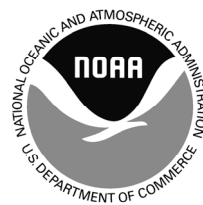


ACES: A Conference on Ecosystem Services

*2008: Using Science for Decision Making
in Dynamic Systems*

December 8-11, 2008
Naples, Florida

www.conference.ifas.ufl.edu/aces



Restoration Program

Natural Resource Damage Assessment & Restoration Program



Welcome to ACES 2008: Using Science for Decision Making in Dynamic Systems

We want to take this opportunity to welcome you to the first ACES: A Conference on Ecosystem Services. The next four days encompass an array of workshops, plenary sessions, panel discussions, presentations, and educational field tours. We are confident that throughout ACES you will gain important information and interact with valuable new contacts to help further the discussion on ecosystem services.

ACES is much more than a series of meetings and presentations. As we share information with colleagues and friends, and listen to discussions and presentations from leading experts on ecosystem services, ACES provides us with an opportunity to identify new ways to move forward and to collaborate with a better understanding of the characteristics, spatial distribution, and value of ecosystem services. ACES is also a venue to synthesize research, methods, and tools needed to more routinely and effectively incorporate ecosystem services into resource management, conservation, restoration, and development decisions.

Planning for ACES goes back to a multi-organization workshop on valuing ecosystem services for decision making, held October 2007, in Denver, Colorado. During this workshop, the broad interdisciplinary nature of research on ecosystem services and the need to combine ecological, geographic, socio-economic, and institutional information and models were discussed. The four ACES themes were also developed at this workshop: (1) mapping and spatial relationships; (2) values and measurement; (3) dynamic systems and drivers of change; and (4) institutional structures and decision making.

Heartfelt thanks goes to our generous partners, sponsors and those who served on our conference committees. Their commitment of time, energy and financial support is the reason this conference is possible.

We look forward to a conference filled with new ideas, spirited discussion, and opportunities to meet old friends and make new ones. We trust that you will find ACES beneficial and will enjoy the experience.

Carl D. Shapiro
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Conference Chair

Malka Pattison
Department of the Interior
Office of Policy Analysis
Conference Co-Chair

Greg Arthaud
Research & Development
U.S. Forest Service
Conference Co-Chair

Table of Contents

Welcome Letter	i
Organizing Committee	iv
Steering Committee	v
Sponsor Recognition	vii
Keynote Speaker Biographies.....	viii
Panel Session Descriptions.....	x
Special Session Descriptions	xii
Agenda-at-a-Glance	xiv
Directory of Poster Presentations.....	xvi
Workshop Descriptions	xviii
Conference Abstracts.....	1
Author Index.....	179
Notes	184

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A Special Thank You to our Conference Partners

Bureau of Land Management

Cooperative State Research, Education, and Extension Service

National Oceanic and Atmospheric Administration

National Park Service

Everglades National Park

National Science Foundation

University of Florida, IFAS

US Department of the Interior

Natural Resource Damage Assessment & Restoration Program

US Department of the Interior

Office of Indian Energy & Economic Development

US Environmental Protection Agency

US Fish & Wildlife Service

US Forest Service

US Geological Survey

Geographic Analysis and Monitoring Program

Office of Global Change

Terrestrial Freshwater and Marine Ecosystems Program

Other Partnering Organizations

Association of American Geographers

MIT-USGS Science Impact Collaborative

University of New Mexico

Science Impact Laboratory for Policy and Economics

University of Pennsylvania

Spatial Integration Laboratory for Urban Systems

Keynote Speaker Biographies

Adam Davis

Tuesday, December 8, 2008 – Opening Plenary Session

Adam Davis is a Partner in Ecosystem Investment Partners (EIP), a private equity fund manager that acquires and manages high priority conservation properties across the United States. EIP delivers competitive returns to its investors through the use of new, market-based mechanisms that reward landowners for the restoration and protection of their natural resources.

Adam also serves as President of Solano Partners, Inc., a consulting firm focused on environmental investment and conservation finance issues. Recent projects have addressed the use of conservation and restoration incentives on Trust Lands and in the Puget Sound Partnership, the use of advance mitigation in addressing renewable energy project siting, and comprehensive analysis of U.S. greenhouse gas offset initiatives.

He is a Co-Founder and previous Editor-in-Chief of the Ecosystem Marketplace, a global information service on market mechanisms and financial incentives for conservation. Previously, Adam served as Director of Consulting for the Environment Division of the Electric Power Research Institute, and also co-founded and served as Principal at Natural Strategies, Inc., a management consulting firm working with companies to integrate sustainability principles into business strategy. Adam is also a member of the Advisory Council for the Aldo Leopold Leadership Program based at Stanford University, which provides training for environmental scientists in public speaking and communications.

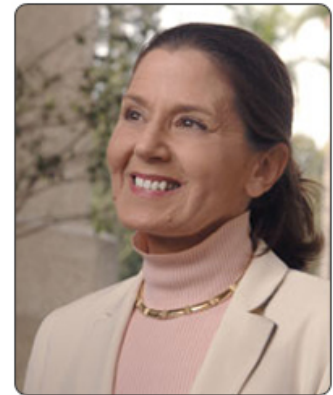
Adam's work was recently featured in *The New Economy of Nature*, by Daily and Ellison, and he received the 2002 Ecological Society of America corporate award for "his contribution to the understanding of connections between recycling, resource recovery and ecosystem health."



Lynn Scarlett

Wednesday, December 10, 2008 – Morning Plenary Session

Lynn Scarlett was confirmed as Deputy Secretary of the Department of the Interior on November 2005, a post she took on after 4 years as the Department's Assistant Secretary for Policy, Management and Budget. She served as Acting Secretary of the Department upon the resignation of former Secretary Gale Norton effective April 1, until the confirmation of Secretary Dirk Kempthorne on May 26, of 2006. She serves on the Executive Committee of the President's Management Council.



Ms. Scarlett coordinates Interior's environmental policy initiatives to implement the President's executive order on cooperative conservation, serving on the White House Cooperative Conservation Task Force. From June 2003-2004, she chaired the federal Wildland Fire Leadership Council, an interagency and intergovernmental forum for implementing the National Fire Plan and 10-Year Implementation Plan. She co-chairs the President and First Lady's Preserve America initiative on historic preservation and heritage tourism. She also co-chairs the Recreation Fee Leadership Council, a federal interagency group to coordinate recreation fee policy and practices on federal lands. She serves on the Board of Trustees of the Udall Foundation as the Department of the Interior representative.

Prior to joining the Bush Administration in July 2001, she was President of the Los Angeles-based Reason Foundation, a nonprofit current affairs research and communications organization. Ms. Scarlett is author of numerous publications on incentive-based environmental policies. Ms. Scarlett received her B.A. and M.A. in political science from the University of California, Santa Barbara, where she also completed her Ph.D. coursework and exams in political science and political economy.

Plenary Panel Session Descriptions

Tuesday, December 9, 2008, 9:00am-10:00am

Why are Ecosystem Services Important and What are the Challenges in Including Them in Decisions?

Moderator:

Olivia Barton Ferriter, Director, Conservation, Partnerships & Management Policy, U.S. Department of the Interior

Panel Members:

Rick A. Linthurst, National Program Director for Ecology, EPA

Mark Myers, Director, U.S. Geological Survey

Ralph G. Stahl, Jr., Principal Consultant, DuPont Corporate Remediation Group

R. Michael Wright, Managing Director, Natural Capital Project; Former Senior Vice-President, World Wildlife Fund

Resource management, restoration, conservation, and development decisions are often made without considering the impacts to ecosystem services or with imperfect information on the impacts. This panel of government, private sector, non-government organization, and academia leaders will focus on the importance of ecosystem services to these decisions. The panel will also discuss the ecological, geographic, socioeconomic, and institutional steps that need to be taken to facilitate more routine and effective consideration of ecosystem services in decision making.

Tuesday, December 9, 2008, 10:30am-12:00pm

Future Directions for Research on Ecosystem Services

Moderator:

David Lightfoot, Social Behavioral and Economic Sciences, National Science Foundation

Panel Members:

James W. Boyd, Senior Fellow, Resources for the Future

Robert Costanza, Gund Professor of Ecological Economics; Director of the Gund Institute for Ecological Economics

Taylor Ricketts, Director of Conservation Science, World Wildlife Fund

J.B. Ruhl, Mathews and Hawkins Professor of Property, Florida State University College of Law

Susan M. Wachter, Richard B. Worley Professor of Financial Management, Professor of Real Estate and Finance; Co-Director, Institute for Urban Research, The Wharton School of the University of Pennsylvania

Single-, multi-, and trans-disciplinary research on ecosystem services has increased greatly during the past couple of decades. However, many environmental management decisions are made with imperfect and inadequate understanding of ecosystem services and the consequences of societal decisions to the services. This panel of leading researchers will discuss needs and opportunities for future research on ecosystem services, with a theme of using science for decision making in dynamic systems.

Wednesday, December 10, 2008, 8:00am-9:15am

Using Markets and Other Institutional Structures to Incorporate Ecosystem Services in Decision Making: Opportunities and Challenges.

Moderator:

Brad Gentry, Co-Director of the Center for Business & the Environment, Yale University

Panel Members:

David S. Brookshire, Director of Science Impact Laboratory for Policy and Economics; Professor of Economics, University of New Mexico

Jessica Fox, Director, Eco-Assets Program, EPRI Solutions

Elaine J. Dorward-King, Global Head, Health, Safety and the Environment, Rio Tinto, Ltd.

Emily McKenzie, Lead, Policy and Finance, Natural Capital Project, World Wildlife Fund

An expanding number of markets and other institutional structures have been developed in recent years to internalize consideration of ecosystem services, including water, wetlands, carbon, and biodiversity, in decision making. This panel of researchers and other leaders in the development of markets and other structures will discuss the effectiveness of these markets and other structures and opportunities and challenges for the future.

Thursday, December 11, 2008, 10:30am-12:00pm

Synthesis: Key Findings and Next Steps

Moderator:

Mark Schaefer, Deputy Director for Environmental Conflict Resolution, Morris K. Udall Foundation

Panel Members:

Ann M. Bartuska, Deputy Chief for Research and Development, USDA Forest Service

Gregory R. Biddinger, Natural Land Management Program Coordinator, ExxonMobil Biomedical Sciences, Inc.

Paula A. Harrison, Environmental Change Institute, Oxford University Centre for the Environment

K. Bruce Jones, Chief Scientist for Biology, U.S. Geological Survey

Molly K. Macauley, Senior Fellow, Director, Academic Programs, Resources for the Future

This panel of leading researchers in government, non-governmental organizations, academia, and the private sector will provide concluding observations and will discuss priorities and next steps for research and institutional adaptation.

Special Session Descriptions

Monday, December 8, 2008, 4:15pm-5:45pm

Public-Private Roundtable on Aligning Tools and Decision-Making in Ecosystem Services

Moderator:

Ralph Stahl, Principal Consultant, DuPont Corporate Remediation Group

Panel Members:

Wayne Munns, Associate Director for Science, U.S. Environmental Protection Agency

Greg Biddinger, Natural Land Management Program Coordinator, ExxonMobil Biomedical Sciences, Inc.

Kit Armstrong, Senior Advisor to Environmental Markets Initiative, Business for Social Responsibility

David Batker, Executive Director, Earth Economics

This roundtable will discuss the need for corporate engagement in the emerging domain of ecosystem service concepts and their applications, and to foster a dialogue on possible paths forward for public-private sector engagement for consideration of ecosystem services in business decision making. One of the key obstacles to the protection of ecosystem services has been guidance and tools that enable companies to incorporate these services into their strategic planning, risk assessment and other decision-making processes. This panel will include a discussion of the results of Business for Social Responsibility's (BSR's) recent assessment of the rapidly expanding landscape of ecosystem services tools, from managerial frameworks to GIS probabilistic models. This roundtable is of interest to those who wish to learn more about the emerging landscape of ecosystem service assessment tools, how business can utilize such tools for decision-making, and how members of the public and private sectors can collaborate to advance ecosystem services concepts.

Tuesday, December 9, 2008, 1:15pm-5:15pm

***Ecosystem Services in the Context of Natural Resource
Damage Assessment and Restoration***

Moderators:

Thomas Campbell, Pillsbury Winthrop Shaw Pittman

Bruce Peacock, National Park Service, Environmental Quality Division

Session Presenters:

Thomas Campbell, Pillsbury Winthrop Shaw Pittman

Susan Finger, US Geological Survey, Columbia Environmental Research Center

Bruce Peacock, National Park Service, Environmental Quality Division

Ralph Stahl, Principal Consultant, DuPont Corporate Remediation Group

Greg Baker, NOAA Assessment and Restoration Division

Natalie Cosentino-Manning, NOAA Restoration Center

Theodore Tomasi, ENTRIX, Inc.

Russ MacRae, New Mexico Ecological Services Field Office, US Fish & Wildlife Service

This session will focus on the evolving understanding of ecosystem services (ecological and human use) in the context of the natural resource damage assessment and restoration (NRDAR) process, particularly the use of ecosystem service metrics to evaluate actions that affect the environment. Science and economic-based methods to quantify ecosystem services have been used extensively in evaluating injury to natural resources and in quantifying the benefits associated with site restoration as part of NRDAR cases. NRDAR experts will discuss the strengths and limitations of the methods used to estimate ecosystem services in NRDAR cases from their legal, economic, and science perspectives. Additional NRDAR experts will present case studies on their experience with developing ecosystem service metrics and implementing the methods. All speakers will join in a panel to discuss how ecosystem services apply to the NRDAR process and how the methods have evolved in meeting NRDAR compensation requirements.

Tuesday, December 9, 2008, 7:00pm-8:30pm

U.S. Climate Change Science Program Listening Session

Session Presenter:

Patricia Jellison, Chief, Global Change Research & Development, Office of Global Change, US Geological Survey

The US Global Change Research Program / US Climate Change Science Program (USGCRP/CCSP) seeks input from the wide variety of stakeholders that the program serves. As part of this effort, the USGCRP/CCSP is conducting this listening session in order to inform the federal government's deliberations about the future of climate change research. At this listening session, representatives from the program will provide a brief overview of the current USGCRP/CCSP structure, research and other activities, and will then solicit and collect input from attendees regarding stakeholder needs for federal climate change monitoring, research and information. The comments provided at this listening session will be used to help define USGCRP/CCSP's future directions.

Agenda-at-a-Glance

SUNDAY, DECEMBER 7, 2008

5:00pm-7:00pm **PRE-CONFERENCE REGISTRATION OPEN** (*Acacia I-III*)

MONDAY, DECEMBER 8, 2008

7:30am-5:30pm **CONFERENCE REGISTRATION OPEN** (*Acacia I-III*)

7:30am-9:00am **MORNING REFRESHMENTS AND POSTER SET-UP**..... (*Royal Palm VI-VIII*)

9:00am-12:00pm **CONCURRENT WORKSHOPS**

10:15am-10:45am **AM BREAK**..... (*Royal Palm VI-VIII*)

12:00pm-1:00pm **WORKSHOP BOXED LUNCH PROVIDED**

2:15pm-2:45pm **PM BREAK**..... (*Royal Palm VI-VIII*)

1:00pm-4:00pm **CONCURRENT WORKSHOPS**

4:15pm-5:45pm **GENERAL SESSION: Public-Private Roundtable on Aligning Tools and Decision-Making in Ecosystem Services** (*Royal Palm IV-V*)

6:00pm-8:00pm **NETWORKING SOCIAL** (*Vista Room*)

TUESDAY, DECEMBER 9, 2008

7:00am-5:30pm **CONFERENCE REGISTRATION OPEN** (*Acacia I-III*)

7:00am-8:30am **MORNING REFRESHMENTS AND POSTER SET-UP**..... (*Royal Palm VI-VIII*)

8:30am-10:00am **OPENING PLENARY SESSION** (*Royal Palm IV-V*)

10:00am-10:30am **AM BREAK**..... (*Royal Palm VI-VIII*)

10:30am-12:00pm **PLENARY SESSION**..... (*Royal Palm VI-VIII*)

12:00pm-1:15pm **BOXED LUNCH**

1:15pm-5:15pm **CONCURRENT SESSIONS**

3:00pm-3:30pm **PM BREAK**..... (*Royal Palm VI-VIII*)

5:30pm-7:30pm **WELCOME RECEPTION** (*Sunset Deck*)

7:00pm-8:30pm **SPECIAL SESSION: U.S. Climate Change Science Program Listening Session** (*Royal Palm III*)

WEDNESDAY, DECEMBER 10, 2008

7:00am-5:30pm	CONFERENCE REGISTRATION OPEN (<i>Acacia I-III</i>)
7:00am-8:00am	MORNING REFRESHMENTS..... (<i>Royal Palm VI-VIII</i>)
7:00am-8:00pm	POSTERS ON DISPLAY..... (<i>Royal Palm VI-VIII</i>)
8:00am-10:00am	PLENARY SESSION..... (<i>Royal Palm IV-V</i>)
10:00am-10:30am	AM BREAK..... (<i>Royal Palm VI-VIII</i>)
10:30am-12:15pm	CONCURRENT SESSIONS
12:15pm-1:15pm	BOXED LUNCH
1:15pm-3:00pm	CONCURRENT SESSIONS
3:00pm-3:30pm	PM BREAK..... (<i>Royal Palm VI-VIII</i>)
5:45pm-7:45pm	POSTER RECEPTION (<i>Royal Palm VI-VIII</i>)

THURSDAY, DECEMBER 11, 2008

7:15am-12:00pm	CONFERENCE REGISTRATION OPEN (<i>Acacia I-III</i>)
7:15am-8:15am	MORNING REFRESHMENTS..... (<i>Royal Palm VI-VIII</i>)
8:15am-10:00am	CONCURRENT SESSIONS
10:00am-10:30am	AM BREAK/ POSTER STRIKE (<i>Royal Palm VI-VIII</i>)
10:30am-12:00pm	PLENARY SESSION..... (<i>Royal Palm IV-V</i>)
12:00pm	CONFERENCE CONCLUDES
12:30pm - 1:00pm	ASSEMBLE FOR EDUCATIONAL TOURS
1:00pm	OPTIONAL POST CONFERENCE EDUCATIONAL TOUR

Directory of Poster Presentations

Poster #	Presenter's Name	Organization	City	ST	Poster Title
1	Katherine Allen	UF/IFAS Suwannee County Extension	Live Oak	FL	Working Towards Energy Independence: Affecting Decisions at the Local Level
2	Jesslyn Brown	USGS Earth Resources Observation and Science	Sioux Falls	SD	Improving Decision Support for Drought Using New Geospatial Models and Online Tools
3	Jana Compton	US EPA	Corvallis	OR	Reactive Nitrogen Impacts on Ecosystem Services
4	Theodore DeWitt	US EPA	Newport	OR	Measuring the Contribution of Benthic Ecosystem Engineering Species to the Ecosystem Services of an Estuary: A Case Study of Burrowing Shrimps in Yaquina Estuary, Oregon
5	Cynnamon Dobbs	University of Florida	Gainesville	FL	Urban Forest Ecosystem Services Indicators based on Soil, Vegetation and Air Characteristics for the City of Gainesville and Tampa
6	Stephen Faulkner	USGS, National Wetlands Research Center	Lafayette	LA	Migratory Bird Stopover in Reforested Lands: a Portable Radar Study
7	Joice Ferreira	EMBRAPA Amazônia Oriental	Belém		Agroambiente Network: Ecosystem Services in Agricultural Landscapes in the Brazilian Amazon
8	Sean Finn	US Geological Survey	Boise	ID	Understanding Ecosystem Services in the High Desert: The Great Basin Integrated Landscape Monitoring Project
9	Craig Fleming	US Army Corps of Engineers	Yankton	SD	Structured Decision Making Rapid Prototyping Application to Biological Opinion Activities on the Missouri River
10	Pamela Fletcher	Florida Sea Grant	Miami	FL	Integrating Climate Data and Ecosystem Forecasts within a Decision Support System
11	Richard Fulford	University of Southern Mississippi	Ocean Springs	MS	Identifying Critical Habitat across Multiple Scales for Estuarine-dependent Fishes with a Landscape Modeling Approach
12	John Gunn	Manomet Center for Conservation Sciences	Brunswick	ME	A Scorecard for Evaluating the Quality of Forest Carbon Offset Projects
13	Brent M Haglund	Sand County Foundation	Madison	WI	Launching a Private Landowner Conservation Initiative: Water As A Crop
14	Simeon Hahn	NOAA	Philadelphia	PA	Regional Restoration Planning Case Study in the Delaware Estuary: Ecosystem Valuation Along an Urban Waterfront
15	Jim Henderson	US Army Corps of Engineers	Vicksburg	MS	Ecosystem Services and NEPA for the Corps of Engineers
16	Melissa Jenks	The Nature Conservancy	Little Rock	AR	A GIS Analysis of Ecosystem Services in the Cache River Watershed, Arkansas
17	Russell Jones	Stratus Consulting Inc.	Boulder	CO	Modeling Potential Impacts of Climate Change on Freshwater Fishing Habitat in the United States
18	Medina Kadiri	University Of Benin	Benin City		Spatio-temporal Dynamics of Phytoplankton of a Tidal Coastal Creek, Lagos, Nigeria
19	Paul Krause	ARCADIS	Los Angeles	CA	Habitat Equivalency Analysis (HEA) as a Tool to Rank Environmental Project Alternatives

Poster #	Presenter's Name	Organization	City	ST	Poster Title
20	Alicia Lawrence	University of Florida	Gainesville	FL	Analysis of Biomass Equations for Common Urban Trees in Gainesville, FL
21	Kristie Maczko	Sustainable Rangelands Roundtable	Fort Collins	CO	A Conceptual Framework & Monitoring System for Rangeland Ecosystem Goods, Services & Processes
22	John Marshall	Arthur R. Marshall Foundation & FL Enviro Inst Inc	West Palm Beach	FL	Value of Ecological Services Provided by Restoring Gravity-Driven Flow to the Everglades
23	Austin Moore	Mississippi State University	Mississippi State	MS	A Tool for Optimizing Site Designs to Mimic Pre-Developed Ecosystem Services
24	Jessica Moy	Michigan State University	East Lansing	MI	Identifying and Analyzing Rural Residential Development
25	James Murray	US Geological Survey	Reston	VA	The Non-Native Red Rimmed Melania (<i>Melanoides tuberculatus</i>) in Biscayne Bay National Park, Florida, and the Potential for the Future.
26	Robert Northrop	University of Florida/ IFAS	Seffner	FL	Sustainable Forest Management In the Face of Rapid Urbanization
27	Jon Perry	Sarasota County	Sarasota	FL	Watershed Age of Development and Watershed Management
28	Alexander Pfaff	Duke University	Durham	NC	Location Affects Protection: Observable Characteristics Drive Park Impacts in Costa Rica
29	Corrie Pieterse	St. Johns River Water Management District	Palatka	FL	Mapping Spatial Relationships of Two Exotic Species Relative to Forest Disturbances and Climate
30	Duane Pool	The Nature Conservancy	Bismarck	ND	Climate, Land Use Land Cover and Migratory Bird Habitat Requirements
31	Dave Reed	Florida Institute of Oceanography	St. Petersburg	FL	Gulf G.A.M.E. (Geospatial Assessment of Marine Ecosystems) - Data Discovery
32	Bruce Sabol	US Army Engineer R&D Center	Vicksburg	MS	Use of Fused Hyperspectral and LIDAR Airborne Data to Map Offshore Sand Migration in Keweenaw Peninsula, Michigan
33	Kathryn Thomas	US Geological Survey	Tucson	AZ	The USA National Phenology Network: Data and Tools for Ecosystem Services
34	Benjamin Thompson	University of Florida	Gainesville	FL	Spatial Analysis of Urban Forest Biomass Distribution in Five Southeastern U.S. Cities.
35	J. Hardin Waddle	US Geological Survey	Lafayette	LA	Using Amphibian Site Occupancy as an Indicator of Conservation Benefits
36	Brian Walker	Nova Southeastern University	Dania Beach	FL	LIDAR-Derived Benthic Habitat Maps Enable the Quantification of Potential Dredging Impacts to Coral Reef Ecosystems
37	Gregg Walker	Oregon State University	Corvallis	OR	Incorporating Systems Thinking into Landscape-level Planning: Tools and Technologies

Workshop Descriptions

Monday, December 8, 2008, 9:00am-12:00pm

Evolution and Valuation of Ecosystem Services

Workshop Organizers:

Joseph Nicolette, Vice President; EcoValuation Practice Director, CH2M HILL

Karin Lilienbecker, Western Region Ecosystems Market Segment Lead, CH2M HILL

Workshop Presenters:

David Nicholas, USEPA OSWER

Joe Nicolette, Vice President; EcoValuation Practice Director, CH2M HILL

Bruce Peacock, Natural Resource Economist, DOI

Mark Rockel, Natural Resource Economist, CH2M HILL

Jon Weier, SE Ecosystems Market Segment Leader, CH2M HILL

This workshop will provide an overview and understanding of the evolving "ecosystem services" field and provide an assessment of how ecosystem services are quantified and can be applied in evaluating actions that affect the environment. These actions will include the integration of ecosystem services into resource management decisions affecting environmental sustainability, conservation, land management and development, site remediation and natural resource damage assessments. The workshop will provide discussion of the recent development of policies, strategies and solutions that utilize ecosystem services (e.g., broadly described as net environmental benefit analyses [NEBA]) in managing both short- and long-term environmental issues. The workshop panel will address the technical, legal, and historical basis for the application of ecosystem services to a wide variety of environmental issues. The panel will present recent case studies that utilize ecosystem service valuation in various contexts.

