

Natural Capital Symposium

Poster Abstracts

Rehnquist Courtyard, Stanford University
March 20th, 2017 at 5:30pm

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Walking Green: Developing an evidence base for nature prescriptions

Teresa H. Horton, Northwestern University

Founded in 1914 and covering over 69,000 acres, the Forest Preserves of Cook County (FPCC), Illinois, are the oldest and largest forest preserve system in the United States. The Preserves ring metropolitan Chicago, IL. The FPCC celebrated its centennial in 2014 by developing a 25 year strategic plan, the Next Century Conservation Plan (NCCP). One goal of the NCCP is to increase the number of people who access the FPCC by:

1. publicizing the health benefits of nature,
2. partnering with health care professionals to develop Nature Prescriptions, and
3. working with public transit agencies to ensure people can reach a Preserve in 45 minutes or less.

To develop effective NRx, we need to know (Sullivan et al. 2014*): 1) what type of nearby nature most effectively promotes health, 2) what concentration – or density – of nearby nature is necessary to promote health, 3) what duration of exposure to nearby nature best promotes health, 4) What frequency of exposure to nearby nature is necessary to promote health, and 5) what exposure pathways effectively promote health.

We use field-friendly methods developed by anthropologists at Northwestern University and the University of Chicago to monitor psychological and physiological responses to walking in natural and built environments. We have collected data from half of the desired sample. This poster reports preliminary analysis demonstrating the feasibility of monitoring both psychological and physiological data using a repeated measures, cross-over design study.

*Sullivan, W. C., et al. (2014). "Gaia meets Asclepius: Creating healthy places." *Landscape and Urban Planning* **127**: 182-184.

Valuing the Storm Surge Mitigation Effect of Coastal Wetland

Fanglin Sun, University of California, San Diego

Storm surge presents a severe threat to life and property along the coast. Coastal wetlands provide a natural levee for storms by attenuating waves and creating a buffer zone between the landfall location of the storm and populated regions. This paper investigates the contribution of coastal wetland vegetation to hurricane storm surge protection. I analyze 59 tropical storms and hurricanes to have hit the U.S. since 1996, and construct a county-level storm surge damage and coastal wetland distribution dataset using geo-spatial data on land cover across the United States. The main result of the paper is that for coastal communities suffering from storm surge damage, a 1% loss of coastal wetland is associated with a 0.6% increase in property damage, controlling for specific storm and county characteristics, as well as property value under flooding risk. Moreover, the average marginal value of coastal wetland for protecting properties from storm surge is estimated to be about \$0.4M per square kilometer along the coast of the Gulf of Mexico.

Laboratory Measurements of Wave Dissipation by Coastal Vegetation

Mary A. Bryant, Coastal and Hydraulics Laboratory, Engineer Research and Development Center, U.S. Army Corps of Engineers

As the vulnerability of coastal communities to combined wave and surge action continues to increase due to sea level rise and a possible change in storm frequency and/or intensity due to climate change, integrated methods that intentionally align engineering with the natural environment are of growing interest. One of these environments of interest is wetlands. There is a general consensus that wetlands offer some degree of coastal protection; however, the engineering benefit of these features must be examined and quantified for natural capital initiatives to be successful. Here, we present the results of a large-scale laboratory flume experiment investigating wave dissipation by coastal vegetation, specifically *Spartina alterniflora*, as well as introduce numerical modelling challenges.

Engineering with Nature (EWN): Establishing “Triple Win” Outcomes through Beneficial Integration of Infrastructure and Ecosystems

Jeffrey K. King, US Army Corps of Engineers

Recent advances in the fields of engineering and ecology offer many opportunities to combine these fields of practice into a single collaborative and cost-effective approach for infrastructure development and environmental management. To that end, the US Army Corps of Engineers (USACE) has pursued the development of an Engineering with Nature Program (www.engineeringwithnature.org). Engineering with Nature (EWN) represents an approach to sustainable development of water resources infrastructure by focusing on solutions that beneficially integrate engineering and natural systems. EWN's focus on developing practical methods provides an achievable path toward an ecosystem approach to infrastructure development and operations. Thus, the application of our EWN technologies result in “Triple Win” outcomes consisting of more socially acceptable, economically viable, and environmentally sustainable projects. EWN principles and practices are being applied across multiple USACE missions and business lines. USACE is also advancing EWN nationally and internationally through the development of strategic collaborations and partnerships with other government agencies, private sector engineering and construction companies, universities, and NGOs. These efforts continue to achieve and expand common EWN-related goals.

Valuing and visualizing sea level rise damage to real estate

Simon Fowell, Kungra

With sea levels in the Bay Area expected to rise by 140cm by the end of the century, reliable valuation of potential damage, as well as effective communication of this damage to stakeholders is important in order to catalyze adaptive responses. This project - using the City of Alameda as a pilot - lays out a methodology to value the potential damage to each individual property owner, thus allowing them to understand their own sea level rise risk. Valuing assets like this builds a business case for deploying projects that use natural capital as a barrier, by showing avoided costs.

