. Adaptive governance accounts for spatial and temporal scale in order to minimize cross-scale effects of management actions. This is particularly important for ecosystem services, and adaptive governance has the capacity to accommodate tradeoffs between stakeholders and scale in the provisioning of ecosystem services. Thus, utilizing adaptive governance for provisioning of ecosystem services has tremendous potential in urban social-ecological systems.

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FOREST RESCILIENCE BOND – FINANCING FIRE MANAGEMNT FOR WATER BENEFITS THROUGHT CONSERVATION FINANCE APPROACHES

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The Forest Service, and other land managers across the West, face extraordinary challenges in reducing the longstanding and unnatural overgrowth 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 to begin to reduce the growing wildfire risk and disease impacts currently experienced by so much of the region the need is up to 2.5 times that amount in the Sierra Nevada Mountain Region alone. Unfortunately, National Forest budgets are not nearly large enough to plan for, treat, and monitor these badly needed treatments. As USDA Secretary Vilsack highlighted in a January press release, the USFS fire suppression spending has ballooned from 16% in 1995, to over 52% in 2015. This steady increase in suppression spending continues to siphon funds away from restoration work that could prevent these fires from occurring in the first place, 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 and other land managers 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 allocating 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.

In this session, we will focus on the development of an FRB pilot to finance forest restoration treatments, so that private capital can be used to leverage additional agency funds through cost sharing agreements. 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 subject matter experts and investors to structure this investment and bring it to market.

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PROTECTING DRINKING WATER AT THE SOURCE: LESSONS FROM WATERSHED INVESTMENT PROGRAMS IN THE UNITED STATES

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Watershed investment programs are sprouting across the United States, offering promising pathways to securing clean drinking water. But what does it take to successfully establish and grow one of these programs? Watershed investment program investors and practitioners are looking for guidance and ideas on how to address challenges to development and how to build a program that works for their own context.

Between 2013 and 2016, the World Resources Institute and researchers from Colorado State University analyzed 13 watershed investment programs in the United States, interviewing key stakeholders associated with each program who represented water utilities, state federal government agencies, municipal governments, nongovernment organizations, and landowner associations. The study identified clear themes, common characteristics, and overarching lessons that were relevant to programs across geographies and in different contexts.

The top 10 common success factors for establishing and growing watershed investment programs identified through the study shed light on approaches to building momentum for watershed investments, as well as program design and implementation.
Water utility sustainability managers, conservation practitioners, and government agencies can use these success factors to identify and assess important conditions and activities that could lead to successful watershed investments in their region. They can also draw on several case studies that illustrate how these factors can be essential to building effective watershed investment programs.

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CASE STUDY—GENERATING GRASSLAND CARBON OFFSETS

Billy Gascoigne
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In 2014, Ducks Unlimited, Inc. (DU) generated and sold the first-ever certified carbon offsets based on the premise of proactively protecting at-risk grasslands from cultivation. The sale was the culmination of nearly eight years of work spanning protocol development, landowner engagement, field data collection, marketing & negotiations, biogeochemical modeling, third-party verification, and registry certification. Through these efforts, DU gained firsthand knowledge of transaction costs that span across a majority of ecosystem service markets. While much improvement has been made in the space, significant hurdles remain and require additional attention. Billy Gascoigne, DU's Environmental Market Specialist and Grassland Carbon Program lead, will give an overview of their experience, the various steps it took to go from concept to reality, remaining challenges, and potential solutions to improve market access.

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USING SCARCITY DATA TO VALUE ECOSYSTEM SERVICES: ASSESSMENT OF CURRENTLY AVAILABLE RESOURCES

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The purpose of this project is to document data and tools that are available to measure scarcity of ecosystem goods and services (EGS). Such data and tools are intended to support the measurement of non-monetary benefit indicators, as used to compare potential EGS benefits across sites or projects. Demonstrating scarcity can suggest value because, in general, the scarcer something is, the more people are willing to pay to increase or prevent a decrease in a good or service. In economic terms, scarcity is demand in excess of supply. Thus, anything that affects demand for or supply of a service can influence scarcity. In addition, scarcity encompasses substitutability, or the availability of inexpensive and comparable substitutes, for a given group of beneficiaries. For intangible benefits of EGS (non-use values), scarcity can be measured in terms of current rarity or future vulnerability.

Scarcity is one element of a non-monetary benefit indicator system that has been proposed for use by the US Army Corps of Engineers and other federal agencies. However, data and tools are needed to simplify the implementation of benefit indicators. Through background research and internet searches we were able to document over 50 unique resources that can be used to represent or calculate EGS scarcity by location. These resources were organized into categories of: biodiversity, food reliability, water reliability, raw materials, and climate. Scarcity is represented in a variety of ways across these resources and includes current status and vulnerabilities of species or landscapes. Current condition data indicate where resources are already scarce for use in restoration or preservation targeting. Future vulnerabilities are assessed based on trends under climate or land use change (e.g., water supply vulnerabilities) and identify areas vulnerable to loss and degradation of EGS.

Many of the resources provide rankings or classifications to represent conservation priorities. Such information can frame the relative value of EGS restoration and protection in terms of a project's ability to address regional or national conservation goals. Further, prioritization information makes it possible to quantify potential non-use benefits. The ranks can be used to create quality-adjusted area metrics to support the comparison of benefits generated by alternative projects.

Within the database, an overwhelming majority of the resources found are within the biodiversity category. In contrast, we have found few resources related to food reliability or raw materials to date. We do not believe these resources to be an exhaustive list and plan to continually add new data or tools as they are made available. Data are catalogued at http://www.waingerlab.cbl.umces.edu/ecoscarcity/.

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BELIEFS, BIASES, SIMPLIFICATIONS, AND OTHER CHALLENGES FOR THE ECOSYSTEM SERVICES PARADIGM

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The Ecosystem Services paradigm (ESp) is a human construction and therefore a biased simplification. Nature is inherently complex, dynamic, and includes humans as system participants, not as objective observers. ESp has enabled greater societal recognition of some previously hidden benefits of nature's stocks and flows for humans. For example, the provisioning and regulating functions of wetlands are likely better appreciated today, even as wetlands disappear as a result of anthropogenic pressures. However, there has been little discussion of (a) the disservices of nature for humans, or (b) more broadly, who the benefits (and disbenefits) are really for: present humans in specific locales, future humans globally, or any combination thereof. The ESp "Nature" that we have conceived, while containing more advanced scientific information over earlier constructs (e.g. the Garden of Eden, the Jungle Book, agricultural conceptions) is still, by design, limited and anthropocentric. It would not resonate with modern society otherwise. While recognizing the social benefits of ESp, we argue that improved management of natural resources and environments and of ourselves, will ultimately require fuller appreciation and understanding of "nature" as a complex adaptive system (N-CAS) that, at any time, has evolving present and future benefits and disbenefits for different constituencies.

Obtaining a critical science-based examination of ESp and understanding drivers for its social resonance and acceptance requires explicit efforts to recognize how the definition and use of ESp is affected by human Beliefs, Biases, Heuristics and Values (BBHV). The importance of recognizing and understanding BBHV has been advanced through the developing field of behavioral economics, and more recently in the construction, application, and use of integrated biophysical models and in transdisciplinary applications to improve management of natural resources and environments. We discuss several BBHV and how they apply to ESp at multiple levels of human thinking and decisons, rom individuals to communities to broader groups. BBHV examples include exceptionalism and positivity biases, cognitive discounting, tribalism, groupthink, static systems thinking, and spatiotemporal discounting. ESp practitioners rarely put the "services" that they discuss or value in the context of ecological systems thinking about the dynamics and complexities of foodwebs, trophic levels, habitats, predator/prey relations, disease and resistance mechanisms, trophic cascades and other disruptions. They also rarely consider human activities within an integrated context of natural processes. For example, the services provided by groundwater or subsurface processes, by mycorrhizal fungi, or by unseen energy and mineral resources are rarely considered or discussed under ESp. Peat, coal, oil and gas are not generally considered provisioning services. Is that a valid, or a value-laden, proposition? What about the growing and cutting of trees and other plants, or hunting and fishing? Asides from more transparent critical discussions of ESp and its use, social learning will also needed at multiple levels for improved knowledge and management of "nature", especially under conditions of polycentric governance. Ultimately, better more explicit recognition of BBHV can provide us with improved information; and with knowledge that can be more easily communicated, transferred, and applied more consciously into practice.

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DETERMINATION & VALUATION OF WATER-QUALITY ECOSYSTEM SERVICES AVAILABLE FROM FARMS

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The identification and valuation of ecosystem services is a critical component of the benefits associated with Federal programs to improve the environment. In the case of Federal, Farm-Bill-Authorized, conservation programs a range of ecosystem services associated with multiple physical actions are often considered. The range of physical actions are broad but include farm and forest management practices such as cover crops, riparian buffer plantings, nutrient management, and tillage systems that aim to improve water quality and quantity, enhance wildlife habitat, and reduce soil loss, among other beneficial outcomes. These biophysical ecosystem service benefits also bring associated public benefits.

This project focuses on developing a process for identifying and estimating the values of public ecosystem service benefits realized because of implementation of conservation plans carried out under USDA Farm-Bill programs. The programs’ voluntary practices can result in improved water quality from agricultural working lands. Agricultural working lands are productively—and often intensively—farmed and provide the agricultural bounty that underlies the food, feed, and biofuel systems. Eligible producers that adopt selected practices may receive financial assistance for improved environmental conditions.

The project started with a common suite of water-quality improvement practices and translated those physical actions in a field through the ecosystem process, identified the relevant indicators, the final ecosystem services produced, and the monetary and non-monetary values of the service benefits to the landowner, watershed, and society as a whole. An interdisciplinary group of experts organized by the Council on Food, Agricultural & Resource Economics and funded by USDA has developed an assessment of what can be stated about the determination and valuation process and identification of the knowledge gaps.

The presentation will be used to describe the findings to date, and provide an opportunity for the audience to provide feedback on the effort. The findings will include an assessment of the best science and data available to support credible estimates of socio-economic benefit measures for changes in selected ecosystem services. In addition, findings will include methods developed to create evidence-based estimates of values, measured with monetary values or non-monetary benefit metrics, and the degree of confidence in each measure.

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THE NON-MARKET VALUE OF THE OUTER COAST OF WASHING STATE

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Natural resources are affected by a number of natural and anthropogenic factors, such as coastal development, natural or technological disasters, and management practices. If these factors negatively affect natural resources, then they may become less available or completely unavailable to the public. With limited resources to invest in the management, protection, and recovery of natural resources, there is a need to rank competing management priorities. From a policy and management standpoint, it is helpful for resource managers to understand how people value, ergo will “miss," a particular ecosystem service or natural resource attribute if it degrades or goes away. Such knowledge is useful because it can help managers decide how to invest limited financial and personnel resources in management activities to serve the public interest.

This study was designed to provide natural resource managers from the Olympic Coast National Marine Sanctuary (OCNMS) and the State of Washington with information about which natural resource attributes are most important to the public and how much the public values them. This information will support the development of Condition Reports, which provide information on the status and trends of Sanctuary resources and ecosystem services, for OCNMS and to aid in marine spatial planning. More specifically, the objectives of this study were to estimate the probable influence of changes in resource attribute conditions on the non-market value placed on those attributes.

Here we present the results of a survey that was administered to about 2,500 households in the Washington State Outer Coast region to estimate the non-market values of ten natural resource attributes. Respondents were asked to choose between three different scenarios where each alternative was described by the condition levels of the resource attributes as well as the annual cost to the household. Econometric methods, specifically logit models, were employed to estimate the values for each resource attribute as well as for various resource attribute bundles. Results show that most natural resource attributes exhibit diminishing marginal returns, suggesting that improving these attributes to their medium condition level will provide the most added value to recreational visitors. Water quality, unobstructed views, and marine mammals are the most valued attributes and crowding and tide pool organisms are the least valued. Values also vary across groups and contributing factors include ecological worldview and experience with the Outer Coast.

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OPTIMIZATION OF AGRO-ECOSYSTEM SERVICES WITH SPATIAL SPILLOVERS

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We explore how mathematical optimization techniques can be used to maximize the net benefits to society from spatially targeted conservation investments at the landscape scale. The approach presented is flexible and can take into account market and non-market benefits from different functional types of ecosystem services, based on location in a heterogeneous landscape composed of natural area, intensely managed agricultural land, water and developed uses. We demonstrate the approach for investment in agricultural conservation practices that provide water quality, biodiversity and pest control ecosystem services to demonstrate how accounting for beneficial spatial externalities from pest control alone can increase social welfare. Privately optimal landowner decisions cannot be expected to lead to socially efficient levels of ecosystem service provision, but targeting conservation investments taking spatial spillovers and the spatial heterogeneity of the landscape into account can.

Our application is to pest control of soybean aphid (*Aphis Glycines Matsumura*) by lady beetles. Natural areas provide habitat for lady beetles and other predator insects that eat the aphid. We study grass filter strips planted in riparian areas adjacent to crop fields based on the US Department of Agriculture's Natural Resource Conservation Service practice standards for grass filter strip plantings motivated by their water quality benefits. We use remotely sensed crop location and land cover data to solve for optimal economic thresholds for spraying insecticides that take spatial spillovers of crop protection benefits into account. Planting non-crop habitat for beneficial insects (natural enemies) that travel over one kilometer around their habitat provides services where the habitat is located and on other farmers' land as well. We then solve for optimal spatial locations to invest in filter strips that provide habitat for beneficial insects that provide pest control services in excess of additional water quality and biodiversity benefits associated with grassland plantings such as avoided pesticide spraying. We compare the market benefits from crop yield protection net of practice installation and crop production costs to quantify a lower bound estimate of the net benefits from pest control ecosystem services optimized over the entire land area of Newton County, Indiana, USA. We find that optimal spatial investment in these practices can achieve an average increase of $15 million dollars of net benefits from protected crop yields and reduced insecticide spraying costs for our study location. If additional water quality and/or biodiversity derived ecosystem services could be valued, the benefits would be even larger.

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CAN A MODEL TRANSFERABILITY FRAMEWORK IMPROVE ECOSYSTEM SERVICE ESTIMATES? A CASE STUDY OF SOIL FOREST CARBON SEQUESTRATION IN TILLAMOOK BAY, OR, USA

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Budget constraints and policies that limit primary data collection have fueled a practice of transferring estimates (or models to generate estimates) of ecological endpoints from sites where primary data exists to sites where little to no primary data were collected. Whereas benefit transfer has been well studied; there is no comparable framework for evaluating whether model transfer between sites is justifiable. We developed and applied a transferability assessment framework to a case study involving forest carbon sequestration for soils in Tillamook Bay, Oregon. The carbon sequestration capacity of forested watersheds is an important ecosystem service in the effort to reduce atmospheric greenhouse gas emissions. We used our framework, incorporating three basic steps (model selection, defining context variables, assessing logistical constraints) for evaluating model transferability, to compare estimates of carbon storage capacity derived from two models, COMET-Farm and Yasso. We applied each model to Tillamook Bay and compared results to data extracted from the Soil Survey Geographic Database (SSURGO) using ArcGIS. Context variables considered were: geographic proximity to Tillamook, dominant tree species, climate and soil type. Preliminary analyses showed that estimates from COMET-Farm were more similar to SSURGO data, likely because model context variables (e.g. proximity to Tillamook and dominant tree species) were identical to those in Tillamook. In contrast, estimates from Yasso were an order of magnitude less than estimates extracted from SSURGO or COMET-Farm. This difference may have been due to lower context similarity between Yasso sites and Tillamook Bay. The greatest logistical constraints in assessing model transferability were the identification and vetting of context variables used in models. Though user-friendly models with an attractive interface may be preferred, documentation on model construction and data sources are often sparse and limit transferability. On the other hand, transferability of models well-vetted in peer-reviewed literature can be limited by site-specificity. Our model transferability framework applied to a real world case study involving ecosystem services helps demonstrate the utility of this approach and highlights important considerations when deriving estimates from transferred models.

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ECOSYSTEM SERVICES IN CLIMATE CHANGE ADAPTATION PLANNING

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The concept of ecosystem services is increasingly being identified in federal and state guidance documents as a useful and needed approach to environmental planning and decision making. Water resources projects are already required to consider ecosystem services as are all U.S. Forest Service projects. One of the most critical types of planning now also involves planning for climate change adaptation. Both processes – the inclusion of ecosystem services into planning, and planning for climate change adaptation- are complex, uncertain, and depend on community and social values as well as the best available scientific information to direct planning process. This presentation will focus on some approaches and tools available to address ecosystem services in integrated planning for climate change adaptation. In particular, this presentation will show how using ecosystem services requires community involvement and as such can potentially strengthen both planning processes.

This presentation will identify and describe innovative applications of ecosystem service quantification outside of the traditional natural resource damage assessment regulatory arena. For example, proposed responses to sea level rise are often focused on extending defensive engineering or 'hard responses' such as building dams, levees and channels to control flooding, and building or reinforcing seawalls to protect from SLR. Such engineered responses may be necessary in some instances, but they will not be sufficient to address the full scope of climate change impacts and can cause their own impacts to natural systems. When a net ecosystem services analysis is brought into this discussion, natural adaptation systems may in fact be more economically prudent than engineered solutions.

As state and local planners begin to consider specific adaptation responses, they must be able to better understand when, where, and under what circumstances nature-based strategies can be an effective alternative to engineered approaches. Wetland and floodplain restoration, coastal reforestation, and other natural restoration work can help human communities become resilient while also helping to preserve the natural systems upon which we rely. The presentation will provide a framework for economic valuation, floodplain management, natural infrastructure (green infrastructure), incorporating uncertainty, and other tools that can facilitate the essential stakeholder involvement that leads to appropriate local decisions. The authors will identify the specific challenges to conducting this kind of planning work, and present successes and failures in working with stakeholders to include ecosystem services into climate change adaptation decision making. Examples will be presented from climate adaptation work in southern California.

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INCORPORATING THE VISIBILITY OF COASTAL ENERGY INFRASTRUCTURE INTO MULTI-CRITERIA SITING DECISIONS

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Concern about the visibility of large infrastructure development often drives public opposition to these projects. However, insufficient analytical tools to assess visibility across a large number of alternate sites prior to siting typically results in the omission of visibility in multi-criteria siting processes, leading to inferior site selection and often costly litigation. This research presents an approach for deriving visibility maps based on the location and duration of viewing by residents and visitors and demonstrates its use in illuminating tradeoffs by comparing these maps to wind energy value maps in the context of offshore wind energy development in the Northeastern United States. While it is introduced in an offshore wind energy siting context, the cumulative viewshed method here is general and can be used in any siting decision where visual impacts are a concern, such as offshore aquaculture and more. This approach is especially useful in areas where siting decisions are non-trivial from a visibility perspective, such as when the geomorphology or distribution of viewers varies significantly across space, a condition that holds at many coastal locations. The fast and accurate production of landscape visibility maps prior to siting decisions is a crucial missing capacity for planning at a time when more than three dozen countries worldwide are starting or continuing to develop marine spatial plans in reaction to expanding use of coastal waters.

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QUALITY INFORMATION AND PROCUREMENT AUCTION OUTCOMES: EVIDENCE FROM A PAYMENT FOR ECOSYSTEM SERVICES LABORATORY EXPERIMENT

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We report results from a laboratory experiment used to study how information revelation in a single-round procurement auction affects auction efficiency when price and quality are both choices in offer formation and are valued attributes to the procuring agency. Single-round auctions are commonly used in conservation procurement, including the Conservation Reserve Program in the U.S. and various tender programs in Australia (Iftekhar et al., 2013). The multi-attribute information treatment design employed in our experiment captures many of the salient features of these field auctions, where bidders can choose both which parcels they enroll and which conservation measures they would like to undertake in addition to the price they require to enroll. By treating quality as a choice variable in the auction and then restricting information about it, bidders face significant uncertainty in the bid formation process. Treating quality as a choice variable extends prior information oriented studies which treat quality as an exogenous factor (Banerjee et al., 2014; Cason et al., 2003; Glebe, 2013; Haruvy and Katok, 2013).

The results of our lab experiment indicate that providing auction participants with detailed information regarding the quality of their conservation action leads to improved auction performance, the opposite finding of studies conducted in the context of multi-round, exogenous quality auctions (Banerjee et al., 2014; Cason et al., 2003). The novel findings of our study are attributed to landowners' inability to identify high quality conservation actions without quality information, leading to choices based solely on cost considerations with effectively random quality. The inability to condition offers on quality reduces rent-seeking but results in an overall decrease in auction performance due to the acceptance of lower-quality items. This reduction in efficiency from withholding quality information is monotone across greater degrees of quality uncertainty. The results demonstrate that a greater degree of information revelation in this common procurement auction format can increase ecosystem-service provision under a budget when quality is a choice variable.

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PAY FOR SUCCESS—ITS BENEFITS AND LIMITATIONS IN FINANCING ECOSYSTEM SERVICE RESTORATION

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The purpose of this session is to describe the ways in which Pay for Success as a financing strategy can be used to test innovations in the large-scale monetization of ecosystem services. As part of this session, this presentation will introduce Pay for Success as a concept and describe the structure of such transactions, using real-world examples to illustrate the relationships of the stakeholders and the flow of financing through the transaction.

The presentation will also describe the various benefits of such a financing strategy, principally the transfer of project risk from the public to the private sector, which addresses the primary concern that prevents more investment in ecosystem services. Other benefits of Pay for Success include the increased efficiency in the use of public funds, the rigorous evaluation processes that are incorporated directly into each transaction, and the alignment of incentives that bring together disparate stakeholders to improve ecosystem service provision.

The presentation will note that Pay for Success financing is not a silver-bullet for increasing investment in ecosystem services, as there are key limitations to this financing strategy – primarily in the unique set of enabling conditions required for Pay for Success financing to succeed. These include policy and regulatory barriers that are unique to each transaction type, the need for high transaction replicability and a large total investible market to justify the sizable initial transaction costs, and that a small number of well-capitalized entities must be willing to pay for improved ecosystem services based on generated revenue streams and/or modeled cost savings.

The presentation will conclude with a set of recommendations that include specific opportunities for where Pay for Success financing structures might increase ecosystem service investment, and how state and federal policies can incentivize more Pay for Success activity by increasing incentives and reducing barriers.

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MAPPING MARGINAL CROPLANDS SUITABLE FOR BIOFUEL CROP DEVELOPMENT

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Growing cellulosic feedstock crops (e.g., switchgrass) for biofuel is more environmentally sustainable than corn-based ethanol. The advantages of this land management practice include (1) reducing soil erosion and improving water quality, (2) decreasing drought impacts on production, (3) reducing greenhouse gas (GHG) emission to the atmosphere, (4) improving regional ecosystem function and service and retaining environmental sustainability (i.e., serves as a carbon sink), and (5) producing cellulosic biomass in areas that are marginal or highly vulnerable to erosion. The main goal of this study is to identify high risk and unproductive marginal croplands that are potentially suitable for growing switchgrass in the U.S. Great Plains (GP). Satellite-derived growing season Normalized Difference Vegetation Index, a switchgrass biomass productivity map obtained from a previous study, USGS irrigation and crop masks, and USDA crop indemnity maps for the GP were used in this study. In addition, the long-term (9-year) averaged net ecosystem production (NEP; g C m^{-2} yr^{-1}) data, an important ecosystem-scale characteristic for assessing terrestrial carbon cycles and ecosystem services, was used to evaluate carbon sequestration of the identified biofuel potential areas. Our hypothesis was that croplands with relatively low crop yield but high productivity potential for switchgrass may be suitable for converting to switchgrass. Areas with relatively low crop indemnity were excluded from the suitable areas based on low probability of crop failures.

Results show that approximately 6,500 km^2 of marginal croplands in the GP are potentially suitable for switchgrass development. The total estimated switchgrass biomass productivity gain from these suitable areas is about 5.9 million metric tons. Switchgrass can be cultivated in either lowland or upland regions in the GP depending on the local soil and environmental conditions. Most identified biofuel potential areas have near equilibrium NEP values (i.e., carbon emitted is nearly equal to carbon absorbed), so converting these areas to switchgrass can improve regional carbon sequestration (cultivating switchgrass can lead to a carbon sink) and help retain future environmental sustainability. This study improves our understanding of ecosystem services and sustainability of cropland systems in the GP. Results from this study provide useful information to land managers for making informed decisions regarding switchgrass development in the GP.

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GETTING TO TRANSFORMATION: THE SCIENCE AND PRACTICE OF USING ECOSYSTEM SERVICE AND ECOSYSTEM-BASED MANAGEMENT APPROACHES IN DECISIONS

Anne D. Guerry
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To manage the use of oceans for the greatest possible benefit, it has become clear to governments and leaders that we need to manage coastal and marine systems for multiple uses, in ways that account for many different marine ecosystem services, and that guide our spatial patterns and types of ocean use to sustain ocean productivity for today's needs and the needs of future generations. Recent paradigms in management of marine systems have moved from single-sector and single-species to ecosystem-based management and to using an ecosystem services approach. At the Natural Capital Project, we develop practical tools and approaches to account for nature's contributions to society, so that we can make smarter decisions for people and the planet. We have taken the sometimes too abstract idea of "ecosystem services" and used it in the real world to inform decisions in over 30 locations around the world. We've developed a free and open-source software platform with 18 ecosystem service models and developed field-tested approaches to reconciling multiple objectives and using ecosystem service outcomes as metrics to compare management plans. Throughout, we have learned a lot about what to do (e.g., iterative engagement with decision-makers, enlisting stakeholders to elicit visions and values for the future, co-developing decision-support tools with end-users, understanding existing authorities) and what not to do (e.g., use the phrase "ecosystem services" at a community meeting). In this talk, I will use examples from our work informing climate adaptation planning in coastal California, ocean planning on the Eastern Seabord, and coastal conservation and restoration planning in the Gulf to highlight lessons learned and to suggest opportunities to effect a fundamental transformation of decision-making for a more sustainable future.

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USING THE ESII TOOL TO IMPROVE CORPORATE-EXTERNAL STAKEHOLDER ENGAGEMENT OUTCOMES

Presented by ***France Guertin***

Elizabeth Uhlhorn

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In 2015, Dow announced its newest set of ten-year Sustainability Goals, including an ambitious goal to identify $1 billion in long term value from projects that are also better for nature. 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 ESII (Ecosystem Service Identification and Inventory) Tool, developed with The Nature Conservancy and ecosystem consulting firm EcoMetrix Solutions Group (ESG), supports this goal by delivering rapid, screening level assessments of the ecosystem services present on a particular site and providing support for monetary and non-monetary valuation of these ecosystem services.

This talk will focus on how the ESII Tool can be used to engage communities and local governments around the impact of restoration or development projects, as in some examples, it is in this dialogue that greater value to the business and the community may be uncovered. The speaker will showcase several features of the tool that facilitate this engagement and will walk through two case studies, covering a project in Michigan and a project in Texas. The projects will show how ESII Tool output, including water storage, water quality, erosion, and air filtration metrics, can help companies prepare for and focus discussions with various stakeholder groups. In one example, ESII Tool outputs were used in discussions with a city in Michigan to support how city action could further improve a restoration project. In another example, ESII Tool outputs were used internally by Dow staff to prepare for discussions with the local community around a small scale development project with several green infrastructure components.

Attendees will learn how they can use the ESII Tool in various phases of stakeholder engagement, including planning and reporting. Results will be discussed generally and in the context of the specific case studies.

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DOW'S 2025 NATURE GOAL: SCALING CORPORATE DECISIONS AND CULTURE CHANGE IN VALUING NATURE

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Six years ago, The Nature Conservancy and The Dow Chemical Company came together with the bold ambition of showing how a company could integrate the value of nature into its core decision-making – for the benefit of the company, society and the environment. Dow's CEO Andrew Liveris said at the collaboration launch that his vision was that Dow "incorporates the value of nature into every single one of our decisions, into every single one of our company-wide goals and plans." Providing "top-down" incentive for that action, in April 2015, Dow announced its 2025 Nature Goal, as part of its next generation of 10-year sustainability goals. With this goal, Dow is committing to integrate nature into its evaluation of all capital, real estate, and R&D projects – a step that could include thousands of decisions each year across the company. In doing so, Dow seeks to both identify opportunities where Dow can enhance the positive and reduce the negative impacts on nature, while also identifying environmentally better projects that create $1B in business value by 2025.

However, nature capital valuation of this magnitude requires not only a top-down goal, but also a bottom up culture change. This discussion will focus on the tools and processes that Dow is creating to foster that culture change, including several examples of process changes, trainings, and workshops that have been held in support of the goal. The speaker will layout the plan for continuing to move toward valuing nature across the company. This talk will invite discussion with other members of the session and the audience on opportunities and challenges in doing this type of work.

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ADAPTIVE GOVERNANCE OF ECOSYSTEM SERVICES IN WETLAND AND RIVERINE SOCIAL ECOLOGICAL SYSTEMS

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Adaptive governance provides a context for managing known and unknown consequences of prior management approaches and for increasing legitimacy in the implementation of flexible and adaptive management. Using examples from iconic water systems in the United States, we explore the proposition that adaptive management and adaptive governance are useful for evaluating the complexities of trade-offs among ecosystem goods and services. Adaptive governance may provide one solution to reconciling uncertainties associated with management for a suite of ecosystem services. One such uncertainty is how to value such goods and services for the purposes of decision-making. Efforts to place monetary values on various ecosystem goods and services continue to be undertaken, in order to make commensurate valuation schemes that fit within rational, cost-benefit management schemes. A growing body of literature seems to suggest that economic methods involving monetization within rational frameworks cannot capture the dynamic complexity of ecosystem goods and services. Adaptive governance and adaptive management are learning based approaches that can help to systematically resolve key uncertainties of these complex systems. Globalization, climate change and other broad drivers increase the uncertainty of the capacity of ecosystems to provide desired goods and services. Adaptive approaches may help us learn how to deal with the complexities of trade-offs and uncertainties in evaluating how to provide and sustain multiple ecosystem services.

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LESSONS LEARNED FROM APPPLING AN ECOSYSTEM SERVICES FRAMEWORK FOR POST-HURRICANE SANDY RECOVERY AND RESILIENCY PLANNING IN LONG ISLAND, NY

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In the wake of Hurricane Sandy, the second costliest hurricane in U.S. history, the United States Environmental Protection Agency, the Federal Emergency Management Agency, Stony Brook University, The Nature Conservancy, and New York State (NYS) Department of State partnered with county governments on Long Island, NY, to identify the value Long Island communities derive from the goods and services provided by nature, and how these values could be incorporated into climate change resiliency and recovery planning after hurricanes and flooding. Integrating the concept of ecosystem services (ES) and resiliency into government planning has garnered attention in recent years. In 2014, NYS passed the Community Risk and Resiliency Act, or CRRA, which requires municipalities to consider the concept of “resiliency” into their planning in order to continue to receive state assistance by 2017, and in 2015, the Office of Management and Budget issued Memorandum M-16-01, which directs federal agencies to develop and enact policies that incorporate ES where appropriate. Within this context, the researchers in this partnership adopted an ES framework derived from the “Federal Resource Management and Ecosystem Services” guidelines published by the National Ecosystem Services Partnership at Duke University to provide a methodical approach for integrating the values of ES into planning. However, the application of an ES framework within a federal interagency and private partnership that also incorporates varying levels of state and local governance can be problematic. From our efforts in the first year, four areas were identified as keys to success including (1) partner buy-in, (2) the role of a facilitator in lieu of adopting a centralized decision making process, (3) outcome- based consensus building, and (4) use of adaptive management. Congruous partner buy-in is critical for advancing project goals, while a facilitator resolves differences amongst partners and partner organizations. Furthermore, emphasis on an outcome-based consensus that balances a process-driven approach with principles of adaptive management engenders project progression and is necessary given the uncertainties that arise in the research process.

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IDENTIFYING SERVICE FLOWS DURING THE ECOSYSTEM SERVICES QUANTIFICATION PROCESS

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An ecosystem services-based assessment of a project can provide information on the natural benefits provided by the site and can be used to anticipate how project impacts may affect the benefits experienced by stakeholders during and after project-related activities. To fully understand the relevance of site-level impact information, it is important to frame that information within the appropriate landscape or community context. In other words, what constitutes the “serviceshed”, or the area within which each service is provided (essentially, the off-site valuation study area(s)), and how the natural benefits that flow from a site are used and appreciated by the communities in the region should be identified. Ideally, an “off-site impact analysis” should provide a means to determine the relative value of the ecosystem service flows provided by the site to local communities, and a means to understand the potential effects of service flow disruptions. Understanding how local communities value the respective ecosystem services produced by a site enables decision makers to better assess potential project risks and to more thoroughly evaluate the trade-offs associated with design alternatives.

This talk will describe an approach for anchoring site-level impacts in a landscape context to help understand whether the changes predicted to result from project-related activities are likely to be of concern to local communities. Once ecosystem services produced on a site have been identified, a three-step framework for assessing community dependence, pathway strength, and impact magnitude is applied. This framework can determine the extent to which surrounding communities are presumed to value the benefits provided by the ecosystem, and the presumed connection the communities have to those benefits. This information can be used to modify project designs to protect resources of value to nearby communities.

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MAKING NATURE VALUATION “ESII”: ENABLING DECISION-MAKING

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The ability to identify and assess the value of nature on a site scale has been discussed, studied and hoped for by many, for years. The ability to conduct ecosystem services evaluations quickly and inexpensively is a necessity for enterprises – both large and small – to incorporate the value of nature into their operations and decision making. Such a methodology would allow businesses to demonstrate their stewardship of nature and commitment to community values, while potentially enabling them to recognize benefits from the natural world that are currently overlooked. At the start of the Nature Conservancy and the Dow Chemical Company Collaboration, an evaluation of site-level ecosystem services in metrics useful to the business enterprise had not been successfully demonstrated. The Collaboration had produced case studies that showed the relevance of ecosystem services science in business, but scaling the incorporation of ecosystem services into decisions across an organization as large as Dow required a unique solution—one that would increase awareness of the value of natural lands, point to areas of concern, and trigger more detailed analyses of selected ecosystem services on a given site.

This talk will describe the development of the ESII Tool (Ecosystem Services Identification & Inventory Tool), a publicly available tool that can be used in the early stages of decision making to identify benefits provided by natural assets so that their value can be incorporated into operational and planning decisions. From early discussions in 2013 describing the desired functionality and technical requirements for a tool that could meet this vision, to the public release of the tool in 2016, EcoMetrix Solutions Group, TNC and Dow worked with a wide range of ecologists, economists, engineers and other scientists and business managers to articulate, refine, and ultimately build a tool that could be used Dow engineers and managers to integrate nature into its evaluation of all capital, real estate, and R&D projects. The discussion will focus on the process of working with TNC and Dow’s internal stakeholders to design the tool, understanding why this type of tool was needed to scale the integration of nature into decisions at Dow, and the lessons learned throughout the entire three-year development process.

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ECOSYSTEM SERVICES IN PERI-URBAN PLANNING FOR SUSTAINABLE URBAN DEVELOPMENT - EXPERIENCES FROM THE STOCKHOLM REGION, SWEDEN

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This study reports on experiences of ecosystem management and ecosystem services in local planning in peri-urban areas in the rapidly expanding Stockholm city region, Sweden. The peri-urban landscape is characterized by a diversified and fragmented land-use with strong relations to functions belonging to an urbanized society with urban, mobile life-styles and high demands for new housing areas and infrastructure. At the same time, there are long traditions of agriculture in the periphery of Stockholm. A particular trend in recent decades is the increasing demand for cultural ecosystem services such as recreational horse keeping and golf courses. These changes affect land use, ecological status and trade-offs between ecosystem services in different ways. A goal and a challenge for the Stockholm region is to become the most attractive urban region in Europe by 2030. The municipalities have the main responsibility for physical planning and for enhancing and implementing a sustainable urban development. This implies changes in planning and decision-making processes towards more ecosystem based holistic approaches including increased collaboration across municipalities and with other stakeholders. For example, water management according to the EU Water Framework Directive adopted in 2000, demands a catchment based approach on several levels necessitating collaboration, but has also sometimes resulted in unclear responsibilities. Further, ecosystem services is in the process of being introduced into municipal planning and decision-making in the region. In this study, we have followed this process in a series of workshops with local municipal agencies and interviews with different stakeholders, combined with analyses of planning documents and maps from the case study area. A number of factors affecting the implementation an ecosystem management and the use of ecosystem services in local planning was identified including; the importance of using ecosystem services as an integrating concept including cultural ecosystem services to more clearly identify synergies and trade-offs, the need for coordination of statistics and information across municipal borders, and of more iterative planning and monitoring processes on the local level, both within municipalities, between municipalities and between municipalities and different external developers.

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BEHAVIORAL SCIENCE IN ACTION: INSIGHTS FROM THE WHITE HOUSE SOCIAL AND BEHAVIORAL SCIENCES TEAM

Michael Hand
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As behavioral economics research has increasingly been applied to the improvement of public policies and programs, governments at all levels have established teams of researchers and professionals to incorporate behavioral insights using low-cost interventions. For example, the Social and Behavioral Sciences Team (SBST), established within the White House's Office of Science and Technology Policy in 2015, has demonstrated the effectiveness of several behavioral interventions in the contexts of retirement savings, education attainment, and government efficiency.

Research has shown that insights from behavioral economics can encourage environmentally beneficial actions (such as reduced home energy consumption). But the application of behavioral insights to environmental and ecosystem services topics has to date been limited within government. This presentation will highlight how the Social and Behavioral Sciences Team applies insights from behavioral economics to Federal programs and policies, and will outline ongoing and emerging applications of behavioral insights in the context of ecosystem services.

The process of incorporating low-cost, behaviorally informed interventions in government programs and policies involves the following general steps: mapping the relevant behaviors, including identifying potential barriers to programs effectively delivering benefits; identifying the point of interaction between people and the program (e.g., a form or application), understanding behavioral economics research and insights that could inform program changes; and identifying data on relevant program outcomes that is being collected or could be collected relatively easily. An important (but not required) aspect of many interventions, including many implemented by SBST, is the ability to use randomized control trials to rigorously evaluate whether the application of behavioral insights achieved the desired outcome.

Several opportunities exist for using insights from behavioral economics to benefit government programs and policies aimed at improving the provision of ecosystem services. These include participation in conservation and payments for ecosystem services programs, management of wildfire incidents, sustainable use of recreation sites, and the development of urban green infrastructure. The application of behavioral insights is discussed for several examples, and issues and challenges associated with evaluating the impacts of low-cost interventions in this context are highlighted.

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RESTORATION SCALING OF LOST ECOSYSTEM SERVICES IN COMPLEX AQUATIC SYSTEMS

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Environmental regulations in the United States and Europe require compensation of lost environmental services due to releases of hazardous substances, oil spills, and other perturbations. Habitat Equivalancy Analysis (HEA) has often been used as a service-to-service approach to supplement primary restoration and to scale present value of lost services with compensatory restoration in order to make the public whole for lost uses of services. The most common form of HEA uses a framework that assumes that all areas within a habitat category are functionally equivalent and exchangeable. This can create challenges for complex aquatic sites for addressing potential issues associated with the biology and life history of the species, the dynamics of habitat, life history and functional connectivity, complex hydrology, and non-stationarity of aquatic and riparian habitats. HEA, as presently used, can be adjusted to align with the complexity of the environmental conditions to reach settlement between resource managers and responsible parties. However, difficulties in aligning the prevailing form of HEA with complex environmental conditions can create obstacles to valuing lost services and compensatory restoration, and thereby, impair settlement negotiations. For example, responsible parties can find it difficult to get management approval of a large environmental settlement when the basis of the settlement is a simplified analysis of complex conditions that poorly aligns with important perceived environmental considerations. The objective of this presentation is to present an overview of an alternative approach for restoration scaling of lost services in complex aquatic systems.

We suggest that a habitat-based approach that is aligned with the life cycle of target indicator species can provide an alternative approach for complex aquatic systems. Such an approach allows consideration of habitat change in the context of the species life history and the interactions that occur across biological and physical scales. For example, the Ecosystem Diagnosis and Treatment (EDT) model was developed to support species recovery and restoration planning for the freshwater life history stages of various species of salmon and trout and has been used extensively for more than 20 years for restoration planning throughout the Western U.S. The model has been used by federal, state, local, and tribal governments to assist scientists and engineers evaluate both the preservation and restoration potential associated with the relative impacts of various chemical, physical, and hydrological perturbations. The software code is publically available and editable making it possible to align the analysis with site-specific issues. Importantly, the model evaluates habitat change in biologically meaningful terms such as the change in potential productivity, capacity, abundance and life history diversity of the population as a function of habitat conditions. In addition to using an explicit habitat-based model for restoration scaling of lost services, such an approach would provide an analytical framework for selecting and quantifying alternative compensatory restoration projects, including geospatial considerations and benefits In some complex settings, a more rigorous habitat-based evaluation would improve transparency of a science-based evaluation in order to support settlement processes.

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WHEN ECOSYSTEM SERVICE FLOWS BREAK DOWN: BARRIERS TO APPLYING ECOSYSTEM SERVICE SCIENCE TO FISHERIES MANAGEMENT

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An understanding of marine ecosystem service production flows can help to inform fisheries management and policy, yet its practice and application is erratic and partial in many management contexts. For example, management of the Atlantic menhaden fishery is informed by traditional stock assessments and socioeconomic analyses, but critical management questions about state harvest allocations could benefit from an ecosystem service framework. Connections are incomplete between ecosystem services that the menhaden fishery supports and human values derived from those services. A lack of interdisciplinary research teams, as well as mismatched spatial and time scales between research products and management decisions lead to undesirable policies for many of the fisheries stakeholders involved. This presentation will highlight barriers to applying ecosystem service science to management decisions and policy development for the menhaden fishery.

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WHO REALLY MAKES THE RULES, ANYWAY?

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Over the past four decades, command and control regulatory approaches to environmental management have been responsible for many environmental gains in the United States. These laws have prohibited some activities, limited environmental impacts, established financial and criminal liability, and mandated the adoption of improved technologies and management. Nonetheless, they have often failed to achieve the desired outcomes; leading some to call for more regulation and others to search for additional tools and more flexible policy instruments.

Market-based tools offer a potentially powerful and effective means to attain environmental goals. Such approaches are capable of encouraging private investment, providing additional resources for conservation, and serving as a catalyst for developing innovative, cost-effective solutions for improving environmental stewardship. Markets connect ecosystem service providers and beneficiaries, facilitate public awareness of the importance of the environment to human health and well-being, and offer an economic incentive for resource managers to provide these goods and services. However, there is no shortage of examples of market failures and failed markets, where efforts to use market-based mechanisms to address environmental problems have not produced the intended results or have created unintended consequences.

This presentation surveys current Federal efforts to promote the development of ecosystem service markets to improve environmental management and identifies how challenging perceptions surrounding existing regulatory structures and market-based approaches can improve environmental outcomes.

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SPATIAL ASSESSMENT OF EQUIVALENCY OF URBAN FOREST ECOSYSTEM SERVICES IN NAGOYA, JAPAN

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Forests in urban regions have a lot of benefits provided for human society. These include carbon stock, recreation, scenic beauty, micro climate mitigation, habitat for wild animals, etc. These are called ecosystem services (ESs) by Millennium Ecosystem Assessment (2005). The benefits provided from each forest are different depend on the types and locations of the forest. Because of development activities, most of forests have been destroyed and/or are facing threats for the degradation of ESs. In Japan, these are one of the important environmental policy issues, especially in large cities, such as, Tokyo, Osaka and Nagoya.

In this study, urban forest ESs in Nagoya City were studied based on field surveys for each forest. The purpose of this study is to categorize forests in urban regions, namely, Nagoya, into several types, and to understand what types and locations of forests and ESs are facing a big threat for the degradation of ESs. Also the spatial distribution of each forest ES were studied, including provisioning, regulating, cultural, and supporting services.

As of July 2016, over 190 forests have already been studied by the field surveys among around 240 forests (more than 1ha) in Nagoya City. The field survey included vegetation, soil, and habitat surveys in a 100-400 square meter quadrat for each forest. Also cultural aspect research and big trees survey were conducted in the whole area of each forest. Then geographical information system (GIS) and statistical methods were used for spatial and statistical analyses.

In conclusion, the forests were categorized into several types by a cluster analysis. For example, regarding cultural aspects, by utilizing nine cultural ES items, 5 large forest categories and 21 sub-categories were identified. Also, ES maps by each ES were developed for further analysis. The results included that the potential ES provisions from each forest were presented. These results can also be used for a conservation priority ranking of forests in the city.

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REDUCING GNP COMPANY’S ENVIRONMENTAL FOOTPRINT ACROSS OUR VALUE CHAIN

Paul Helgeson
GNP Company, Columbus, OH USA

Maintaining a healthy ecosystem is critical to our survival as a company–and as a global community. We’re committed to measuring and reducing environmental impacts within our own operations and across our supply chain. We have conducted a life cycle assessment in 2010 and used that information to set aggressive goals related reducing energy, water and waste in our operations. Additionally we have developed an offsetting approach to provide renewable energy credits for our Just BARE Chicken line. Finally we are supporting the development of the Field Stewards program as part of our supply chain sustainability strategy.

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INTEGRATING PROTECTION OF ECOSYSTEM SERVICES INTO THE COMPREHENSIVE PLANNING PROCESS: THE FLORIDA EXPERIENCE

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Large-scale community development adds tremendous stress on natural resources and ecosystems including habitat and water resources. This presentation focuses on recent examples in Florida of comprehensive large-scale and long-term land use plans which have successfully led to the private protection of regionally significant ecosystems that provide valuable ecosystem services.

This presentation provides an overview of the evolution of innovative comprehensive plan policies developed in Florida under the Growth Management Act (1985), the Community Planning Act (2011), and the Water Policy Act (2016). The presentation presents three case studies that were developed under planning frameworks authorized by these laws and have been hailed as models of sustainability: the Collier County Rural Lands Stewardship Area program, the Farmton Local Plan, and the North Deseret Ranch Sector Plan. The presentation reviews the different types of ecosystem services that have been protected through these comprehensive plans, and identifies sustainable management activities such as forestry, mitigation banking, water resource development, and hunting that generate the revenue which supports the long-term conservation management of the properties.

Based on the comprehensive plans reviewed, this presentation outlines a set of recommendations critical to the successful integration of protection of ecosystem services into the comprehensive planning process. This presentation also presents a set of recommend metrics for evaluation of the tradeoffs associated with this type of planning process to enhance the likelihood of perpetual protection of essential ecosystem services.

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THE FUTURE OF ECOSYSTEM SERVICES IN LATIN AMERICA AND THE CARIBBEAN

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Latin America and the Caribbean is one of the world's most naturally endowed regions. We estimated the terrestrial ecosystem services value (ESV) of the 33 countries that make up this region to be $US15.3 trillion/year. The gross domestic product (GDP) of the region is $7.6 trillion/year. Modeling four scenarios out to 2050, we also estimated changes in terrestrial ESV in the future depending on policy decisions. Results show that there is a potential for the terrestrial ESV to decrease to $8 trillion/year or increase to $19 trillion/year within the region, by 2050, a different of a 47% decrease or a 25% increase. We also show detailed maps and results for 7 countries in the region (Brazil, Colombia, Costa Rica, Guyana, Mexico, Nicaragua, and Saint Vincent and the Grenadines) and compare our results with a previous national study done of Mexico. Our results indicate that adopting appropriate policies could greatly enhance human wellbeing and sustainability in the region.

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A METHODOLOGICAL FRAMEWORK FOR INTEGRATING CULTURAL ECOSYSTEM SERVICES IN FEDERAL ECOLOGICAL RESTORATION PLANNING

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This poster details development of a flexible methodological framework that incorporates tools and best practices from participatory research, cultural ecosystem services (CES) research, and federal restoration planning protocols. Participatory research methods can facilitate improved credibility and validity of CES indicators or categories identified to represent value in specific, localized cultural and ecological contexts. At the same time, inclusion of new and innovative methods for cultural ecosystem services content-generation (e.g., identification, measurement and/or representation of cultural values and services) can increase ease of integration of qualitative information in decision-making.

Cultural information is commonly missing from federal natural resource decision-making processes. For example, cultural elements are often left out of ecosystem services valuation and modeling efforts, both because they are difficult to measure and quantify, and because cultural datasets are often lacking as a result of logistical and financial costs associated with data collection. Numerous dangers arise from omission of cultural information from decision-making, including the risk of unintentionally leaving out or undermining non-economic forms of value, and further marginalizing cultures that depend on these services for their well-being.

The methodological framework synthesizes a range of tools and methods that can be tailored to specific needs and circumstances of a given ecological restoration project. Research design, including co-definition of relevant cultural ecosystem services and values between researchers and local stakeholders, can be facilitated using participatory methods such as focus groups or community workshops. Selection of locally-relevant cultural ecosystem services categories or indicators can be informed by existing models or approaches, e.g., identification of subsistence-use activities or other traditional or local ecological knowledge related to ecosystem services, identifying dimensions of community well-being associated with CES, and/or direct assessment of cultural ecosystem services categories.

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QUANTIFYING AND VALUING FLOODPLAIN NUTRIENT AND SEDIMENT RETENTION

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The ability of floodplain areas to retain sediments and nutrients provides critical ecosystem services to downstream communities. Floodplain areas often serve as hotspots for nutrient processing within a watershed because these areas lie at the intersection of terrestrial and aquatic ecosystems, allowing for the deposition of sediments and increased opportunities for nutrient processing. This presentation will give a general overview of the methods used to quantify nutrients and sediments retained on floodplains in the Chesapeake Bay watershed and to translate those quantities into ecosystem functions and ultimately economic values. To assess the provisioning of nutrient and sediment retention services by floodplains, we leveraged existing USGS field studies that estimated net sediment, nitrogen, and phosphorus flux from bank erosion and floodplain deposition in the Chesapeake Bay watershed. Using a combination of mapping and modeling, data from field studies were scaled up to estimate net sediment and nutrient loads retained by floodplains (i.e., reduced export to the river). We then developed an approach to correlate the changes in nitrogen, phosphorus, and sediment to changes in recreational fishing participation and visitation to derive the monetary benefits of nutrient and sediment retention. This assessment of floodplain conditions and associated ecosystem services can then be used to target management to maintain areas with high ecosystem service values and also to target restoration of areas currently providing limited ecosystem services.

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LEVERAGING THE USGS NATIONAL WATER-QUALITY ASSESSMENT PROGRAM DATA IN HEDONIC PROPERTY MODELS

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Future management and land use changes have the potential to affect the quality of water in rivers and streams throughout the country, which in turn impacts aquatic ecosystems and the valuable services they provide to people. The U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program currently measures water-quality, habitat stressors, biological communities, and evaluates the relative importance of factors affecting stream health, but stops short of connecting water quality to ecosystem services and economic value. Understanding the relationship between human disturbances and the economic benefits from water quality can have important implications for land use planning. Using the revealed preference hedonic property premium method, this study combines housing price data with NAWQA regional stream health data to estimate the economic value of water quality changes. Two case studies leveraging regional NAWQA data are presented: 1) the Midwestern U.S., and 2) the U.S. Pacific Northwest. In both cases, the effects of water quality on housing prices along a multi-dimensional land use gradient are examined. Results from this study are anticipated to have implications for local land use decision making, but also present a general approach for adding value to a nationwide, long-running data collection and assessment program such as NAWQA.

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THE EVOLVING ROLE OF GOVERNMENT IN THE ADAPTIVE GOVERNANCE OF FRESHWATER SOCIAL-ECOLOGICAL SYSTEMS IN THE WESTERN US

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The role of government within the western United States is shifting, as government command and control policies inadequately address freshwater management complexity. As growing human and environmental needs intensify water resource governance challenges, government is increasingly combining existing regulatory structures with collaborative exchange mechanisms, such as Investments in Watershed Services (IWS). We explored the changing role of government through IWS in the western US, a region that holds one of the highest concentrations of IWS globally. Through a survey, we collected and analysed information on the influence of government in IWS. All 48 identified IWS contained some form of government presence: as program participants, regulation drivers, or land owners, and in both voluntary and regulatory contexts. Government influence on IWS varies across water issue (in-stream flow, water quality, and source water protection), and level of government (local, state and federal). Our work demonstrates how the government is expanding its roles and responsibilities, moving beyond historic command and control roles to support and facilitate new mechanisms. Although most government presence in early IWS was regulatory, local, state and federal governments are increasingly participating directly in IWS. We provide case examples of: (1) state government expanding regulatory structures for instream flow, and (2) federal and local government collaborating in source water protection and wildfire risk reduction on public lands. This government-specific analysis of IWS in the western US shows how government is reactionary, pragmatic, and incremental in their responses to water management. Our work provides insights into the evolving role of government in adaptive governance of freshwater resources, and tangible examples of programs operating on the ground with government actors as key participants.

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USING ECOSYSTEM SERVICES TO JUSTIFY LAND CONSERVATION

Marc Hudson *and Elizabeth Guthrie*
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Florida's population will likely double by 2060. As the state's population continues to grow, it is crucial that important natural areas are preserved, to ensure resources are protected for years to come. North Florida Land Trust is a non-profit focused on the preservation of the most ecologically, agriculturally, and historically significant lands of North Florida. We work with landowners, public agencies, foundations, and others to safeguard the natural character of our region. As a conservation non-profit, we can easily make arguments for preservation of lands to our supporters, but we realize a need to communicate the importance of land conservation to local governments. Using an ecosystem services values, we are now able to make a financial argument for preservation in our region.

North Florida Land Trust's operating area encompasses over three million acres in northeast Florida. To focus our efforts and prioritize lands which should be preserved, North Florida Land Trust developed a GIS-based strategic land prioritization tool to identify areas with the highest natural, agricultural and historic values, as well as areas most at risk from population growth and sea level rise, resulting in a map of what we now refer to as Preservation Priority Areas (PPAs). In order to make an additional financial argument for the preservation of these lands, we used ecosystem services as a justification for conservation.

For our analysis, we used widely accepted research and studies on the monetary value of ecosystem services. We studied the potential ecosystem service benefits of preservation and calculated their values. Those benefits fall under a number of categories, including: removal of air pollutants and greenhouses gases; protection from storms, floods and droughts; regulating water supply; building organic soils for farming and forestry; removing nutrients and contaminants from our waterways; maintaining native habitats and wildlife we enjoy, and the production of food and fiber, to name a few.

For each of our Preservation Priority Areas, we have estimated the general cost of acquisition and the value of ecosystem services. Using these numbers, we calculated a "Return on Investment" (ROI) which refers to the length of time each Preservation Priority Area would take to pay back its acquisition cost in terms of ecosystem services. For example, the Long Branch Preservation Priority Area has an estimated acquisition cost of $14.9 million, but an annual ecosystem service value of $33 million, and therefore has a Return on Investment time of 5.5 months.