Agenda Topics:

1. Origin and Evolution of Ecosystem Services
2. Environmental Economic Methods for Ecosystem Service Valuation and Quantification
3. Understanding Net Environmental Benefit Analysis (NEBA): Application as it applies environmental sustainability, conservation, land management and development, site remediation and natural resource damage assessments:

Case Studies:

1. Application of Methods: Demonstrating the Net Benefit of Site Cleanup: *An Evaluation of Ecological and Economic Metrics at Two Superfund Sites*
2. NEBA Case Study

Discussion:

With a significant part of regulatory decision-making focused on the protection of human health, regulatory agencies have recently re-emphasized their mandate to protect the environment while providing sustainable solutions with increased attention to the ecological benefits of their policies and actions. This renewed effort recognizes that these agencies face a growing demand for more rigorous and comprehensive accounting of the ecosystem impacts. Therefore, an understanding of ecosystem services, how they are quantified, and how quantified ecosystem services can be applied in decision-making is paramount.

Monday, December 8, 2008, 9:00am-12:00pm

Florida's Cooperative Conservation Blueprint: A Scientifically Based Statewide Ecosystem Services Program for Private Lands

Workshop Organizers:

Stan Bronson, Executive Director, Florida Earth Foundation

Workshop Presenters:

Tatiana Borisova, Economist, University of Florida IFAS

Thomas Eason, Florida Fish and Wildlife Conservation Commission

Tom Hootor, University of Florida GeoPlan Center

John Oetting, Florida Natural Areas Inventory, Florida State University

Laila Racevskis, Economist, University of Florida IFAS

The goal of this workshop is to provide an overview and understanding of the Florida Fish and Wildlife Commission's Critical Lands and Waters Identification Project and the Cooperative Conservation Blueprint Project. An educational workshop showing how Florida's Fish and Wildlife Conservation Commission, in conjunction with the Century Commission for a Sustainable Florida, has developed a public-private partnership to develop and incentivize private land owners to engage in ecosystem services projects. CCB is based on the Critical Lands and Water Identification Project (CLIP), which is a scientific analysis of the entire state's areas of ecological significance conducted by the GeoPlan Center at the University of Florida and Florida Natural Areas Inventory at Florida State University. The workshop will show how that scientific data can be incorporated into a practical plan for ecosystem services utilization on a comprehensive scale.

Agenda Topics:

1. Description of the Critical Lands and Water Inventory Project
2. Discussion of Ecosystem Services Efforts and Economics
3. Discussion of the Cooperative Conservation Blueprint Project
4. Update on Findings in CCB Process
5. Panel and Audience discussion

Discussion:

Florida has significant conservation issues that have resulted in the most aggressive public land purchase program of any state. The Florida Forever Act allocated \$3B over a ten year period from 2000 until 2010. In 2008, the Florida Legislature renewed its commitment to land preservation by another \$3B commitment for the next ten years. However, it has become quite evident that the increased value of land over the last several years limits the amount of acreage that can be acquired. Incentives can play a significant role in leveraging the private sector in making the decision to be engaged in conservation activities and projects. As a pre-cursor to that effort it is essential to find those lands that are critical to water recharge and storage, wildlife habitat, carbon sequestration and other conservation concerns.

Monday, December 8, 2008, 1:00pm-4:00pm

Drivers of Integrated Agricultural Systems

Workshop Organizers:

Gretchen F. Sassenrath, Research Plant Physiologist, USDA-ARS Application and Production Technology Research Unit

Dwight S. Fisher, Rangeland Scientist, USDA-ARS J. Phillip Campbell, Sr. Natural Resource Conservation Center

Workshop Presenters:

David W. Archer, Research Agricultural Scientist, USDA-ARS Northern Great Plains Research Laboratory

Dinku M. Endale, Agricultural Engineer, USDA-ARS J. Phillip Campbell, Sr. Natural Resource Conservation Center

Dwight S. Fisher, Rangeland Scientist, USDA-ARS J. Phillip Campbell, Sr. Natural Resource Conservation Center

John M. Halloran, Agricultural Economist, USDA-ARS New England Plant, Soil and Water Research Laboratory

Jon D. Hanson, Supervisory Rangeland Scientist, USDA-ARS Northern Great Plains Research Laboratory

John R. Hendrickson, Research Rangeland Management Specialist, USDA-ARS Northern Great Plains Research Laboratory

D. Wayne Reeves, Supervisory Research Agronomist, USDA-ARS J. Phillip Campbell, Sr. Natural Resource Conservation Center

Gretchen F. Sassenrath, Research Plant Physiologist, USDA-ARS Application and Production Technology Research Unit

Harry H. Schomberg, Ecologist, USDA-ARS J. Phillip Campbell, Sr. Natural Resource Conservation Center

In this workshop, we will present an examination of drivers of agricultural production systems and their role in shaping production systems. A detailed examination of agricultural systems from two regions, the Southeast and Northeast, will be used as examples of how drivers interact to develop production systems, and how this information can be used to address future challenges of economic and environmental sustainability. By understanding the forces internal and external to production agriculture, we can expand our definition of agriculture and enhance ecosystem services that agriculture can provide beyond traditional production. Critical issues that must be addressed by producers, researchers, and policy makers will be explored.

Agenda Topics:

1. Introduction to Drivers of Agricultural Systems
2. Promoting Agricultural System Sustainability in the Southeastern Piedmont
3. Towards an Understanding of the Interactions Between Drivers of Agricultural Production and their Potential to Direct the Development of Sustainable Systems
4. Critical Issues Impacting the Future Sustainability of Agricultural Systems

Discussion:

Agricultural systems develop in response to internal and external influences that shape the production system. The Integrated Agricultural Systems Workgroup brings together scientists and producers to share ideas, concepts, and philosophies of agricultural production systems. The goal of the group is to organize common principles, criteria, and indicators that exist across physiographic regions of the US to provide insight into the management of agricultural systems. The IAS Workgroup has examined agricultural drivers and compiled them into four groups: social/political, economic, environmental and technological. Through an examination of production systems, their drivers and the unique characteristics of the systems, we gain insights into the basis for producers' decision making and the underlying principles of production. By identifying the responsiveness of current production systems to forces that are shaping agricultural production, we can determine successful strategies that can be used to address future challenges to agriculture. In exploring the development of sustainable agricultural systems, it is important to recognize the drivers impacting the system, and how these forces can be used to shape sustainable production systems. This information can be used by producers, scientists and policy makers to direct agricultural production, research and policy towards sustainability.

Monday, December 8, 2008, 1:00pm-4:00pm

***Providing Multiple Resource Benefits and Economic Opportunities
through Biomass Utilization***

Workshop Organizers:

Edmund Gee, National Woody Biomass Utilization Team Leader & National Partnership Coordinator, Forest Management, USDA Forest Service, Forest and Rangelands

Marcia Patton-Mallory, Biomass & Bioenergy Coordinator, USDA Forest Service

Workshop Presenters:

Diana Jerkins, CSREES, USDA

Marcia Patton-Mallory, Biomass & Bioenergy Coordinator, USDA Forest Service

John Stewart, DOI - National Fire Plan

The woody biomass utilization pre-conference workshop will be sponsored by the interagency woody biomass utilization group (WBUG). The WBUG membership is made up from six main Departments involving Interior, Energy, Agriculture, Defense, Commerce, and Environmental Protection Agency. These federal partners will focus on “National Policies and Legislation for Woody Biomass Utilization” with a brief overview of the policies affecting woody biomass. There will be a presentation on “Why Woody Biomass” is important to the health of our forest ecosystems, livelihood of rural communities, and effects on climate change. “Managing on a Landscape Level for Woody Biomass” will be of special interest to those practitioners who manage large parcels of land. An emphasis will be placed on “Managing Woody Biomass” as a resource rather than a waste material. Lastly, there will be a presentation to look at “Funding Opportunities for Woody Biomass Projects and Development.”

Agenda Topics:

1. National Policies and Legislation for Woody Biomass Utilization
2. Why Woody Biomass?
3. Managing on a Landscape Level for Woody Biomass
4. Funding Opportunities for Woody Biomass Projects and Development

Discussion:

Exciting opportunities are arising at an astonishing rate to meet domestic energy needs and environmental opportunities through woody biomass combined heat and power (CHP) and thermal applications. Several indicators are showing that the global supply of known fossil fuel reserves are on the decline and the rapid and volatile increase in the price per barrel of oil has opened the door for woody biomass to be one of the most competitive CHP and thermal applications in our country. Woody biomass utilization can also address several environmental and social concerns and benefits; such as, mitigating climate change by offsetting fossil fuel use since biomass is considered green house gas neutral, hazard fuels reduction, improvement of wildlife habitat, mitigate for insect and disease outbreaks, watershed restoration and job creation and diversification for state, county and tribal communities. This workshop will provide an overview of biomass resource applications, biomass technology pathways, steps to biomass project development, environmental, social political and economic benefits, and market opportunities.

Monday, December 8, 2008, 9:00am-4:00pm

Land Use Codes and Ecological Services: Actively Engaging the Opportunities and Constraints of Restoring Ecological Function through Responsible Site Design

Workshop Organizers:

Jason B. Walker, Mississippi State University Landscape Architecture Facility

Timothy Schauwecker, Mississippi Agriculture & Forestry Experiment Station, Landscape Architecture Facility

Workshop Presenters:

Charles Taze Fulford III, Department of Landscape Architecture, MSU

Austin Moore, MLA Candidate, Department of Landscape Architecture, MSU

Timothy Schauwecker, Mississippi Agriculture & Forestry Experiment Station, MSU

Michael Seymour, Department of Landscape Architecture, MSU

Jason B. Walker, Department of Landscape Architecture, MSU

The primary goal of the workshop is to create a dynamic learning experience that examines the role of ecological services in the built environment. The workshop will focus on integrating ecologically sound water management approaches into site design. After the workshop, attendees will be familiar with the following concepts and technical issues:

- Knowledge of the stormwater treatment chain
- Knowledge of the impact of land use codes on ecological services
- Application of simple stormwater calculations for ecological site design
- Application of a design process in mitigating the effects of stormwater on-site
- Knowledge of the relationship between land use codes and design for ecological services

Agenda Topics:

1. Stormwater Treatment Chain
2. Land use codes
3. Ecological site design
4. Site Design Retrofit

Discussion:

Funded research through the partnership between the Northern Gulf Institute (NGI) and the National Oceanographic and Atmospheric Administration (NOAA) investigating the relationship between land use ordinances and Non Governmental Organizations (NGOs) influence on water quality provides the underpinning for this proposed workshop. With the implications of a changing climate and a growing population, the landscape and its ecological and social processes require analysis and understanding in order to promote and ensure their stability and resilience. Because the human population is increasing and because trends show much of this increase occurring in coastal areas, it is important to understand the affects of growth on water quality. The division of political boundaries range from federal, state, county down to municipal governances, and thus requires a holistic approach for understanding watershed regulations and codes. Community resiliency can only occur through wise management and public responsibility in regards to regional watersheds and water quality. Enacting a code or ordinance and its subsequent enforcement is important, but may be difficult to due to budget, equipment, and well-trained personnel and may not adequately address ecological services. The workshop will significantly benefit the communities where workshop attendees provide civil, professional, or volunteer services by increasing their understanding of integrating ecological services with site design. In addition, the workshop will benefit the attendees by enhancing their awareness of the influence and impact regulatory codes, ordinances and NGO efforts have on watersheds by improving their understanding of the relationship between regulatory action and water quality.

Monday, December 8, 2008, 9:00am-4:00pm

Building the Ecosystem Services Approach: New Directions, Case Studies and Tools in Use within DoD and Partnering Organizations

Workshop Organizers:

James Spatarella, Associate, Booz Allen Hamilton

Greg Evans, Senior Associate, Booz Allen Hamilton

Workshop Presenters:

Kelly Burks-Copes, Ecologist, US Army Engineer Research and Development Center

Greg Evans, Senior Associate, Booz Allen Hamilton

Leslie Gillespie-Marthaler, Assistant for Sustainability, Office of the Secretary of the Army

Marc V. Hewett, PE, Lt Col, USAF, NIM Program Lead, Office of the Secretary of Defense

Rick Linthurst, National Program Director for Ecology, US EPA ORD

Carl Lucero, National Leader for Clean Water, USDA/NRCS

Belinda Morris, Senior Economist, The Nature Conservancy

Jon Parsons, Executive Director, Sustainable Sandhills

Richard Pinkham, Associate, Booz Allen Hamilton

James Spatarella, Associate, Booz Allen Hamilton

The purpose of the workshop is to bring together policy makers, government natural resource managers, and scientific specialists to summarize and discuss approaches that have been evolving over the last few years in DoD and with partnering organizations such as USDA and EPA, specific to the assessment, characterization and overall management of air, land and water resources. This workshop will highlight new policy and research directions in natural resource and ecosystem service management; provide examples of regional collaborative planning approaches to ecosystem services via case studies; and will highlight tools used to characterize and quantify ecosystem services to better inform decision-making. The workshop will also underscore the importance of managing natural resources as assets (the basic approach underpinning DoD's natural resource management programs); integration of ecosystem services and sustainability concepts; and market based approaches

Agenda Topics:

1. Ecosystem Services Concepts, Strategies, and Questions
2. Overview of DoD's Natural Infrastructure Management (NIM) Program
3. Natural Resource Management in the Army: Ecosystem Services and Sustainability
4. EPA's Ecosystem Services Research Approach
5. Enhancing Market Based Approaches to Ecosystem Services: USDA Leadership for Federal Guidelines and Methods
6. Federal Guidelines and Methods
7. Case Studies and Tools - Introduction and Overview of Subjects
8. Understanding Key Conditions for Success: The Nature Conservancy's Approach to Ecosystem Services
9. New Tools for Incorporating Ecosystem Services into Traditional Ecosystem Restoration Evaluations, with a Case Study of the US Army Corps of Engineers Middle Rio Grande Bosque Riparian Ecosystem Restoration Study
10. Tools and Lessons for Community Engagement in Ecosystem Protection: Land Suitability Mapping and Growth Management in the Sandhills of North Carolina
11. Roundtable – Facilitated discussion between speakers and audience on directions for further development of ecosystem service-driven policies, strategies, tools, data, and partnerships

ACES: A Conference on Ecosystem Services

Discussion:

Presenters will discuss new policy and program frameworks that are emerging and will highlight tools and processes that are evolving in their agencies. This will include the natural infrastructure asset management initiative at DoD, ecosystem services science and tools at EPA, and market based approaches at USDA. Collaborations between these agencies will be highlighted. Case studies will be presented that illustrate regionally based collaborative efforts between Federal, State, NGO, and local actors to identify, protect, and restore ecosystem services; and will illustrate a variety of supporting tools and processes, including several types of geospatial analysis. The concluding roundtable discussion will provide a forum to exchange ideas on major challenges to the ecosystem services approach to natural resource management; ways that the policies, strategies, and tools described in the presentations can be improved; and additional ideas for implementation of an ecosystem services approach.

Conference Abstracts

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

Working Towards Energy Independence: Affecting Decisions at the Local Level

Katherine Allen¹ and **W. Randy Hatch²**

¹UF/IFAS Suwannee County Extension, Live Oak, FL, USA

²Suwannee County Board of County Commissioners, Live Oak, FL, USA

1) Purpose: To partner county government officials with Extension to gain firsthand knowledge of ethanol production and the challenges facing the US.

2) Scope: A group of 13 Floridians (Five county commissioners and eight faculty from the University of Florida) visited Brazil for five days.

3) Method: Each commissioner from around the state was paired with a County Extension Faculty member interested in biofuels. Extension covered all trip expenses. The group visited many facets of ethanol production: Universities; a sugarcane association; a research institution; a conglomerate getting into the business; sugarcane/ethanol processing mills; a growers' cooperative and a mill equipment manufacturing plant. The group asked questions about infrastructure, policies, research, actual processes, worker issues, etc.

4) Results: Because Brazil is investing in its own economy for energy independence, its economy is booming. Participants were educated firsthand about techniques like mechanical harvesting and biological pest control, which are being utilized to reduce the water consumption and pesticide usage. They visited mills which are creating bioelectricity to power the plants and sell the excess back to the grid. They learned that flex-fuel vehicles have become standard. The group was taught about the three grades of ethanol, one of which is used in cognac production. These attendees might not have otherwise had the resources, contacts or interest to schedule such an intensive agenda.

5) Conclusions: Brazil was an early adopter of ethanol production and adoption due to the military dictatorship mandating ethanol usage. Government subsidies contributed to the success of ethanol production. If the US is looking seriously at energy independence, we need to look at alternative crops, the application of cellulosic technology, and the mistakes and successes of Brazil.

6) Recommendations: Local government mandates need to be enacted for ethanol through purchasing flex-fuel vehicles; adjusting particulate levels for burning biomass; reconsider lifting export/import tariffs on ethanol with Brazil, etc. The partnership with key decision makers in county government and Extension was successful, but needs to continue. Local governments are the answer for implementation of changes that will give us energy independence. In addition, continued research into biofuels and alternative crops is needed.

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The Landscape Framework for the Spatial Characterization and Mapping of Ecosystem Services: What is the State of the Science?

Paula E. Allen, Ricardo C. Lopez, Maliha M. Nash, Jay R. Christensen, Nita G. Tallent-Halsell, Larry Butler, Ann M. Pitchford and Anne C. Neale

U. S. Environmental Protection Agency, ORD/ESD/LEB, Las Vegas, NV, USA

Ecosystem services (ESS) represent an ecosystems capacity for satisfying essential human needs, directly or indirectly, above that required to maintain ecosystem integrity (structure, function and processes). The spatial characterization and mapping of ESS is an essential first step in establishing existing conditions to characterize, assess, value and communicate the impact of decisions that affect the flow of ESS benefits to society. The US Environmental Protection Agency is charged with developing a National Atlas of Ecosystem Services by the year 2012. We conducted an intensive literature survey related to characterizing and mapping ecosystem functions, processes, and services. We reviewed approximately 250 journal articles dated from 1990 to 2008. The number of articles on ecosystem services and related functions and processes has increased exponentially since 1990. We summarized the current state of the science regarding issues of scale, mapping and modeling tools, and statistical aids. Less than 3% were explicitly related to "mapping ecosystem services". The largest number of reviewed articles were published in *Ecological Economics* (22) followed by *Ecological Applications* (20). When journals are grouped into major categories, those published in ecological journals (40%) outpaced those published in economic journals (11%); however, the distribution of publications across journals was surprisingly heterogeneous. Research was conducted on individual or multiple ecosystems; forest was the ecosystem most studied followed by urban, wetland, and agricultural systems. The dominant focal area of research has been North America, primarily the United States, followed by Europe, Asia, and Global studies but the focal area was highly dependent on the service. Research extent ranged from that of individual households to the world with data of highly variable resolutions. Data resolutions ranged from 0.1 m (bathymetric mapping with sonar) to grids of 5 degrees of latitude by 3.7 degrees of longitude (used as global nitrogen cycling model inputs). Remote sensing (RS) data and derived products often dictated the resolution of the study outcome; and constraints of scale were apparent when dealing with different data types (e.g., geopolitical versus biophysical units). Approaches to characterizing and mapping ESS included landscape change detection; suitability analyses or classification; risk or vulnerability assessments; future scenarios; neutral models; index development; and mass balance. RS and GIS were the primary tools used to present ESS results. The statistical tools applied were generally driven by the approach taken and the focal ESS. For example, clustering tools are most often used for remote sensing data classification, whereas geostatistical techniques are used in biodiversity studies due to the nature of available datasets consisting of point data. The state of the science is rapidly evolving; challenges remain in integrating scales particularly between biophysical and economic data. Increased availability of land use and land cover data will likely drive research toward approaches utilizing landscape change detection techniques and modeling to quantify uncertainties related to the integration of data at multiple scales.

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Influence Diagram and Adaptive Management Methods to Guide Management of Oyster Reefs with Consideration of Ecosystem Services

Richard M. Anderson¹, Jonathan H. Grabowski², Charles H. Peterson³, Hunter S. Lenihan⁴ and Sean Powers⁵

¹Division of Environmental Science and Policy, Nicholas School of the Environment, Duke University, Durham, NC, USA

²Gulf of Maine Research Institute, Portland, ME, USA

³Institute of Marine Sciences, University of North Carolina at Chapel Hill, Morehead City, NC, USA

⁴Bren School of Environmental Science and Management, University of California, Santa Barbara CA, USA

⁵Department of Marine Sciences, University of South Alabama and Dauphin Island Sea Lab, Dauphin Island, AL, USA

Restoration of oysters and the reefs they create would be more effective if the question "What defines success?" were first addressed. Addressing this question involves an assessment of societal values in making tradeoffs between oyster fishery benefits and other ecosystem services provided by ecological functions because traditional fishery practice involves destruction of the habitat upon which oyster populations depend. These judgments have not to-date been explicitly quantified for North Carolina, USA. In addition, little attention has been given to the uncertainty implied by different hypotheses about how flows of some services depend on oyster reef ecosystem functioning. We describe a decision analytic framework in which an influence diagram is used to represent preferences and scientific uncertainties in linking management decisions about oyster harvest to oyster reef ecosystem function and ultimately to a suite of valued ecosystem services. The preferences included within the model represent possible tradeoff judgments and are elicited from North Carolina natural resource managers. The scientific relationships represented in the model are based on oyster reef field experiments conducted in the lower Neuse River estuary, North Carolina USA that have been applied to subtidal habitat throughout the North Carolina oyster fishery. These experimental results have been extended by relationships expressing hypotheses about how reef function produces (1) water filtration benefits and (2) enhanced productivity of finfish and large crustaceans. Quantification of these ecosystem services is combined with a representation of annual fishery income from subtidal oyster habitat to demonstrate how different definitions of success drive alternative management actions under predictive uncertainty about outcomes. Finally, we outline how these model relationships can be updated by an adaptive management framework that would involve monitoring to gather data that could be used to refine estimates of predictive uncertainty.

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An Analysis of the Urbanizing Forests of the Tampa Bay Watershed along the Urban to Rural Continuum

Michael Andreu¹, Robert Northrop², Melissa Friedman¹, Francisco J Escobedo³ and Wayne Zipperer⁴

¹Gulf Coast Research and Education Center, University of Florida, Plant City, FL, USA

²Hillsborough County Extension Service, Seffner, FL, USA

³School of Forest Resources and Conservation, University of Florida, Gainesville, FL, USA

⁴USDA Forest Service, Southern Center for Urban and Interface Forestry, Gainesville, FL, USA

The forests of Florida are rapidly changing in part due to an increase in population and expansion of urban areas into rural forests and farmland. While this trend is not new in Florida the rate of expansion has increased and some argue we are approaching an ecological “tipping point” from which these forests will no longer provide the ecosystem services society desires. To address this point it is necessary to quantify the forest composition, structure and function in across the landscape along the urban to rural continuum.

To address this issue of the effect of urbanization on the function we utilized the Urban Forest Effects Model (UFORE) methodology to sample the forests within the city of Tampa, FL which is a highly urbanized city. The UFORE model is a relatively new tool used to quantitatively assess urban forest function in ecological and economic terms. To quantify our understanding of urban to rural continuum sampled beyond the municipal boundaries to include the surrounding watersheds. We established over 500 permanent plots in a systematic random sample to establish both a baseline for long-term study as well as to begin to compare and contrast the urban forest to the urbanizing forest along this continuum of development. This study is a modification of the traditional chronosequence by reflecting change over time as a function of urbanization.

Using the data from the permanent plots we are able to describe forest species composition, size class distributions, canopy cover and other commonly calculated metrics regarding the forests within the city limits of Tampa and in the immediately surrounding watershed. In addition to these values the UFORE model calculates values for some of the environmental services provided by the forests including: carbon sequestration, energy conservation for residential homes, pollution reduction, and estimates of replacement value.

While there are many other services provided by the forests of the Tampa Bay Watershed than those we have quantified, this study provides a starting point for future studies on other environmental services including, water quality and quantity. Already the existence of this robust data set in a rapidly urbanizing area has generated interest from researchers and managers interested in a range of basic and applied scientific investigations ranging from habitat assessment to potential biomass accumulation following hurricanes. Establishing these long term studies will also assist with the development of models that can incorporate both land use change with the associated functions of the forests in a range of structural conditions.

While we intend to re-measure these plots in five years and develop and refine the models we use to analyze the data sets, the immediate insights gleaned from this study will be used to better understand some of values the forests of the Tampa Bay Watershed provide and to develop forest management strategies and policies for a rapidly urbanizing region.

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Spatial Allocation of Wilderness Recreation Value

Kenneth A. Baerenklau¹, A. González-Cabán², C. Paez¹ and E. Chavez¹

¹Department of Environmental Sciences, University of California, Riverside, CA, USA

²USDA Pacific Southwest Forest and Range Experiment Station, Riverside, CA, USA

Non-market valuation methods and geographic information systems (GIS) are potentially very useful analytical tools for public resource managers. For many years, non-market valuation methods such as travel cost analysis, hedonic pricing, and contingent valuation have been used in a variety of contexts to help inform natural resource management decisions. Notable applications include the Glen Canyon Dam, Hell's Canyon, Mono Lake, and the spotted owl. The development and proliferation of GIS software has enabled public land managers to characterize and monitor landscape features more accurately and precisely and to develop more detailed land management plans. An example is the USDA Stewardship and Firehed Assessment (SFA) process which utilizes GIS-based fire modeling software to generate estimates of the costs of fire prevention and mitigation efforts and the effects of those efforts on fire behavior.