Natural Infrastructure for Sea Level Rise Adaptation along the California Coast

Maya Hayden, Point Blue Conservation Science

Coastal communities in California are extremely vulnerable to future sea level rise, with up to 500,000 people and \$100 billion dollars in assets at risk from flooding. Coastal ecosystems, which already suffer from the impacts of development and other landscape modifications, are also threatened by rising seas. Hardened approaches, such as sea wall or levees, are the default adaptation option most familiar to coastal decision makers, yet these further degrade coastal ecosystems. In recent years, California state policy has adjusted to prioritize the consideration of natural infrastructure, natural features or ecosystem processes, as alternatives to hardened infrastructure for protecting human communities. Natural infrastructure can potentially increase the quantity and improve the quality of coastal ecosystems while providing cost-effective flood and erosion protection for human communities. However, coastal decision makers need accessible information describing what natural infrastructure is, what options are feasible for the California coast, and what technical standards they should use to design and implement natural infrastructure adaptation measures. Our project team is working with a technical advisory committee comprised of coastal decision makers and managers from throughout the state to develop guidance that would support the consideration of natural infrastructure for sea level rise adaptation planning. Our team is developing case studies where natural infrastructure has been implemented, general typologies classifying the conditions where different natural infrastructure options are appropriate, and a scaled-down “blue print” at two sites demonstrating how our guidance can be applied for future projects. I will present our project approach and results to date, highlighting information on case studies where natural infrastructure has been implemented successfully in coastal California.

A review of riverine ecosystem service quantification: shortcomings and recommendations

Dalal Hanna, McGill University, Department of Natural Resource Sciences

Riverine habitats support multiple ecosystem services that are essential to human-well being, including drinking water, fish as a food resource, recreational areas, water for agricultural irrigation, and many more. This poster presents results from a review in which we compile information from published studies quantifying riverine ecosystem services accessible via ISI Web of Science, and provide an up-to-date overview of the current state of knowledge regarding riverine ecosystem services quantification. We found 89 studies that explicitly quantify one or more riverine ecosystem services, most of which were conducted in Europe, Asia and the United States. Across studies 33 unique types of riverine ecosystem services were identified, a majority of which were regulating and provisioning services. The majority of studies evaluated one or two ecosystem services (although some evaluated up to 20), and did not assess interactions among ecosystem services. InVEST was used to quantify ecosystem services in 11% of the compiled studies. Across studies, we found a great degree of variability in the types of indicators and methods used to quantify the same type of ecosystem service. Looking across our findings, we identify important knowledge gaps in the field of riverine ecosystem services, and provide recommendations for ways in which the field can move forward.

Exploring the impacts of climate change on freshwater ecosystem services in Canada

Joyce Arabian, WWF- Canada

The purpose of this study is to understand the dynamics of freshwater ecosystem services under future climate change scenarios. The InVEST Toolkit created by The Natural Capital Project was used to predict water yield and to assess potential areas of water risk in Canadian watersheds. To assess the accuracy of the model, outputs from InVEST were validated against observed water yield for the baseline year of 2005. Additionally, using three climate change scenarios defined by the Intergovernmental Panel on Climate Change (IPCC) in its fifth Assessment Report, and results of the Canadian Global Coupled Model Version 4 (CGCM4) for key climatic variables, we have assessed the projected change in the chosen three ecosystem services for future timelines of 2025, 2050 and 2100. Future projections of water yield were compared to forty years of historic data for the given watershed to identify areas where future values varied significantly from the expected range.

Across all time steps and climate models, spatial patterns show reoccurring trends of future drought prone areas in Central Canada and flooding in the Prairies and Arctic region. These future projections allow us to identify areas of significant projected declines of key freshwater ecosystem services, or conversely areas where provisioning of those services may increase. As such, our results can inform adaptation planning in watersheds across the country. Combined, these analyses create an important and novel way to communicate the current value of freshwater ecosystems in Canada, as well as the potential risk these ecosystems face in the future.

Sourcing benefits: The multiple values of nature-based solutions for protecting water

Kari Vigerstol; Adrian Vogl, The Nature Conservancy; Natural Capital Project

Cities are increasingly investing in nature-based solutions within source watersheds to secure water supplies, improve water quality, and reduce water treatment costs. Source water protection activities can also generate co-benefits beyond water security, including in the areas of biodiversity conservation, climate change mitigation and adaptation, and human health and well-being. We analyzed the ceiling of potential benefits that could be achieved through full implementation of source water protection activities within the existing and potential source watersheds of 4,000 cities around the world. We found that activities like forest protection, reforestation, and agricultural best management practices can make meaningful contributions in each of these co-benefit areas. On average one in six cities may be able to pay for source water protection activities using annual water treatment savings alone, and additional cities may be able to achieve affordable source water protection by 'stacking' the values of co-benefits. Focusing on the source watersheds of six of Colombia's largest cities, we also analyzed the cost savings of achieving sediment, nutrient, and carbon emission reduction targets through optimized portfolios of source water protection activities. We found a range of 13 to 95 percent cost savings when land uses are optimized to achieve multiple goals simultaneously rather than individually, representing on average a 63 percent savings in public investment. Additionally, we found that the same portfolios could result in increases in potential base flow contribution up to 11 percent, suggesting additional water available in these source watersheds that could translate to improved dry season water availability. We will discuss these findings and the ways in which actors whose concerns span different co-benefits can come together to enable good land stewardship and secure water across the world's source watersheds.

Ecosystem Services: a Method for Sustainable Development

Lehmann Anthony, University of Geneva

The University of Geneva is proud to launch a new MOOC on Ecosystem Service that covers scientific (technical), economic, and socio-political dimensions of the concept through a mix of theory, case-studies, interviews with specialists (shot at the NatCap symposium in 2016) and a serious tradeoff game. By the end of this course, our aim is to enable the student to:

Impacts of Land-Use Management on Ecosystem Services and Biodiversity

Marcus Becker, Alberta Biodiversity Monitoring Institute

An integrated, multiple ES modelling system was designed to evaluate how alternative land-use management strategies affect the balance of ES, biodiversity, and other socio-economic indicators in Alberta, Canada. Four distinct ES were modelled (water purification, forest carbon storage, crop pollination, timber production) along with a biodiversity intactness index. Results provide insight into trade-offs between ES provision and other socio-economic indicators.