As a result, North Florida Land Trust has now published its Preservation Portfolio, which outlines the 112,000 acres of land desired for preservation, as well as the cost of acquisition and value of ecosystem services for those areas. Using this methodology, we now have a new way to justify conservation to our communities, businesses, non-profit partners, political leaders and government agencies.

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POLLINATOR HABITAT: A CASE STUDY IN POLICY-RELEVANT ECOSYSTEM SERVICE VALUATION

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The Presidential Memorandum in 2014 on pollinator health is testament to the increasing awareness of both the significant role that pollinators play in human wellbeing and the litany of threats they face, including pesticides, pests, pathogens, and habitat loss. Pollinator habitat is being converted to crop production at rates that are of concern, and particularly so on the prairie landscapes of the Northern Plains.

Conservation programs administered by the United States Department of Agriculture (USDA) have the potential to reduce or even reverse the decline in pollinator forage habitat. By taking marginal cropland out of production and providing assistance for ecological restoration, land retirement programs, such as the Conservation Reserve Program (CRP) and the Agricultural Conservation Easement Program, can directly impact the amount of pollinator habitat on the landscape.

Unsurprisingly, incorporating pollinator concerns into program policy is not a trivial task. Because programs and efforts like the CRP are explicitly or effectively acreage or budget constrained, restoration of pollinator habitat can affect the amount and spatial configuration of other benefits (e.g., water quality improvement), creating tradeoffs. While knowing how much beneficiaries value the services generated by pollinator habitat would be invaluable for policy making and enrollment decisions, this is likewise is non-trivial.

We investigate whether the services associated with pollinator habitat can be valued to a policy-relevant degree using available data and models. In the case of CRP, this means an approach that is National in scope and generates field-level estimates in order to support site selection and performance reporting. Focusing on five services, we first develop causal chains to describe the relationship between actions undertaken on the field, ecosystem service flows, and conservation benefits. These services include honey production and commercial pollination services provided by honeybees, local pollination services provided by native pollinators, and cultural services (e.g., recreation, aesthetics, and existence values). Pollinator habitat also provides refuge for other beneficial insects and valued vertebrate species, which generate pest management and additional cultural services.

We then identify the data and models available to quantify each link in the chain through to estimates of benefit-relevant endpoints, including monetary values, and conclude with recommendations about how to assess the suitability of an analytical approach for policy use in terms of its applicability, assumptions, and uncertainties.

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MANAGING COFFEE AGROFORESTS FOR BIODIVERSITY AND ECOSYSTEM SERVICES

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Ecologically complex agroecosystems often provide multiple conservation benefits. However, if conservation strategies are to be widely adopted, they must also be financially viable for farmers. Understanding the agricultural practices that favor biodiversity conservation, therefore, is a largely theoretical task unless we simultaneously demonstrate the economic impact of such practices. Furthermore, while farming systems are inherently multifunctional, in contemporary practice, strategies for their improvement are often one- or few-dimensional and, therefore, may not accurately depict reality. Here, we provide a detailed multifunctional analysis of various ecosystem services thought to influence coffee farm profit in Puerto Rico, as well as of several biodiversity clades. We also assess how local and landscape environmental variables influence the ecosystem multifunctionality of farms. We found that although the various services and biodiversity clades responded differentially to local and landscape heterogeneity, more ecologically complex agroecosystems generally promote biodiversity. However, ecologically complex farms do not consistently promote farm profit-related ecosystem services, including coffee yield. Attaining farms that are both the most profitable and ecologically complex (i.e., harboring the most biodiversity) will open critical opportunities for rural livelihoods and conservation. Therefore, we explore various incentive schemes and determine that subsidy restructuring, improved premiums from certification, or a combination of premiums plus payments for ecosystem services can be realistic options for farms to meet this dual challenge.

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STRATEGIC COMMUNICATION AND ITS UTILITY IN ECOSYSTEM SERVICES SCIENCE

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The field of Strategic Communication involves a focused effort to identify, develop, and present multiple types of communication media on a given subject. A Strategic Communication program recognizes the limitations of the most common communication models (primarily "one size fits all" and "presenting everything and letting the audience decide what is important") and specifically focuses on building a communication framework that is composed of three interlinked pillars:

- **Message** – Identifying the right content for a given audience and a vehicle
- **Audience** – Identify the right target group for a given message and vehicle
- **Vehicle** – Identifying the right types of media for a given message and audience

In addition to serving as an organizational framework, the physical structure of a Strategic Communication plan also can serve as a way to show an audience where they, the message, and vehicle fit into the larger picture (i.e., "*you are here*").

This presentation will explore the process of designing a Strategic Communication plan and examine some examples of its utility in the field of ecosystem services science. Ideally, a strategic communication matrix can be utilized to identify and access the materials of interest for any given activity (i.e., avoids the need to recreate materials or use the wrong materials for the wrong audience). Challenges in implementation will also be explored.

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FINE-SCALE ENVIRONMENTAL INDICATORS OF PUBLIC HEALTH AND WELL-BEING FOR URBAN COMMUNITIES

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Urban ecosystem services contribute to public health and well-being by buffering natural and man-made hazards, and by promoting healthful lifestyles that include physical activity, social interaction, and engagement with nature. As part of the EnviroAtlas online mapping tool, EPA and its research partners have identified urban environmental features that have been linked in the scientific literature to specific aspects of public health and well-being. Examples of these features include tree cover along walkable roads, overall neighborhood green space, green window views, and proximity to parks. Associated aspects of health and well-being include physical fitness, social capital, school performance, and longevity. In many previous studies, stronger associations were observed in disproportionately vulnerable populations such as children, the elderly, and those of lower socioeconomic status.

EnviroAtlas researchers have estimated and mapped a suite of urban environmental features by synthesizing newly-generated one-meter resolution landcover data, downscaled census population data, and existing datasets such as roads and waterways. Resulting geospatial metrics represent health-related indicators of urban ecosystem services supply and demand at the census block-group and finer. They have been developed using consistent methods to facilitate comparisons between neighborhoods and across multiple U.S. communities. Demographic overlays, also available in EnviroAtlas, permit analyses of disproportionate distribution across population groups.

Metric validation is an important component of this research. Regression analyses have explored the power of selected EnviroAtlas urban environmental metrics to explain observed variability in measures of children’s health in featured communities. Observed effects to date have been statistically significant, but small. These findings suggest the potential for meaningful ecosystem services benefits to health and well-being at the population level, and cumulatively across multiple benefit types. Statistical models have also been used to predict aspects of neighborhood green space using socioeconomic characteristics of the local population. Ongoing research is expanding across multiple communities to increase sample size, environmental and population heterogeneity, and generalizability of results.

This abstract has been reviewed and approved by the U.S. Environmental Protection Agency. However, it does not necessarily reflect the views and policies of the Agency.

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LOOKING BEYOND ECOLOGICAL FUNCTIONS TO THE VALUE OF ECOSYSTEM SERVICES

***Deborah January-Bevers**, Lindsey Roche, and Lauren Harper*
Houston Wilderness, Houston, Texas, USA

Natural landscapes and organisms serve our wellbeing in a great variety of ways: water purification, flood protection, recreation, recharging of aquifers, protection from damage by hurricanes and tropical storms, pollution reduction, carbon sequestration and more. Identifying and understanding the services provided by local ecosystems can lead to impressive, cost-effective success in using ecosystem services to solve infrastructural and environmental issues. The Greater Houston-Galveston Bay region, which encompasses 10 distinct ecoregions, is a huge and diverse assemblage of forests, prairies, bottomlands, wetlands and bays, and receives a tremendous amount of benefits (economic and social value) from the natural world in the form of ecosystem services. Without the ecosystem services provided by these ecoregions, the Greater Houston Region would economically and environmentally suffer in trying to provide equivalent services to its residents and industries. Incorporating the value and benefits of ecosystem services into infrastructure and policy decisions in the Greater Houston Region is still evolving but a few best management practices now exist. This paper discusses ways for determining ecosystem service values using 6 different study/valuation methods depending on the goal(s) of the targeted ecosystem service study. Key case studies are provided to illustrate results from these various study methods. Local and regional Gulf area examples are discussed, including corporate use of tertiary treatment wetlands to replace gray infrastructure, increased juvenile production of fish species in pristine wetland areas, and the role of wetlands for hurricane protection. In an expanding urban core such as the Houston-Galveston Region, there is a critical need to: (1) Provide more opportunities for regional recognition and support of the ecological functions in the ecoregions of the Greater Houston Region; (2) Engage in more region-based studies on ecosystem services to better understand the value of natural benefits and the cost-effective infrastructure policies that this understanding will enable; (3) Compare the economic value of ecosystem services to other alternative approaches when making public policy decisions regarding land-use and infrastructure; and (4) More fully incorporate ecosystem services into infrastructure decisions.

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USGS MULTI-RESOURCE ANALYSIS: POWDER RIVER BASIN PROOF OF CONCEPT

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The Multi-Resource Analysis (MRA) is an analytical approach that is designed to deliver a next-generation suite of products to meet demands for better integrated science information and landscape-scale perspectives to support land use and resource management decisions in the face of significant uncertainties. The purpose of this talk is to introduce the elements of an MRA, illustrate potential end products through a description of a recent proof-of-concept study, and to highlight critical questions about how ecosystem services concepts and valuation approaches can be applied within this decision-support context. The development of the MRA concept and its potential to become a new type of USGS product highlights the importance of ecosystem services research and applications as a critical input to decision-support products that can inform land use and resource management decisions.

One of the novel goals of the MRA is to be able to compare alternative future scenarios in terms of the impacts on multiple natural resources simultaneously, across a relatively large geographic area, to make it easier for resource managers to consider the tradeoffs between those impacts. Ecosystem services and ecosystem service valuation are promising tools for making those comparisons and tradeoffs salient and meaningful to managers.

This talk will describe a proof–of-concept study focused on some of the important energy, water, and ecological resources in the Powder River Basin of Wyoming. In this study we defined a set of future scenarios driven by energy development, and modeled the potential impacts of those scenarios on ground and surface water resources, and on surface disturbance and disruption. While these impacts are in quantitative terms, they are not yet provided in a single metric that would allow for simple comparison. We are learning how to identify and quantify some of the ecosystem services associated with these resources and will share our progress and challenges in this presentation. To date, those challenges include: characterizing ecosystem services associated with subsurface resources such as coal, oil, gas, and ground water, quantifying changes in those and other services under different scenarios, and quantifying the value of those services (and changes to those services) in this arid and very sparsely populated region.

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PRACTICAL APPLICATIONS OF SOCIAL-ECOLOGICAL URBANISM (ECOSYSTEM SERVICES) WITHIN A LIVEABLE CITY FRAMEWORK

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There is a need for evidence-based, integrated and holistic models to support landscape planning and urban design in order to manage the complex social and ecological challenges currently facing our cities and the built environment. Social-Ecological Urbanism is a model for sustainable urban development and may provide, at least, part of the solution to rebuilding the links between urban living, ecology and individual health and well-being. According to Barthel et al (2013) in *Principles of Social-Ecological Urbanism,* such a methodology provides a strong ecological perspective and promotes an urban development framework that interacts closely with precious local ecosystems and green spaces.

In this presentation, we describe case studies from the Swedish cities of Allingsås, Uppsala, Norrtälje and Malmoe where the principles of social-ecological urbanism have been applied. 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 ecosystems 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 ecosystems 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 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. Social-Ecological Urbanism, ecosystem services and liveability are three frameworks with strong connections to research and can bolster the legitimacy of planning efforts aimed at sustainability and effective management of our built environment.

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MULTIDIMENSIONAL SPATIAL HETEROGENEITY IN ECOSYSTEM SERVICE VALUES: ADVANCING THE FRONTIER

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Stated preference methods are often used to estimate willingness to pay (WTP) for ecosystem service improvements, and are the only methods available to measure some types of value (e.g., nonuse values). It is well established that the value of ecosystem services is often related to spatial factors such (a) how and where services are generated, (b) where beneficiaries are located, and (c) the preference of beneficiaries for services distributed over different distances, directions and areas. Hence, the use of WTP estimates for policy analysis requires information on spatial welfare heterogeneity—how values for particular services are distributed across geographical space, for any given quantity and location of an ecosystem service. Within stated preference analysis, this heterogeneity is typically modeled as a function of Euclidean or travel distance between each household and the nearest point of the resource, area or ecosystem that provides the service to be valued. Value is assumed to diminish as a continuous function of distance, leading to traditional distance-decay analysis. Related discrete threshold analyses evaluate similar patterns based on whether a household is within a predefined and often proximate surrounding area, such as a geopolitical region or watershed. Other approaches to WTP heterogeneity include kriging, spatial autocorrelation, and hot spot analyses.

Approaches such as these can provide useful information, but are all fundamentally distance-based. The traditional focus on distance as the primary measure over which heterogeneity is evaluated can lead to analyses that overlook other relevant patterns. An example is WTP heterogeneity related to the area or quantity of affected resources or services proximate to each beneficiary household. That is, current economic evaluations typically consider the effect of distance alone on ecosystem service value (distance-to-nearest-point; a one-dimensional measure); they do not evaluate the effect of the quantity of an affected resource at these distances (quantity-within-distance-x; a two-dimensional measure). The latter could be an equally if not more important measure of proximity for welfare and policy analysis.

This paper discusses alternative methods to characterize spatial heterogeneity in ecosystem service value, emphasizing approaches with multidimensional perspectives. As an example, we illustrate an approach to spatial heterogeneity associated with the quantity of an affected service surrounding each geocoded beneficiary household, at distance bands optimized using a likelihood-based grid-search algorithm. Results from these models are compared to those from alternative approaches, illustrating the insights and policy implications that can emerge.

The proposed methods are are illustrated using a discrete choice experiment addressing ecosystem service outcomes of riparian land restoration in the Merriland, Branch Brook, and Little River (MBLR) watershed in south coastal Maine, USA. Results demonstrate that the resulting quantity-within-distance models better capture spatial variation in ecosystem service values, identifying patterns that are undetectable using other types of analysis. Policy simulations show that these patterns can have substantial implications for the estimated value provided by riparian restoration across affected municipalities. These and other results demonstrate the insights that can be provided by alternative perspectives that relax traditional distance-focused paradigms in ecosystem service valuation.

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EVIDENCE FOR HOW NATURAL CAPITAL UNDERPINS THE DELIVERY OF ECOSYSTEM SERVICES

Presented by: ***Laurence Jones***[1]

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Natural capital encompasses the elements of nature that directly or indirectly produce value for people, including ecosystems, species, freshwater, land, minerals, air and oceans, as well as natural processes and functions. These different components of natural capital underpin the delivery of ecosystem services in complex ways. However, improving understanding of at least some of the key relationships between natural capital and ecosystem service provision will help guide effective management and protection strategies.

Scientific evidence for the linkages between natural capital and ecosystem services was collated based on a systematic search of peer-reviewed literature across four provisioning, seven regulating and two cultural ecosystem services. Data from 780 relevant journal articles published in the English language was extracted into a spatial database structured according to a simple classification system which enabled analysis of the links between biotic (including biodiversity) and abiotic factors and associated ecosystem service providers for particular ecosystem types and geographical locations. The database also recorded any indicators measuring actual or potential ecosystem service delivery, as well as the impact of human activities and policies. Finally, it considered positive or negative interactions between the ecosystem services as reported in the papers, and the existence of any biophysical thresholds.

The review provides valuable information on the contribution of different species, habitats and management techniques to the delivery of ecosystem services. This presentation will provide a synthesis of this information, focusing on how biotic and abiotic attributes contribute to ecosystem service delivery, and the synergies and trade-offs between them. Overall, the review emphasises the importance of conserving natural capital in order to continue to deliver robust and resilient ecosystem services in a world with increasing human demands.

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MODELLING CULTURAL ECOSYSTEM SERVICES: EXAMPLES FROM FOUR PROJECTS

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There are numerous barriers to modelling and mapping cultural services. Many of these challenges arise because cultural services are dependent on the interaction between landscape settings and people, which are difficult to quantify in practice, to represent spatially and to incorporate in models. In this study we test a framework designed to separately identify the components of natural capital and human-derived capital which are necessary for an ecosystem service to be realised, within a systems approach. The framework is designed to be flexible enough to cope with the difficulties of modelling cultural services, as well as to model provisioning and regulating services.

Therefore, we aimed to use data-rich case studies from four different ecosystem services projects in the UK BESS (Biodiversity and Ecosystem services Sustainability) programme to model cultural services using a capital stocks and flows framework. We focus on cultural services because that is where the greatest challenges lie. The objectives were to:

i) Assess the framework's fit for purpose.

ii) Test the framework across a range of scales (planted wildflowers in urban parks right up to upland rivers) and settings (urban, lowland agriculture, coastal and uplands).

iii) Provide an assessment of the strengths & weaknesses of the approach, including opportunities for further development.

We explored and revised the framework within an inter-disciplinary workshop setting, followed by modelling of the case studies. Here we present the outcomes of the comparison and identify ongoing challenges in implementing such models for cultural services.

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USING CAUSAL MODELS FOR PRIORITIZING WETLANDS

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Wetlands provide enough important ecosystem services that they are called out for protection under the Clean Water Act. However, different wetlands provide very different services in varied amounts to different communities. Understanding the value of the different services to the people who benefit from them should be the basis for decisions about wetlands conservation or restoration. In practice, a general assessment of wetland conditions is used to approximate functions or services provided by wetlands. These rapid wetland assessment protocols are implemented in many different U.S.A. states, and these are sometimes used to define the amount of restored wetlands required or to select priority wetlands for restoration or protection.

The Institute for Natural Resources has recently developed and used causal models applied to generally available spatial data to identify which of the many services provided by an individual wetland may be most important to people in the community. The method included the development of a geospatial tool, which focused on a selected set of services which are critical in the state of Oregon and elsewhere: flood storage, late season flow, temperature control, sediment control, water quality enhancement, and biodiversity maintenance.

The causal models identify both the ecological data and the social data needed, and have a number of benefits. First, it allows users to clearly identify the range of information needs, making for better assessments, rather than having available data drive the analysis process. Secondly, it allows the individual services that matter the most to be prioritized. Lastly, it allows wetland decision-makers to justify mitigation requirements, and allows those working on wetland restoration to get credit for the myriad of services they may be providing to both local constituents and to those living very far downstream in the watershed.

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DROUGHT, HYDROLOGY AND MANAGEMENT IMPLICATIONS FOR ECOSYSTEM SERVICES IN WETLANDS OF CALIFORNIA'S CENTRAL VALLEY

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The loss of over 95% and 98% of California's depressional and riparian wetland followed decades of hydrological and land use alteration. The U.S. Department of Agriculture's Wetland Reserve Easement program sought to restore these lost habitats by helping landowners protect and restore wetlands, however, ecosystem services associated with these restored wetlands was largely unknown till now. Wetland hydrology is the principal driver of ecosystem service delivery. Whereas historic wetland hydrology was mainly a function of climate, current wetland hydrology is also influenced by state legislature governing water appropriation rights. Most wetlands in the Central Valley now rely on a vast artificial network of channels and drainage ditches to deliver the water needed to regulate hydrology. Because of this, most wetlands in the Central Valley are artificially managed and the depth, duration and timing of flooding depend on management objectives. Wetland management objectives are not always achieved due to frequent water shortages and drought. Though moderate seasonal droughts are common, prolonged exceptional droughts such as the one that occurred between 2012 and 2015 are expected to become more frequent in coming decades impacting water availability and wetland management decisions. Previous work has shown that wetland management in the Central Valley strongly affects wildlife habitat and emerging research indicates the same for water quality. Understanding the impacts of drought on hydrology and management is critical to determine ecosystem service outcomes. Here we present conceptual models comparing historic versus present day wetland hydrology and assess the implications for wetland ecosystem service delivery. Based on empirical data and published literature we estimated impacts of altered hydrology to avian habitat quality and water quality on various wetland habitats and assessed the influence exceptional drought on these services. The results will be used to provide guidelines for future conservation in the Central Valley providing managers and policy makers with tools to identify optimal sites and practices to deliver desired outcomes.

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FOREST CULTURAL ECOSYSTEM SERVICES IN ZAMBIA'S FOREST ECOSYSTEMS

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Cultural ecosystem services remain the least studied among ecosystem services in many forest ecosystems of Africa. What are the main cultural ecosystem services in African woodlands? This paper provides empirical evidence of forest cultural ecosystem services that are provided by Zambia's savannah woodlands to local communities, and further examined perceived changes in the capacity of the ecosystem in providing this ecosystem services. The study employed a mixed method approach combining household interviews, focus group discussions and in-depth interviews with key informants. In-depth interviews were conducted with traditional leaders (chiefs, village headmen) to assess changes in the woodland's provisioning of cultural services. Results show that in Zambia, savannah woodlands are important in providing cultural services to local people. Many traditional ceremonies and rituals are performed in the woodlands and utilise a range of plant parts from specific tree species. The majority of respondents reported that hills and graveyards within the woodlands are important mediums of communicating with spirits of ancestors and accessing blessing. Current levels of deforestation and forest degradation pose a danger to cultural erosion among indigenous peoples. Forest ecosystems are important in providing cultural ecosystem services to local people in Zambia's forest ecosystems and therefore need to incorporate cultural uses of forests in policy and practice to guide integrated landscape management.

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LANDOWNERS' PREFERENCES FOR A PAYMENTS FOR ENVIRONMENTAL SERVICES PROGRAM: A CASE STUDY IN EAST THAILAND

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This study aimed to design a desirable payments for environmental services (PES) program to be implemented in Bu Pram sub-district in Prachinburi Province in eastern Thailand. Landowners' preferences on program factors were both identified and quantified using a choice experiment. The results showed that all hypothetical programs attributes were statistically significant to landowners' participation decisions, except free-to-choose in-kind benefits. On average, landowners preferred the land use option that allowed them to cultivate and manage the enrolled land under the program. The length of contract adversely affected landowners' participation in the hypothetical PES program. The other three program attributes of unrestricted amount of minimum land to enroll into the program and two in-kind benefits (advisory services and ecotourism-related job training) had positive impacts on landowners' participation decisions. Willingness to accept (WTA) calculations suggested that higher monetary incentives could help induce landowners to participate in PES programs that generate desirable environmental benefits. Moreover, the WTA estimates showed that in-kind benefits could enhance the attractiveness of a PES program and significantly reduce the need for monetary incentives.

It was recommended that: (1) policy- makers have to trade off the use of practices that generate higher levels of environmental benefits for a lower participation rate, (2) Since the study shows that landowners base their decision-making on their perceived on-farm profits, it is suggested that using objective opportunity costs in designing PES payment levels may not match actual decision behavior, and (3) In-kind benefits should be provided in addition to the direct monetary incentives.

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AN ECOSYSTEM SERVICES APPROACH TOWARD ASSESSING BENEFITS OF FLOOD PLANNING IN THE CENTRAL VALLEY OF CALIFORNIA

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The California Department of Water Resources (DWR) conducted feasibility studies of the San Joaquin and Sacramento River Basins to refine the State's investment approach for the 2017 Central Valley Flood Protection Plan (CVFPP) Update. Planning objectives of the feasibility studies stem from the following three CVFPP goals: (1) Improve Flood Risk Management, (2) Promote Ecosystem Functions, and (3) Promote Multi-Benefit Projects. This approach recognizes the interdependencies between managing flood risk, ecosystem function, the market economy, and non-market goods and services. It thus represents a departure from and an improvement upon single purpose flood management approaches.

This presentation primarily addresses the methods and results from goals (2) and (3). The study involves an assessment of benefits from restoring ecosystem function to advance the goals of the Central Valley Flood System Conservation Strategy as well as of direct benefits to humans including recreation, open space aesthetics, groundwater recharge, water quality, and commercial fisheries. Finally, the study examined benefits from avoidance of loss of transportation, power, and water/wastewater services outside the actual inundation area. To our knowledge, this study represents the first effort to investigate these benefits, which, after the fact, were determined to be significant for Hurricanes Sandy and Katrina.

Several alternative configurations of project elements, including the recommended plans for each basin, were evaluated and compared. Each benefit was assessed qualitatively or quantitatively. Although the primary goal of the planning process is to manage flood risk, the combined recommended plans for the two basins in the Central Valley would restore and improve thousands of acres of marsh, other wetland and riparian habitats benefitting 17 target species identified in the Conservation Strategy. Thousands of acres would be managed for groundwater recharge contributing to water supply and decreasing subsidence. Tens of thousands of wildlife-related recreation visitor days per year would be generated by managing the restored and improved ecosystems in a manner similar to other national and state wildlife areas. Water quality would improve both through reduced flood flows and changes in land use. Commercial and recreational fisheries would benefit, but the change is not quantifiable given the multitude of factors affecting the fisheries. The avoidance of power losses and water/wastewater service were estimated to be relatively small; whereas transportation service losses could amount to tens of millions of dollars depending upon severity of flooding. In conclusion, the feasibility studies in support of the CVFPP Update demonstrate a multi-objective flood planning approach goes beyond mere avoidance of creating unnecessary harm to the ecosystem and direct human uses of the resources in the Central Valley and actively seeks opportunities to generate additional benefits.

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INVESTIGATING THE RESILIENCY OF ECOSYSTEM SERVICES TO CLIMATE CHANGE IN SOUTH FLORIDA COASTAL ECOSYSTEMS

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Resource managers are tasked with making decisions to both enhance the sustainability of their trust resource and conditions for human society by allowing for the continued production and use of benefits produced by their trust resource. This task is increasingly difficult as climate change increases and alters the dynamics of ecosystems. Scientists meanwhile are tasked with applying scientific methods and techniques to provide resource managers with the best available information to optimally accomplish their task. The concept and framework for Ecosystem Services provides an opportunity to address both goals by providing information both on the human benefits being produced and the sustainability of the ecosystem through supporting services.

We are examining the resiliency of ecosystem services in four study areas (estuaries and bays) across a gradient of urbanization in south Florida. The project is using multiple techniques to quantify resiliency of ecosystem services to anticipated changes in climate (Sea-Level Rise, Temperature, and Precipitation) in all four study areas. This will allow for cross-comparison among the studies areas to determine if the degree of urbanization affects the resiliency of ecosystem services. We are using habitat suitability index models for key species that directly contribute to final ecosystem goods and services to examine resiliency empirically. Additionally, we are employing semi-quantitative network techniques to examine the resiliency of ecosystem services. The network itself is developed based on expert opinion of how the ecosystem functions and produces ecosystem services. This network is then perturbed using agreed upon climate scenarios to investigate how this changes the delivery of services. We are applying meta-regression techniques to conduct value transfer for these ecosystem services using the GecoServ database (http://www.gecoserv.org/). This will allow estimation of the current value of the ecosystem services and predict the potential change in value of these services due to climate change.

This project aims to support resource managers in south Florida by working with them throughout the project. Resource managers help plan and participate in the expert opinion polling. The project also investigates the efficacy of potential climate mitigations strategies resource managers are considering. Perturbing the network with likely climate change conditions then perturbing it again with the climate change conditions and the likely mitigation strategy allows us to determine if the mitigation effectively improves the production of ecosystem services over unmitigated climate change. If it does provide improvements, the value transfer techniques can estimate the potential economic benefit of the mitigation allowing for more complete cost-benefit analysis.

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THE FARMER PART OF THE INVESTMENT EQUATION

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Municipalities throughout the United States are now beginning to face a variety of stormwater management considerations. Often, these relate to mitigating flood concerns. In Iowa, many of the cities facing these issues are located amidst vast expanses of farmland. The use of numerous green infrastructure projects strictly within urban boundaries may be implemented to lessen the impacts of stormwater on municipal stormwater or combined sewer systems. However, recent state and federal reports have noted that while green infrastructure can work over the long term, regional detention projects, for example, may prove a more effective management option.

Various urban BMPs can be used to mitigate flooding caused by stormwater including the strategic placement of constructed wetlands, though this option is often limited by availability of sufficient vacant land within the municipal footprint. And while constructed wetlands can provide numerous ancillary benefits outside of flood mitigation (including nutrient and sediment capture was well as habitat), the total cost and land requirements for this particular BMP may be prohibitive for many municipalities. The Iowa landscape provides a unique opportunity to demonstrate how constructed wetlands at the rural/urban boundary can be a financially sustainable BMP that may address not only urban goals, but also solve a related need for agriculture.

Under the 2014 Farm Bill, farmers who drain or alter a designated wetland must mitigate the loss acreage by either constructing a wetland or purchasing wetland ‘credits’ from a mitigation bank, the latter being the preferred option. In Iowa, the presence of farmed prairie potholes may prevent farmers from improving farm field drainage and increasing productivity due to an inability to mitigate new drainage improvements. The multiple benefits afforded by constructed wetlands to address urban goals may in turn, encourage investment by agricultural stakeholders for mitigation. This paper will explore examples of the synergy between urban and agricultural needs for constructed wetlands in Iowa, and how the range of environmental benefits will interrelate to the Nutrient Reduction Exchange discussed by other authors in this session.

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THE PROMISE AND CHALLENGES OF ALTERNATIVE FARM MANAGEMENT PRACTICES FOR DELIVERING MULTIPLE ECOSYSTEM SERVICES: A REVIEW OF THE EVIDENCE

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The increasing scale and intensity of agriculture continues to have significant impacts globally on ecosystems. This is not only threatening biodiversity, but also diminishing the ecosystem services upon which food production and society depend. Services like pollination, soil health, water quality, pest regulation, and climate regulation are almost universally declining. Some of these ecosystem services have been replaced by industrial or imported replacements (e.g. inorganic fertilizers, pesticides, and honey bees), but these replacements often have unintended consequences and can be unsustainable. Therefore, there is increasing interest in incentivizing more diversified and ecologically-based farming practices to recover and enhance ecosystem services, increase the sustainability of agriculture, and reduce environmental impacts. Many studies have examined the impacts of agricultural practices on specific ecosystem services. However, there have been few efforts to synthesize this evidence or to assess the impacts on multiple ecosystem services. In this study, we reviewed experimental evidence for the biodiversity and ecosystem service impacts of soil and habitat management practices in Mediterranean agricultural systems. We applied the standardized, systematic approach developed by the Conservation Evidence Group at Cambridge University to summarize the evidence and synthesize the results. Experts then scored the certainty of the evidence and the effectiveness of agricultural practices in providing ecosystem services. Our results reveal that many practices result in trade-offs between different conservation objectives and that the effects of many practices are difficult to interpret based on available evidence. Thus, it is challenging to design and optimize programs for achieving multiple ecosystem service benefits. We present examples of specific trade-offs and evidence gaps, and we propose a model for translating existing evidence into spatially-optimized incentive programs to enhance the sustainability of agricultural systems in California.

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A NATIONAL SYSTEM TO MAP AND QUANTIFY TERRESTRIAL VERTEBRATE BIODIVERSITY

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Biodiversity is crucial for the functioning of ecosystems and the products and services from which we transform natural assets of the Earth for human survival, security, and well-being. The ability to assess, report, map, and forecast the life support functions of ecosystems is absolutely critical to our capacity to make informed decisions to 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 precisely, especially within a systematic manner and over multiple scales. Nevertheless, the need to measure and assess occurrence of biodiversity, changes over time and space, agents of change, and consequences of change to the provision of ecosystem services for human livelihood remains important. In answer to this challenge, the U.S. Environmental Protection Agency has created a partnership with other Federal agencies, academic institutions, and Non-Governmental Organizations to develop the *EnviroAtlas* (https://www.epa.gov/enviroatlas), an online national Decision Support Tool that allows users to view and analyze the geographical description of the supply and demand for ecosystem services, as well as the drivers of change. As part of the EnviroAtlas, an approach has been developed 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 that reflect elements of A) Biodiversity Conservation; B) Food, Fiber, and Materials; and C) Recreation, Culture, and Aesthetics. Several metrics, such as species and taxon richness, have been developed and integrated with other measures of biodiversity down to the 30m scale of resolution. Collectively, these have been aggregated up to the national level of interest and thus provide a consistent scalable process from which to make geographic comparisons, provide thematic assessments, and to monitor status and trends in biodiversity. Within the EnviroAtlas platform, the smallest reporting unit is the subwatershed, a 12-digit Hydrological Unit Code (which on average is 104 km^2 in area). Once complete, the national biodiversity component for the conterminous U.S. will operate across approximately 85,000 12-digit HUCs and will include 1787 terrestrial vertebrate species (686 bird spp., 475 mammal spp., 322 reptile spp., and 304 amphibian spp.). The project has progressed incrementally at multiple scales in a phased approach, starting with place-based studies, then multi-state regional areas, culminating in the national-level EnviroAtlas. As an example of this incremental approach, we provide selected results for the contiguous United States along with sub-national areas of interest to demonstrate the multi-scale utility of the system. In these examples, geographic patterns differed among metrics and across the study areas. Additionally, we have created a dynamic element to the system to allow the exploration and addition of other metrics as they become identified and tested.

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DESIGNING AND IMPLEMENTING AN ECOSYSTEMS SERVICES DATA INTEGRATION AND DISTRIBUTION FRAMEWORK

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Federal policy directs agencies to integrate scale-appropriate assessments of ecosystem services into relevant programs and projects. That seemingly straightforward directive presents a multitude of challenges for resource managers. The amount of data, number of different data formats and data models, and multitude of information sources presents a confusing and fractionated IT landscape for these decision-makers.

The USGS used a case study approach to evaluate four information architectures as a solution to this information flow challenge:

- Monolithic
- Modularized monolithic
- Hybrid composable service agents
- Highly decomposed microservices

Based on results from this study the USGS settled on the hybrid composable service agents approach. The selected architecture uses a container-based IT design pattern that efficiently captures, processes, integrates, and distributes data from these many different information sources while maintaining a significant amount of flexibility. A number of replicated and scalable containers are managed and secured by a gatekeeper application, with step-by-step data processing steps logged in a Provenance-as-a-Service repository. The user accesses information streams through a lightweight web portal application, one that hides the underlying data integration framework complexity.

This presentation will discuss this case study, reviewing the design options, architectural considerations, and results. The talk will include examples of the current ecosystem services data integration framework as well as review the current portal application, the Sustaining Environmental Capital (SEC) Dashboard. This will demonstrate how users can use the workflow to integrate ecosystem services into decision making. Finally, we will discuss IT design pattern recommendations for groups who want to build comparable infrastructures.

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A NUTRIENT REDUCTION EXCHANGE TO UNIFY INTERESTS AND EFFORTS UNDER THE INRS

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A recently awarded USDA-NRCS Conservation and Innovation Grant (CIG) to the Iowa League of Cities provides an opportunity for the State to evaluate and develop a water quality trading (WQT) framework as a means to advance the goals of the Iowa Nutrient Reduction Strategy (INRS) for Gulf Hypoxia. This project importantly recognizes that motivations to reduce nutrient loading vary between municipal stakeholders (investing in wastewater as well as stormwater infrastructure improvements) and agricultural stakeholders (investing in land management-based practices). Though nutrient load reduction is a key motivation, other goals to accommodate economic growth, flood mitigation, or increased farm productivity ultimately drive decision-making.

Given the diverse nature of potential projects and water quality benefits resulting from these decisions, this CIG project will capture these important outcomes by developing program structures that can reliably track and account for nutrient reductions and as well as other water quality improvement project outcomes. To this end, the League of Cities and their project team are developing the concept of a “Nutrient Reduction Exchange” (NRE) to capture these values.

Conceptually, the NRE will serve as a tracking system that will allow nutrient sources across the state to register and track nutrient reductions resulting from installed best management practices (BMPs) that target NRS goals. For point sources, NRS reduction goals amount to 66% for total nitrogen (TN) and 75% for total phosphorus (TP) over current discharges. A 45% NRS goal applies to agriculture for TN and TP. WQCT will not necessarily be needed to meet either set of these NRS reductions. However, creatively financed near-term investments in the non-point source sector by point sources are prompting the desire to register benefits as nutrient reduction “credits” that could later be used by WWTPs for WQCT. Point sources anticipating additional nutrient reduction requirements beyond the NRS to address localized water quality impairments foresee the need for trading where expensive WWTP upgrades to achieve what may be small incremental discharge reductions over NRS goals will be expensive. This creates opportunities for trading as a cost-effective compliance tool to meet these future limits. Growth by municipalities may spawn even further needs to offset additional WWTP discharges or new non-point source nutrient loads associated with stormwater. The NRE and associated WQCT program structures will therefore serve a crucial role for tracking nutrient load reduction investments as well as future water quality credit trades.

Ancillary benefits such as flood reduction and habitat creation that result from select non-point source nutrient reduction projects can also be tracked in the Exchange. The NRE will attempt to recognize the myriad of these ancillary benefits along with nutrient load reductions when they occur. This presentation with introduce the proposed structure and function of the NRE in these regards.

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INTEGRATION AND EXTRAPOLATION: WHERE CAN THIS GO?

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Environmental markets around water quality continue to languish where program developers, potential buyers and sellers, even investors await regulatory drivers to stimulate the market. Ample evidence exists of market advancement where such drivers are in place, though often scale and levels of participation are still limited. Environmental market principles and tools have, however, continued to be refined and in many settings stand ready to be used support accountable and defensible investments in water quality.

Related efforts in Iowa presented by Miller, Smith, Kelly and Kieser in this session will identify barriers to more robust markets, but will importantly point to broader implementation opportunities using these market principles despite languishing regulatory drivers. Thanks to municipal and private sector interests, substantial investments in water quality improvements beyond just grants and subsidy programs are starting to unfold in Iowa. State goals for nutrient reductions to address Gulf Hypoxia, local eutrophication and flooding issues, even pressing drinking water supply concerns are stimulating investment interests. Where these provide multiple benefits, market movers and shakers are identifying beneficiaries and exploring integration of multiple funding streams from the market perspective.

Speakers from this session will serve as panelists in a wrap-up discussion that will cut to the chase on what’s needed to open the doors for more water quality investments. Though Iowa-centric in their presentations, speakers will be asked to speculate on the potential scale of opportunities when barriers are removed or overcome. Old songs of woe about the lack of regulatory drivers for water quality markets will not be on the venue.

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CONSERVATION FINANCE AND INTEGRATION WITH URBAN DEVELOPMENT PRIORITIES

Laura B Kimes
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Fresh Coast Capital is an ecosystem service developer on vacant land. We help cities turn their largest liability for maintenance costs, crime, and property values – vacant land—into ecosystem service assets for the community. Fresh Coast operates currently in Rustbelt region cities in the Midwest, and has partnered with cities including Flint Michigan, Youngstown Ohio, Gary Indiana, and St Louis Missouri. Our work to date has focused primarily on developing urban forestry projects and flower farms on vacant lots in 70 acres and 7 Midwest cities. In 2017, we are scaling partnerships with cities to expand these operations into a multi-layered vacant land management strategy that optimizes ecosystem service development types for vacant land across an entire city landscape. Our work merges real estate development, conservation finance, ecosystem services and payments, and community development. Our work to date has shown that we can significantly reduce certain costs to cities through alternate revenue streams through working landscapes credits and cost savings. Our attention to ecosystem services allows us to tap into a network of impact investors and other funding sources for scale. This presentation will discuss the early results and lessons from the field as Fresh Coast prepares to scale from $1M of projects to $20-50M in projects. The presentation will also provide general recommendations for others working in urban redevelopment.

As a social entrepreneur dedicated to finding solutions to slow mitigate change and create resilient communities, Laura Brenner Kimes co-founded Fresh Coast Capital based in Chicago, Illinois. Previously, Laura has worked for energy efficiency consulting firms and electric utilities, the Biomass Coordinating Council of the American Council On Renewable Energy, the US Environmental Protection Agency, and the US Department of Agriculture. She received her B.S. in Environmental Science and Policy with a concentration in Restoration and Management from the University of Maryland, College Park and her MBA with a concentration in Social Entrepreneurship from the Kellogg School of Management at Northwestern University.

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PAYMENT FOR ECOSYSTEM SERVICES TO REDUCE BACTERIA FROM AGRICULTURAL LIVESTOCK

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The Moody County Conservation District of South Dakota led an effort to conduct a feasibility study and pilot project testing project for an environmental market mechanism in the Central Big Sioux River Watershed (CBSRW). Market solutions were considered to address water quality parameter reductions required by an approved 2012 Total Maximum Daily Load (TMDL) for E. coli/fecal coliform bacteria surface water impairment. The City of Sioux Falls faces storm water reduction requirements for E. coli that range from 57 to 99 percent to achieve the loading allocations stated in the TMDL.

This presentation will discuss findings from the project findings regarding using a market-based approach that was selected based on the pollutant suitability and economic viability. Livestock bacteria reductions are not considered totally suitable for WQT due to multiple types of pathogens in urban area that are not produce by livestock. However, because numerous health risks are derived from water-born livestock pathogens, river reaches inside the City benefit from a voluntary Payment for Ecosystem Services (PES) bacteria program. The subsequent focus was on the use of a PES approach to accelerate conservation practice implementation in the CBSRW. This mechanism provides conservation funding to agricultural producers who agree to implement Seasonal Riparian Area Management (SRAM) buffers and production lot controls. Implementation of this set of practices resulted in bacteria load reductions and subsequent "credit" generation that can be used in regulatory requirement and compliance schedule development.

The project verified the Conservation Districts previous work in the watershed and Sioux Falls which previously developed a conservation payment program that is analogous to the PES framework recommended. The City of Sioux Falls has contributed moderate, non-mandated funding to conservation practices such as the SRAM program, non-CAFO enclosed barns and heavy use lot upgrades. The SRAM program was used to test the developed PES program protocols and forms.

In addition, the presentation will provide results of the stream monitoring to evaluate program performance. Monitoring has verified that the PES program is capable approach for reducing *E. coli* concentrations in the right settings.

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VALUING ECOSYSTEM SERVICES AND DISSERVICES ACROSS HETEROGENEOUS URBAN GREEN SPACES

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This study investigates small-scale variability in ecosystem services and disservices that is important for sustainable planning in urban areas (including suburbs surrounding the urban core). We quantified and valued natural capital (tree and soil carbon stocks) ecosystem services (annual tree carbon sequestration and pollutant uptake, and stormwater runoff reduction) and disservices (greenhouse gas emissions and soil soluble reactive phosphorus) within a 30-hectare heterogeneous green space that included approximately 13% wetland, 13% prairie, 16% forest, and 55% subdivision. We found similar soil organic carbon across green space types, but spatial heterogeneity in other ecosystem services and disservices. The value of forest tree carbon stock was estimated at approximately $10,000 per hectare. Tree carbon sequestration, and pollutant uptake added benefits of $1,000+ per hectare per year. Annual per hectare benefits from tree carbon stock and ecosystem services in the subdivision were each 63% of forest values. Total annual GHG emissions had significant spatial and temporal variation. Soil soluble reactive phosphorus was significantly higher in the wetland than in forest and prairie. Our results have implications for urban planning. Adding or improving ecosystem service provision on small (private or public) urban or suburban lots may benefit from careful consideration of small-scale variability.

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RECREATION USE VALUES FOR ESTIMATING OUTDOOR RECREATION BENEFITS

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Natural resource professionals are often tasked with weighing the benefits and costs of changes in ecosystem services associated with land management activities and decisions. In many cases, federal regulations even require land managers and planners to account for these values explicitly. Outdoor recreation is a key ecosystem service provided by national forests and grasslands, and one of significant interest to the public. This presentation will report on the most recent update of the Recreation Use Values Database. The Database has long provided federal land managers, non-governmental organizations, and private consultants with reliable recreation use value estimates. The update is based on an exhaustive review of economic outdoor recreation studies spanning 1958 to 2015 conducted in the United States and Canada, and provides the most up-to-date recreation use values available. When combined with data pertaining to recreation activities and the quantity of recreation use, such as is provided by National Visitor Use Monitoring data, the recreation use values can be used for estimating the economic benefits of outdoor recreation for various landscape scales of interest. This proposed presentation will: (1) highlight the history of the Recreation Use Values Database database; (2) describe the expanded source research literature on which it is based; (3) briefly review the methods used to develop use values for the array of outdoor recreation activities included; and (4) present an example application of the database involving the the computation of total economic benefit of recreation for a given landscape. The presentation should roughly coincide with release of the USDA Forest Service general technical report documenting the Recreation Use Values Database update. The report likely will be available for distribution at the conference.

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FRAMEWORK FOR SOIL HEALTH AS NATURAL CAPITAL THAT GENERATES ECOSYSTEM SERVICES

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Future food security is predicated upon the maintenance of healthy soil ecosystems. The health of soils is determined by the integrity and functionality of the soil elements in the production of ecosystem services, such as harvestable phytomass, soil carbon and soil moisture infiltration and retention, soil fertility, plant nutrient acquisition and nutrient cycling, and disease resistance. Soil loss, the destruction of soil structure and the associated diminishment of soil moisture holding capacity and plant available nutrients have lead to increasing reliance on energy intensive inorganic fertilizer and pesticide inputs to produce food, which further deteriorates soil function and represents serious threats to future food security. In part, this has resulted from increasing emphasis on monocultures and technological solutions to increased crop yields and concomitant decline in use of integrated multi-crop and livestock production systems that improve soil health.

Broadly, capital is defined as the resource stocks within a system that generate flows of benefits. The productivity of a system is determined by these resource stocks and factors affecting processes that are needed for benefit flows. Natural capital is determined by ecosystem infrastructure (key elements) and biophysical processes that generate nature's benefits. These benefits, or ecosystem services, can be grouped into two categories: (1) extractable goods that can provide private benefits through market transactions; and (2) ecosystem functions that operate in situ and provide pubic benefits that do not lend themselves to market valuation. The infrastructure of soil ecosystems is comprised of soil particles and organic matter that determine soil structure, as well as microorganisms that facilitate various soil functions, including soil organic matter accumulation, nutrient cycling, and soil moisture and nutrient transfer to plant roots, and disease resistance. Numerous external biophysical and anthropogenic factors affect the components and functionality of soil ecosystems. These include amount and distribution of precipitation, plant and animal community composition, and human resource extraction and management interventions.

Based on climate change predications it is anticipated that many rangelands will experience greater rainfall and temperature extremes. It is, therefore, imperative that rangeland management becomes more adaptive to accommodate these extremes and to prevent further soil degradation, which has occurred in many rangelands globally due to overgrazing and inadequate post-grazing rest for plant recovery. To respond to such changing conditions in a pro-active systematic manner, a management approach is needed that explicitly integrates the biophysical and social-economic elements of rangeland ecosystems to maximize the delivery of ecosystem services. However, such an approach is hindered by the complex multi-scale interactions between biophysical and socioeconomic factors that affect ecosystem function and by the inconsistent use of concepts and terms to describe complex social-ecological systems. To address these challenges, the Sustainable Rangeland Roundtable (SRR) developed the Integrated Social, Economic and Ecological Conceptual (ISEEC) framework to disentangle complexity affecting the delivery and use of rangeland-based ecosystem services.

In this paper we present the ISEEC framework in the context of soil health as the natural capital needed to ensure future food security in a changing social-ecological world. We identify key linkages affecting soil health and indicators that facilitate integrative and adaptive land management to ensure regeneration of healthy soils on rangelands under predicted climate change scenarios.

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ANALYSIS OF VOTER PREFERENCES AND WILLINGNESS TO PAY FOR CLEAN WATER SERVICES IN THE EASTERN US

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The protection of forest lands from the advance of urban sprawl has emerged as one of the more pressing environmental issues in the United States. To help protect public goods (e.g., clean water resources), citizens are becoming directly involved in forest conservation though local and statewide ballot initiatives. An examination of voter behaviors on environmental referendums may (1) help reveal public preferences and willingness-to-pay for the clean water services provided by forest lands and, (2) serve as a source of external validation for estimates derived using stated preference methods. We econometrically assessed the language and outcomes of 76 rural land referendums held in the Eastern U.S. between 1991 and 2013 and compared our results with the outcomes of a stated preference study. We found voter behaviors were impacted by geographic context, time and the type of information provided in the ballot statement. We also found it difficult to compare study outcomes with the type of information produced using stated preference methods. We conclude that public demand for clean water services is increasing, but voters may exhibit “concerned citizen” or “free rider” behaviors rather than consumer behaviors when participating in a referendum. As such, referendum outcomes may be a problematic source of external validation for stated preference studies.

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FOREST LANDOWNER CULTURAL VALUES AND WILLINGNESS TO ACCEPT COMPENSATION FOR PROTECTING IMPERILED SPECIES ON PRIVATE FOREST LANDS IN FLORIDA

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Private forest lands in Florida cover over 16 million acres and are considered beneficial to state listed imperiled species, such as the gopher tortoise. While the protection of imperiled species can provide benefits to the public (e.g., existence value) landowners who provide wildlife habitat, at little or no cost to the public, are often concerned about the potential impact government regulations (e.g., Endangered Species Act) may have on their forest operations. In this study we examined landowner response to several types of incentives including a new type of regulatory assurance provided through the Florida Wildlife Best Management Practices Program (WBMP) and an offer of financial compensation in the form of a traditional cost-share. We also examined the relationship between landowner attitudes towards forest management (i.e., cultural values) and willingness to accept the costs of good land stewardship. The study was conducted using a web/mail survey containing a choice experiment which was distributed to 800+ forest landowners in Florida in December, 2015. We found landowners were generally not interested in the regulatory assurance provided by the WBMP program and were willing to assume the costs of maintaining forest habitat. The rejection of the regulatory assurance was based on the belief that their forest land uses and management practices would not cause harm to state listed species. Rejection of the cost-share incentive may be because landowners are discriminating of how and when they receive financial assistance (because of the contractual obligation associated with a monetary exchange). We conclude that the cultural values held by many forest landowners in Florida help support wildlife habitat protection, but also make them cautious about being compelled through government regulations or incentives. We expect study outcomes will help broaden our understanding of how payments for ecosystem services strategies for imperiled species protection may be received by forest landowners.

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CHANGING COASTAL GEOMORPHOLOGY AND VULNERABILITY OF SUBSISTENCE FOODS

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Climatic, tectonic, and human-related impacts are changing the distribution of shoreline habitats and species associated with local and traditional food resources. There is a need to summarize current and future shoreline geomorphic – biotic relationships in order to better understand potential impacts to both Alaska Native and other residents' gathering patterns. By strategically integrating Alaska Native's and other local resident's knowledge and observations, we are creating an inclusive vulnerability assessment strategy resulting in a win-win opportunity for both resource users and research scientists.

We merged the NOAA ShoreZone database with results from over 60 student intern-resident discussions collected in six southeast Alaska Native communities. In year two some aspects of the study were expanded to encompass 13 communities in Southeast Alaska and Prince William Sound. Changes in shore width and unit length were derived using near shore bathymetry depths and available isostatic rebound, tectonic movement, and rates of sea level rise. Physical attributes including slope, substrate, and exposure were associated with presence and abundance of specific species. Eighteen high school student interns, selected by Tribes, Tribal associations and local communities, conducted resource-based discussions with community members that resulted in a summary of species use, characteristics of species habitat, transportation used to access collection areas, and potential threats to habitats for each community. Geomorphic trends and community observations were summarized to assess potential threats to important foods within a spatial context.

Given current measured rates of uplift and sea level rise, 2.4 to 0 m of uplift along with 0.20 m of sea level rise is expected in the next 100 years. Coastlines of southeast Alaska will be subject to both submergence (primarily to the south) and emergence (primarily to the north). We predict decreases in estuary and sediment-dominated shoreline length and an increase in rocky habitats. These geomorphic changes, combined with residents' concerns, highlight six major interrelated coastal vulnerabilities: (1) reduction of clam habitat quantity and quality; (2) reduction in chiton quality and quantity; (3) harmful expansion of sea otter populations; (4) overharvest and pollution of black seaweed habitats; (5) overharvest of salmon and decrease in salmon rearing areas; and (6) decrease in quantity of deer. Spatial trends and possible solutions are discussed.

This project provided an opportunity for high school students to engage in a research activity enabling them to learn and apply both social science and physical science research methods and work alongside Forest Service and university scientists. Students assisted with fieldwork and initiated conversations with local elders and other residents, learning firsthand about their community, its residents, and how people are experiencing change.

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COUNTY-WIDE AMPHIBIAN MONITORING FOR WATERSHED CONDITION & PUBLIC ENGAGEMENT

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This research examines factors influencing the presence or absence of two common amphibian species, in one Virginia County. The amphibian species serve as a biotic indicator, or proxy, for water quality and watershed condition. Amphibians are vulnerable to pollutants and poor water quality since they spend part of their life cycle submerged in water. The two target species are generalist amphibians whose breeding sites require aquatic habitat and riparian vegetation. The presence of the target species serves as an indicator of water quality, functioning riparian buffers and corridors to forested areas. Landscapes that sustain amphibian populations have the potential to reveal land use, design, planning, or regulations that support water quality and ecosystem services. This this detailed study of amphibian occurrence can reveal trends and thresholds of the factors that allow or limit amphibian presence, contributing to our understanding of anthropogenic impacts on biotic communities. The purpose in reporting on watershed condition is to engage citizens in dialogue about their water resources and what can be done to promote and protect watershed integrity and ecosystem services. County-wide amphibian monitoring can become a citizen science effort capable of raising awareness of water resource issues and engaging citizens in water policy.

The study area, Frederick County, Virginia, was divided into sub-watersheds and reconnoitered via publicly accessable county roads for routes crossing streams and providing county-wide monitoring coverage. Land use and stream condition (where visible) were noted. Auditory surveys were conducted from these routes using protocols adopted or modified from FrogWatch USA (www.frogwatch/org) between March 15 and July 29, 2016. Time, location, calling intensity and a distance metric were captured using a voice recorder. Data was transcibed into documents and then into spreadsheets. Weather conditoins were compiled from National Weather Service observations at the Winchester Regional Airport. Road segments were identifed and collected using GIS software. A ½ mile buffer area around each road segment will be created and the amount of forest, water features, riparian vegetation and impervious surfaces will be calculated for each buffer polygon; percentages of each land type will be quantified for analysis.

This study of the landscape patterns, watershed integrity and amphibian presence may contribute to our understanding of how aquatic habitats and ecosystem services are maintained in areas subject to land cover change. The baseline data can be used to raise awareness of water quality issues as well as amphibian conservation. Coupling amphibian presence/absence with water quality data brings a tangible element to a somewhat abstract and complex categorizing of watershed integrity. In a democracy, public policy actions need to have citizen support. Enlisting local families to monitor amphibian populations has the potential to build awareness and momentum towards incentivizing riparian buffers and including watershed integrity and "ecosystem services" in comprehensive planning.

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ARE CARROTS, CORN AND CATTLE REALLY PROVIDED BY NATURE – IF NOT, HOW CAN WE APPROPRIATELY IDENTIFY THE GOODS AND SERVICES DERIVED FROM AGROECOSYSTEMS?