More recently researchers have begun combining these tools to derive spatially explicit representations of landscape values. This is a promising innovation because valuation methods traditionally have limited spatial elements. For example, the travel cost method might be used to determine the value of access to a backcountry trailhead. Explanatory variables in the travel demand regression might include features of the trail and the landscape, but traditionally there is no attempt to allocate the access value to the landscape in a meaningful and informative way. That is to say, a recreation trip is valuable presumably because the user experiences an appealing landscape; but a traditional analysis does not attempt to ascertain the specific values of each piece of the landscape. Spatially allocating the recreation value of a wilderness to the landscape is an essential part of any GIS-based benefit-cost analysis, and a desirable part of overall planning and management efforts, but researchers have only begun to investigate methodologies for doing so.

The purpose of this research is to present an objective method for spatially allocating wilderness recreation value that is based on readily available data, and to demonstrate the method for a Southern California wilderness area. We combine values derived from a standard travel cost analysis of hiking activity with spatial information about backcountry routes, destinations, and scenic "viewsheds" to allocate trailhead access value to the landscape. We obtain annual per-hectare values for visible parcels ranging from \$41 to \$10,369 throughout the wilderness with a mean of \$378/ha-yr and a median of \$173/ha-yr. Ninety percent of these values are less than \$750/ha-yr. The skewness of the distribution is due to a relatively small number of high-value parcels that are concentrated in areas with the highest elevations (and thus visibility) and levels of use. Some areas of the wilderness are not visible from any trail segments and thus are allocated no recreation value.

Our method appears to work well and generates reasonable estimates for the annualized recreation value of different parts of the landscape. Future work will aim to verify and calibrate the methodology with additional primary data collection, and to compare results with other locations. We also will incorporate these and other land values into a spatial-dynamic cost-benefit analysis of fire prevention and mitigation efforts in the study area to help foster better tools for wilderness management decision-making.

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Contextualizing Ecosystem Services in the Present and Future Urban Environment: A Chittenden County, Vermont Case Study

Ken Bagstad, *Austin Troy* and *Brian Voigt*

University of Vermont RSENr, Aiken Center, Burlington, VT, USA

In recent years, land use and transportation modeling have become standard tools for urban and regional planning. Despite the importance of ecosystem services in providing well-being across urbanizing landscapes, urban growth models have not yet evaluated ecosystem services. Urban growth models offer the opportunity to compare ecosystem service provision for alternative future scenarios. Yet for these grid-based models, appropriate mapping units must be defined for each ecosystem service. These mapping units must use appropriate geographic scales for the specific benefits each ecosystem service provides to different groups of human beneficiaries. They must also incorporate relevant ecological and socioeconomic data that provide context about the level of provision and use of different services. In this study, we examine future scenarios of ecosystem service provision in Chittenden County, Vermont, based on the results of an UrbanSim growth model. We analyze how provision of several ecosystem services differs under alternative growth scenarios. By mapping ecosystem services using mapping units appropriate to each service along with contextually relevant spatial data, we more accurately represent the value of ecosystem services across the landscape. A transparent, rule-based system incorporating spatial data, as used for this project, can assist in mapping ecosystem services across complex, urbanizing landscapes.

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Ecosystem Services in the Context of NRDAR – An Oil Spill Case Study

Greg Baker¹ and **Natalie Cosentino-Manning²**

¹NOAA Assessment and Restoration Division, Menlo Park, California, USA

²NOAA Restoration Center, Santa Rosa, California, USA

This presentation is part of a two part session that focuses on the evolving understanding of ecosystem services (ecological and human use) in the context of the natural resource damage assessment and restoration (NRDAR) process, particularly the use of ecosystem service metrics to evaluate actions that affect the environment. Science and economic-based methods to quantify ecosystem services have been used extensively in evaluating injury to natural resources and in quantifying the benefits associated with site restoration as part of NRDAR cases.

This case study will provide a recent concrete, real-world example, the 2007 *M/V Cosco Busan* oil spill in San Francisco Bay, building on the scientific/economic/legal framework discussed in the first NRDAR session. The presentation will identify the types of resources and service losses being assessed in this case, and then focus on one specific habitat, eelgrass, and present study designs and methodologies used to determine baseline ecological services and measure/compare specific ecological attributes across different eelgrass beds over time. Finally, the presentation will describe how this information may be employed to scale service losses in relation to the benefits of potential restoration actions.

This case study will illustrate how ecosystem services concerns are being addressed in the context of a west coast oil spill that affected numerous trust natural resources. The six-person panel will then discuss how ecosystem services apply to the NRDAR process and how the methods have evolved in meeting NRDAR compensation requirements.

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Natalie Cosentino-Manning, NOAA Restoration Center, Santa Rosa, California, USA, Phone: 707-575-6081, Email: natalie.c-manning@noaa.gov

An Integrated Assessment Framework of Crop Production and its Pollution

Richard Bernknopf¹, Will Forney¹, Tamara Wilson¹ and Molly Macauley²

¹Western Geographic Science Center, USGS, Menlo Park, CA, USA

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A study is underway to assess policy and economic considerations of corn production, its biophysical characteristics and associated impacts on ecosystem services. Socioeconomic drivers in our economy such as the price of oil, demands for alternative fuel sources, and rules and guidelines to reduce the impact of climate change (USDOL, USDA, and USEPA; e. g., Federal Register, August 6, 2008), have led to recent increases in corn production. To track the growing extent of the crop, mid-resolution satellite imagery (MRSI) can be applied to monitor temporal changes of the crop's geographic distribution. This study seeks to link a model of crop production with models of natural resource damages to derive estimates of yield and pollution (e.g. greenhouse gases, sedimentation, groundwater pollution), or joint output, at a particular location. The linkage of production and pollution models creates an integrated assessment framework that is applied at regional scale in the Midwest, US. Depending on the heterogeneity of the landscape, the joint output of yield and pollution is derived from intrinsic differences in land quality (e.g. soil characteristics, geomorphology, temperature, climatic regime) and external inputs (e.g. irrigation, nutrient application, pest management). Within the framework, the joint output can be compared to various ecosystem goods and services such as carbon sequestration, soil resources, and water quality.

In addition to joint output, market price and risk preferences influence a farmer's or producer's decision criteria in allocating their lands, or portfolio, to various uses. Their decisions may incorporate government policies and regulations such as price subsidies, energy policies, and cost-sharing programs focused on sensitive land protection. Given that these policies and regulations often overlap and conflict, MRSI provides consistent, site-specific information that can be 1) included in production function models for corn, 2) included in physical models of pollutant loading, 3) compared to USDA and NRCS programs and 4) incorporated into regionally-aggregated, broad-scale assessments of overlaps and conflicts. For example, the National Agricultural Statistics Service (NASS) has classified MRSI, specifically Landsat (30 meters) and AWiFS (56 meters), for particular crop types throughout the Midwest. With a dataset of NASS products back to 1999, a Bayesian approach can incorporate new information over time to improve model estimates with prior knowledge. Furthermore, the pattern of the joint output, or an alternate portfolio to land allocation, creates a quantitative framework of publicly-provided information to screen locations and offer an expected return on investment from the producer's decisions.

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The Northeast Megaregion - Growth and Sustainability Challenges: A Planners Viewpoint

Eugenie Birch

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The Northeast Megaregion with 50 million people is expected to add 18 million new residents by the year 2050. Will the new growth be sustainable or will it be characterized by energy dependent exurban development that further erodes the natural environment and contributes to global warming?

The Northeast Corridor is in a great position to capitalize on this trend. Much of the region is defined by aging cities that are undergoing transformation and redefinition. This is especially true in center cities and in former industrial areas along the corridor.

Beyond the corridor, new urban cores are emerging along existing commuter rail lines in former suburban areas surrounding traditional cities. Additionally, there are lessons learned from around the world, as we examine examples from other countries.

The question then becomes, what effect do these trends have on the traditional city? The subject can be explored from an environmental perspective. What have been the traditional planning approaches to environmentally sensitive areas and how are they adapting to the new challenges posed by the expected growth in population? What challenges will planners face and how they will adopt strategies and technologies that feed growth on one hand but minimize or contain the impact on ecosystem services?

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Development of an Ecosystem Services Assessment Tool for Private Landowners

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Most of the land in the eastern US is privately owned. Therefore, the flow of ecosystem services derived from that land is influenced by the management actions and decisions of private landowners. Financial incentive systems such as credits for ecosystem services are being developed to reward private landowners for managing land to maintain or increase the provision of these services. Landowners must therefore be able to make informed decisions about how management activities will affect the flow of ecosystem services from their land.

The Commonwealth of Virginia Department of Forestry and Virginia Tech have begun development of web-based resources to provide forest landowners with analytical tools to quantify the impact of management actions on (initially) two ecosystem services: carbon sequestration and reduction of non-point source pollution (specifically nitrogen, phosphorous, and sediment) in streams. The tools are incorporated in MEASURES- Management-scale Ecosystem Assessment Using Remote Sensing. The tools are spatially-specific (using widely available spatial data), and are based on extant, widely-adopted models such as FASTLOB (a loblolly pine plantation growth and yield system), FVS (the USFS Forest Vegetation Simulator), and NTT (the Nutrient Trading Tool).

This presentation will discuss the need for spatially-specific, transparent, management-focused analysis tools and will review the development of the prototype for MEASURES.

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Saving the Everglades the Cowboy Way: Paying Ranchers for Providing Environmental Services

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In 2008 Florida state agencies responsible for Everglades Restoration efforts identified the need for an additional 1 million acre feet of water storage north of Lake Okeechobee to achieve ecosystem restoration goals. Among the options they identified to provide this storage capacity was an approach proposed by the Florida Ranchlands Environmental Services Project (FRESP) to pay cattle ranchers in the watershed for the provision of documented water related environmental services.

Launched in October 2005, the goal of FRESP is to design and field test a program in which agencies of the state and other willing buyers buy water retention and phosphorus load reduction services from ranchers in the Northern Everglades¹ (primarily the Lake Okeechobee watershed). Cattle ranching is the dominant land use in the heavily drained 3.4 mil acre watershed. Through water management project on ranchlands—rehydrating drained wetlands, water table management, and pumping water from public canals through existing ranch wetlands and flowing back into public canals—ranches have the capacity to store and clean water. FRESP is being implemented through a collaboration between World Wildlife Fund (WWF), 8 participating ranchers, state and federal agencies and with technical support from the MacArthur Agro-Ecology Research Center and the University of Florida. Funding for the 6 year pilot project from Federal, state and private sources exceeds \$6 mil.

Elements of a payment for environmental services program are being field tested on 7 ranches where water management project have been designed, permitted and implemented. At these ranch sites, FRESP is evaluating different methods of monitoring and modeling of hydrology, water and soil chemistry, and vegetation change to document the level of environmental services provided by ranch water management projects. By 2011, learning from the operation of the pilot water management projects and the documentation approaches will inform the design of a payment for environmental services program to be implemented by agencies of the state of Florida.

Planning level estimates generated by the existing pilot projects suggest that ranch water management projects dispersed through the watershed could provide a third to half of the needed 1 mil acre feet of storage in the Northern Everglades. These ranches can bring services on line quickly as compared to other options and will complement public investment in regional water storage and water treatment facilities while providing other valuable services such as restoration of wetland habitat.

Lessons for other Payment-for-Environmental Services (PES) Programs include: 1) Identifying the “buyer” of the service is critical. Specifics about the environmental services the buyer wants influence the price, program design, and how the service needs to be documented. 2) Place matters. Designing a PES program must address and integrate complex and overlapping regulatory and program boundaries of state and federal agencies that are at play in the targeted landscape.

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Ecosystem Services and Green GDP: Economically Valid Accounting Measures of Natural Wealth

James Boyd

Resources for the Future, Washington, DC, USA

Systematic measurement of natural wealth requires an accounting system to consistently track public and private goods arising from nature. The talk will describe the essential elements of an economic accounting system (e.g., GDP) and translate those elements into the realm of ecosystem goods and services.

The presentation will emphasize the data requirements and models necessary to build an account of natural wealth and illustrate the construction of an account to capture the benefit of services as different as flood damage avoidance, recreation, beauty, and species preservation. The new abundance of geo-referenced data and mapping platforms present a new opportunity to build environmental accounts.

Ecosystem accounts pose unique challenges. In particular, the location of ecosystem services is crucial to their economic value. How do accounting systems deal with geography? Also, it is important for an ecosystem services account to depict future depletion of services if they can be predicted. How are future “debits” to our natural wealth integrated into an accounting system?

Economic accounts like GDP are politically independent, scientifically derived, and rule-based system to measure how our “conventional economy” is doing. Our natural wealth deserves a similar scorecard to hold our leaders accountable, detect the loss of natural wealth, and help identify successful environmental interventions.

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Mapping Ecosystem Services of the Coastal Environment

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Ecosystems, if sustainably managed and protected, benefit current and future citizens. The concept of ecosystem services, the flow of benefits from nature to people, provides one novel framework to put forward this vision. The challenge for current and future generations is to identify and understand these benefits in a way that enables a sustainable quality of life for humans. Although ecosystem services science has evolved in the past decade, little has been said on how the concept of a flow of benefits can promote sustainable development and conservation in the coastal zone.

A spatial inventory of the sources of ecosystem goods and services in the coastal zone is presented in this study. The case study illustrates the criteria and techniques used in mapping the benefits provided by the Coastal Bend area in Texas. The inventory of the natural and semi-natural ecological components and structure was developed using a geographic information system. The systematic characterization of ecosystem services followed that proposed by the Millennium Ecosystem Assessment including supportive, provisioning, regulating and cultural services. Services were assessed at the different functional domains in which they operate in the land-water interface to create a continuum coastal zone model.

This application should be considered as the first step in the analysis of benefit provisioning models, monetary and non-monetary valuations and conservation planning efforts. Results show how natural infrastructure is a vital part of the stock of facilities needed for biodiversity conservation and human well-being in the coastal zone.

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Markets for Ecosystem Services: A Water Leasing Application

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Since 1950, the demand for water has more than doubled in the United States. Virtually all water supplies are allocated, leading to the question of where will water come from? The concept of water leasing has gained considerable attention as a volunteer, market-mediated system for transferring water between competing uses. For a water leasing system to be truly effective, detailed knowledge of the available water supply and the factors that affect water demand is critical. Improving understating of the factors that determine residential, industrial, agricultural and environmental demand for water using experimental economics and then integrating into hydrological model is essential. Thus, a framework that is a coupled system of physical and economic considerations is essential for a better understanding of the potential of market-based mechanisms to allocate water resources. Our stylized model utilizes an open market trading system known as a double auction, where buyers and sellers declare their bids and offers to the market and the economic model is coupled through a decision support system to the hydrologic elements of the basin. Participants in the experiment represent the interests of specific users, including farmers, Native Americans, urban and environmental interests. Participants in the experiments are motivated by a utility function specific to each water users needs. Fourteen experiments have been run in four different climatic scenarios (decreasing, increasing, normal and dry water scenarios.) The experiment produces results on price per acre-foot, income for each player before and after trading while at the same time tracking how water moves around the system. The results have shown the market is robust, with multiple trades occurring in each trading year. Student t-tests were conducted finding that the expected market equilibrium price per acre-foot were not statistically different from the observed weighted average price per acre foot. The trading process is efficient and participants effectively take on the assigned role of their user group. In analyzing how the water moves we found that water was saved from evaporative loss as trading occurred upstream. Finally the market yields welfare gains showing positive gains from a 25% gain in earnings to a 55% gain for the aggregate economy. This indicates there is increased efficiency that can be obtained through the short term leasing of water.

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Improving Decision Support for Drought Using New Geospatial Models and Online Tools

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Drought can alter ecosystem goods and services. As a natural hazard and a natural feature of climate, drought produces complex impacts spanning multiple societal sectors. The effects of a drought episode can be considered direct or indirect. Reduced rangeland and forest productivity, increased risk of wildfire, reduced water supply, increased livestock and wildlife mortality rates, and damage to wildlife and fish habitat are a few examples of direct impacts affecting ecosystems.

Frequently collected data from earth observing systems provide synoptic measurements of land surface conditions in near-real time. These data provide proxy information about the status of ecosystem goods and services, particularly those direct effects listed above. Through a partnership, the U.S. Geological Survey Earth Resources Observation and Science Center, the National Drought Mitigation Center, the U.S. Department of Agriculture Risk Management Agency, and the High Plains Regional Climate Center are developing a drought decision support tool that integrates climate, satellite, and biophysical information at a sub-county scale. The Vegetation Drought Response Index (VegDRI) is an indicator of vegetation condition (or stress) as the canopy responds to available soil moisture, solar energy, and other potentially limiting factors. In 2008, VegDRI maps and data for 22 central and western states were provided to drought decision makers throughout the growing season. In 2009, modeling efforts will be expanded and drought effects on vegetation will be monitored and mapped across the 48 contiguous states.

Communicating the characteristics and effects of drought in human and natural systems to decision makers is challenging. For this purpose, a number of decision support activities are sponsored by the partnership. Since 2004, this team has provided online map services and related materials, held citizen panels and training workshops, and collected feedback from an established advisory panel. An evaluator network has been active in assessing both the accuracy and utility of VegDRI for drought monitoring. Valuable feedback on VegDRI from decision makers has resulted in changes in map format and content.

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Emergy and Environmental Services: A Biophysical Approach to Evaluating the Environment

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In this paper we explain an environmental accounting methodology that is based on the scientifically derived measure termed **EMERGY**. Termed **emergy accounting** the procedure relies on evaluating natural capital, environmental services and economic good and services without resorting to human preferences or utility, but instead, based on the environmental and economic work necessary to make them. The approach is holistic, evaluating economic goods and services, natural capital, and environmental services within the same framework. Thus, it is possible to include both environmental services and economic values within the same accounting framework. Results from an emergy accounting can be used in conjunction with more traditional economic analysis to provide a multifaceted approach to decision making.

To demonstrate the accounting technique we use the Millennium Ecosystem Assessment (2005) categories of service and focus on water, developing market prices based on environmental costs of: *provisioning services* (fresh water), *regulating services* (water regulation, water purification and waste treatment), *cultural services* (recreation and ecotourism), and *supporting services* (water cycling). We examine water from a biophysical perspective using emergy accounting to establish values of water from different sources (natural capital value), its contribution to various economic processes, its value as a sink for pollutants, and its value to environmental systems. Further, we develop a regional production function to test allocation of water between urban, agricultural and environmental uses. Using Florida as a case study, the model suggests that maximum total production occurs when the fresh water remaining after evapotranspiration is allocated at the rate of 25% to urban uses, 30% to agricultural, and 45% to the environmental.

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Wellbeing: Synthesis. Washington D.C.: Island Press.

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Restoring Puget Sound with an Incremental Market-Based Approach

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The Puget Sound Partnership, created by the Washington State Legislature in 2007, is currently crafting an Action Agenda to achieve recovery of the Puget Sound ecosystem by 2020 and beyond. This effort addresses the broad suite of ecosystem services and factors of ecosystem health including water quality, water quantity, biodiversity, habitat and human health. Achieving these goals focuses on protection and restoration of ecosystem services via a broad-based approach from small loans for septic retrofits and Low Impact Development to large-scale acquisition and restoration of resources from ridgetops to estuaries. The efforts must coordinate with programs for salmon recovery, growth-management, and Washington's participation in the Western Climate Initiative, an ambitious interstate effort to reduce greenhouse-gas emissions.

For some of its goals, the Partnership is innovatively promoting experiments and other efforts to spur the development of new tools: market-based mechanisms that offer methods to maintain and expand ecosystem services with greater effectiveness and lower cost than traditional regulatory approaches. Such mechanisms involve payments for goods and services with varying roles and levels of intervention by the state. These schemes can involve 1) payments to the state such as in-lieu fees, 2) payments from the state such as landowner incentives, or 3) payments brokered by the state such as water quality credit trading programs. These options have varying degrees of direct state control as the buyer, seller, broker or demand-inducing regulator. The experience of existing programs involving in-lieu fees, incentives, and trading bears mixed success in terms of level of activity and ecological improvement. Consequently, the Partnership is pursuing implementation for this strategy via a mixed approach that employs market mechanisms in an incremental and cumulative fashion.

A number of market-based mechanisms require components that can later be useful to more full-blown markets, allowing gradual implementation. Components of in-lieu fee and targeted procurement programs can be expanded for trading programs. Adaptive management facilitates assessment and potential reduction in government involvement and increased market flexibility. Rather than assuming markets simply need to be set loose to reach optimal outcomes, this approach recognizes the number of potential market failures that must be avoided at all stages.

Potential market failures can arise due to the distribution and diffusion of costs and benefits, both real and perceived, as well as high levels of risk, uncertainty, and ignorance regarding outcomes. With market failures can come unintended consequences that the Puget Sound Partnership is not willing to tolerate. Mechanisms must also account for decision-making considerations of individual rationality, morality and convention. The communities in Puget Sound see many benefits from a healthy ecosystem, and the governments are motivated to act. Under these conditions, new market-based mechanisms offer promise of substantial gains for ecosystem services.

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New Tools for Incorporating Ecosystem Services into Traditional Ecosystem Restoration Evaluations, with a Case Study of the US Army Corps of Engineers Middle Rio Grande Bosque Riparian Ecosystem Restoration Study

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Historically, the Rio Grande was a heavily braided, aggrading stream meandering freely across a wide floodplain of the arid southwest. The river renewed a mosaic of riparian communities from cottonwood riparian gallery forest and coyote willow shrublands, to wet meadows, oxbow ponds, and open water areas referred to collectively as the “Bosque.” Urban development and water management measures have resulted in disruption of the Bosque’s original hydrologic regime along the Albuquerque Reach of the Middle Rio Grande.

The goal of Middle Rio Grande Bosque Ecosystem Restoration Project was to propose, evaluate, and assess the efficacy of activities to restore the Bosque’s unique ecosystem structure, function and services, thereby restoring overall ecosystem integrity (i.e., health, biodiversity, stability, sustainability, naturalness, wildness, and beauty). The project developed and evaluated the effectiveness of proposed ecosystem restoration alternatives using state-of-the-art technology developed by the U.S. Army Engineer Research and Development Center’s Environmental Laboratory (ERDC-EL) as part of several ongoing research program initiatives. The tools and procedures included: 1) development of a community-based index model for the cottonwood riparian gallery forests using a customized Habitat Evaluation Procedures (HEP) approach; 2) development of a suite of ecosystem service indices targeting key aspects of the unique urban setting using a non-monetized index methodology in ArcGIS described first by Boyd and Wainger as Ecosystem Benefit Indicators; 3) urban growth modeling and spatial context modeling using newly developed ArcGIS 9.2 Add-ins (Patch Tool Calculator, and Nearest Neighbor); 4) development of a spatial heterogeneity (mosaic) index using ArcGIS Spatial Analyst; 5) assessment of 50+ alternatives using the newly developed Habitat Evaluation and Assessment Tools (HEAT) software’s EXHEP (EXpert Habitat Evaluation Procedures module); and 6) multi-criteria decision analysis to combine metrics.

The project injected valuable, scientifically-based tools and procedures into the strategic planning of the study’s alternative designs and served as a forum for the transparent assessment of the benefits to the system’s critical ecosystem functions and structure. It clearly demonstrated the efficacy of this approach. However, existing Corps policies and guidance do not expressly support the incorporation of “socioeconomic” features into ecosystem restoration planning and development initiatives. The presentation discusses the findings of the study in light of these institutional barriers, and compares/contrasts outcomes of using ecosystem services to justify plan formulation and selection under a more holistic Corps planning paradigm.

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Environmental Accounting of Forest Ecosystem Services and the Proposed Development of an Ecological Investment Corporation

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The Forests of the United States provide tremendous benefits to its citizens. These benefits include economic goods such as timber products, social goods (i.e. recreation), also the natural functions performed by the forest provide services such as storm flow abatement, air pollution reduction, improvement of water quality, the generation and maintenance of soils, and habitat for wildlife. The services that fit into the first two categories, economic and social, have value placed on them through the receiver perspective based market system. The third category, ecosystem services, does not. However, the value can be ascertained using the technique of environmental accounting (aka emergy synthesis).

An emergy synthesis has been performed for the USFS as a whole, its nine regions, and two case study USFS Forests. Emergy synthesis values the components of the studied system through the total amount of direct and indirect energy it has taken to make a product or service. The amount of emergy is then related to the economic system using the emdollar ratio, the ratio of emergy circulating in the economy to money circulating, over a given year. This allows comparison between the dollar and emdollar values of both economic and ecological services and capital. The value of ecosystem services from the USFS provided to the United States was found to be 129 billion emdollars for the year of 2005. This number represents the contribution that the National Forests are making to society as a whole.

The National Forests output much more emergy than is necessary to manage them (the emergy yield ratio is nearly 10 to 1). This means that the USFS is a beneficial investment for the US government to make. The final conclusion of the USFS study was that it is of the utmost importance for the National Forests to be managed in order to maximize their function of providing economic, social, and ecological services to the public. This goal is starkly evident in the mission statement of the USFS "to provide the greatest amount of good for the greatest amount of people in the long run" (Gifford Pinchot). This fundamental goal is not necessarily evident or present in the privately owned forest lands of the US. Forested lands are providing more benefits than the market currently rewards the owners for, therefore to continue to receive these benefits an equitable exchange between the consumers (the public) and the providers (forest landowners) must be established. The proposed mechanism for this is an Ecological Investment Corporation (EIC). A temporally dynamic model will be developed to construct the economic link between the consumer and landowner, using values for the ecosystem services by means of emergy synthesis. The EIC will allow more public lands to be purchased as well as provide financial incentive for the preservation of privately held land, insuring the continuation of ecological, economic, and social services in perpetuity.