Evaluating Water-Related Ecosystem Services with NatCap Software RIOS and MESH

Erica Honeck, University of Geneva

Urbanized areas in developed countries such as Geneva, Switzerland, benefit from numerous services generated by regional ecosystems. In an effort to give value to Switzerland's natural capital and promote its conservation, a federal law for environmental protection was created in 1998 and completed in 2009. In this context, our project will attempt to contribute in filling the knowledge gap in the assessment of hydrologic services provided by the watersheds in Geneva. In a fast-changing world with increasing environmental pressures from human development and climate change, it is crucial to assure an effective collaboration between different stakeholders to face future challenges. In order to further this objective, policy makers are using the concept of ecosystem services (ES) as a communication tool to connect parties from various backgrounds.

Our study focuses on three water-related ES in Geneva: water yield, nutrient and sediment retention. These three ES's are explored in InVEST's simulation models. The objective of this project is to analyze the ES from two different approaches using software tools developed by the Natural Capital Project. We will explore how MESH can be useful for predicting the changes in ES with different scenarios, and how RIOS enables to optimize investments in a watershed. We will also evaluate the tools' adaptability to industrialized countries and their suitability to bring simple and concise responses to authorities for making well-informed decisions.

Global assessment of factors explaining the carbon performance of REDD+ projects

Johannes Förster, Department Environmental Politics, Helmholtz Centre for Environmental Research - UFZ

This meta-analysis of 66 projects for reducing carbon emissions from deforestation and degradation (REDD+) reveals the potential of the projects for mitigating climate change and identifies factors explaining their carbon performance. The analyzed REDD+ projects are validated and/or verified by major carbon standards including the Verified Carbon Standard (VCS), the Climate, Community and Biodiversity Standards (CCB Standards) and Plan Vivo. Using multilinear regression analysis, key factors of biophysical and socio-economic context as well as factors of project design are identified to determine the carbon performance of REDD+ projects. These include highly effective strategies in reducing carbon emissions as well as trade-offs in addressing multiple ecosystem services. This meta-analysis can inform the design of REDD+ projects, policies on safeguards as well as the advancement of carbon standards.

Influence of Spatial Data on the Uncertainty of Biogenic Greenhouse Gas Footprints of Palm Oil production

Wan Yee Lam, Unilever/ Radboud University

Palm oil is the most widely used of oils and fats worldwide; its production represents 30 % of global supply. Besides degradation of ecosystem services, deforestation and peatland drainage in palm oil producing regions are significant contributors to climate change. Life Cycle Assessment has been increasingly used for greenhouse gas footprinting of industry average palm oil production, but impacts from land use change are not well characterized. Most current assessments that adhere to the PAS2050:1 are based on statistics describing only 3 land use classes (arable land, perennial crops and forests) without consideration of spatial distribution and without consideration of peatlands. Recent efforts to capture land use change using satellite data provide an improvement, but underlying data are associated with significant levels of uncertainty. Different land cover data sources provide different information on the locations, quantity and quality of land use change over time. Furthermore, the current methods do not promote consideration of forest edge effects that affect carbon storage. Using a number of selected data sources, the goal of this study is to quantify the possible uncertainty of biogenic greenhouse gas footprints of industrial average palm oil resulting from the choice of land cover and carbon storage datasets and consideration of forest edge effects. We would then combine the biogenic emissions from land use change with the industrial average of fossil emissions during mill processing and transport to obtain the full cradle-to-gate GHG footprint of one tonne of crude palm oil. This project will contribute towards the EU-funded RELIEF project for improving the reliability of land-related GHG footprints of consumer products. Better understanding of uncertainty of GHG impacts can help companies in focusing future efforts for developing targeted mitigation efforts.

Agroforestry system parameters for land use scenarios in Southeastern Brazil

Claudia Moster Barros, Universidade de São Paulo

The implementation of agroforestry in rural areas is considered a positive transition to alternative in degraded land, especially in the context of the small family farm. This study aimed to select the appropriate values for modeling the agroforestry system, considering the data available in Model Invest, in order to develop scenarios for annual production of water in river basins located in southeastern Brazil. In this model, the main characteristics that affect the outcome of the simulation is the depth of the roots and the annual evapotranspiration. References indicate that the soil quality attributes related to porosity and permeability, in agroforestry, resemble the native forests in early stages of development and the infiltration rate, the residence time in the deep layers of the soil and depth of roots are improved. Evapotranspiration of production systems with trees was higher in arrangements with high density, but the shading and decreasing winds contributed to lower values in agroforestry systems with low tree density when compared to conventional agricultural cropping systems. According to agroforestry practices based on temporal and spatial arrangement, horizontal and vertical, of timber and non-timber practiced in southeastern Brazil, it is considered appropriate to use three classes of agroforestry systems for simulation of land use scenarios: initial agroforestry (0 to 3 years), a pioneer agroforestry (4-8 years), advanced agroforestry (above 9 years for timber harvesting), similar to the stages of pioneering, initial and secondary development of natural regeneration forests. The proper parameters to model the values of agroforestry classes are tropical mixed agriculture, mixed forest/agriculture/pasture and tropical deciduous forest, by Invest model. The values 1550, 1896 and 2220 mm for the depth of roots, and 1.1, 1.03 and 1.0 as for evapotranspiration, can be applied for initial agroforestry classes, agroforestry pioneer and advanced agroforestry, respectively.