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People harbor different perspectives regarding the aspects of agroecosystems or cultivated lands that are or could be considered ecosystem services. The first issues that need to be addressed in this regard are to define agro-ecosystem services and to establish their potential purpose (or use) to human beneficiaries. This early decision provides the foundation for what ecosystem services are, who uses them, and if or how they can be quantified. An important point to consider is that agricultural activities, while performed in and on environments provided by nature, are characterized by human labor and capital originating in the human economy. There are inherent reasons to quantify (i.e., measure) ecosystem services in a relatively standard way across landscapes and even within political units, such as counties or nations. Standard approaches to defining and measuring can underpin a multitude of accounting activities such as assigning value to them using either monetary or non-monetary approaches. The ecosystem services community could benefit by applying an ecosystem services definition that embodies from where in the environment the "service" originates and, equally as important, the user or beneficiary of this service. If we focus on the subset of ecosystem services which are Final Ecosystem Goods and Services by adopting the definition of Final Ecosystem Goods and Services (or FEGS)*, "components of nature, directly enjoyed, consumed or used to yield human well-being"* (after Boyd and Banzhaf, 2007), the use of the service (by a specific potential human beneficiary) aids greatly in identifying metrics or indicators most suitable for quantifying the entity we are calling a FEGS. A FEGS in this regard could be the quantity or quality of the soil to the farmer beneficiary while a non-FEGS might be the cultivated crop or livestock that exists only because of the human inputs. Importantly, this Final Ecosystem Goods and Services approach minimizes double counting, which can be very problematic from an accounting perspective. We apply this concept to agroecosystems and provide a finite list of the potential beneficiaries that define a diverse set of Final Ecosystem Goods and Services within agroecosystems.

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ECONOMIC VALUES OF COASTAL EROSION MANAGEMENT: JOINT ESTIMATION OF USE AND PASSIVE USE VALUES WITH RECREATION AND CONTINGENT VALUATION DATA

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The coastal zone is a dynamic and recalcitrant ecological system. Problems stemming from coastal erosion, storms, and sea level rise are exacerbated by development along the coast and, especially, by development at the water's edge. Options for management of shoreline erosion on barrier islands include shoreline hardening, beach replenishment, and coastal retreat. We analyze survey data from North Carolina households in order to evaluate the welfare effects of beach erosion management alternatives on the general population. The survey gathers data on use (and non-use) of coastal beaches, perceptions of coastal resource quality, knowledge of coastal processes, and stated preference referendum votes for programs to manage coastal erosion. We build on the microeconomic models of Eom and Larson (JEEM 2006) and Huang, et al. (AJAE 2016) to jointly estimate parameters of recreation demand and passive use values. Our model does not impose weak complementarity (typically invoked in welfare analysis of recreation demand), but rather can test for its existence. By combining contingent valuation and contingent behavior data, we employ a consistent behavioral model that permits analysis of co-existing use and passive use values and how these values are affected by beach width, erosion management strategy, and the presence of environmental impacts engendered through management.

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GHG EMISSION REDUCTION QUANTIFICATION ON FARMS AND RANCHES; THE OFFSET REGISTRY PERSPECTIVE

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Although a GHG offset credit represents an actual reduction in emissions (or enhancement of sequestration), the credit itself is fairly intangible. Buyers cannot hold offsets in their hand and assess their quality directly. Rather, they must rely on the information they have been given about the credit, the project, and the program under which it was created. Offset quality is crucial to the integrity of the market, and high-quality GHG offsets must meet several, explicit criteria: real, additional, permanent, verified, and owned unambiguously.

All five of these criteria must be addressed in the creation of a GHG offset credit, either at the programmatic or the project protocol level. Project activities related to agriculture, especially those which rely on natural processes, present unique challenges along several of these dimensions. This session focuses on the importance of quantification, which most directly impacts criteria one, three, and four. In the realm of agriculture and ecosystem-related activities, the Reserve has developed offset protocols for forestry, livestock manure management, rice cultivation, nitrogen fertilizer reduction, and avoided grassland conversion.

First, there must be a robust body of scientific evidence that supports the notion that the specific project activity will actually generate GHG emission reductions. This certainty of GHG benefits becomes less clear as the system impacted by the project activity becomes more complex. As the system complexity increases, the cost and efforts required to measure and quantify the GHG benefits increases. Additionally, the uncertainty around that quantification typically increases. GHG offset quantification must be inherently conservative in order to ensure the integrity of the market. If uncertainty grows too large, wherein there is a possibility that the activity generates no GHG benefit, it may be impossible to create GHG offsets. The quantification must be such that every offset credit can be traced to a specific activity at a specific facility, with reasonable assurance.

Second, it must be not only technically but also financially feasible to measure and quantify the GHG benefits with a level of certainty that is acceptable for the creation of GHG offsets. From a technical standpoint, the measurement and quantification approaches must be proven to be accurate and reliable. From a financial standpoint, the cost of measuring and reporting GHG reductions must be some amount less than the potential revenue from the sale of the credits. A major variable in this question is the volume of potential GHG reductions, which impacts the unit cost of creating offsets (higher volume projects will likely have a lower unit cost).

Lastly, it must be technically and financially feasible to have the project activities and quantification audited by a third party technical expert. Verifiers must be able to reach reasonable assurance that the project activity and quantification were in conformance with the requirements of the project protocol.

The Reserve works with expert stakeholders from industry, government, and academia when developing offset protocols to ensure that the end result will be robust, rigorous, accurate, and usable. Technical examples to support these points will be included in the presentation.

These criteria are elaborated in the Reserve's Program Manual (last updated September 2015), available at: http://www.climateactionreserve.org/how/program/program-manual/.

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CHANGING CONSERVATION EASEMENT STRUCTURES: PAYMENTS FOR ECOSYSTEM SERVICES (PES)

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Conservation easements are voluntary agreements between landowners and government or non-profit organizations that limit landowner actions in return for financial and lifestyle benefits. Conservation easements have emerged as one of the primary channels for protecting private land against development. Easements restrict development in designated areas, and these restrictions apply both to current and future owners of the land. Since easements reduce development potential, resale value of the land is presumably diminished. Landowners are typically compensated with a one-time payment from a conservation group, which may receive government support. Between 2000 and 2010 the amount of US land protected under conservation easements more than tripled to 8.8 million acres (Chang 2011). Within Northern California conservation easement establishment is also on the rise. The Sonoma County Agricultural Preservation and Open Space District has protected over 106,000 Sonoma County acres through easements since 1990, and the Marin Agricultural Land Trust has protected nearly 48,000 Marin County acres since 1983 (Sonoma 2015, Marin 2015).

Conservation easements have traditionally been used to purchase the development rights of a property, however easements have the potential to be purchased based on the land's provided ecosystem services. Our central question examined which conservation easement payment structure delivers the greatest combined welfare to landowners, conservation groups, and the public at large. Taking Sonoma County as our case study, we constructed an economic model of stakeholder behavior, determine the socially optimal level of conservation, and compare the social welfare outcomes corresponding to several conservation easement payment structures, including annual PES, leases, and lump-sums. Conservation programs could be developed or existing ones modified to provide measurable conservation benefits while preserving working landscapes for future generations.

We based our PES structure on the ecosystems service assessment performed by Butsic, Larson, and Shapero (2016), which calculated the level of four biophysical services for all of Sonoma County. We will update and expand existing survey data generated by Rilla and Sokolow (2000), surveying Sonoma County landowners that have sold conservation easements. Respondents will be asked to express their preferences among lump-sum payments, leases, and Payments for Ecosystem Services, thus providing anecdotal support for payment structure feasibility. Survey data will bring the economic model's predictions and insights into higher relief, and provide an external validity test. Our survey will emphasize how landowners allocate proceeds from easement sales, providing evidence of the existence and extent of development leakage and conservation spillover. By identifying the optimal payment structure for conservation easements, our findings provide immediate value to landowners and conservation groups.

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IMPLEMENTING A PUBLIC-PRIVATE INVESTMENT STRATEGY TO OVERCOME DEMAND UNCERTAINTIES OF NEVADA'S CONSERVATION CREDIT SYSTEM

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Nevada consists of twenty million acres of mapped Greater Sage-grouse (GRSG) habitat, the majority of which is managed by federal agencies. As part of the State's GRSG Conservation Plan, Nevada developed the Nevada Conservation Credit System (CCS) to ensure net benefit from anthropogenic disturbances in the State. The CCS was unanimously approved and adopted by Nevada's Sagebrush Ecosystem Council in December 2014, was pilot tested and adapted in 2015, and was the proposed mitigation for a mine expansion in a FEIS released June 22, 2016.

The Nevada CCS is a market-based approach that encourages landowners to carry out GRSG habitat conservation projects. By enrolling in the Nevada CCS, private landowners can generate credits for the functional acres protected and enhanced, and then sell those credits to entities requiring compensatory mitigation to offset any residual impacts as result of anthropogenic disturbances. The Nevada CCS is administered by the State to oversee the exchange of credits for debits to ensure that net conservation gain is being achieved. Although the Nevada CCS is a state administered program, the state does not become involved in the cost of transactions between parties.

The Nevada CCS is an emerging market and there are supply, demand and market uncertainties that come with an emerging conservation market. Recognizing that there are uncertainties with an emerging market, the State of Nevada appropriated $2 million in general fund revenue with two goals: (1) improving GRSG habitat across the State and (2) creating a supply of credits for the Nevada CCS. A requirement for utilizing the state funds is that recipients must reimburse the State when the credits are transferred to a mitigation buyer.

The State's goal was to maximize the habitat protected and enhanced with the appropriated funds, and considered a reverse auction to procure verified credits. However, due to demand uncertainties, it was not realistic for private capital to completely finance the projects. To address this, in 2015/2016 the State implemented a public-private partnership investment model where the State provided seed-funding to cover a requested portion of the project cost with a requirement that the funding provided must be repaid when the credits are transferred. This strategy addressed the demand uncertainties enough to attract twenty-one landowner applications, and also leveraged significant private capital for on the ground conservation.

As the projects funded by the 2016/2016 solicitation are implemented, there will be many questions answered and lessons learned. Specific questions that the State will be looking at are 1) Did the public-private partnership investment model generate more outcomes than expected from other strategies; and 2) Did the insertion of public funds into a system that is market driven result in any negative unintended consequences?

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SPATIAL AND TEMPORAL MODELLING OF ECOSYSTEM SERVICES

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Ecosystem services (ES) have become a key notion of the environmental governance over the last decades. Mapping is seen as one crucial way to implement it. However, ES mapping still faces various conceptual and methodological challenges. Most of the critical work is dedicated to ethical or economic issues. Yet, the accuracy and usefulness of the maps vary greatly depending on the spatial and temporal scales used. We aimed to take different spatial and temporal scales into account while mapping ES.

We based our study on the case of Brazilian pioneer fronts from remote sensing (Landsat TM and DEM Aster at the local and MODIS at the regional scales) and field data (4 ES indicators). For two spatial scales, local, three study sites, and regional, Pará State, and two temporal one, current situation and evolution over one decade, we applied statistical methodologies to link field and remote sensing data, in order to map ES.

Firstly, if many ES maps still rely on ES values found in the bibliography and are hardly completed with an estimation of uncertainty, all our maps are based on field data and our statistical modelling allowed us to complete ES local maps with uncertainty estimation. Moreover, if large-scale representations suffer lack of validation and are very costly, we proposed a low-cost methodology that link spatial scales in order to get validated regional ES maps. In this sense, our prospective analyses maximize the link between field data and ES maps, and thus stakeholders. Secondly, beyond the interest related to multiscale information, stakeholders could also be interested in the way landscapes and ES have evolved through time. The evolution of ES supply over the last decade gives information to target the areas where ES were gained and lost and to evaluate the past environmental policies.

To conclude, we considered advantages and limitations of each scale underline the necessity of considering maps' final goals while mapping ES. For instance, ES large-scale maps, as they give a general overview over a large area, could be considered as a pedagogical tool. ES local maps could help to feed dialogue between actors or to evaluate the impact of past or current public policies. Regarding our results, we argue that multiscale and temporal approaches should be developed (1) as there is a complementarity of scales and (2) as information about ES temporal evolution should facilitate the implementation of environmental mitigation policies.

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ECOSYSTEM SERVICES AND SUSTAINING COUPLED SOCIAL-ECOLOGICAL MARINE SYSTEMS

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Sustaining ecosystem services and the coupled social and ecological systems that support and generate them is a central goal of marine spatial planning and stewardship, both in the US and globally. However, operationalizing this goal in ways that are Specific, Measurable, Attainable, Relevant and Timely remains a challenge in many contexts. My presentation will address this challenge by focusing on the emerging opportunities to further develop and apply ecosystem services science and tools in the implementation of the Northeast Ocean Plan. The Northeast Ocean Plan, the nation's most fully developed regional ocean plan, is close to being finalized, following four years of close collaboration among state, federal, and tribal partners. Scientists from the Bay of Fundy to Long Island Sound, together with researchers working in other marine settings, have played a significant role in supporting plan development; their participation in its implementation will be equally if not more important. I will draw on my nearly 20 years of experience in the science and practice of coastal conservation in the Northeastern US, as well as my substantial engagement in Mexico's Gulf of California region, where I lead an interdisciplinary research program focused on sustaining the coupled social and ecological systems associated with the region's small-scale fisheries. I will make the case that by leveraging approaches from both the natural and social sciences – particularly analyses framed by the concepts of ecosystem services and social-ecological systems – and committing to meaningful and long-term engagement with coastal community members and other key stakeholders, the Northeast Ocean Plan has the potential to make ecosystem-based management for the oceans real in ways that matter for the varied coastal communities of America's oceans.

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PAY FOR SUCCESS: DC WATER'S GREEN INFRASTRUCTURE ENVIRONMENTAL IMPACT BOND OVERVIEW

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On January 28, 2016, with Quantified Ventures serving as the Pay For Success Broker, DC Water issued the nation's first Environmental Impact Bond (EIB), a Pay For Success transaction, to fund the initial green infrastructure project in its DC Clean Rivers Project. This $2.6 billion program is designed to control stormwater runoff and improve the District's water quality, creating a healthier future for District residents. The $25 million EIB offers a new type of financial instrument to fund environmental capital projects. The tax-exempt EIB was sold in a private placement to the Goldman Sachs Urban Investment Group and Calvert Foundation. The proceeds of the bond will be used to construct green infrastructure practices designed to mimic natural processes to absorb and slow surges of stormwater during periods of heavy rainfall, reducing the incidence and volume of combined sewer overflows (CSOs) that pollute the District's waterways. CSO reduction has become an increasingly urgent environmental challenge as a result of climate change, which has increased the frequency and severity of intense rainfall events.

The EIB allows DC Water to attract investment in green infrastructure through an innovative financing technique whereby the costs of installing the green infrastructure are paid for by DC Water, but the performance risk of the green infrastructure in managing stormwater runoff is shared amongst DC Water and the investors. As a result, payments on the EIB may vary based on the proven success of the environmental intervention as measured by a rigorous evaluation. By financing this project through the EIB, we sought to create a model funding mechanism that other municipalities can leverage to advance the use of green infrastructure to address stormwater management in their communities. As part of this project, DC Water is also undertaking an ambitious Green Jobs initiative that targets local workforce development and sustainable job creation, including training and certification opportunities for District residents interested in green infrastructure construction, inspection and maintenance.

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A RETROSPECTIVE AND CURRENT EXAMINATION OF THE LIFE-CYCLE GREENHOUSE GAS EMISSIONS OF CORN-BASED ETHANOL

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Purpose: The purpose of this study is to conduct an assessment to better understand and articulate ethanol's potential role across a wide range of current and potential policies, programs, and actions aimed at mitigating greenhouse gas (GHG) emissions, both within the agriculture sector and in the context of multi-sector strategies.

Scope: Under the Energy Independence and Security Act of 2007, the Renewable Fuel Standard was expanded, and the U.S. Environmental Protection Agency (EPA) was required to apply life-cycle GHG performance threshold standards—considering both direct and significant indirect emissions—to ensure that renewable fuels emit fewer GHGs than the petroleum fuels they replace. The assessment used to determine these GHG performance factors are detailed in EPA's 2010 Regulatory Impact Analysis (RIA) of the Renewable Fuel Standard (RFS2). The scope of this study is to conduct a retrospective and current examination of the life-cycle GHG emissions of corn-based ethanol based on more current information.

Methods used: The authors reviewed the scientific literature, technical reports, new data, and other information that was available after 2010 related to the full life cycle of GHG emissions for corn ethanol in the United States. We used the information from the review to develop a set of updated GHG emissions values for each emissions category included in the EPA life-cycle assessment (LCA), and used the updated emissions values to develop a full GHG LCA emissions value for each of the following three cases: (1) current conditions (i.e., what is the GHG footprint of ethanol today); (2) a medium emissions potential LCA projection for 2022; and (3) a low emissions potential LCA projection for 2022.

Results: EPA's LCA value for corn ethanol is 79,180 gCO_2e/MMBtu compared to 98,000 gCO_2e/MMBtu for gasoline. Our current conditions case value is 42,787 gCO_2e/MMBtu. Our medium emissions case is a 62% GHG reduction compared to gasoline and a 12% reduction compared to the current conditions case; and our low emissions case is an 89% reduction compared to gasoline and a 75% reduction compared to the current conditions case.

Conclusions: Opportunities exist to reduce the emissions associated with corn production through the adoption of agricultural conservation practices (e.g., reduced tillage, nutrient management, and cover crops) as well as the emissions associated with corn-ethanol production (e.g., biomass combustion). Other life-cycle emission contributions, especially those from international land-use change, are shown in recent studies to be less than those estimated in the EPA RIA.

Recommendations: The study shows the importance of estimating the GHG-benefits of corn ethanol using a full life-cycle assessment, and the importance of accurately assessing the contribution from international land-use change, agricultural conservation practices, and fuel production.

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MANAGING AGRICULTURAL LAND FOR GREENHOUSE GAS MITIGATION WITHIN THE UNITED STATES

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Purpose: This presentation describes results from a final study that assesses the greenhouse gas (GHG) mitigation potential of US agriculture using a Marginal Abatement Cost Curve (MACC) framework. The report is available at http://www.usda.gov/oce/climate_change/White_Paper_WEB_Final_v3.pdf.

Scope: The MACC framework used in this study begins with a set of farms differentiated by region, size, and commodity produced; a set of about 20 specific GHG mitigating production and land management technologies and practices; associated sets of farm-level adoption costs and resulting GHG mitigation quantities; and for each unique farm–technology/practice combination, the CO_2 price that would just cover the costs of adoption (i.e., the CO_2 break-even price). The MACC framework combines the information with various data and assumptions describing how current technologies, practices, and land uses are distributed across US agriculture and estimates how much GHG mitigation would result from adopting these technologies and practices for a schedule of CO_2 prices.

Methods used: A specific set of GHG mitigating technologies and practices and their associated farm-level adoption costs, GHG mitigation quantities, and CO_2 break-even prices were obtained from the ICF report, *Greenhouse Gas Mitigation Options and Costs for Agricultural Land and Animal Production within the United States* (ICF, 2013). Data on the distribution of existing tillage, nutrient, and manure management systems were obtained from the USDA ARMs data base and augmentmented with other data. ICF's MACC tool combined the farm-level data on adoption costs and GHG mitigation with the region and sector level distributions of current practices to develop supply curves for GHG mitigation for manure management systems, tillage and nutrient management systems, and changes in land uses.

Results: The results provide insights into how much GHG mitigation US agriculture could economically supply at CO_2 prices between $0 and $100 per mt CO_2, as well as, the how this mitigation would be distributed across technologies and practices, farm regions, farm sizes, and/or commodities.

Conclusions: The mitigation level associated with a CO_2 price of $20 per mt, 63 Tg CO_2 e, exceeds the GHG benefits of USDA conservation programs. The implied total cost, a little over $1 billion, is well within the range of costs associated with various components of USDA's conservation prorams. The mitigation level associated with a CO_2 price of $36 per mt is about 93 Tg CO_2 e. This level is a little under 17 percent of agriculture's total GHG emissions, which mirrors the Administration's goal of reducing national GHG emissions by 17 percent below 2005 levels by 2020.

Recommendations: Significant opportunities exist to cost-effective mitigate U.S. GHG emissions in the within the agricultural sector. The lowest cost options are dominated by land retirements, changes in manure management, shifts to no-till, and adoption of precision agriculture.

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UNDERSTANDING AND EVALUATING ECOSYSTEM SERVICES AT SUPERFUND CLEANUPS

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Superfund cleanups often affect the quality and quantity of ecosystem services (ES), but the effects of remediation on ES are not systematically documented or measured during the cleanup process. The EPA Superfund Program's Green Remediation Strategy recommends a qualitative description of the effects of a remedy on ES, and EPA's Ecological Risk Assessment may opt to estimate the effects of contaminants on ES endpoints. A quantitative ES evaluation can address the need to understand how Superfund cleanups impact or improve ES, and contribute to providing transparent information about EPA cleanup decisions to communities.

The goal of this project is to better integrate the consideration of ES into the existing Superfund process by developing an ES evaluation methodology or protocol. After reviewing ES literature, the Superfund cleanup process, and the needs of Superfund site teams, a conceptual framework was created for evaluating ES at Superfund cleanups. Then, publicly available ES evaluation tools were utilized to identify and measure ES endpoints at two Superfund pilot sites representing different ecosystems and scales (a rural watershed-scale setting in the Rocky Mountain west, and a smaller urban setting in the northeastern U.S.). Input for the ES evaluation was derived from land cover maps, reuse planning documents, stakeholder discussions, site visits, and other existing data.

The ES evaluation can help site teams examine relationships between remedial actions and the production and delivery of ES. With this information, site teams can select management practices to mitigate impact to, or improve delivery of, ES during the remedial process. Evaluation results provide a comparison point for any ecological revitalization efforts when the pilot sites go into the reuse phase. The site teams will use the ES evaluation as a communication tool for the public and stakeholders.

Outcomes from the pilot sites' evaluations will be codified into a replicable and transferable methodology for ES evaluation at other Superfund sites. Moreover, the ES evaluation methodology can be incorporated into Superfund's green remediation strategy and ecological risk assessment approaches.

The views expressed in this abstract are those of the authors and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency.

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A HYPOTHESIS-DRIVEN FRAMEWORK FOR ASSESSING CLIMATE INDUCED CHANGES IN COASTAL FINAL ECOSYSTEM GOODS AND SERVICES

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Understanding how climate change will alter the availability of coastal final ecosystem goods and services (FEGS; such as food provisioning from fisheries, property protection, and recreation) has significant implications for coastal planning and the development of adaptive management strategies to maximize sustainability of natural resources. The dynamic social and physical settings of these important resources means that there is not a “one-size-fits-all” model to predict the specific changes in coastal FEGS that will occur as a result of climate change. Instead, we propose a hypothesis-driven approach that builds on available literature to understand the likely effects of climate change on FEGS across coastal regions of the United States. We present an analysis for three FEGS: food provisioning from fisheries, recreation, and property protection. Hypotheses were restricted to changes precipitated by four prominent climate stressors projected in coastal areas: 1) sea-level rise, 2) ocean acidification, 3) increased temperatures, and 4) intensification of coastal storms. Our approach identified links between these stressors and the ecological processes that produce the FEGS, with the capacity to incorporate regional differences in FEGS availability. Linkages were first presented in a logic model to conceptualize the framework. For each region, we developed hypotheses regarding the effects of climate stressors on FEGS by examining case studies. For example, we hypothesized that sea-level rise in the Gulf of Mexico may increase the availability of flooded marsh habitat accessible to fish and shellfish and increase the abundance of food provisioning FEGS in that area over the short-term. However, our analysis suggested that food provisioning in the Gulf of Mexico could decline over the long term if marsh habitat is eliminated due to accelerating sea level rise. Lastly, we analyzed factors that could increase FEGS resilience in a particular location. We found that, higher species diversity in the catch portfolio will likely improve the sustainability of commercial fishing, compared to regions that rely on fewer species for their fishery. We present our framework as a tool for coastal community stakeholders to proactively plan for climate-driven changes in FEGS.

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PROVISIONING ECOSYSTEM SERVICES AND CLIMATE CHANGE: A CASE STUDY USING GULF OF MEXICO BROWN SHRIMP, FARFANTEPENAEUS AZTECUS

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Brown shrimp are commercially important shellfish that support one of the largest fisheries in the southeastern United States, contributing to a shrimp harvest revenue that can exceed $100 million per year. Therefore, understanding how climate-driven changes in habitat availability might affect current and future shrimp productivity is fundamental to developing optimal management strategies. We developed a theoretical framework to link life stage-specific demographic parameters to fishable stock abundance and investigated the effects of changes in density-dependent settlement, assumed to reflect differences in marsh habitat availability, on long-term population abundance. By working successively through Beverton-Holt relationships and incorporating catch data and fisheries-independent abundance estimates into a Bayesian modeling framework, we assessed the degree of density dependent settler survival underlying observed population trends over a 25 year period. The fitted model served as a baseline for projecting stock abundance over the next 20 years and altered our underlying assumptions of density-dependence. We explored how a 10-50% change in the degree of density-dependence, a possible climate change scenario, affected the estimated recruit and adult populations relied upon by Louisiana fishermen. Although external, market-driven factors will largely drive commercial fishing rates, our framework addresses stock availability with potential implications for pending climate change in the Gulf of Mexico. Simulated results suggested that Louisiana brown shrimp catch rates could be fairly resilient to moderate (10-25%) declines in marsh habitat. However, if the level of density-dependent settlement increased by 50% (*i.e.*, 50% decline carrying capacity), the population could not sustain even the average fishing pressure exhibited over the study area during the previous ten years. State and federal agencies working to sustain and protect food-provisioning ecosystem services on the Gulf coast may consider prioritizing habit protection and restoration efforts to mitigate some of the more uncertain effects of climate change (*e.g.*, ocean acidification and altered circulation patterns) on commercial shrimp fisheries. We present a framework for evaluating how actions targeting habitat preservation and restoration may ultimately inform this important food provisioning ecosystem service.

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DO COMBINED SEWER OVERFLOWS HAVE AN IMPACT ON HOUSING PRICES?

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Discharge from combined sewer overflows (CSOs) impair water quality and the health of aquatic habitats, and can adversely affect nearby residents through unpleasant odors and reduced aesthetics. Economic studies have examined the least cost approaches to reduce CSOs and their impacts; however, few studies examine the benefits of reducing CSOs. We propose to examine how CSOs can affect housing prices and infer the benefits of reducing CSOs using the hedonic pricing approach. The hedonic pricing model estimates the value of environmental improvement by estimating the relationship between house price, house characteristics (e.g., lot size, number of rooms), and the environmental attribute. We currently have house transactions for Cuyahoga County, OH (from 1976 to 2016) and are compiling the characteristics of the CSOs throughout the area. We expect houses that are closest to CSOs to have lower prices, holding all else constant. Additionally, the number of actual (or predicted) overflows per year may have a negative impact on house prices. Preliminary results and future directions will be discussed.

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ECONOMIC VALUATION OF SHORELINE PROTECTION PROVIDED BY NATURAL INFRASTRUCTURE

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In this project, we estimate the economic value of shoreline protection provided by natural habitats (such as marshes) to areas in and around the Jacques Cousteau National Estuarine Research Reserve (JC NERR) using a series of coastal models (i.e. InVEST). The economic value of natural infrastructure in the area is estimated by first identifying and mapping shoreline habitats and lands vulnerable to environmental threats such as storm surge and sea level rise. Then, researchers estimate the amount of shoreline protection provided by existing shoreline habitats relative to other shoreline types. Finally, we calculate the value of damages avoided (e.g., from storm surge and sea level rise) to coastal communities due to the presence of natural infrastructure. With the assembled data, additional analyses may help determine locations for future green infrastructure projects to increase the coastal community's resilience to future environmental disturbances.

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ESTABLISHING A CARBON-NEUTRAL GOAL FOR MONSANTO COMPANY BY 2021

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In December 2015, at the Paris Climate Negotiations, the Monsanto Corporation announced a corporate goal of becoming a carbon neutral company by 2021. In previous years, Monsanto has reported 3rd-party assessments of the company's existing carbon footprint for corporate transparency and planning purposes. In preparation for announcing this goal, life-cycle assessment (LCA) studies were commissioned at both the national level (USA) as well as at the field level to better understand which crop-based strategies have the greatest potential to reduce GHG emissions. It was recognized that Monsanto would be able to leverage partnerships with farmer customers to promote and incentivize practice changes that increase carbon sequestration and GHG reductions on private lands. Through this evaluation, Monsanto identified several strategic opportunities to promote agricultural productivity on farm lands while also improving carbon sequestration, soil health and water quality.

Monsanto's seed production and farmer customers will be able to implement carbon sequestering and GHG reducing products (e.g. nitrogen stabilizers, soil amendments and advanced germplasm) and practices (e.g. variable rate input use, swath control, reduced tillage and cover crop use) on agricultural lands while ensuring consistent or increasing yields. However, work is underway that will demonstrate the impacts of these practices on productivity, profitability and risk. In order to track progress, Monsanto is partnering with academic and other 3rd-party experts to develop a scaleable and verifiable carbon accounting framework that will provide a transparent system for reporting GHG reductions. The framework will be designed to rely on peer-reviewed biogeophysical models such as DNDC, DayCent and COMET-Farm for quantification of net carbon changes in the system. In addition, data platforms such as AgSolver are being used to capture field and management data and process through the quantification models. Finally, a low-cost, low-touch verification system using satellite imagery will be developed that will enable temporal and spatial confirmation of practice changes.

GHG reductions that occur will count towards offsetting Monsanto's annual GHG goal. This approach is common in the coffee and chocolate industries and has been referred to as GHG 'insetting' which is similar to offsetting except GHG offsets are generated and retired entirely within the supply chain. A benefit of insetting is that it delivers an incentive and mechanism for corporations to enable climate smart practice implementation while scaling broadly across supply chains.
In order to further drive change across the company, Monsanto simultaneously established an internal price of carbon that is factored into strategic decision-making and investments. This shadow price is designed to increase the cost of carbon-intensive options relative to more climate-friendly alternatives. In the event that carbon-neutrality is not achieved with the above strategies, additional purchases of offsets from voluntary carbon markets are also possible.

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LINKING NATURAL FLOODPLAIN FUNCTIONS, FLOODPLAIN MANAGEMENT, AND ECOSYSTEM SERVICES TO ADVANCE FLOODPLAIN RESTORATION AND POLICY OBJECTIVES

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Riverine floodplains support an array of natural functions that sustain ecosystems, maintain river form, and benefit human communities (ecosystem services). Natural floodplain functions are often unaccounted for in floodplain management regulations, and are lost where floodplains are disconnected from rivers and converted to other uses. Reconnecting and restoring floodplains is a means to return natural functions to a river-floodplain system. American Rivers is working to advance policies that recognize natural floodplain functions, and develop resources to support floodplain restoration efforts in communities across the United States. Effectively connecting factors of hydrology and ecology, with floodplain management and flood control practices, to flows of ecosystem services is critical to making progress in this field.

Through a review of literature and gathering of practitioner expertise, we identify four biophysical attributes that underpin functional floodplains; connectivity, variable flow, spatial scale and habitat and structural diversity. We present a conceptual model connecting those biophysical attributes to specific ecosystem and hydrologic functions (e.g. productive fish habitat, floodwater conveyance, groundwater dynamics), and the ecosystem services they provide (e.g. flood mitigation, fisheries, water supply). This model offers a platform for connecting floodplain management policies to natural floodplain functions and human benefits. When effectively communicated, models like this can generate stakeholder support for sometimes-contentious policy changes and restoration projects. We discuss how this model is being used by American Rivers to advance restoration objectives in different river basins across the United States.

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TOWARD AN ECOSYSTEM SERVICES APPROACH TO COASTAL MANAGEMENT

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Coastal managers are becoming increasingly interested in incorporating ecosystem services into their work, yet too frequently they are lacking the resources or expertise. NOAA's Office for Coastal Management is working to build awareness and understanding of the ecosystem services approach to help the coastal management community incorporate these services into their decision-making processes.

In alignment with the *Federal Resource Management and Ecosystem Services Guidebook*, four key elements (biophysical science, social science, communication, and stakeholder engagement) are emphasized within the framework and tailored to help coastal decision makers understand the essential pieces of ecosystem services work. This poster describes the ecosystem services approach suggested by the NOAA Office for Coastal Management for coastal managers to plan, implement, communicate, and assess their ecosystem services projects. The poster also provides examples of ecosystem services work carried out by the national estuarine research reserves, and shares information about available resources to help the coastal management community get started. Many of the resources, which include data, tools, and training, are available on the Digital Coast. A series of products are under development to help demystify the concept for a novice audience and provide more in-depth guidance for those who are starting their own ecosystem services projects.

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SOCIAL VALUES OF CHARLESTON AREA BEACHES

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How do we account for the value beaches bring to communities? Often we cite the economic benefits and ripples throughout coastal economies of tourist dollars. Our accounting should also include the social benefits that, residents and visitors alike, value from our beaches when making decisions about erosion, renourishment, beach hardening, public access and environmental health. The results may be used by local communities to inform beach management and public access as well as amenity placement and improvement decisions.

A survey of more than 500 beach goers accessed aesthetics (beauty), biodiversity (wildlife), economic, legacy, in and of itself (just because it is here), learning, human needs, recreation, spiritual, therapeutic (peace or relaxation), inspiration, nostalgia and socialization values. The environmental social values were first identified by Rolston and Coufal for forestry applicaitons, further developed by Brown and Reed and later slightly refined and validated by the author to be easily understood by non-scientists. Additonally, place attachement questions were asked to better provide an understanding of the environmental psychology associated with the values. Participants were also asked to describe their activities and their attitudes about the idea of sea walls on beaches. Most participants used public access to get to the beach and went to the beach to swim, walk, relax and sun though eating and reading scored well too. Most held a variety of values for the beach with recreation, relaxation, beauty, peace and socialization being the most common. Specific results, including demographic and location differences will be discussed.

Masters of Environmental Studies students as the College of Charleston collected beach social data as part of a Social Science Methods class during the fall of 2013 and 2014. After training in protection of human subjects, students conducted structured surveys on the Atlantic Ocean beaches of the Isle of Palms, Sullivans Island and Folly Beach which are all sandy barrier islands just outside of the Charleston harbor.

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MUD OR MONEY - SIMPLE TOOLS TO OFFSET CITY OF SEATTLE MARINE SHORELINE ECOSYSTEM SERVICE LOSSES WITH EQUAL GAINS OR PAYMENT

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To help the City of Seattle ensure no net loss of ecosystem services from its marine shoreline, we developed a simple model to quantify ecosystem service losses and gains from shoreline development and habitat restoration, respectively, in terms of juvenile Chinook salmon habitat units. By applying the models to previously constructed habitat enhancement projects we were able to calibrate the models and determine realistic costs per habitat unit.

Washington State and local laws, in order to ensure no net loss of ecological functions during shoreline development, require that habitat lost during development be mitigated by the creation of equal habitat through habitat restoration. This occurs through the local permitting process. The City is developing a Habitat Evaluation Procedures (HEP) program to determine impacts and provide mitigation for a standard set of development activities that occur within the City Shoreline Jurisdiction. Additionally, payment for a fee-in-lieu of mitigation is part of this program.

The City’s HEP program is evaluating shoreline ecological function through the lens of habitat requirements for juvenile Chinook salmon. Developing a framework based on one species allows for consistency in measuring impacts and establishing equivalency between different types of shoreline impacts. A panel of experts provided knowledge and insight to the primary uses and functions of the City's marine and estuarine shoreline by juvenile Chinook salmon. This information was used to develop Habitat Suitability Index (HSI) models representative of marine and estuarine shoreline reaches with respect to ecological services for Chinook salmon.

The resulting HSI model is constructed to be as simple as possible with few metrics and each metric having few possible values (e.g., 1.0 = optimal habitat, 0.5 or lower = intermediate quality habitat, 0.1 = poor quality habitat, and 0 = unsuitable habitat). Six metrics are included in the model: bank/shoreline condition, riparian vegetation, bed slope, substrate composition, submerged aquatic vegetation, and overwater structures. These metrics are characterized in three zones, riparian, intertidal, and subtidal. Additionally, because landscape connectivity is important to juvenile Chinook habitat, value adjustment categories of “fully functional” and “baseline adjusted” are applied to habitat metrics for those areas with, or without, adjacent supporting habitat, respectively. Habitat features (e.g., riparian vegetation) were assigned associated habitat values over their areal extent on the landscape, be it project or landscape scale.

The resulting model was used to quantify the City's marine shoreline habitat units on a landscape scale using readily available GIS data and on a project-specific scale using site drawings. By applying the model to several previosly constructed restoration projects, the habitat units required to offset a standard set of development activities were quantified along with associated costs. This habitat unit and cost data were used to determine standardized costs to be charged under the payment for a fee-in-lieu of mitigation.

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BUILDING STAKEHOLDER CONSENSUS USING MULTI-CRITERIA DECISION ANALYSIS TOOLS

Doug MacNair
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One of the challenging parts of ecosystem service valuation is achieving stakeholder consensus about the definition and relative importance of the potentially affected services. For example, workshops can often get bogged down by either highly technical or overly vague conversations about the ecosystem services that need to be measured and evaluated, due to different terminology and confusion about what can and will be affected by the project or decision (the supply of ecosystem services) and what stakeholders value (the demand for ecosystem services).

Multi-criteria decision analysis (MCDA) is well suited to help stakeholders define and weight the ecosystem metrics that are most important to them. By combining audience response technology with interactive, trade-off exercises, we can relatively quickly get stakeholder groups to start using a common language to define the key environmental sustainability metrics and to establish relative values for those metrics. This presentation will include a live demonstration of MCDA and describe the key best practices for implementing MCDA, based on experience with corporate and public stakeholder groups.

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ECOSYSTEM GOODS AND SERVICES PROVIDED BY RANCHERS

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The purpose of this survey research was to query ranchers about the ecosystem goods and services that they provide as they manage rangeland resources to pursue their core business of raising cattle. Rangeland ecosystem goods and services include extractable goods, tangible and intangible services, and core ecosystem processes that underlie them. While rangeland amenity values matter to some, profit potential may motivate others to engage in conservation to maintain supplies of goods and services. Ranchers manage rangeland systems for their livelihood, also providing wildlife habitat, clean water, carbon sequestration, open space, hunting, fishing, and recreation opportunities. As competing land uses vie for finite resources, identifying rangeland goods and services, along with conservation practices contributing to their viability, becomes more important. The Sustainable Rangelands Roundtable (SRR) recognized that querying ranchers about goods and services their operations provide would produce useful information. SRR distributed a mail survey in 4 regions - Great Basin, Colorado Plateau, Southwest, and Central Rockies - during Spring and Summer of 2015. Results reflect the importance of natural resources to ranching operations; management practices used to improve conditions, and motivations for doing so; species for which habitat is provided; how much is charged for recreation activities; and days of recreation provided. Responses show that ranchers stewardship supports a variety of ecosystem services on public and private rangelands. Ranchers also manage to enhance goods and services, and they don't always charge a fee to those who enjoy the benefits. It is important to identify and quantify benefits emanating from rural communities while ranchers pursue their core business of providing protein to a growing population. Additionally, sharing strategies for enterprise diversification and alternative income streams associated with ecosystem goods and services may help ranchers improve their operations' long term sustainability.

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AN ECOSYSTEM SERVICES CASE STUDY – HOW THE NORTH RIVER WATERSHED IN TUSCALOOSA COUNTY, ALABAMA BENEFITS AFFECTED COMMUNITIES

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The North River is a major tributary of the Black Warrior River that drains a 1,110 km^2 area in Fayette and Tuscaloosa Counties, Alabama. In addition to providing drinking water, the watershed provides many ecosystem services and goods to the local community, including agricultural products, timber, raw materials, recreational and education opportunities, as well as regulating services such as carbon sequestration and storage and air pollutant removal. This study had several objectives: (1) identify and characterize the ecosystem service flows of the North River watershed; (2) calculate the dollar value of natural goods and services provided by the watershed; and (3) help community members in assessing the relative importance of the watershed when considering future restoration and conservation actions.

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CARBON EXCHANGE AND WATER USE EFFICIENCY FOR MISCANTHUS IN THE SOUTHEAST UNITED STATES

Jerome Maleski, *Randy Williams, David Bosch, and Tim Strickland*
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Miscanthus (*Miscanthus × giganteus*) is a C4 perennial rhizomatous grass that is considered a promising lignocellulosic biomass feedstock for biofuel production. *Miscanthus* has the potential for greater biomass production and carbon uptake than maize or switchgrass, as well as the possibility of growing on degraded land; however, productivity depends on the relative availability of water, nutrients, and environmental suitability of the crops. In order to determine how *Miscanthus* might perform in the Southeast, we evaluate the annual evapotranspiration, net carbon uptake and water use efficiency of *Miscanthus* grown in a rainfed field near Tifton, Georgia, USA during the 2015 and 2016 growing seasons. CO2 and Latent Heat flux measurements are taken using an eddy-covariance system, part of the USDA Long Term Agroecosystem Research (LTAR) network. Annual evapotranspiration (ETc) for the rainfed *Miscanthus* was estimated at 668.2 mm and the carbon net ecosystem exchange (NEE) at 3899 kg C/ha for a water use efficiency of 5.8 (NEE/ETc). These values are relatively low compared to reported *Miscanthus* yields in the upper Midwest around 9000-12000 kgC/ha and WUE around 12-18.

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OREGON DIPS ITS TOE IN THE WATER: MARKET-BASED APPROACHES TO FLOODPLAIN MANAGEMENT

Nicole Maness *and Sara O'Brien*
Willamette Partnership, Portland OR, USA

Functioning floodplains are a critical component of healthy ecosystems as well as for the economic and cultural activities that rely on it. A rapidly-changing policy and physical environment, however, makes management of floodplain resources in an effective and integrated way a daunting challenge for many US communities. Flood frequency and severity is expected to increase in much of the US, yet cities face strong pressure to realize the economic and development value of floodplain areas. Litigation on the National Flood Insurance Program, changing municipal stormwater rules, and projected impacts of climate change are all pushing planners to think about increasing resiliency and reducing risk to people and property. Many towns have small or even volunteer planning commissions and limited budgets to navigate this complexity.

Market-based incentives for the restoration of floodplain function will be a key component of encouraging communities to invest in the protection and improvement of local floodplain systems. The concept of an advanced mitigation program for floodplain function has been identified as one potential tool or incentive for achieving this. An effective compensatory mitigation program for floodplains will need to address multiple functions including water quality, fish habitat, and flood storage. It will also need to operate at a geographic scale that promotes ecologically meaningful restoration of floodplain function while providing communities flexibility to address impacts created by development in a way that meets the relevant local, state and federal regulatory requirements associated with floodplain management.

Willamette Partnership has experience building multi-credit ecosystem service accounting systems and is bringing that expertise to floodplain systems. This presentation will provide an overview of the work being done to design an advanced mitigation program for floodplain functions in Oregon. It will outline the policy, information, data, tools, processes and infrastructure needed to develop a floodplain function mitigation program that meets multiple regulatory requirements. It will highlight the challenges associated with quantifying dynamic floodplain systems at the local and watershed scale, and make recommendations for how policy makers and local governments can use a compensatory mitigation program to support more integrated management of local floodplains.

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USING ECOSYSTEM SERVICES QUANTIFICATION TO DRIVE BETTER MANAGEMENT DECISIONS: CAN SIMPLE SUCCESSION MODELS HELP?

Presented by: **Nicole Maness**

Sara O'Brien
Willamette Partnership, Portland, OR

The ability to transparently, accurately, and consistently quantify the outcomes of development and Ecosystem Services in Climate Change quantification tools have been created primarily for this purpose.

However, effective quantification of ecosystem services can and should also be used to support improved decision-making and adaptive management in conservation. To the extent quantification tools are designed to serve these multiple functions, there may be both useful synergies and an inherent tension between the level of precision needed to track outcomes in conservation markets and the need for simplicity and ease of use in tools that are intended to support management decisions.

This presentation outlines one approach to building a habitat quantification tool that effectively supports both tracking of mitigation outcomes and effective and adaptive ecosystem management. The habitat quantification tool currently being developed for Oregon's sage-grouse habitat mitigation program uses simplified state-and-transition models to project and track outcomes of mitigation projects; help credit producers understand, plan, and adaptively manage ecological interventions; and anticipate and describe the landscape-scale results of those interventions.

This approach to quantification balances precision and accuracy against practicality and easy of use in a way that creates both benefits and challenges compared to other existing tools for sage-grouse habitat quantification. The presentation outlines pros and cons of the approach and recommends a path forward for creating tools that effectively serve these multiple functions.

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ECOSYSTEM SERVICES AS ASSESSMENT ENDPOINTS IN ECOLOGICAL RISK ASSESSMENT

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The purpose of the publication **"**Ecosystem Services as Assessment Endpoints in Ecological Risk Assessment**"** is to establish the technical foundation needed to (1) enhance the societal relevance and responsiveness of ecological risk assessment (ERA) in environmental decision making by incorporating ecosystem service assessment endpoints and (2) support the revision of *Generic Ecological Assessment Endpoints (GEAEs) for Ecological Risk Assessment* (USEPA 2003). The documents describe emerging concepts of ecosystem services, the rationale for their use as important considerations in environmental decisions, and a method for doing so.

The scope of this poster covers both the technical background paper, *Ecosystem Services as Assessment Endpoints in Ecological Risk Assessment,* and the 2nd Edition of the *Generic Ecological Assessment Endpoints (GEAEs) for Ecological Risk Assessment.* The focus of an ERA is on assessment endpoints that are explicit expressions of the environmental values to be protected. GEAEs are applicable in a variety of environmental management contexts. This work represents an expansion of the conventional assessment endpoints in the GEAE with examples of generic ecosystem service assessment endpoints for inclusion in ERA. Exploratory case studies illustrate how ecosystem service assessment endpoints add or can add value to decisions commonly made by the U.S. Environmental Protection Agency (EPA).

These documents were prepared by a Technical Panel under the auspices of EPA's Risk Assessment Forum. The Risk Assessment Forum (the Forum) was established by the Agency to promote scientific consensus on risk assessment issues and incorporate this into appropriate risk assessment guidance. The Forum assembles experts from throughout EPA in a formal process to study and report on issues from an Agency-wide perspective. These documents are intended to supplement the use of the Forum's *Guidelines for Ecological Risk Assessment* (1998).

The result is a method to improve environmental management by considering more explicitly the benefits that humans receive from ecosystems. The biotic and abiotic components of a functioning ecosystem that interact to produce the outputs from which humans can derive ecological benefit are termed "ecological production functions" (EPFs). Changes in EPFs are related directly to ecological benefits, which can be expressed through economic analysis or other valuation methods. A major scientific requirement of an ecosystem service-based risk assessment is to understand EPFs and the measures of ecosystem functioning and condition that are essential for determining the production of ecosystem services. Together, this information can be used to evaluate changes in production of ecosystem services based on changes in the condition of the ecosystem.

The documents conclude that the central role played by societal values in decision making requires that the outputs of ERA be amenable to market and nonmarket valuation so that the environmental, economic and social dimensions of ecological risk can be integrated, thereby giving risk managers a more complete, holistic accounting of the tradeoffs involved with various decision alternatives. A recommendation for how to relate ecosystem service assessment endpoints to conventional assessment endpoints and measures of effect is made; and next steps are identified for incorporating ecosystem service assessment endpoints in ERAs and the research needed to enhance their value for informing environmental decisions.

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USING A SUSTAINABILITY CONTEXT TO DRIVE ECOSYSTEM SERVICES ANALYSIS FOR DECISION MAKING

Lawrence Martin
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The purpose of this research is to provide sociological context for the qualitative and quantitative use of ecosystem services for decision making, and challenges to its use. Research conducted by this author on the use of ecosystem services information by the U.S. National Estuary Programs (NEPs) (Martin, 2014) concluded that NEP environmental managers looked favorably upon ecosystem services (ES) information, and favored its qualitative use for stakeholder education. The primary reason appeared to be the relatively low cost of qualitative ES information. Quantitative information was viewed by many survey respondents as too uncertain and/or expensive for rigorous decision making methods. This paper explores the significance of ES as an element in the sustainability framework, the significance of sustainability as a signifier of cultural values, and how this context will drive the adoption of ES information to inform institutional (public and private) decision making.

The scope of this presentation incorporates NEP survey research on the use of ES information for decision making, literature reviews of sustainability science and decision science methods (Martin, 2015), and the theories of Communicative Action and Ecological Modernization. The topics and theory support examination of how cultural values are shaped by framing information as well as how framing information affects institutional decisions. The NEP research is used to support the theoretical construct being presented, and from which conclusions and recommendations are drawn.

Methods used in this presentation include survey research with the NEPs, and reasoning following upon study of the peer reviewed literature addressing ES, sustainability science, decision making science, and the theories of Communicative Action and Ecological Modernization. The result is a characterization of how the context for environmental decision making can change based upon cultural values identified with sustainability. ES is identified as a relevant and incisive performance measure for sustainability, and thus easily incorporated into a sustainability cultural value framework. Theories of Communicative Action and Ecological Modernization describe how such a sustainability cultural value framing can arise as a result of the environmental consequences of industrialization, and how as a result, institutional, rational decision making evolves to both reflect and accommodate the cultural framing of issues.

Results and conclusions point to ecological modernization theory as a plausible explanation for the growth in sustainability science in decision making methods, particularly with regard to environmental outcomes. The use of ES information is consistent with the sustainability framework, and communicative action theory would predict that as it becomes more conceptually familiar as a cultural value, its use will increase as a quantifiable performance metric to inform decision making.

A principle recommendation is for the use of both qualitative and quantitative ES information in characterizing options and making decisions. Qualitative ES information relates to stakeholders concepts of place, linking familiar experience to quantifiable data. Quantifiable information will increasingly become more useful as reflecting cultural values, and be more widely incorporated into decision making. Communicative action theory asserts that values and concepts are stronger when held concurrently on both the cultural-normative and rational-analytic realms of experience.

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NATURAL CAPITAL ACCOUNTING AND THE GEO EO4EA INITIATIVE

John Matuszak
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A new Group on Earth Observation (GEO) initiative to utilize Earth Observations for Ecosystem Accounting (EO4EA) is presented. This initiative will seek to understand and enhance the use of Earth Observations for the development of Ecosystem Accounts based upon and consistent with the UN Statistical Commission's System of Environmental and Economic Accounts – Experimental Ecosystem Accounts (SEEA-EEA). The initiative will include participants from the Earth Observation, Ecosystem Assessment and Ecosystem Accounting, and Environmental Economics communities, in order to facilitate the interdisciplinary approach needed to address key challenges. Ecosystem Accounts that are developed will allow facilitate better understanding of the interaction of environment and natural resource with various economic sectors, the economy overall and the broader societal benefits. The information generated should prove useful to land and resource managers, program and project designers and managers and policy makers. Using accounts based approach which allows the state and trends of resource stocks and ecosystem conditions to be tracked over time, will also facilitate the assessment of the effects of programs, projects and policies.

The primary work streams will be: Compilation and assessment of ecosystem accounts and their use of earth observation; information needs to define ecosystem extent and condition, including, biophysical (e.g. climate, hydrology, soils, topography, land cover, biodiversity); classification of ecosystem types; sampling needs and gaps (including periodicity and scale of measurements needed); ecosystem services classification and identification of EO measurements to track ecosystem services (e.g. carbon storage, water provisioning); and, the development of pilot assessments at national and regional scales.

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A REGIONAL SCALE 'STOCK-TAKE' OF NATIONAL POLICY IMPLEMENTATION OF THE ECOSYSTEM SERVICES CONCEPT

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It's been over a decade since the release of the Millennium Ecosystem Assessment (MA). Since its release many global Platforms (e.g. IPBES, IPCC), Multilateral Environmental Agreements (e.g. CBD, CITES, Ramsar), and sustainability monitors (e.g. SDGs, UNEP GEO) assess the status, trends and drivers of change on ecosystems and the services they provide people; or use outcomes of these assessments to monitor progress in addressing societies most pressing issues (e.g. climate change, biodiversity loss, resource security). Of high importance is the actionable national policy-relevant suggestions provided by these initiatives on the basis of assessment outcomes. However, these suggestions are being developed without a 'stock-take' on where and how ecosystem services are already being incorporated in national policies and being implemented; or knowledge of the gaps, challenges and opportunities that national governments face at the interface of national policy-implementation.

One of the most prominent global intiatives is the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) whose mission is to strengthen the science-policy interface for biodiversity and ecosystem services, and whose multi-scale assessments provide a form of 'follow-on' from the MA. As national governments provide a pivoting point between international initiatives and local implementation, a survey was distributed to all IPBES National Delegates aimed at conducting a 'stock-take'. This presentation provides the preliminary results of where ecosystem services concepts are currently being incorporated into national government policies (e.g. Agriculture, Forestry, Biodiversity, Fisheries, Climate Change, Planning); how these policies are being implemented (e.g. National Biodiversity Strategies, Protected Area Networks, Sector Plans); and the challenges and opportunities national governments face in the process of policy implementation. In total, 82 responses were provided respresenting 54 of the 124 nations signatory to IPBES. Responses were provided from all IPBES regional assessment areas (i.e. The Americas, Europe and Central Asia, Africa and the Asia Pacific), and all sub-regions (except Central Asia).

Previous, current and emerging societal issues and drivers of change for each IPBES region were identified through outcomes of regional assessments conducted by other global intiatives (e.g. UNEP GEO, IPCC assessments). By reviewing the stock-take of national policy implementation in light of the key isues or drivers identified, discussions can be had on how well we are using assessment outcomes and bridging the policy-implementation interface. Although only preliminary findings, outcomes of this research can provide national governments, researchers and practitioners, and global initiatives a benchmark from which they can (over time) track progress towards the uptake of ecosystem services concepts in national policies; as well, the effective implementation of these policies to meet global objectives and targets (e.g. SDGs, Aichi Targets). From this research, opportunities are created for sharing knowedge, skills and experience across governments on national policy-implementation.

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CONSERVATION PROGRAM AND PRACTICE EFFECTS ON ECOSYSTEM SERVICES IN THE MID-ATLANTIC REGION OF THE U.S.