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Evolution of Ecosystem Services in Law

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The use of methods, such as habitat equivalency analysis (HEA), resource equivalency analysis (REA) and human use service valuation, to quantify ecosystem services have expanded into regulation outside of NRDA applications. For example, state agency regulations associated with remedial alternative evaluation in Texas and Louisiana have recently been developed. As such, the application of these methods, which are scientifically based and litigation tested, has grown to address a wide variety of actions that affect the environment. These areas have included permitting, EIS alternative comparison, remedial alternative selection, land development design evaluation, and others. This presentation will cover ecosystem service quantification approaches and their acceptance and use in various regulatory arenas.

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Measuring the Ecosystem Service Value of National Natural Heritage Investments

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The purpose of this presentation is to present a new concept for quantitatively indicating the relative value returned from public investments in the security of future ecosystem service opportunities. A keystone ecosystem service is ecosystem maintenance of national natural heritage that provides future opportunities for maintaining and enhancing all natural services. Sustaining natural heritage is central to the goals of the National Environmental Policy Act, the Endangered Species Act (ESA) and other legislation, and is intrinsic to the concepts of sustainable development and environmental sustainability promoted by the United Nations. While the importance of natural heritage is well recognized, neither its connection to ecosystem services nor its quantitative measurement are well developed. Whereas the value of many forms of natural service demand are measurable either directly or indirectly in monetary terms, natural heritage value can be measured monetarily only by using controversial techniques unacceptable to many, including the U. S. Army Corps of Engineers. The Corps has an ecosystem restoration mission that is focused on recovery of degraded environmental quality value that cannot be acceptably measured in monetary terms. The Corps has long sought a quantitative non-monetary metric that is universally applicable to facilitate its project and program planning process.

A new metric, the Biodiversity Security Index developed at the Institute for Water Resources (USACE), seems to satisfy much of that need. The history of non-monetary measurement of ecosystem and other environmental value was reviewed for consistently used indicators of value. The results formed the basis of BSI development, which indicates the relative scarcity of ecosystem species components with respect to a desirable sustainable state of species as expressed in the goals of the ESA and other law. The primary variables in the BSI are species scarcity, species distinctiveness, and the risks associated with not realizing the desired return on investment. BSI calibration relies on species conservation and taxonomic data maintained by NatureServe and now widely used by conservation organizations and agencies. The metric appears to have widespread applicability within the Corps, and possibly elsewhere, for indicating the relative value of protection and restoration investments in sustaining the Nation's unique biological heritage. The BSI needs to be more fully vetted for conceptual integrity and tested in practical applications. For the Corps at least, the metric appears to provide a universal indicator of relative value for comparing the expected value returned from proposed ecosystem restoration projects. It may have wider applications as well.

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Reactive Nitrogen Impacts on Ecosystem Services

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The Ecosystem Services Research Program (ESRP) is a new, multi-year research initiative under development by the Environmental Protection Agency (EPA). As one of its components, ESRP has chosen to focus on reactive Nitrogen (Nr) for stressor-specific ecosystem research through a new research theme (ESRP-Nitrogen). Reactive nitrogen is a very important limiting nutrient, required for the growth and maintenance of all of earth's biological systems. For humans, there are services provided by natural and anthropogenic sources of Nr, including the production of plant and animal products (food and fiber) for human use. Yet, over the past century, human intervention in the nitrogen cycle has led to substantial increases in human and ecosystem exposure to Nr. Nitrogen is one of the leading stressors on small stream condition in the US, and increasing Nr has led to eutrophication-related harmful algal blooms, loss of dissolved oxygen, fish kills, loss of productivity, and loss of desirable habitat in sensitive coastal ecosystems. The amount of Nr applied to the nation's landscape and released to the nation's air and water has reached unprecedented levels, and projections show that Nr pollution will continue to increase for the foreseeable future. The Millennium Ecosystem Assessment underscored that handling the tradeoffs inherent in controlling this class of environmental pollutant is one of the major challenges the EPA will face in the 21st century.

Collectively, the research and regulatory community knows a great deal about the beneficial and adverse effects of Nr. One key gap in our collective ability to assess the impact of reactive nitrogen is being able to see the entire picture and adequately illustrate the tradeoffs. Some of the impacts of increasing nitrogen can benefit ecosystem services, such as food, wood and fiber production (cropland and industrial forestry), yet many native ecosystems (e.g., biodiversity of alpine grasslands and high altitude lakes) are negatively impacted by reactive nitrogen at much lower input levels. An important goal of ESRP-Nitrogen is to develop a framework to represent positive and negative impacts of nitrogen on important ecosystem services, across an N loading gradient. Developing a defensible ecosystem services accounting framework would allow managers and regulators to see the range of effects of Nr. ESRP-Nitrogen is currently developing approaches to bundle and measure multiple ecosystem services influenced by Nr, and initiating a research program comprised of national, regional and place-based studies to address these issues.

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Modeling the Effects of Climate Change on Multiple Ecosystem Services

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In this paper we use InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs), a new spatially explicit modeling tool that predicts the consequences on land-use and land-cover (LULC) and climate change on the production of multiple ecosystem services, biodiversity, and commodity production (Nelson et al. 2008), to investigate the ecosystem service consequences of LULC and climate change in the Willamette Basin, Oregon, USA.

Specifically, we investigate how projected changes in LULC pattern and temperature and rainfall patterns will affect future carbon sequestration rates, agricultural production, and biodiversity in the Basin. We convert the changes in future carbon sequestration rates and agricultural production into monetary value.

We repeat the above analysis assuming only the projected changes in LULC pattern occur while climate remains fixed. By finding the differences between the two analyses we are able to isolate the effect of expected climate change on modeled ecosystem service production and biodiversity. In addition, we are able to place a monetary value on the climate-induced change on carbon sequestration rates and agricultural production.

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Integrating Ecosystem Services into the Decision Making Process -- the Possibilities

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The Tampa Bay Regional Planning Council is participating with the US EPA in a five-year process to determine values for ecosystem services within the region, including the Tampa Bay estuary. Over the past 20+ years, considerable work has been done within the region to understand the relationships between ecosystems and the various economic engines of our region, such as recreational and commercial fisheries, agriculture, development, mining and shipping. Yet the benefit of maintaining natural systems, and the cost of impacting natural systems, has not always been easy to explain in terms that can be understood by all.

While it remains to be seen exactly what the outcome of the valuation process will be, it is clear that planners, environmental advocates, elected officials, and the general public need better ways to communicate the costs and benefits of various projects and activities. Putting a dollar value - or range of values - on the components of the environment may be one way to increase communication and an understanding of these costs and benefits.

Incorporating dollar values of ecological services into an overall cost-benefit analysis may result in a loss of awareness of the intrinsic value that an ecological system has over the long-term, or it may provide decision makers with another tool for evaluating the worth of a project.

Ways in which the values of ecological services could be integrated into decision making may include: a) Incorporation of an ecosystem value module into the REMI© model of economic impact analysis; b) Requiring inclusion of an ecological services calculation with each development proposal which requires a permit or development approval; and c) Calculation of various development scenarios using the ecological services values as part of the development approval process.

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Agriculture, Renewable Energy & the Environment: Costs & Benefits

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Policymakers aim to have biofuels displace 30 percent of national petroleum consumption by 2030. This goal has considerable implications for the management of lands used for agriculture and livestock operations, lands that provide society with numerous ecosystem services. Animal agriculture could be an important resource in the renewable energy field, both by providing biomass (frequently waste) to use and serving as a producer of energy. Economic modeling combined with Geographic Information Systems (GIS) mapping is an effective way of analyzing the impact of livestock operations on the environment and obtaining a more holistic assessment of the costs and benefits of agriculturally based energy production. The impacts of animal feeding operations (AFO) via runoff pollution or odor upon local communities constitute an externality that does not currently carry a market price. Quantifying this externality, allows us to determine if linking energy production and AFOs while simultaneously decreasing the environmental impact of AFOs would result in net economic gains to society. Furthermore, quantifying the effects of animal agriculture will create considerable incentives for more ecologically sound management of these lands.

Quantifying the effects of agriculture is accomplished by the development of several hedonic pricing models. A hedonic model allows one to measure the value of goods such as environmental amenities (or disamenities in this case) that do not carry market prices. This is accomplished via proxy variables (in this case housing) that reflect the value of the good in question (the local environment). Houses located in close proximity to AFOs are expected to be of lower value relative to houses farther removed from AFOs and therefore located in a potentially cleaner environment; a cleaner environment provides a greater variety of ecological services and is likely to be more valuable to society. Separate hedonic models are developed for each of five representative Ohio counties, allowing us to obtain a range of the environmental amenity costs associated with AFOs. Defining these non market values allows us to create estimates of the potential social gains associated with decreasing the environmental impact of animal agriculture. These results have considerable implications for the sustainability both economically and ecologically of AFOs.

Environmentally sound management of lands used for crop and livestock production is not unfeasible. Synergies exist between the ecosystem services these lands provide and their agricultural productivity. We use GIS mapping to describe the extent of AFOs across Ohio and to assess the potential of on farm energy generation across the state. However, even though tapping energy from animal agriculture and simultaneously reducing externalities may create economic gains these will be of little benefit if they are not translated into policy. By combining evidence from hedonic modeling and GIS mapping we aim to demonstrate that animal agriculture and renewable energy production are complementary activities with the potential to reduce the environmental footprint of agriculture.

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Wild Rice—Cultural and Ecological Implications

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Manoomin, or wild rice (*Zizania* sp.) is an aquatic plant upon which several Native American Nations depended. It is particularly significant culturally to the Ojibwe, who migrated from the eastern seaboard to the western Great Lakes region in search of "the food that grows on the water", and who consider the plant sacred. Unique, complex and diverse, manoomin wetlands provided a highly nutritious food for native communities, while supporting a myriad of other species - such as fish, furbearers and waterfowl - that in turn provided for many subsistence needs.

Wild rice still holds great cultural, subsistence and economic significance to the Ojibwe. However, many historic wild rice beds have been lost, and management of the resource has been hindered by a lack of coordination beyond the local level. This paper will review the historic and contemporary significance of manoomin to the Ojibwe, and highlight various threats currently facing the resource. It will also discuss how the re-affirmation of off-reservation Native American treaty rights has stimulated greater efforts to manage, restore and study wild rice, and how tribal natural resource agencies are now working with state, federal, local and private resource agencies to coordinate manoomin management at a regional level. It is hoped that this renewed effort to protect and enhance wild rice will ensure that it remains present on the landscape to provide its myriad of cultural and ecological values for the seventh generation yet to come.

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Linking Ecosystem Indicators to Ecosystem Services in the Review of the Secondary Standards for NO_x and SO_x

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The U.S. Environmental Protection Agency (EPA) is currently conducting a review of the secondary National Ambient Air Quality Standards (NAAQS) for nitrogen oxides (NO_x) and sulfur oxides (SO_x). The secondary standards focus on welfare effects, including ecosystem services. As part of the review, EPA will develop methodologies for linking changes in NO_x and SO_x ambient air concentrations to the changes in ecosystem services and ultimately to changes in welfare. Indicators of ecological function and ecosystem service provision together with risk and economic assessments can inform decisions regarding the adequacy of current NAAQS, ecosystem protection afforded by potential revisions to the current primary standards for NO_x and SO_x, and the consequences of alternative secondary NAAQS for oxides of nitrogen and oxides of sulfur.

To that end we have developed a summary of methods and models that could be used to help link changes in NO_x and SO_x ambient air concentrations to changes in ecosystem services and associated changes in welfare. In the Scope and Methods Plan (U.S. EPA 2008), EPA describes the approach that will be used to conduct the risk and exposure assessment. The Scope and Methods Plan presents assessment endpoints, data needs, and analysis plans for the approach proposed by EPA. As outlined in the plan, EPA is using a set of case studies to characterize the risk associated with NO_x and SO_x ambient air concentrations in different sensitive areas around the United States.

Through the case studies, we are exploring potential ecological indicators of the effects of NO_x and SO_x on terrestrial and aquatic ecosystems. The indicators will form the basis of a conceptual model of potential ecological changes in various sensitive ecosystems. Focusing on the Chesapeake Bay Watershed (CBW), we review the literature and modeling approaches relevant to conditions in the CBW. We identify the ecological effects; the ecosystem services, both aquatic and terrestrial, that could be affected by NO_x deposition; and economic studies, models and data that could be used to measure the monetary value of the ultimate changes in welfare.

We identify studies and models that could be used to bridge the gaps between ecological indicators or assessment endpoints, ecosystem services and economic valuation. We are evaluating the feasibility of linking indicators, services and valuation for the ecological endpoints identified in the four risk assessment case studies currently underway and in the CBW report and the ecosystem services and valuation studies identified in the CBW analysis.

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A Framework for Bundling Ecosystem Services

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All of the recent activity around markets for ecosystem services has created considerable interest among stakeholders and shows potential for increasing forestland value thru market-based incentives. However, there is concern that the lack of an integrated program will simply add to the complexity of these services without generating significant public benefits. The current approach is to develop separate programs, each with its own set of rules and administrative requirements, for each service provided. These disconnected programs often result in the restoration of many small sites that lack ecological integrity and are unlikely to provide as high a level of benefits as could be provided by protecting larger and more contiguous areas. An integrated approach that combines or bundles services and provides financial incentives for forest landowners may be more effective to achieve broad conservation goals, including fish and wildlife habitat, improved watersheds, carbon sequestration, and other ecosystem services at an ecologically relevant scale.

We outline some of the policy and regulatory frameworks for some of the emerging markets for ecosystem services in the USA, and discuss the role that different regulatory agencies play for each of these services. We then assess the potential benefits for bundling different ecosystem services including carbon credits, water quality trading, and wetland and species mitigation banking. As an example of this approach, we develop a methodology to integrate relative values for timber, carbon and wildlife habitat for a set of watersheds in central Oregon, USA. Our purpose is to establish a framework for assessing the potential value for different ecosystem services, understand the process for combining these services on a given land area, and develop an integrated approach for bundling these services.

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Applications of Ecosystem Services by the Nez Perce Tribe

John DeGroot

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The Nez Perce culture is intimately connected with the land and natural resources. Current Nez Perce Tribal management activities are focused on recovering diminished resources and ensuring sustainable resources for future generations. These management activities are considered ecosystem services that can be categorized as provisioning, regulating, supporting, cultural and preserving.

This presentation will provide an overview of the territory and natural resources of the Nez Perce, including land ownership and treaty resources. A description of management activities including providing food, fiber and clean water, regulating climate and disease, supporting ecosystem function, and preserving and maintaining biodiversity will be provided. Specific management activities to be presented include land acquisition, land use change, restoring fire-adapted ecosystems, carbon sequestration, bio-control of noxious weeds, watershed restoration, salmon recovery, reintroduction of wolves, big horn sheep management, and no-till agriculture.

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Measuring the Contribution of Benthic Ecosystem Engineering Species to the Ecosystem Services of an Estuary: A Case Study of Burrowing Shrimps in Yaquina Estuary, Oregon

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Burrowing shrimps are regarded as ecosystem engineering species in many coastal ecosystems worldwide, including numerous estuaries of the west coast of North America (Baja California to British Columbia). In estuaries of the U.S. Pacific Northwest, two species of large burrowing shrimps (*Neotrypaea californiensis* and *Upogebia pugettensis*), can occur at great densities (exceeding 300 m⁻²) and high biomass (up to 200 g m⁻², dry wt), and can occupy more than 75pct of the extensive tide flats in middle and lower estuarine reaches. As ecosystem engineers, burrowing shrimps physically and biogeochemically modify the sedimentary habitat through bioturbation (sediment mixing) and bioirrigation of their burrows. Bioturbation by *N. californiensis* can negatively affect the abundance of some bivalve shellfish (particularly oysters). On the other hand, bioturbation and bioirrigation by both species greatly accelerates carbon and nitrogen cycling, and filter feeding by *U. pugettensis* removes phytoplankton and seston from the water column. Both species are prey items for fish, crabs, birds and occasionally, grey whales, and the shrimps are harvested commercially and recreationally as bait.

A major focus of our research has been to measure and model the density-dependent effects of both shrimp species on carbon and nitrogen cycling, filter feeding, and food web dynamics within the Yaquina estuary, located on the central coast of Oregon (USA). We have also developed methods for mapping the abundance and distribution of shrimp populations, and have used those maps to interpolate the ecological functions of burrowing shrimps to whole-estuary scale. We are currently working on translating these ecological functions into ecosystem services and estimating the value of those services. As noted above, the shrimps have both positive and negative impacts on ecosystem services, some of which are dependent on the spatial distribution of human activities (i.e., molluscan aquaculture, recreational clam digging, bait harvesting). In this presentation, we will summarize our progress toward estimating the contributions of burrowing shrimps to the ecosystem services of Yaquina estuary, and highlight the challenge of reconciling the beneficial and detrimental impacts that ecosystem engineering species can impart on ecosystem services.

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Modeling Vegetation Change for Non-market Valuation of Riparian Ecosystems

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Management of rivers for human uses, particularly in arid and semi-arid regions, may significantly impact riparian ecosystem services. Non-market valuation can be a useful tool for assessing the costs and benefits of alternative courses of natural resource management. Science can play an important role in this process, as predicting the effects of management actions on riparian ecosystem services requires an understanding of key ecological and hydrologic driving processes and how they are affected by perturbations.

The goal of our research is to assess the impacts of alternative management options on non-market values of riparian ecosystems in the Southwest. Our two study systems, the Upper San Pedro River in southeastern Arizona and the Middle Rio Grande in New Mexico, are similar in terms of supporting riparian forests that provide habitat for breeding and migratory songbirds within a semi-arid landscape, and are both faced with management challenges related to human water use. The San Pedro is an unregulated river, but is threatened by groundwater pumping in its basin, while the Rio Grande is a regulated system that is undergoing intensive, active vegetation management for fire control, ecological restoration, and water salvage. Projecting and valuing changes in these systems under alternative management scenarios requires integrating models built on sound ecological and hydrological science with methods for assessing non-market economic values.

On the San Pedro, we are using a riparian assessment model to classify river reaches into one of three condition classes (wet, intermediate, dry), based on vegetation attributes and hydrologic thresholds. The riparian assessment model is being coupled with results of hydrologic models in a Decision Support System to project spatially-explicit changes in riparian vegetation under alternative water use strategies. On the Rio Grande, the drivers we are simulating represent vegetation management approaches, from no management ("benign neglect") to intensive clearing of exotic understory vegetation, with vegetation responses based on professional judgment and an understanding of plant life history characteristics. On both systems, vegetation outputs are being linked with models to project reach-scale, system-wide changes in bird community composition and abundance. Summaries of these vegetation, river flow, and bird attributes are being presented in choice surveys to assess how members of the public value the outcomes associated with alternative management options. Translating the science into a form that can be incorporated in the surveys is a significant challenge in the entire valuation process.

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Urban Forest Ecosystem Services Indicators Based on Soil, Vegetation and Air Characteristics for the City of Gainesville and Tampa

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Background/Question/Methods

Urbanization is the process of removing or modifying the rural or natural ecosystem structure of an area with the purpose of the establishment of an urban settlement. Through urbanization, human activities usually result in an alteration of ecosystem functions and subsequent services such as air filtering, microclimate regulation, noise reduction, rainwater drainage, recreational or cultural values, air quality, erosion regulation, disease regulation, pest regulation, pollination, aesthetic values, soil formation, primary production, and nutrient cycling. Many studies of these new urban ecosystems focus their objective on one service or one function, and just give a static picture of the state of this service (e.g microclimate regulation) or functions (capture of CO₂), without accounting for many of its complex interactions. Indicators are a tool for providing information about the changes in processes that occur between the original and the modified ecosystem. So the objective of urban ecosystem services indicators is to summarize the impacts of urbanization on the functions of soil, vegetation and air quality in relation to human well-being. Indicators are easy to understand and allow noticing variability across space and time. Ecosystem structural and functional components were recorded and calculated according to filed data collection, spatial and temporal analyses and UFORE model results; weights or importance values were then assigned to each through statistical analyses, and a principal component analyses was performed. Using these weights indicators for each urban ecosystem service were developed, this will allow us to evaluate how urbanization has affected the services mentioned previously. We also compare indicators from a large and small urban ecosystem, exploring how different histories of urbanization affect them.

Results/Conclusions

Each indicator will give a more comprehensive assessment of urban ecosystem services (base on changes of the functions and structure of soil, vegetation and air quality) dynamics. It will show major changes and improvements; especially it will give a suggestion of what the situation could be if there is a change in land use or what are the different situations that appear on different land uses.

These indicators will provide a way for understanding how urbanization affects an area and how this effect increases or decreases over time, and if they are related to a particular type of land use or neighborhood (spatial trend).

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Ecosystem Services Provided by Wetlands Reserve Program Wetlands in the Central Valley of California

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California's Central Valley and the Upper Klamath River Basin in California and Oregon historically supported large areas of freshwater wetlands. Today, the landscapes of both regions have been extensively modified for agricultural production, resulting in loss of most wetlands. Since 2000, NRCS has implemented almost 30,000 individual conservation practices (projects) in these two combined regions

Conservation practices funded through the NRCS Wetland Reserve Program (WRP) represent only about 2% of these projects. However, the 29 types of conservation practices included under WRP in these two regions are also funded through other NRCS programs. Collectively, projects implementing these conservation practices represent 56% of 1,468 projects in the Upper Klamath River Basin and 32% of 28,089 projects in the Central Valley. Conservation practices having direct linkage to WRP; wetland creation, enhancement, restoration and wetland wildlife habitat management comprise only 2.1% of all projects in California's Central Valley since 2000. These same conservation practices represent 4.1% of all projects in the Upper Klamath River Basin since 2000.

Information with which to assess the effectiveness of these conservation practices in improving wetland ecosystem services has been imbalanced. While considerable information about vernal pool ecology and the use of freshwater marshes by migratory waterfowl exists, literature on other aspects of wetland ecology in these regions is either lacking or insufficient for assessment purposes. CEAP-Wetlands is initiating an assessment of conservation practices in these regions that should help guide future NRCS conservation programs.

Ecosystem services provided by freshwater wetlands in the Central Valley, for which information exists, include water quality improvement and biodiversity support. We are currently assessing multiple ecosystem services provided by WRP wetlands in these areas, including nutrient storage (carbon, nitrogen and phosphorus), flood water storage, and biological diversity (birds, fish, amphibians, native bees and plants).

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The Cooperative Conservation Blueprint

Thomas Eason and **Christine Small**

Florida Fish and Wildlife Conservation Commission, Tallahassee, FL, USA

The Cooperative Conservation Blueprint is a process that builds agreement between government and private interests to use common priorities as the basis for statewide land-use decisions. It consists of the following elements: (1) a fully unified set of Geographic Information System (GIS) data layers of priority statewide natural land and water resource areas, working landscapes and development areas, (2) an online application to make the GIS data layer(s) available to all Floridians and (3) a package of recommended landowner incentives needed to apply the integrated land-use, natural resource and habitat conservation strategies statewide.

The purpose of the Blueprint is to help government, landowners, nonprofits, businesses and others make sound conservation and economic decisions to guide Florida's future development and achieve long-term sustainability. The Blueprint will help conserve vital working landscapes and natural resources while maintaining both a sustainable economy and agriculture opportunities. The Blueprint will help to guide future land-use planning decisions and recommend market-based incentives that encourage conservation.

The Cooperative Conservation Blueprint is needed for several reasons: to help envision Florida by looking 25 and 50 years into the future, to address the impacts of population growth and the conversion of natural, rural and agricultural lands, to lead a coordinated effort that integrates environmental, social and economic factors to enhance the quality of life for future generations of Floridians, and to make the process of developing habitat conservation priorities transparent to everyone.

Collaborative work among government agencies and broad-based public user and interest groups are working together to develop the Blueprint. There are 60+ volunteers leading and participating in the Blueprint development process. The Century Commission for Sustainable Florida, Florida Fish and Wildlife Conservation Commission and Defenders of Wildlife provide project leadership.

The Blueprint builds on the *Critical Land and Waters Identification Project* (CLIP). CLIP updates, unifies and prioritizes existing GIS databases. CLIP identifies and prioritizes statewide natural resource, and serves as a starting point for the Blueprint. The CLIP Phase I & II reports, a link to the database viewer and to the database are located on the Century Commission's website http://www.centurycommission.org/current_projects.asp.

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Shifting to Performance-Based, Market Driven Agricultural Conservation Strategies

Alex Echols

Sand County Foundation, Madison, WI, USA

Most agricultural conservation strategies were developed as supplements or alternatives to regulatory programs and predate the concept of ecosystem services. Whether these strategies are directed at biomass for energy or other services, they do not use market or performance mechanisms to prioritize conservation investments. Recognizing that financial resources will always be a limiting factor Sand County Foundation believes that techniques need to be developed which will deliver a higher conservation return on investment.

The prevailing delivery strategy in the U.S.A. neither distinguishes between the effectiveness of various “Best Management Practices” (BMPs) nor assesses where practices will be more effective. We seek to reduce several impediments, whether to policy maker or to landowner, to achieving a performance-based incentive program for delivery of ecosystem services. This presentation will assess the potential to more effectively reduce water pollution from agriculture by shifting to a performance-based market oriented delivery system and will articulate obstacles to achieving this objective.