Biophysical, economic and cultural valuation of ecosystem services of Meirama's coal mine (A Coruña, Spain)

Sebastian Villasante, University Santiago de Compostela

The objective of this poster is to evaluate a biophysical, economic and cultural valuation of ecosystem services provided by the Meirama's coal mine (A Coruña, Spain). The coal mine has stopped its production in 2008 and the responsible enterprise of the mine ("Union Fenosa", the largest energy company in Spain) decided to reconvert ancient the mine into an artificial lake of 150 hectares with the aim to provide potable water (around 150 millions cubic litres) to inhabitants (around 400,000 people) of the surrounding municipalities.

After the investment of 90 million euros done by the company since 2008 and with the support of the regional and national governments, the company decided to design the implementation of a Natural Capital Protocol to value and monitor the ecosystem services provided by the artificial lake.

Afforested Plantations Alter Ecosystem Services in Pampas Grasslands in Argentina

Colin Phifer, Michigan Technological University

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 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. To clarify and quantify the potential trade-offs between expanding plantations and ecosystem services, we modeled changes in pollination services, carbon sequestration, and

biodiversity using InVEST ecosystem service modeling software using both primary and secondary data sources. We considered two future plausible scenarios, one representing “business as usual” based upon land-use trends from the last 10 years and a second scenario representing a significant expansion of eucalyptus, which is expected based on expanded tax incentives for forestry, and contrasted these scenarios with a 2014 baseline land use map. We also incorporated the community values of the region, based on interviews and social surveys, to capture social acceptability and local perspectives of plantations. Preliminary results suggest that the expansion of eucalyptus will cause a decline in pollination service provided by wild bees and a reduction in bird species richness, along with variable changes in soil carbon values. The degree of eucalyptus expansion drove much of the changes in ecosystem services. Results suggest that the expansion of eucalyptus plantations will likely result in the reduction of our modeled ecosystem services. Final results will further incorporate effects on water usage of eucalyptus plantations at stand and landscape perspectives.

An Impact Assessment of a Legislature-driven Intervention on Household Energy Access for Cooking in Kwara Central Senatorial District of Nigeria

Innocent Onah, Dept. of Geography, Nasarawa State University

It has been estimated that seven in ten households in Nigeria use firewood for cooking. Smoke from the traditional use of firewood is estimated to cause 95,000 deaths annually. After malaria and HIV/Aids, this would be Nigeria's third highest killer mostly of who are women and children. Urban households spend an average of N4, 500 monthly to buy firewood, while rural households particularly women and children walk long distances and spend hours a week into community forests in search for biomass/fuelwood. Poor households may inevitably end up paying more for having energy access for cooking when you factor in externalities. This may also contribute to increased deforestation and further expose households to the effect climate change.

Yet, Nigeria is one of the world's largest exporter of cooking gas or LPG. The energy poverty issue in Nigeria has been well documented but government interventions have not yielded much result. While energy access policies existed since 2005, legal instruments for prevention of logging and export of timber have been absent. There has also been observable trend that interventions should only be initiated and or executed by the Executive arm of government while the Legislature should be restricted to appropriation, oversight and representation. Some argue that any ban on the use of firewood will have to be followed by a strategy to ensure regular and affordable access to and provision of sustainable alternatives for cooking. In response to the coking energy crisis, a Legislature-driven pilot intervention by budgetary appropriation was launched in 2012 by the Senator Bukola Saraki-led Committee on Environment and Ecology tagged the National Assembly Intervention on Clean Cooking (NAICC) expected to run till 2020. This research is an attempt to evaluate NAICC after 4 years of implementation at one beneficiary pilot location - Kwara Central Senatorial district of Kwara state in Nigeria.

Within the context of assessing the impact of NAICC on beneficial households and their ecosystem assets, a randomized assessment of the determinants for the observed impact will be carried out across socio-economic, ecological, technological, fuel use, and climate change mitigation considerations. The impact of the intervention on natural capital asset (community forest) becomes an essential part of the study towards, a review of lessons learned, the best way to promote a socio-economically acceptable, environmentally sustainable, ecologically stable, and climate friendly clean and efficient cooking technologies and fuels.

Primary data will be collected from the field from over 300 randomly selected beneficiaries across all the different Local Government areas in Kwara Central Senatorial district. Measures of central tendencies and dispersion will be used to establish the distribution of stoves types, fuels and gender of primary users of the distributed stove technology and fuel. Appropriate statistical tools of analysis such as regression and correlation analysis will be used to determine and explain the significance of determinants for observed household energy access for cooking. The hypothesis of the research will be tested using chi square analysis while the spatial analysis of the ecological and climate footprint of the intervention on household (natural capital and carbon stored in aboveground fuelwood biomass) will be produced and mapped as experimental scenarios (intervention areas and non-intervention areas,) using InVEST software.

The impact assessment study is expected to scientifically measure the performance of the National Assembly Intervention on the Clean Cooking Initiative and prove that a legislature-driven socio-economic development strategy works in Nigeria. It will reveal the drivers responsible for the performance of the intervention, as well as provide new insights into the socio-economic, climate and ecological footprints of increased logging of community forest that may continue unabated without the legislature-driven intervention.

Global projections of cropland expansion to 2050 and direct impacts on biodiversity and carbon pools

Amy Molotoks, University of Aberdeen

This poster will show global projections for the model IMAGE 3.0 for cropland expansion to 2050. It will examine the impacts of this land use change on biodiversity, including biodiversity hotspots defined by Conservation International and AZE sites, containing endangered and critically endangered species as identified by the IUCN Red List. It will also determine the loss of carbon stocks both in the soil using the Harmonised World Soil Database and in above ground biomass using the Global Land Cover 2000 Project for vegetation and soil carbon stocks data.

What is the role of public and private lands in Idaho for conserving ecosystem services?