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The U.S. Department of Agriculture (USDA) Mid-Atlantic Regional (MIAR) Wetland Conservation Effects Assessment Project (CEAP-Wetland) study area covers approximately ~58,000 km^2 in the eastern United States, including areas of within five states (North Carolina, Virginia, Maryland, Delaware, and New Jersey) and the District of Columbia. Wetlands are abundant within the study area, in large part due to the region's relatively flat topography, close proximity to groundwater and the coast, and relatively high precipitation to ET ratio. Wetlands in the region provide critical ecosystem services, including the provision of freshwater, regulation of pollutants (e.g., nutrients), climate, hydrological flows, and natural hazards, as well as support for biotic communities. The study area's wetlands are especially important as they help to maintain water quality and aquatic habitat in multiple inland Bays, comprising some of the largest and most productive estuarine ecosystems in the United States, and provide ecosystem services to a large and rapidly increasing human population. Wetlands are critical areas for nutrient transformation, and help mitigate eutrophication of many inland water bodies and coastal bays.

A total of 48 primary study sites were selected (18 restored, 16 prior converted cropland, and 14 natural) to support assessment of current wetland restoration practices. Both remote sensing and in situ assessments were used to evaluate ecosystem service provision. The services evaluated include: climate regulation, pollution (nutrient) mitigation, water storage and biodiversity.

Key recommendations to maximize ecosystem service provision include: 1) Longer easement/contract periods should be promoted to allow time for slower environmental processes to proceed; 2) Soil compaction should be avoided to encourage root growth and the movement of nitrate rich groundwater into wetland soils capable of nitrate removal; 3) Either a greater number of restored wetland cells and/or larger wetland cells should better support the regulation of hydrologic flows and groundwater levels, and the mitigation of natural hazards, such as flooding; 4) Natural wetlands should be conserved, not only due to the high level of ecosystem services that they provide, but also because they directly enhance provision of ecosystem services from restored wetlands and prior converted croplands; 5) Because local topographic relief does not predict groundwater flow pathways in flat landscapes, an effort should be made to restore wetlands in locations that are low relative to broader-scale topographic gradients and are more likely to intercept up gradient groundwater containing agricultural contaminants, such as nitrate; 6) Wetland basins should be relatively shallow with gently sloping topographies, such that they support hydroperiods and water depths characteristic of natural wetlands to encourage colonization and growth of species that are representative of more natural conditions; 7) Intra-regional variations in physical and biological parameters should be considered when targeting, implementing, and managing wetland conservation practices.

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A NEW APPROACH FOR USING PAYMENTS FOR ECOSYSTEM SERVICES (PES) TO ENCOURAGE ADOPTION OF MORE RESILIENT AGROECOSYSTEMS: A CASE FROM CENTRAL HAITI

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By encouraging the adoption of more resilient agroecosystems, Payment for Ecosystem Services (PES) holds promise as a mechanism for ecological restoration and poverty alleviation in the developing world. However, the scale at which small farmers can participate in the sale of ecosystem services is often not large enough to compensate for the high costs of certifying and managing PES schemes. We have implemented a PES program designed to encourage the planting and maintenance of shade-coffee based agroecosystems aimed at improving incomes, stabilizing soil through tree planting, and sequestering carbon in Haiti's Central Plateau. Funded by a student "green fee", Sewanee, the University of the South, is the first buyer of the ecosystem services provided by Haitian farmers, which include carbon sequestration, and the protection and enhancement of watersheds and biodiversity. In a pilot study of 45 small farms where families established agroforestry systems in 2014, we have been monitoring the impact of payments to farmers on tree survival, agroecosystem health, biodiversity and household livelihoods. Teams of trained Haitian and Sewanee students visit each farm every year to monitor tree survival and carbon accumulation, soil and canopy conditions and ant diversity. Yearly payments of $30-$80/farm are made to families, based upon survival data. Two years of study reveal greater than 100% survival for canopy species, suggesting that farmers are planting or encouraging additional trees on their own. Farmers are maintaining nursery stock with canopy trees and seeking out additional opportunities for tree planting. In 2016, to discourage charcoal making, payments were disbursed early to support farmers during a millet blight. With the University as a guaranteed buyer and yearly farm surveys conducted by students, this approach has greatly reduced PES program expenditures and ensured effective monitoring with 100% verification, both of which represent significant obstacles to PES adoption in a developing world context. Other advantages of this model include educational opportunities for students and community-based conversations about sustainable agricultural practices that appear to be positively impacting attitudes about tree planting and maintenance. We discuss how incorporating academic institutions as partners in developing world PES programs can help overcome challenges to PES adoption in the poorest of countries and provide incentives for the adoption and study of more sustainable agroecosystems.

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REVENUES FOR WATER SHEDS FROM THE VOLUNTARY CARBON MARKET

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Many water sheds are located in urban and urbanizing areas, where almost 80% of the population lives. Urban areas are growing, with urban land area in the lower 48 states projected to increase from 3% to 8% by 2050. The increase alone is the size of Montana.

One of the critical components of green infrastructure in cities and towns is the urban forest. The massive ecosystem benefits of the urban forest have been and are continuing to be documented. Despite the ecosystem services delivered by urban trees, and their contribution to healthy watersheds, urban forestry remains poorly funded.

Meanwhile, voluntary buyers of carbon credits spent over $700 million in the U.S. over the last decade, with world-wide voluntary carbon purchases exceeding $4 billion over the same period. Yet none of those voluntary carbon dollars can flow to urban forests or urban watersheds. What needs to be done to access this revenue source for urban greening, including water shed protection?

The Urban Forest Carbon Registry is developing an urban forest carbon protocol that will enable tree-planting projects in urban areas to earn and sell certified carbon credits. This will open, for the first time, urban forestry to voluntary carbon dollars.

Our presentation will describe the following:

- How the urban forest carbon protocol will work;
- What the urban areas boundaries would be and whether they would include water sheds;
- Who would undertake urban forest carbon projects;
- What they have to do to earn certified carbon credits;
- Who would buy these carbon credits;
- How much revenue they would generate;
- Our efforts to create a bundled credit that will bundle carbon with other ecosystem services like storm water retention and cooling;
- Sample urban carbon projects;
- How carbon revenues can be applied to water sheds.

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ESTIMATING ECOSYSTEM SERVICE BENEFITS FROM A WESTERN US WILDERNESS AREA

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Wilderness resides at a unique nexus in ecosystem services research: on the one hand, the natural systems in wilderness areas are often highly regarded for being maintained in a relatively "preserved" state; we expect a priori that they provide substantial ecosystem service benefits to society. On the other hand, many characteristics of wilderness areas present obstacles to estimating the economic benefits associated with either the areas themselves or their management. For example, what is the realistic counterfactual when considering the benefits of managing a remote, high-elevation area as wilderness, and how does this bear upon the economic value of the ecosystem services produced by that management?

This presentation will discuss such questions as it focuses on an in-progress effort to develop a case study of the economic ecosystem service benefits of a wilderness area in the western United States. Particular attention will be given to some of the challenges and opportunities of this effort and how they influence the scoping of the research question, the selection of the study area, and the development of its analytical methods. This presentation will also discuss the role of this assessment exercise as a bridge between two different agency initiatives for estimating the benefits of ecosystem services.

Specifically, this case study contributes to a broader effort by the Aldo Leopold Wilderness Research Institute's Wilderness Economics Working Group (WEWG). The WEWG was established in 2014 to facilitate research collaboration among federal agencies on the economic and social dimensions of current and emerging issues confronting American wilderness areas and to develop better communication with the American public and land managers about this important topic. The WEWG is engaged in other case studies of valuing the benefits of ecosystem services in different regions of the country, each of which faces different challenges in defining the research questions and methods. It also includes related efforts that contribute to its overall goal to assess the current status of, and trends in, the economic values and ecosystem service benefits provided by wilderness lands. At the same time, this project is embedded as a case study within the USGS-led Sustaining Environmental Capital Initiative (SECI). The SECI, which will be discussed in more detail in other presentations, is aimed at developing and enhancing science and research on ecosystem services in support of improving natural resource management. The SECI capitalizes upon interdisciplinary USGS expertise and knowledge within existing National Programs. Thus, this case study leverages two different efforts and helps to foster collaboration and integration across agencies (i.e., USGS and USDA FS).

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EVALUATING THE ECONOMIC BENEFITS OF INVASIVE SPECIES MANAGEMENT IN NON-TIMBER FORESTS: STAKEHOLDER GROUPS AND MEANS-VERSUS-ENDS

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High-elevation, five needled-pine forests consist of the foxtail pine, Rocky Mountain bristlecone pine, Great Basin bristlecone pine, limber pine, and whitebark pine: species known as containing some of the oldest living organisms on Earth. These non-timber forests span approximately two million acres of public land in western North America, including several “flagship” National Parks, and are associated with many ecosystem services, including wildlife habitat, watershed regulation, and recreational opportunities. White pine blister rust (WPBR), a lethal tree disease caused by the non-native fungus *Cronartium ribicola*, has slowly spread across much of these forests' range, leading to mortality at all stages of the trees' lifecycles. This degradation of forest health thereby threatens the long-run sustainability of these forests.

Although many aspects of market and nonmarket values related to managing forests have been studied extensively, very few studies address the effects of forest diseases or pathogens. This talk presents the results of an original study for estimating the economic benefits of increasing the resilience of non-timber, high-elevation white pine forest ecosystems. Unique aspects of this study include extensive collaboration across disciplines from the early stages, employment of multiple valuation methodologies (a referendum-style contingent valuation [CV] question and a multi-attribute choice experiment [CE]), and use of a joint latent class modeling approach to combine different types of survey data.

Results demonstrate significant public benefits associated with management for the long-term sustainability of the forests. They also suggest substantial differences in benefits among different stakeholder groups within the general population, which in turn provides insight into the different motivations underlying the benefits. However, despite the research group’s interest in evaluating preferences over different types of management of these forests, results suggest that, in this case at least, the public generally cares more about the *ends* of the management than the *means* taken to get there.

In addition to showcasing the empirical results of the study and implications thereof, the presentation will focus on drawing lessons from this project for the design and implementation of similar efforts in the future. For example, the presentation will consider: why was it necessary to develop an original study, rather than use benefit transfer or related methods; what were the implications of including two different empirical approaches; and, how does the information developed by the two approaches differ, particularly in light of the latent class modeling techniques?

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CARBON-NEUTRAL PORTFOLIO SOLUTIONS VIA CARBON OFFSETS: TURNING THE PUBLIC EQUITY ASSET CLASS INTO AN IMPACT ASSET

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This is an abstract for a report written for The Climate Trust in my capacity as the Packard Environment Fellow for the Summer 2016.

Purpose: The purpose of my report was to assess the demand and feasibility of delivering a carbon-neutral investment product to retail and institutional investors through the procurement of carbon offsets. From The Climate Trust's perspective, the value of this program is in mitigating the market risk inherent to developing new carbon projects that would otherwise lack the market assurances to come to fruition. Additionally, because this is a voluntary buyer program, it would provide funds to develop offset projects currently outside of the scope of California ARB's allowed project types, such as Grassland Conservation and Wetlands Conservation & Restoration. From the client's standpoint, this would facilitate aligning personal values with investment holdings without forgoing the financial benefits of holding public equities and / or having to reallocate assets to private, direct investment funds to have impact asset-like benefits. In so doing, the clients receive the benefit of knowing their money is funding new, innovative carbon project development with neither the direct risk nor the cost (overt and opportunity) of other impact assets. Additionally, by maintaining positions in large publicly-owned companies, the client's ability to advocate via shareholder engagement mechanisms is not precluded (as they would be with other divestment-focused portfolio strategies).

Public equity-focused investment advisors and asset managers are gradually moving towards lower carbon emitting products in order to accommodate climate-focused clients. Between 2012 and 2014 alone the investment vehicles that consider climate change and carbon-related issues grew from 280 with $134 billion in assets to 325 with $276 billion in assets, respectively. The current high watermark for investment products in the U.S. targets an 80% portfolio emissions reduction; however, above the 80% reduction level, the tracking error introduced (i.e., the divergence between the price of the benchmark index and the portfolio's actual performance) becomes too significant for most prudent climate-focused clients and counters rational portfolio theory. Therefore, the ability to use offsets to reduce a portfolio's carbon footprint could be attractive to clients and advisors alike. While the focus of this report is on public equity holdings, this is a portfolio strategy and service that could be applicable to any client's portfolio, assuming that their portfolio footprint (i.e., carbon footprint) could first be quantified accurately.

Methods: While there is not a scientifically based methodology for data collection to support this project, the results and conclusions are a product of numerous direct conversations with asset managers, investment advisors, consultants, financial data providers and other professionals in the financial services industry.

Results & Conclusions: Significant fee pressure from a variety of passively managed funds available to clients (at a cost of ~20 – 40bps) may make this alternative (which itself costs ~20 – 30bps) too expensive for the typical investor with "full carbon" (i.e., 0% reduction in emissions). However, for those investors already pursuing low-carbon strategies the ability to offset emissions is economically feasible (5 – 15bps). Therefore, the program is currently being discussed with a handful of select partners to bring to market in 2016 / 2017.

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THE CENTRAL VALLEY HABITAT EXCHANGE: QUANTIFYING BENEFITS FOR MULTIPLE SPECIES AT PARCEL AND LANDSCAPE SCALES

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Land use conversion, drought, and climate change are conspiring against many native species once abundant in the California's Sacramento- San Joaquin Delta and Central Valley. Restoring and protecting habitat is critical for their recovery, and private lands, which make up over 80% of the Central Valley, are a necessary part of the solution. How do we engage private land owners in this effort to effectively address multiple species needs?

We developed and piloted a scientifically based, transparent and accessible tool to assess habitat quality for multiple species native to the Central Valley. The Multispecies Habitat Quantification Tool (mHQT) applies a multi-scaled approach for assessing habitat quality and quantity, and for tracking conservation or mitigation outcomes for native species in the Central Valley. To date, these species include Swainson's hawk and riparian landbirds; tools for other species including Chinook salmon and giant garter snake, are under development and expected to be in completed draft form by September 2016. The mHQT can assess a specific parcel as well as the relative value of that site on a landscape scale, when compared to other sites. Within the Central Valley Habitat Exchange (CVHE), habitat credits and debits are assigned to the most beneficial locations for species, and parcel scale contributions to species' habitat are tracked over time.

We compared tool scores for Swainson's hawk and riparian land birds to species use and occurrence at six locations in the Delta and Central Valley using ranked comparisons. Our findings support use of the tool as a valid, transparent and accessible means of prioritizing areas and actions to create multiple species benefits. The CVHE is working with private land owners and local planning agencies to apply the mHQT to inform management and to improve planning, tracking, and reporting. The mHQT provides clear and concrete guidelines with response scores that private landowners can use to demonstrate good stewardship, implement conservation and mitigation projects, and to guide land management planning.

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BEHAVIORAL NUDGES IN COMPETITIVE ENVIRONMENTS: A FIELD EXPERIMENT EXAMINING DEFAULTS AND SOCIAL COMPARISONS IN A CONSERVATION CONTRACT AUCTION

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Governments and nongovernmental organizations are increasingly applying insights from behavioral economics to influence human behaviors. Governments in both the US and the UK have established Behavioral Insight Teams (also known as “nudge squads”), and the U.S. Department of Agriculture recently created the Center for Behavioral and Experimental Agri-environmental Research (CBEAR). Empirical studies have supported claims that behavioral economics-based interventions can cost-effectively change short-term behavior. That evidence, however, comes exclusively from the context of consumer (individual) choices rather than producer choices—in other words, utility-maximizing agents rather than profit-maximizing agents. An open question is whether behavioral nudges affect agents that are profit-maximizers in competitive environments. Some studies (e.g., List, 2006) have found evidence suggesting that well-functioning competitive markets can mitigate various forms of anomalous behavior.

This study explores this question through a field experiment in which farmers from Texas, Delaware, and Maryland compete in an auction of conservation contracts that require them to adopt practices that reduce nutrient run-off. The competition consisted of bids submitted as the percentage cost-share offered by the farmers toward the total cost to implement the practice. The farmers were informed that up to $40,000 was available to implement nutrient management practices on their lands. They were randomized into four treatment arms in a 2x2 design that varied by (1) the presence or absence of social priming and (2) a default cost-share status quo of 0% or 100%. We find that bids under the 100%-cost-share status-quo default were substantially higher than (and statistically different from) bids under the 0% cost-share status-quo default. The social priming information did not significantly affect the value of bids made, but did influence the likelihood of placing a bid, especially the low desirability priming, which lowered the likelihood of placing a bid. These result shows that behavioral nudges can be effective in competitive environments that involve profit-maximizing agents.

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EVALUATING ECOSYSTEM SERVICE RETURN ON INVESTMENT FOR ALTERNATIVE CONSERVATION FUTURES

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Several studies have shown there are trade-offs in the provisioning of ecosystem services depending on conservation priorities. Interest in emerging conservation finance strategies calls for aligning conservation returns with economic returns. Water and watershed conservation is a high priority for many environmental and social impact investors, yet identifying opportunities that generate economic returns while maximizing conservation returns remains a challenge. Sebago Lake and its feeder the Crooked River provide clean water for 200,000 residents in the greater Portland, ME region. The Portland Water District, with an interest in keeping the watershed heavily forested, currently provides upstream investments, as match to other conservation finance, to local land trusts purchasing land and conservation easements. Yet development, largely in the form of second-homes, outpaces the rate of land protection. Recently several local and regional conservation organizations came together to assess the feasibility of developing a water fund to attract more private funding to protect the watershed.

The objectives for this study were to: (1) identify the areas within the watershed that have the highest value for drinking water; (2) to assess the trade-offs with other ecosystem services from focusing on these lands; and (3) to identify areas that may have higher potential to generate revenue from natural resource management and carbon sequestration. We used an alternative scenarios framework to evaluate future provisioning of water yield, nutrient and sediment retention, carbon storage, timber, and biodiversity. Using the InVest ecosystem services tools, we compared outcomes for each of these services under a trend scenario and three alternative watershed conservation strategies driven by focuses on: water quality, biodiversity, and large landscape conservation. We also evaluated each scenario at both the current level of land protection investment and a higher investment, as a surrogate for new private impact investments in watershed protection.

We have completed the ecosystem services modeling work and have developed the four future scenarios for the region. We incorporated existing trends in land protection, and prior stakeholder-based conservation priorities in the region in the scenarios. Results comparing the outcomes from the different scenarios and the two levels of investment are forthcoming. Results to be presented include: (1) identified large conservation areas that meet water protection objectives and have high probability for forest management and carbon offset projects; (2) the specific trade-offs between business-as-usual land protection and strategies focusing on water protection and/or large landscapes; and (3) an assessment of the ecosystem services protection possible through a tripling of investment in the watershed. Recommendations will be offered for attracting new investments in the watershed, developing a water fund to transfer finance from downstream users to upstream producers, and the scalability of the approach.

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FINANCING GREEN/GREY COASTAL INFRASTRUCTURE

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Purpose: Provide greater understanding of the need to quantify the service benefits provided by integrated green (natural and nature-based) and grey (traditional engineered) coastal protection infrastructure so that it aligns better with the motivations and needs private investors of different types (market to philanthropic). Given the variation in types of US marine, estuarine and freshwater coastlines, risk factors, and concomitant protection needs, the degree of protection that can be provided by natural features or ecosystems (such as wetlands, oyster reefs, mangroves, or dune systems) will also vary significantly. The panel will explore these varying settings and needs in context of managing risks to adjacent communities, infrastructure and ecosystem sensitivities and discuss sources of non-federal capital that might correspond to risk reduction opportunities using natural or integrated green and grey features.

Scope: Panelists will come from public, non-profit (conservation and environmental) and private (industry and investor) experiences to examine the alignment of coastal green/grey (SAGE) infrastructure with private capital to provide a range of perspectives on opportunities for and challenges to generating increased private investment in future SAGE infrastructure projects.

Methods: Individual panelists will present remarks and key points on accompanying slides then engage in a facilitated discussion with the panel moderator. The moderator will seek to identify key needs for additional information on green/grey infrastructure performance; investor expectations, including relative levels of risk and return; and potential sources of revenue to supplement existing public funding (e.g., Water Resources Development Act appropriations to US Army Corps of Engineers projects) that would enable non-federal (local and state government) and private funding to match available federal funds.

Conclusions and Recommendations: These will emerge from the discussion. The panel is organized to cover key considerations involved in generating more private and non-federal investment in green/grey (SAGE) coastal protection projects and not to deliver a formula applicable in all situations. The expectation is that each coastal protection project will require a tailored plan for financing that ties to the level and type of protection needed; the location and type of beneficiaries; and the mix of green and grey infrastructure selected.

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MULTIRESOURCE INTEGRATED ASSESSMENT (MRIA): CHALLENGES AND POSSIBLE REFINEMENTS TO A PROOF-OF-CONCEPT APPLICATION, ANOSY REGION, MADAGASCAR

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Natural resources seldom occur in isolation with respect to one another, and controversies often arise concerning perceived environmental, economic, and societal needs and values. New and innovative approaches are necessary to delineate natural resources, characterize interactions among resources, engage stakeholders and incorporate their concerns, and strike a balance among competing resource interests. MRIA, a multiresource integrated assessment, is an interdisciplinary analysis of multiple, frequently coextensive, biophysical and socioeconomic resources that evaluates the net effect of developing or conserving one or more resources in relation to others. The intent is to synthesize resource information, harmonize conservation and development concerns, and optimize decision-making for the combined management of multiple natural resources in response to alternative socioeconomic policy scenarios. MRIA should be transparent and purpose-driven, providing decision-support to specific questions for an intended audience.

USGS scientists from the Mineral Resources, Water, and Ecosystems Programs developed such an analysis and, in 2006, applied it to the Anosy Region of southeastern Madagascar. The purpose of the assessment was to enhance knowledge of natural resource potential in the region and to provide information and decision-making guidance in order to create sustainable economic development driven by mineral resources. The assessment was designed to be practical and to work in data-poor and -rich environments using expert-driven, fuzzy-set geospatial integration and modeling techniques. Specifically, relationships among geologic/metallogenic, hydrogeologic, ecologic, and socioeconomic data were used to (1) identify priority mineral resource areas and (2) highlight development growth-poles and -corridors.

This proof-of-concept study identified a number of methodological challenges and possible refinements to the application of MRIA, including: (1) development of a multidisciplinary workflow that allows for interdisciplinary assessment (a framework that maps the flow of data integration and analysis, but also provides a construct for integration and management of multiple scientific disciplines and team members), (2) implementation of an internally consistent and well-defined data-reduction method to re-cast resource potential into a standard fundamental unit by which inter-resource comparisons can be made (an “assessment tract”), (3) linkage to and application of a uniform, comparable, and equitable resource valuation metric across all resource types considered (an expanded “mineral service” role within ecosystem services), (4) usage of a variety of data integration and optimization methods (techniques that take into account legal, regulatory, and economic/market constraints), (5) integration of data of multiple and disparate scales (processing techniques to enhance resource data quality and mitigate the effects of mixed-scale data), (6) representation of at-distance affects (impacts of spatially proximal factors outside of the study area), and (7) explicit specification of resource confidence and uncertainties, with tracking of error propagation across integrated resource data layers (measures of error and uncertainty for categorical, ordinal, interval, and ratio data types).

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STATE REVOLVING LOAN FUNDS: INNOVATIVE FINANCING UNDER THE IOWA NUTRIENT REDUCTION STRATEGY

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The Iowa Nutrient Reduction Strategy (INRS) is an innovative approach to nutrient reduction for Iowa waters and downstream Mississippi River Basin (MRB) that coordinates both Iowa point sources and non-point sources. From the beginning of its implementation in 2013, stakeholders have expressed interest in the development of market-based incentive programs like Water Quality Trading (WQT) to bolster cooperation between groups and improve water quality in the state. Point sources under the Strategy are required to monitor their facilities for nutrient outflow for one year and then in year two conduct a feasibility study on the affordability of achieving a 66% reduction in total nitrogen (N) and a 75% reduction in total phosphorus (P) during the renewal of their NPDES permits. The INRS allows the flexibility by a point source to achieve their reduction through a combination of technology changes at the facility and/or reductions with other point sources and non-point sources. This flexibility provides an opportunity to develop a voluntary early "Nutrient Reduction Exchange" that mimics formal water quality trading (WQT) credit systems to meet such commitments. Subsequent to point sources reaching these reduction goals in the Strategy, future more stringent water quality based effluent limits for permits stemming from numeric nutrient criteria and/or TMDLs may trigger formal WQT.

Unique to this setting is Iowa's state revolving loan fund (SRF) which encourages grantees to implement nonpoint source controls by offering additional "grant" funding for the purposes of installing land management control practices within their watershed. Such nutrient load reductions achieved through nonpoint source controls may be crucial for municipalities to meet current and future regulatory requirements, and encourages collaboration between urban and agricultural entities. In a region dominated by agriculture, this will prove vital if the state is to achieve the reduction goals of 45% for total nitrogen and phosphorus.

This presentation will discuss how the SRF funding mechanism provides the flexibility and opportunity to bridge point source and nonpoint source reduction goals in the context of these voluntary investments by municipalities. These will be discussed in the context of the NRE and WQT.

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A REGIONAL LANDSCAPE SUSTAINABILITY MODEL – A WEST TEXAS APPROACH

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Contemporary sustainability studies focus primarily on landscape performance of one project or one geographic site, often times within an urban context. This research considers a strategy to expand landscape sustainability practices to the neighborhood or community scale, through application of an index of sustainability variables that are comparative across location and scaleable to regional planning processes. In addition, we focus on rural and ex-urban landscapes, where sustainable planning practices in the current political climate critical, but resources for landscape planning and implemention more scarse. From over five years of testing in the Southern Plains communites of West Texas, a model was developed using 7-10 landscape suitability variables. Evaluation and summation of these variables gives land manager and designers an opportunity to establish a geographical base of sustainability which can then guide logical, specific strategies for improving landsacape sustainability ratings. In addition, the model creates a quick data base of sustainability, indicators that can be mapped and easily applied in long or short range rural landscape planning. The landscape variables can be applied (and additional variables considered) to other North American landscapes, whether it be natural conservation lands, parks, small towns, agricultural areas or small town, industrial and commercial sites, or large metropolitan areas. Utilizing this strategy, field surveys with over 300 samples can easily be calculated and inventoried in days rather than weeks, and incremental future surveys can bee developed to expand the model data.

The case studies presented here, cover a range of rural communities in West Texas, and consist of over 300 canvassed sites, that were mapped using GIS and Autocad software. Analysis of data colledted indicated a strong correlation to good sustainaility using landscape variables in descending order: native plant selection, water conservation/irrigation design, professional landscape design, flooding and erosion mitigation, materials, maintenance, and innovaiton. Additional variables used to consider sustainble practices at the community level included, food access, carbon footprint, industrial pollution, green products, recycling, and waste management. The main conclusion is mapping the cumultive score/index illustrates a strong geographical pattern in locations of landscape sustainability relative to neighborhoods. Thus, the focus of landscape sustainability management or rehabilitation efforts for a regional or neighborhood perspective can be finely tuned and specifically directed using these key variables.

Looking beyond the first steps presented in this research, we are envisioning strategies to make this model accessible to and engage the local community members through a cell phone app that allows inventory for their own properties, compare their values to others in their area, and then access guidelines and commerical venders to improve future sustainability indicators for their properties. This is modeled after *the Whole Earth Catalog*, a 1970's warehouse of susutainability products, services and expertise.

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ESTIMATING THE IMPACTS OF CLIMATE INDUCED CHANGE ON RIVER FLOW AND ECOSYSTEM SERVICES

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The ecosystem services generated by high altitude river systems are likely to be impacted annually and over the century by the changes in seasonal as well as long-term hydrological conditions as triggered by climate-mediated changes in precipitation and temperature patterns as well as the melting of snow and glaciers. The ecosystem services generated by river system through its provisioning, regulating and cultural services depend on the volume of flow. With the changes in flow and increasing demand for water to support the growing and developing population, inter and intra-sectoral water allocation issues are expected which in turn will impact the ecosystem services. Such changes often results in stressed regulating and cultural services of an ecosystem attributed to upfront market value of provisioning services. We developed an integrated assessment framework that couples physical process-based models with economic models to estimate the impacts of flow on ecosystem services and evaluate the impacts in High Mountain Asia Region (HMA). Changes in snow and glaciers is quantified using glacier melt models and geospatial analyses using remotely sensed data and field data. Projected temperature and precipitation data is obtained by downscaling the Global Climate model output to 12KM resolution in order to address the extreme spatial heterogeneity of the rugged mountain. Geospatial stream flow model is used for forecasting hydrological flow and estimating the impacts on river flow at various points in a river stretch. Water use optimization tool is used to come up with a number of water allocation scenarios based on the multiple objectives of energy production and river functionality for agricultural and other ecological functionality of the river. The monetary value of change in biodiversity protection downstream is estimated using benefit transfer method for this presentation (if the surveys are not completed in time). Estimated changes in economic value of the ecosystem services of Arun River (preliminary) under various scenarios will be presented.

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ENABLING BUSINESSES TO INCORPORATE THE ECONOMIC VALUE OF ECOSYSTEM SERVICES INTO PROJECT EVALUATION

*Presented by **Jennifer Molnar**[1]*

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Many businesses have natural capital initiatives but project managers face challenges implementing them. Project managers need practical methods to value ecosystem services in project evaluation. While emerging tools make it increasingly practical to model ecosystem services, project managers still need to translate services to business values. We provide guidance on how project managers can value ecosystem services by applying their existing project evaluation approaches and financial models. We focus this guidance on four project types that occur at manufacturing companies and may benefit most from consideration of ecosystem services (real estate, infrastructure, process improvement, and products). We identify the links between ecosystems and business values for these four project types. We propose methods for quantifying the links between ecosystems and business values, drawing on methods from business and ecosystem service valuation. We apply these methods to evaluate two decisions that a global manufacturing corporation made related to real estate and natural infrastructure. The real estate decision evaluated the sale of a forested greenbelt property into conservation. The infrastructure decision evaluated the use of a constructed wetland as part of a water management system. We used the Ecosystem Service Identification and Inventory (ESII) Tool to model ecosystem services resulting from the real estate decision, while we used engineering specifications to estimate the ecosystem services resulting from the natural infrastructure decision. We calculated the financial value to the company resulting from the decisions in terms of enhanced revenues or avoided costs using the company's financial models. We used data on ecosystems and services as non-financial indicators of value to communities and nature. The results suggest that financial models provide a reasonable estimate of business values and may be sufficient to inform project management decisions for natural infrastructure projects. However, many ecosystem service values are still external to the business (e.g., under the policy conditions in this study, the company does not avoid costs from conserving habitats that manage stormwater or control air quality) or difficult to quantify (e.g., financial models do not value resilience or reputational benefits well). In these cases, we demonstrate how evaluating the potential value of ecosystem services to the business under market or policy conditions that internalize these values may help managers understand future opportunities or risks. This study highlights the need for new corporate and public policies to internalize services so that they have a financial value to the business and the need to also manage for non-financial ecosystem service metrics.

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MAKING A CASE FOR INTEGRATING NATURE IN BUSINESS: LESSONS FROM A UNIQUE NGO-CORPORATE COLLABORATION

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The Nature Conservancy and The Dow Chemical Company came together as unlikely partners with an ambitious vision 6 years ago: to change how companies do business by incorporating the value of nature in decisions. The collaboration sought to test and demonstrate how businesses like Dow could better understand the risks and opportunities related to their business's reliance and impacts on nature. This could both lead to smarter business decisions, and greater investment in conservation because it makes good business sense.

This discussion will focus on lessons from this unique cross-sector, science-based collaboration – how it began and lessons that can be applied in other partnerships. There were challenges along the way, testing new applications of ecosystem service science and tools in a business context, while working across cultures within and across the two organizations. But the collaboration was able to draw on the different strengths, expertise and implementation experience in each organization as new analysis and business solutions were co-created.

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APPLICATION OF ECOSYSTEM SERVICES IN NATURAL RESOURCE MANAGEMENT DECISION-MAKING

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An ecosystem services approach to natural resource management can provide the framework for balancing economic, ecological, and societal drivers in decision making. The efficacy of such an approach depends on the successful execution of several key activities, from early and continuous engagement with relevant stakeholders, to development and application of ecological production functions, to explicit recognition of uncertainty in the process. Although there are obstacles to the implementation of an ecosystem services approach in natural resource management, including unclear regulatory and policy frameworks and the paucity of useful ecological production functions, many of the tools are currently available or sufficiently developed. An ecosystem services approach can, and in some cases, should involve qualitative, rather than quantitative assessment, where the stakes are not very high or where quantitative approaches would not be cost effective due to highly uncertain results. This presentation will summarize results from the 2014 SETAC-ESA jointly sponsored Pellston Workshop focused on developing a framework and practical guidance for incorporation of ecosystem services in natural resource management decision making. While ecosystem services are being utilized in traditional Natural Resource Management programs this effort represents one of the first attempts to incorporate ecosystem services in a formal decision-making framework and provide practical guidance for implementation.

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USE OF ECOSYSTEM SERVICE ANALYSIS AT THE BUREAU OF LAND MANAGEMENT

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The BLM's socioeconomics 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. This presentation will briefly describe the objectives and findings of multiple pilots, highlighting commonalities and challenges. Then, as a recent example of how BLM is considering ecosystem service principles and tools, this presentation will describe a recently completed study that evaluated the ecosystem service benefits expected from the Greater Sage-Grouse (GRSG) conservation actions outlined in 15 regional environmental impact statements (EISs) across the western U.S. This project documents the connections between these actions, expected changes in land cover, and the projected effects on a range of ecosystem services, such as air quality regulation and recreation. The results of the project will allow the BLM to better communicate the full range of benefits provided by the GRSG conservation actions.

Collectively, these projects provide examples and illustrate the challenges involved in more systematic application of ecosystem service principles and tools across the BLM. With these challenges in mind, the BLM is currently pursuing multiple approaches aimed at building capacity and increasing consistency and rigor of ecosystem service analyses. The volume and variety of decisions faced by BLM, combined with the limited internal capacity, presents significant operational challenges. There are also technical barriers to widely adopting an ecosystem service approach to planning and management decisions. One major problem is the lack of readily available and consistent data at the scale and depth needed, as illustrated by the GRSG project. An ecosystem services approach requires both biophysical and socioeconomic data. Across large landscapes, socioeconomic data is often limited to demographic or economic indicators. It can be expensive and time-intensive to acquire data reflecting population preferences or values related to ecosystem services.

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IMPACT OF RELATIVE DEMAND FOR ECOSYSTEM SERVICES ON THEIR STACKING MARKETS

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The potential of multiple markets for ecosystem services raises intriguing questions about how such markets contribute to conservation objectives. For instance, a water quality improvement program aimed at nutrients likely produces joint benefits, such as enhancing wildlife habitat. This raises an important but less often asked question of will additional payments motivate farmers to install additional best management practices (BMPs)?

A blended actual and hypothetical ecosystem services stacking scenario is developed to enhance a water quality trading (WQT) program in Jordan Lake Watershed, North Carolina. Nutrient pollution is a critical issue in Jordan Lake and a WQT program was suggested to address water quality issues in this rapidly urbanizing watershed. According to the Jordan Lake WQT rules, farmers are required to install riparian buffers as their BMP to reduce their total nitrogen (TN) load if they are willing to participate in trading. We designated our primary ecosystem service market as TN load reduction (TNR). We then examined whether the demand for a second service, relative to a primary service, will enhance the incentives associated with installing BMPs for that primary service. Relative demand was estimated for TNR and simulated for total phosphorous (TP) load reductions (TPR). TNR and TPR are indicators of joint ecosystem services produced by a single BMP, riparian buffers. TPR is a hypothetical, secondary ecosystem service that we introduced to determine when its demand, relative to TNR, creates appropriate incentives for implementing additional BMPs. We used the Soil and Water Assessment Tool (SWAT 2012) to build a model for the Jordan Lake Watershed to simulate TN and TP loads from agricultural fields and effectiveness of riparian buffers in reducing them.

The results show that relative demand for TNR and TPR credits plays a profound role in the success of the stacking program. A secondary service with relatively low demand will result in insufficient incentives, or in some cases double dipping, but sufficient incentives to increase conservation will be available in a stacking program when demand for the secondary service is relatively high for the secondary service. Our results for the Jordan Lake Watershed model show that credit stacking is insufficient if additional secondary product is of no value to buyers, which occurs for TPR when its demand intercept is less than 20% of the TNR's. Importantly, we find that ecosystem stacking is most likely to generate more revenue to producers and to reduce pollution emissions when demand is relatively high for the secondary service. Accurate assessment of relative demand can therefore help policy makers determine where stacking policy is appropriate.

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ECOSYSTEM SERVICES IN RISK ASSESSMENT AND MANAGEMENT

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The ecosystem services concept provides a comprehensive framework for considering ecosystems in decision making, for valuing the services they provide, and for ensuring that society can maintain a healthy and resilient natural environment now and for future generations. A global Pellston Workshop was convened by SETAC and the Ecological Society of America (ESA) in Shepherdstown, WV, USA, in September 2014 to develop broad consensus and practical guidance for the application of the ecosystem services concept to environmental decision making as part of a movement towards environmental sustainability. This presentation will highlight opportunities and implications of including ecosystem service endpoints in risk assessments and the decisions that risk assessment informs. We describe five assertions about the benefits that will accrue from application of the ecosystem service concept in risk assessment and risk management, stating that the use of ecological services will lead to more comprehensive and transparent environmental protection, help articulate the net benefits of environmental decisions/policies/actions, better inform the derivation of environmental quality standards and specific protection goals, and enable the bridging of human health and ecological risk assessment across multiple regulations and programs. We also describe recommendations that emerge from these assertions and the issues, challenges, and path forward associated with employing ecosystem services in risk assessment and decision making.

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INCORPORATING AN ECOSYSTEM SERVICE APPROACH IN NRDA

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Under current NRDA practice, injuries to natural resources and losses are commonly measured in ecological terms (e.g., number of acres injured or number or biomass of fish and invertebrates killed), and restoration often follows relatively straightforward habitat and/or resource equivalency approaches (e.g., acres of habitat restored or biomass of fish/invertebrates replaced). However, these habitat- or resource-to-resource compensatory calculations and associated restoration plans can miss important ecosystem connections and linkages that are important for comprehensive injury restoration, particularly when injuries occur to multiple habitats and services. Considering these ecosystem services in damage assessment requires overcoming challenges, specifically: (1) shifting or dynamic baselines, (2) the lack of complete or validated ecosystem models that capture the full complexity of ecosystem interactions in the GoM, (3) quantifying these ecological services in a manner that can be used to scale restoration, and (4) understanding the tradeoffs between restoration options to make the public whole.

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CONSERVATION EFFECTS ON ECOSYSTEM SERVICES IN THE U.S. PRAIRIE POTHOLE REGION

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The intermixed wetland and grassland ecosystems of the Prairie Pothole Region (PPR) of the northern Great Plains perform a suite of services valuable to society. Conservation programs, such as the U.S. Department of Agriculture's Wetlands Reserve Program (WRP), can have a marked effect on these services. We used the Integrated Valuation of Ecosystem Services and Tradeoffs model (InVEST) to explore how WRP in the Des Moines Lobe ecoregion of the PPR has impacted the provisioning of key ecosystem services. The PPR is a geologically young, glacially formed landscape that covers approximately 700,000 km2 of North America. Due to the high biological diversity of wetland-embedded grasslands, the PPR is especially well known for its value in maintaining continental populations of waterfowl. However, wetland losses due to wetland drainage have been severe throughout the region, especially so (>90%) throughout the Des Moines Lobe.

We quantified above- and below-ground carbon stores, amphibian and grassland bird habitat suitability, native plant community quality, and floral resources for pollinators under scenarios that both included and removed the influence of the WRP on land-cover (e.g., grasslands, various crop types, pasture land, urban) of the Des Moines Lobe landscape. Additionally, we demonstrate how information derived from application of the Agricultural Policy EXtender model (APEX) provides insight into effects of WRP on other services, including floodwater storage, sediment entrapment, and nutrient retention, by reducing both edge-of-field effects and effects on wetland ecosystems embedded within agricultural fields. By using conservation practices that reduce agricultural effects on wetlands, edge-of-field effects become more sustainable than in scenarios in which increased sedimentation rates lead to the rapid filling of depressional basins, leading to the loss of wetland ecosystem functions and the delivery of the services these ecosystems provide.

Although we focused on the WRP for demonstration purposes, the tools and techniques we developed can easily be applied to quantifying the ecosystem service effects of other conservation programs, practices, or actions that influence land-cover in the other ecoregions of PPR, i.e.,the Glaciated Plains, Northwestern Glaciated Plains, and Lake Agassiz Plains.

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ECOSYSTEM SERVICES APPROACH AS A TOOL FOR REGIONAL PLANNING

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Throughout Scandinavia and particularly in Finland, local governments and urban planners are including ecosystem services in spatial mapping exercises and using the information to support decision making for local and regional-scale landscape planning. The consideration of ecosystem services in regional planning is relatively new, less than 10 years old; and yet, it is rapidly becoming an essential component of urban and landscape planning conducted at both the municipal, regional and national governmental level. The work begins by identification of the set of ecological and human uses of the environment valued by the community, and then proceeds to visualization of the environmental attributes and services necessary to support the community's preferences. This approach has proven to be very important to regional planners during the strategic planning process. The approach has also proven useful for highlighting a region's natural capital assets and for identifying so-called ecosystem hot spots where conservation, protection and/or rehabilitation may be needed to preserve or enhance the ecosystem services valued by communities in to the future.

In this presentation, we describe the approach to regional planning adopted in several Finnish communities, using examples where ecosystem services maps have been prepared and valuation methods used to identify community preferences to guide long-term strategic urban development. For example, we introduce a project where the ecosystem services of a river ecosystem were defined by municipal planners before and after river restoration to highlight the benefits that the local community realized from improvements to native fish habitats. We also introduce examples of urban applications of ecosystem services mapping and valuation as part of redevelopment planning for aging infrastructure in large cities. We describe the methods linking spatial land use to ecosystem services and discuss the regional planning results, as well as the lessons learned to date in Finland about the utility and applicability of these methods during the regional planning process. We identify limitations and point to research needs that typically arise during this work.

In Finland and elsewhere in the Nordic region, we find using this approach emphasizes the importance of urban nature and the context-specificity of natural capital discourse. We argue that some mismatches exist between the ecosystem service framework and its practical applicability, and that the main problem is not necessarily the transferability of tools and indicators, but the transfer of values and the assumptions and choices behind valuation. Notwithstanding these challenges, a regional planning framework that includes ecosystem services has proven to be valuable for evaluating and guiding future land use. Our results and the experiences learned during the process clearly demonstrated that spatial mapping tools can be used as a communication tool to initiate discussions with stakeholders, visualizing the locations where valuable ecosystem services are produced or used and explaining the relevance of ecosystem services to the public in their communities.

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HUMAN AND ENVIRONMENTAL INFLUENCES ON ECOSYSTEM SERVICES AND WEST NILE VIRUS VECTOR INFECTION IN SUFFOLK COUNTY, NEW YORK (USA)

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Healthy, functioning aquatic ecosystems provide the ecosystem service of mosquito population control. Nutrient and pesticide pollution, along with destruction and filling of wetlands, lead to impaired waterbodies that are less effective in vector regulation due to reduction or removal of predators of mosquito larvae. The first confirmed outbreak of West Nile Virus (WNV) infection in North America was New York City, NY in 1999. As a result, a number of nearby counties are a particular locus for transmission, and mosquito trapping and testing are conducted regularly to assess the prevalence of the virus in local mosquito populations. The common house mosquito (*Culex pipiens-restuans*) is implicated as a primary vector of the disease in the northeast U.S., and is known to breed in impaired fresh waters. This vector species complex is actively controlled by the local government in Suffolk County, NY, and robust decision support tools are required to select critical areas for pesticide application and public health outreach, as well as to identify land use patterns and other human influences leading to increased disease incidence.

Using WNV mosquito surveillance data from 2008-2015, logistic regression and an analysis of spatial and temporal factors were used to identify ecosystem attributes, meteorological variables, and anthropogenic ecosystem alterations that are indicative of WNV-positive mosquito populations. Emphasis was placed on evaluating explanatory variables related to coastal and freshwater wetland ecosystems and the built environment, to quantify the impact of land use decisions on WNV prevalence. The resulting model can be used to prioritize areas that have a relatively higher risk of harboring WNV for vector control treatment and public health support, leading to more informed management of ecosystem services for human health outcomes.

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VALUING ECOSYSTEM SERVICES FROM SALT MARSH RESTORATION RELATED TO HURRICANE SANDY

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Superstorm Sandy had significant impacts on ecosystem services in the New York and New Jersey area. Restoration work related to Sandy has started and will continue for some time. This presentation will discuss work funded by NOAA to place economic values on restoration and resiliency work using work being performed at the Forsythe National Wildlife Refuge (FNWR) as a case study. The FNWR work involves both thin layer placement of sediment to raise marsh elevation and tidal flow restoration work. This project involved developing a choice experiment survey and implementing the survey in the New Jersey area. The presentation will discuss the design of the project, the results from the project and the implications of the results to making decisions on future restoration work. Although the project focuses on restoration from Sandy, the use of a choice experiment will allow for broader application of the results. Choice experiments allow for assessing the economic trade-offs that people make between different levels and types of ecosystem services. Thus, the study provides estimates for the value of the specific restoration work being performed at Forsythe, but also provides information that can be used to inform future restoration decisions.

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ECOSYSTEM SERVICES ASSESSED IN FOREST PLANNING: INDICATORS, TRENDS AND BENEFICIARIES

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The 2012 National Forest Land Management Planning rule directs National Forests and Grasslands to assess ecosystem services, and account for ecosystem services when developing plans that guide constributions to social and economic sustainability. National Forests and Grasslands encompass a vast spectrum of ecological, social, and cultural communities facing diverse stressors, drivers, and risks. We therefore consider a variety of methods and indicators for assessing ecosystem services and describing changes in potential contributions to ecosystem services during land management planning.

Since 2012, a number of National Forests have completed planning assessments, and some have completed draft plans. These assessments and draft plans provide examples of how forests from different regions of the country are characterizing ecosystem services and establishing a more transparent foundation for describing the benefits people receive from National Forests and Grasslands. A variety of classification systems can be adopted, ranging from comprehensive schemes based on the United Nation's Millennium Ecosystem Assessment, to hybrid systems incorporating concepts from USEPA's National Ecosystem Services Classification System (September, 2015). Options for indicators of goods and services include proxies derived from readily available biological or ecological information and monitoring data, or more direct measures of service provision incorporating geospatial data reflecting potential beneficiary populations or service use.

We will present an overview and share insights on the variety of approaches and indicators used to address ecosystem services and beneficiaries in existing National Forest planning efforts, thereby shedding light on potential trends and needs regarding ecosystem service methods and data.

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DO OFFSHORE OIL AND GAS PLATFORMS AND INFRASTRUCTURE PROVIDE VALUABLE ECOSYSTEM SERVICES?

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The question as to the value of offshore oil and gas platforms and subsea infrastructure (e.g., in the North Sea, Gulf of Mexico, California, Southeast Asia and Arctic Regions) to provide ecosystem services is of increasing importance. Recent fisheries and marine mammal data indicate that offshore structures can create significant ecological productivity above natural reef systems and support a variety of marine mammal populations. The costs for decommissioning are projected to be over $125 Billion over the next 35 years and these actions can cause significant adverse impacts to the ecosystem and associated services. This session will focus on the ecological value of offshore structures and application of a net environmental benefit analysis (NEBA) approach to evaluate options for offshore decommissioning. A recent 2016 New York Times article6 also touches on these values.

Within recent and developing guidelines for decommissioning, sustainable development is an obligation incorporated into alternative decision-making. This obligation focuses on balancing the economic, environmental and social factors associated with the selected decommissioning alternatives. A NEBA approach, developed to balance the risks, benefits and tradeoffs associated with competing alternatives that focuses on the environmental, economic and social factors inherent within the potential alternatives, is presented from a decommissioning perspective.

Within the decommissioning process, a NEBA can be used to evaluate competing alternatives such as complete removal, partial removal, conversion to other uses (e.g., rigs to reefs), or a combination of these. A NEBA can also provide information to demonstrate that a decision meets ALARP (as low as reasonably practical) requirements, considering a wide-range of stakeholder concerns. A NEBA is similar to a cost-benefit analysis (CBA) in that it is a systematic process for quantifying and comparing the benefits and costs between competing alternatives. However, a NEBA does not necessarily rely on monetization but can include non-monetary ecosystem service metrics as well. A NEBA and a CBA are similar in that they consider time accumulated service flows (i.e., benefits and costs over time).

Each panel member will present a 10-minute overview that includes the following: overview of NEBA and application to offshore decommissioning (Joe), regulatory and legal considerations (Tom), case study examples – Australia/North Sea (Larry), marine mammal scientific evidence (Victoria), and ecosystem service valuation approaches (Mark). The panel will then join in a Q&A session with the audience for the remainder of the session.

http://www.nytimes.com/2016/03/08/science/marine-life-thrives-in-unlikely-place-offshore-oil-rigs.html?_r=1

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USING THE STEPS FRAMEWORK TO DEFINE THE IMPACTS OF AIR POLLUTION ON AQUATIC FINAL ECOSYSTEM GOODS AND SERVICES

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Increases in human-caused anthropogenic emissions of sulfur (S) and nitrogen (N) have resulted in increases in associated atmospheric deposition. This deposition has initiated a cascade of negative environmental effects on ecosystems, resulting in a degradation or loss of valuable ecosystem goods and services. Understanding these losses, and the beneficiary groups that care about them, can help identify desired policy or management actions.

Experts were assembled to identify and document the sensitive ecosystem ecological endpoints that humans value, and the environmental pathways through which these endpoints may experience degradation in response to atmospheric deposition using the STEPS Framework (**ST**ressor – **E**cological **P**roduction function – final ecosystem goods and **S**ervices). Critical loads of N and S deposition were used in the stressor module to understand broader impacts of ecosystem changes. We created Ecological Production Functions (EPF) to link changes in biological indicators of critical loads to ecological endpoints that are directly used, appreciated, or valued by humans. Potential beneficiary groups were identified for each sensitive ecological endpoint to clarify relationships between humans and the effects of atmospheric deposition, and to lay the foundation for future research and analysis to value these Final Ecosystem Goods and Services. A group of 27 scientists, land managers, and economists were assembled into four teams, each team focusing on a different category of ecosystem impacts from deposition: aquatic acidification, aquatic eutrophication, terrestrial acidification, and terrestrial eutrophication. Results from all teams will be discussed, but this presentation will focus on the results of the aquatic acidification examination as the primary case study.

The teams identified 169 unique environmental pathways linking a change in a biological indicator to a FEGS, resulting in 1073 unique links between a CL exceedance and a beneficiary (identified as chains). The aquatic acidification team identified 361 chains, which included seven unique biological indicators, nine unique ecological endpoints, and 15 unique beneficiaries. While not exhaustive, these chains allow us to explore the environmental pathways through which atmospheric deposition can impact ecological endpoints, and identify ecological endpoints that experience compounding effects from deposition. The chain strength of science scores help identify research gaps, as well as areas where research is strong enough to form the basis for policy and management decisions. An examination of the beneficiaries of these ecological endpoints highlighted patterns in the categories of beneficiary groups that care about most, if not all, ecological endpoints, including the fact that many of these groups were non-consumptive users. Non-consumptive and small quanitity uses, often overlooked when impacts are enumerated and valued, can accumulate into significant concern. All of this information can be used to support policy and management actions to better protect the ecological endpoints that humans care about from the negative impacts associated with atmospheric deposition. In addition, the results of the analysis can be transferred to the social science community for valuation efforts, providing a more comprehensive analysis of the effects of anthropogenic stressors on measures of human well-being.

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A CASE IN POINT: ECOSYSTEM SERVICE CAUSAL MODELS IN SOUTHEAST US FIRE MANAGEMENT

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After decades of research and demonstration on ecosystem services we are now seeing a rapid transition from the research community into policy guidance for managers and practitioners. The use of causal chains based conceptual maps to draw the connection from actions, policies and programs, to the ecosystem service and social outcomes they produce, has been proposed as a method for integrating ecosystem services into decision making (NESPguidebook.com) and as a way to create an integrated socio-ecological evidence bases for conservation, natural resource management and development (Conservation by Design). The presumption is that causal chain conceptual maps can form the basis for quantitative analysis. The assumptions (arrows) linking the system changes (boxes) can be articulated and in some cases quantified describing the ecological production function connecting action to outcomes. Evidence in the form of expert elicitation, published research or models, or research-based models can be matched to each assumption and assessed for its quality (certainty, precision, etc.…). With this information these maps can be used to develop quantitative spatial models (like structural equation models) to test various management or policy scenarios. These causal chains may form a foundation for best practice and consistency for use of non-value based measures of ecosystem services (also called benefit relevant indicators (BRIs)) in federal decision making. If so, they may also be a path toward more transferable and scalable quantification of non-value based measures in addition to informing the transfer of values. If causal chain based conceptual models are going to be more widely used in decision making, the approach requires further testing, high quality examples, and clear guidance on best practice.

Through the course of two workshops with diverse groups of experts including federal agency practitioners, we developed an example causal chain based conceptual model of forest management designed to reduce the risk of catastrophic fire in Southeastern US forests. We focused on understory thinning and touch on how the model can be varied to address different treatment methods. We present the causal chain model and the assumptions connecting each step in the chain, as well as our progress in collecting evidence for each assumption. We will discuss (1) progress in the development of a high quality example, (2) what it would take to move toward quantification of this model, (3) how much the model needs to vary to capture alternative fire management contexts, (4) the role ecosystem services classification systems and lists of outcomes can play in constructing these models, and (5) what we learned about best practice and guidance for the development and use of causal models of ecosystem outcomes.

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ASSESSMENT OF ECOSYSTEM SERVICE SUPPLY AND LANDOWNER PRIORITIES AND THEIR IMPLICATIONS FOR PROGRAM DELIVERY: A MODEL FOR TARGETING LANDOWNER ENGAGEMENT

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Given that private land dominates the eastern US, Landscape Conservation Cooperatives (LCCs) and other conservation focused organizations working in the eastern US need to engage private landowners in conservation activities. These same conservation organizations are also interested in understanding how ecosystem services could guide conservation decisions and foster engagement with landowners. Our Mississippi State and Duke University collaborative project is working with the Gulf Coast Plains and Ozarks LCC to develop an approach to identify effective landowner engagement strategies for promoting and sustaining ecosystem services (e.g., clean water**,** biodiversity, wildlife habitat, recreation, aesthetics) among farmers, ranchers, and forest landowners**.**

While we hope our approach will be repeatable and transferable to other regions, we will develop the approach in the Southeastern United States through a focused case in three major habitat types (bottomland hardwoods, open pine stands, and grasslands) in the GCPO LCC territory. We will present the results from the following activities: 1) Two surveys – one focused on understanding the priorities of resource support organizations and the other focused on a spatially explicit understanding of what ecosystem services are most important to landowners and their willingness to engage in resource management activities on their lands; 2) A social network analysis to inform engagement pathways; 3) Mapping of existing areas of the 3 habitats and areas of potential habitat where restoration may be possible; and 4) Mapping of ecosystem services supply and, where possible, relative demand. The mapping of ecosystem services is an exploratory analysis to determine what is possible given existing nationally available databases and covers services such as agricultural products, merchantable timber, forest carbon storage, pollination, at risk species, hunting, birding, priority natural areas, and water filtration capacity. These different layers of information can be combined to inform where current habitat patches on private lands can be managed or restored and on these lands which services can best be provided with some indication of tradeoffs (biodiversity vs food production). In addition, the survey of landowners can tell us, of the services these lands can provide, which are most important to landowners in these areas.