Sand County Foundation has operated a series of tests to examine the acceptance of targeted incentives by farmers in three Upper Mississippi Basin states. These are done in partnership with mainstream agricultural institutions. Results indicate a high degree of interest by farmers in participating in targeted incentives. We have concluded that farmers are often poorly informed about the effectiveness of specific nutrient techniques. This hinders an efficient shift to a performance-based delivery strategy.

The project also seeks to better understand the performance of specific management techniques in reducing nutrient loss from agricultural lands, variables that affect performance of management techniques, and how to utilize market principles to target investments. Additional research is needed to establish reliable estimates of reductions in nutrient loss as affected by wide variations in climate, soil types, farming practices, diverse landscapes, and agricultural economy.

Ecosystem service strategies for biomass or nutrient management could help substantially improve environmental return on conservation investments. To achieve this objective, better performance and cost data are required. In addition, to deliver these new strategies, significant development of social infrastructure needs to be cultivated.

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The Role of the USDA CEAP-Wetlands to Develop Integrated Landscape Modeling and Monitoring Tools to Improve Wetlands Conservation

S. Diane Eckles

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The USDA-led Conservation Effects Assessment Project (CEAP) was initiated in 2003, initially as a mechanism to provide information for Farm Bill conservation program accountability needs. It has since been expanded in scope to be a primary source of scientific information for USDA to improve conservation implementation. Four national assessment components – Cropland, Wildlife, Grazing Lands and Wetlands – and a Watershed component currently comprise CEAP. CEAP-Wetlands goals and the inter-related objectives were designed to address the initial accountability task articulated for CEAP – primarily through a literature synthesis and results from collaborative regional studies - but also were designed to capitalize on the opportunity to institute a landscape monitoring process to improve conservation decisions affecting wetlands on agricultural landscapes. The focus of CEAP-Wetlands on ecosystem services in lieu of the traditional focus on wetland “functions” is intended to highlight the benefits wetlands provide to individuals participating in Farm Bill programs and provided to society. Arising in large measure from the first CEAP-Wetlands regional study in the Prairie Pothole Region, a collaborative USDA and USDI effort was initiated to develop a landscape-scale ecosystem model that would capture spatial and temporal changes in ecosystem services provided by wetlands on agricultural landscapes resulting from conservation decisions within a changing climate context. The model is intended to provide USDA with simulation and forecasting capabilities. This presentation will provide an overview of CEAP-Wetlands, emphasizing the USDI and USDA collaboration to develop the Integrated Landscape Model, and its intended application as part of a USDA National Wetlands Monitoring Process.

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Landscape Prioritization Techniques for Water-Related Ecosystem Services

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Water-related ecosystem services are gaining attention globally, regionally and locally, weighing heavily in policy and management decisions. Many hydrologic models exist that can aid in water-related management, but these models are often inapplicable to policy decisions because they 1). focus on the streamflow and its components rather than the landscape positioning, 2). focus on hydrologic processes rather than ecosystem services, and 3). require a substantial amount of data, considerable modeling skills, and time consuming calibration and validation that are not practical in fast-moving management processes. We have developed a series of spatially distributed modeling tools to help assess water-related ecosystems services using readily available data. These models are part of a larger ecosystem service framework called the Integrated Valuation of Ecosystem Services and Tradeoffs tool, or InVEST. Our water-related models link provisioning and regulating processes on the landscape to ecosystem service demand points, providing estimates of ecosystem service levels in biophysical and economic terms for the following services; water yield for irrigation or hydropower production, sediment retention for reservoir maintenance, nutrient retention for regulatory compliance and flood mitigation. These models are based on widely accepted and simplified hydrologic laws and economic principles. They bring together ecological processes including water yield, water recharge index, storm peak flow, water quality and sediment yield with information on human demands for multiple uses. Economic valuation is based on avoided damage costs and production functions. To improve accessibility of the models, they have been created in an ArcGIS framework and require relatively few data inputs. Given the simplifications and assumptions inherent in the models, they are most appropriate for providing order of magnitude estimates of which parts of a landscape contribute to ecosystem service provision, either today or in the future.

This talk will highlight the applications of water models in different watersheds in different eco-regions with different area scales. We have verified the hydrologic biophysical process portions of several of the ecosystem service models against SWAT model. Linear correlation coefficients vary from 60% to 98% for water yield results in different watersheds within Texas Gulf, Tennessee, and Willamette basins in the United States. Given that comparison using the other models shows similar trends but have monotonic relationships, Tau Statistics were used. On most accounts, trends were fairly correlated with p-values of less than 0.01. The largest errors occur in the drier basins where rainfall patterns are more dominant drivers of hydrology than geomorphology, vegetation and management. Given the relatively strong agreement between our simple models and the widely accepted SWAT model, InVEST provides a practical ecosystem service modeling approach for engaging stakeholders, prioritizing activities across a landscape, targeting payments or projects for ecosystem service provision, and informing management, monitoring or restoration plans.

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Ecosystem Services and Value of Florida's Urban Forests

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Florida's urban forests are multi-scale, variable, and heterogeneous ecosystems that provide a suite of services that contribute to the improvement of human well-being. Urban forests are the sum of all vegetation in urban ecosystems relative to the human inhabitants and the built infrastructure. These urban ecosystems are defined by human norms and perceptions, regional climate and vegetation biomes, and the morphology of the built infrastructure. The management of the structure of these ecosystems and its affect on function can have both positive and negative effects on ecosystem services. Urban ecosystems are also dynamic, due to anthropogenic and natural disturbances, budgets, human influences, land-use decisions, and natural succession and growth.

We are currently assessing the structure, function, services, and value of urban ecosystems in Florida. Using sampling protocols established by the Urban Forest Effects model we have quantified tree-palm-shrub structure and diversity, building and surface covers as well as soil chemical and physical characteristics. Coupling these with hourly air pollution and meteorological data we have modeled the function of trees and shrubs in removing air pollution, carbon storage- sequestration, and building energy use. We also assessed the effects of urban forests on hurricane damage mitigation using FEMA hurricane tree debris, LANDSAT imagery, NOAA weather station, and US Census data. Finally, we have used emissions of volatile organic compounds, allergenicity ratings, and increased energy use due to shading to further evaluate urban forest ecosystem services.

Air pollution control costs, carbon dioxide equivalents, kilowatt hour prices, tree replacement prices, and financial costs related to maintaining urban forest structure were then used to assign a monetary value to urban forest ecosystem services. Mail surveys of Broward and Hillsborough County community leader's perceptions towards urban forests were used to estimate the non-monetary value of urban forests. Literature on the limitations of urban ecosystem services was also reviewed.

Remote sensing methods using time-series satellite and aerial image interpretation have been used to evaluate drivers of urban forest cover change in Gainesville and Miami. The role of race, age, income and education levels on urban forest change is also being assessed in Miami-Dade County.

Results from this study will provide decision-makers, community leaders, and researchers the metrics and information necessary to understand the flow of urban ecosystem services, influences, products, and goods to communities. Additionally our analyses have identified indicators to monitor changes in these bundles of ecosystem services.

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A Conceptual Basis and Framework for the Quantification of Ecosystem Services in the Prairie Pothole Region

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The Integrated Landscape Monitoring Initiative—Prairie Pilot has developed a framework to model and monitor the performance of federal conservation programs, especially their provision of specific ecosystem goods and services (e.g., carbon sequestration, greenhouse gas flux, flood water storage, water quality, erosion reduction, wildlife habitat) in the Prairie Pothole Region. Concurrently, we are developing the capability to forecast change in ecosystem services under future events of interest, such as climate and land-use change, to facilitate adaptive management and policy goals of federal agencies. The Prairie Pothole Region is characterized by a highly dynamic inter-annual climate with long periods of drought interspersed with major deluge periods that reflood dry wetlands and often flood human infrastructure. This highly dynamic wet/dry cycle is the primary factor driving the ecology of the Prairie Pothole Region, and it affects the temporal provision of essentially all ecosystem goods and services of interest to society. To address this challenge, we designed a modeling framework for the ILM—Prairie Pilot based on conceptual models developed by USGS that can be structurally linked to national datasets based on hydrologic and geochemical landscapes. This will allow us to apply our modeling framework throughout the Prairie Pothole Region and potentially other geographic areas. Our modeling framework is designed to separate change in ecosystem services due to natural factors (e.g., dynamic mid-continental climate) from those attributable to federal conservation programs. Thus, our modeling framework accounts for the unique climatic drivers in the Prairie Pothole ecosystem and is designed to provide a transparent means of incorporating the best available scientific information into a decision support tool to facilitate consistent evaluations and forecasts of program performance by governmental agencies and other users.

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Conceptual and Rapid Prototype Models for Predicting Ecosystem Services

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The landscape-scale alteration of hydrologic, biotic, and biogeochemical functions in the Lower Mississippi Valley (LMV) requires an integrated, landscape-scale restoration and monitoring approach in order to replace those lost functions. Large-scale efforts are under way to restore former riparian forest habitats on both public and private lands in the LMV with explicit goals to restore wildlife habitat, improve water quality, and increase flood storage and retention. However, the success of these restoration efforts in achieving these goals is not clear. In addition to field research, the use of conceptual and rapid prototype models (RPM) can help identify the underlying natural processes controlling ecosystem structure and function and the response to stressors and disturbance. This will provide a framework, based on sound science, for developing appropriate performance standards, monitoring approaches, decision support tools, and guiding resource management decisions.

We are combining patch- and landscape-scale field research with modeling to quantify the ecological services of restored wetlands in Lower Mississippi Valley (LMV). The inter-disciplinary research team collected a variety of edaphic, vegetative and morphologic characteristics on restored wetlands, active cropland, and native forested wetland sites in each of two LMV watersheds, located in Arkansas and Louisiana. The species richness of migratory and breeding birds, and amphibians was measured at each site. Various landscape variables were calculated at different scales from GIS layers.

A frame-based RPM was selected to explore the relationships between site and landscape variables and the response variables (species richness/abundance). The RPM parameters were chosen based on expert-designed conceptual models, analysis of field data and existing literature. The RPM is designed in an Excel worksheet to simulate a 10x10 km land-use map (landscape) surrounding a restored wetland. The land-use classes are represented by different cell values and several landscapes are depicted on the same worksheet to illustrate the impact of different landscape patterns on the response variables. The response variable value is automatically updated as the input variables are changed to reflect spatial and temporal effects. The temporal change at the site level could be a change in forest structure representing a mature, native forested wetland. Changes in the size or number of restored wetland patches or connecting restored wetland patches reflect the spatial changes in the landscape at discrete time steps.

There are several advantages to the RPM approach. The simple structure of the RPM leads to the fast model development time and allows testing of various scenarios. Sensitivity analysis helps identify the variables that should be targeted by monitoring. New variables from monitoring can be added later to refine the model or to make it evolve into a more complex type of model. The design transparency and simplicity also make the RPM an effective way of presenting the modeled processes and their outcomes to various stakeholders. We will discuss the results of the model runs under various management and land-use alternatives and the applicability of this approach to integrated landscape science and monitoring.

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Migratory Bird Stopover in Reforested Lands: A Portable Radar Study

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In 2006, the U.S. Geological Survey's National Wetlands Research Center, and Farm Services Agency (FSA) collaborated on a study to evaluate the conservation benefits of the Conservation Reserve Program (CRP) as it relates to migratory bird habitat in the Lower Mississippi Valley (LMV). Specifically, we monitored autumn migratory stopover patterns on CRP easements and adjacent agricultural fields in northeastern Louisiana by using a marine weather radar system during September and October, 2006. Most migratory landbirds are nocturnal migrants and use stopover habitat for rest and refueling during the day. Migration resumes just after sunset, and these evening departures are easily detected by radar. We measured the number of migrants during exodus with a portable, vertically aligned, X-band radar system (Furuno, FR-8100D, 10 kW) operated at a 1.8 km setting with 24 rotations per minute and a pulse length of 0.08 μ s. The radar unit was placed between CRP and agricultural fields so that radar observations of birds were collected simultaneously. The number of radar targets exiting each habitat type was compared. Radar data analysis shows higher numbers of birds over the CRP easements compared to the agricultural fields. Results from this study will create a better understanding of the conservation effects CRP lands may have on migratory birds in the LMV.

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Animating Market Forces for Sustainable Stormwater Management and Enhanced Ecosystem Services

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The City of Portland's Stormwater Marketplace Program seeks to use market forces to promote and facilitate property owners to develop green stormwater management features on private property. Managing stormwater in this manner serves to both reduce overall system demand and provide ecosystem services that are absent in traditional engineered stormwater solutions.

Modeling efforts have shown that shifting future resources towards developing green stormwater infrastructure will achieve improved system effectiveness, cost savings, and greater provision of ecosystem services. This shift from grey to green infrastructure necessitates a fundamental change in the relationship between public utilities and property owners. Traditional approaches to public-private partnerships are evolving to recognize the critical role of private action, and embrace new engagement strategies that fully utilize information technologies, social networks and market forces to achieve environmental goals.

The City is currently conducting an assessment of the level of community interest in privately-owned and -managed stormwater facilities. A market research firm has been hired to conduct a series of surveys and interviews with owners of private property in the City's combined sewer overflow (CSO) area. In-depth interviews will be conducted with commercial and industrial property owners who have previously been solicited to participate in stormwater management programs. Both participants and those who declined to participate in these programs will be interviewed in order to gain insight into the successes and shortcomings of program outreach. Similar, more concise interviews will also be conducted with a larger number of owners of single family residences to gauge their propensity to invest in stormwater management facilities, and the motivations and challenges that shape investment decisions.

A major objective of this research is to obtain greater insight into the importance of community understanding and commitment to common solutions in stormwater management. Another goal is to increase the City's understanding of property owners' valuation of the provision of ecosystem services in the form of habitat, aesthetics, flood control, and other benefits. These elements are believed to be some of the key drivers behind landowners' decisions to invest in stormwater infrastructure on the individual level.

The study, scheduled for completion in October 2008, will test the City's assumptions regarding private property owners' attitudes towards stormwater management. It is expected that four key components will act as the foundation of a community that encourages private management efforts: (1) integrated markets of buyers, sellers, vendors, and suppliers; (2) effective communications networks that engage citizens and assist them in finding ways to participate; (3) technical expertise in multi-disciplinary approaches to producing well-designed sustainable stormwater infrastructure; and (4) invested leaders in government and the private sector who can put forth a unifying vision based on sound science and long-range planning.

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Strengthening Capacity to Address Climate Impacts on Living Marine Resources and Coasts

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NOAA is committed to improving society's ability to plan for and respond to climate variability and change. This includes enhancing the conservation and management of living marine resources, coastal resources and coastal communities to meet economic, social, and environmental needs. The public is demanding more information and services from NOAA on (1) how climate change and variability will impact marine life, coastal resources and the communities that depend on them, and (2) what can be done to mitigate and/or adapt to these impacts. NOAA is committed to communicating with and serving decision-makers and other stakeholders who are formulating strategies to prepare for, mitigate, and adapt to climate impacts on ocean and coastal resources. NOAA, as both a source and user of climate data, can better meet its mandates by enhancing observations and predictions, delivery of regionally-focused climate information and tools, and communication.

NOAA convened two internal workshops in 2008 in response to a request from its Administrator for strategies to better incorporate climate variability and change information into NOAA's management responsibilities related to living marine resources, coastal resources, and coastal communities. The two workshops brought together staff from across the Agency and focused on (1) climate information needed to fulfill NOAA's living marine resource management requirements, and (2) needs for strengthening NOAA's and its partners' capacity to address climate impacts on coastal communities and ecosystems (e.g., better communication, additional research, training opportunities).

This presentation will cover workshop findings (e.g., the need for better information, communication, and capacity building for vulnerability assessments and adaptation planning, as well as enhanced models and projections, especially those scaled to regional and subregional levels). Increasing communication and collaboration between NOAA's climate, ocean and coastal programs and activities offers significant benefits for addressing the impacts of climate change, within NOAA and for outside partners and stakeholders.

Based on workshop findings and consultations with its leadership, NOAA has developed a list of near term actions it will pursue to provide critical support to fulfilling NOAA's living marine resource and coastal mandates in a changing climate. This list includes establishing NOAA working groups to oversee implementation of the recommendations, engaging federal agencies and other stakeholders in planning and actions, increasing access to climate data and decision-support tools, and, in due course, developing guidance for incorporating climate change into NOAA's stewardship activities. This presentation will conclude with case studies of climate planning resources and efforts involving NOAA that are publicly available or under development.

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Agroambiente Network: Ecosystem Services in Agricultural Landscapes in the Brazilian Amazon

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Family farms are by far the most numerous component of the agricultural sector in the Brazilian Amazon. However socially vital for the development of the region, these small landholdings' agricultural and cattle ranching activities frequently overdraw and degrade natural resources, threatening important ecosystem services. Predominant agricultural practices have been marked by shifting cultivation, with intense use of fire and low productivity, causing high rate of destruction of natural forests. These current production patterns have not been able to alleviate poverty in many local communities, calling for changes in land use planning and agricultural management strategies toward more sustainable practices. Agroambiente is a research network from Embrapa and collaborators committed to investigate alternative agricultural practices for the maintenance of ecosystems services in the Brazilian Amazon. The network was firstly created to offer scientific support to a Government Program for ecosystem services compensation to family farmers (Proambiente Program), but has been expanding its scope to integrate social and environmental scientists focusing their studies mainly on: factors influencing provision of environmental services; methods for assessing ecosystem health status; management practices with lower impact on the environment; land use changes and market-based mechanisms for poverty alleviation through ecosystem services. Current research activities and their respective methodologies are: 1) Links between social perspectives and agricultural management decisions, carried out by interviews with land owners; 2) Search and validation of innovative production systems applied by farmers assessing inputs and productivity rates in different management conditions; 3) Construction of indices for assessment of ecosystem health in rural establishments through the development of an evaluation system (Ecocert-Proambiente); 4) Management alternatives for fire risk and accidental burnings abatement; 5) Evaluation of land use/land cover dynamics based on Landsat TM images and land use histories by interviews with the farmers; 6) Evaluation of carbon sequestration potential by estimating carbon stocks in different compartments of secondary forests; and 6) Appraisal of available market-based mechanisms for carbon schemes. Some rural communities have already been involved in sustainable agriculture practices such as agroforestry systems and fair trade (e.g. south western Brazilian Amazon). Production systems adopting no-till and no-fire may have initially lower productivity than traditional systems, but some viable management alternatives have been found. The Ecocert-Proambiente system was developed and validated with 62 indicators that covered social, economic, environmental and property management aspects. Avoided deforestation and maintenance of secondary forests were more feasible alternatives in terms of cost-benefit than the CDM negotiations from the establishment of agroforestry systems. Considering this scenario, estimatives in secondary forests of Pará state indicated aboveground biomass varying from 22 to 247 Mg ha⁻¹. Altogether, these results are important to guide public policies in Brazil towards environmental conservation and social benefits in the Amazon.

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Understanding Ecosystem Services in the High Desert: The Great Basin Integrated Landscape Monitoring Project

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The Great Basin encompasses over 65 million hectares in the western U.S. characterized by mountain ranges with large elevational gradients, expansive playas and valleys, and rare or unique wetlands and riparian areas. Although still sparsely populated due to limited water availability, the region is relied upon for a range of ecosystem services such as livestock grazing, agriculture, recreation, minerals, energy production and wildlife. Urban expansion, altered fire regimes due to invasive species, water extraction and modified water regimes, and climate change resonate throughout the region, resulting in rapid cumulative ecological and social change.

In 2005, the USGS Integrated Landscape Monitoring (ILM) science thrust recognized the changes occurring in the Great Basin and the need for a coordinated approach to track land uses and associated ecosystem changes. The interdisciplinary Great Basin Integrated Landscape Monitoring Project (GBILM) has since identified a set of key ecosystem drivers to frame the monitoring approach. Drivers include groundwater extraction, surface water flow regime, aquatic and terrestrial exotic species invasions, livestock grazing, fire-invasive species interactions, land treatments, and climate change. GBILM has focused on drivers that are relevant across spatial and temporal scales, significant to and manageable by resource management agencies, and are closely tied to ecosystem services such as livestock forage, wildlife habitat, and recreational opportunities. The GBILM team is in the early stages of evaluating how changes to these drivers will impact ecosystem services. While consolidating and evaluating existing data to initiate a coordinated monitoring program, GBILM is developing tools to help land managers cope with the pervasive and interactive drivers of change and to balance resource consumption with ecological conservation. This talk will focus on the interactions among demands for ecosystem services and the priority drivers unique to the Great Basin. We will provide examples of how GBILM is pursuing landscape-scale monitoring to manage for sustainable ecosystem services and to forecast future changes and management scenarios.

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Promoting Agricultural System Sustainability in the Southeastern Piedmont

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The southeastern USA and particularly the Southern Piedmont region is rapidly changing from rural to suburban. This change in land use has resulted in a greatly increased demand for water and land resources. Agricultural producers face pressures to eliminate negative impacts of historically common agricultural practices on natural resources such as soil, water and air quality. Segregation and specialization of crop and animal production has increased producer economic risks. Increasing system diversity can spread risks but more complex systems require greater management skills to reduce negative environmental impacts such as runoff, erosion, and losses of nutrients and pathogens.

Information is needed on how the drivers of systems function individually and collectively to modify the agricultural systems to increase robustness and sustainability. Producers in the Southern Piedmont of the USA face particular challenges as a result of environment and urbanization. The drivers may be considered in the four interacting areas of 1) Economics and Economic Policies, 2) Social and Political, 3) Technology, and 4) Environmental. These drivers do not necessarily promote sustainable systems.

Historically, these drivers will be used to briefly describe and explain the proliferation and collapse of the agricultural systems that resulted in massive losses of top soil from the region. Primarily, the proliferation was driven by economics and enabled by technology without social or political constraints. Sustainability was not a serious consideration although there were notable exceptions such as in the work of George Washington Carver. Eventually the systems altered the environmental factors (including an introduced pest) sufficiently that interactions with economic factors occurred and altered the agricultural systems common in the Southern Piedmont. At this point, low capital grazing systems increased and erosion decreased.

These principles will also be applied evaluate the agricultural systems that are common in the Southern Piedmont today and to consider the sustainability of the current practices. The agricultural systems of today's Southern Piedmont face economic challenges in the valuation of land. In particular, beef production is challenged by the high land requirement and the increasing value of land. Economic policies supporting the use of land trusts and agricultural easements can partially ameliorate the effect but they are relatively rare solutions. Social supports for producers are dwindling as neighbors become urban without any background in rural land management or agricultural production. Political support for agricultural systems has weakened as the percent of the constituency directly involved in agriculture has decreased.

Technology has made it possible to solve the environmental problems of a century ago and to produce row crops and manage grazinglands in an environmental sustainable manner. However, if agricultural systems are to remain in the Southern Piedmont, economic viability will remain a critical challenge and require high returns per unit land.

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Structured Decision Making Rapid Prototyping Application to Biological Opinion Activities on the Missouri River

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To improve our effectiveness in implementing the Missouri River Biological opinion (BO) the US Corps of Engineers and the US Fish & Wildlife Service explored the use of Rapid Prototyping in a Structured Decision-Making framework as we continue to build an adaptive management (AM) program for our Missouri River Recovery. We chose two components of the BO: the Shallow Water and Emergent Sandbar Habitat programs as case studies in real-world application of this emerging tool for resource management. The process included multi-agency teams of biologists and managers working over several weeks to draft initial SDM structures for each program that relate to the much broader river-level AM program. Results to-date have included focused objectives, system and species models helpful to the decision making process, and consequences of specific scenarios/alternatives. This process has also resulted in a broader understanding of the complexity of the decision support needed to evaluate our management actions, and apply that information to better management of the river. We found rapid prototyping and the SDM process helped us articulate both the decisions and alternatives under consideration, as well as provide a consistent method of measuring results. These are valuable tools in the natural resource management arena to ensure focused progress towards goals and objectives.

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Integrating Climate Data and Ecosystem Forecasts within a Decision Support System

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In 2002, the Florida Keys National Marine Sanctuary (FKNMS) established a conceptual model and science plan to identify major information gaps and to formulate adequate management responses to external stresses of their ecosystems. While model results and monitoring data have proliferated, greater understanding of the integration of scientific knowledge and management implementation has not kept pace. More recently, decision support activities have expanded to include both computational and social constructs to aid stakeholders in evaluating uncertain information at varying scales (time, space and discipline).

An interdisciplinary team comprised of modelers, biophysical researchers and extension/ outreach professionals are developing an ecosystem forecasting decision support system (DSS) highlighting climate data. This pilot study integrates and tests ecosystem scenario models linked with real-time data from NOAA's Atlantic Oceanographic and Meteorological Laboratory's Integrated Coral Observing Network (ICON) and short-term forecast datasets from the Southeast Climate Consortium (SECC) within an interactive DSS. The purpose of the pilot project is to illustrate ecosystem risks and vulnerabilities at Molasses Reef in the Florida Keys National Marine Sanctuary. The project products are presented to resource managers and targeted audiences in a facilitated 'gaming styled' DecisionPlace™ session that provides educational information on climate products (ICON and the SECC), ecosystem monitoring and forecasts, extreme events, and resource management in marine and coastal environments.

This project integrates outputs from several ongoing research efforts to formulate a novel system for adaptive exploration of complex environmental challenges: (1) climatic and ecosystem data from the ICON and SECC projects, (2) software development including scenario and game-style modeling, (3) electronic group participation aids for ease in interpreting datasets for decision-making.