Dainee Gibson, Idaho State University

In the United States, the growth of public protected areas has stagnated. However, privately protected lands, such as conservation easements continues to grow. Protected areas are essential for conserving biodiversity, and these lands have traditionally been set aside for this purpose alone. However, the increasing global demand for agricultural and forestry commodities creates conflict and tradeoffs between dedicating land for conservation versus food production and resource extraction. The overarching goal of this research is to evaluate if private protected areas provide as many ecosystem services as public protected areas. We used ecosystem service mapping and InVEST modeling to map food production, habitat quality, carbon sequestration, and freshwater provisioning in two watersheds in Idaho, USA. We hypothesize that public protected areas provide more because they have been in place for longer period of time, and thus have likely had less disturbance to the drivers of ecosystem services. Our preliminary results, however, indicate that private protected areas provide comparable levels of food production to those from public protected areas. Next, we will

overlay spatial boundaries of private protected areas (i.e. conservation easements) and compare the capacity of private conservation easements and federally managed public lands to provide a suite of ecosystem services. We will identify ecosystem services tradeoffs and synergies as well as determine areas that supply ecosystem service bundles. This research could improve the targeting of private protected areas by identifying areas with ecosystem service bundles. Furthermore, appreciating the variety of ecosystem service benefits of private protected lands would provide justification for more investments in conservation easements.

New strategies for the dynamisation and revalorisation of the agrarian sector in Madrid region (Spain): Agrolab, an open farming Laboratory

Marina Garcia-Llorente, Carmen Haro, Alejandro Benito, IMIDRA

We present a participatory action research initiative that takes place to revitalize the agricultural sector in Madrid, one of the largest cities of Spain with a significant metropolitan area and a suitable agrarian potential at rural and periurban areas. The experience is based on: (1) the promotion of training and entrepreneurship in the sector, (2) the creation of an agrarian network based on collaborative work with local communities and urban dwellers, (3) the promotion of social inclusion and equal opportunities, (4) the valuation of farming ecosystem services, and ultimately (5) a transition towards sustainable models of production-commercialization and consumption.

To do so, we are running a pilot experience in a rural municipality at 38 km to Madrid. The initiative had involved more than 60 participants, who run two agrarian plots of nearly 1ha, together with the support and monitoring of local authorities and an agrarian research institute. The communication describe the steps given since February 2015 and the follow up of the project provided by its participants.

The conversion of agrarian landscapes at rural areas in Spain: biophysical and participatory mapping of crop production

Irene Pérez Ramírez & Marina García-Llorente, Madrid Institute for Rural Development, Agricultural and Food Research (IMIDRA)

The spatial visualization of ecosystem services constitutes a powerful tool for supporting environmental and landscape decision making. Furthermore, the supply and demand of services may differ geographically and temporally within the same region requiring from approaches able to integrate biophysical and social values of ecosystem services. To this end, participatory mapping aims to collect the diversity of stakeholders' knowledge and empower people to participate in spatial decision-making issues.

Las Vegas rural district, located at the southeast of Madrid Region and crossed by three main rivers, is characterized by its agricultural tradition of horticulture, extensive crops in its valleys, olive, and vineyard in its upper areas. During the last decades, land-use has changed and the population has got disconnected from landscape experience because of the abandonment of rural areas, aging of the population with a lack of replacement and the influence of urban areas. In this research, we analyze the spatial distribution of farming ecosystem services. To do so, we have characterized the service of food production for the period 2000-2015 calculating yields (Kg/Ha/Year) and analyzing the changes in the main crops. Then participatory GIS has been done by four workshops to describe the social importance of ecosystem services related with the agrarian landscapes at the region (food production, sense of belonging, soil fertility and freshwater provision). In this way, we crossed in a spatial explicit way, biophysical and socio-cultural information, obtaining an integrated assessment of ecosystem services and understanding the main landscape changes that could be used in the application of rural development programs.

Modeling the environmental services as an instrument for the territorial planning. Presenting the case of study. Of the integrated watershed management action plan of La Antigua, Veracruz, México.

José Machorro Reyes, National Institute of Ecology and Climate Change

This paper highlights the importance of the analysis on the Supply-demand relationship of the environmental services to be used as a support tool in the territorial planning process. The present study case of La Antigua watershed, describes the process developed during the construction of the Integrated Watershed Management Action Plan. The outputs from the modules of water yield and sediment delivery ratio of InVEST were used as a scientific basis to focus the efforts and resources on the territory and detonate adaptation process to climate change.

A Study on Selection Method of the Top-Soil Management Regions in the Environmental Impact Assessment: Focus on Soil Carbon Storage and Soil Loss

Jongsung Kim, Korea Environment Institution

The soil provides ecosystem services for support service, regulating service, provisioning service, cultural service. The soil carbon storage function absorbs carbon dioxide in the atmosphere, reduces the carbon dioxide in the atmosphere and serves as a carbon reservoir in the process. Also, natural phenomenon such as water, wind, gravity and man-made effect generate soil erosion. It causes environmental economic problems, such as deterioration of water ecosystem, degradation of water resources and hydraulic structure. For this reason, the study focused on selection method for top-soil management region in the environmental impact assessment and comparing the soil valuation method in the Korean environmental assessment.

In this study, the selection method of the top-soil management region evaluate soil carbon storage with Carbon Storage module in InVEST model and assess soil erosion by Sediment Delivery Ratio module. In that order, comparing the result with Korean EIA's soil evaluating results. Based on these results, the top-soil management regions were selected as the area where was low level of soil erosion and high carbon storage capability by overlay analysis.