Our use of mixed methods to collect differing sources of data and perspectives about complex issues provides more depth and insight than relying on any single method alone. Using diverse sources of information is essential for designing targeted landowner engagement strategies that can achieve conservation and social benefits in the GCPO LCC region, as well as for guiding policy development.

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CONSISTENCY IN ECOSYSTEM SERVICES MEASURES FOR DECISION MAKING

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Efforts to better incorporate nature's benefits into decision making are progressing rapidly. In October of 2015, the U.S. Executive Offices of the President – the Office of Management and Budget, the Council on Environmental Quality, and the Office of Science and Technology Policy – released a memo titled "Incorporating Ecosystem Services into Federal Decision Making" which calls for federal implementation guidance by the end of 2016 that will describe how agencies should incorporate ecosystem services into their decision making. Many practical questions remain about how ecosystem services can most effectively be used in decision making. The questions we are exploring in our paper are (1) when do decision makers need to use a set of ecosystem services categories or measures that are consistent across decisions or decision components? And (2) when this is needed, how is this best achieved? There is no simple answer nor one right way to create consistency, in part because the ecosystem services that need to be considered will depend on the ecosystem type, the services it can generate, the scale and vulnerabilities of surrounding human communities, the ways in which humans use or appreciate these ecosystems, and the preferences and values of human beneficiaries in different areas and policy contexts, as well as the temporal and spatial scale of the project, plan, program, or policy under consideration. In addition, how consistency is achieved depends on the methods being used.

In the paper we discuss 1) common inconsistencies in measures used in current practice, 2) the types of consistency in categories or measures of services that could be used by decision makers, and 3) describe which types of decisions require what level of consistency (low, medium or high). We then describe a proposal for how consistency in ecosystem service categories and measures can be developed for specific decision contexts and provide an example of how consistency in ecosystem services measures could be incorporated into forest planning. Forest plans have a common set of management actions at their core. Our proposal is that a set of common conceptual diagrams (also known as means-ends diagrams, box and arrow diagrams, or causal chains) can be developed – one for each of these common management actions. We will briefly review a detailed example causal chain conceptual model for one of these management actions - forest fire risk reduction. We will also touch on how ecosystem services classification schemes or lists of human well-being endpoints can be used to inform development of these conceptual diagrams and the selection of categories or measures of services.

We propose that these conceptual casual chain diagrams, which can be the foundation for quantitative analysis of ecosystem services outcomes, can also provide the basis for consistency within a specific decision context when appropriate.

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ROLE OF LANDSCAPE DESIGN IN MITIGATING AGRICULTURAL INTENSIFICATION

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This is a sample of the body of the abstract. Please pay strict attention to the preparation of your abstract. The abstract should be as informative as possible and cover six key areas: 1) purpose, 2) scope, 3) methods used, 4) the results, 5) conclusions, and 6) recommendations.

Sustainable and resilient agricultural systems are needed to feed and fuel a growing human population. However, the current model of agricultural intensification which produces high yields has also resulted in a loss of biodiversity, ecological function, and critical ecosystem services in agricultural landscapes. A key consequence of agricultural intensification is landscape simplification, where once heterogeneous landscapes contain increasingly fewer crop and non-crop habitats. Landscape simplification exacerbates biodiversity losses which leads to reductions in ecosystem services on which agriculture depends. In recent decades, considerable research has focused on mitigating these negative impacts, primarily via management of habitats to promote biodiversity and enhance services at the local scale. While it is well known that local and landscape factors interact, modifying overall landscape structure is seldom considered due to logistical constraints. We propose that the loss of ecosystem services due to landscape simplification can only be addressed by a concerted effort to fundamentally redesign agricultural landscapes. Designing agricultural landscapes will require that scientists work with stakeholders to determine the mix of desired ecosystem services, evaluate current landscape structure in light ofthose goals, and implement targeted modifications to achieve them. We evaluate the current status of landscape design, ranging from fundamental ecological principles to resulting guidelines and socioeconomic tools. While research gaps remain, the time is right for ecologists to engage with other disciplines, stakeholders, and policymakers in education and advocacy to foster agricultural landscape design for sustainable and resilient biodiversity services.

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LANDSCAPE INFRASTRUCTURE AS FRAMEWORK FOR CITY-BUILDING

Sean O'Malley
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The transformation of our cities into vibrant places of work, living, and entertainment encourages us to search for greater and more creative use of open space. The structures that tie our cities together, from the streets, rivers, drainage ways, utility corridors, and alleys to forgotten public spaces, present an opportunity to build a new landscape infrastructure—one that combines various forms of transportation, utilities, and natural systems into a comprehensive framework for growth, and that utilizes ecological systems and their associated processes as a foundation for city building.

Designing with ecological processes in concert with a site's natural systems has significant benefits for urban design and planning, resulting 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; a multiplicity of formal arrangements; reduced environmental impacts; less need for hard infrastructures; and wildlife habitat preservation. Landscape infrastructure has the potential to utilize ecological systems as a basis for city connectivity and public space at a large scale. Around the world, abandoned rivers, bayous, under-utilized streets, and rail lines are being reborn as trails, linear parks, sky parks, and neighborhood gathering places. Our most beautiful cities, planned in bold strokes, are built around these structures, weaving the natural and man-made into new urban forms that make our environments more sustainable and livable.

The Pearl River Delta of Southern China, near the industrial powerhouses of Guangzhou and Shenzhen, and the financial engine of Hong Kong, is a rapidly expanding high-tech and industrial zone. Also famous for its smaller-scaled canal-centric villages, the delta is experiencing ever-expanding flooding events, putting life and property at growing risk. Conceived in response to this growing development pressure, and designed around a natural solution to alleviate flooding risk, Shunde New City incorporates a constructed wetland delta system into a new 72-square-kilometer multimodal city, thereby restoring bird and wildlife habitat, reconnecting people to a lost water culture, and expanding flood storage capacity. A multi-dimensional water framework employs an abandoned delta system to include trails, recreational spaces, wetlands, community buildings, museums, water taxi, and light rail, and also improves land values, thus attracting creative industries and an educated workforce.

In our search for solutions as urban designers, we look to nature for inspiration. Somewhere within her complexity and interdependence, there exist clues to improving our built environment. We seek to combine the scientific understanding of natural processes with their formal exhibition into an artistic composition that reflects an intentional, sustainable vision.

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RUBBER AGROFORESTRY: ECOSYSTEM SERVICE, LIVELIHOOD DEPENDENCE & SUSTAINABILITY - A CASE STUDY OF PANAMKARA REGION IN KERALA

Sujith P S

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Cash crop likes rubber, coffee, cocoa and tobaccos etc are typically produced by smallholders in developing countries and are considered to be a major source of export revenue. Small scale plantation linked producers of cash crops are crucial for development and environment protection. Patchy and anecdotal evidence suggest that the aggregate scale of their contribution on a global platform has been huge. Rubber is a big business around the world, it has not only helped billions of household by creating various livelihood opportunities but has also helped greatly to reclaim ecosystem that were severely damaged due to anthropogenic reasons. Studies at Rubber Research Institute of India (RRII) has shown carbon sequestration potential of natural rubber is much greater than most tree species used for afforestation.

The southernmost state of India Kerala is a long narrow strip of land on the extreme west coast of India with an area of 38,863 km square and approx 80 percent of the state is under rubber cultivation and out of which 90 percent is cultivated by small scale planters which has not only enriched the state with afforestation but has also has transformed the lives of many along its length and breadth. For well over 90 years, millions of households in Kerala have been directly dependent on natural rubber plantations for their livelihood by means of harvesting, processing or product making sectors in the state. However the characteristic of small-scale plantations, the nature of their activities and difficulty in capturing their impact on national data set have left these groups largely overlooked by policymakers moreover the implication of decision by COP 9 of including afforestation and reforestation into the CDM of Kyoto Protocol and the volatile nature of rubber in terms of price variability at local and global level has left the rubber economy vulnerable.

The study was carried out in a sub-village Panamkara of Kadavoor village which comes under Kothamangalam block of Ernakulam district one of the prominent belt of rubber cultivation in the State of Kerala. This study area was selected purposively considering three norms firstly, the presence of market here is dominant than the state, secondly, the concentration of small holding plantation are high and lastly unawareness of local people about the strategic measures being taken for the sustainability of the rubber economy.

The study tries to unravel the reasons behind the failure of economic policies for the sustainable development of rubber economy while understanding the pattern of responses being adopted by stakeholders at different nodes of the rubber value chain in a situation like this.

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RECOVERING ECOSYSTEM SERVICES THROUGH AGRICULTURAL INTENSIFICATION IN DEGRADED LANDSCAPES

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Agriculture without appropriate management leads to loss of multiple ecosystem services, including the basic provisioning service of food production. In many cases it also leads to clearing new lands for more, unproductive agriculture eroding biodiversity and other essential ecosystem services. But in many places there are no new lands for agricultural expansion, resulting in a spiral of low productivity, degraded lands and impoverished livelihoods. Although there is substantial information on these interrelated declines, there is little information and few studies on the recuperation of agriculture and related ecosystem services and livelihoods. We explore a few cases of intentionally, well-managed agricultural intensification in degraded areas, looking at some of the changes in ecosystem services. We present new data from a long term site in Kenya where agricultural intensification was actively coupled to managing the environment with the multiple objectives or recuperating agricultural production, ecosystem services and livelihoods.

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ECONOMIC VALUATION OF TREE COVER IN PERTH, AUSTRALIA

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Trees in urban areas provide a variety of ecosystem services and have economic value. But trees are found in different locations in the urban areas, raising the question that are trees in all different locations have same economic value? Understanding of the economic value of trees in urban areas based on their spatial location – whether in private or public space - would help urban planning. In this research, we value tree canopy cover in private and public spaces in Perth, Western Australia, using hedonic property price model, controlling for other factors affecting property prices including three types of spatial effects – dependent valiable lag, independent variable lag, and error. Our results suggest that tree cover on the property has no effect on property value, whereas the tree cover on neighbouring property decreases the property price. However, the tree cover on public open space within 20 m buffer of the property increases the property value. In addition, in relation to the location of the property, nearer and larger bush reserves, golf courses, and lakes increase the property price, but increased burglaries and robberies in the suburb decrease the property price. All three forms of spatial effects exist that influence the property price. Our results suggest that tree cover in different spatial locations has different economic values. In particular, tree cover in private space either won't affect the property price or even affect it negatively, indicating negative externality of tree cover from neighbouring property. The positive spill-over benefit of tree cover on adjacent public open space to home owners suggest the importance of urban forestry or urban greening programs to provide economic and environmental values to urban residents.

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MAINSTREAMING PAYMENT FOR ECOSYSTEM SERVICES IN DRINKING WATER SCHEMES: EVIDENCES FROM KOSHI HILL NEPAL

Presented by: ***Ram Pandit***[1]

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This study focuses on process and mechanism to develop Payment for Ecosystem Services (PES) Scheme in Drinking Water Project. The study was carried out in Dhankuta town of the eastern Nepal. Concerned stakeholders were interacted several times either in individual and/or in group in various stages from understanding the scenarios to negotiation for establishing PES scheme. The study followed four critical steps including an assessment of scope of developing PES, Focus Group Discussion to understand background, Household survey to determine preferences of ecosystem managers and service consumers, and District level workshop to validate results from household survey and to facilitate negotiation between ecosystem managers and service consumers. The study suggests that implementation of PES scheme is feasible creating multi-stakeholder institution at local level. This would create trust between ecosystem managers and consumers, and encourage their participation in watershed management. However, the study also shows that water users may try to pay less than their willingness to pay (WTP) while they are in group compared to that they expressed individually. In this context, ecosystem managers may have to wait some years to increase their bargaining power implementing activities as per the plan to enhance the supply of targeted services. However, in the short run, developing annual plan by Central Government and Local Government agencies in line with PES scheme may enhance the welfare of upstream communities without putting additional financial burden to water consumers. The study also suggests providing support to upstream communities in kind rather than in cash to address governance issues and also to reduce cost of delivering required materials in rural area. This also ensures the utilization of fund in the planned activities.

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USING US EPA'S ENVIROATLAS TO IDENTIFY LOCATIONS FOR URBAN HEAT ISLAND ABATEMENT

Stephanie Panlasigui
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Excessive heat in the summer months can be dangerous to human health and increases demand for water and electricity. Cities tend to experience higher temperatures than the surrounding natural area, a phenomenon known as an urban heat island (UHI). Trees are provisioners of ecosystem services, including heat mitigation in the urban environment. Trees and other types of green infrastructure, such as rooftop gardens and green rooftops, can help reduce the effect of UHI, leading to health benefits such as lowered risk of heat stroke, dehydration and respiratory distress. Often green infrastructure is not uniformly distributed, resulting in some neighborhoods being more affected by UHI than others. Project planning which targets areas having low levels of green infrastructure may help with community revitalization, UHI abatement, and improved community health for a more sustainable future.

To this end, we demonstrate the use of US EPA's EnviroAtlas data along with other data sources to explore one solution for minimizing the negative impacts of excessive summer heat due to urbanization. EnviroAtlas contains a variety of ecological, economic and demographic data related to ecosystem goods and services for the contiguous US and featured communities. For the Portland, OR community, we created a data layer representing a summer daytime UHI index using Landsat 8 scenes. We used thermal infrared information in Band 10 to estimate land surface temperature (LST) for multiple summer dates, then calculated an index that is the average difference from median LST. We incorporated an EnviroAtlas data layer of percent tree cover along busy roads that is based on the 1-m resolution land cover product. We also explored the demographic metrics to view the exposed and vulnerable populations. Based on US EPA's Making a Visible Difference recommendations we selected neighborhoods in need of revitalization efforts by local governments. By prioritizing areas with a high UHI index and low amount of tree cover along busy roads, we identified four sections of major roads that may be good candidates for installation of street trees or other green infrastructure. Planning green infrastructure into the revitalization efforts would provide additional benefits beyond just reduced heat mitigation for the community, such as increased property values and improved human health and well being. While this analysis was conducted in Portland, OR, it can be applied to any other location.

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DATA COLLECTION CHALLENGES AND OPPORTUNITIES FOR THE QUANTIFICATION OF GHG EMISSION REDUCTIONS ON WORKING LANDS

Robert Parkhurst[1]*, Sara Snider*[1]*, and Lisa Prassack*[2]
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One of the opportunities for working land owners and managers to generate new revenue streams is through the creation of carbon offsets, particularly through California's cap-and-trade market. Between 2013 and 2020, California companies are allowed to purchase more than 200 million metric tons of reductions from non-capped entities throughout the United States.

To take advantage of this market potential, sufficient data must be collected in order to calculate and demonstrate GHG reductions have been achieved. We looked at the features and trends of nearly two dozen farm and field management applications to determine their ability to collect the necessary data to create nitrous oxide (N_2O) carbon offset projects. We then selected a handful of the more capable, more widely adopted, and/or more forward looking applications to do a more in-depth probe. We evaluated each of the applications for their ease of use and ability to capture and represent the data required to run various carbon quantification models.

We identified three different approaches where data could be exchanged with carbon quantification models: a push-pull model, a pull only model, and a push only model. Each of these approaches has various advantageous and disadvantages including level of technical complexity, ability to implement, and cost to develop.

This presentation will focus on the challenges and opportunities of collecting data from select farm and field management applications, how to integrate them into carbon offset protocols and related tools, and the potential methods of exchanging data between farm and field management applications and protocols and tools.

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REDUCING THE VERIFICATION COSTS FOR CARBON OFFSETS ON WORKING LANDS

Robert Parkhurst, *Sara Snider, and Rebecca Haynes*
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Carbon offset markets have emerged in the United States over the last decade as an innovative idea to engage sectors of the economy which often are not the focus of reducing greenhouse gas emissions. As of the end of July 2016, 12 different protocols have been adopted by the American Carbon Registry, Climate Action Reserve and Verified Carbon Standard which focus on croplands and rangelands, commonly referred to as working lands. Unfortunately only five projects have been created and only two of them have generated credits totaling 39,385 credits.

Through its work on these protocols, EDF has determined that verification costs are consistently the highest cost in developing carbon offset projects on working lands; often topping more than 50% of total costs. The cost of verification is driven by a number of factors including: the number of landowners, requirement to visit all landowners in a project, distance between those landowners, and traditional frequency of verification of offset projects. There are examples where alternative and cost-effect verification has been used in international offset markets as well as in other sectors, such as performing risk-based and randomized verifications. However, these practices have yet to be adopted in U.S. carbon offset markets.

This presentation will focus on:

1. The historic challenges in developing offset projects on working lands
2. The drivers for the current state of verification
3. Opportunities from other markets which could be applied to the U.S. carbon market
4. Recommendation for a path forward

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ECOSYSTEM SERVICES AND WATER RESOURCES INVESTMENTS - IMPLEMENTING CEQ'S PRINCIPLES, REQUIREMENTS, AND GUIDELINES (PR&GS) FOR WATER AND LAND RELATED RESOURCES IMPLEMENTATION STUDIES

Presented by: ***Emily Pindilli***

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The recently issued water resources *Principles, Requirements and Guidelines* (PR&G) have a strong ecosystem service focus. This paper will discuss the ecosystem service component of the PR&G, how the PR&G have been implemented at the Department of the Interior, and how the PR&G implementation activities fit into the broader context of how DOI is approaching CEQ's guidance to integrate ecosystem services into agency decision making.

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WHAT LESSONS HAVE LEFT THE ECONOMIC VALUATION STUDIES OF ECOSYSTEM SERVICES IN MEXICO?

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The literature about economic valuation studies have been heavily biased in favor of developed countries. One clear example is the number of contingent valuation studies, in which only 3% of all worldwide studies come from developing countries. In recent years, several international initiatives (i.e., the Millennium Ecosystem Assessment in 2005 and The Economics of Ecosystems and Biodiversity in 2010) have sparked more research on this issue everywhere, including Mexico. Using various sources of information, we reviewed the literature about the economic valuation of ecosystem services (ES) in Mexico. We examined those works that explicitly recognized the public nature of nonmarket ecosystem services, which are characterized by a diversity of direct, indirect, and especially passive use values. Our objectives were to analyze the diversity and consistency of value estimations, identify research gaps, and suggest points of direction for future research according to the international mainstream literature. We found 48 studies that used non-market valuation methods to estimate the economic benefits of 25 types of ecosystem services. The most evaluated service was recreation, followed by water and food resources. Contingent valuation was the most cited method followed by the choice experiment and travel cost methods. While the number of studies (and interested scholars) is encouraging, many important ecosystem services still remain unnoticed and are not accounting towards the total economic value (e.g. pollination, medicine, bioenergy, etc.). In addition, the majority of studies revealed a lack of validity tests, which challenges the reliability of results. Hypothetical bias and the embedding effect are serious problems that must be addressed in future stated preference studies. Considering the issues reviewed here, we believe that the scientific community in Mexico should keep doing more research on economic valuation. The economic valuation studies could help identify the areas, the stakeholders, and other issues that are critical in the decision-making process involving ES. They can also assist in implementing real markets for ES and appropriately allocating the costs and benefits to consumers through partnerships involving the government, providers, and the private sector. In sum, this information can help highlight the critical role of ecosystem services in society.

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IMPACT OF AFFORESTED EUCALYTPUS PLANTATIONS ON ECOSYSTEM SERVICES IN ENTRE RÍOS, ARGENTINA

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Ecosystem services provide essential goods and services to human communities, but many of these services can be impacted by land-use change. In Entre Ríos province in northeastern Argentina, large-scale eucalyptus plantations are replacing ranchlands and annual crops as the dominant land cover and land use. These afforested eucalyptus plantations represent a new land use in a region that historically was once part of the Pampas grassland. Favorable government policies and market conditions will likely result in the continued expansion of large-scale monocultures of even-aged eucalyptus stands with unknown consequences for multiple ecosystem services. As part of an international, interdisciplinary team we studied the impact of these plantations on birds, native bees, soil and water in the region. As a next step, we have begun to model relative changes in pollination services, carbon sequestration, water usage, and wildlife habitat quality using Natural Capital Project's InVEST software to understand how land-use change may impact these services at the landscape scale. We considered two future scenarios, one representing a "business as usual" case based upon land-use trends from the last ten years and a second scenario representing a potential expansive eucalyptus alternative. We then contrasted these results with a current land-use map and one we designed based upon the communities' values of ecosystem services, which we also surveyed for, for a total of four maps. Preliminary results demonstrate that the expansion of eucalyptus may cause a decline in pollination provided by wild bees and a reduction in wildlife habitat for bird communities, along with variable changes in soil carbon values and water usage. Final results for our modeled ecosystem services will be shared with the communities we surveyed as a focus group, and we plan to incorporate the communities' views into final recommendations. Our early results suggest the expansion of eucalyptus plantations will likely result in the reduction of these modeled ecosystem services. Future research should seek to study ways to minimize the impacts alternatives to such as silvo-pastoral system or agro-forestry techniques of eucalyptus production.

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PRIORITIZING BOTTOMLAND HARDWOOD FOREST CONSERVATION

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Bottomland hardwood forests are among the most biodiverse and productive, from an ecosystem services standpoint, of the several native and managed forest types in the southern US. Particularly in the coastal zone, the value of these forests for protection from storms, as carbon stores, as habitat for resident and migratory bird species, for aesthetics, and, to a lesser degree, timber for value-added manufacturing, may greatly exceed that of the pine plantations and other land cover types to which bottomland hardwoods are often lost (Schmidt, Moore, & Alber, 2014).

Much of the Coastal South's bottomland hardwoods are gone, however, replaced in earlier times by cropland, pine plantations, or development that do not provide the same range or level of ecosystem services. According to the US EPA (2012), 60% of the original extent of this forest type have been lost. And while the loss has been staunched since the 1970s, a new wave of stressors could mean further erosion of the extent, health, and important ecosystem service contribution of these forests.

To identify areas where bottomland hardwoods could or should be preserved and/or where their management for diverse ecosystem services could be improved, our research is looking at current and likely future conditions across a 12-state region to help determine where enhanced conservation could do the most to ensure the provision of those services into the future.

The study region consists of the states of the coastal U.S. from Virginia around to Texas, as well as portions of Arkansas, Tennessee, Kentucky and Illinois, where significant remnants of wetland forest remain. In the ecosystem service dimension, our scope focuses on those services stemming from water regulation (supply, quality and timing), control of damages from extreme weather events (coastal and other flooding), carbon storage and sequestration, and habitat value.

Our methods consist of first identifying the current extent and location of the remnant wetland forests and developing two scenarios for their future extent. The first, a "business as usual" scenario, considers urbanization, fiber demand and other trends leading to the conversion of wetland forests to developed uses and/or to intensive forest management regimes, including plantations. The second, a conservation scenario, considers how the remaining forests could be allocated to protected / conservation status (e.g. as public land or under conservation easements), to ecologically sensitive forestry, and to more intensive timber management. This allocation will be guided by the relative intensity of the target ecosystem service as well as the forests' proximity to beneficiaries and other stakeholders.

Specific results and conclusions will be available before December, but we do intend that the results will inform recommendations regarding the location of preserve areas and the allocation of other areas to different types of forestry. The overall objective is to assist the design of strategies to sustain the highest possible flow of ecosystem service value from the region's remaining wetland forests at the least possible cost.

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CHESAPEAKE BAY WATERSHED: STREAM AND FLOODPLAIN ECOSYSTEM SERVICES

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Streams and floodplains provide ecosystem services including water quality regulation, wildlife habitat, flood attenuation, and recreational opportunities. Protecting and restoring these services is increasingly being recognized and prioritized by land use decision-makers. However, there is a lack of information on ecosystem services and values applicable to the local scale at which decisions are made. This is in part due to the complexity of characterizing ecosystem data and functions. This presentation will describe an ongoing project designed to make ecosystem service information on streams and floodplains available and useful for land use decision-making at appropriate scales via LiDAR mapping of stream and floodplain physical characteristics, development of biophysical metrics to estimate ecologic function based on physical characteristics, and economic valuation of the services provided. This research focuses on the Chesapeake Bay watershed in the mid-Atlantic region of the United States.

LiDAR mapping includes characterizing floodplain features such as floodplain extent and width, levees, terraces, wetlands, toe slopes, and channel dimensions. The physical characteristics are directly relevant to the ecosystem services capacity of the floodplain and will be directly used in service quantification. The ecosystem services of interest include water quality (e.g., nutrient and sediment removal, retention, and transformation functions), flood protection or attenuation, wildlife habitat (living resources and healthy watersheds), carbon sequestration, and recreation potential. Each service has both local and downstream mainstem Chesapeake Bay benefits that will be considered.

The presentation will include a discussion of the methods used to value the ecosystem services. Downstream benefits of reduced sediment and nutrient loads to the Chesapeake Bay are being assessed using benefits transfer focusing on the recreational values associated with lower concentrations of sediment and nutrients. Flood attenuation benefits are being assessed based on damage costs avoided. The value of wildlife habitat is being considered via its recreational benefits for activities such as fishing, wildlife watching, and boating, using benefits transfer from primary data studies conducted in the Chesapeake Bay watershed.

This research project is designed to demonstrate the benefits of an integrated approach to evaluating ecosystem services. Another critical objective is to consider and provide information at the local decision-making scale. By utilizing geospatial information and developing metrics to associate floodplain physical characteristics with ecosystem services, there is a substantial potential to apply this methodology to other watersheds greatly increasing the availability of ecosystem service information on streams and floodplains for local decision-making.

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CONSIDERING TRADEOFFS OF MANAGEMENT ACTIONS IN THE GREAT DISMAL SWAMP NATIONAL WILDLIFE REFUGE USING AN ECOSYSTEM SERVICES PORTFOLIO APPROACH

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There are often tradeoffs associated with land management decisions. Wildlife refuge managers have the difficult task of balancing diverse ecological requirements and varying societal values. An ecosystem services approach supports decision-making by quantifying the multiple benefits provided by a system. Valuation of those services provides a tool for considering them in an integrated way. This presentation will describe an ongoing multi-disciplinary research initiative taking place in the Great Dismal Swamp National Wildlife Refuge, a forested peat wetland located in southeastern Virginia and northern North Carolina (USA).

In partnership with the FWS and others, USGS is evaluating how much carbon is stored and/or sequestered on the refuge. Carbon sequestration is an important ecosystem service; however, it is just one of multiple services that the refuge ecosystem provides. To evaluate tradeoffs associated with management activities on the refuge, a portfolio of ecosystem services is being assessed. In addition to carbon sequestration, the following services are also being considered: recreational wildlife viewing, fire mitigation, flood protection, and nutrient cycling.

The approach to derive the quantities and values of the portfolio of ecosystem services under current conditions will be briefly described during the presentation. For carbon sequestration, literature values associated with refuge vegetation and soil pools are being used to populate a state and transition model. The social cost of carbon is being applied to total refuge carbon sequestration to determine the monetary value for this ecosystem service. Recreational wildlife viewing was assessed using visitation information that is collected by the refuge and a benefits transfer approach using consumer surplus values for travel-costs. A number of benefits stem from fire mitigation, the quantification of health impacts due to peat fire and the value of avoiding those impacts will be discussed. The methodology to assess flood protection and nutrient cycling will also be described. Finally, the state and transition model and future simulation of management actions on the refuge using that model and connecting it to ecosystem services will be discussed.

The presentation will focus on why is is important to consider a portfolio of ecosystem services and the impacts of management actions on all of those services when making refuge management decisions. If considering only one service, such as carbon sequestration, the tradeoffs are not fully recognized and may lead to unintended consequences.

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NEXT STEPS IN MAINSTREAMING THE VALUE OF NATURE: CHANGES IN CULTURE, POLICY, AND INDUSTRY

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In 2015, Dow announced an ambitious goal to identify $1 billion in long term value from projects that are also better for nature. The “Valuing Nature” goal requires the Company to look differently at the services nature is providing, and to attribute value appropriately to those services. As the Company works to attain this ambitious goal, we see examples where policy and regulatory changes are needed to enable investment in nature as a business solution.

This discussion will focus on those external drivers and how they can support or hinder a goal focused on the value of nature to industry. The speaker will share a vision for continuing to move toward mainstreaming valuing nature within industry, share examples of the methodology for valuing natural capital and ecosystem services from the six year history of collaboration across The Nature Conservancy and Dow and note how differences in these external drivers can impact that valuation. This talk will invite discussion with other members of the session and the audience on opportunities and challenges in doing this type of work.

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CUMULATIVE IMPACTS - NEW SUSTAINABILITY FRAMEWORK FOR THE APPALACHIAN LCC

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The region covered by the Appalachian Landscape Conservation Cooperative (LCC) encompasses a rich diversity of forests, streams, and other natural resources. Millions of people benefit from ecological services provided here as diverse as clean water, forest products, outdoor recreation and tourism, fish and wildlife conservation, and the recycling and storage of carbon and nutrients. The region is also the scene of rapid environmental change—both realized and expected—which may compromise the sustainability of ecological services. The drivers behind such change broadly include changes in land use, land cover, and climate; large-scale disruptions associated with wildland fire, forest pathogens, and invasive species; and other factors acting across large landscapes.

Understanding the linkages among and vulnerabilities to ecosystem services and drivers of broad-scale change within the Appalachian region is essential to effective management. Such understanding helps managers, scientists, industries, and the public establish a common language for linking the environmental and economic values of the region's natural assets in a way that encourages protection of and investments in these resources.

This presentation reports on the initial products generated through a grant to the LCC to the USFS Eastern Forest Environmental Threats Assessment Center to deliver (a) an inventory and synthesis of existing ecosystem service assessments, related products including geospatial data, and decision-support tools, that have relevance for the Appalachian LCC region, and (b) building on this inventory, the conceptual framework for a comprehensive vulnerability assessment for select services that provide critical social and environmental functions. Progress on the second phase of the work (c) will be presented using the conceptual assessment framework to design a set of tools, data, and analyses that identify vulnerabilities associated with key stressors in a spatially explicit way across the LCC. These products will provide managers and other partners the means for understanding the potential effectiveness of alternative planning and management strategies, given expected environmental change.

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THE CASE FOR CONSERVING AND REGENERATING ECOSYSTEMS THROUGH THE CREATION OF AN "ECOSYSTEM EQUITY LINE OF CREDIT"

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Globally the largest cause of deforestation and forest ecosystem loss is the conversion of forest resources by smallholders. Smallholders are rational decision makers, and until the value of conserving and regenerating forest ecosystems is greater than the return to forest conversion, smallholders will continue to convert forests into marketable products and land for agricultural production.

Several market-based approaches have emerged on local, national, and international levels to incentivize smallholders to conserve and regenerate the forest resources that provide valuable ecosystem services such as habitat provision, carbon sequestration, and soil preservation and restoration. One of the most high profile and relatively successful approaches is payments for ecosystem services (PES) schemes. PES schemes however face several significant constraints. Well-functioning government institutions are necessary for the successful administration of PES schemes, a condition that is unfortunately too often absent in regions experiencing ecosystem degradation and loss. Additionally, PES schemes are dependent on a continuous source of funding for payments, something that can be both financially and politically difficult to sustain by governments that are also striving to provide access to basic services for their populations.

An alternative method to PES that also incentivizes the conservation and regeneration of ecosystems is a market-based approach that effectively creates financial equity for smallholders' resource conservation and restoration efforts. Much as the equity in a house can collateralize a line of credit (e.g. a home equity line of credit, or HELOC), the valuation of ecosystem conservation and regeneration efforts as equity could create collateral for smallholders to use to access a line of credit (i.e. an ecosystem equity line of credit, or EELOC).

This presentation will provide an overview of some of the PES schemes currently employed in Latin America, including an analysis of current payment amounts available to participants. Comparing current PES payments and interest rates in microcredit markets, one key conclusion is that the opportunity to access credit at lower interest rates would in many cases be more valuable to smallholders than receiving PES payments. Valuing smallholders' participation in ecosystem conservation and regeneration efforts as equity and providing an opportunity to smallholders to leverage this ecosystem equity to access credit has the potential to provide a more viable and cost-effective approach than PES schemes in slowing the conversion of forests and in protecting valuable ecosystems.

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THE IMPACT OF ECOSYSTEM SERVICES ON DECISIONS

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The need to integrate ecosystem services into decision-making is among today's most pressing environmental challenges. The conservation community has broadly articulated how an ecosystem services approach improves decision making, but what is the evidence for this claim? Effectively synthesizing and communicating the evidence that an ecosystem services approach positively impacts decisions, especially with policy audiences, is critical to coalesce support and momentum for conserving, restoring, and enhancing ecosystem services.

In this presentation, I will investigate the evidence that ecosystem services approaches and knowledge impact decisions. I will report on a study that tracked an ecosystem services valuation initiative in California to quantitatively evaluate how the project created key conceptual shifts in decision-makers and altered the social capacity to make conservation-oriented decisions. I will also describe some of the factors that can explain the impact of ecosystem services knowledge on decisions, including the importance of co-producing knowledge that is perceived as unbiased and representative of many diverse viewpoints. Finally, I will present ongoing boundary work to facilitate communication and build relationships among scientists and policy audiences in the U.S. — critical and timely work, given the October 2015 White House memorandum directing federal agencies to integrate ecosystem services into decision making. This presentation will evaluate the impact of ecosystem services interventions on decision makers; identify pathways through which ecosystem services impacts decisions; and provide insights for scientists who aim to do ecosystem services research that impacts real-world decision making.

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A SYNTHESIS OF HABITAT THRESHOLD DATA FOR USE IN COASTAL RESILIENCE PLANNING

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Coastal ecological and human communities are increasingly vulnerable to the impacts of rising sea levels and coastal storms, which are changing physical landscapes, disrupting natural systems, and pushing wildlife populations to the brink of irreversible change. These effects can disrupt and reduce the benefits that coastal habitats provide to human communities. A multi-LCC coastal resilience project, with leadership from the North Atlantic LCC and the Gulf Coast Restoration Program, compiled and synthesized information and tools for increasing resilience and adaptation of communities and priority coastal resources along the U.S. Atlantic and Gulf Coasts and Caribbean as a way to deliver the information to the LCC community and its partners. This work is highlighting restoration and management actions that increase resilience of coastal systems and species in the face of increasing rates of sea level rise and increased frequency and intensity of storms while also increasing the resilience of coastal communities.

In the early stages of this work, threshold data for focal habitats and species under future projections of sea level rise and storms was identified as a major need across LCCs and USGS Climate Science Centers, as well as for managers and other stakeholders. We compiled threshold data, vulnerability assessments, and qualitative research related to the threats from SLR and storms for four coastal habitats: tidal marshes, beaches and barrier islands, mangroves, and shellfish beds. We further synthesized information on system responses to management approaches and their effects on ecosystem service provisioning. Accelerating rates of sea level rise and changes in storm activity are altering coastal habitats in ways that may reduce the ecosystem services they provide. Information on thresholds of viability for coastal habitats can help inform when and where management actions should occur to ensure that ecosystem services are preserved and even enhanced over time.

The recommendations from this work include the incorporation of habitat and species information into community resilience planning using quantitative threshold data if available. The benefits of these considerations are enhanced understanding of how sea level rise and storms may affect ecosystem services provided by these habitats and guidance for natural resource managers to prevent threshold crossings. This work will shed insight on how approaches to increase the persistence and resilience of priority natural resources will benefit community resilience, and the degree to which, if any, natural and nature-based approaches to community resilience will benefit habitats and species. The ultimate goal for the network of coastal LCCs is to have decision makers informed about the potential impacts, adaptation strategies, and management approaches that incorporate both ecological and human communities in their decisions and that provide a range of ecosystem services through natural and nature-based approaches.

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INTEGRATING BIOPHYSICAL SCIENCES, SOCIAL SCIENCES, AND ECONOMICS IN ECOSYSTEM SERVICE ASSESSMENT: NEW GUIDANCE

Susan M. Preston
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Of the numerous guides to completing aspects of ecosystem service (ES) assessment, the majority focus principally on economic analysis. Few of them offer practical guidance on how to incorporate the biophysical sciences. Fewer still provide readers with explanations and advice about the equally important role of social sciences in ecosystem service assessment.

To address these limitations and others a national taskforce in Canada was assigned to develop practical guidance for government managers and analysts. Their mandate was to explain: 1. how to determine if ES assessment is the right approach for a particular decision or policy context, 2. how to complete a robust, fully integrated interdisciplinary ES assessment, 3. how to understand what the results of such analyses mean and what they do not mean – and how to communicate them, and 4. how to make use of ES analyses in a wide range of government policy and decision making contexts. The task was to provide tangible, step-by-step advice with supporting resources all on one “Toolkit”.

This presentation highlights the key features of the resulting new *Ecosystem Services Toolkit*. In particular this presentation discusses the Toolkit’s integration of a six-step assessment protocol with a suite of nine essential tools. These tools include advice on ES assessment involving Indigenous communities, a table of biophysical and social indicators for assessing each ecosystem service, worksheets, advice about both economic and socio-cultural valuation approaches, and a compendium of methods and tools, among others.

Ecosystem Services Toolkit: Completing and Using Ecosystem Service Assessment for Decision Making. An Interdisciplinary Toolkit for Managers and Analysts (Canada 2016). Electronic version available on request from the presenter.

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MAINSTREAMING ECOSYSTEM SERVICES IN POLICY AND DECISION MAKING: PRACTICAL GUIDANCE

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The last five years have seen increased commitments from governments around the world to reflect the diverse values of biodiversity and ecosystem services (ES) in decision making. Most publications developed to support these commitments have sought to resolve the numerous conceptual and methodological challenges that limit capacity to measure, map, interpret, value, analyse, and assess ES. There have been comparatively very few guides or published accounts of explicitly *how to incorporate* ES considerations in government activities. Reported 'lessons learned' reveal that it is not as simple as providing monetary estimates of ES values, but that decision makers want to know what is happening in the ecosystems they are responsible for, and how human communities are being affected (e.g. Ruckelshaus et al. 2015).

From all levels of government we hear calls for practical advice on exactly how to integrate ES into existing frameworks that must be followed for many different policy and regulatory functions.

This presentation shares practical advice developed with Canadian federal and provincial government agencies in ten different policy and regulatory areas of responsibility such as Environmental Impact Assessment, Land Use Planning, and Conservation Incentive Programs. It demonstrates how ES assessment results, analyses, or even conceptual considerations can be integrated into agency decision analysis and management processes by identifying "entry points" and explaining how ES can be addressed at each entry point. The advice reported in this presentation is fully documented in new national guidance titled *Ecosystem Services Toolkit: Completing and Using Ecosystem Service Assessment for Decision Making. An Interdisciplinary Toolkit for Managers and Analysts* (Canada 2016). Electronic version available on request from the presenter.

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GLOBAL FOREST WATCH WATER: EXPLORE THE CONNECTIONS BETWEEN FOREST AND WATER

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The World Resources Institute has developed Global Forest Watch Water (GFW Water), a publicly available global database and interactive mapping tool designed to help users to discern and glean key information on natural infrastructure to enhance water security. By 2030, the world is projected to spend an estimated $10 trillion on repairing and expanding water infrastructure. As water demand surges, dams and treatment plants age, and more frequent extreme weather events threaten our water security and drive up water management costs, need is growing for lower-cost approaches to secure ample and clean water. At the same time, efforts to safeguard water resources with innovative “natural infrastructure” approaches – such as forest protection, watershed restoration, and sustainable management of landscapes – are expanding around the world. These solutions are often easier on ecosystems, human communities and bank accounts than traditional energy-intensive, hard infrastructure approaches. As awareness on the linkage between the health of watersheds and their capacity to supply sufficient, clean water grows, stewards of watersheds – government agencies, businesses, and communities – still face many challenges and lack of information as they explore opportunities for integrating natural infrastructure approaches. To fill the gap, GFW Water allows anyone with internet access to visualize watershed related information, threats to watershed health, and screen for cost-effective, sustainable natural infrastructure solutions. GFW Water provides spatial data sets, summary statistics, and watershed risk scores for watersheds, with functionality that allows users to locate and delineate subwatersheds for analysis anywhere in the world.

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CAUSAL NETWORKS LINKING ECOSYSTEM CHANGE AND SOCIETY: FROM THEORY TO APPLICATION

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Conserving natural capitals that underlie the life-support services for humanity has been increasingly recognized as the major focus of management and policy efforts around the world. However, significant challenges remain that prevent these efforts from achieving desirable outcomes: (1) knowledge to inform management and policy actions is inherently interdisciplinary but originates from diverse sectors and often disparate disciplines; (2) concerted collaborations among academics, stakeholders, and practitioners are generally lacking; and (3) the scope of these efforts sometimes tends to be piecemeal and a spectrum of social and ecological consequences are not fully explored. Causal chains or networks, drawn from a rich legacy of theories from different fields, are conceptual or logic models that connect causes to consequences, or actions to outcomes. It has gained increasing recognition in conservation and natural resource management in recent decades, and has been proposed as a transformative approach towards holistic understanding of how management strategies or policies could alter ecosystems and the services they provide, and ultimately human well-being in complex social-ecological systems. In this research, we first review the theories and intellectual basis of causal models, and then provide three case studies of causal networks developed for representative management practices in forest, agricultural and urban ecosystems in the U.S., on the basis of workshops and co-development with experts from diverse groups ranging from academics to practitioners. These causal networks demonstrate diverse effects on a range of ecosystem services manifested through ecological production functions, and illustrate cascading effects on different aspects of human welfare. We further discuss approaches (e.g., literature review, data synthesis, quantitative models, and expert knowledge) that can be used to populate conceptual causal networks with quantitative evidence for comparing and testing effectiveness of alternative management and policy scenarios, identifying knowledge gaps, facilitating adaptive management, and better integrating into decision-making processes. Insights are also drawn from these case studies regarding effects of scale and hierarchy, landscape context, nonlinearity, and multiple drivers of environmental change on the robustness and generality of developed causal relationships. We finally conclude with several lessons for constructing effective causal networks in conservation and management, and point to gaps for future research.

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UPDATES TO THE BENEFIT TRANSFER TOOLKIT FOR NONMARKET VALUATION

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Public land managers often lack the necessary time or funding resources to collect original data for nonmarket economic valuation analyses. In response of this need, USGS partnered with the Bureau of Land Management, National Park Service, and the USGS Sustaining Environment Capital Initiative to develop a Web-based tool that facilitates the use of existing data to support the monetization of nonmarket values. The Toolkit builds upon existing nonmarket valuation tools, databases, and resources, including Colorado State University's Benefit Transfer and Use Estimating Model Toolkit (http://dare.agsci.colostate.edu/outreach/tools/) and Oregon State University's Recreation Use Values Database (http://recvaluation.forestry.oregonstate.edu/). There have been updates to the toolkit's recreation databases to incorporate more recent publications as well a new database on the value of water quality has been added to the toolkit. Furthermore, several additions were made to the toolkit to help disseminate its information to less technical users: 1) an interactive map displaying the location of each study, general details of the study and the value estimate, and 2) a series of factsheets that give descriptive statistics on each recreation database, provide average value estimates by region, and briefly explain nonmarket valuation and the mechanics of the Benefit Transfer Toolkit. This progression of the Benefit Transfer Toolkit will allow a broader base of users to effectively incorporate nonmarket values into planning efforts.

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A "SMART" NUTRIENT MARKET FOR POINT AND NONPOINT SOURCE USERS AND WETLAND BUILDERS

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Nutrient trading programs continue to suffer thin trading due to the high transaction costs and uncertain trading environment. At best, policymakers may attempt to start trading only among point source users, because a market incorporating both point and nonpoint users seems implausible. Separately, researchers have proposed constructed wetlands as solutions to reduce nutrient pollution.
Nutrient trading is a complicated common-pool problem which requires proper market design. A typical market design uses trading ratios to account for nutrient fate and transport. Trading ratio schemes have been surprisingly ineffective even for point source trading alone, partly because trading ratio systems cannot accurately account for the hydrology, but also because the proposals have not solved the problem of high transaction costs. It is no wonder that no one (to our knowledge) has attempted to set up a market that includes point source users, nonpoint source users, and wetland builders.

We propose a market design for trading credits for both nitrogen and phosphorus, with point and non-point source users, while enabling trades for wetland construction. Our market design should drastically lower transaction costs, while maintaining high fidelity to the hydrology. The proposed design is a "smart market" centrally cleared with an optimization. The smart market takes into account all relevant hydrogeological information. The optimization matches supply and demand among both point and nonpoint source users. The design incorporates the lumpy "all or nothing" nature of wetland investments. Our work follows 50 years of market design for other commodities, including electricity, natural gas and transportation, much of it developed by experimental economists.

To test our proposed design, we simulated the market for the Big Bureau Creek watershed in north-central Illinois, with a sophisticated hydrology model and detailed data. The combination of low transaction costs and locational pricing would incentivize farmers to join the market and reduce nutrient runoff. Point source users could obtain cost effective trades. The market located wetlands taking into account both cost and nutrient reduction efficiencies. We found that a few strategically-placed wetlands can offset the loads of several point source users. The market clearing mechanism ensures reasonable payments for the wetland builders taking into account the locational prices of nutrient credits – for both nitrogen and phosphorus – which balance demand and supply in every season. Payments for wetlands are likely to be closer to their true economic value, compared to bilaterally or centrally negotiated payments.

The market design is quite general. It can work for other pollutants and combinations of pollutants, e.g., biological oxygen demand, temperature, and sediment. It can work for any segment-based configuration of streams, constructed wetlands, or other best management practices. We will also outline some of the prerequisites needed for implementing the proposed smart market. In general, implementing those prerequisites should be done anyway, whether or not a market is the intended outcome. We will show that the prerequisites are more palatable when a market is the intended outcome.

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USE OF ECOSYSTEM SERVICES IN EPA DECISION MAKING FOR CRITERIA AIR POLLUTANTS

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The U.S. Environmental Protection Agency (EPA) currently is conducting a joint review of the existing secondary (welfare-based) National Ambient Air Quality Standards (NAAQS) for oxides of nitrogen (NOx) and sulfur (SOx). EPA has decided to assess jointly the science, risks, and policies relevant to protecting public welfare associated with oxides of nitrogen and sulfur due to both their atmospheric interactions and ecological effects. As stated in the Clean Air Act (CAA), the purpose of a secondary NAAQS is to “protect the public welfare from any known or anticipated adverse effects associated with the presence of such air pollutants in the ambient air.” Assessments of adverse public welfare effects are based on how ecologically adverse impacts translate into adverse impacts on public welfare via changes in ecosystem service delivery. While adversity is not explicitly defined in the CAA, it can be inferred that adverse ecological impacts have some corresponding impact on the well-being of humans, through reductions in ecosystem services that might include direct (e.g., timber production) or indirect (e.g., provision of habitat for endangered species) services to humans. These ecosystem service linkages are being used to inform the standard setting process.

Ecosystem services are being used to characterize adversity to public welfare of ecological effects associated with current levels of nitrogen and sulfur deposition. Ecological effects associated with terrestrial nitrogen enrichiment, aquatic nitrogen enrichment (including eutrophication), and terrestrial and aquatic acidification due to nitrogen and sulfur are being evaluated by linking critical loads to ecological chains (i.e., ecosystem production functions) to final ecosystem services. By synthesizing across various ecological effects and ecosystems, we will show how nitrogen and sulfur deposition can affect the same ecosytem service(s) across the country. For example, timber production can be affected by both acidification and eutrophication through various pathways and locations resulting in a cumulative effect on the national production of timber. Combining these ecological chains provides an analysis of the effects of decreased timber production through the economy and links to metrics of social welfare. If quantified, this type of synthesis can aid in defining the magnitude of the effects on public welfare resulting from nitrogen and sulfur deposition.

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NATIONAL ASSESSMENT OF ECOSYSTEM CARBON SEQUESTRATION AND GREENHOUSE GAS FLUXES

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In accordance with the Energy Independence and Security Act (EISA) of 2007, the U.S. Department of the Interior (DOI) is conducting an assessment of carbon storage, carbon sequestration, and fluxes of three greenhouse gases (GHG) for the Nation's ecosystems. The assessment includes a baseline component and a potential sequestration component. The baseline component uses existing inventory and remote sensing data to analyze spatial and temporal distributions of carbon stocks and GHG fluxes. The potential component uses IPCC scenarios and associated economic and policy assumptions of the scenarios to develop projections of future land use/land cover (LULC) change and carbon sequestration. Carbon storage, carbon sequestration capacities, and GHG emissions are assessed using a biogeochemical modeling system that incorporates management activities and ecosystem properties (such as elevation, vegetation characteristics, and soil attributes) and integrates them with land use change, fire, and climate data. Four regional assessments (Great Plains, Western US, Eastern US, and Alaska) have been completed to date, and the Hawaii assessment is presently under review. In addition to the assessments, the USGS is actively participating in carbon research and application activities with other Department of Interior bureaus. This includes a valuation of carbon in U.S. national parks, and land management activities and their effects on carbon sequestration in National Wildlife Refuges.

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INTEGRATED ASSESSMENT OF ECOSYSTEM SERVICES FOR SUSTAINABLE MANAGEMENT OF NATURAL RESOURCE, A CASE OF LAKE HAWASSA BASIN, ETHIOPIA

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The recent anthropogenic activities coupled with population pressures and point and non-point source pollutions contributed for the degradation of natural resources. This has a direct or indirect effect on annual potential ecosystem services of the basin provided by Lake Hawassa Basin (LHB) ecosystem. The purpose of this research is to assess and map the use and importance of Lake Hawassa Basin ecosystem services and identify possible impacts due to point and non-point source pollution to recommend best management practices. The study used primary and secondary data, expert judgment matrix, conducted site visit, and consultations with relevant stakeholders at different level and mapping of ESS with ArcGIS v10.1.

During consultation, stakeholders selected ten (10) LULC and thirteen (13) provisioning, regulating, and cultural ecosystem services (ESS), which are the benefits that humans obtain from nature in the study area. Results of the study revealed that, spatial and temporal variation of ecosystem services identified within the LHB based on the relevant capacity of the LULC classes to provide annual potential ESS for the community residing in the basin. 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 were 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 and LULC maps plotted for 2037 and selected ESS. In addition, the study identified potential impacts of point and non-point source pollution on the existing annual potential ecosystem services of Lake Hawassa Basin and recommended best management practices to offset and/or minimize these impacts.

The study provides an alternative development options and basic information used as a tool to communicate decision makers and other development partners during future watershed management plan and other development activities to ensure sustainable management of natural resources in Lake Hawassa basin.

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MANAGING FOR WATER SUPPLIES AND WATERBIRDS IN IRRIGATED FARMLANDS OF CALIFORNIA

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With the loss of over 60% of the world's wetlands, wetland-dependent wildlife increasingly rely on compatible management of agricultural lands for habitat needs. Conservation of biodiversity on private agricultural lands poses many challenges and successful programs need to create and incentivize the most effective management practices in durable ways that work for farmers. However, this objective is challenged by poor information about species needs and habitat availability, a lack of tools for deploying conservation actions efficiently, and the high cost of implementation at meaningful scales. In addition, agricultural landscapes are spatially and temporally dynamic, adding to the complexity of delivering valuable habitat reliably. We have been developing and testing new approaches and tools to address these challenges, as applied to creating temporary wetland habitat for migratory waterbirds at the right times and places in intensively cultivated agricultural landscapes of California. Working with farmers, agencies, and research partners, we have applied big data analytics and emerging precision science tools to enable more targeted delivery of habitat investments on farmlands and have coupled these tools with a novel habitat procurement market in which farmers are paid to modify their practices in order to create bird habitat. These approaches to delivering temporary habitat meet the needs of migratory species, use water efficiently, especially in drought conditions, and respond to the practical reality of sourcing habitat from a dynamic, intensive agricultural system. Through agency and industry collaborations we have partnered with over 300 farmers, and delivered over 90,000 hectares of habitat, demonstrating the large-scale applicability of these approaches, as a nimble and cost-effective complement to traditional permanent protection strategies.

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CLASSIFYING ECOSYSTEM SERVICES FOR ECOSYSTEM ACCOUNTING AND RESEARCH PURPOSES – STATE OF THE ART AND KEY CHALLENGES

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Purpose and scope: This presentation explains current progress and challenges associated with international efforts to build an ecosystem services (ES) classification system that meets the needs of multiple users. “Ecosystem services” has become a key research topic for academics, agencies, and governments, but is also a central concept in the UN handbook on “Experimental Ecosystem Accounting” (see: http://unstats.un.org/unsd/envaccounting/eea_white_cover.pdf), which aims to use the rigor of national accounting principles to measure the contribution of ecosystems to the economy and to human well-being.

The United Nations Statistics Division (UN-SD) has the task of developing standards for the “System of Environmental-Economic Accounting” (SEEA) to be used by statistical offices and official research efforts. As part of this process UN-SD has asked the developers of three ES classification systems to explore what common ground exists between them, with the goal of developing a unified and multi-functional ES classification (or set of linked classification systems). The systems are the Common International Classification of Ecosystem Services, (CICES), the Final Ecosystem Goods and Services Classification System (FEGS-CS), and the National Ecosystem Services Classification System (NESCS). This paper sets out the approach and objectives for this exercise.

Methodology and interim outcomes: The first step in the comparison of the three systems is to establish key user requirements in different communities (accounting, ecosystem assessment, trade-off analyses, etc.) and to identify criteria essential for statistical classifications. The second step is to clarify key concepts and terminology used in all three systems, in order to find agreement on conceptual interpretations and a common vocabulary, or at least to inform a joint translation tool where necessary – for example, the “final ecosystem services” concept is interpreted differently between the systems and in different application contexts. The third key step is to apply the three systems to a selected set of case studies, to compare approaches and outcomes. The final step involves reviewing whether the main user requirements and criteria can all be accommodated within a single system, or whether a small set of linked systems would be the better approach.