Our approach to engage and provide meaningful tools to managers and stakeholders brings together biophysical *visualization*, human *interaction* and model-based *calculation*. It uses *Questions and Decisions* (QnD), an innovative scenario modeling technology for developing a DSS tool with which stakeholders can explore and visualize the potential biophysical, institutional and human dimensions science outcomes of different management options. The QnD model links the spatial components within geographic information system (GIS) files to the abiotic, biotic and human interactions that exist in an environmental system. Subsequent, iterative discussions aid in identifying and addressing the ongoing questions, risk and uncertainty that supports truly adaptive and transparent ecosystem management decisions. This is the first DecisionPlace™ presentation that provides background information on the process and the pilot project outputs. It is intended to foster a discussion of the utility of DecisionPlace™ tools and format for decision making in dynamic systems.

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Identifying Critical Habitat across Multiple Scales for Estuarine-Dependent Fishes with a Landscape Modeling Approach

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Identifying and protecting important habitat for estuarine-dependent fishes is crucial for minimizing negative effects of human development on fish production. Habitat quality can be defined at several spatial and temporal scales that must be accounted for in defining what habitat is critical to maintaining fish production targets. Landscape modeling approaches allow for the development of a habitat mosaic that includes habitat change over a broad range of scales and can be integrated with fish physiology and movement to understand how annual and multi-annual production may be influenced by habitat change. We developed a general landscape model in one coastal estuary which accounts for both spatial variation in static habitat based on landscape mapping and temporal variation in ephemeral habitat characteristics based on real-time, high resolution field data. This habitat mosaic was overlaid with a production and movement model to examine predictions of juvenile fish movement and production that account for both physiological limits on growth, density-dependence and behavior. Results from this demonstration analysis suggest a landscape approach can be useful for understanding the linkage between static habitat loss, inter-annual variability in physical characteristics of the aquatic environment and longer term changes in fish population production.

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Estimating Landscape Suitability for Pollinators: The Importance of Landscape Configuration for Honey Bees

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The Prairie Potholes and Northern Great Plains are important landscapes for maintaining honey bee colonies and for agricultural pollination services at local and national scales. Long summer days and grasslands rich in flowering species, especially legumes, provide the ideal mix of pollen and nectar sources required by bees for healthy nutrition and for long foraging periods that result in record honey crops. Lands in the Conservation Reserve Program (CRP) are often prime sources for this type of vegetation cover. Certain agricultural crops, such as oil seed sunflowers, canola, and alfalfa, also are beneficial for bees. When the growing season comes to an end in this part of the country, bee hives are generally shipped to states such as California, Georgia, and Florida to pollinate fruit, nut, and other crops worth \$15 billion annually. Transporting the bees around the country exposes them to multiple stressors, including pesticides, nutrient-limited monoculture diets, other bees that may be carrying diseases or parasites, and the stress of the long-distance move, itself. We hypothesize that bees having good nutritional health prior to being shipped around the country will be more resistant to disease and stressors while they provide national pollination services. Further, we believe that this healthy nutritional status can be attained through appropriate land-cover configurations around hives. We have prototyped and are now refining an approach to classify landscape suitability for honey bees in the Prairie Potholes and Northern Great Plains. The importance of CRP lands is already evident from our initial results, as they provide critical habitat in areas that are extensively planted in non-nectar producing crops (e.g., corn, wheat) that offer no nutritional value for bees. Our approach can be applied to many scenarios affecting ecosystem services provided by honey bees, such as shifting climate and economic incentives that encourage changes in land use (e.g., bioenergy crops in the Prairie Potholes and Northern Great Plains).

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Integrated Assessment of Climate Change and Biofuels Production on Ecosystem Services and Sustainability

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We apply an integrated approach to evaluate the effects of an expanded agricultural base for biofuels and concurrent changes in climate on ecosystem sustainability across the northern Great Plains. This research tests whether land-use patterns driven largely by economic considerations are sustainable. We begin with a 2001 landscape classified using remotely sensed data (ETM+ and MODIS satellite-based sensors) and project alternative landscapes at annual time steps through 2050, analyzing the results to estimate effects on ecosystem processes and services. Land-use history data derived from MSS, TM, and ETM+ satellite-based sensors are used to inform projection of future change. We incorporate socioeconomic drivers, such as national policy and programs, commodity prices, and biofuel demand, to develop multiple scenarios that variously emphasize production of corn, soybeans, switchgrass, and mixed prairie species. We further address management practices, such as tillage, crop rotation, and retention of crop residue, that we expect to have appreciable impacts on soil organic carbon, soil erosion, and, subsequently, water quality. Each scenario is being run under current, low-change, and high-change climate conditions. We are applying the model FOREcasting SCEnarios of Land Cover Change (FORE-SCE) to develop the annual maps of landscape change; the General Ensemble biogeochemical Modeling System (GEMS) to model the biogeochemical response to land cover and land use; the Better Assessment Science Integrating Point & Nonpoint Sources (BASINS) model to estimate associated levels of soil erosion and nutrient, pollutant (e.g., nitrate), and sediment loadings to major waterbodies; and economic and econometric models to determine agricultural profitability and energy costs and benefits. We will assess environmental quality and sustainability based on carbon accounting, agricultural productivity, greenhouse gas emissions, sediment and nutrient loadings to waterbodies, and availability and quality of wildlife habitat.

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Accounting for Ecosystem Service Values of Natural Capital within Areas of Influence of the California Bureau of Land Management Community Assistance and Hazardous Fuels Programs

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Evaluations of fire hazard mitigation programs tend to focus primarily on the number of acres treated and treatment costs associated with mitigation without adequately assessing the benefits of these treatments. While some evaluations account for the value of protected structures or the avoided costs of suppression, few account for the ecosystem service value of the natural capital that is protected as a result of treatments. In this study, we provide a framework for assessing the social and environmental benefits associated with BLM's Community Assistance and Hazardous Fuel Programs in California.

The identification and valuation of economic benefits associated with ecosystem goods and services are not only possible but have proven to be increasingly useful for informing the allocation of resources among competing demands on the environment. This assessment is novel in its consideration of both the market-based and non-market values that are at risk from wildfire. Using a decision support methodology called the Natural Assets™ Information System, the study presents data that allow the BLM to more effectively quantify and account for the social and environmental benefits derived from fire mitigation treatments. The database for NaturalAssets™ stores the best-available valuation estimates for ecosystem services from the peer-reviewed literature in a relational structure, allowing for the querying and reporting of value estimates broken down by ecosystem service, ecosystem type, and geographic context. To assist the California BLM, we have developed a conservative, baseline ecological-economic assessment of the ecosystem goods and services for three selected counties in the State of California. Counties were selected based upon the frequency of BLM projects, the availability of land cover data, landscape heterogeneity, and transferability. Our goal has been to use the best available methods, data sources, and spatial analysis techniques to generate defensible value estimates that can then be integrated into better land use planning and environmental decision-making.

National policy and regulatory trends are clearly moving in the direction that necessitates more effective accounting for the economic benefits provided by ecological goods and services. While this study necessarily was limited in its scope, suggestions are provided for how this approach could effectively be scaled up and used at a national, regional or state-wide level to analyze the efficacy of various BLM programs. The ecosystem service baseline layer used in this study is a lower-bound estimate as it is limited to ecosystem services and land cover types that have been valued in the peer-reviewed literature. Many important ecosystems, such as desert and grassland, are absent from the valuation literature, yielding a zero value for these types, which is clearly unrealistic. Increasing coverage would broaden the scope of the ecosystem service estimates and improve the specificity of the results by bringing California-based studies to the foreground.

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Mangrove Forest Distributions and Dynamics (1975-2005) in the Tsunami-Impacted Region of Asia

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Mangrove forests, distributed circumtropically in the inter-tidal region between sea and land in tropical and sub-tropical latitudes, provide important ecosystem goods and services. Recent findings suggest that mangrove forests helped saved lives and property during the Asian Tsunami. The forests have long been proposed to play an important role in the carbon balance of tropical coastal ecosystems. The continued destruction and degradation over the past thirty years has decreased the protective capacity of mangrove forest, and affected their ability to rebound from natural disasters such as tsunami and hurricanes. However, our scientific understanding of present distribution, and historic rates and causes of mangrove deforestation and degradation is limited. With this information, we could better understand the protective role of mangrove forests and learn more about deforestation dynamics, carbon fluxes, forest fragmentation, and provision of other ecosystem goods and services. The main objective of this research is to estimate the present extent of the tsunami-impacted mangrove forests of Asia and their rate and causes of deforestation from 1975 to 2005.

The region lost 12% mangrove forests from 1975 to 2005, to a present extent of ~1,670,000 ha. Deforestation rates and causes varied both spatially and temporally. The annual rate of deforestation was highest in Myanmar (~1%) and lowest in Sri Lanka (0.1%). In contrast, mangrove forests in India and Bangladesh remained unchanged or gained slightly. At the local level, deforestation occurred with varying intensities, with localized hotspots of rapid change for both deforestation and forest re-growth. In terms of temporal variation, net deforestation peaked at 137,000 ha during 1990-2000, increasing from 97,000 ha during 1975-1990, and declining to 14,000 ha during 2000-2005. The major causes of deforestation were agricultural expansion (81%), aquaculture (12%), and urban development (2%). The results of our study can be used to better understand the role of mangrove forests in saving lives and property from natural disasters, and to identify possible areas for conservation, restoration, and rehabilitation.

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The Prairie Pothole Regional Assessment: Results of a Survey to Estimate Ecosystem Services Derived from USDA Conservation Reserve (CRP) and Wetlands Reserve Program (WRP) Lands

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Implementation of the U.S. Department of Agriculture (USDA) Conservation Reserve Program (CRP) and Wetlands Reserve Program (WRP) has resulted in the restoration of > 2 million ha of wetland and grassland habitats in the Prairie Pothole Region (PPR). Restoration of wetland habitats through these conservation programs are perceived to provide various ecosystem services such as increasing plant diversity, providing wildlife habitat, improving soil and water quality, and sequestering carbon. However, little work has been conducted to quantify and evaluate environmental benefits achieved by these programs. To address this need, the USDA initiated the National Assessment component of the Conservation Effects Assessment Project (CEAP) to provide scientifically credible estimates of environmental benefits obtained from USDA conservation practices and programs. The CEAP-Wetlands component consists of 10 collaborative regional assessments to quantify the effects of conservation practices on ecosystem services provided by wetlands in agricultural landscapes. The focus of this presentation is on the CEAP PPR assessment that was initiated during 2004 by the U.S. Geological Survey in collaboration with the USDA. The goal of the PPR assessment was to develop approaches to facilitate estimation of ecological services provided by conservation practices in the PPR and use these approaches to quantify changes in ecosystem services resulting from wetland catchment restoration activities funded by USDA conservation programs.

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Field Evidence that Ecosystem Service Projects Support Biodiversity and Diversify Options

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Ecosystem services are being championed as a new strategy for conservation, under the hypothesis that they will broaden and increase support for biodiversity protection. Where traditional approaches have focused on setting aside land and purchasing property rights, ecosystem services approaches have the potential to broaden conservation mechanisms especially by incorporating production activities. This is particularly important given the rapid expansion of human population and human modification of ecosystems for production, especially agricultural production. Here we use field research on 34 ecosystem service projects and 26 traditional biodiversity projects from the Western Hemisphere and find that the ecosystem service projects attract on average more than four times as much funding through corporate sponsors and use of a wider variety of finance tools than biodiversity projects. Ecosystem service projects are also more likely to encompass working landscapes. Despite previous concern, we show that not only do ecosystem service projects expand opportunities for conservation, but they are no less likely than biodiversity projects to include or create protected areas. In addition, they do not draw down upon limited financial resources for conservation but rather engage a more diverse set of funders. However, we also found that monitoring of conservation outcomes in both cases is so infrequent that it is impossible to assess the effectiveness of either traditional biodiversity or ecosystem service projects.

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Mapping Ecosystem Services for Land Use Planning: Hawaii as a Case Study

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The ecosystem services framework holds significant potential to inform land use planning decisions by considering the effects of alternative scenarios of land use change on service provision. We applied the Integrated Valuation of Ecosystem Services and Tradeoffs (“InVEST”) software tool developed by the Natural Capital Project to land use planning in Hawaii in partnership with Kamehameha Schools (KS), a major educational trust and the largest private landowner in the State of Hawaii. Our analysis focused on KS’ land holdings on the north shore of the island of O’ahu: 26,000 acres comprised of rural communities, agriculture, and forested areas. The agricultural lands were in sugarcane production for over 100 years, ending in 1996. In planning for the future, KS is particularly interested in what could happen on these former plantation lands. To address this question, we developed three spatially-explicit scenarios of land use change to explore contrasting futures: (1) returning the plantation to sugarcane production for ethanol, (2) using the fields for diversified agriculture and forestry, and (3) selling the fields for a rural residential housing development. For the current landscape and each scenario, we quantified carbon storage, two hydrologic services, income generation, and biodiversity.

A key insight from our analysis is that, although any scenario has a higher projected income than the current landscape, the resulting impacts on carbon and hydrologic services vary (with minimal impacts on biodiversity). The residential development scenario maximizes income but would also lead to liquidating KS’ core asset. The diversified agriculture and forestry scenario is the only one with a higher projected carbon stock and improvement in local water quality. While the sugarcane ethanol scenario would reduce carbon stock due to land clearing, it does have the potential to “pay off” the lost stock by using ethanol to offset more carbon-intensive energy sources.

The differing projected impacts on ecosystem services of alternative scenarios provide decision-makers at KS with an array of information, both spatially-explicit and in aggregate form, to guide land use planning efforts with local communities. The benefits and costs, in monetary and non-monetary terms, of projected changes will affect stakeholders differently, including the local community, KS as an organization, and the broader public through provision of public goods, as well as current and future generations. Deciding how to weigh different perspectives in decision-making is a question inherent to land use planning, and one that this modeling approach can support by making explicit the tradeoffs and synergies of land use change on ecosystem services contributing to human welfare.

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Complex Ecosystem Valuation: A Study in the San Pedro and Rio Grande

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Conservation of freshwater systems is critical in the semi-arid Southwest where groundwater and flood regimes strongly influence the abundance, composition, and structure of riparian (streamside) vegetation. At the same time these systems are in high demand for competing human use. To address this conflict, natural scientists must evaluate how anthropogenic changes to hydrologic regimes alter ecological systems. A broad foundation of natural science information is needed for ecological valuation efforts to be successful. The goal of this research is to incorporate hydrologic, vegetation, avian, and economic models into an integrated framework to determine the value of changes in ecological systems that result from changes in hydrological profiles. We have developed a hydro-bio-economic framework for the San Pedro River Region (SPRR) in Arizona that considers groundwater, stream flow, and riparian vegetation, as well as abundance, diversity, and distribution of birds within a protected area encompassing the San Pedro Riparian National Conservation Area (SPRNCA). In addition, we are developing a similar framework for the Middle Rio Grande of New Mexico (MRG). Distinct valuation studies are being conducted for each site with benefit-transfer tests to be conducted between the two sites. This research is novel in that it provides much more detailed scientific information for economic valuation models than is typically available. There are five research components for this project: (1) scenario specification and the hydrologic model, (2) the riparian vegetation model, (3) the avian model, (4) methods for displaying the information gradients in the survey instrument, and (5) the economic framework. As such, our modeling framework begins with the identification of factors that influence spatial and temporal changes in riparian vegetation on the two rivers. For the SPRR this is principally through impacts on the availability of surface water and groundwater, while in the MRG the impacts are through regulation of flooding and human restoration activities. We use the construct of “current conditions” as a basis for making spatial predictions of vegetation change and avian populations in both river systems through linked modeling frameworks. This framework utilizes the best available information through the direct focus on science-based linkages between flow regimes, habitat quality, birds, and human values.

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Geospatial Tracking of Black Footprints in Florida

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It has been estimated that the total global soil carbon pool is four times the biotic pool and about three times the atmospheric pool. Hence, even relatively small changes in soil carbon storage per unit area could have a significant impact on the global carbon balance. Approximately 1,500 Pg C is stored in the upper 1 m of soil in the world, and the sequestration of carbon in soils has been suggested to counteract rising atmospheric greenhouse gas emissions. The soils carbon reservoir is complex due to many overlapping ecosystem processes that continually reshape labile, recalcitrant and total carbon pools in space and time. Thus, much uncertainty still exists to accurately characterize soil carbon – *black footprints* - across larger regions.

Our objectives were to (1) develop a soil carbon inventory of the State of Florida and characterize soil carbon variability using state-of-the-art soil information databases; (2) use a class-pedotransfer function and GIS to upscale soil C from field samples in the Santa Fe River Watershed (SFRW); and (3) backcast and forecast soil carbon in the SFRW accounting for land use shifts.

Florida ranks highest among all other States in the U.S. in terms of soil carbon storage per area. Climatic conditions, high water table and extensive coverage of forest favor accumulation of soil carbon in vegetation and surface and subsurface soils. Major soils that accumulate carbon are Spodosols (~32% coverage in FL) and Histosols (~11% coverage in FL), the latter occurring in wetlands, depressions and areas with high water table. Using a geospatial upscaling process we assessed that the mean soil organic carbon content standardized to a depth of 1 m across all soil types is 7.75 kg m⁻² (SD: 11.0) and 11.64 kg m⁻² (SD: 13.94) across the whole soil profile in the State of Florida. However, soil carbon variability is high depending on site-specific conditions and modulating factors such as land management and carbon inputs, land use shifts, hydrologic conditions, gaseous emissions (e.g. methane) that make soils a sink or source for carbon. Soils high in carbon are Histosols with mean 60.94 kg m⁻² and Spodosols with 16.14 kg m⁻² across the whole soil profile, while in Entisols, due to the high sand content and excessive leaching processes, carbon is low with a mean of only 5.99 kg m⁻². In the SFRW, the total soil organic carbon ranged spatially from less than 0.5 to 61 kg m⁻². A total of 16.513, 6.576, 7.498 and 4.549 million metric tons of carbon were stored in 0-30, 30-60, 60-120 and 120-180 cm soil depth, respectively.

In Florida, soil carbon storage is linked to land use gradients that determine the attainable carbon sequestration in soils which are set by factors that limit the input of carbon to the soil system and environmental factors that conserve soil carbon (e.g. hydrologic/climatic conditions). Since land use shifts in Florida are prominent, soil ecosystem services provided by carbon-rich soils that sequester major amounts of carbon may be lost in the future due to expansion of urban areas, losses of wetlands, and natural conservation land. In multi-functional landscapes, the type, intensity and spatial arrangement of land uses are anthropogenic controlled and could serve as a management tool to optimize soil carbon. Monetary and non-monetary valuation of these black (carbon-rich) footprints in landscapes will be critical to balance carbon losses and gains.

In an on-going project (USDA-NRI #69579) several soil and environmental scientists investigate in more detail black footprints in FL, analyze relationships to various environmental controlling drivers, and develop spectral-based, rapid and cost-effective soil carbon models.

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Ecosystem Services Provided by the Nearshore in Puget Sound: An Analysis of Change

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In principle, the framework of ecosystem services can inform ecosystem approaches to managing coupled social-ecological systems such as Puget Sound, WA. However, the transition from theory to practice is challenging. Making ecosystem services a useful concept to Puget Sound ecosystem management requires basic research on how services vary across the region and how they might be affected by alternative management schemes. We examine a diverse suite of ecosystem services that are derived from nearshore marine habitats across the Puget Sound region and model how changes in the nearshore are likely to affect the flows of those services. First, we will outline the scope of our program, summarizing the range of services within our purview and the ways in which we are modeling them. Then, we will discuss model results from some key services (e.g. the provisioning of seafood and carbon sequestration by eelgrass). Throughout we will emphasize three key themes: 1) the utility of modeling change in ecosystem services under alternative management scenarios, rather than tallying static ecosystem services and their values, 2) the importance of incorporating spatially-explicit information into ecosystem-service modeling, and 3) the benefit of close interdisciplinary collaboration between economists and ecologists undertaking ecosystem services work.

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Development of an Efficient and Credible Forest Carbon Credit Program for Family Forest Landowners in Maine, USA

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High transaction costs and complex rules create barriers for family forest landowners (i.e., those owning 5,000 acres and less) to participate in emerging voluntary and regulatory forest carbon offset markets. Yet more than 40% of the timber harvested annually in Maine comes from these lands. There are more than 100,000 family forest owners in Maine, who together own more than 5.5 million acres, or 33% of Maine's woodlands. Efficient and credible systems are needed if family forest owners are to participate in carbon credit markets or contribute significantly to regional forest carbon sequestration objectives. We present a model carbon credit program based on 12 family forest parcels (3,000 acres total) located throughout Maine, USA.

We used existing infrastructures such as Group Forest Stewardship Council (FSC) certification, cost-share incentive programs, and widely-available forest growth models (USFS NED-2) as a platform for the program. Basic forest inventory data were collected on the family forest parcels and grown in simulation models for 50 years under seven different management scenarios. Practices based on the Maine Forest Practices Act do not define typical management practices for family forest owners in Maine. Therefore, baseline practices were defined based on silvicultural activities reports and input from a technical advisory group. Additionality was defined as the difference between quality management and baseline or "Business as Usual" (BAU) practices. Permanence was addressed by developing a contractual agreement between the landowner and aggregator that is recorded with the land deed. This agreement is less costly and simpler than a conservation easement yet is an enforceable legal instrument to address the permanence of carbon stocks.

We propose that FSC certification provides a useful organizing platform to address the monitoring and verification requirements of a credible forest carbon program. Internal leakage can also be addressed through the requirement of a landowner to enroll their entire ownership in an FSC pool. The FSC standard also provides a third-party assessment and documentation of the co-benefits that can be associated with forest carbon projects. This is particularly useful if projects are being considered for verification under standards such as the Climate, Community, & Biodiversity Standard.

We conclude that significant efficiencies can be created to develop credible forest carbon programs for family forest landowners. However, defining important elements such as "additionality" in a managed forest context remains complex and challenging to prove in the absence of rigorous data and consensus on BAU forest management practices. Transaction costs can be minimized through group certification but overall participation by landowners will likely be limited by carbon price offered and length of agreement required. We also propose recommendations for refinement of forestry offset protocols based on lessons learned from the program development.

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A Scorecard for Evaluating the Quality of Forest Carbon Offset Projects

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Carbon markets are growing rapidly, with virtually no oversight or standardized rules. From 2006 to 2007, the combined regulatory and voluntary carbon markets grew by 72%, from an estimated 1.73 million tons of carbon dioxide equivalent (MtCO₂e) to 2.98 MtCO₂e. Forestry projects are one of the most transacted project types, holding 18% of the global carbon market. Many standards and protocols are used to develop carbon projects and they vary widely. Understanding and navigating the carbon market can be overwhelming, particularly for those unfamiliar with it. How does one determine if a project is legitimate? Has the project adequately addressed issues like additionality, leakage and permanence? How can the relative merits of several projects be compared when different standards or protocols have been used? Manomet attempts to answer these and other questions about forest carbon projects with its *Forest Carbon Offset Project Scorecard* (Manomet Scorecard).

The Manomet Scorecard is a tool for project developers, offset buyers, and others to evaluate the quality of any forest carbon offset project. It is based on an analysis and synthesis of existing GHG protocols and standards. Using 42 yes/no questions, the scorecard examines eight general characteristics of offset projects: (1) contract structure, (2) baselines, (3) additionality, (4) monitoring, reporting, and verification, (5) permanence, (6) leakage, (7) transparency, (8) and co-benefits/costs. We have determined that a high quality forest project is one that is legally sound, accounts for all relevant GHG stocks and flows, results in a net reduction of atmospheric GHG levels, can be easily verified by a qualified third party, results in the permanent removal of GHGs, does not cause leakage, is fully transparent, and does not compromise other important social or environmental benefits derived from forests.

We conclude by applying the scorecard to contrasting forest carbon offset projects to demonstrate its use and utility. We then discuss the implications of the scorecard results. The scorecard is intentionally rigorous to capture the range of forest projects that might exist in any voluntary or regulatory carbon market; therefore, no project is likely to score 100%. The value of the scorecard is in identifying areas of weakness that can be strengthened prior to a carbon offset transaction.

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Launching a Private Landowner Conservation Initiative: “Water as a Crop”

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With a wide array of potential landowner and conservation partners in mind, Sand County Foundation is launching a cross-cutting initiative: “Water As A Crop.” At this time we seek partners, critique, and support so that together we may start to fulfill the need we believe exists for landowners to come to understand that their lands can produce cleaner, more certain supplies of water. It is important that landowners, ranchers, farmers and those who use water begin to think about water as something you create and value.

Landowners throughout the United States – arid regions to humid regions – have a considerable opportunity to enhance the management of their agricultural or forestry operations to produce a cleaner, more consistently flowing, and perhaps, even greater quantities of water. Rewarding landowners for producing water as a “crop” would be a major advance that could transcend political controversies and regional policy disparities.

Sand County Foundation proposes to educate landowners, create awareness in significant policy and natural resource arenas, and seek specific “Water As A Crop” pilot projects on the land. It also plans to connect that awareness and those demonstrated, measured practices to the other side of the demand and use structure so there would be a landowner understanding of its creation, its transfer, and its additional uses and market values.

Demonstrations will tie in with Sand County programs like Pioneering Solutions – Agricultural Incentives and Leopold Stewardship Fund. Elements will include publishing on use of rights and market-based solutions, interaction among leading professionals, outreach to private landowners willing to take on demonstrations which value making decisions based on water as a crop, and encouragement of related research and targeted communications with water buyers, users, and policy leaders. An essential element is to establish long-term demonstrations and monitoring of “Water As A Crop” on private land catchments being committed to higher levels of stewardship.