Investigating water scarcity and governance across social-ecological systems (WaterSES): a program on ecosystem change and society (PECS) perspective

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Environmental and social change in water-scarce regions across the globe pose significant challenges to the well-being of social-ecological systems (SES). WaterSES is a sponsored working group within the Program for Ecosystem Change and Society that promotes transdisciplinary, place-based comparative research to identify appropriate operational scales for SES stewardship and management. WaterSES aims to understand and compare the social-ecological dynamics of water scarcity across international research sites with conflicting local and regional water needs and governance, including arid southern Spain, the south-central Great Plains of Oklahoma (US), and the Portneuf and Treasure Valleys, Idaho (US). The sites have different climates, water needs and socio-ecological dynamics, but are all experiencing new regional, societal demands for limited water resources. WaterSES goals are (1) synthesize data collected across research sites to identify novel and pressing SES science questions, (2) identify data needed to make cross-site comparisons and identify sustainable policy solutions at a range of spatial scales and contexts, and (3) target cross-institutional funding opportunities at the national and international level. Here we discuss a preliminary assessment of these goals based on an international WaterSES workshop.

Housing growth in and near forest lands in New England impacts their conservation value

Raphael Filippelli, University of Vermont

The increasing footprint of housing developments in the United States are likely to pose a threat to biodiversity and impact the provision of ecosystem services delivered by natural areas. This increase in development fragments native habitats, aids the establishment of invasive species and impacts water quality (Radeloff et al. 2005; McKinney 2006). Here we extend (Radeloff et al. 2010) assessment by looking at the rate of housing development across a much broader suite of forest governance regimes, including state lands, municipal lands and private lands. This analysis provides an in-depth, regional look at the potential differential rates of infringement on forests as a function of their governance regimes. We use a synthesized map of land ownership in New England, including both open and restricted data, with information on 105,817 parcels of land and 9 different governance types grouped into federal, state, municipal, NGO and private. We then create a dataset of housing density by updating census data compiled by Radeloff et al. with data from the 2010 Census. We analyze the rate of change of housing density in forest buffers over time and compare this rate of change for each of our governance regimes.

Biodiversity Finance Initiative: Financial solutions sustainable development

Andrew Seidl, UNDP

BIOFIN is a global partnership addressing the biodiversity finance challenge in a comprehensive manner. The BIOFIN methodology allows countries to measure their current biodiversity expenditures, assess their financial needs and identify the most suitable finance solutions to bridge their national biodiversity finance gaps. A major task for policy-makers in financing the 2030 Agenda and biodiversity is to devise financing solutions to attract and direct investments to areas where greater benefits for people and biodiversity can be achieved. The UNDP Financing Solutions toolkit provides guidance for countries to review and operationalize financing solutions that help implement sustainable development strategies including the country's biodiversity strategy.

Green infrastructure in Madagascar, investing for the sustainable development and inclusive growth

Tiana Ramahaleo, WWF Madagascar Country Office

In line with the Vision of the National Development Plan (NDP), WWF and the Government of Madagascar are increasingly committed to protecting the country's most important "green infrastructures", crucial to the survival of its fauna and flora and the wellbeing of the country's citizens. Securing natural ecosystems such as forests and rivers is a key to the sustainability of Madagascar's development. Most of Madagascar's soil is extremely degraded, and this already has significant consequences on food security, according to the 2016 Living Planet Report. Most of the soil is hardly exploitable due to desertification in some areas. Moreover, the natural capital is being depleted in addition to economic losses due to climate change. Through this approach, green infrastructures will strengthen the capacity of ecosystems to produce goods and services, to promote an integrated land development or to integrate appropriate measures in the various land use and occupation plans and policies. The approach will also contribute to the development of a green and sustainable economy by investing in the natural capital and its valuable environmental services.

Marine Ecological Capital: Assessment, Management and Investment

Shang Chen, First Institute of Oceanography, SOA, China

Marine Ecological Capital (MEC) is defined as marine ecological resources which have direct or indirect contributions to humans' social and economic production and provide benefits for humans. MEC is the important component of natural capital. MEC value is defined the monetized benefits for humans from marine ecological capital, including both the standing stock value of marine ecological resources and value of marine ecosystem services. Marine ecological resources (MER) consists of marine living resources and their habitats (i.e. seawater, surface seabed), as well as the marine ecosystem that they act as a whole. Ecological (or natural) capital has been become the emerging issue in both scientific and economic communities. The cooperation on marine ecosystem services has already been accepted in the outcome list of 8th Sino-US Strategic and Economic Dialogue (June 2016 in Beijing). Three scientific issues focus on assessment frameworks, management mechanisms and investment models of marine ecological capital are preliminarily addressed in this paper. The ecosystem-based marine management needs mainstreaming of MEC in both marine management and commercial investment activities. The MEC theory and approaches may play key role to balance both the ecological and economic benefits from human's marine activities.

Blue Carbon Modeling: Integrating Carbon Sequestration Hotspots into Coastal Adaptation Planning