All three ES classification systems are complete, consistent within their own objectives, and ready to be used. However, each would need modification to be fully "SEEA compliant.” All three seek to identify “final ecosystem services,” but each system frames the concept differently, especially as they classify abiotic elements of the environment in addition to biotic ones. The three systems further differ in how they identify beneficiaries and benefits.

Conclusions and next steps: The cooperative process established for comparing the ES classification systems offers a useful way forward. Results will receive feedback from experts and SEEA advisory bodies. Feedback is also sought from disciplines represented at ACES. The UN-SD process foresees developing a common approach across purposes and academic disciplines by mid-2017. Commitment to a common approach should also enable easier comparison of ES assessments results across different research teams, and perhaps enable the building of a joint database of results that estimate the benefits that human society derives from ecosystems.

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IMPROVING CORPORATE PERFORMANCE WITH FINAL ECOSYSTEM SERVICES

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Businesses are not getting the full benefits of ecosystem services due in part to weaknesses in classification systems. The "final ecosystem services perspective" embodied by the Final Ecosystem Goods and Services Classification System (FEGS-CS) and the National Ecosystem Services Classification System (NESCS) resolve bottlenecks to mainstreaming ecosystem services in corporate decision making. Compared to other systems, these are arguably easier to use, improve materiality analysis and aid stakeholder engagement.

Ecosystem services can be differentiated into ecosystem processes and functions ("intermediate ecosystem services") and "final ecosystem services" (FES). This takes into account the steps necessary to translate components of an ecosystem into a "service" that directly impacts well-being. For example, for a fish to make it to market, a boat, fishing supplies, fuel and labor are needed in addition to a ready stock of fish. The fish depend on numerous environmental functions, from habitat quality to nutrient cycling.

The principles of (1) focusing on the transition point and (2) noting the beneficiary at that transition point can be considered the "final ecosystem services perspective." When applied to classification systems, as with the FEGS-CS and NESCS, it helps to eliminate double counting, make more efficient analytical choices and improve stakeholder engagement.

Managers are finding benefits in adopting the FES perspective across business processes.

Working papers on **natural capital accounting** mention final ecosystem services, noting the advantages of avoiding double counting and identifying beneficiaries. One example from these papers values food, recreation, and climate regulation services from a site. FEGS-CS would eliminate carbon sequestration from the list of FES—moving it to the environmental accounts.

Some experts caution that the FES perspective could increase **reporting** requirements; but it should reduce burdens by reorganized natural capital reporting into three groups. The first would use the mitigation hierarchy as a basis for defining and disclosing material impacts on species and ecosystems. The second would report on benefits from FES. The third group would disclose the implications of natural capital impacts and dependencies on"ecosystem resiliency."

Most product **certification** systems measure both intermediate and final ecosystem services without distinction, often referring to ecosystem services that are used by communities. FEGS-CS and NESCS would not classify many of these as FES while sharping definitions within certification systems.

FES would bring clarity to **Impact assessments** by distinguishing between threatened species, ecosystems, and the services they provide. This would largely eliminate the supporting and regulating ecosystem services and make beneficiaries a larger part of assessments earlier in the process. Grupo Argos used FEGS-CS to help organize a sites' existing biological research. It yielded clear, compelling risks to the firm.

The FES perspective likely provides corporate managers an improved system for mainstreaming ecosystem.

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VALUING CARBON SEQUESTRATION ACROSS THE NATIONAL PARK SYSTEM

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The National Park Service (NPS) manages some of the Nation's most treasured places. These protected public lands provide a wide range of ecosystem services that benefit society, one of which is the capture and storage of atmospheric carbon dioxide. Carbon sequestration helps regulate the earth's climate by reducing greenhouse gas concentrations in the atmosphere, and as a result, provides economic benefits in the form of avoided future damages and losses from climate change. NPS has partnered with the U.S. Geological Survey (USGS) to determine the ecosystem service value of climate regulation from terrestrial carbon sequestration in parks across the United States.

To conduct this analysis, annual net ecosystem carbon balance data from USGS' LandCarbon program is combined with spatially explicit NPS land unit boundaries to determine the average net metric tons of carbon dioxide (CO_2) sequestered annually by park unit under baseline conditions. Social Cost of Carbon (SCC) estimates are then used to monetize the value of carbon sequestration across the National Park System. These SCC estimates were developed by a U.S. interagency working group to capture the avoided economic damages associated with a small decrease in carbon dioxide emissions. Based on three integrated assessment models, the SCC estimates capture future changes in the value of agricultural productivity, human health, damages from increased flooding, and the value of additional ecosystem services due to climate change.

Results from a preliminary analysis reveal that, in aggregate, park lands within the conterminous United States sequester more than 14.8 million metric tons of CO_2 annually. The societal value of this service is approximately $582.5 million per year with a 3% discount rate. Great Smoky Mountains National Park was found to sequester the largest amount of CO_2, valued at $64.4 million per year. On a per area basis, Muir Woods National Monument and Fort Raleigh National Historic Site sequester the most CO_2, each capturing more than 16 metric tons of CO_2 per hectare per year. Work is currently underway to complete this analysis for parks in Alaska and Hawaii. This overall effort contributes to the limited body of literature on nonmarket values supported by national parks, revealing the significant societal value of just one of many ecosystem services provided by the Nation's park lands.

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VALUING ON-SITE AND VIRTUAL BEAR VIEWING IN KATMAI NATIONAL PARK & PRESERVE

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More people visited national parks in 2015 than ever before, and many individuals are complementing or substituting their trips to national parks with off-site, ‘virtual visitor’ experiences, such as viewing national park landscapes and features through one of the 76 National Park Service (NPS) webcams. Understanding the economic benefits associated with both on-site and off-site national park experiences is critical for informed management decisions. The NPS relies on consumer surplus estimates for recreation activities in cost benefit analyses of regulatory actions and in analyses used to determine compensation for resource injuries. In addition, understanding the economic value derived from virtual visitor experiences can help determine whether budgets spent on maintaining NPS webcams and websites are justified on economic efficiency terms. Despite this need, value estimates specific to national parks are limited, and to our knowledge, no studies have attempted to value off-site, virtual visitor park experiences.

In an effort to contribute to the limited literature, we estimate both the on-site and off-site economic value of a unique wildlife viewing experience in a remote national park. Katmai National Park & Preserve, located on the Alaska Peninsula, is one of the premier destinations in the world to view brown bears up close in their natural habitat during the salmon migration. Many of the Park’s annual visitors come to witness this spectacle, which is a once in a lifetime experience for many. However, the Park offers more than just the opportunity to view brown bears in person. Through a partnership with Explore.org, the bears can be viewed online through a series of webcams by anyone with an internet connection. Some people watch the bears on the webcams before or after a trip to the Park, but many view the webcams instead of visiting the park. Some individuals simply don’t have the time or money to visit the park, whereas others may not feel safe being in close proximity to brown bears in the wild. The goals of this study are twofold: First, we use 2014 visitor survey data and a variation of the individual travel cost demand model to value on-site bear viewing. This innovative model addresses the complications of valuing visitor use when visitation is very infrequent. Thus, the model developed here is applicable to other remote world class sites that many people visit just once in their lifetime (e.g. Antarctica, Machu Picchu, Galapagos Islands). This value is estimated to be $290 per visitor per day. Second, we use exploratory benefit transfer methods and an approach based on the opportunity cost of time to value web-based virtual bear viewing. These results add to the limited stock of nonmarket valuation research focused on national parks, and provide a starting point for consideration of how to value virtual visitor park experiences, a research area with considerable promise.

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WHAT INFORMATION DO WE HAVE TO IDENTIFY AND EVALUATE ECOLOGICAL METRICS AND INDICATORS THAT DIRECTLY MATTER TO PEOPLE?

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The use of ecological metrics and indicators that matter directly to people makes ecological information more useful. By more useful we mean in communication with people and for social and economic analysis. While the need to specify these metrics and indicators is a view widely held, specific guidance on how to identify these indicators is lacking. The intersection of three factors – 1) beneficiary perspectives (perspectives on the ways in which people benefit from ecosystems often delineated with social science methodology), 2)economic theory especially on linked production functions, and 3) ecological understanding and practice -- provide a foundation to identify these indicators and then to evaluate the competence with which they have been identified. In our research we integrate multiple sources of information on beneficiary perspectives. This includes qualitative social science methods such as depth interviews and focus groups which provide insight into the information needed for decision making and the underlying values that are to be embodied in indicators. Linked production function theory provides a first principles foundation to refine or integrate those results. Integration with ecological understanding and practice then generates hypotheses about practical ecological indicators that matter directly to people. Other social science methods, e.g. experiments embedded in valuation studies, and biophysical methods, can provide for the evaluation of this integrated analysis. We illustrate our methods with stream data from the western United States. We recommend that such work continue and be conducted in partnerships between biophysical and social scientists

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METHODS AND CHALLENGES FOR VALUATION OF SOIL HEALTH BENEFITS

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Valuation of any ecosystem service can be a challenging endeavor, as many of the benefits accrue over a long time horizon, and at different levels to different sectors of society. Healthy soils have the potential to provide benefits worldwide, however changes, especially in rangelands in the western U.S., are expected to occur slowly. Further, any practice that is initiated to improve soil health will need to be treated as a business investment, at least from the perspective of a private ranch, and timing of the costs and benefits will likely determine an individual's willingness to adopt such practices. However, if the societal benefits from ecosystem goods and services enhanced by improving soil health outweigh the costs of required management practice(s), there exists an opportunity for government intervention in the form of a subsidy to encourage private landowners to adopt practices that provide publicly desired ecosystem goods and services. We aim to show how using a Net Present Value (NPV) approach to quantify the impacts to forage availability at the ranch level is a starting point to value changes to soil health.

We recommend using a mathematical programming model to show how optimal management decisions, and resulting returns, will be impacted as soil health changes. In order to accomplish this, there needs to be a known relationship between soil health and some productive value. We recommend using forage as the consumptive input provided, in part, as a function of soil health. Forage quantity and quality are both likely impacted by changes in soil health, and quantity can easily be both amount and timing of forage production. By accounting for changes in the availability, and quality, of forage throughout a year, we can show the impacts to profits from implementing practices that improve soil health over time. Often, due to existing constraints on season of use, additional forage is valued at above the market AUM rate. Further, the timing of benefits greatly impacts a producer's willingness to pay for improvements. Accounting for the time value of money, the Net Present Value (NPV) of benefits from a private perspective can be compared to the NPV implementation and maintenance costs of various practices. At this stage, inclusion of other ecosystem goods and services is beyond the scope of these modeling efforts. However, this approach allows for comparison of various practices as well as shows whether a practice is likely to pay for itself over a predefined planning horizon or whether subsidies are required for adoption.

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POTENTIAL EFFECTS OF CLIMATE CHANGE ON SOIL HEALTH AND ECOSYSTEM GOODS AND SERVICES

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Worldwide, climate change is predicted to alter precipitation regimes, annual temperatures, and occurrence of severe weather events. These changes have important implications for soil health--defined as the capacity of a soil to contribute to ecosystem function and sustain producers and consumers-- and, as a consequence, ecosystem goods and services. Soil health affects the ability of ecosystems to sustain productivity and sequester carbon. In extreme cases, such as those experienced during the 1930s Dust Bowl, soil degradation can result in a nearly complete loss of plant productivity and subsequent erosion of bare, nutrient-rich topsoil. Soil health is especially dependent upon the presence of soil organic matter, which provides nutrients to plants and improves the water-holding capacity of soils, among other functions. Climate change will affect soil organic matter content to varying degrees, since climate change is not predicted to affect all areas to the same extent or in the same manner. Drought occurrence is expected to increase in some areas, resulting in decreased plant productivity and increased loss of soil due to wind and water erosion. In other regions, predicted severe weather events will potentially increase rates of soil weathering and nutrient loss. Inputs of organic matter to the soil are also likely to alter as plant communities shift with changing climate, affecting soil fertility and water-holding capacity. This presentation will detail several (predicted?) effects of climate change on soil health, especially those that have the largest potential to affect ecosystem goods and services in the United States.

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LAND CARBON POLICY ROADMAP - SUPPORTING A ROBUST LAND CARBON SINK

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The vegetation and soils found in landscapes across the United States serve as carbon sinks, removing an estimated 850 million metric tons of CO2-equivalent (CO2e) from the atmosphere each year and offsetting 16 percent of annual industrial emissions. The land carbon sink is critical to ensuring that the United States meets its 2025 carbon emissions reductions targets, and more ambitious goals thereafter. However, there is little consensus on the right policies to ensure that agriculture and forest management can contribute fully to these goals. Agriculture and forestry organizations and government agencies have yet to prioritize land carbon in their strategic planning, and considerable work is required to reduce uncertainties, develop effective policies that can be a part of evolving U.S. climate policy, and build stakeholder support. Without the right policies in place, there is a chance that the sink could diminish over time, or even turn into a source due to changing land use types and management.

The Land Carbon Policy Roadmap (LCPR) initiative brings together stakeholders working at the policy level with those working on the land (farmers, foresters, ranchers), to develop bold recommendations to policymakers on the transition team for the incoming administration. This outreach and policy development will be supported by close collaboration with a policy modeling team led by Christopher Galik at NC State University. Land carbon policy interventions modeled by the analytics team will be socialized with landowners from the forestry, agriculture and ranching sectors through roundtable events and direct dialogue to build consensus support for the most promising interventions, and identify those that are less viable due to lack of impact or political will.

The LCPR will provide a basis for policy action by (a) identifying biggest bang-for-buck policy interventions, (b), clarifying the level of certainty around various land management interventions and policy design structure, and (c) identifying and engaging critical stakeholders across the land sector for supporting new policy. It seeks to embed land carbon as a policy priority for the next Administration's climate strategy, including the 2018 Farm Bill and any future climate legislation. Finally, this project aims to create a positive vision for forestry, agriculture and grazing within a carbon-constrained world, reframing previously difficult discussions about these topics within the context of supporting rural livelihoods, sustainable land management and healthy lands.

Forest Trends brings unique attributes to land carbon work, including extensive experience with convening stakeholders on challenging topics, applying technical research to real-world policy problems, and insights on how markets and private finance can be harnessed to address environmental problems. The project team brings trusted relationships with key agency and administration decision makers, and stakeholders at the national and state level. As a result of our stakeholder engagement and modeling work, the LCPR will produce ambitious policy recommendations for the incoming administration with the capacity to strongly influence the carbon sink, that have been vetted with key stakeholders. Ready to go policy recommendations built from a strong scientific basis and vetted through a robust stakeholder engagement process will allow the new administration arriving in Washington D.C. in 2017 to move forward efficiently to incorporate land carbon into current programs under existing authorities, and to begin identifying the need for creating new programs through legislative action.

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ADAPTIVE MANAGEMENT OF ECOSYSTEM SERVICES ACROSS DIFFERENT LAND USE REGIMES

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Using adaptive management to manage desired flows of ecosystem services may seem on the surface to be a good fit, but many social, economic, environmental, legal, and political factors influence how good a fit. One strongly influential factor is the land use regime within which the profile of ecosystem services is being managed. Shaped largely by legal mandates, market forces, and social and cultural practices, different land use regimes present different opportunities for and constraints on goals for ecosystem services and pose different decision making environments. Even where all other conditions appear amenable to using adaptive management, therefore, it is essential to consider the constraining (or liberating) effects of different land use regimes when deciding whether to adopt adaptive management to achieve those goals and, if so, how to implement it. The discussion covers several key points:

1. Different land use regimes influence the range of options for setting and managing for ecosystem services goals.
2. Five major land use regimes are preservation, dominant use, multiple use, developed, and engineered.
3. Multiple use and engineered land use regimes present the greatest flexibility for setting and managing for ecosystem services goals
4. Dominant use regimes may be suitable for adaptive management of the ecosystem services associated with the dominant and compatible land uses
5. Preservation and developed regimes constrain options for setting and managing for ecosystem services goals

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INCORPORATING CLIMATE CHANGE INTO ECOSYSTEM SERVICE ASSESSMENTS AND DECISIONS: A REVIEW

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Climate change is having a significant impact on ecosystem services, and is likely to become increasingly important as this phenomenon intensifies. Future impacts can be difficult to assess as they often involve long time scales, dynamic systems with high uncertainties, and are typically confounded by other drivers of change. The regional variation in climate drivers and pressures can create further challenges when assessing and managing their impacts at sub-global scales. Despite a growing number of studies assessing the impacts of climate change on ecosystem services, there are no quantitative syntheses of this information. Consequently we lack a broad understanding of these impacts, how they are being assessed, and the extent to which other drivers, uncertainties, and decision making are included.

To address these gaps, we systematically reviewed the peer-reviewed literature that assesses climate change impacts on ecosystem services at sub-global scales. This allowed us to quantify the impacts of climate change and other drivers on ecosystem services, and determine how these impacts were measured or modelled. In doing so, we determined the sources of uncertainty being incorporated in these assessments, and quantify which approaches are the most common. Last, we examined to what degree these assessments are being integrated with decision making (actions, policies, or other interventions).

We found that the impact of climate change on most types of services was predominantly negative (59% negative, 24% mixed, 4% neutral, 13% positive), but varied across services, drivers, and assessment methods. This highlights the importance of conducting local and regional ecosystem service assessments, rather than relying on averages or aggregates from other contexts. Although uncertainty was usually incorporated, there were substantial gaps in the sources of uncertainty included, along with the methods used to incorporate them. We found that relatively few studies integrated decision making, and even fewer studies aimed to identify solutions that were robust to uncertainty.

For management or policy to ensure the delivery of ecosystem services, an integrated approach that incorporates multiple drivers of change and accounts for multiple sources of uncertainty is needed. This is undoubtedly a challenging task, but ignoring these complexities can result in misleading assessments of the impacts of climate change, sub-optimal management outcomes, and the inefficient allocation of resources for climate adaptation.

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REDUCING RISK IN RESERVE DESIGN FOR COASTAL ECOSYSTEM SERVICES UNDER SEA LEVEL RISE

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Coastal wetlands provide essential ecosystem services and species habitat at the land-water interface, but they are subject to multiple stressors and uncertainties. Sea level rise projections span a wide range and can alter the distribution of wetlands through loss due to inundation and landward migration. Furthermore, modelling wetland response to sea level rise is confounded by imperfect elevation data, and uncertainties in other biophysical parameters. This creates substantial challenges when deciding where to set aside coastal land to allow for the migration of wetlands. Coastal planning is often based on deterministic modelling, but this fails to account for potential losses from more extreme change, or potential windfalls from relatively minor changes.

Using a case study in Moreton Bay, Australia, we model the distribution of wetlands, carbon sequestration, and nursery habitat for fisheries under uncertainty in the rate of sea level rise and other model parameters. Here, we apply modern portfolio theory to an integer linear programming framework with unidirectional connectivity constraints to select a complimentary set of sites that are robust to the range of uncertainties and achieve mulitple objectives.

Relative to this robust optimisation, the current reserve network and other planning strategies were inefficient as they failed to capture the areas where the distribution of wetlands was robust to the range of uncertainties, or over-estimated the area required to adequately protect wetlands. This highlights the importance of explicitly incorporating multiple uncertainties and objectives in climate change adaptation plans.

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AN OPERATIONAL STRUCTURED DECISION-MAKING FRAMEWORK FOR ASSESSING CHANGES IN FINAL ECOSYSTEM GOODS AND SERVICES WITH CONSEQUENCES FOR HUMAN WELL-BEING.

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Since publication of the Millennium Ecosystem Assessment Reports, the need to develop an operational framework that helps decision makers to employ the concepts of ecosystem goods and services in order to assess changes to human well-being has been increasing. Many conceptual frameworks have been proposed, but most do not offer operational methodologies and tools that would facilitate incorporation of ecosystem services into decision-making. The structured decision-making approach consists of six steps: 1) clarify the decision context; 2) define objectives and evaluation criteria; 3) develop decision alternatives; 4) estimate consequences; 5) evaluate trade-offs and select one alternative; and 6) implement and monitor. Building on shared components of existing conceptual frameworks for ecosystem services and human well-being assessments, we apply a structured decision-making approach to develop an operational framework and suggest tools and methods for completing each step as follows: 1) characterize decision-specific human beneficiaries using the Final Ecosystem Goods and Services (FEGS) approach and an appropriate classification system (e.g. FEGS-CS or NESCS); 2) determine, through stakeholder engagement or review of planning documents, the relative priorities for human well-being domains in the Human Well-Being Index (HWBI), and identify beneficiary-relevant metrics for FEGS using the National Ecosystem Services Classification System (NESCS); 3) develop decision-specific scenarios that describe several alternative futures; 4) link decision alternatives to changes in FEGS using the EcoService Models Library (ESML); 5) translate changes in FEGS to domains of well-being using the relative priorities established in step two, and calculate beneficiary-specific tradeoffs and overall changes in community well-being for each scenario/alternative using the HWBI and select an alternative; and 6) implement the selection and monitor resulting changes in ecosystem status and human well-being using metrics for FEGS and domains from the HWBI.

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IMPLICATIONS OF INDUSTRIALIZATION TO THE PROVISION OF ECOSYSTEM SERVICES

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In September 2012 arrangements were made for an automotive company to establish a new assembly complex in San José Chiapa, a small town with less than 8,000 people, located 1 hour away from Puebla, at the heart of México. The complete project is supposed to house more than 200,000 inhabitants by the year 2050, representing thus an unprecedented alteration to the natural state of the region. The provision of ecosystem services is bound to the ecological integrity *in situ*, in cases of large disturbances the flow of such services can be seriously compromised; as this project involves changes in the land use/land cover at such a big scale, it is important to consider how will the processes and structures responsible for the provision of ecosystem services will be affected.

This work comprises two different methodologies, on one hand there is the life history research that was made in order to get to know the region and the current inhabitants via non-structured interviews that followed pre-stablished guide questions. On the other hand, there is a work on GIS, based on the information published by INEGI (Statistics and Geography National Institute in México) in order to classify land uses and apply such criteria to LandSat images ranging from 1986 up to 2014. The satellital information was then contrasted with the results of the Matrix Model by Burkhard *et al.*, first published in 2009.

The rapid urbanization process that the region is being subjected to, will increase the momentum of effects that are already happening, for example the forest cover in the region will shrink even more than what has been happening in recent years, in what can be seen as the transition from woods to agriculture, therefore presenting a swap in the kind of ecosystem services that are available to the general population. At the same time, the growth in urban areas will result in an expansion of sealed soil without precedent by the end of the decade; this increase will affect directly the potential provision of ecosystem services, as well as the demand for such services that will have to be imported from the surrounding (still) natural areas. We argue that it is necessary to include an ecological consideration during the process of development in the region; it seems like the government is considering only the economic outcomes in the long term, nevertheless, the industrialization process has also social and environmental results that need to be addressed in order for the project to have a real sustainability.

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66 WAYS TO SAVE THE WORLD: FORMS OF ONLINE ENGAGEMENT FOR ECOSYSTEM SERVICES AND BIODIVERSITY PROTECTION

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This study presents an analysis of online platforms that offer the possibility for interested private individuals, organizations, or corporate businesses, to get engaged for ecosystem services and biodiversity protection, either on the demand or the supply side. Altogether 66 online platforms were analyzed, including both national platforms in Germany, but also international platforms (about half each). Identification of the platforms was done through an online search using Google search based on a number of search terms (either used alone or in combination), such as ecosystem services, ecosystems, biodiversity, natural capital, crowdfunding, investing, markets, marketplace, etc., both in English and in German). Sometimes also links provided on one platforms lead to the identification of further platforms. Platforms were then analyzed in view of different questions, which included the following: What is the stated mission/claim? Who is responsible for running/maintaining the platform? Who is/are the targeted user group/s? How are these groups addressed? What ecosystem services are in the focus? What is the geographic location of the projects that are implemented to safeguard these ecosystem services? Is the provision of ecosystem services measured somehow? And, finally, what type of engagement is possible (e.g. different forms of financial engagement vs. time engagement)? Results show that most platforms are crowd-funding or crowd-investing platforms where people can give money for a concreate project which gets only implemented when enough money is pooled. This is followed by platforms which offer the possibility to donate for 'green' projects which are mostly already ongoing. A further category of platforms can be classified as information platforms dedicated to provide detailed information on certain issues related to one or several ecosystem services, including biodiversity. Often these platforms have a blogging function so users can also get in touch over the platform. Some of the platforms also offer trainings or organize other events where users can meet in real life. Only few platforms resemble actual markets, where ecosystem services can be traded between individual buyers and sellers, linking the demand and supply side. Some platforms also combine different forms, e.g. the crowdfunding with the information provision option, or similar. Financial engagement is the most prominent way of engagement offered, while platforms which also offer the possibility for time engagement/honorary work are rather rare. Interesting aspects include that many platforms feature a filter function so users can look for projects in a certain geographic region or for a specific ecosystem service. Some platforms also address different user groups differently, e.g. by providing tailored user menus for private individuals and corporate businesses on the demand side, or for farmers or foresters on the supply side. Overall, the possibilities for engagement are very versatile and range from an anonymous one time online donation to actually becoming part of group of dedicated individuals who actually meat in real life to become involved in a certain project or participate in a specific event for ecosystem service and biodiversity protection.

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INTEGRATING NATURE-BASED TOURISM INTO COASTAL RESILIENCE

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The health of coastal habitats is decreasing due to a variety of stressors. One way to stem that loss is to integrate nature-based solutions (i.e. natural infrastructure) into local and state decision making to increase health and resilience of coastal habitats. Communities are more likely to adopt these nature-based solutions when conservation groups take into consideration community priorities. The Nature Conservancy's work with Delaware Bayshore municipalities serves as an informative case study for integrating community priorities and visitor surveys into conservation planning.

The Nature Conservancy has been involved in the Tourism and Economic Development (TED) Committee of the municipalities that are located along the Bayshore. The TED was formed during the Federal Emergency Management Agency led Hurricane Sandy recovery process, where municipalities realized that Sandy recovery went beyond rebuilding homes and was also dependent upon economic development. The tourism goal of the committee is to increase the number of visitors to the area, increase spending at locally owned businesses, while maintaining the cultural and natural integrity of communities. Yet the TED was having challenges getting buy-in from the county and state agencies to support tourism investments in the region. There were many unanswered questions: would visitors return to the area after they visited and saw how rural the area is? Do visitors spend money? Which activities to visitors prefer? We implemented a survey from May 2015 through October 2015. The results of the 250 visitor surveys show that nature-based tourism is a more promising strategy than previously known, with 99% of visitors saying they would return to the NJ Delaware Bayshore and wildlife viewing was reported as the top activity of interest.

The results of the study are beginning to influence the dialogue around both conservation projects (e.g. living shoreline projects) and county economic development strategies. Conservation groups and economic development partners are now joining forces in the county to implement tourism projects that benefit communities and nature. Lessons learned from this case study can help by providing a process for finding shared values among a diverse set of stakeholders.

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INCORPORATING ECOSYSTEM SERVICES INTO NATURAL RESOURCE DECISION MAKING: DEPARTMENT OF THE INTERIOR WORK PLAN & THE SUSTAINING ENVIRONMENTAL CAPITAL INITIATIVE

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Objective: This presentation will provide an overview of the The Department of the Interior's (DOI) work plan and response to memorandum M-16-01. We will also provide an overview of the Sustaining Environmental Capital Initiative (SECI) and how the SECI can facilitate the use of ecosystem Services. Specifically, the DOI work plan will highlight:

- Key examples of how ecosystem services are currently being used by the Department's bureaus and offices; and areas where the ecosystem service approach could be explicitly integrated into the decision processes.
- Next steps in how the Department plans to research and incorporate ecosystem services into decision making.

The SECI overview will highlight:

- The SECI genisis; the SECI components; how the components function to provide a broad demonstration of ecosystem service application; and a description of the team.
- The Current work plan and Intended outcomes.

Background: The goal of executive memorandum M-16-01 titled "Incorporating Ecosystem Services into Federal Decision Making" and subsequent implementation guidance is to better integrate into Federal decision making due consideration of the full range of benefits and tradeoffs among ecosystem services associated with potential Federal actions, including benefits and costs that may not be recognized in private markets because of the public-good nature of some ecosystem services. The Department of the Interior (DOI) plays an integral role in conserving America's natural resources and heritage, honoring our cultures and tribal communities, and supplying the energy to power our future. In doing so, Interior's people, programs, responsibilities, and missions impact Americans across all 50 States and territories. DOI serves as the steward of 20 percent of the Nation's lands, managing national parks, national wildlife refuges, and public lands and assisting States, Tribes, and others in the management of natural and cultural resources.

The Obama Administration is taking steps to implement the fourth recommendation of President's Council of Advisors on Science and Technology (PCAST) report, *Sustaining Environmental Capital: Protecting Society and the Economy.* In fiscal years 2015, 16, and 17, USGS is funded to provide scientific backbone to the Administration's ecosystem services priorities. The goal is to develop, integrate, and enhance natural resource management decision support tools, systems and information to better enable managers to account for the benefits people receive from ES and provide guidance for using ES information in management decisions. The envisioned SEC Initiative will have a physical presence (represented by policy and science coordinators) and virtual presence (on-line website) referred to as the SEC Dashboard. The SEC will be designed so it can grow to include case studies, data, and tools from other ecosystems in future iterations (e.g. forest, dryland, or mountain)

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APPLYING THE DPSER FRAMEWORK TO CHANNEL ISLANDS NATIONAL MARINE SANCTUARY

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The Office of National Marine Sanctuaries (ONMS), part of the National Oceanic and Atmospheric Administration (NOAA), serves as the trustee for a system of 14 marine protected areas encompassing close to 180,000 square miles of ocean and Great Lakes waters that are of special national significance. Each sanctuary has developed a condition report that provides a standardized summary of resources in each sanctuary, drivers and pressures on those resources, current conditions and trends for resources, and management responses to the pressures that threaten the integrity of the marine environment. Condition reports include information on the status and trends of water quality, habitat, living resources and maritime archaeological resources, and the human activities that affect them. The reports serve as a tool for resource managers, researchers, policy makers, and educators to inform program development.

The first generation condition reports (2007 – 2013) were structured on a Pressure-State-Response (PSR) framework and omitted information on ecosystem services and the impact human activities have on the economic value of these resources and human well-being. Consequently, the second generation condition reports will be structured on an expanded framework – the Drivers, Pressures, State, Ecosystem Services and Response (DPSER) Model. Drivers will bring additional understanding of the forces behind the pressures, based on various societal values and behaviors, and how changes in those societal values and/or behavior affect the pressures. The addition of an ecosystem services section will allow us to examine how humans benefit or suffer loss with changes in the environmental, biological, archeological or cultural resources. By providing this information within the condition reports, community members and user groups are provided with information about how their uses or non-use values are impacted by changes to sanctuary resources.

Ecosystem services are final ecosystem services and are based on attributes of the environment that people care about and we can therefore value from and economic perspective or rank. Evaluating and ecosystem service requires a suite of ecological, economic and human dimensions non-economic indicators. An expert panel will be used to evaluate and rate each ecosystem service based on the suite of indicators and research providing interpretation of the indicators. An uncertainty matrix will also be developed by the expert panel. In some applications, the deep research might not be available for a particular ecosystem service, but indicators might be. The panel might rely on the relationships from studies at other similar sites to interpret the indicator, resulting in a lower certainty rating. This presentation will present the process of using the DPSER model to develop a suite of indicators and the preliminary findings of the expert panels for the Channel Islands National Marine Sanctuary Condition Report conducted this summer.

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FEDERAL ECOSYSTEM-BASED MANAGEMENT TO SUSTAIN MARINE ECOSYSTEM SERVICES: FROM CONCEPT TO PRACTICE

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Ecosystem-based management is an integrated approach to making decisions to protect the resilience of ecosystems and sustain the benefits they provide to communities, economies, and cultures. EBM is informed by science, considers the many interactions between humans and the natural environment, and provides an essential framework for the sustainable delivery of a broad spectrum of marine ecosystem services essential to environmental and human wellbeing. These services are threatened by the cumulative impacts of multiple human activities and are at risk due to future change, whether natural or the consequence of human activity. Sustaining them requires effective, systematic, and integrated management of those activities.

Recent Federal policies and directives, notably the 2010 National Ocean Policy, identify a comprehensive ecosystem approach to management as a foundation for successful policy, planning, and management. However the transition from traditional single species or sector management to one that considers and integrates the whole ecosystem or multiple management objectives is an evolutionary process. While the theory and principles of EBM and Ecosystem Service Assessment have been defined in the academic literature, the implementation of ecosystem approaches to management, particularly by government resource agencies, remains a challenge. Practitioners remain unclear on many of the concepts and practices, or how to implement them under their legal authorities, statutes, and mandates.

Multiple approaches and methods can be tailored and applied to meet stakeholder and management requirements. But the key to any practical and effective ecosystem approach to management is that it is adaptive, based on natural and social science, considers multiple services and objectives of user sectors, and evaluates trade-offs. This presentation will provide examples of Federal programs, such as the NOAA Ecosystem-Based Fisheries Management Policy, as they progress through policy, planning, governance, research, and management, leading to decision making that will reduce or mitigate the impacts of ecosystem stressors and enhance system resilience to future change. It also will highlight windows of opportunity in the Federal process for research collaborations, intergovernmental consultations, partnerships, and stakeholder engagement.

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INFLUENCE OF RISK ON TRANSACTION COSTS IN WATER QUALITY TRADING MARKETS

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Water quality trading programs can be complex to develop, implement, and administer, particularly when they involve nonpoint sources and operate within a regulatory framework. Water quality credits generated by diffuse or nonpoint sources, such as aggriculture, can have inherent uncertainties around their quantification and the credit generator's behavior. As a result, water quality trading programs may take various approaches to address these uncertainties and alleviate risks, such as by using verification standards, trade ratios, and credit clearninghouses.

Some of these assurances that are established to create certainty in the market can result in transaction costs. Transaction costs refer to the costs to develop, implement, and participate in a program. For example, regarding program implementation, program administrators must review credit-generating project proposals to ensure credit estimations are accurate and achievable and then must register certified credits for purposes of accountability and transparency. Interested buyers and sellers in the market spend resources creating project plans, determining eligibility, and negotiating contracts.

Adequately addressing the risks of uncertainty can mean the difference between a vibrant water quality trading market and a stagnant one in which permitted entities must either invest in expensive technological upgrades or fail to meet permit limits and accomodate growing populations. On the other hand, while strict oversight and processes are critical for the credibility of these programs, too much complexity can increase transaction costs and decrease the efficiency and cost effectiveness that trading programs are designed to achieve in the first place.

The purpose of this presentation is to identify (1) the types of uncertainties and risks, (2) how mechanisms to address these risks influence transaction costs, and (3) what best practices are available for minimizing transaction costs while at the same time maintaining the integrity of the program.

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IMPLEMENTATION CHALLENGES FOR ECOSYSTEM SERVICES IN THE PUBLIC SECTOR: LESSONS LEARNED FROM A BLM CASE STUDY

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Resource managers have been interested in incorporating ecosystem service information into management and planning processes for many years. Interest has increased further since the Presidential Memorandum in October 2015 directing agencies to incorporate ecosystem services into Federal decision making. In practice, however, the process of incorporating ecosystem services into management has been challenging. As much as data and model availability, the specific decision context and process must be considered to maximize potential for successful implementation.

We describe our experience working with the Bureau of Land Management on a pilot study designed to explore the potential for incorporating ecosystem service valuation into management. A master leasing plan (MLP) for energy and minerals in the Moab area of southeastern Utah was used as a case study. The Field Office was interested in assistance with comparing the alternative configurations of land-use stipulations that were to be considered through the MLP process. Specifically, they were interested in the potential for viewshed impairment given the importance of recreational tourism to the local economy, as well as potential impacts to water resources given the desert setting. We quantified aggregate landscape visibility from both point locations such as scenic viewpoints and linear features such as roads or trails, which together are the destinations of many recreational tourists visiting the Moab area. The analysis permitted quantitative comparison of alternative land-use stipulations by considering the percentage of the landscape in each stipulation type that is visible from different viewing areas, as well as from viewing areas with different levels of use. For water resources, our ability to quantify potential impacts was limited by the stochastic nature of events that could lead to impacts.

Despite the wealth of available data for the Moab area, data limitations remained a key constraint in our ability to use ecosystem service information to compare alternatives. This was particularly true for tracking services through to specific ecological endpoints for economic valuation, which the Field Office was interested in for evaluating potential impacts to scenic resources. We lacked primary social science data linking viewshed impacts to visitor experience, as well as a complete inventory of water use. Further, no established models existed that were applicable to the specific services important in this area, which necessitated their custom development for this project. The biggest challenge, however, was the nature of the MLP process itself and specifically where in the process we were asked to contribute. MLP alternatives define areas where development might be allowed, but within these areas it is unknown where development might actually occur. Comparing alternatives is therefore limited to the estimation of potential rather than actual impacts, which is of limited use if development can be specifically sited to avoid impacts. Ecosystem service information could be more effectively employed earlier in the process to assist in designing alternatives that minimize the potential for impacts, or at a later stage when considering specific development proposals. Careful consideration of the decision context and process, together with a systematic approach to filling data gaps, are needed to expedite the incorporation of ecosystem services into resource management and planning.

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PINOT OR POTATOES? A CASE STUDY OF GOVERNANCE & ACCOUNTABILITY IN EMERGING WATER QUALITY MARKETS

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Water quality trading (WQT) programs are increasing in practice, with approximately 30 active programs in existence within the U.S. today. However, as a relatively new market-based instrument for addressing the common-pool resource (CPR) problem of water quality impairment, the key ingredients needed for WQT program success are still under debate. Research suggests that accountability, transparency, and integration with broader legal-regulatory context are important enabling conditions for market-based approaches to managing CPR and their associated ecosystem services. Despite the acknowledgement that these conditions are critical to the function and sustainability of CPR institutions and WQT programs, in particular, they are relatively inconsistent and unstandardized across the WQT population. Our research speaks to this diversity by exploring how the involvement of governance institutions from different hierarchical scales—local, regional, state, multi-state, and federal—impacts the design of enabling conditions deemed essential for market-based CPR institution success. We investigate if and how emerging WQT programs exhibit characteristics of accountability, transparency, and legal-regulatory integration, and how those characteristics might be expected to manifest given the levels of governance from which WQT programs are initiated and led.

Our research employs a multiple case study approach to explore in-depth two emerging water quality trading programs in terms of their strategies for monitoring and reporting, as well as the extent to which the programs are embedded within larger legal-regulatory contexts. We then analyze the cases for similarities and differences in monitoring and reporting strategies and legal-regulatory integration in relation to whether the locus of program development and leadership is located at the local, regional, state, multi-state, and/or federal level. We utilize a network sampling approach to capture interviews with all central program actors, including federal agencies, municipalities, state and local water authorities, NGO intermediaries, and private landowners, in order to better understand the perspectives of each participant group. Content analysis of political and organizational guidance documents, administrative reports, meeting notes, and other related documents provides further insight into program development and design processes.

We present our findings through both academic and practitioner lenses, contributing to theoretical conversations about institutional design and ecosystem services governance, as well as technical discussions about program development, monitoring and reporting strategies, and policy design outcomes. Our results provide enhanced understanding of how WQT programs emerge and develop through both "top-down" and "bottom-up" pathways, and how those different governance pathways—and other contextual factors—influence the way WQT programs manage for accountability, transparency, legal-regulatory integration. Our findings and conclusions yield implications at both the political and programmatic level regarding the successful design of market-based solutions for water quality and ecosystem services, more broadly.

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RURAL LIVELIHOODS IN CAMBODIA: THE EFFECTS OF FINANCIAL CREDIT AVAILABILITY, MARKET REMOTENESS AND NATURAL RESOURCE ACCESSIBILITY

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As one of the largest rivers in the world, the Mekong is a dynamic hydrological system linking communities across China, Burma, the Lao PDR, Thailand, Cambodia, and Vietnam. The defining feature of the Mekong River system is its flood-pulse regime in which annual monsoons contribute to significant fluctuations in water levels and nutrients, and shifts in floodplain habitats. As a result of these flood-pulse hydrodynamics, the Mekong River system is responsible for producing one of the largest floodplain areas in Southeast Asia and some of the world's highest rates of biodiversity and productivity for freshwater ecosystems. Correspondingly, the Mekong system supports a wide range of ecosystem services for millions of people including drinking and irrigation water, hydroelectric power, fish and agricultural production, and cultural resources. However, biophysical and anthropogenic stressors, including upstream hydropower dams, urbanization and climate change are transforming Mekong hydrodynamics with serious implications for long-term sustainability of the riverine system and the ecosystem services upon which humans livelihoods depend. The purpose of this research is to examine how rural agricultural livelihoods depend on economic and ecological systems, in order to identify strategies for adapting to both imminent and long-term changes.

Using spatial analysis and econometric analysis applied to a longitudinal data set comprised of primary household survey data from 2400 households in 64 Cambodian villages collected in 2005 and 2007, as well as data from Cambodian national censuses and socio-economic surveys, this research will identify the factors contributing to livelihoods to better understand the income-generating decisions of rural households dependent on natural resources and ecosystem services. The results will provide insights into how households depend on natural resource availability and predictability, and identify possible economic-based strategies to manage changes. Specifically, this research examines effects of economic factors, including the availability of financial credit and accessibility to markets, and ecological factors defined by forest and water accessibility, on rural agricultural livelihoods as measured through household income and expenditures.

While most households in the study are predominantly engaged in rice farming, initial analyses show significant variations in both household incomes and household expenditures across the sample. Preliminary results show that the availability and use of financial credit, accessibility to markets, and the accessibility of natural resources, as well as the ability to generate off-farm income, all contribute to the inequality across households engaged in otherwise similar farming practices. Since all of these contributing factors are dynamic and interactive, it is expected that these differences will affect household's ability to adapt to changes, leading to variation in vulnerability and resilience. The results of this research are intended to be useful for regional planning and policy for rural development, rural-urban economic and social linkages, and understanding the role of access to natural resources and ecosystem services on rural livelihood strategies.

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NATIONAL FOREST VISITATION SCENARIO IMPACTS ON CULTURAL ECOSYSTEM SERVICES

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Participation in outdoor recreation within U.S. national forests is projected to increase significantly by the year 2060. The increased demand on forest resources will challenge forest managers to balance the availability of recreational activities with the preservation of other ecosystem services. Cultural services, which have not been well represented in ecosystem service assessments, will need to be more fully considered. These considerations include how the intensity and spatial distribution of cultural service values will be impacted by increased forest use. Social values, the perceived nonmarket values the public assigns to ecosystem services (particularly cultural services), provide a nonmonetary, quantitative indicator to explicitly account for cultural ecosystem services. Using data collected from the public through value and preference surveys along with explanatory environmental variables, the GIS tool Social Values for Ecosystem Services (SolVES; http://solves.cr.usgs.gov) provides functionality to develop spatially explicit models of social values for cultural ecosystem services and to apply these models to modified environmental layers describing future scenarios.

Using SolVES, we generated maps and corresponding models of social value assigned to aesthetics and recreation for the Pike, San Isabel, and White River national forests in the Southern Rocky Mountains. These models incorporated recent visitation estimates developed by the U.S. Forest Service's National Visitor Use Monitoring Program (NVUM). These estimates are disaggregated by four forest site types: day-use developed sites, overnight-use developed sites, wilderness, and general forest area. Forest Service projections of recreational activity participants by the year 2060 were used to provide scientifically plausible targets for future forest visitation. We used NVUM visitor estimates from two time points approximately five years apart to calculate annualized rates of change in visitation for each forest site type. These annualized rates were then applied to the most recent NVUM estimates until total estimated visitation in each forest approximated the 2060 projections. The existing aesthetic and recreation value models were then applied to the explanatory environmental data layers including the modified visitation layer representing the 2060 projections. The resulting value maps were then compared to original value maps to determine where and how much values might change due to the anticipated increase in visitation.

Our results demonstrate how spatially disaggregated visitor data can be included in spatially explicit models of cultural ecosystem service values. These models provide a means to develop and analyze scenarios that reflect the impacts of visitation change on values over time. Future work to overcome some limitations of the current study should include improving the spatial resolution of visitor estimates as well as refining the estimates of visitation change rates at the forest site-type level. Forest managers could be greatly assisted by an effective tool to account for changes in cultural ecosystem service values resulting from increased visitation.

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THE IMPACT OF URBAN PATTERN ON ECOSYSTEM SERVICES: EXPLORING THE POTENTIAL FOR SPRAWL ALTERNATIVES TO REDUCE ENVIRONMENTAL DEGRADATION AND ACCOMMODATE ECONOMIC GROWTH

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Expanding demand for exurban development is restructuring the urban-rural frontier, converting forests and farmlands to impervious covers and shifting the burden of ecosystem provisioning to increasingly fragmented green infrastructure remnants. Planning approaches to retain green infrastructure have focused on controlling low-density development ('sprawl') that dominates North American exurbia. However, we know little about the performance of sprawl alternatives such as infill, and the ecological and economic ramifications of implementing these designs remain unclear to planners and policy makers.

To estimate regional ecosystem response to metropolitan pattern by 2030, we used a novel integration of land change modeling and ecosystem services simulation to assess un-regulated and prescribed urban growth scenarios across watersheds in the rapidly urbanizing Charlotte (NC) region. For each scenario we estimated terrestrial balances of non-point source pollutants (NPSP) nitrogen and phosphorus, changes in carbon sequestration and biodiversity, as well as expected monetary returns (i.e. rents, timber/crop revenues) to landowners. When compared to business-as-usual trends, we found no single scenario simultaneously reduced pollution, stored carbon, and retained sensitive habitat, underscoring the difficulties likely to be encountered when balancing economic and environmental outcomes. The infill scenario tested retained the maximum area of sensitive habitat, but generated more NPSP and sequestered less carbon than sprawl and deregulation alternatives. However, increased land use density yielded stronger financial returns to landowners as concentrated economic activity drove up land rents while minimizing broader pollution costs. These findings emphasize the need for ecosystem service analyses to more adequately anticipate development trade-offs in metropolitan context.

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BEHAVIORAL ENVIRONMENTAL ECONOMICS AND NUDGES (ACES)

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The behavioral economics perspective has arrived in environmental policy debates. After three decades of work in environmental economics, my colleagues and I have long been open to using insight from other disciplines, albeit ecology, biology, physics, or psychology. We have helped identify new biases, old heuristics, and unique quirks emerging from people trying to answer public opinion surveys about their willingness to pay for nature and environmental protection, and we have watch people struggle to coordinate actions and cooperate over controlling externalities, non-convexities, public goods, and common property resources. In this paper, we explore how and when new behavioral insight can help us better understand how people interact with nature in a non-market setting, and how policy can be designed to provide more environmental protection at less costs.

Today a new "green nudge" community has emerged based on the teachings of behavioral economics. They ask whether behavioral economics can help guide cost-effective policy through the use of social norms, moral licensing, moral cleansing, opt-in vs. opt-out, social isolation, trust, peer pressure, contagious cooperation, optimal unselfishness, teachable moments, self-perpetuating perceptions. Behavioral economics uses insight from psychology to help reshape basic economic principles. Behavioral challenges to rational choice theory are nowadays common in debates over core theory and in the design of incentives in public policy. We know people are not autonomous econobots operating in a sterile market—rather we are linked strategically and emotionally as we try to gain experience through experimentation and by watching others. We are also linked by our desire for sociality and social identity: we have preferences for being with others and how others see us helping others. These links help us form our own beliefs and preferences within an economy, and create a social interdependence otherwise not address in neoclassical theory.

Herein we examine the idea that people operate in both markets and non-market allocation simultaneously. And while one irrational person can ruin predictions about play in a strategic game, one rational person can move society toward a predicted market equilibrium. This razors edge matters for behavioral economics aimed at public policy (read environmental protection) because society allocates resources both markets and missing markets. The key question to be examined is whether society can create the missing institutional context to induce more rational choices rather than on relying on documenting a taxonomy of biases and heuristics. These institutions can help people help themselves by learning what it means to be the rational agents we presume inhabit our models. Institutions can create money pumps to either extract resources from inconsistent decisions or to lower the transaction costs of consistent decisions. If we can create an institution that allows one rational person to drive society toward efficiency, perhaps we can better understand the power and limits of market-like arbitrage mechanisms to remove biases, heuristics, aversions, and limits that exist in social interactions. Behavioral economics can help environmental policy if the insight generated leads to lower health risks and environmental conflicts, encourages more coordination and cooperation, and helps us design better incentive systems. We will discuss the three big challenges exist when thinking about all this: (1) markets and rationality, (2) the theory of second best, and (3) the moving baseline against which to judge success.

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SPATIALLY-EXPLICIT TECHNOLOGY SOLUTIONS FOR GREATER SAGE-GROUSE HABTAT ASSESSMENT

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Open Range Consulting has developed unique, exceptional and spatially-explicit assessment technologies to measure key land cover attributes of Greater sage-grouse habitat. These cover attributes can be mapped at 1-meter resolution and at 1-percent continuous cover percentage for each of the attributes throughout the entire priority area. These technologies assessment have been used on over 5 million acres of priority habitat in 5 western states. They are be published in a peer review international journal. The process evaluates the key land cover attributes (bare ground, sagebrush, herbaceous vegetation, juniper, cheat grass) that have been shown to be important sage-grouse survival and population growth. Testing was completed in one priority habitat area in Montana (500,000 acres), which has 5,000 telemetry points of sage-grouse locations for all seasons of use. Our work characterizes what ground cover conditions the birds prefer by season. This data can help planners and funders to know which areas should be preserved, protected and enhanced, which are the most cost-effective and timely to establish. This quality habitat classification can be extrapolated to other nearby priority habitat areas and deliver this geographic information in a format to be easily used by managers via phone or desktop.

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CARBON BALANCE MODELING FOR THE GREAT DISMAL SWAMP ECOSYSTEM

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The Great Dismal Swamp (GDS) is a critical wetland habitat to many plant and animal species and offers many services to citizens. However, the habitat conditions have been altered over the recent centuries from intensive land use and land management, leading to high carbon (C) emissions and increasing ecosystem vulnerability. As a consequence, natural disturbances such as wildfire have a higher probability of escalating into catastrophic events, resulting in deep peat burns and massive terrestrial C losses. To better understand how to enhance C sequestration and assess the potential tradeoffs among the needs to manage multiple ecosystem services at the GDS National Wildlife Refuge, we use the Land Use and Carbon Scenario Simulator (LUCAS) model. LUCAS provides the functionality needed to integrate annual C stock and flow values with fire and vegetation behavior, as a response to active land management strategies. This research discusses the LUCAS model framework and input data sources, as well as calibration and testing, a critical step for statistical validation.

The LUCAS model structure organizes the landscape spatially as a grid of simulation cells. Each cell at model onset has a defined set of initial conditions and bio-physical attributes such as: forest-type, stand-age, and hydrologic moisture zone. Transitions between forest types are driven by probabilistic values relative to historical disturbance trends (drainage, logging, wildfire, hurricanes, drought, and species invasion), and/or representative management actions (re-wetting, re-planting, prescribed burn, and herbicide application). To address the C stock-flow parameters, we are currently collecting a range of in situ measurements such as: GHG flux (CO_2 and CH_4), aboveground biomass, soil chemistry, peat depth and subsidence, soil saturation, and hydrologic monitoring of surface/groundwater levels. Most of these field measurements will be available in 2017 and will be directly incorporated into LUCAS for our final ecosystem services assessment at that time. In the meantime, we have calibrated and tested the LUCAS model functionality using literature-based values as proxies for annualized C stocks and flows.

LUCAS model testing produced preliminary results comparing historical (1985 – 2015) C loss estimates from two recent fire events (South One in 2008 and Lateral West in 2011), which occurred on approximately the same 25km^2 land area. The LUCAS model assumed a soil surface elevation loss of 1-m depth from the two combined fires, resulting in a cumulative above and belowground C loss totaling 2.06 Tg C. The C loss in belowground biomass alone totaled 1.73 Tg C, with the balance (0.33 Tg C) coming from aboveground biomass and detritus. Recent LiDAR based estimates from Hawbaker and others (2016) corresponded to a soil surface elevation loss of 0.63 m and a cumulative C loss of 1.83 Tg C, where 1.47 Tg C came from belowground biomass. Our preliminary results of historical events indicate that the annualized stock-flow input parameters, as well as the fire emission assumptions, are producing statistically significant results compared to recent published findings. Our next steps include simulating future land management scenarios to assess the impacts on the ecosystem C balance of the GDS.

These data are preliminary and are subject to revision. They are being provided to meet the need for timely ‘best science’ information. The assessment is provided on the condition that neither the U.S. Geological Survey nor the United States Government may be held liable for any damages resulting from the authorized or unauthorized use of the assessment.

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PRESSING LEGAL QUESTIONS FOR MULTIPLE CREDITS AND FUNDING STREAMS UNDER THE IOWA NUTRIENT REDUCTION STRATEGY

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The Iowa Nutrient Reduction Strategy (INRS) is an innovative approach to nutrient reduction that engages both point sources and non-point sources. INRS is Iowa's attempt to reduce their significant nutrient load to the Mississippi River. Water Quality Credit Trading is a proven tool that provides an additional funding opportunity for agriculture to implement conservation technologies. Such applications in the context of trading programs, provide an accountable means for demonstrating how farming practices are contributing to water quality improvements. Trading affords municipal WWTPs a cost-effective means for compliance with nutrient limitation in their permits. In Iowa, a state dominated by agriculture, several legal questions arise during the development of such trading programs. Of particular interest in the prairie pothole region of the United States is, for example, how Swampbuster and Farm Bill provisions may or may not affect supply of credits within a trading market.

Swampbuster determines producer eligibility for several types of grants, subsidies, loans, production flexibility contract payments, marketing assistance loans, and other benefits available through the Agricultural Act of 2014, a/k/a the "Farm Bill." Swampbuster is voluntary and there is no mandate against producers planting crops on converted wetlands or highly erodible soil. Rather, the program operates as an incentive program through which a producer's compliance affords it eligibility for several forms of Farm Bill assistance. In order to determine compliance, the U.S. Department of Agriculture ("USDA") Natural Resources Conservation Service ("NRCS") determines if a producer's land has wetlands or highly erodible lands that are subject to the Swampbuster provisions.

The proposed Iowa Nutrient Reduction Exchange (NRE) may afford the opportunity to link programs link this to the Iowa's Nutrient Reduction Strategy and potentially, Water Quality Trading (WQT). This presentation will examine such linkages as well as other prevailing legal issues that are being encountered during the creation and implementation of the NRE and WQT in Iowa.