Sand County Foundation advances the use of ethical and scientifically sound land management practices and partnerships for the benefit of people and the ecological landscape. Building landowners’ awareness of, capacity for, and experience with delivering ecosystem services -- biomass for energy, secure wildlife populations, retention of nutrients -- will be a powerful set of approaches for improved land health.

Aldo Leopold had an appreciation for goods and services that could be produced by well-managed lands and waters, as well as the critical role incentives play in reinforcing responsible land stewardship. Among Leopold’s essays are these quotes of relevance “. . . Conservation will ultimately boil down to rewarding the private landowner who conserves the public interest. . .” and “Conservation is a protest against destructive land use. It seeks to preserve both the utility and beauty of the landscape. It now invokes the aid of science as a means to this end.” Sand County Foundation sees “Water As A Crop” as an opportunity to apply these important words to modern conservation.

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Regional Restoration Planning Case Study in the Delaware Estuary: Ecosystem Valuation Along an Urban Waterfront

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A Regional Restoration Initiative (RRI) is being initiated by the Partnership for the Delaware Estuary, a National Estuary Program, working with several government and non government organizations. The primary goals for this initiative are to (1) facilitate cross-sector coordination among various conservation, enhancement, and restoration efforts already underway, (2) apply best scientific principals to quantify natural capital values for the structural and functional outcomes resulting from different types of restoration efforts, (3) provide decision tools and a registry of high value projects, and (4) encourage ecosystem-based approaches that maximize natural resource benefits over long time scales within the Delaware Estuary and its watershed.

For this effort the Estuary will be divided into four major subregions. Basic restoration matrices (BRMs) will contrast the range of restoration activities that may be applied to benefit various natural resources. Each BRM will be linked to a project database (i.e. a registry) to show where current opportunities exist as well as highlighting areas of project need, especially for “signature” natural resources within that region. The BRMs will evolve into Value Added Restoration Matrices (VARMs) which will include a natural capital layer that includes ecoservice values. This layer will enable decision-makers to pick projects that will yield the highest value of natural capital per restoration investment, and considering long-term ecological trajectories and outcomes. To launch the Regional Restoration Initiative (RRI), the Partnership’s workgroup will initially develop BRMs and preliminary VARMs for up to three natural resource case studies: tidal wetlands, shellfish, and urban waterfront.

The Pennsylvania Environmental Council is leading an effort for ecological restoration along the tidal Delaware River in Philadelphia PA through a Coastal Zone Management grant. Restoration activities within the urban corridor of the Delaware Estuary face many challenges and this effort will provide important information for the urban waterfront case study of the RRI. Urban habitat restoration is challenging because of concerns over high costs, potential contamination, potential impacts on infrastructure, etc. However when a broader suite of ecosystem services in addition to local habitat considerations are considered in the evaluation, urban areas provide substantially more ecoservices than are traditionally realized. An evaluation of this urban pilot area using the BRM and VARM approach in the Delaware Estuary RRI will be presented. Ecosystem valuation for a potential compensatory restoration site in the same area (Lardners Point) for the Athos Oil Spill will also be discussed.

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Critical Issues Impacting the Future Sustainability of Agricultural Systems

Jon Hanson and **John Hendrickson**

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Rapid changes occurring in the agricultural environment are placing increased demands on producers. To respond to these demands, farmers need to manage their systems by reducing risk, while retaining management flexibility. Integrated agricultural systems have the potential to meet these objectives. Six critical issues must be addressed by agricultural managers, policy makers, and researchers to ensure a sustainable agriculture. First, sustainable systems must be flexible enough to respond to the future challenges facing agriculture. Second, newly emerging social and political factors include rising fuel costs, obesity, potential decreases in commodity subsidies, consumer awareness and demands to know how food is produced, and economic returns to land are beginning to drive agriculture. Third, American agriculture operates in a market driven economy that is impacted by policy, technology, and environmental concerns and in turn affect the scale of operation, while controlling management flexibility. Fourth, agricultural incentives control management decisions often to the detriment of the environment. Fifth, enhanced technology has increased the complexity of farming. Sixth, future agricultural systems must address emerging issues in land use, decline in work force and societal support of farming, global competition, changing social values in both taste and convenience of food, and increasing concerns for food safety and the environment. Policies with adequate incentives must be provided for ecosystem services such as clean water and air, productive and healthy soil, habitat development and restoration, and carbon sequestration and storage. Future agricultural systems need to be developed to balance multiple goals and ensure sustainability. A dynamic set of integrated agriculture production principles and practices will allow producers the flexibility to achieve this balance.

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A Conceptual Framework to Analyze the Effects of Environmental Change on Ecosystem Services

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The provision of ecosystem services in the future will be influenced by multiple and interacting environmental change drivers. Assessing the complex effects of these drivers is not a trivial task, made all the more difficult by the lack of a consistent conceptual framework that integrates across multiple ecosystem services. Integration is desirable for a number of reasons: it creates a common framework for applications in different contexts; it standardises concepts and terminology; it makes explicit the exogenous and endogenous components of the system and it can build on well established approaches that are embedded in a number of policy and decision-making organisations and institutions.

We present a new conceptual framework for the assessment of the impacts of environmental change drivers on ecosystem service provision and the policy and management responses that would derive from these impacts and their valuation. The framework is based on an interpretation of the widely-used DPSIR model (Drivers-Pressures-State-Impact-Response). The DPSIR is specifically geared towards policy and management development, explicitly structuring statistics and indicators across the interactions between man and nature. The widespread use of DPSIR should ensure 'buy-in' from many stakeholder organisations involved in the monitoring of indicators related to demographic, socio-economic and environmental conditions.

The new framework includes the definition of Service Providing Units (SPUs) as functions of: (i) the attributes of the biology of the species providing the service, (ii) the attributes of the supporting habitat, and (iii) the attributes of the human beneficiaries of the service. Service Providers can also be defined in terms of functional groups based on their response traits and effect traits to circumvent problems associated with the individualistic responses of species to environmental change. The impacts of environmental changes on service provision then result from the overlap and/or co-occurrence among response and effect traits of service providers. The impact is assessed using valuation techniques to examine trade-offs between the level of service provision from biodiversity and alternative (non-biological) approaches to the provision of the service. Responses, such as policy measures and/or conservation management, are then implemented in accordance with the measured costs of the impact. Results from the EC RUBICODE Project (Rationalising Biodiversity Conservation in Dynamic Ecosystems; www.rubicode.net) will be used to illustrate the framework.

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The Role of Ecosystem Services in Addressing Improved Water Quality in the Chesapeake Bay Watershed

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The Chesapeake Bay is listed as an impaired water body under the Clean Water Act due to poor water-quality conditions for fisheries and submerged aquatic vegetation. The Bay is impaired largely because of low dissolved oxygen levels and poor water-clarity conditions related to nutrient and sediment pollution. To be removed from the impaired water body list, nutrient and sediment related problems in the Chesapeake Bay and its tidal tributaries must be substantially improved. The Chesapeake Bay Program's (CBP) 2008 report to Congress describes partner efforts to achieve a 48 percent reduction in total nitrogen loads to the Bay and a 53 percent reduction in phosphorus from 1985 levels; the resulting load caps are 175 million tons per year for nitrogen and 12.8 million tons per year for phosphorus (http://cap.chesapeakebay.net/docs/EPA_Chesapeake_Bay_CAP.pdf). Current resources to the restore the Bay have been inadequate and the CBP Partners (Federal, State, and local government agencies, academia, and Non Governmental Organizations) have been unsuccessful in meeting their nutrient and sediment load reduction targets. Therefore, a regulatory clean-up plan for the Bay and all impaired tidal waters will be initiated in 2010.

Ecosystem services play a critical role in maintaining and eventually improving the health of the Bay, principally through the removal and storage of harmful nutrients. For example, riparian forest buffers and wetlands can remove and store substantial amounts of nitrogen, phosphorus, and sediment from cultivated fields and animal feed lots, as well as in urban and developed areas. Stream restoration and tree planting have also been shown to be effective in reducing nutrients and sediment. Numerous studies cited in the literature provide both estimates of the nutrient removal efficiencies of these ecosystem services as well as indications of how the efficiencies vary by geomorphic region. However, much work remains to be done to conduct the field and laboratory studies that are needed to better characterize the efficiencies of Best Management Practices (BMPs) and the uncertainty of these measurements.

BMPs that provide ecosystem services, such as riparian forest buffers and wetlands, are a particularly important category of BMPs available to mitigate water quality due to the additional benefits they provide (e.g., habitat, carbon sequestration, aesthetics). Currently, the U.S. Geological Survey and the Chesapeake Bay Program are developing the Chesapeake Online Adaptive Support Tool Kit (COAST), a Web-based framework of tools and information to help meet the needs of CBP partners by applying adaptive management principles to decision making. Data on the characteristics and efficiencies of BMPs involving ecosystem services are being used to build a decision support tool within the COAST framework, which will allow managers to evaluate alternative management approaches to nutrient reduction.

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How to Value Ecosystem Goods and Services in Agriculture at Increasing Land Use Pressure

Katarina Hedlund

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Biodiversity is pivotal for delivering food, fiber and biofuels and carbon storage in agricultural land. However, the demand of land is currently greater than the amount available, as production of biofuels competes with areas for food production and nature. Moreover, intensified land use reduces biodiversity and the resulting ecosystem services and some regions in Europe are approaching the limits of their natural functioning or productive capacity. This talk will give an overview of a recent European research project, SOILSERVICE (<http://www.kem.ekol.lu.se/soilservice.html>), that will link ecological and economic models to develop a system for valuing soil biodiversity and ecosystem services in agriculture. The project will interact with EU policies and strategies to identify what ecosystem services are at risk and how to mitigate changes in soil biodiversity to achieve a sustainable use of soils and contribute to a future EU directive on soils.

The most important ecosystem services in agriculture will be identified and different ways of valuing biodiversity through the impact on ecosystem services will be discussed. New approaches on how to develop ecological and economic models for valuing soil biodiversity in relation to ecosystem services will be presented in the talk. Future scenarios of European agriculture and the impact of the demand of land use will be used for discussion of the value of ecological services.

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Ecosystem Services and the Corps of Engineers – Now that We’ve Looked, What Do We Do?

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The Corps of Engineers is undertaking research to identify the ecosystem services affected by the Corps. This work is part of a larger environmental benefits analysis program, intended to identify concepts, such as ecosystem services, and tools for improving assessment and evaluation of Corps restoration projects. In June 2008, a work group of outside experts, other agency personnel, and Corps planners and resource managers identified 14 ecosystem services affected by Corps actions. A number of the ecosystem services identified are closely related to the Corps' water resources development activities, e.g. Natural Hazard Regulation, Water Supply and Regulation, Erosion Regulation. Other ecosystem services affected by the Corps incorporate an understanding of the systemwide and human uses of the natural resources affected by the Corps missions, e.g. Climate Regulation.

The ecosystem services affected by Corps activities are being reviewed externally, and within the Corps discussions are underway on how these ecosystem services could be used for project formulation and evaluation. The Corps has a rigorous evaluation process, and incorporating new evaluation considerations, such as ecosystem services, would require development of new implementation guidance. Development of that guidance will be part of a broader discussion of guidelines for the environmental benefit tools for planning and evaluating restoration projects.

Ecosystem Services Affected by Corps Activities (Under Review)

- ◆ Water Supply and Regulation
- ◆ Erosion Regulation/Sediment Management
- ◆ Water Purification and Waste Treatment
- ◆ Natural Hazard Regulation
- ◆ Biodiversity Maintenance
- ◆ Recreational Opportunities
- ◆ Food
- ◆ Fiber, Fuel, and Other Raw Materials
- ◆ Climate Regulation
- ◆ Clean Air
- ◆ Science and Education
- ◆ Maintenance of Cultural Diversity
- ◆ Spiritual and Inspirational
- ◆ Aesthetics

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Ecosystem Services and NEPA for the Corps of Engineers

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The Corps has worked diligently to incorporate NEPA into all aspects of our activities. The focus in NEPA on, for instance, quantification of adverse impacts, commitments of resources, and identifying trade-offs, sometimes can detract in Corps studies from understanding the “big picture.” Consideration of ecosystem services is a potential way to portray that “big picture” understanding and to better communicate the outcomes the public can expect from Corps actions. Guidance to address ecosystem services in Corps planning activities will provide the rationale and the services to consider, so that including ecosystem services in NEPA documents will consistent with other planning actions.

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Introduction to Drivers of Agricultural Systems

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Agriculture has been very successful in addressing the food and fiber needs of today's world population through the development of highly specialized but uncoupled agricultural enterprises. However, concerns have arisen because of real or perceived negative impacts of highly specialized agriculture systems on ecosystem services such as water supply, erosion control and nutrient cycling. Over half of the land area in the lower 48 states is used for cropland or grazing compared to only 3.1% for urban uses. Thus, agriculture has an opportunity to have a strong positive impact on ecosystem services. To maximize this opportunity, agricultural systems need to be re-coupled through the development of integrated agricultural systems. In order to understand how this may be possible, current agricultural systems, as well as the drivers that shape them, need to be defined. We have identified four main groups of drivers, social/political, economic, environmental and technological, that have impacted and continue to shape agricultural systems. We defined integrated agricultural systems as systems with multiple enterprises that interact in space and time, resulting in a synergistic resource transfer among enterprises. We feel integrated systems have two major advantages over more specialized systems. First, the resource transfer between enterprises can address many concerns regarding water quality, erosion control and nutrient cycling. Second, integrated systems, because of their diversity, may be more able to adapt to changes than specialized agricultural systems. This ability to adapt to unforeseen future changes is a key aspect of sustainability.

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Florida Critical Lands and Waters Identification Project

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The Florida Critical Lands and Waters Identification Project (CLIP) is a cooperative effort between the Florida Century Commission, the Florida Fish and Wildlife Conservation Commission, the University of Florida GeoPlan Center (UF), and the Florida State University Florida Natural Areas Inventory (FNAI) and other partners to identify areas of ecological significance throughout Florida. The UF and FNAI have been working since 2006 to identify Geographic Information Systems (GIS) data sources that are available at a statewide scale for identifying areas of significance and then developing methods for integrating these data.

The CLIP database is hierarchical including individual GIS layers identifying priorities for specific resources, resource categories representing priorities within defined categories, and an integration of all layers to identify aggregated ecological conservation priorities. Current categories include biodiversity, landscape, surface water, ground water, and marine. Three of these categories (biodiversity, landscape, and surface water) are integrated using a combination of rules and geographic overlays to identify aggregated priorities. All of these categories represent aspects of ecosystem services that are critical for protecting Florida's green infrastructure.

The CLIP database identifies ecological priorities throughout Florida, with approximately 50% of land in Florida within high priority areas. Specific areas of interest in the results include: south-central Florida north and west of Lake Okeechobee; the primarily public lands of south Florida and the Everglades; the large National Forests, Department of Defense lands, and connecting corridors through central and north Florida; the Big Bend coast; and large river systems such as the St. Johns, Kissimmee, Suwannee, Apalachicola and Choctawhatchee. These results do not identify all areas of ecological significance. CLIP will be an iterative database that will be enhanced as new and updated data becomes available. Specifically, we are still developing the marine and ground water data for full integration into the next version of the CLIP database. In addition, we will be exploring the incorporation of other data including ecosystem services such as carbon sequestration. We may also represent management and landscape context priorities such as smoke buffers in future iterations.

CLIP provides a consistent statewide spatial conservation planning tool that can be combined with other information to support a variety of state, regional, and local planning programs and activities. CLIP can serve as a flexible spatial tool to facilitate the identification of conservation constraints and opportunities when compared to other data including working landscapes, development proposals, growth projections, and transportation infrastructure. Florida is fortunate to have a wealth of high quality GIS data, and CLIP provides an integrated data support framework that utilizes this wealth of GIS data to support the critical planning needed at all scales to ensure a sustainable future.

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Quantifying Environmental Services in a Resource-Limited World

Skip Hyberg and *Richard Iovanna*

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During the preindustrial era when the U.S. economy, population, and resource needs were relatively small, society benefited from converting more and more land. Farming and resource extraction was limited to a fraction of the landscape and there was plenty left over to generate the other more subtle ecosystem services that sustain life and contribute to human well being. In fact, the losses in services from breaking out another acre of sod during this time were so marginal that the services, themselves, typically went unappreciated and even unnoticed.

Now we find ourselves in a “limited” world where the situation has reversed and virtually all of the landscape in some regions of the country is developed for human habitation or otherwise intensively managed to produce food and raw materials. As a consequence of its newfound scarcity, the ecosystem services that are generated by land whose ecological integrity remains intact or that has been restored are becoming increasingly apparent. Farming, in particular, occurs at such a scale and at such intensity that it can be the case that the ecological losses associated with farming a particular acre are more significant than the benefits in terms of reduced crop prices.

As awareness that tradeoffs even exist has developed, so too has our ability to assess ecosystems’ contribution to our well being. To achieve a socially-optimal mosaic of land uses on the landscape, tools are needed that quantify the impact of conservation programs on the provision of ecosystem services. These tools have to be able to assess the effect of land-use changes at a very fine scale on the larger landscape context within which the change occurs. Further, policy-relevant tools have to be as comprehensive as possible: Precise estimates of a subset of ecosystem services and little sense of the magnitude of the rest will result in welfare losses for society. It is incumbent upon research and implementing agencies to collaborate in the required effort.

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Quantifying Environmental Services in a Resource-Limited World: The Significance of Scale and Scope

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Our ability to quantify environmental services is greatly influenced by the scope of the system being examined and the population deriving benefits from that system. Applying the appropriate analytical framework is essential to accurately estimating the services provided by that system. Quantifying environmental services from wetlands in the Mississippi Alluvial Valley (MAV) provides an example of the role of scale and scope in evaluating large integrated ecosystems.

The role of scale and scope will be illustrated by contrasting issues involved in estimating environmental services provided by wetlands in the MAV against those provided by pothole wetlands in the Northern Prairie Region. By comparing estimation processes used to calculate services provided by a precipitation/evapo-transpiration system and a sub-continental watershed system we emphasize the need to clearly identify and specify the markets being analyzed.

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Valuing Ecosystem Services from Wetlands Restoration in the Mississippi Alluvial Valley

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Under appropriate conditions, restoring wetlands on crop fields can result in a net increase of ecosystem services and therefore a net benefit to society. This study assesses the value of actions to restore wetlands via the Wetland Reserve Program (WRP) in the Mississippi Alluvial Valley (MAV) of the U.S. by quantifying and monetizing ecosystem services. Focusing on hardwood bottomland forest, a dominant wetland type of the MAV, *in situ* measurements of multiple ecosystem services are made on a land use continuum of agricultural land, wetlands restored via WRP, and mature bottomland forest. A subset of these services, namely greenhouse gas (GHG) mitigation, nutrient mitigation, and waterfowl recreation, are selected to be monetized with benefit transfer methods. Above- and belowground carbon estimates and changes in methane (CH₄) and nitrous oxide (N₂O) emissions are utilized to project GHG flows on the land. Denitrification potential and foregone agriculture-related losses are summed to estimate the amount of nitrogen prevented from entering water bodies. Increased duck energy days on the landscape represent the WRP-induced expansion of waterfowl habitat. We adjust and transform these measures into per-hectare, valuation-ready units and then monetize them with prices from emerging markets (GHG) and environmental economic literature (GHG, nutrient, recreation).

Valuing all services produced by wetland restoration would yield the total ecosystem value of the change; however, due to data and model limitations we generate a partial estimate by monetizing three ecosystem services. Social welfare value is found to be between \$1,800 and \$1,851 per hectare per year, with GHG mitigation valued at \$162 to \$213, nitrogen mitigation \$1618, and waterfowl recreation \$20 per hectare. Limited to existing markets, the estimate for annual private value is merely \$117 per hectare whereas, when accounting for potential markets, the estimate rises to \$1243 per hectare. The estimated social value surpasses the one-time public expenditure or social cost of wetlands restoration (\$2526 per hectare) in the MAV in only 2 years, indicating that the ecosystem service value return on public investment appears to be very attractive in the case of the WRP. Moreover, the result that annual potential private value is substantially greater than regional agricultural rents (\$368 per hectare) indicate that payments to private landowners to restore wetlands could be profitable for individual landowners as well as be value-enhancing to society. This should help to motivate the development of ecosystem markets to more fully integrate societal values into land use decisions.

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A GIS Analysis of Ecosystem Services in the Cache River Watershed, Arkansas

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This U.S. Forest Service funded study intends to visually and spatially lay out the menu of ecosystem services provided to landowners by restoration of bottomland hardwood forests in the Cache River watershed, Arkansas. These ecosystem services include land suitable for the sale of hunting leases, land suitable for carbon sequestration services, and assessing land for runoff and erosion potential. Key services were identified on marginal agricultural land where the owner would receive a greater payment for ecosystem services than for farming the marginal land.

The Nature Conservancy's (TNC) goal was to identify sub-watersheds and landowners within the Cache River watershed that would benefit most greatly from ecosystem services provided by reforestation of marginal agricultural land. Using the GIS "Pollution Potential" toolbox developed by Giasson*, a watershed can be assessed for its potential to generate non-point source pollution. The toolbox uses slope, flow length and natural soil drainage characteristics as well as elevation data to determine areas at greater risk of generating non-point source nutrient runoff. The information provides a basis for discussion with landowners regarding ecosystem services and potential management strategies.

In addition to applying the toolbox created by Giasson, TNC created a suite of ArcGIS tools for application on additional Hydrologic Unit Code (HUC) 8-digit watersheds in the Lower Mississippi Valley (LMV). The Ecosystem Services Assessment Toolbox (ESAT) includes detailed help files and prepackaged models designed to define priority sub-watersheds within larger watersheds. Geographic Information Systems (GIS) data used in the ESAT are adapted from sources that are readily available and accessible to researchers. TNC also created a cadastral database to identify landowners with greater than 500 contiguous acres that fall within the boundaries of priority sub-watersheds. Larger tracts of land would yield greater payment from services and have a larger impact on the ecosystem.

Further validation and testing of the ESAT on additional watersheds throughout the LMV is in progress. The ESAT is being used by TNC in addition to on-the-ground monitoring as a decision support tool for prioritizing conservation efforts in the Cache River watershed. The ESAT is intended to advance the effectiveness of ecosystem services throughout the LMV. Quantifying and mapping ecosystem services is a critical step in implementing this up-and-coming conservation initiative in the LMV.

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Modeling Potential Impacts of Climate Change on Freshwater Fishing Habitat in the United States

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The Intergovernmental Panel on Climate Change's Fourth Assessment Report indicates that a doubling of CO₂ in the atmosphere would likely result in a 2 – 4.5°C increase in average global temperature compared to the 1980-1999 time period. Projected future increase in temperatures, as well as changes in precipitation patterns, will undoubtedly influence freshwater fisheries in the United States.

In this study, we developed a model to examine the potential impacts of climate change on habitat suitability for freshwater fish assemblages in the United States. Our analysis focused on projecting potential impacts from changes in temperature and precipitation, estimated from three climate change models over three periods, on fish communities.

Using a geographic information system (GIS), we developed a spatially-explicit modeling framework of grid cells organized into 8 digit hydrologic unit code (HUC) polygons for the coterminous United States (a total of 2,099 HUCs). Projected temperature and precipitation changes associated with climate change were obtained from the Model for the Assessment of Greenhouse-gas Induced Climate Change (MAGICC) and SCENGEN (a regional climate SCENario GENerator). Climate projections were obtained for three time periods (2030, 2050, and 2100) and three greenhouse gas emissions scenarios representing low, moderate, and high emissions (IPCC scenarios B1, A1B, and A1FI respectively). We then generated a grid of projected water temperatures using regional air/water temperature regressions. These regressions were developed using available stream temperature data and air temperatures determined from PRISM. To assess thermal habitat suitability for fish, the average water temperature within each 8-digit HUC was compared to a maximum water temperature tolerance of coldwater and warmwater fish guilds. To examine the impact of changes in precipitation, we quantified the MAGICC/SCENGEN projected changes in precipitation over the contributing area of each watershed and used the percent reduction in total precipitation as a proxy for the change in stream flow and subsequent reduction in habitat.

Although projections vary somewhat by emissions scenario and year, in general the spatial distribution of coldwater fisheries is predicted to contract as a result of future climate change, being replaced by warm/coolwater and rough fisheries. Habitat for warmwater fish, in turn, is projected to be replaced by waters suitable only for rough fisheries. As expected, these projected changes are more pronounced in 2100 than in 2030, and are greater under the A1FI high-emission scenario than the low-emission B1 scenario. Under the A1FI scenario, by 2100 the habitat of coldwater fisheries is projected to decline by roughly 55%, and would be limited to mountainous areas in the western United States and cooler areas of New England and the Appalachians. The results of our qualitative precipitation analysis show that under all emissions scenarios, precipitation contributing to streamflow in the eastern and northern United States is anticipated to increase, and will likely lead to increases in streamflow. In contrast, precipitation over watersheds in the western United States and southern Florida is projected to decrease, which will likely result in decreases in streamflow that would likely correspond to reductions in fish habitat.

The results of this study can help local stakeholders and decision-makers understand the potential impacts to freshwater fisheries resulting from climate change. These results can further be used to estimate the potential benefits from reductions in greenhouse gases.

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Integration of Ecosystem Services into a Decision Support Platform

Mark A. Judson

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Explore the possible impacts and alternate futures of land management decisions with an introduction to tools and methods available to enhance decision-making activities. Real world scenarios are presented to develop a business case for making an allowance for ecosystem services in day to day business activities.