Jessica Williams & Monica Moritsch, Center for Ocean Solutions

Coastal habitats, despite their small global extent, provide important carbon sequestration benefits, among many other ecosystem goods and services. However, climate impacts and coastal development pressures threaten these habitats and their provision of services. To support decisionmakers in effectively allocating limited resources for managing coastal ecosystems, the Center for Ocean Solutions is leveraging the best available data and the InVEST Blue Carbon Model to map and value California's blue carbon – the carbon sequestration and storage potential in coastal habitats. Using the cost of carbon dioxide in the California carbon market, land use maps containing tidal wetland habitats, and carbon storage capabilities of wetlands, we can project the amount of carbon sequestered in key habitats and its value under future land use scenarios. We can also estimate the market value of the carbon sequestered in a given area. By identifying carbon stock and “hotspots” of carbon sequestration we can assist managers in prioritizing locations for conservation and restoration to successfully manage overall carbon budgeting, ocean acidification mitigation, and other ecosystem services. Our team is engaging with state management agency staff and local scientific, legal, and policy experts in California to provide science-based information on the role of blue carbon that is relevant to local and regional climate adaptation decisions. We present our findings from a recent case study conducted in Elkhorn Slough along California's central coast, in which we demonstrate the application of the Blue Carbon Model as a flexible and iterative decision-support tool that aids managers in adaptively managing the coastline. Our modeling efforts yielded maps of carbon stock and value within a network of marine protected areas, showing a considerable amount of carbon storage inside protected areas, demonstrating the benefits of protecting natural habitats. Through this approach, we can guide resource prioritization efforts as scientists, planners and managers effectively engage on the role of blue carbon in climate change policy and management at various scales.

Myanmar: Home to 800 Undeveloped Islands

Theodora & Helen Horangic, Myanmar Seagrass Partners LLC

Myanmar is one of earth's great treasures. Sixty years of a brutal military dictatorship and isolation from outside influence has left rainforests, estuaries, coral reefs, and seagrasses virtually untouched. But this is about to change. With a more welcoming government now in place, the Myeik Archipelago, a group of over 800 undeveloped tropical islands on Myanmar's southern border, is a primary target for developers. Ecosystem baseline data needs to be collected, so that the natural capital of this area can be accounted for and development can be carefully monitored.

Our work currently focuses on collecting baseline data about the archipelago's seagrass resources. Data on coral, mangroves, and island flora and fauna has yet to be collected by other scientists beyond one of the larger islands. We plan to develop and incrementally improve our natural capital analysis as we or other scientists collect data from this area over the next decade.

Within the last two years of a new government, Myanmar and the Myeik Archipelago have seen huge changes and a new focus on developing tourism in the country. This has resulted in the first three small resorts being built in the archipelago, and the purchase of many more islands by Singaporean and Chinese developers. Local people are already being displaced and forced out of their island villages, as developers move in to build these facilities. If there was ever a time to guide development in Myanmar, it is now!

Assessing carbon storage and sequestration on Andros Island, The Bahamas to inform sustainable development planning

Jaclyn Mandoske, Scripps Institution of Oceanography/ The Natural Capital Project

Understanding the value of nature's services is critical to conservation and development decisions that balance the long-term needs of people and the environment. To inform sustainable development on Andros Island – the largest island in The Bahamas – researchers with the Natural Capital project have been collaborating with the Office of the Prime Minister (OPM), with support from the Inter-American Development Bank (IDB), to address the challenges of sustainable development planning and help inform the design of a Master Plan for development. Researchers have conducted ecosystem services analysis and risk assessments for a variety of services across four development scenarios. However, they have not yet done an assessment of blue carbon storage or sequestration distribution and economic values for mangroves and sea grasses across Andros. This study will add to the analysis by including the value of carbon services Andros ecosystems provide. This project will answer the following questions: 1) How does carbon storage and sequestration vary spatially across Andros and among habitat types? 2) How does spatial variation in carbon storage and sequestration change under several alternative development scenarios? 3) What are potential management strategies or financial mechanisms that can be used to address conservation and development decisions to ensure sustained delivery of carbon storage and sequestration services into the future?

Development Impacts and Offsets in Geneva, Switzerland

Laura Dias, University of Geneva

Assessment of the 2030 development plan for Geneva, Switzerland.

What values motivate homeowner engagement with their yards (i.e., ecosystems)?

Nick Neverisky, University of Washington

Nearly half of the land areas of many U.S. cities is zoned for single family residences (e.g., 49% of Seattle). These are fragmented management landscapes -- large numbers of parcels are individually managed yet collectively comprise substantial portions of local ecosystems. Promoting the health of urban ecosystems therefore requires engagement with owners of these properties. Here, I investigate the benefits for which homeowners manage their properties. What motivates their engagement with ecosystem services? What are the most salient values homeowners attribute to their properties that can be leveraged to promote pro-environmental management? To answer these questions, I conducted semi-structured interviews with homeowners in Seattle, Washington across a range of socio-economic contexts spanning 10 zip codes. My thematic content analysis of these interviews revealed that homeowners have a range of motivational goals they address by engaging with ecosystem services derived from their properties. Most prominent are those goals associated with in-group well-being (e.g., providing a healthy environment for one's own children, or building relationships through collaborative gardening) and personal stability and security (e.g., feeling a sense of place, or perceiving

neighborhood safety). The fact that any given ecosystem service may address multiple motivational goals suggests that service assessments may be more robust when these goals are considered. Furthermore, urban homeowners may be more responsive to appeals and persuasion strategies highlighting benefits to the well-being of in-group members and themselves than as a means to experience something novel or to achieve personal development.

Planning for the future of coastal communities in Cuba

Teresa Gomez, The Nature Conservancy/ Brigham Young University

Cuba is the largest country in the insular Caribbean. The country is the home of the majority of the Caribbean's endemic species and one of the most well-preserved coral reef systems. While the archipelago boasts some of the best-preserved biodiversity in the world, it is under increasing threat with the prospect of sudden and massive growth in tourism when the US embargo lifts. This possible increase in anthropogenic pressure will especially affect the coastal regions of the island which are naturally subject to erosion and inundation. We are using the InVEST coastal vulnerability model to qualitatively estimate coastal exposure and differentiates areas with relatively high or low exposure to erosion and inundation during storms. As a decision support system, this model will guide efforts to focus conservation on important areas and help Cuba make informed decisions about the future development in ways that will promote sustainability without sacrificing ecological integrity.