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CONSERVATION PROGRAM AND PRACTICE EFFECTS ON ECOSYSTEM SERVICES IN THE U.S. HIGH PLAINS

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We examined the effects of USDA Conservation Programs on ecosystem service provisioning in playa wetlands and their immediate watersheds in the High Plains from Nebraska and Colorado in the north to Texas and New Mexico in the south. Playas are shallow depressional recharge wetlands that primarily receive water through runoff. Therefore, any land use treatment in playa watersheds affects their ability to supply different services. The Conservation Reserve Program (CRP) is the dominant USDA program in the western High Plains while the Wetlands Reserve Program (WRP now under ACEP) is the dominant program in the Rainwater Basin of Nebraska. We examined biotic services (i.e, amphibian, avian, and plant communities) as well as abiotic services (i.e., floodwater storage, contaminant amelioration, greenhouse gas amelioration, soil carbon storage, and sediment deposition) within playas surrounded by CRP, native grassland, and cropland in the Western High Plains and playas in reference state, cropland, and WRP in the Rainwater Basin. Effects of CRP on abiotic services are primarily positive while influences on biotic services are primarily negative. The practices of CRP in the Western Plains generally involved planting exotic grasses in playa watersheds which restricted water flow and reduced hydroperiod causing a concomitant increase in water storage potential, contaminant amelioration, etc. but with a shorter hydroperiod biotic communities were negatively affected. The effects of WRP on biotic and abiotic services were all generally positive. The primary practices employed under WRP were sediment removal and adjacent watershed restoration. This improved hydroperiod and had a positive influence on biotic communities as well as abiotic services such as water storage and contaminant amelioration. We recommend changes to CRP that will reduce abiotic and biotic service tradeoffs and expansion of WRP practices across the Rainwater Basin.

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INCORPORATING ECOSYSTEM SERVICES IN TRADEOFF ANALYSIS TO FACILITATE FOREST PLANNING

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Choices among forest planning approaches involve assessments of complex issues such as landscape conditions and stressors, diverse interests among stakeholders, and uncertainties across space and time. Under the U.S. Forest Service 2012 Land Management Planning Rule, ecosystem services must be considered in planning, and environmental documents are expected to discuss tradeoffs among services provided. Integrating consideration of ecosystem services in analysis of plan alternatives helps forest managers make informed decisions that address implications from environmental, ecological, social and economic perspectives.

Forest Service staff have been exploring diverse approaches to address required tradeoff analysis among ecosystem services in planning processes. These approaches are capable of comparing alternative sets of National Forest plan objectives and guidelines with respect to key ecosystem services identified in the assessment phase of planning. We will discuss methods and resources for conducting tradeoff analysis that consider both the supply-side of forest provisioning of ecosystem services and the public's demand-side interests. Approaches and tools vary in complexity, ranging from simple qualitative tables to the use of weights or thresholds in multi-attribute utility theory-based analysis.

We will share insights on the advantages and challenges of various methods as well as findings from beta testing of tools in focus groups. We welcome dialogue with session participants as we continue to investigate and adapt practical approaches for considering ecosystem services and conducting tradeoff analysis in forest planning.

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TOWARDS BRIDGING THEORY AND PRACTICE TO CONSIDER BIODIVERSITY AND RESILIENCE FOR ECOSYSTEM SERVICES

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We aim to begin a dialogue towards incorporating recent scientific results from ecology into management and business practice. First we will present recent results from a theoretical study of how the level of biodiversity impacts the productivity of plankton ecosystems. The key finding is that, because of inescapable trade-offs in the physiology and ecology of all organisms, a higher-level trade-off emerges, for communities or whole ecosystems: More diverse ecosystems tend to have greater short-term Adaptive Capacity (resilience) in response to disturbance, but lower Long-term Productivity under stable conditions. Therefore, the optimal level of diversity for sustaining productivity depends on the frequency and intensity of disturbance experienced. This means that the frequency and intensity of disturbance should be considered in order to efficiently allocate funds and other resources for sustaining biodiversity and ecosystem function. Another key aspect is that this emergent trade-off became clear by considering the functional diversity of trait values (characteristics) of species, rather than species diversity alone. This implies that management decisions with respect to biodiversity should consider the distribution of functional trait values of the component species as well as the particular disturbance regime likely to be experienced by the system under consideration. Finally we will suggest some approaches for implementing these ideas in practice for the management of ecosystem services, with the hope of stimulating further discussion.

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SCALE EFFECTS & CONSUMER DEMAND FOR URBAN FOREST SERVICES AND DISSERVICES

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Ecosystem services are important for Floridians as they are directly related to water quality, clean air, property values and overall quality of life. Several studies have valued the economic benefits of these services from wildland forests and Floridian's willingness to pay for ornamental attributes and control of invasives. However, little is known about preferences for - and the economic value of - ecosystem services from Florida's urban forests. To address this, we used a panel of 1,300 Florida homeowners and renters who answered a hypothetical urban forest landscape survey. The questionnaire was electronically administered, and featured multiple urban forest improvement programs that varied in terms of: tree-shade, property value improvements, tree condition, and maintenance cost.

Consumer preferences were elicited using a recent innovation in best-worst scaling, called best-worst choice, which produces estimations of scaling, while enabling measurements of traditional discrete-choice experimentation (e.g., willingness to pay). We have three specific research objectives: 1) Determine the urban forest structure and diversity attributes consumers prefer; 2) Identify the ecosystem service/disservice attributes; and 3) Analyze the tradeoffs in preferences among homeowners and renters. We use existing plot field data, conjoint survey analysis, and econometric modeling to identify attributes and tradeoffs between urban forest structure and ecosystem service/disservice.

Results suggest that: 1) Property Value has the highest impact on urban forest preferences, followed by Tree Condition and Tree Shade; 2) Evidence of a backward-bending demand curve for urban forest ecosystem services, and significant scale effects; and 3) To increase participation in efforts that generate urban forest ecosystem services, design programs that cost < $7.00 per month, while maintaining good condition trees that provide high tree shade.

The integration of these approaches is novel and can better assess the value of ecosystem services of Florida's urban forests. It can also be used to identify the preferences of homeowners towards urban forests in their community and private properties. Findings can be used to develop best management practices and lead to a better understanding of what specific landscape design and forest structures homeowners prefer, and policy-makers can manage, for the sustainability and provision of ecosystem services.

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LINKING WATER MANAGEMENT AND NATURAL CAPITAL USING AN ECOSYSTEM SERVICES FRAMEWORK

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Although the Delaware River Basin is considered one of the “healthier” watersheds on the U.S. East Coast, there exists potential for degradation and environmental stressors, which can reduce the flow and function of the river’s ecosystem services. The Delaware River provides drinking water to fifteen million people, habitat for threatened and endangered species, and supports opportunities for world-class recreation. Improving our understanding of the provisioning and value of ecosystem services supported by the quality of water found in the Delaware River Basin is of utmost importance when such services may change under future land use scenarios. Of particular interest is linking the supporting role of healthy freshwater mussel populations to the provision of ecosystem services in the Delaware River. Freshwater mussels are a native group of filter feeders commonly found throughout North America. Through filtration activities, they capture and remove materials that would otherwise be flushed to the Delaware Bay. In turn, these filtration activities facilitate the growth and biodiversity, invertebrates and fish, and contribute to the overall health of aquatic ecosystems. An interdisciplinary science effort is investigating several approaches to assess ecosystems services in the Delaware River Basin, including: (1) Leveraging USGS models and tools to evaluate biofiltration, nutrient flux, storage, and retention associated with freshwater mussel populations within the Delaware River; (2) Quantifying the economic value of the ecosystem services generated by the Delaware River using a stated preference nonmarket valuation method implemented with a household survey and; (3) Developing a predictive model for estimating changes to ecosystem services associated with predicted changes to the Delaware River Basin. The results of this effort will provide valuable and currently non-existent information to decision-makers that have expressed interest in the outcome of this research, such as the National Park Service’s Upper Delaware Scenic and Recreational River.

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USING A MULTI-BENEFIT, MULTI-CRITERIA ECOSYSTEM SERVICES APPROACH TO PRIORITIZING OPEN SPACE PROTECTION IN CENTRAL PUGET SOUND

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It is a well-established fact; people are drawn to the unparalleled quality of life enjoyed in the Puget Sound region, making it one of the fastest growing regions in the country today.

Over the next 25 years, 1 million new residents are expected to move to the region. This expansion is a testament to the economic and environmental vitality of the region and its thriving communities. Current growth is already putting tremendous strain on the same natural and built green infrastructure that supports present-day lifestyles and makes the Puget Sound region so attractive. So 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--its prized open spaces and natural landscapes.

But what are the most important open spaces to preserve? And how do decision makers plan for open space protection in the face of other pressing regional challenges: climate change, environmental degradation, social equity concerns, and the economic vitality and health and well-being of their communities and people? By way of answering these compelling questions, this session will introduce participants to an innovative planning initiative called the Regional Open Space Strategy (ROSS) – a collaborative, research and planning effort conducted by the University of Washington's Green Futures Lab in collaboration with the region's broad network of open space experts.
The ROSS strategy embraces a cross-disciplinary, multi-pronged approach focused on:
Envisioning a regional open space system;
Improving regional coordination and decision-making;
Building a regional advocacy community; and
Developing frameworks and tools to help advance the most important projects and actions.

Included in this presentations will an overview of the ROSS approach, key findings and recommendations of the ROSS final Strategy and a preview of a new ecosystem services (or open space services) valuation tool developed as part of the ROSS effort in partnership with the Trust for Public Land. This new tool informs decision-making and supports open space planning and prioritization by quantifying and mapping the multiple benefits that open space provides.

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THE ROLE OF IN LIEU FEE PROGRAMS IN ACCELERATING THIRD PARTY COMPENSATORY WETLAND MITIGAITON

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Under Clean Water Act Section 404 permitting programs, permittees are responsible for securing compensatory mitigation for unavoidable adverse impacts on wetlands, streams, and aquatic resources. Historically, regulatory authorities adhered to a permitting sequencing process that first sought to avoid and minimize adverse impacts and then preferred compensation for unavoidable impacts as close as possible to the permitted impact. Third party compensatory mitigation - provided by private banks, in lieu fee programs, or permittee offsite banks (single user banks) - was allowed if “on-site” mitigation was deemed impractical. While compensatory mitigation credit markets developed in some areas, many parts of the country were characterized by limited credit demand (Shabman and Scodari 2004).

In 2008, the Army Corps of Engineers and the EPA promulgated new compensatory mitigation rules intended to encourage the off-site third party compensatory mitigation. While maintaining the avoid-and-minimize preference, the rules prioritized the use of consolidated off-site compensatory mitigation. In particular, the rule established a preference for private mitigation banks that generate compensatory mitigation prior to permitted impacts. The rule also recognizes that in some circumstances private banks may be unable to supply wetland and stream mitigation credits. In lieu fee programs, operated by government or nonprofit organizations, could provide off-site compensatory mitigation through the issuance of “advance credits”. Regulatory officials authorize ILF programs to sell a limited number of advance credits to permittees prior to any offsetting compensatory mitigation projects. While allowing losses in advance of compensation, advanced credits allows the ILF program to collect enough advance credit fees revenue to successfully provide offsetting mitigation. The rule, however, provides conditions and limits on the use of advance credits.

This presentation will analyze the credit demand conditions that might limit private investment in compensatory mitigation and evaluate the degree to which ILF programs using advance credits can provide financially viable compensatory mitigation. We develop a firm-level simulation model that simulates net present value and rates of return for an offsite compensatory mitigation project. Planning and approval costs, construction costs, land prices, and post construction monitoring costs are specified for several different hypothetical wetland restoration project sizes. For each project type, financial outcomes are simulated for different credit demand conditions that vary based on the size and frequency of wetland credit sales. The credit demand conditions specified in the model will be informed by evidence found in ILF programs. The results will highlight the extent to which program rules limit the ability of ILF programs to provide financially viable compensatory mitigation in thin demand situations.

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TRANSACTION COSTS FOR NONPOINT SOURCE WQT CREDITS: IMPLICATIONS FOR THE CHESAPEAKE BAY

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Gwendolen Deboe (née Rees) contributed to this research in her personal capacity. The views expressed are her own and do not represent the views f the ACCC.

Agricultural nonpoint sources figure prominently in the design of many water quality trading programs. In concept water quality trading programs can create incentives for agricultural operators to supply low cost pollutant reductions while still keeping land in agricultural production. Numerous cost analyses indicate that low nutrient abatement costs from agricultural best management practices (BMPs) could induce permitted sources facing mandatory nutrient control requirements to purchase nonpoint source credits. In practice water quality trading programs have produced relatively few trades involving permitted sources buying agricultural nonpoint reduction credits produced from working agricultural land.

Transactions costs are a critical, but poorly understood, feature of nutrient trading programs. In particular, the transaction costs associated with the certification and verification of nonpoint source nutrient credits can add costs to producing nonpoint source credits. The objective of this study is to examine the transactions costs associated with agricultural NPS credits in the Chesapeake Bay watershed (United States). The Chespeake Bay watershed has been at the center of the development of nutrient trading programs in the United States and Virginia, Maryland, and Pennsylvania all have developed programs to add compliance flexibility in a number of regulatory programs for nutrients.

Transaction costs associated with credit creation and monitoring are estimated for different classes of agricultural nonpoint source credit generating practices (land conversion, structural BMPs, and management BMPs). Transaction costs to create agricultural nonpoint sources are estimated using evidence from nonpoint source cost-share contracting progams and a number of water quality trading programs in the United States. Agricultural practices are differentiated on the complexity of the credit certification process and type of credit monitoring regimes.

Results indicate that transaction costs associated with creating and monitoring transferable credits from working land best management practices can be considerably higher than credits generated by converting and retiring agricultural land to less intensive uses. In some cases, transaction costs may be relatively large compared to nonpoint source abatement costs. Various options to reduce the transaction costs of nonpoint source credits are explored.

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GULF OF MEXICO ECOSYSTEM RESTORATION: BASED ON A FOUNDATION OF ECOLOGICAL, ECONOMIC AND SOCIAL COMPONENTS

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Healthy and sustainable ecosystems are essential for thriving and resilient coastal communities. Across the Gulf of Mexico, cultures, economies and societies are built upon and sustained by natural ecosystem services that provide clean water, abundant fisheries, storm protection and more. Even before the Deepwater Horizon (DWH) oil spill of 2010, the health and function of the Gulf ecosystems and economies suffered from decades of significant human and natural stressors. Chronic loss of critical wetland habitats, erosion of barrier islands, imperiled fisheries, water quality degradation, impacts from invasive species, substantial coastal land loss due to natural forces and the alteration of hydrology, and impacts from other human activities reduce social, cultural and economic benefits of functional ecosystems. In addition, the Gulf Coast region has endured repeated natural catastrophes, including major hurricanes such as Katrina, Rita, Gustav, and Ike. In the Initial Comprehensive Plan, the Gulf Coast Ecosystem Restoration Council (Council) committed to restoring the Gulf ecosystem and economy and science-based decision-making. The Council, as a federal agency, is also exploring ways to implement the White House memo on *Incorporating Ecosystem Services into Federal Decision Making.* As the Council moves forward with an update to the Comprehensive Plan and making decisions based on the best available science, ecosystem services will play a role in the project and program selection and implementation. Therefore, the Council can help communities enhance their ability to recover from natural and man-made disasters and thrive in the face of changing environmental conditions through such services as habitat revitalization, storm protection, pollution removal, nutrient cycling, and many aesthetic, cultural, and recreational values, as well as tourism and jobs is an economic imperative for the Gulf region.

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THE POTENTIAL FOR MANAGING COASTAL SYSTEMS TO PROVIDE ECOSYSTEMS SERVICES AND ENHANCE RESILIENCE

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Coastal ecosystems are some of the most beloved landscapes. People choose to both live and/or vacation in these ecosystems. For example, in the U.S. in 2010, 39% of the population lived in coastal counties that represent just 10% of the total land area. And by 2020 there is expected to be ~4x as much growth in population in coastal counties than in other parts of the U.S. As a result, coastal ecosystems are some of the ecosystems under the most pressure from human use and development. At the same time, coasts are dealing with increasing sea levels and increases in the intensity and/or frequency of coastal storms and nuisance flooding. As coastal managers and policy and decision makers attempt to sustainably manage coastal ecosystems for multiple uses, it is important to consider ecosystem services, such as storm risk reduction and carbon sequestration, and who the beneficiaries are of different services. It can also be important to consider the full array of interactions within an ecosystem, including multiple desired human uses, when examining options for management and considering trade-offs of different options which is enabled when using ecosystem-based management (EBM). Ecosystem services are often one of the factors considered as part of the EBM process to ensure that desired services are incorporated into the decision context and options. For example, if carbon sequestration is an important goal while doing no ecological harm, then restoring degraded coastal wetlands or protecting existing wetlands are both good practices. In some cases where there are multiple conflicting uses, however, it may take an EBM approach with stakeholder engagement to determine where and how to complete wetland restoration to achieve the goal of carbon sequestration while balancing other coastal human uses. This presentation will present some examples of how using both the ecosystem services approach and/or an ecosystem based management approach can help achieve policy and management goals for sustainable coastal ecosystems and communities.

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EVALUATING TRADEOFFS IN ECOSYSTEM (DIS)SERVICES FROM A WORKING CATTLE RANCH IN FLORIDA: ADDRESSING THE QUESTION OF SPATIAL SCALE

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Interdisciplinary and landscape-scale approaches are needed to evaluate trade-offs among ecosystem services and disservices and to consider trade-offs at spatial scales from local to regional to global. One component of Southeastern US Agriculture that provides important ecosystem services is central Florida rangelands. Florida ranks 11th in beef cow and calf enterprises nationally, and the state's grazing lands overlap extensively with the headwaters of the Everglades. This watershed of 1.062 million hectares drains south into Lake Okeechobee, with important implications for agriculture and for water quality and water supply for 8 million Floridians downstream. To sustain ecosystem services from Florida rangelands it is imperative to understand the trade-offs among services and their counterpart disservices, and to examine these in relation to economic return and landscape context. We address these issues by integrating extensive long-term research from a cow-calf operation in the headwaters of the Everglades, Buck Island Ranch, which is the location of the MacArthur Agro-ecology Research Center, one of 18 sites in the national USDA Long-term Agro-ecosystem Research Network. We compare ecosystem services and disservices from improved pasture, semi-native pasture, and natural lands on this ranch to illustrate trade-offs in relation to the scale (local, regional, and global) at which they accumulate, and to economic viability. Furthermore, we discuss how sustaining ranchland ecosystem services into the future will be highly dependent on regional land use decisions and landscape configuration.

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TREND OF THE PUBLIC'S EVALUATION OF ECOSYSTEM SERVICES BY WTP FROM A NATIONAL SURVEY IN JAPAN

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Public attitude toward ecosystem services needs to be considered in decision-making regarding environmental conservation and urban development. Influences of urban development on ecosystem services should be discussed in terms of scientific as well as social rationality as the former cannot always satisfy public acceptance. The contingent valuation method of willingness to pay (WTP) is often used in the evaluation of public attitude toward ecosystem services. WTP has been adopted in each case study with assumptions regarding specific areas or environments. However, high values for certain ecosystem services may easily be gained regardless of the case study, and another ecosystem service may gain a low value statistically. The purpose of this study was to analyze the trend of the Japanese public's evaluation of ecosystem services by WTP through a national survey.

We conducted a nationwide online survey for Japanese citizens in February 2016. Respondents were recruited with stratified sampling based on the population ratio in each of the eight districts by gender and age. The number of respondents was 1,800. We showed respondents 12 green space conservation activities corresponding to 12 ecosystem services, and asked them to indicate WTP for each activity. The question was: "Suppose you allocate a subsidy to conservation activities carried out in your town. Please choose 4 out of 12 activities and allocate a total of 6.7 million yen to them." Respondents were asked to indicate WTP by allocating between 500,000 and 3 million yen per chosen activity. We formulated the question after the model of Japan Fund for Global Environment, which offers large-scale subsidies by the Japanese government. One yen equaled approximately 0.00826 USD.

Selected rates of and allocations to each service were analyzed by the statistical method of "the analysis of means". All results showed that Japanese citizens tended to select regulating services significantly, whereas cultural and provisioning services were not very often selected. Moreover, all results showed that high prices of average WTP were allocated to regulating services, and low prices of average WTP were allocated to cultural and supporting services. Japanese citizens thus tended to favor regulating services, but they didn't intend to support cultural services very much in WTP.

In addition, we analyzed WTP results by cluster analysis, which divided respondents into 10 clusters (e.g., cluster with high regard for food provisioning services (182 respondents) and cluster with high regard for global warming prevention services (178 respondents)). Focusing on each of these clusters, potential relationships between evaluations of ecosystem services by WTP and gender, age, and willingness to participate in conservation activities were determined. Provisioning services in particular were related to these respondents'attributes.

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GETTING SPECIFIC: CONSISTENT IDENTIFICATION OF ECOSYSTEM SERVICE AND HUMAN WELL BEING OUTCOMES FROM ENVIRONMENTAL MANAGEMENT DECISIONS

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The Nature Conservancy has updated its vision statement and science-based approach to conservation with the intention of recognizing the value of nature for its own sake, and its ability to provide benefits to people. This expanded view requires that we alter our planning and management purview from a more narrow focus on environmental outcomes to a broader focus on environmental outcomes and linked outcomes for ecosystem services and human well-being. The US Federal government has embraced a similarly expanded view in its 2007 Office of Management and Budget memo calling for the accounting of ecosystem services in federal decision making.

As these and other management organizations shift to adopt these expanded practices, a common challenge is consistently identifying ecosystem services and human well-being components of relevance, and clearly detailing how management actions will or have affected them. We will share the results-chain based approach and human well-being framework being adopted by The Nature Conservancy to address this challenge. The approach uses a consistent set of human well-being components as a reference point across projects, and details specific connections to specific human well-being elements for specific beneficiary groups on a case by case basis. We will provide examples from North America urban conservation, renewable energy citing in the western US and rangeland management in Kenya to demonstrate how the use of this framework can help consistently specify relevant ecosystem service and human well-being elements in widely varied management contexts.

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INCORPORATING ECOSYSTEM SERVICES INTO RESULTS CHAINS TO INFORM RESTORATION DECISIONS

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Environmental restoration commonly happens in complex systems where nature and people are interacting in many ways. Given this context, connections between restoration actions and human outcomes need to be understood, planned for and in many cases measured, either to ensure no unintentional harm to people or to attempt and track progress towards joint benefits. Such a case exists in the Gulf of Mexico in the context of the Deepwater Horizon spill restoration efforts. The oil spill caused harm to the environment and to the Gulf residents and economy, and restoration efforts will affect those multiple elements of the system as well. Activities being supported with restoration funds include those that target environmental recovery, like restoration of habitat, and those that aim for joint benefits for people and nature, like work force development through restoration-based employment or green infrastructure projects (living shorelines) that restore habitat and reduce coastal flood risk. How can such a broad set of actions be compared and prioritized against these multiple goals, and how can consistent metrics be selected to allow reporting to Congress and society on environmental and social benefits?

We will discuss emerging guidance from conservation practice (The Nature Conservancy's Conservation by Design 2.0 Guidance) and federal decision making (guidance from the National Ecosystem Services Partnership and National Academies) that encourages answering these questions by using results chains extended to include ecosystem services. Typical environmentally focused results chains show the conceptual logic of how a proposed restoration action is likely to change the environment towards ecological restoration goals. Most environmental changes today in complex systems lead to additional positive or negative changes in social or economic conditions, but these changes are often left out of results chains in restoration design and evaluation. By extending results chains to include ecosystem services, the links between environmental change and human well-being are captured. This expression of the likely linkages within a system allows clear identification of which social or economic outcomes are likely. Results chains that include ecosystem services provide a common frame for comparing restoration projects, consistently identifying metrics for measuring outcomes and clarifying likely tradeoffs or potential co-benefits. We will use an example of oyster reef restoration to show how extended results chains can be relevant in the Gulf restoration context.

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ACES 2016 THE NEED FOR A UNIVERSAL EVIDENCE BASE FOR ENVIRONMENT, HEALTH AND DEVELOPMENT

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People and nature are linked. This simple statement belies the complex reality confronting the environment, health and economic development sectors today. Each community has come to this recognition in their own way, and a wave of efforts continues to bring increasing clarity to the linked challenges at hand. The environment community was galvanized by the Millennium Ecosystem Assessment to understand and correct the challenges of declining ecosystem services, and US federal agencies are starting to follow suit with the broad adoption of this concept. Recent reviews by the Lancet-Rockefeller Commission on Planetary Health and the World Health Organization point to strong connections between the environment and human health. The intergovernmental community recognized health as a key contributor to economic development in its adoption of the Millennium Development Goals, and has now expanded that lens to the environment, placing sustainability front and center in the new Sustainable Development Goals.

As these communities pivot to act, they need to find shared solutions to what we now recognize as our linked problems. This is where our current evidence bases fall short. Efforts like GEO BON compile evidence in an attempt to better understand linked challenges, but we find that simply aggregating evidence is not enough. The environment, health and development communities have used different methods, metrics and principles, and evidence is seldom interoperable. However, we find that these communities use a common entry point into designing and evaluating projects and programs that could form the basis for an evidence revolution. Each community uses some form of conceptual framing (e.g. results chains) that details the causal pathway through which a project or program is likely to lead to desired outcomes. Today each community uses different approaches to creating results chains and focuses relatively narrowly on environmental or socio-economic elements of a system, even though these elements are intertwined. Aligning these approaches and expanding results chains across communities could unlock the shift in evidence creation we see as necessary to confront linked challenges for nature and people.

We propose the creation of a unified evidence base for environment, development and health built off of three components; 1) shared principles for results chain creation and evidence grading; 2) model results chains that provide reference points for all communities and; 3) evidence for model results chains synthesized on an ongoing basis to identify strong interventions ready for use against linked challenges and key research gaps for each community. We will describe the Bridge Collaborative, a trans-disciplinary, cross sector effort underway to initiate this evidence transformation.

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SPATIAL VALUATION OF ECOSYSTEM SERVICES IN AGRICULTURAL LANDS

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Agricultural lands provide various provisioning ecosystem services to humans, including food, water, fibers, fuel, and components of pharmaceuticals. These ecosystems also support and regulate such services as pollination, water provision, and the retention of nutrients and soil. The value of these ecosystem services, while tremendous, historically has been vaguely defined and underappreciated. Numerous efforts in attempting to evaluate the worth of ecosystem services have been done. However, most proposed values are dependent upon stakeholders and/or available funding. Only a limited number of work has shown to directly incorporate existing market values as the referenced values.
This research built a comprehensive framework to spatially map and quantify the ecosystem services provided by agricultural lands in Galveston County, Texas using an open-source ecosystem services modeling tool called the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) models. Five ecosystem services models were investigated, including: water yield, nutrient retention, sediment retention, pollination abundance, and habitat quality. Biophysical data, such as land use/land cover, precipitation, evapotranspiration, soil and pollinator characteristics, and threats to habitat were input into the InVEST models to determine the amounts and spatial patterns of these ecosystem services. Results showed spatially distributed ecosystem services throughout the study area, with hot spots of ecosystem services where certain activities were concentrated, such as streams, croplands, and intensely developed lands. A hedonic price model was designed to appraise the value of these ecosystem services based on the prices of the agricultural land as well as other relevant factors (neighborhood, structure, and market segmentation). The model was used to estimate the marginal implicit price of a per unit increase in each ecosystem services variable.

The estimates suggested that ecosystem services were included in appraisals of the land prices – to various degrees of statistically significant correlation – except with regards to pollination abundance and habitat quality. The habitat degradation value, a derivative of the habitat quality model, was shown to be most closely correlated with land prices, which could be explained by highly degraded lands as a result of extensive cropping systems.

Together, this suggests that more planning, thoughtful policy making, and resource management could help avoid land degradation and prolonged effects that could potentially deplete more resources and habitats within (and beyond) these areas. Further model calibrations that include comparisons of different scenarios (e.g. a baseline scenario, constrained development, and non-constrained development) to manage these lands would help determine efficient steps forward, as accounting for the economic value of ecosystem services is now vital for managing and sustaining our irreplaceable natural resources.

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HOLISTIC GROWTH: STRATEGICALLY EXPANDING A STUDENT GARDEN BY PAIRING STAKEHOLDER NEEDS WITH LANDSCAPE SUITABILITY

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The Student Garden at the College of Charleston, located in the low country of the South Carolina Coastal Plain, serves as an experiential education facility for the College, local K-12 children, and the broader community by demonstrating sustainable agricultural techniques. The Garden is planning to expand its mission to include student research, and a campus supported agriculture (CSA) produce subscription program. Correspondingly, the Garden requires increased land. This project seeks to strategically plan that expansion by pairing a stakeholder analysis with an ecosystem and land suitability assessment of this site, in order to create a landscape design that maximizes stakeholder needs fulfillment within the constraints of the landscape and its ecosystem. In this case, the ecosystem service of major value to stakeholders is soil quality and productivity.

The scope of this project encompasses the ~6 acres surrounding the Student Garden, utilizes existing soil data, and involves examining the three main stakeholder groups. Interviews were conducted with Garden Administrators (those directing the Garden), Student Managers (graduate students performing day to day labor and maintenance), and Student Users (graduate and undergraduate students using the Garden for research and volunteer purposes). Interview data was collected regarding perceptions of the mission, vision, and major projects of the Garden, along with needs associated with each. Areas of strongest stakeholder agreement were used to set priorities for the proposed landscape design. This was paired with ecosystem and landscape suitability data addressing agricultural productivity of the soil, drainage, and building suitability (SSURGO Soil Survey Geographic Database, ESRI 2014). Based on these findings, an expansion plan was devised.

Stakeholders consider the main mission of the Garden to lie in three areas: education, student research projects, and vegetable production. Landscape suitability analysis determined that the Garden is currently situated in the least favorable location, from an ecosystem standpoint, within its available land area. The landscape design incorporates the stakeholder needs of education, research, and production while proposing an expansion in a new, more centralized location that has soil better suited for agriculture along with new infrastructure. It incorporates a centralized building with office, rest area, and shaded work area that has facilities approved for vegetable processing for the CSA. Adjoining the building are beds showcasing sustainable agricultural techniques, greenhouses for seed starting and production, area for a food forest, and open fields for row crops.

This project addresses the stakeholder, ecosystem, and landscape requirements for the Garden. An existing partial financial model must be further developed, along with a timeline, in order to implement the plan and achieve the shared vision of holistic growth.

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UPSTREAM, MIDSTREAM, AND GENTLY-DOWN-THE-STREAM: INTEGRATING ECOSYSTEM SERVICES INTO THE ENERGY BUSINESS

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Traditionally, the energy business, especially for fossil fuels, has been divided into an upstream segment (exploration for resources and their production), a midstream segment (gathering, processing, transportation and storage), and a downstream segment (refining, trading, marketing and sales). However, most aspects of developing and producing energy and mineral commodities are becoming more complex with time, challenging the fit and usefulness of this linear business model. These aspects include: (1) increased interest by stakeholder communities to be more involved in decision-making; (2) the need to address up-front concerns about potential environmental impacts of resource extraction and use; (3) doing business in a global marketplace and weathering the cyclical financial nature of the resource industry; (4) changing regulatory requirements; (5) the need to communicate effectively to an ever-widening and diverse range of audiences, and (6) incorporating new technology to interpret very large datasets for optimizing operations.

Tools and approaches are needed that inform and improve resource-related decision-making within this real-life complexity experienced routinely by those working in the areas of energy business, policy, or regulation today. The imperative for resource development businesses going into the future is to effectively manage the entire span of resource development for both environmental and commercial viability. Broadening the traditional linear business model to encompass a full resource life cycle perspective brings in aspects often overlooked or left out. These include remediation, recycling, disposal, facility closure/de-commissioning, maintenance, perpetual treatment, well abandonment, and other end-of-life activities.

In recent years, as the extractive industries have begun to engage a range of new tools and approaches, terms have emerged such as "sustainability", "resource development life cycle", "full cost accounting", "the circular economy", and "cradle-to-cradle". Such terms attempt to bridge the gap commonly occurring between the environmental and economic aspects of resource development, with mixed success. Ecosystem services valuation used as a key organizing framework for decision-making regarding resource development has shown greater promise to be useful and gain traction within the energy sector. A conceptual model is presented which integrates values for ecosystem products and services through the energy life cycle, with the traditional industry resource development business model. Use of this integrated model will improve understanding of interdependencies in the energy resource development enterprise and enhance the ability to effectively manage trade-offs between resources.

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DEVELOPING AND USING SOCIO-ECONOMIC METRICS TO MEASURE PROJECT BENEFITS AND ECOSYSTEM SERVICES AFTER HURRICANE SANDY

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The Department of the Interior (DOI) is evaluating the benefits and ecosystem services provided by resilience projects in the area impacted by Hurricane Sandy. The DOI social and economic metrics associated with ecosystem services builds on the previously described Metrics Expert Group ecological performance metrics, and were developed to provide measures of community well-being and resilience resulting from the DOI resilience projects. Measures and methodologies to address community resilience are broad and therefore less established than ecological metrics. Development of the socio-economic metrics began with extensive review of the DOI projects and existing disparate efforts that assess community resilience, ecosystem services, and metric frameworks. The DOI projects were categorized by one or more project activity(s) (e.g. community planning, habitat restoration, green infrastructure, etc.), These project activities and associated planned or realized ecosystem services informed the development of 16 resilience goals that are organized by four main resilience categories: human health and safety, property and infrastructure, economics, and community empowerment. Over 200 socio-economic metrics were identified, summarized in tabular format as metrics suites for each combination of ecosystem services and resilience goals. Additionally, methodologies and recommended data and tools are provided for each ecosystem service according to varying degrees of difficulty and detail. Finally, a framework was developed and tested to assign ecosystem service metrics to each project based on project activity(s). This presentation will provide an overview of the socio-economic metric framework and how to use the metrics table, including identification of metrics and project co-benefits based on project activity, desired project outcomes, and resilience goals. The application of ecosystem service metrics will be demonstrated for Prime Hook National Wildlife Refuge, with examples of how the metric suites provide narrative, qualitative, and quantitative details on how DOI and future resilience projects have or may improve ecosystem benefits and coastal resilience.

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NATIONAL GREEN INFRASTRUCTURE CERTIFICATION PROGRAM

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Initiated under the leadership of DC Water and the Water Environment Federation, the National Green Infrastructure Certification Program (NGICP) sets national certification standards for green infrastructure (GI) construction, inspection, and maintenance workers. Designed to meet international best practice standards, the certification advances the establishment of sustainable communities by promoting GI as an environmentally and economically beneficial stormwater management option, supporting the development of proficient green workforces, and establishing a career path for skilled GI workers.
While NGICP is being created primarily to support GI installers and maintainers, it also offers benefits to utilities who want to take advantage of GI's ability to control stormwater pollution as well as trainers who seek to provide GI knowledge to their students.

The NGICP covers the following GI types:

- Bioretention (includes rain gardens, curb cuts/curb extension, stormwater planters/tree boxes, tree trenches, and bioswales/vegetated swales)
- Permeable pavements (porous asphalt, pervious concrete, pervious pavers)
- Rainwater harvesting (rain barrels and cisterns)
- Rooftop detention practices (green roofs and blue roofs)
- Dry wells
- Stormwater wetlands

The partners are: DC Water, San Francisco Public Utilities Commission (SFPUC), Fairfax County, Milwaukee Metropolitan Sewerage District (MMSD), Kansas City Water Services Department, Louisville Metropolitan Sewer District, City of Baltimore Department of Public Works, Montgomery County, Capital Region Water, New Orleans Delegation, Pittsburgh Water & Sewer Authority, Metropolitan Water Reclamation District of Greater Chicago, Boston Water and Sewer Commission, Greater Cincinnati Water Works, District of Columbia Department of Energy and the Environment (DOEE). The NGICP program development process is being carried out by several stakeholder groups.

- Governing Body
- Technical Advisory Group
- Strategic Advisory Group

These groups will work together to develop the program and assist with building the components to support certification of candidates in the construction, inspection, and maintenance of green infrastructure practices.

The certification process involves the following steps:

- Meeting the eligibility criteria
- Attending a GI training course in your region
- Submitting a certification application form and fees
- Taking the exam and receiving a passing grade

The first certification exam (called the operational pre-test) is being offered to partners only in Dec 2016. Trainings are underway starting Nov 2016. The first certifications will be awarded in Jan 2016. Once the national roll-out happens in 2018, this certification will be available to all regions across the country.

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ECOSYSTEM SERVICES: A NEW FRAMEWORK FOR OLD IDEAS?

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The organizing framework of ecosystem services is promoted as a new and important way to recognize and account for the benefits that nature provides to humans. Our research demonstrates that concepts that appear in ecosystem services approaches emerged earlier, and have been used for decades, in fields such as environmental planning and sustainable forest management.

For example, foundational ideas in the disciplines of landscape architecture and environmental planning include recognition of the interdependence between people and the land, acknowledgement of the importance of natural processes to support human land use, and the systematic documentation of landscape data. The concept of green infrastructure - the use of natural structures and functions instead of technology - is in current vogue in planning and urban-forest scholarship. In sustainable forest management, themes within criteria and indicators that were developed in the 1990s echo themes of the Millennium Ecosystem Assessment (MEA); for example, conservation of biological diversity, maintenance of productive capacity of forest ecosystems, and conservation and maintenance of soil and water resources, to name a few.

We have conducted a comparative analysis of the MEA ecosystem services framework and its underlying concepts against approaches and concepts from land-use planning and forest management. The research questions are:
What concepts are shared between the MEA ecosystem services framework and approaches used in related fields?
How are concepts in the MEA and related fields currently organized and operationalized?

We examined historic and current planning and management approaches developed and used in North America and Europe through a review of the scholarly and non-scholarly published literature, as well as grey literature such as practice manuals and land-use policy. Approaches in other disciplines share elements and themes of ecosystem services approaches, but organize the concepts differently. Landscape suitability approaches in planning, for example, are spatially- and process-oriented approaches that account for landscape structure and function in assessing fitness of the land for a specific use.

The research provides an understanding of how the MEA ecosystem services framework is conceptually related to other approaches. The research also offers insight on a range of challenges with ecosystem services frameworks, such as implementation at the local level and how to account for interdependences among services. We also reflect on what the MEA ecosystem services framework might offer to other approaches.

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USING ECOSYTEM SERVICES TO BUILD A HARDWOOD BIOFUELS PROGRAM

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Biofuels and biochemicals made from renewable resources such as poplar trees can reduce greenhouse gas emissions, reduce reliance on foreign oil, and support local economies. Current economics, markets, and policies make a viable biofuels and biochmeicals industry challenging. Many promising bioenergy crops such as poplar, willow, and switchgrass are also grown to provide ecosystem services. Combining the need for renewable energy with an ecosystem service, could be a way to help the biofuels industry move forward and also provide double environmental benefits.

In the Pacific Northwest, the Advanced Hardwood Biofuels Northwest (AHB) research project has found interest in biofuels among current growers of poplar for environmental benefits. We have found 1200 acres of poplar being grown for ecosystem services, with waste water management being the primary use followed by phytoremediation. The AHB Extension team has met with waste water professionals and other stakeholders at field tours of poplar bioenergy farms to determine their needs as well as suggested areas for collaboration. This has resulted in workshops for these stakeholders and a national conference on how to find and build markets for poplar particularly in the area of bioenergy in combination with ecosystem services.

The Extension team is collaborating with other biofuel research projects that focus on crops that can provide ecosystem services. A product of this work includes a roadmap to identify the barriers, benefits, opportunities, and solutions for growing crops for renewable energy and ecosystem services. We recommend fully exploring and quantifying the ways in which bioenergy crops can be grown for ecosystem services.

In conclusion, there are significant barriers to developing a successful poplar-based biofuels and biochemicals system, with the largest barrier being economic viability. However, there is potential for wastewater treatment facilities to serve as early adopters for poplar production for an eventual biofuels and biochemicals market.

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COASTAL RESILIENCE AND LANDSCAPE CONSERVATION DESIGN IN SW FLORIDA

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The Resilient Lands and Waters initiative, as called-for by the President's Priority Agenda for Enhancing the Climate Resilience of America's Natural Resources, will build upon the National Fish, Wildlife, and Plants Climate Adaptation Strategy (NFWPCAS: http://wildlifeadaptationstrategy.gov) as well as the work of landscape-scale collaboratives nationwide to demonstrate the resilience benefits of the landscape-scale approach to planning. Identifying such priority areas also benefits wildfire management, mitigation investments, agriculture/conservation incentives, restoration efforts, water and air quality, carbon storage, and the communities that depend upon natural systems for their own resilience. SW Florida was selected as one of the seven resilience pilot study areas in the US. The Peninsular Florida landscape conservation Cooperative (PFLCC) and NOAA are using previously developed sea level rise and climate change scenarios and a modified DPSIR (Driver-Pressure-State-Impact-Response) model and will map ecosystem services and resilience in SW Florida. Resilience products from this project are being developed into ecosystem services analysis and will be incorporated into agency and non-governmental organizations management plans to guide future planning decisions.

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BASIN-WIDE ASSESSMENT ON IMPACTS OF CLIMATE CHANGE ON ECOSYSTEM SERVICES IN THE LOWER MEKONG BASIN

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The Lower Mekong Basin (LMB) covers parts of riparian countries of Lao PDR, Viet Nam, Cambodia and Thailand and supports over 60 million people for food and livelihood. Recently, the LMB is threatened by climate change. This paper aims to quantify water yields and sediment retention at current and in short- and long-term climate scenarios. The InVEST model was used to spatially assess both ecosystem services. The results indicated that the estimated annual water yield in the entire LMB in 2010 was 639 km^3 and the average soil erosion was 43.2 ton/ha/year. In addition, 175 million tons of sediment were predicted to export from the LMB. The predicted annual water yields in 2030 and 2060 derived from a drier overall projection in combination of medium and high emissions indicated a substantial reduction of predicted water yields by 9-24% from the baseline and a reduction of soil erosion of 7-10% was predicted. The effects of the severe drought were forecasted in northern and southern Lao PDR and central Cambodia due to these areas lack of irrigation system. In contrast, the increased seasonality and the wetter rainfall scenarios in connection with high emissions would result in an amplification of 5-26% from the current runoff and would produce greater amount of soil erosion in the watershed and sediment load transported to the outlet. The research results are being embedded in the Mekong Adaptation Strategy and Action Plan 2020.

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A FRAMEWORK FOR CATEGORIZING THE SPATIAL DELIVERY OF ECOSYSTEM SERVICES

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This paper outlines a proposed framework for categorizing and accounting for ecosystem services based on their spatial delivery. The primary characterization that is typically used to describe ecosystem services comes from the four functional groupings established by the Millennium Assessment: Provisioning, Cultural, Regulating, Supporting (in the related TEEB framework the last category is "Habitat or Supporting"), under which sits a number of nested categories. This system of categorization, which has dominated the ecosystem services lexicon for years, is valuable as an abstract intellectual framework, but does a poor job of communicating the enormous differences in spatial provisioning for different types of services—distinctions that are critical to ecosystem service accounting and to communicating the value proposition of ecosystem services with stakeholders. For instance, greenhouse gas sequestration and flood mitigation are both considered "regulatory" services, but one's benefits accrue globally while the other's accrue just downstream. While a number of categorization approaches have been proposed in the literature as alternatives or complements to the MA approach (e.g. de Groot et al 2002, Wallace 2007, Fisher et al. 2009), some of which address space, none provides a comprehensive taxonomy or vocabulary for addressing spatial connections between beneficiaries and ecosystems. In the interests, therefore, of generating more meaningful ecosystem account ledgers and more effectively communicating with stakeholders, it is essential that such a spatial taxonomy is developed to clearly articulate the mechanism of spatial linkage from ecosystem to beneficiary.

The proposed framework, based on the findings and methods from several of the author's past ecosystem service accounting and assessment projects, provides such a spatial nomenclature and taxonomy—one that can be used consistently across almost any context. It classifies a given instance of ecosystem service provision (that is the service flows associated with a given unit of land) using three dimensions: a)medium of transport; b)level of diffusion; and c)regularity. Medium of transport refers to mechanism by which the service is delivered from a provisioning ecosystem to beneficiaries, for instance atmospheric mixing, surface water flow, line of site, conceptual knowledge, etc. Level of diffusion refers to how concentrated or diffuse the service provided is with respect to beneficiaries. For instance, carbon sequestration by a stand of trees has an impact that is highly diffuse because it positively impacts almost all humans in a very small degree, while flood regulation by a wetland may have a very direct and concentrated effect on a riverside community just a few kilometers downstream. The same ecosystem service could be either diffuse or concentrated depending on context: for instance, fresh water provisioning by a forested watershed could be a concentrated service in a case where the entire watershed's supply is appropriated by a nearby downstream community while it could be considered diffuse in a more distant watershed where the water yielded mixes with water in a large river system before it hits municipal intakes. Regularity refers to how regular or predictable a service flow is. For instance carbon uptake by trees can be treated as a given as long as those trees don't die; flood mitigation services are less predictable, requiring that there be a precipitation event over some threshold before the regulation becomes meaningful. Individual units of land can then be mapped based on these two dimensions. This presentation outlines the taxonomy, how each dimension is calculated spatially, and illustrates these methods and mappings using several case studies in the US and Canada.

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DEPARTMENT OF THE INTERIOR'S APPROACH TO SCIENCE AND ECOSYSTEM SERVICES FOLLOWING HURRICANE SANDY

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Responding to Hurricane Sandy's landfall along the Northeast coast challenged our existing knowledge of how to make our coastlines more resilient to future large storms and sea level rise. Should breaches in barrier islands be closed to avoid direct damage to the mainland from future storms? How do response strategies to breaches impact ecosystem health, water quality and the long-term evolution of the coastal landscape? Which wetlands can be managed in-place to adapt to sea-level rise, and which need to be allowed to move inland? Which wetlands can be adjusted in-place to adapt to sea-level rise, and which ones need to be allowed to move inland? Where are we most vulnerable, and what can be done about it? What are the key ecosystem services that underpin a resilient coastline?

Without improvements in scientific understanding, best practices for management of coastal infrastructure and ecosystems were uncertain at best. Further, the complex interactions among the built and natural components of coastal environments will often determine their overall resilience to storms. This session will discuss how several of the Department of the Interior Hurricane Sandy projects have led to a better understanding of the current vulnerability of coastal environments and the processes controlling coastal resilience, or have factored into measuring the long-term success of strategies to enhance resilience. High-resolution topographic mapping of the coast and near-shore bathymetry have allowed improved modeling of vulnerability to storm surge, overwash, and inundation. New sea-level rise and coastal response models are revealing our most vulnerable coastal features and communities, and socio-economic assessments are being linked to these models to inform cost-effective decisions to improve coastal resilience. New monitoring techniques for surge and waves are providing enhanced forecasts and early warning of inundation hazards. Mapping of sand resources and research on beach and dune processes have improved our capacity to sustain coastal habitats. Studies in the Jamaica Bay area of New York City (NYC) engaged youth and the public in improving the resilience of urban coastal regions, and a web application enables the public to create and share their own climate-resilient designs for NYC based on rapid and realistic model assessments of carbon, water, biodiversity, population, and economics. Research on the processes controlling coastal erosion, sea-level rise, breach evolution in barrier islands, marsh restoration, and contaminant transport, and testing of best practices for sustaining or migrating valued coastal features, have provided a new capacity for enhancing ecosystem services, and anticipating and managing coastal change.

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BUILDING CONSISTENCY THROUGH HIERARCHICAL CLASSIFICATION SYSTEMS FOR ECOSYSTEM SERVICES

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One of the first steps towards measuring and assessing the ecosystem service implications of a decision is to identify the specific types and categories of services to be evaluated. Different lists of ecosystem service categories are available for this purpose, including the commonly used Millennium Ecosystem Assessment categories of provisioning, cultural, and regulating services. Although generally easy to use and understand, these lists can have limitations for rigorous assessments of ecosystem services. In particular, the potential for overlapping categories and double counting of ecosystem services often exists, and the level of specificity may be constrained by a limited number of unique categories. To address these limitations, the National Ecosystem Service Classification System (NESCS) is designed to provide a system that is flexible, comprehensive, and avoids double counting. It does this by providing a classification system that is both combinatorial and hierarchical. In NESCS, each distinct final ecosystem service category is uniquely defined by a combination of two main elements: (1) the ecological "end-product" that is provided by nature to humans (supply side) and (2) the way in which the end-product is directly used or appreciated by humans (demand side). The large number of potential combinations of supply and demand side elements offers scope and flexibility for identifying the individual ecosystem services of interest. The supply and demand sides are also organized into separate hierarchical (nested) classification structures, which gives the user the flexibility to choose the level of desired specificity. Using example applications, the purpose of this presentation is to demonstrate the adaptability of NESCS and its ability it to provide a common and consistent structure for identifying ecosystem services across different environmental and natural resource management decision contexts.

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USING ECOSYSTEM SERVICE INDICATORS TO PRIORITIZE LAND CONSERVATION INVESTMENTS: AN APPLICATION FOR THE TAUNTON RIVER WATERSHED

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The Taunton River Watershed in Massachusetts is recognized for its rich ecological, recreational, and cultural resources; however, its location, topography, and economy make it particularly vulnerable to climate change impacts and development pressures. Land conservation is one key strategy for strengthening the resilience of the watershed; however, effective implementation of this strategy requires methods for targeting conservation investments. To support these efforts, the purpose of this study funded by USEPA's Healthy Watersheds Program is to develop and demonstrate an assessment framework and decision support tool that uses ecosystem service indicators to assist local decision makers in identifying and prioritizing natural lands for conservation. We constructed the framework by dividing the watershed landscape into a network of stream catchments and by creating an inventory of currently unprotected natural land units within each of these areas. To compare and rank these units we developed measurable indicators representing (1) the provision of six ecosystem service types -- flood protection, water quantity protection, water quality protection, habitat protection, air quality protection, and open space preservation – and (2) vulnerability to development. For each unit, we then developed initial indicator scores based on geospatial data for its own catchment and, as appropriate, for its upstream and downstream catchments. This assessment framework was then used to produce a computer-based user-interactive decision support tool. This tool is designed for conducting screening-level analyses in the watershed to assist in targeting areas that are best suited for conservation projects. It is designed so that stakeholders and decision makers can easily assign weight the ecosystem service and development vulnerability indicators and scores, according to their own preferences, interests or concerns. Based on these specifications, the tool generates tables listing the top-ranked spatial units. These outputs can then be easily exported for further examination, mapping, and analysis.

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NEW APPROACHES TO ENGAGING STAKEHOLDERS REGARDING URBAN ECOSYSTEM SERVICES ON VACANT LAND

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This research introduces new forms of stakeholder engagement to seek consensus on urban (ecosystem) service provision on vacant land. Based on an analysis of different public participation have been used between 2005 and 2015, this paper categorizes which stakeholders have been engaged, and how, in the redevelopment of vacant land in four shrinking cities in Ohio, namely Hamilton, Mansfield, Lima and Youngstown. The findings indicate that two key indicators, namely capacity in key government institutions and varying types of spatial targeting of resources, are not connected to different types of public engagement and show little evidence of additional support for ecosystem service provision on vacant land.

In one of these four cities, Lima, OH, the research was extended by experimenting with a consensus-based stakeholder engagement process. This approach consists of combining a visual survey of all vacant parcels with a spatially explicit stakeholder assessment. This research project produced a targeted area within which investment can be made. Within that cluster, key stakeholders were invited to participate in a negotiation simulation to model new forms of collaboration around (ecosystem) service provision on vacant parcels. Based on semi-structured interviews with key participants, policy analysis and action research this indicates significant potential of connecting stakeholders with particular types of parcels and places, an approach with possible applications in ecosystem service programs beyond urban areas as well.

Urban areas with high rates of vacant land frequently struggle with the management, (re-) activation and/or disposition of previously occupied parcels (Community Research Partners and ReBuild Ohio, 2008 and Dewar, 2015). While many of these shrinking cities have active demolition programs to reduce the number of blighted buildings within their boundaries, once physically vacant many of these parcels are maintained at the city’s expense or sold through auctions, lot-next-door programs or other forms of managed sales. City planners, landscape architects and environmental advocates have long seen opportunities for significant ecosystem service provision at relatively little cost. Large cities like Detroit, Philadelphia (Ryan, 2012) and Cleveland (Schwarz, 2011) have started significant planning processes to convert abandoned parcels to productive systems providing key urban (ecosystem) services. The success of implementation of these well-publicized efforts remains somewhat contested, but small and mid-sized cities generally do not have the means to execute large-scale planning processes primarily focused on vacant land. The notable exception here is probably Youngstown, OH, a city that has received a significant amount of attention for its Youngstown 2010 plan, issued in 2005. This research project analyzes the connection between public participation and ecosystem service provision on vacant land, and introduces promising new methods to connect stakeholders to opportunities on vacant land to produce urban (ecosystem) services.

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STORMWATER CREDIT TRADING & SCALING OF GREEN INFRASTRUCTURE IN WASHINGTON, DC

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Forty-three percent of the land area in Washington, DC (the District) is impervious, and the stormwater runoff from this area severely degrades District waterbodies. Runoff-reducing stormwater Green Infrastructure (GI) provides a potential technical solution for retrofitting these impervious areas. However, the District Department of Energy and Environment (DOEE) estimates the cost of retrofitting to the required scale at upwards of $7 billion, while DDOE's annual budget for such work is only about $10 million. The challenge is multi-layered, including how best to finance such an investment, how to maximize the impact of the investment, and how to avoid a permanent financial burden for the District government and its ratepayers and taxpayers. DDOE's Stormwater Retention Credit (SRC) trading program is key to that effort, helping make strong regulations possible, enabling a shift in GI to priority locations, providing a pay-for-performance tool for DDOE to cost effectively invest in GI, and allowing the costs of these retrofits to be internalized in the cost of development over time.

A critical step toward scaling GI in the District was establishing strong runoff-reducing regulatory standards so that development, which is mostly re-development in an ultra-urban area like the District, results in impervious surface GI retrofits. DDOE expects regulated development to retrofit roughly ten times the area that DDOE's budget can retrofit on an annual basis through its voluntary cost-share programs. Allowing regulated sites to meet a portion of their obligation by purchasing SRCs from properties that voluntarily install GI retrofits was essential to making these regulations acceptable.

SRC trading also makes it possible to harness the investment in GI by regulated projects and shift it to locations that can increase waterbody benefits. A traditional regulatory approach would require strict compliance on the regulated site, even though GI retrofits could provide greater benefit in other locations. Under SRC trading, there is an economic incentive for regulated sites with high capital and opportunity costs for GI to buy credits from less-affluent areas with lower land costs and more open space for GI retrofits, because GI retrofits typically have lower capital and opportunity costs in these locations. GI in these locations is particularly critical because, in the District, these areas typically drain with little or no treatment to small streams that are heavily impacted by stormwater. By contrast, regulated sites expected to buy credits predominate in the affluent core of the District, where GI has less water quality benefit since these areas typically drain to the combined sewer system for which large underground tunnels are currently being built.