Streets lined with gold? Structure, function and value of streets trees in California

Natalie van Doorn, USDA Forest Service

Street trees, defined as trees growing along public street right-of-way and managed by the city, account for a relatively small fraction of the entire urban forest but they contribute considerable ecosystem services and disservices to the urban landscape and thus require municipal budget spending for their management. The goal of our study was to assess California's municipal forest structure and estimate corresponding street tree function and value. We compiled recent municipal tree inventory data from 929,823 street trees in 50 cities to evaluate trends in tree number, density and species relative abundance. iTree Streets (www.itreetools.org) was used with tree inventory data to quantify structure, function, and value of annual benefits.

The number of street trees increased from 5.9 million in 1998 to 9.1 million in 2014, about one for every four residents. However, average street tree density in California has declined from 65.6 to 46.6 tree per km of street length, nearly a 30% drop. State-wide, city streets are at 36.3% of full stocking (assuming full stocking is having 15.2m between stems of street trees) and there are approximately 16 million vacant tree sites. On the state-wide scale, London planetree (*Platanus x hispanica*, 10.5%) is the sole species that claimed more than 10% relative abundance, but the need for further diversification is evident at the city and climate zone scale. These 9.1 million street trees contribute an estimated annual value of \$1 Billion in ecosystem services. Ecosystems services are reported for five categories: energy, carbon dioxide, air quality, stormwater, and property values and other benefits. The total annual monetary value of energy savings from the state's street trees is \$101.15 million. Net annual CO₂ removed from the atmosphere totals 567,748 t year⁻¹ state-wide (equivalent to taking 120,000 cars off the road), with an associated monetary value of \$10.32 million per year or \$1.13 per tree on average. The net annual value of trees' effects on air quality is \$18.15 million or \$1.59 per tree on average. California's street trees intercept 26.19 million m³ year⁻¹ of rainfall annually, which totals \$41.5 million. They also contribute to the sales price of homes and provide other benefits valued at \$839.94 million per year. Overall, the asset value of the state's street trees when considered as a capital investment similar to other infrastructure is \$2.49 billion, which averages to \$2,677 per tree. Given an average annual per tree management cost of \$19.00, \$5.82 in benefit is returned for every \$1 spent. These findings suggest that investing in the long-term health of municipal forests can provide positive returns.

How can local communities benefit from a National Park?

Siyuan He, Luc Hoffmann Institute, WWF

In September 2015, the Chinese government announced its decision to explore a new national park system to change the multi-headed management of protected areas. The management objectives of national parks are to prioritising conservation for public welfare. Several pilots then have gradually been launched by combination of separate protected areas in one region. Since rural people are highly dependent on natural resources for livelihood, a key question emerges that how to guarantee the livelihood of local communities that will be part of a national park? This matters to land use management, payment for ecosystem services and sustainable livelihood, all are part of the institutional change of the national park system construction and is on the agenda of local government.

To answer this question, we would like to use an ecosystem services approach for Wuyishan national park pilot. We would go deeper to three aspects: 1) as ecosystem services beneficiaries, what are local people's major demand? 2) so far, what are their perception to the management of prioritised ecosystem service within the old protected area systems? 3) so far, what do they think as conflicts between their practice and conservation goals?

We have visited more than 350 households both inside and outside of the planned pilot within the administrative boundary. We have a map of ecosystem services demand of communities; we find their major concerns are policy change in land tenure, natural disaster prevention and mitigation and standardisation of production; there is no major conflicts, but lacking of traditional knowledge/habitat or unclear regulation and implementation of rules. Based on these answers, we have proposed the forest conservation easement for tea plantation aiming to maintain it ecologically compatible to forest conservation and adding value to production through "national park" brand.

Natural capital data visualization to enhance sustainable decision making

Charlotte Weil, NatCap

Natural capital assessments reveal the specific benefits provided by nature in order to develop approaches to manage environmental assets sustainably and take nature into account in major decisions. Effective communication of their results, including clear visuals, is crucial for supporting decision-makers. However, no consolidated practical guidance exists to support analysts in synthesizing their results, and visualization tools are scattered. The present work addresses

this gap, and aims to facilitate understanding and spread of natural capital assessments, hoping to increase engagement in a field with large potential for impact.

First, we gather the existing knowledge on design strategies for displaying complex information through a literature review and surveying analysts in the field. Complex information refers here to the specificities of natural capital data, i.e typically large numbers of maps and aspatial statistics that result from considering multiple objectives, scenarios, and uncertainties.

Secondly, this work scopes the gaps in the field by analyzing and prioritizing the visualization needs, through a survey and interviews. Findings from this assessment guide the development of (1) a toolbox to help analysts in their task of communicating natural capital information; and (2) an innovative tool to display natural capital results, merging knowledge from previous points in the form of a prototype user-friendly dynamic web visualization. In an interactive dashboard combining multiple linked views, this tool allows visualization of tradeoffs between objectives, comparison of scenarios and assessment of uncertainty.

The master thesis can be found here: <http://www.charlotteweil.fr/masterthesis>

How do watershed characteristics and data resolution affect sediment delivery modeling?

Perrine Hamel(a), Kim Falinski(b), Rich Sharp(a), Daniel A. Auerbach(c), María Sánchez-Canales(d) and James Dennedy-Frank(a,e)

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Sediment transport models seek to represent the sources and volumes of sediment that leave a basin. Predictions from such models help quantify the sediment retention service and inform land management decisions at various spatial scales. One class of spatially distributed models, similar to the InVEST sediment delivery model, combine an estimate of soil erosion with a transport model.