To accelerate investment in GI retrofits in priority locations, DOEE is making SRC purchase agreement option contracts available to voluntary GI projects in these areas. This program, with initial funding of $11.5M, has begun to leverage private investment in GI. These option contracts will allow SRC-generating sites to sell their credits to a regulated site, while providing an option to sell SRCs to DOEE. DOEE intends for this to significantly increase SRC generation in priority locations and for regulated sites to disproportionately purchase credits from these locations, improving the outcomes of investment in GI. DOEE will also buy SRCs and retire them, taking advantage of the efficiencies of the private SRC market to save money for District ratepayers and taxpayers compared to DOEE's building GI itself. Over time, regulated development will retrofit much of the city, internalizing the externalities of stormwater runoff into the cost of development, and DDOE can reduce its own SRC purchases.

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PLANNING FOR CLIMATE CHANGE ADAPTATION: THE ROLE OF ECOSYSTEM SERVICES IN COASTAL LAND MANAGEMENT AND POLICY DECISIONS

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Saltwater intrusion along the coast of North Carolina (USA) presents a significant threat to ecological systems and the services that they provide. For rural communities located within the Pamlico-Albemarle peninsula of North Carolina, saltwater intrusion will impact surface water and soil salinity, subsequently affecting local agriculture and timber production. In addition, overall increases of and local variations in salinity will directly impact species composition of local fisheries, wetlands, and terrestrial habitats, affecting ecosystem services such as flooding and storm surge protection and resource extraction.

The extensive network of irrigation, drainage, and flood control infrastructure throughout the peninsula makes for an interesting and informative case study of large-scale land management decisions. A mixture of federal, state, and local actors are responsible for land management and policy decisions within the study area. Competing management goals, such as maintaining a flooded environment to prevent forest fires or promoting drainage as part of a wetland restoration project, may lead to reduced efficacy of agents acting to support their desired outcomes, as land management decisions made in one area can impact conditions in another.

In order to better understand the drivers of land management decisions, we will conduct semi-structured interviews with land managers and local officials in our study area to identify the extent to which ecosystem services, ecological resilience, and adaptation capacity are considered within the decision-making process. Responses will be used to assess ecosystem priorities during the development of management goals and policies. Results will inform future research regarding saltwater intrusion management and adaptation in the study area, and may also inform management goals and decisions for other communities facing similar climate change impacts.

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MAPPING LIVABILITY BY INTEGRATING ECOSYSTEM AND URBAN SERVICES WITH STAKEHOLDER PERCEIVED IMPORTANCE

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In the anthropocentric view of landscape, natural and human components interact generating service flows to local populations. Ecosystem Services (ES), defined as structural and functional ecosystem contributions to human well-being, can be supplied by natural components through different levels of interaction with human components. Some specific services, traditionally linked to urbanization—hereafter referred to as Urban Services (US)—can be considered as being supplied directly by the human component (e.g., police services, recreational facilities, schools, hospitals). The ES and US of a place influence how suitable a place is for human habitation, or in other words, its livability. As a consequence, their integrated spatial assessment can result in coherent and effective landscape livability analysis, which is also in view of better ES integration in policy-making processes. In addition, livability is strongly dependent, not only on objective landscape features, but also on subjective perception held by local populations. Hence, mapping landscape livability by integrating ES and US, and considering their relevance as expressed by stakeholders, can provide better assessment and management of local service flows and support landscape planning in general.

In this study, a hierarchical classification, including both ES and US, was designed through simplification and integration of the Common International Classification of Ecosystem Services (CICES). This classification was then used to develop a participation process involving local stakeholders of a specified Italian study area for assessing the importance of services. Accessibility indices were calculated using GIS spatialization techniques for the majority of services included in the classification using the same area. On this basis, according to a Spatial Multicriteria Decision Aiding (Spatial-MCDA) model, service weights and spatial indices were hierarchically integrated by means of multiple weighted linear combinations to calculate intermediate and overall livability indices. Moreover, at the various levels, cumulative weights of mapped services were used to calculate the percentage of "explained livability".

Results include specific and overall livability maps effective at local scale, capable of including the local accessibility of both ES and US, as well as their perceived relevance according to stakeholders. The proposed approach can help for determining how a single ES or US (or a group of them) contributes locally to perceived landscape livability and for identifying those areas where livability is affected by low accessibility to specific services. This information can provide very useful results for policy-making processes and for developing targeted information campaigns aimed at improving ES awareness.

In future applications, uncertainty of weights and spatial indices should be considered in order to properly assess the final output reliability. Together with ES and US, a more comprehensive livability mapping will require the integration of ecosystem and urban disservices, so as to consider those factors that reduce a place's overall livability.

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QUANTITATIVE TOOLS FOR LINKING ADVERSE OUTCOME PATHWAYS WITH PROCESS MODELS: BAYESIAN RELATIVE RISK NETWORKS

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In a complex and changing environment (e.g., in the face of climate change) and with an increasing emphasis on sustainability of coupled human-natural systems, reductionist approaches to environmental management that fail to consider interactions, multiple stressors, and spatial and temporal characteristics of exposures and populations no longer suffice. Ecological risk assessment has traditionally focused on adverse biological effects of chemical exposure to individuals. A more comprehensive assessment of ecological risk is needed to link chemical effects on individuals to those at increasing levels of biological complexity and to evaluate the spatial and temporal context in which chemical exposures occur to provide better linkages with ecosystem service endpoints valued by society. An integrated understanding of species activities (e.g., migration), physical stressors (e.g., habitat, climate, etc.) and biological factors (e.g., trophic interactions) is required to link individual-level exposures to population-, community- and ecosystem-level consequences. The Adverse Outcome Pathway (AOP) framework has emerged as a framework for explicitly linking molecular initiating events to regulatory outcomes of interest. However, existing AOPs in the literature are qualitative rather than quantitative – here we demonstrate how existing data and models can be integrated through a Bayesian Relative Risk (BN-RRM) framework to incorporate the influence of multiple stressors. The flexible approach allows multiple stressors linked to multiple outcomes based on a synthesis of existing data and underlying process models. We provide several examples of ongoing case studies – one for a legacy contaminant with a rich database and existing AOP based on acetylcholinesterase inhibition in fish, and another with a less well understood AOP based on immunotoxic effects of pefluorinated compounds and how they ultimately link to ecosystem service endpoints.

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CRUCIAL ELEMENTS OF A SYSTEMATIC REPORTING SYSTEM FOR ECOSYSTEM SERVICE VALUATION

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Federal agencies seek to use ecosystem service values to better understand the impacts of their decisions and improve communication with the public. However, up to this point, the variety of methods applied to measure ecosystem service values have lacked a consistent concept of value, which has resulted in a multitude of analytic approaches and measurement units. Given the interest of US government agencies in integrating ecosystem services into environmental policy and procedures, it is now vital for federal agencies to refine these approaches for their use. Most critically, approaches need to effectively evaluate the conditions that lead to social benefits, even if benefits cannot be valued in monetary units.

An ecosystem services reporting system effectively represents benefits when it is systematic in how it defines and measures value but also analytically flexible to adapt to the diversity of information and decision contexts within federal agencies. In addition, analytic approaches need to be efficient and replicable, if they are to be readily incorporated into existing policies and procedures. For example, agencies may build upon existing monitoring and modeling programs to minimize the burden of implementing an ecosystem services valuation framework.

This talk will present the crucial elements of valuation analysis and reporting as identified by a multi-investigator transdisciplinary project, *Valuing the Ecosystem Services from Farms and Forests.* This project has been organized by the Council of Food, Agriculture, and Resource Economics (C-FARE) in collaboration with the USDA Office of Environmental Markets. The key elements identified to date include appropriately flexible service definitions to fit different context; characterization of the strength of evidence for cause and effect models; and approaches for concisely representing values measured with benefit indicators rather than dollar values, as appropriate. Examples from the group effort will be used to illustrate concepts.

Also covered in this talk will be the lessons that have emerged from the use of causal chains and webs (cause and effect relationships) to elaborate functional relationships and assumptions necessary to quantify economic benefits. Further, the degree of consistency achievable across diverse programs with current data and understanding will be evaluated. Finally, the talk will describe the types of research and data collection that could expand the set of ecosystem service benefits that are monetizable or quantifiable with benefit indicators.

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LIMITATIONS OF CLASSIFICATION SYSTEMS AND RATIONALE FOR FLEXIBLE DESIGN

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A consistent and broadly applied ecosystem service classification system is desirable to enable aggregation and comparison of effects of human actions, yet consensus on such a system remains elusive for a variety of reasons. Consistency and thoroughness in any endeavor can be simultaneously helpful and burdensome. Consider the recently adopted US electronic health records system that enables record sharing and statistical analysis by imposing a standard set of diagnoses. Doctors have complained that the classification system is time consuming to navigate and does not always have the precise choice available, forcing then to record a similar, but incorrect, diagnosis. Similar problems are inevitable in ecosystem service classification systems intended to serve many different uses.

Currently proposed systems use distinct approaches to classification creating an opportunity to compare strengths and weaknesses. Perhaps the most widely used system, the Millenium Ecosystem Assessment (MEA or MA), has been criticized for mixing intermediate and final services (or means and ends), thereby creating conditions that would double count benefits or confuse potential vs actual benefits. More recent systems proposed in the US have taken those criticisms to heart and propose approaches similar to economic national accounts to thoroughly specify end users (FEGS-CS) or cross-walk supply side (ecosystem outputs) and demand side (end user) categories (NESCS). These US approaches are distinct from some recent international efforts that have created systems that are largely expansions and refinements of the MEA system, which is dominated by ecosystem outputs (CICES and TEEB).

In addition to different emphases on supply or demand side elements, these systems differ in the level of detail. The recently developed US systems include high levels of detail and the NESCS system states that their goal is to develop, an “exhaustive set of mutually exclusive categories”. Yet, to encourage broad adoption, system design must seek to balance operational ease with end user requirements. A tension arises when an end user (e.g., government agency) might wish to separate similar ecosystem service benefits, such as those derived from control of aquatic vs wetland invasive plants, in order to link outcomes to separate funding sources. Yet, separating those benefits or empirically linking actions to outcomes might be operationally impossible. The inability to isolate contributions of ecosystems to highly specific services is likely to make double-counting and under-counting inevitable in some systems. Achieving balance in the level of detail and other challenges might depend on choosing a narrow set of end uses to support with any given system and to incorporate knowledge limitations into design.
This talk will be aimed at raising challenges and tradeoffs in design to spark debate on how to reduce the burden imposed and increase the quality of information gained. Clearly, much can be learned from consistent measurement across agencies and actions in order to understand cumulative effects. However, a system to account for benefits should not be so burdensome that it detracts substantially from important agency missions to manage, restore and protect natural resources.

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MORE THAN THE SUM OF ITS PARTS: SPATIAL AGGLOMERATION AND NETWORK EFFECTS ON ECOSYSTEM SERVICE BENEFITS

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While we have many examples of spatially optimized landscapes created to achieve a mix of ecosystem service benefits, we have limited policies for achieving those optimal landscapes. Further, many optimization models do not account for the dependence of benefits on dynamic spatial arrangements of land cover/use or aquatic spatial processes. Even when models do provide such information, it is not clear that such knowledge can be effectively incorporated into laws or incentive payments. The challenge of incorporating spatial dependencies is that policy makers prefer simple rules because they have lower transaction costs, increase perceived fairness, and generally encourage voluntary participation or regulatory compliance. Yet, it is important to understand the tradeoffs in performance between simple and complex rules, in order to understand when simple rules (or second-best policies) will not achieve meaningful ecosystem service benefits.

This talk will use two case studies from the Chesapeake Bay to compare the payoff of simple vs complex performance-based conservation incentives in terrestrial and aquatic environments. The more complex incentives will use information on agglomeration, network relationships, and/or complementarity of conditions to target performance. In addition, this talk will synthesize some of the empirical evidence of the types of spatial dependencies that affect value. Two related question addressed will be, Which measures of location heterogeneity can be demonstrated to substantially affect benefits from a given ecosystem service? and, When is total ecosystem area, which is usually positively correlated with agglomeration, the driving factor of ecological performance and/or benefits? Results of models that project policy adoption as a function of policy complexity and landscape conditions will be used to evaluate effects of policy design on benefits to biodiversity conservation and water quality-derived ecosystem services.

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PROPELLING MOTIVATION TO FORM ATYPICAL PARTNERSHIPS A WATER UTILITY'S PERSPECTIVE

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How does a water utility protect its source water when the intake and most of the watershed for the source is in another county and jurisdiction that is land rich and cash poor? The solution for the City of Savannah, Georgia, may be the collaboration with others who have allegiance in protecting that same source. The Savannah River Clean Water Fund is a commune of two states, six water utilities, a research institution, and land conservation enthusiasts. Though each has a unique motivation the end result, protection of the water source, is the common denominator.

Every water utility knows the importance of source water protection, yet it can be a daunting task depending on the size and political divisions in that watershed(s). A water utility's expertise is protecting public health through testing, treating, and distributing safe water. The skill it takes to position land for water quality protection is typically outside the average utility realm, as is the knowledge and equipment to monitor the progress in-stream of those protection efforts. In addition all of these activities require more money than any one pot can hold. What will motivate the conservative water utility to form uncommon partnerships? What are the key strategic steps in ratifying the partnership? Though the Savannah River Clean Water Fund is still in its infancy, valuable lessons can be learned from its conception 5 years ago to the present. A model track for success will be revealed.

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PAYMENTS FOR ECOSYSTEM SERVICES FROM FORESTS: DO THEY REPRESENT WILLINGNESS TO PAY?

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Forests in a watershed can provide a range of ecosystem functions, such as prevention of erosion and sedimentation, filtration of pollutants from agricultural and storm water runoff, floodwater storage, protection of habitat, carbon sequestration, and more. These functions, in turn, provide valuable ecosystem services, many of which are related in one way or another to water. Forests can protect source water supplies, attenuate flooding, and improve water quality and water temperature to protect aquatic species. All of these services have value to humans but because many of the services are not directly traded in markets, it is difficult to measure their full value.

Economic values are typically defined by economists as the maximum amount that individuals will pay rather than do without a particular amount of a good or service. This definition is referred to as willingness to pay (WTP) and several federal agencies (U.S. Office of Management and Budget, NOAA, EPA, Bureau of Reclamation, to name a few) use this standard definition in benefit-cost analyses of their projects and programs. For goods and services traded in markets, prices generally reflect individuals' WTP for those goods and services. The question we address in this study is whether prices in "created" markets for ecosystem services are also reflecting WTP.

There are few true market-based payments for ecosystem services (PES) programs in existence. Government programs in the U.S. and around the world use payments to landowners to incentivize conservation, but programs in which private markets, or quasi-private markets, are established to incentivize conservation, restoration, and other ecosystem-related activities are rare. We create an inventory of PES programs in the U.S. that focus on forest conservation and restoration for provision of hydrological, or watershed, services. We describe program features, summarize prices paid, and lay out the programs' accomplishments. We then evaluate several key factors related to the ability of the programs to generate payments that accurately reflect WTP, including the degree to which payments are linked to the provision of ecosystem services; whether the buyers are the beneficiaries of the ecosystem services; how prices are established; whether the activity covered in the payments is additional to baseline activities; and more. Our analysis serves as an example that researchers and practitioners can follow when deciding whether or not payments observed in a given PES program are useful for procedures that involve WTP, such as impact evaluations and benefits transfer.

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VALUING ECOSYSTEM SERVICES OF COASTAL WETLANDS: PROTECTION FROM STORM SURGE

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Wetlands and other natural lands in coastal areas can provide a wide range of ecosystem services. One of the most important may be protection from hurricane storm surge-related flooding. The dense vegetation and shallow water within wetlands tends to slow the movement of surge inland and the vegetation dissipates waves, thereby reducing the amount of destructive wave energy that propagates on top of surge and worsens its impacts. As the climate warms, scientists predict that the worst hurricanes will increase in frequency along the Atlantic coast of the U.S. thus wetlands and other coastal natural lands may become more valuable in the future.

In this paper, we integrate state-of-the-art mathematical modeling of storm surge and waves with a careful economic valuation exercise to calculate the value of coastal protective services from wetlands and other natural lands. Our study region is the Maryland counties on the Atlantic coast and bordering the Chesapeake Bay and its tidal waters. We combine results from surge and wave simulations using the ADCIRC+SWAN hydrodynamic and wave models, calibrated to the Chesapeake Bay, with detailed information on property values and land cover. The surge is simulated for eight historical hurricanes that made landfall in the Chesapeake Bay region; results from the surge modeling are used in a regression analysis of flood depths on land cover, topography, and storm characteristics to develop a relationship between wetlands and flooding. The results show that having wetlands in a buffer surrounding a property reduces flooding but the effect varies substantially across hurricanes. The results are combined with established depth-damage functions from the literature to calculate avoided flood damages, a measure of the protective services provided by wetlands.

We analyze alternative future scenarios for land use change in Maryland counties, including population growth and land conservation. These scenarios are used to highlight how ecosystem service values are highly dependent on a variety of different factors. We discuss the implications of our findings for state and local decision makers managing land use and population growth.

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A PROTOTYPE ENVIRONMENTAL HEALTH ASSESSMENT OF DEVELOPING UNDISCOVERED SANDSTONE-HOSTED URANIUM RESOURCES IN THE TEXAS COASTAL PLAIN

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In 2015, the U.S. Geological Survey (USGS) completed an assessment of the probable amounts of undiscovered uranium resources in sandstone-hosted deposits in the Texas Coastal Plain. There is a need to evaluate the potential environmental effects of developing these mineral resources in a manner that is integrated with the mineral-resource assessment. Accordingly, the USGS is developing a framework to integrate the results of uranium resource assessments with an environmental health (air, land, water, and biota) assessment of resource development. As part of this framework, a prototype project has begun to assess potential environmental health effects to water resources from future development of Texas Coastal Plain sandstone-hosted uranium deposits.

The prototype assessment will cover the same geographic extent as the uranium-resources assessment. It will use output from the resource assessment including the geographic extent favorable for uranium occurrence, the probable mass of uranium oxide (as U3O8), the probable number of deposits, and the mineral deposit genetic model as baseline information. The prototype assessment will contain three components: (1) a geoenvironmental model (GEM), (2) maps showing vulnerability of water resources to uranium resource development, and (3) a quantitative analysis of water resources related to uranium resources. GEMs use information from literature review and the genetic model for the uranium deposit type to describe how geology, mineralogy, climate and geographic setting of a mineral deposit type influence environmental characteristics of the deposits. The GEM will include more quantitative information, for example, by comparing regional and existing mine-site water-quality data to regulatory standards to constrain baseline water-quality conditions and delineate which elements associated with uranium deposits (for example, arsenic, copper, lead, selenium, uranium, vanadium) are constituents of concern. Vulnerability of groundwater and surface water is a function of intrinsic properties that control contaminant pathways including geochemical and hydrologic characteristics of the potential receiving bodies of water, and the geochemical and mineralogic characteristics of a contaminant. Information from the GEM will guide collection of relevant, existing data (such as spatial variations in water quality, aquifer thickness, recharge rates, and depth to water) needed to construct vulnerability maps. Methods to combine these data into vulnerability maps are varied and will be chosen based on applicability of available data to particular methods, ability to produce scientifically defensible output, and ability to produce output useful to stakeholders. A hydrogeology-based method will be employed to capture regional variations in geologic and hydrologic attributes to generate a region-by-region comparison of the probable indicators (such as porosity, aquifer volume, aquifer composition) of the amounts of water associated with the probable amounts of uranium oxide (as U3O8) present over the spatial extent of land favorable for uranium occurrence. Finally, approximately mid-way through development of the prototype assessment, a group of stakeholders will be assembled to review the method and products to date. The review will allow the assessment team to receive feedback from stakeholders concerning relevance and content of the prototype assessment, and to incorporate revisions into the prototype to increase its utility to stakeholders.

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INDICATORS AND METHODS FOR WATER-RELATED ECOSYSTEM SERVICES IN FOREST PLANNING

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National forests are the single largest source of water in the United States, accounting for 14 percent of all runoff. These amounts vary widely throughout the United States. In the West, where most of the water originates in the mountains, half of all water originates in national forests. In Colorado, the percentage of water originating from National Forest land climbs to almost 70. In the Mississippi River Basin, by comparison, only 2-5 percent of water originates on national forest land. Forest health in the upper reaches of the watershed have implications for both the amount of water available and the quality of that water. Differences in volume of water available, along with the types of use of water in the basin, affect its value, the way it’s managed, and the types of partnerships necessary to maintain a healthy watershed.

This paper focuses on indicators and methods for monitoring water-related ecosystem services. Nearly every National Forest that has begun plan revisions under the 2012 Planning Rule has included water as a key ecosystem service. Little guidance, however, exists on how to accomplishment those requirements, and no clear consistent method of monitoring has emerged. Three objectives will be accomplished in this talk: 1) We take a look at what Forests are currently doing to address water-related ecosystem services in their Forest Plans, 2) We show how effective monitoring and an ecosystem services perspective can help restore watershed health, and 3) We develop a roadmap for developing future monitoring efforts flexible enough to address major challenges like growing populations and climate change.

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SPATIAL VALUATION OF ECOSYSTEM SERVICES IN THE CHICAGO METROPOLITAN REGION, USA

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Natural ecosystems provide essential services to humans, contributing in many ways to human health and quality of life. Yet because most of these services are external to traditional market economics, they are usually excluded from decision making, and such decisions, e.g. whether or not to convert natural land to other uses, are made without considering the consequences. The subsequent losses of ecosystem services cause damages that are then difficult and costly to repair. To help quantify the economic benefit of land conservation, we examined the economic value of ecosystem services provided by natural and semi-natural areas in (1) the seven-county Chicago Metropolitan Agency for Planning (CMAP) region; (2) the three-county Northwestern Indiana Regional Planning Commission (NIRPC) region; and (3) specific to Lake County, IL. From an initial list of 24 ecosystem services, we examined nine, identifying economic values from studies within and outside the region. Concurrently, we identified networks of key habitats and connecting corridors for four ecosystem types: forests/woodlands, wetlands, prairies/grasslands/savannas, and lakes/streams. Within these networks, we spatially mapped 4-6 ecosystem services depending on local priorities and conditions and data availability, using values specific to each ecosystem type. In the CMAP region (4 services mapped), these totaled $6.3 billion/year ($2014), in the NIRPC region (6 services), $8 billion/year, and in Lake County (5 services), $3.5 billion/year. Flood control had the highest values in all cases. In Lake County, recreation ranked close behind. This underestimated total ecological value because it only included a fraction of the 24 ecosystem services. These analyses, though limited, illustrated that even in heavily urbanized areas, areas of natural land and water have major economic value. We hope that such information will lead to increased awareness of decision makers and the public regarding the importance and contribution of healthy landscapes to human health and quality of life.

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DEVELOPING AND USING ECOLOGICAL RESILIENCE METRICS TO MEASURE PROJECT PERFORMANCE AFTER HURRICANE SANDY

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The Department of the Interior (DOI) is taking a leadership role in evaluating how recovery and restoration projects are enhancing the ecological resilience in the area impacted by Hurricane Sandy in 2012. To assess the benefits of these projects, DOI assembled a combination of DOI and inter-agency experts to produce a Metrics Expert Group report (MEG report). The MEG report generated a suite of core ecological resilience measurements as practical first steps to test resilience-improvement strategies. These measurements will provide an early assessment of the effect on resilience by the DOI projects. The MEG report identifies natural and artificial coastal features and ecosystem services most affected by Hurricane Sandy along the Northeast coast, such as marshes, beaches, estuaries, and recommends a suite of metrics that would indicate changes in the resilience of those features and services. The list of performance metrics is extensive, given the diversity of coastal features and project objectives, so subsets of core ecological resilience performance metrics were identified. Applying core ecological resilience performance metrics on DOI Hurricane Sandy funded projects to assess project success at multiple levels is ongoing. The results will inform future responses and help evaluate economic investments of tax dollars toward improved resilience. The knowledge gained from assessing project performance is expected to provide significant transfer value to natural system applications throughout the region – further enhancing understanding of ecosystem services. The development of the ecological resilience performance metrics and the application of those metrics at a project scale will be highlighted by presenting the work that has been conducted at Prime Hook National Wildlife Refuge (NWR) along with the resulting ecosystem services realized by the project. The project at Prime Hook NWR will restore ecological functions by reestablishing hydrologic connection to Delaware Bay and restoring the beach, dune and marsh complex. The resulting 4,000 acre functioning marsh complex will provide ecological and community benefits.

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IF YOU DON'T LIKE THE OUTCOME, CHANGE THE RULES: POP-UP HABITAT

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With the majority of lands in the United States privately owned, and much of this land unavailable or too costly for easements or acquisitions, we must find new ways to engage private landowners to address today's conservation challenges. For over a century, conservationists have successfully protected private lands by using a variety of tools that provide incentives for landowners to voluntarily protect their lands in perpetuity. For example, land acquisitions, conservation easements, habitat conservation plans, safe harbor agreements – all have become established tools of the conservation trade, sanctioned by federal and state governments, funded by federal and state agencies, embraced by landowners, and widely adopted by the broader conservation community.

These tools are essential, but by themselves they are not enough to achieve the pace and scale of conservation needed to solve the big environmental challenges of our time. New approaches are needed that allow landowners the flexibility to provide temporary habitat – to complement permanent habitat – precisely when and where it is needed most. We also need tools that facilitate flexible, adaptive conservation investments in response to changing conditions and threats.

We call this Dynamic Conservation (DC). A new set of DC tools – enabling farmers, ranchers and other private landowners to meet the needs of plants and animals at precise times and places and on a temporary basis – will dramatically expand the scale and footprint of conservation practices across private lands.

Recognizing this opportunity, the Conservancy has stepped up its investment in DC strategies, and the BirdReturns program allows us to demonstrate the full range of these new tools. Begun in 2014, BirdReturns has already provisioned over 40,000 acres of pop-up bird habitat and received applications from farmers for over 100,000 acres of Central Valley farmland. BirdReturns employs a set of tools designed to leverage a relatively small amount of water to achieve huge gains for migratory birds at precise places and times of year. The program's short-term nature enables us to work with an entirely new set of landowners who are not interested in permanent habitat solutions. As evidence, we have attracted more than 200 private landowners to our program thus far. Even better, it allows us to flexibly, adaptively tailor the program each season by applying precision science in response to changing conditions and habitat needs, making it an especially valuable tool during drought, as we have demonstrated over the last two years. Finally, it enables us to deliver habitat cost-effectively, using market forces and new habitat valuation tools to secure the highest ecological response for our investment.

BirdReturns has been particularly successful in meeting a conservation goal for migratory birds – which only utilize Central Valley habitat for a couple months per year – in a place where high real estate values and opposition to land use restrictions preclude conservation at scale via permanent acquisitions. Through short-term rental payments, we can provide thousands of acres of habitat for over 100 years at a lower cost than permanently protecting the same amount of habitat.

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THE DEPARTMENT OF COMMERCE INITIATIVE TO SUPPORT THE PRIVATE SECTOR IN INCORPORATING NATURAL CAPITAL VALUES INTO BUSINESS DECISIONS

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This presentation will discuss the Department of Commerce's efforts to engage the business sector in integrating natural capital values into their business decisions and operations. Incorporating natural capital values into business decisions and operations is a strategic, multi-objective, and community-oriented approach to reduce risk, increase revenue, enhance branding, and increase ecological and economic resiliency.

The Department of Commerce hosted four Business Roundtables, two focus groups across the country, and a National Summit to identify businesses challenges, facilitate the exchange of information and lessons learned, and foster cross-sector partnerships. The Department also developed a Natural Capital website to provide resources and information to all businesses seeking to incorporate natural capital values into their decisions and operations (https://www.commerce.gov/naturalcapital). Market opportunities, regulatory and fiscal incentives, availability of credible business-relevant natural capital data, potential for risk mitigation, pressure from customers and competitors, and buy-in from leadership were among the main issues identified as influencing businesses' ability to incorporate natural capital.

The partnerships created by these events position the Department as a key player in supporting and connecting businesses to integrate natural capital into their decisions and operations. The Department's Natural Capital website is a first step in the right direction as it provides businesses with the information and resources available to help them move forward. Looking ahead, businesses need site-specific natural resources and economic data, mature and well-verified methods for applying natural capital valuation, and case studies to show how other companies use natural capital-focused tools and data. As consumers, we can all drive businesses to innovate products that are more sustainable environmentally.

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ECOSYSTEM SERVICES AND ADAPTIVE MANAGEMENT: A FRAMEWORK FOR SYNTHESIS

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Adaptive management and ecosystem services represent approaches to understanding and management of ecosystems, with the potential for synergies from their integration. Adaptive management recognizes uncertainty about ecological processes and the influence of management on them, and seeks through the use of iterative management to increase understanding while pursuing management goals. An ecosystem services framework recognizes value in the goods and services produced by ecosystems, and the importance of sustaining ecological structures and functions by means of which they are produced. In this presentation we consider the integration of these two frameworks, whereby ecosystem services are incorporated into an iterative decision making process that facilitates the identification, valuation, and management of ecosystem services. The integrated framework includes identifying and valuing ecosystem services, incorporating these values into management objectives, comparing tradeoffs, evaluating the consequences of management decisions, and folding what is learned into ongoing management through adaptive decision making. Benefits and challenges of this integration will be highlighted.

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USING VOLUNTEERED GEOGRAPHIC INFORMATION TO VISUALIZE COMMUNITY VALUES AND ECOSYSTEM SERVICES FOR HABITAT RESTORATION AND NEIGHBORHOOD REVITALIZATION

Kathleen Williams[1], *Jonathan Launspach*[2], *Ted R. Angradi*[1], *David Bolgrien*[1], *Jessica Carlson*[3], *and Joel Hoffman*[n1]

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Volunteered geographic information (VGI), specifically geotagged photographs available from social media platforms, is a promising technology that can be utilized to identify public values for ecosystem goods and services in a defined geographic area. VGI can help researchers indirectly survey and report on the values and preferences of communities involved in restoration and revitalization projects. This project uses geotagged images from three social media platforms: Flickr, Instagram, and Panaramio. Images are obtained for the neighborhoods to the St. Louis River in the Duluth, MN and analyzed along several dimensions including the spatial distribution of images from each platform and the types and frequencies of social values and ecosystem service depicted. This study will demonstrate a method for translating the values of ecosystem goods and services as captured in social media into spatially-explicit data. Study outcomes are the incorporation of social media-derived indicators of ecosystems services into City of Duluth's Comprehensive Planning and community revitalization efforts, habitat restoration in a Great Lakes Area of Concern, and the USEPA's Office of Research and Development Sustainable and Healthy Community research.

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CULTURAL SERVICES AS A LIMITING CASE FOR THE ECOSYSTEM SERVICES PARADIGM

Robert Winthrop

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The ecosystem services (ES) paradigm is one of several approaches to understanding coupled human and natural systems. Like other approaches, ES involves both strengths and limitations. This paper considers some limitations of the ES paradigm by examining one category of ES: cultural services, including the environmental basis for aesthetic, spiritual, and recreational experiences, cultural heritage, sense of place, and ways of life. It asks whether cultural ES can be assessed in terms of purely individual benefits or if social/collective considerations must be included; and whether the concept of 'services' even provides an appropriate framework for understanding such values.

Building on research with tribal communities of the American Pacific Northwest, I suggest that many examples of cultural ES – such as a multigenerational 'sense of place' – involve the social construction of environmental experience, the symbolic character of environmental knowledge, and the multidimensionality of environmental value. All three of these characteristics are problematic for the ES paradigm. I explore the implications, arguing for a pluralistic approach to human - natural systems in which ES is one of several potentially complementary frameworks.

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HEALTH AND THE OUTDOORS IN CITIES: PRELIMINARY ECONOMIC VALUES

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Contact with nature generates substantial and varied ecosystem services, including extensive psychosocial and physical human health and well-being benefits. The evidence of community wellness and public health responses have been summarized in the Green Cities: Good Health science outreach web site, and a recent publication by The Nature Conservancy. Benefits are gained from contact with metro nature, a notion that includes endemic ecosystems, such as urban forests, greenbelts, conserved open spaces, and riparian corridors that may be expressions of native ecological associations. It also includes culturally constructed nature such as parks, streetscapes, community gardens, pocket parks, and recreation paths. Finally, metro nature includes structural innovations that are integrated within built form to serve specific functions, such as green roofs, green walls, or green infrastructure facilities.

While the 40 year history of research about the human services provided by nature encounters is extensive, economic valuations of these benefits have lagged other ecosystem services. The purpose of our analysis, recently published, was to understand the implications of metro nature for public health expenditures. Health costs represent nearly 20% of the U.S. Gross Domestic Product, and other industrialized nations are experiencing similar expenses. Greater investment in urban greening may be a viable approach for disease prevention and health promotion costs management.

We applied recognized economic analyses to derive valuations using information secured from published research studies, selected using a multi-step, iterative screening process. An initial assessment of peer-reviewed literature yielded 15 health and well-being outcomes likely associated with economic benefits. After preliminary valuation efforts we validated six human life course situations: birth weight, ADHD, secondary school performance, crime, cardiovascular disease, and Alzheimer's disease. We then conducted economic data interpretations, and valuation strategies included human population effects, scale of study findings, factor incomes, avoided costs, burden of illness, and cost-effectiveness analyses.

Summing the valuation estimates, we found a potential annual range of $2.7 billion to $6.8 billion (2012 USD) value for health benefits associated with experiences of metro nature. Although this is but a fraction of annual health industry spending (more than $2.9 trillion in the U.S. in 2012), it is still noteworthy, and there may be variable and higher impacts depending on locale and the secondary savings associated with health promotion if early onset interventions prevent later disease conditions.

We concluded that that investment in metro nature and urban greening merits additional analysis, and potentially greater investment by health agencies. We learned about various inconsistencies in metrics regarding urban nature presence and health response that made valuation difficult. A new inter-disciplinary approach that combines public health, natural resources, and economics is necessary to gain greater precision in benefit/cost analysis. Additional conceptual work, and public policy, is needed to develop a more productive nexus of public health and urban greening. With increasing populations worldwide, there is an urgent need for improved, integrated research methods linking the fields of natural resources, public health/epidemiology, and economic valuations.

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ACCOUNTING FOR FLOODPLAINS FUNCTIONS

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Surface water is regulated by a multitude of local, State, and Federal regulations each with its own set of priorities and rules. Oregon is facing increasing surface water regulations related to the recent Biological Opinion on the National Floodplain Insurance Program, which will require stricter regulations for floodplain development including stormwater management, buffers, and setbacks. Meeting surface water regulations requirements on a piecemeal basis is increasingly complex, expensive, and has a high risk of failure. This is because ecosystem services operate as interdependent processes that cannot be parsed out and accounted for in isolation. The need to integrate watershed context and function is broadly applicable to habitat, species, and water quality management planning and restoration actions in streams. The challenge is demonstrating accountability to regulators and documenting the ecosystem benefits of particular actions within a watershed context over time. Navigating this maze of layered and overlapping compliance measures is increasingly challenging for surface water management agencies and regulators alike.

This presentation will examine tools and methodologies to evaluate the effects of floodplain development or restoration on key floodplain functions at both the site-level and at the broader watershed context. We will describe how our methodology of modeling restoration scenarios will help to evaluate the effectiveness of specific floodplain alteration strategies on floodplain storage and attenuation and to measure their associated effect on floodplain habitat and water quality. In addition, we will describe stream resilience strategies that can integrate surface water goals with watershed functional uplift.

This approach provides an opportunity for jurisdictions to step back and assess ecosystems as a network of interdependent systems that support diverse ecosystem services such as water quality, habitat, and flood control. Additionally, it supports the application of restoration and conservation actions a way that complies with multiple local, State and Federal regulations governing floodplain management. The goal is to demonstrate that a systems level approach to floodplain function assessment and accounting is more cost effective, self-sustaining, and resilient than a traditional approach that addresses single resource issues independently.

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STRATIGIC USE OF ECOLOGICAL PRODUCTION FUNCTIONS TO ADVANCE POLICY

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Governments worldwide are recognizing ecosystem services as an approach for addressing sustainability challenges like human health, poverty alleviation, environmental protection, and economic growth. The policy challenge is developing clear and practical strategies to effectively manage ecosystems for a diversity of societal needs. A key technical problem is to quantitatively link ecosystem structure and functions to human benefits (i.e., final ecosystem services), and one approach for doing so is ecological production functions (EPFs). Currently there exists a data gap, the lack of biophysical measurements linking ecosystem characteristics to final ecosystem services, because disciplinary frames separating ecology from economics and policy have resulted in confusion on concepts and methods. We address this gap by developing a measurement and evaluation approach of ecosystem services for public policy to help government agencies determine the synergies and tradeoffs associated with different decisions.

We created a 10-step approach to offer strategic guidance for addressing the data gap to advance application of ecosystem services with the ultimate goal of creating effective actions and improving understanding on the importance of ecosystem change to the public. First we explain the 10-step approach, focusing on three main components: (1) estimating ecosystem characteristic metrics using biophysical models, (2) identifying human welfare indicators using endpoints, and (3) connecting them via regression models to quantify synergies and tradeoffs. Next we present an application of the approach where we evaluated five ecosystem services from a green infrastructure project, known as the Yongding River Ecological Corridor in Beijing, China. The Beijing government invested 17 billion yuan (2.7 billion USD) to create seven lakes and wetlands on the Yongding River. The policy objective is to improve five ecosystem services (*human benefits*): (1) water storage (*water supply for groundwater recharge*), (2) local climate regulation (*cooling for human comfort to mitigate urban heat island effects*), (3) water purification (*water quality*), (4) dust control (*air quality*), and (5) aesthetics (*scenic beauty for economic development*). We explain how we implemented the approach to develop EPFs to evaluate system performance for the five services, and our recommendations to the Beijing Water Authority to improve the management of the Yongding River. Lastly, we conclude with lessons learned from our preliminary work on the strategic use of EPFs for government agencies in China.

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STREAMLINING PRACTICES FOR GENERATING WATER QUALITY TRADING CREDITS: BMP GUIDELINE NATIONAL TEMPLATES

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Water quality trading (WQT) programs provide farmers and ranchers across the country the opportunity to improve water quality, enhance cropland resiliency, and access new revenue streams. Landowners can generate credits to sell by adopting best management practices (BMPs) that help reduce sediment and nutrient loads such as nitrate and total phosphorous. These BMPs include practices such as sediment basins, riparian forest buffers, cover crops, filter strips, and conservation tillage. While there is set of agricultural BMPs commonly used to improve water quality, little technical guidance exists for landowners seeking to implement these practices on their croplands. This project seeks to develop a set of BMP guidelines that will act as national templates for practices commonly included in water quality trading programs.

BMP guidelines have the potential to ensure that projects seeking credits are implemented to a high standard, do not create unanticipated environmental impacts, and are maintained in a way that achieves the credited water quality benefits for as long as the project is valid. The templates are intended for developers of state or other agency trading programs, and provide guidelines that set design, installation, maintenance, and performance standards that can help ensure that BMPs are performing as anticipated.

The guidelines correspond to the components of the BMP Guideline proposed in the National Network publication, *Building a Water Quality Trading Program: Options and Considerations* (National Network Guide), which was itself developed through review of NRCS practice standards and BMP guidelines from existing trading programs. Each template was developed in collaboration with subject area experts, agricultural service providers, and a review of relevant literature and national monitoring standards and programs. These template will continue to evolve as they are applied in trading programs. The project's overall goal is to facilitate BMP implementation, strengthen the effectiveness of water quality credits, and contribute to the national dialogue surrounding water quality trading.

National Network on Water Quality Trading, *Building a Water Quality Trading Program: Options and Considerations* (June 2015). Available at: http://willamettepartnership.org/publications/.

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http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/.

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BUILDING SOIL CARBON FOR ENVIRONMENTAL AND HUMAN WELLBEING

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Soil management is essential to effective conservation and agriculture because soils control whether nutrients, sediment, and water contribute to human wellbeing through crop production or contaminate aquatic ecosystems and increase greenhouse gas production. Yet conservation-oriented projects rarely manage directly for soils because of uncertainty about which soil properties to manage—and to what amounts—to achieve desired outcomes. Soil organic matter is an especially relevant target for conservation and agriculture because it is the principle arbiter of soil quality and can be strongly impacted by management. In this project, we report on soil carbon stocks in several sites managed by The Nature Conservancy to evaluate to what degree can management practices influence soil organic matter. To place these results into a broader context we also report on different stocks of soil carbon from long-term research experiments around the world.

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SOIL SALINITY UNDER SEEPAGE IRRIGATION AND IRRIGATION DRAINAGE TILE SYSTEMS IN NORTHEAST FLORIDA

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This study evaluated the differences in soil salinity under Seepage Irrigation (SI) and Irrigation Drainage Tile (IDT) systems. Results indicated which of the two irrigation systems better reduced soil salinity when operated under similar conditions. This is important especially in low rainfall or drought conditions when leaching of salts by rainfall is reduced and salt concentrations potentially build up in soils.

Salinity in crop production is an issue of concern because crop yield is highly dependent on the amount of salts a plant is exposed to at different growth stages. Vast areas of the world are encountering problems with soil salinity at different intensities. The Tri-County Agricultural Area (TCAA) is the production hub for potatoes in southeast USA. It lies within St. Johns, Putnam, and Flagler counties in Florida. The area received relatively low annual rainfall of about 40 inches from 2010 to 2012, compared with the annual average of about 50-53 inches. Growers in the region experienced reduced crop yields which they partially attributed to increased soil salinity. Concerns therefore heightened about the impacts of soil salinity especially during droughts or low rainfall conditions. Low rainfall conditions imply reduced leaching of salts, as well as high evapotranspiration rates which leave more salts concentrated in the fields. Additionally, irrigation rates are increased to compensate lowered rainfall conditions, thereby adding more salts to the fields, especially when water quality is poor.

Soil samples were collected from six farms in the TCAA three times, between 2013 and 2015. A hand augur and Amity Technology-4804 soil sampler were used. At each farm, two fields were sampled: SI and IDT fields. For SI fields, soil samples were collected at three distances (1.2m, 2.4m, and 3.6m) from a reference water furrow. At each sampling location, four samples were collected in one-foot increments; 0-1ft, 1-2ft, 2-3ft, and 3-4ft. This was replicated at three different zones in the field representing areas of water inflow, outflow, and center of field. This layout was same in sampling the IDT fields except for sampling distances from the reference IDT pipes which varied among fields, due to differences in IDT pipe layout on different farms. Distances from IDT pipes were approximately 7ft, 14ft, and 18ft. Soil samples were transported to the laboratory, prepped, soil water extracted, and analyzed for electrical conductivity (EC)(dS/m).

Overall results indicated that IDT field soils were significantly lower in salinity than SI fields in five out of six farms. This was true in at least one of the three sampling periods. Comparing salinity at different depths, IDT fields at three farms were significantly lower at all four depths compared with SI fields. Variable observations were made at one farm, and at another farm, both fields recorded no significant differences at all four depths. At the last farm, the IDT field recorded significantly lower salinities at depths 0-1ft,1-2ft, and 2-3ft compared with the SI field, with no significant difference at depth 3-4ft.

In conclusion, this study showed that IDT systems have the potential to lower soil salinity compared with SI systems. It should however be noted that local conditions, including farm management practices affect the performance of these systems. The added advantage of reducing soil salinity makes IDT systems recommendable for adoption in agricultural practices in the TCAA.

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PREDICTING EFFECTS OF CLIMATE AND LANDUSE CHANGE ON HUMAN WELL-BEING VIA CHANGES IN ECOSYSTEM SERVICES

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Landuse and climate change have affected biological systems in many parts of the world, and are projected to further adversely affect associated ecosystem goods and services, including provisioning of clean air, clean water, food, and biodiversity. Such adverse effects on ecosystem goods and services could have consequences for human well-being, with potential impacts on human health and safety, culture, and quality of life. Our ability to predict how changing landuse and climate may impact human well-being depends on our ability to 1) characterize changes in ecosystem services under a changing landscape, and 2) to link those changes in ecosystem services to quantifiable endpoints of human well-being.

The U.S. Environmental Protection Agency has recently developed a framework for characterizing the relationships between social, economic, and ecosystem services on an index of human well-being. The Human Well-Being Index (HWBI) quantifies human well-being by a suite of indicators with 8 domains of well-being, including connection to nature, cultural fulfillment, education, health, leisure time, living standards, safety and security, and social cohesion. County-level data for the United States has previously been used to develop a series of models predicting how changes in ecosystem services, such as air quality regulation, food and fiber provisioning, green space, and regulation of water quality and quantity, impact the domains of HWBI. To link HWBI to changing climate and landuse, we connected the HWBI models to a suite of ecological production function (EPF) models describing ecosystem goods and services production in the landscape. Models describing effects of changing landuse on ecosystem services (EPFs) were integrated with models linking ecosystem services to human well-being (HWBI) using the spatially explicit software tool Envision.

As a proof of concept, we obtained future climate and landuse change scenario maps (FORE-SCE) for the Pensacola, Florida watershed. Ecological production functions were applied to predict changes in ecosystem goods and services production under future scenarios of landuse and precipitation. HWBI models were then applied to predict changes in human well-being as a result of changing ecosystem goods and services. Integrating the models within the software tool Envision, provides flexibility to transfer these models to other locations, as well as look at alternative kinds of landuse decisions. Communities often characterize sustainability goals, not solely in economic terms, but in terms of sustainable well-being, and predictive models linking landuse to ecosystem services to human well-being provide a step forward in our ability to more fully assess alternative decision scenarios.

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OPEN SPACE PREMIUM NEAR COMMERCIAL ZONES – A CASE STUDY IN THE CITY OF CORONA, CALIFORNIA

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Urban sprawl, the spreading development into undeveloped rural area, has become a common phenomenon throughout both developing and developed countries. It creates challenges for both residential developers and landscape planners to manage limited resources such as land, labor, and capital, to maximize their returns on investment. One of those challenges is how to allocate undeveloped open space between housing and other desirable land uses in an economically efficient manner. Desirable types of open spaces such as urban tree and vegetation are known to generate a wide arrays of benefits such as water quality improvement, scenic beauty, provision for wild-habitat, recreational opportunities, etc. From an economic perspective, documenting accurate economic values of urban open space is crucial to the efficiency of their management. In addition, it has important implications for establishing effective zoning regulations, in a way that improves the social well-being of urban residents. Lastly, previous studies have shown that values differ with location, and context, and therefore knowledge of the spatial pattern of the values of open space in a particular city will provide customized implications for efficient management of undeveloped lands.

The primary contribution of this paper is two-fold. First, using hedonic price approach, the paper investigates the capitalized values of open space in one of the fastest growing cities in California, Corona in Riverside County. Using 4,243 non-arms-length transactions and a spatial error model (SEM), the paper estimates the mean marginal willingness-to-pay (MWTP) for increasing the area of developed open space by 10% within 100m buffer of residential properties. Second, the paper explores varying impacts of open space, which is a function of the Euclidean distance to the nearest commercial and industrial zones. The study leads to the conclusion that properties with more urban open spaces are valued higher than identical properties with less urban open spaces, as shown in a broad range of literature on the topic of open space values. The paper builds on existing literature, however, to provide more insight on how the capitalized value of open space is measured in the industrial and commercial neighborhoods. The analysis suggests that open space property premiums decline with the distance to commercial areas, while they are not impacted by the distance to industrial areas. The capitalized value of increasing the area of urban open space by 10% within 100m buffer of the representative residential property in Corona is approximately $3,500 when properties are located right next to commercial center. However, for every 500m increase in distance to the nearest commercial center, open space premium decreases by around $420-$440.

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AN OPPORTUNITY TO MEASURE THE *IMPACT OF INVESTMENT* OF GULF OF MEXICO RESTORATION ACTIVITES.

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The Deepwater Horizon disaster has brought much needed scientific and political attention to the condition of the Gulf of Mexico's ecosystems and the services they provide. Approximately $14.5 billion will be spent on restoration and conservation activities between the efforts of all the primary settlement recipients from this event. Yet, as we move forward are we considering the potential impact on human well-being as we plan, execute, and monitor restoration and conservation projects? And if we do, is there an explicit connection between the biophysical structure, function, and processes and the ecosystem services supplied and then human well-being? There currently exists a significant opportunity in the Gulf of Mexico to change the way we conduct our "restoration" business. Ecosystem services can play a role in selection among project alternatives but more importantly it can help elucidate the benefits of restoration and act as a measure of the "impact of investment" that is taking place.

The metrics of "impact" can be tricky, especially for environmental investments. Is it enough to say that we have restored 35 acres of oyster reefs or 200 acres of salt marsh? Does the number of acres protected or restored connote "impact?" Those are outputs but they are not outcomes. A potentially important way to demonstrate the impact of investment in conservation and restoration is capturing the full suite of benefits that are produced and affect human well-being. Incorporating ecosystem service assessments into project selection and monitoring complements the bio-physical metrics that will be used.

A significant opportunity exists in the Gulf of Mexico to advance the use of ecosystem services in the resource management decision-making in general. What happens in the Gulf over the next 15-20 years will influence the way coastal restoration and conservation work is conducted in the United States for decades to come. For practitioners of ecosystem services assessments, this is a significant opportunity to prove up the value of integrating measurements of human well-being into the evaluations of these projects and communicating the impact of the investment.

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LEVERAGING PRIVATE CAPITAL FOR WATERSHED PROTECTION

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Despite the growing interest in projects that demonstrate models for the public sector or philanthropic sector to collaborate and leverage private capital, the general view is that stormwater management – and watershed restoration, more generally – require stronger and more widespread regulation to compel private sector participation. While changes in the regulatory environment would certainly help, our analysis suggests it is not a necessary precursor to engaging private capital to support watershed restoration.

Evidence indicates that the private sector already suspects it has role to play in supporting projects that meet the double bottom line of financial and environmental returns. In conservation impact investing alone, private investors are expected to deploy $5.6 billion over a five-year period (2014-2019). Yet despite rising interest and availability of capital, investors consistently report the supply of investment-ready projects is not keeping pace with demand.

This imbalance between the supply and demand for the deployment of private capital to projects with a positive social impact signals opportunity. Our work explores the necessary and sufficient conditions for public or philanthropic capital to leverage this unmet demand by private investors. It began with a focus on mechanisms to finance and/or fund watershed activities, but quickly concluded that existing instruments for deploying multi-sourced capital are sufficiently robust and applicable to watershed restoration. As a result, the research turned to assessing where capital flows and the market dynamics that direct the flow of capital.

We developed a diagnostic framework that: (1) fundamentally shifts the focus away from buying environmental goods to greening economic activity, and (2) looks for leverage from the private sector in the form of financial *and* human capital. This approach has its foundation in understanding the specific role(s) of capital as innovation progresses through early to mature market stages and assessing the barriers to growing the supply of projects that support watershed restoration while generating opportunities to leverage private investment.

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CARBON SEQUESTRATION VALUATION OF UNITED STATES FORESTS AND THE POTENTIAL FOR POLICY IMPACTS

***Kathryn Zook**[1], Robert Haight[2], Steven Polasky[3], Jeffrey Kline[4], David Ervin[5], Randall Bluffstone[5], Greg Arthaud[6] and Caron Gala[7]*

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Forests in the Unites States (US) are a major sink for carbon and continue to be the primary sequestering agent for carbon. Forests are seen as an important component of increasing carbon storage to address climate change. The focus of this paper is on understanding the effects of USDA policies and programs for increasing carbon sequestration rates on both public and private lands on forest carbon and associated ecosystem services. USDA policy, including a new Forest Service Planning Rule, for example, calls on the Forest Service to lead efforts to mitigate and adapt to climate change, in part focusing on the management and restoration of National Forest System lands. Additionally, there is recognition that USDA policies and programs also could increase stored carbon through incentives targeting agricultural landowners to both retain land in forest and agriculture, and increase afforestation of especially marginal agricultural lands.

This paper also explores the uncertainties surrounding carbon sequestration valuation, including leakage, production functions, and valuation methodology (with a focus on the social cost of carbon). Several case studies are also presented to illustrate the principle concepts and difficulties in valuing carbon sequestration in forests.

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TRANSACTION COSTS IN U.S. ENVIRONMENTAL MARKETS

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Environmental markets are active across the United States for carbon, water quality, wetlands and habitat. For many, environmental markets are a promising mechanism for implementing environmental solutions on the landscape by incentivizing private landowners to make improvements on their land that can generate credits. However, for some markets, such as carbon offset markets and water quality markets, market transactions involving private landowners have been relatively infrequent. While this is due to many factors, transaction costs play a role in limiting the efficiency of these markets, particularly those involving land-based mitigation.

Despite the myriad benefits of using agriculture and forestry practices to generate carbon and water quality offsets, there are challenges that have kept their market potential in check. Transaction costs in these markets are often exacerbated by several factors, including:

- **Small size of projects**: When generated at the farm or field scale, agriculture and forestry projects tend to generate few offsets compared to other environmental improvement opportunities. Although it may be inexpensive to generate these offsets, the processes necessary to track, register, and verify projects increase costs and difficulties of getting offsets to the market (see below).
- **Spatial distribution**: Agriculture and forestry projects are distributed across the landscape, and are typically in rural areas. This increases verification costs, particularly in carbon offset markets, as verifying parties must travel to the project location in order to ensure greenhouse gas reductions are real.
- **Difficulty of measuring environmental improvements**: Creating processes to quantify, measure, and track emissions from agriculture and forestry mitigation practices is difficult. By nature, they tend not to have a single point from which emissions can be measured—which introduces the need for modeling and other quantification methods. Developing methods and models accurate to an acceptable degree of certainty takes time and investment, and varies for each type of conservation practice.
- **Variable project performance**: By nature, agriculture and forestry project performance is variable depending on soils, weather, and cultural practices.
- **Risk and Uncertainty:** Real or perceived risk and uncertainty within environmental markets can also influence transaction costs. For instance, in carbon markets aversion to risk of non-additionality has led to strict verification protocols which drive up the cost of generating a credit. Similarly in water quality markets, measures to address uncertainty can drive up transaction costs through application of uncertainty ratios, strict verification protocols, and insurance requirements.

These factors can be influenced in a variety of ways that decrease transaction costs—including increasing the scale of projects, reducing or embracing legal and scientific uncertainty, utilizing tools to make verification easier, selecting validated projects, and designing protocols that work for landowners. In this session, we will describe transaction costs that exist in carbon and water quality markets, factors that influence these costs, and discuss ways markets are adapting to overcome them.

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