Ecological forecasting tools provide an indication of the future health of ecosystem services deemed most valuable to human wellbeing. Such tools can be extremely valuable in defining actions required to maintain services that many urban coastal regions provide, while enhancing the revenue base to their associated communities.

Remote Sensing products are being integrated into decision support platforms for the purpose of landscape characterization and assigning a meaningful valuation of benefits provided by ecosystems services over a short, medium and long period of time. Decision support platforms of the future will deliver maps and models to render a spatial visualization of the valuation of ecosystems services presented within a given area.

New methods of exploring ecosystems services are being developed to transform ecosystem services into web based decision support tools. Next Generation environmental dashboards will combine spatial information, ecological models, and historical/near real-time sensor data within a common framework to qualitatively and quantitatively describe the effects of change and impacts of urbanization, and environmental policies.

Interactive simulation models are also introduced to hypothesize on the tradeoffs associated with a land use decision. The results enable policy-makers to anticipate the outcome and make better decisions. Improvements in the quality of environmental data will also allow decision-makers to optimize the benefits of ecosystems services against the benefits of manmade development projects.

The insights discovered by utilizing such tools allow both federal and local government policy-makers to determine budget allocation among local and state agencies to best maintain the quality of ecosystem services provided in a specified region of interest.

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Spatio-Temporal Dynamics of Phytoplankton of a Tidal Coastal Creek, Lagos, Nigeria

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An annual study of phytoplankton and physical and chemical variables of Five Cowries Creek, Lagos, Nigeria, was undertaken from January 2002 to December 2002, to investigate spatial and temporal variations in water quality and phytoplankton flora. Samples were collected at monthly intervals from three stations. Phytoplankton samples were collected for qualitative and quantitative analyses. While qualitative phytoplankton samples were obtained by towing a 55-micron mesh plankton net, quantitative samples were collected by concentration using sedimentation technique. Water quality measurements were made with Hach DR 2000 and phytoplankton were enumerated using the drop count method. The results showed spatio-temporal variations. There was a distinct seasonal variation in the parameters studied. The phytoplankton assemblage comprised moderately diverse taxa categorized into the divisions Bacillariophyta, Chlorophyta, Cyanophyta and Dinophyta. The diatoms or Bacillariophyta dominated the phytoplankton both qualitatively and quantitatively. There was no incidence of bloom-formation during the study period, though there was presence of bloom-forming species. The Creek is brackish, with slightly acidic to circum-neutral pH, with high levels of nutrients and prone to high levels of pollution. Regular and continuous monitoring of the creek is recommended to ascertain the possible onset of phytoplankton bloom and occurrence of harmful algae, to enable formulation of good management practices important or critical for fisheries, recreation and ecosystem health.

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Evaluating Hydrological Response to Forecasted Land-Use Change: Scenario Testing in Two Western U.S. Watersheds

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Envisioning and evaluating future scenarios has emerged as a critical component of both science and social decision-making. 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 environmental services now and into the future. During the past two decades, important advances in the integration of remote imagery, computer processing, and spatial-analysis technologies have been used to develop landscape information that can be integrated with hydrologic models to determine long-term change and make predictive inferences about the future. Two diverse case studies in northwest Oregon (Willamette River basin) and Southeastern Arizona (San Pedro River) were examined in regard to future land-use scenarios relative to their impact on surface-water conditions (i.e., sediment yield and surface runoff) using hydrologic models associated with the Automated Geospatial Watershed Assessment (AGWA) tool. The base reference grid for land cover was modified in both study locations to reflect stakeholder preferences twenty to sixty years into the future and the consequences of landscape change were evaluated relative to the selected future scenarios. The two studies provide examples of integrating hydrologic modeling with a scenario analysis framework to evaluate plausible future forecasts and understand the potential impact of landscape change on ecosystem services.

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Quantifying Links between Ecosystem Services and Poverty in Rural Mali

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While the importance of ecosystem services for supporting human livelihood is often assumed, it is rarely explicitly demonstrated. Our research tests the hypothesis that ecosystem services contribute to human well-being, starting with the assumption that reliance on ecosystem services is most pronounced among the rural poor that are directly dependent on their local environment. We chose rural Mali, a nation in West Africa that spans a climatic gradient from semi-arid to desert, as the study area because of well publicized effects of climate and soil variability on rural production capacity. Environmental services were evaluated at two scales using remote sensing. First, time series analysis of rain use efficiency (RUE) trends (up, down, no change) over the last 30 years in the Sahel were detected via analysis of high-frequency NDVI patterns extracted from the MODIS satellite platform. Regions of the landscape that have become detectably less efficient at using available rainfall to generate primary production were judged to provide lower levels of ecosystem services. Second, Landsat imagery from a local administrative district (Segou) was used to determine metrics of soil quality (for bare areas) and forest cover. Household proximity to high quality soils and dense forests were judged to have greater access to ecosystem services. To evaluate human well-being, we used household level livelihood analysis from over 2800 households within 77 villages in the Sahel zone of central Mali. Villages were selected across the full range of RUE trend values; in addition villages were selected based on differential levels of market integration (proximity to regional markets), access to natural resources (principally rivers) and infrastructure (principally roads). The wealth survey used to evaluate livelihoods used community-defined wealth indicators, addressing a universal weakness of previously published surveys by including an explicit accounting of all assets instead of only asset presence or absence. A hierarchical mixed model was used to evaluate covariance between evidence of environmental services and human well-being. By incorporating various factors which contribute to household wealth, this study is the first that explicitly quantifies the environment-poverty link and establishes the relative importance of ecosystem services in supporting human livelihood.

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Conceptual Framing for Landscape-level Assessment of Ecosystem Management Choices

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Policymakers and public lands managers desire ways to evaluate and display the likely outcomes of policy and management alternatives to address forest health, wildfires, habitat for endangered species, and other social goals regarding ecosystems. In practice, however, landscape planning and ecological assessment efforts face challenges arising from their multidisciplinary nature. Landscape ecologists and economists, for example, initially may approach land management questions using different language and concepts. Ecologists might focus first on how management actions affect key ecosystem components and influence interactions with other components, while economists might focus more on the ways in which management outcomes benefit or harm humans. Developing a common language and agreement on key concepts and problem framing is a necessary first step for research teams initiating multidisciplinary projects.

The desire to describe and evaluate the human benefits arising from landscapes—especially federal forests—is not new. Early attempts can be found in the work of economists dating from at least the 1950s who characterized multiple-use management as the joint production of beneficial forest outputs, such as timber, forage, and water, and habitat for species of commercial or recreational interest. However, implementing such problem framing in multidisciplinary research has been hampered by a lack of common understanding about what such framing calls for in the actual work by economists and ecologists. The ecosystem services concept provides an effective way to foster multidisciplinary analysis regarding ecosystems and their management by better bridging the language and concepts of economics and ecology. For economists, the only real difference between ecosystem services and economists' traditional notion of multiple forest benefits is the emphasis on ecosystems as an organizing structure of benefits. Emerging ecological economics perspectives also consider the role of natural capital as a factor of production to more fully account returns to ecosystem protection. For ecologists, ecosystem services describe human benefits in terms that more closely match the ecosystem components that ecologists study, allowing greater consideration for the spatial processes and interactions involved in their production. Increasingly, multidisciplinary interests also include the role of ecosystem services outputs as feedbacks that influence subsequent policy and management objectives.

We will describe an ecosystem services conceptual framework for multidisciplinary landscape planning and ecological assessment to support public lands policy and management. We will briefly discuss issues in identifying workable ecosystem services typologies and distinguishing between stocks and flows in the production of human benefits. We then will focus on the challenges involved in projecting ecosystem services metrics through time as trajectories that are influenced by management actions and ecosystem dynamics. This arguably is the biggest obstacle to effective integration of economics and ecology in landscape planning and ecological assessment. We will highlight both the most promising and the most challenging aspects of applying the conceptual framework to addressing real-world landscape policy and management questions, drawing upon our research experiences in Alaska and Oregon.

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Bayesian Modeling of Ecosystem Services in Human-Environment Systems

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The adaptive management of ecosystem services requires knowledge about the interdependence of land use decision-making and the ecosystem features in a given landscape; and how this coupled human-environment system is influenced by drivers of global change. The problem in this context is, that both decision-making processes and the ecosystem changes are subject to large uncertainties and incomplete information. Furthermore, trade-offs between different ecosystem services and biodiversity exist and actors tend to maximize only one feature. The adaptive management of an entire system thus needs to find a solution, which optimizes all ecosystem services given uncertain information.

For this purpose, we develop a Bayesian Network BN of the human-environment system allowing evaluating simultaneously the effect of different decision-making processes on ecosystem responses and updating the results when better information becomes available.

We test the approach in a case study in the Swiss Alps, where we focus on integrating the value of different ecosystem services as a support for landscape planning. Results show that if uncertainties are not explicitly integrated into the modeling framework, the information provided to the decision-makers might be misleading.

For a case study in a Costa Rican watershed, we expand the BN with exogenous drivers from market (e.g., change in price for crops), policy (e.g., change in national park border) and climate (e.g., change in frequency of heavy rainfall). Policy instruments like command and control, park zoning and payments for ecosystem services can help reaching a more balanced management of a watershed. For the planning of those instruments, however, it is helpful to have a model which shows how the manager of individual land units, takes policy measures, together with expected market changes and climate change into account in his land use decision-making. For each management unit, the prior probability of a specific land use and cover is updated with a posterior probability, when additional information about the management unit (e.g., slope, soil type, governance) is available.

This type of model can be used to plan and simulate new policy measures like payments for ecosystem services, because it simultaneously takes the ecosystem, socio-economic system and the policy system into account. The model allows identifying management units with high and low values for each ecosystem services and thus the targeting of available financial funds can be optimized. First working steps show that such a BN provides a robust modeling environment, useful for better informed and participatory decision-making.

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Law and Policy of Ecosystem Services

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Ecosystem services are complex ecologically, geographically, and economically. So are invasive species, climate change, nanotechnology, poverty, and a host of other “wicked” issues that challenge law and policy. The difference is that all those problems have found the attention of policy makers and have been addressed, albeit with varying success, in tangible ways through law and policy, whereas ecosystem services have been largely ignored.

The central purpose of this paper is to focus debate on the essential need to construct a law and policy of ecosystem services and how it can be configured. We emphasize that ecosystem services are complex in all their dimensions, but that the disciplines of ecology, geography, and economics are making significant strides in forming qualitative and quantitative understandings of the value of natural capital and the ecosystem services it provides at various scales.

We show that natural capital and ecosystem services are valuable and of critical importance to the continuance of modern society, but also that law and policy do not adequately take those values into account while providing a protective framework. We develop the concept of The Tragedy of Ecosystem Services, a case of *under-production* that happens because mechanisms are missing for rewarding investments in natural capital that produce ecosystem services. No one devotes resources to improving the pasture or habitat for fish in the ocean or sequestering carbon or restoring wetlands that filter water pollutants because they would not receive a resulting revenue stream to finance the investments made. Rather the ecosystem services made possible by these investments are public goods, they are common pool benefits that accrue over time to a population within a geographical area affected by the improved ecosystem service flows. Once produced and made available to the larger community as *positive* externalities, no one in this geographical area can be denied the benefits, and the owner of the natural capital therefore lacks a means to charge the beneficiaries, even if they would be willing to pay the cost of ecosystem service provision and even if the generation of ecosystem services is the highest and best use of natural capital resources such as land.

There are no simple solutions to the Tragedy of Ecosystem Services and we do not attempt to provide a silver bullet. Nevertheless, with a proper diagnosis we can point to potential cures along three avenues that will guide the transition from the status quo to more desirable conditions: (1) changes in the common law of property as, (2) readjusting the economic playing field into an ecological-economic playing field by signally the value of ecosystem services in decisions over the allocation of natural capital, and (3) the development of geographically defined governmental institutions for the regulation of natural capital and the provision of ecosystem services as public goods.

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Habitat Equivalency Analysis (HEA) as a Tool to Rank Environmental Project Alternatives

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Project alternatives for environmental projects are often difficult to compare and rank because each alternative may have different magnitude and types of impacts to multiple habitats over varying time scales (e.g., short-term, long-term). Habitat Equivalency Analysis (HEA) is a methodology developed by the National Oceanic and Atmospheric Administration (NOAA) that can quantify and compare the net environmental effects on affected habitats, including the short-term and long-term effects of project alternatives and compensation measures. It can be used to rank the alternatives according to their relative net environmental impact, which helps project teams and decision executives identify the alternatives with the most favorable (or most adverse) environmental effects.

The use of HEA proved critical to identifying the environmentally superior alternative proposed to regulatory agencies for the disposition of the Chevron 4H Shell Mounds. The 4H Shell Mounds are drill cuttings (and associated drilling fluids) piles, covered by several feet of shell hash, off the coast of California that were left following removal of the 4H platforms. As part of a California Environmental Quality Act process, Chevron was requested to propose a project for the final disposition of the 4H Shell Mounds. Chevron evaluated four project alternatives: leave in place with offsite compensation in the form of enhancement of a nearby salt marsh, enhancing with an artificial reef, capping, and removal by dredging. A HEA was performed that compared the net environmental impacts of the four project alternatives on an important marine biological resource (i.e., fish habitat value). The HEA demonstrated that leaving the mounds in place with enhancement of a nearby salt marsh (i.e., offsite compensation) provides the greatest gain in fish habitat value while averting significant and unavoidable impacts to the local marine environment associated with mounds removal. Besides this demonstrated use of HEA to identify the environmentally superior alternative within an environmental impact assessment (EIA) process, HEA should prove equally valuable for scaling the actions necessary to mitigate environmental impacts.

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A Marginal Value Priority Setting Framework for Ecosystem Services

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The field of systematic conservation planning can offer much to the growing interest in the conservation and management of ecosystem services. In particular, dynamic spatial frameworks for setting conservation priorities that can model and map ecosystem services, assess trade offs, and prescribe actions to meet conservation goals could greatly assist environmental managers. Here we present a general conservation planning tool and discuss its applicability to ecosystem services. Our marginal value approach differs from many others due to its ability to incorporate multiple criteria that can represent different interest groups, conservation goals, or various ecosystem services. The inclusion of potential conservation expenditures allow for the planning model to work within the goal of cost-effectiveness, while incorporating threats into the conservation calculus directs actions to protect resources that would likely be lost without intervention. We demonstrate with a case study examining multifunctional farmland conservation in the Central Valley of California. By assessing the similarity of parcel rankings we find our results are relatively robust to different hypothetical conservation interests, yet the distribution of scores is highly skewed, indicating few 'win-win' situations. These results highlight the need for planning support tools that can differentiate between acceptable and exemplary conservation investments to secure valuable ecosystem services. Future research directions include ecosystem service models that can be calibrated and verified using empirical data and an automated dynamic updating routine to allow scenario planning.

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Ecological Valuation for Land Use Planning Decision Support in South Florida: The Ecosystem Portfolio Model

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Land use decision-makers and natural resource managers in South Florida must reconcile intense land development pressures with the goal of sustaining the natural environment, including Federal, State, and County protected lands. In an effort to promote the consideration of integrated ecological, economic, and quality-of-life information in this context, we have developed the South Florida Ecosystem Portfolio Model (EPM), using Miami-Dade County as a pilot site.

The EPM is a Geographic Information System-based multi-criteria decision support web tool that evaluates land use plans and proposed land use/land cover (LU/LC) changes in terms of performance criteria related to three dimensions of value: 1) modeled ecological criteria related to ecosystem services, expressed as “ecological value” 2) predicted land market prices and the associated probability of LU/LC conversion, and 3) community quality-of-life indicators. Each of these dimensions is implemented as a sub-model of the EPM that generates “value maps” for a given land use pattern and set of user-elicited preferences, where the value map reflects changes in parcel and landscape attributes. The modeled parcel/landscape attribute changes are related to land use/cover change, including changes in habitat potential and landscape fragmentation, distances to human perceived amenities, community “character”, flooding and hurricane evacuation risks, water quality buffer potential, ecological restoration potential, and other relevant performance criteria. The individual performance criteria and metrics used to implement the ecological value component and the community quality-of-life indicators were chosen in consultation with potential EPM users and land use stakeholders, using the principles that the criteria must reflect the range of values at stake and predictably respond to land use/cover change.

The EPM web interface allows the user to explore the individual value maps for each unique criterion or, after applying user-chosen multi-criteria weights, as an aggregated value map. The EPM also allows users to evaluate and compare potential land use patterns in a variety of ways. For example, users can examine the resulting value maps for one or more land use/cover patterns under different weighting schemes, allowing the user to explore how different prioritizations of objectives affects the evaluation process. More broadly, users can also compare ecological value maps, predicted land price maps, maps of community quality-of-life indicators for sets of land use/cover patterns to characterize regional-scale trade-offs between ecological, economic, and social values. By using maps as the means of comparison, local details are retained, while regional patterns emerge.

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Provision of Multiple Services by Mountain Grasslands is Determined by Land Use History

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In European mountains, biodiversity of grasslands has been determined by multiple centuries of agricultural use. Multi-functionality has been for centuries an essential feature of these agroecosystems, where multiple services are valued beyond fodder production. Today, the political and socio-economic context makes this multi-functionality a potential asset for these fragile systems, and understanding its drivers to predict its future is a priority. Using a complete survey of vegetation floristic and functional composition, grassland production, along with locally established relationships between this biodiversity and key ecosystem functions, we analysed the main factors controlling the distribution of biodiversity and ecosystem services within the pastoral landscape of Villar d'Arène, France. We asked: (1) What are the relative roles of abiotic (topographic, altitude) and land use factors on the distribution of individual services? (2) Where are the hot (many valued services) and cold (low value for the majority of services) spots for multi-functionality in this landscape? (3) What determines tradeoffs and synergies among different services? Results are interpreted in the context of possible scenarios of land use change within the next decades.

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The Role of Place-Based Projects as Ecosystem Service Laboratories

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Successfully addressing the increasingly complex ecological problems throughout the United States requires an integrative and innovative approach. In this regard, the concept of ecosystem services has emerged as a promising approach for improving environmental decision making. Within the USEPA Ecological Services Research Program, a set of place-based studies are being implemented to explore a wide range of attributes associated with ecosystem services. The places were selected to capture within region gradients of the broad scale drivers of climate, N deposition, and human population. Moreover, the study sites provide unique associations of community and stakeholder involvement not typically included in traditional ecological research. The community and stakeholder context of ecosystem services for these study sites is as variable as the landscapes, climates and management regimes in which they are located. Presently, there are four place-based studies within the ERP: The Future Midwest Landscapes, Coastal Carolinas, Tampa Bay and Willamette Ecosystem Service Projects. The mixture of sites provides an opportunity to investigate multiple components of variability and predictability under relatively defined, and in some cases manipulated, systems and landscapes. While various sites have different foci, a common set of services will act as the starting point for evaluating societal/ecological issues and provide the scientific data and knowledge necessary to move ecosystems services from the concept realm to that of implementable policy. We explore the nature of this place-based approach using the Willamette Ecosystem Service Project as an example of approaches to investigating ecosystem services to address such issues as mapping, developing response functions between ecosystem services and forcing variables, bundling ecosystem services, valuation, spatial scaling and linking societal needs to ecosystem services via decision support tools.

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Evaluating Ecosystem Services Using the Virtual Watershed Model

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Decisions regarding land use have economic and environmental consequences. However, the relationships among market and policy forces, land use decisions, and economic and ecological outcomes are not well understood. *Virtual Watershed* captures the interactions among economic and ecological conditions, public policies, land manager behavior, and historical land use in generating rural landscape patterns. *Virtual Watershed* combines environmental simulation models, geographic information systems, evolutionary algorithms, and agent-based modeling to determine the optimal or near-optimal production of suites of agricultural commodities and ecosystem services at a watershed scale. The model facilitates the assessment of different landscape patterns associated with these suites. Informed by knowledge of near-optimal landscape performance, the set of public policies affecting land managers in a watershed can be modified and the resultant economic and ecological outcomes can be monitored. Of particular interest is the complex nature of landscape change over time and the capability of adaptive management processes to guide landscape change to meet user-defined social goals in a co-evolving socio-environmental system.

The introduction of *Virtual Watershed* will provide for an understanding of the interactions and feedbacks that result from policy initiatives. In this capacity it serves as an educational tool and as a laboratory for policy makers to test the outcomes of public policy alternatives. One primary hypothesis is that the environmental performance of agricultural landscapes can be markedly improved while not reducing income to land managers through changes in incentive structures such as forms of agricultural subsidization, land retirement programs, and cost-sharing for adopting new practices. In testing these hypotheses, the project achieves a better understanding of the independent and interdependent roles of economic conditions and incentives, environmental policies, behavior of resource managers, and pre-existing landscape patterns on the dynamics of landscape change, as well as the trade-offs and complementarities among economic and ecological goals for agricultural watersheds.

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Analysis of Biomass Equations for Common Urban Trees in Gainesville, FL

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Large trees in urban areas claim a great presence in our daily lives, but the role they play in the urban carbon cycle is becoming more important than ever. As carbon emissions from cars and energy consumption are reduced, the amount of carbon stored and sequestered by urban trees is becoming a significant part of the total carbon pool. Moreover, as climate change leads to more severe windstorms, post-hurricane debris estimates from urban trees are needed to aid in city planning. Biomass estimates based on urban tree surveys need to be as accurate as possible, not only for carbon storage but also for post-storm debris estimation and urban planning. In 2007, Gainesville, Florida was assessed by the Urban Forest Effects Model (UFORE) to determine the size and composition characteristics of Gainesville's urban forest as well as other components such as tree condition and shading. The results revealed that Gainesville's total biomass is mostly comprised of *Pinus elliottii*, *Quercus laurifolia*, *Quercus virginiana*, and *Pinus taeda* (17.7%, 16.5% , 14.1%, and 8.7% respectively). Diameter based allometric biomass equations have been obtained from tree studies for many species and regions across the United States. Generalizing a plethora of equations for different sites and objectives with inconsistent definitions, equation forms and input data standards proves very difficult and few scientists have attempted such a project. The purpose of this study is to create a protocol to compare biomass estimates obtained using two sets of published generalized biomass equations and biomass estimates from UFORE, with a University of Florida biomass study of *Quercus laurifolia*, *Quercus virginiana*, and *Pinus taeda*. This is important because many of the biomass studies used to develop published equations were conducted in northern regions with less sunlight and shorter growing seasons. We will compare estimates of the generalized biomass equations with each other, the Gainesville UFORE estimates (which are adjusted for Gainesville's specific characteristics), and a local tree biomass study. This will reveal regional discrepancies created when using generalized biomass equations to make estimates in specific geographic areas. Ultimately adjustment factors can be generated for a local region based on the comparison of generalized biomass equations and locally sampled trees from the city of interest. Being able to adjust for regional differences when determining biomass will prove valuable when the cost of underestimating the economic value of urban carbon storage is realized, especially for large trees that comprise the largest proportion of biomass in a city's carbon pool.

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A Valuation of England's Terrestrial Ecosystem Services

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The value of ecosystem services provided by England's terrestrial ecosystem services has been estimated by the authors in a study commissioned by the UK Department for Environment, Food and Rural Affairs (Defra). This formed part of the 'Ecosystems Approach project', which is developing UK policy for the natural environment. The objectives were to:

- estimate the 'total' annual value of England's terrestrial ecosystem services; and
- move the field of ecosystem valuation forward through investigation of the existing evidence base, methodologies and limitations.

This paper discusses the lessons learned and insights gained during this exercise and the implications for policy and for future research efforts. Key issues included the implications of attempting a 'total' rather than a 'marginal' valuation; defining an appropriate counterfactual; employing a 'service based' rather than a 'habitats' approach; gaps in the scientific understanding of the biophysical relationships that ecosystem services are derived through; data gaps; and aggregation issues.

A typology of ecosystem services is proposed, using the framework in the 'Millennium Ecosystem Assessment' as a starting point. The typology maps ecosystem services against final benefits to society, helping to avoid issues associated with double counting and suggesting suitable valuation methods.

Provisioning Services were valued based on the Market Value (MV) of goods sold and Gross Valued Added (GVA) generated; a Damage Cost Avoided approach was employed for Regulating Services; Recreation was valued based on participant expenditure, income generated and consumer surplus estimates; a lower bound for Non-use value was found based on an illustrative source valuation. Supporting Services were not valued, as they are 'intermediate' rather than 'final' benefits, although in many ways their value may be considered infinite.

The total annual benefits provided by England's ecosystem services are estimated to be:

- Provisioning services: £10.2 billion MV, resulting in £4.2 billion GVA;
- Regulating services: £1.0 billion;
- Cultural services (Recreation): £5.4 billion expenditure, generating £2.0 billion economic income; plus £266 million consumer surplus; and
- Cultural services (Non-use value): at least £399 million.

These values are illustrative, lower bound estimates and must be interpreted with care; in particular, it is not appropriate to sum these values together.

It is recommended that: in future the focus should be on marginal valuations, both to inform policy and for advocacy; research is needed into how (and at what scales) benefits are generated; a benefits transfer strategy should be developed; primary valuations should be undertaken with benefit transfer requirements in mind; and statistics on MV and GVA should employ standards that fit with an ecosystems approach.

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Financing Conservation through Ecosystem Services: Implementation in Asia

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Highlighting the value and importance of Ecosystem Services (ES) in the developing world can create new and sustainable financing opportunities for conservation (sometimes referred to as 'Payments for Ecosystem Services'). This can prompt actions that result in both conservation outcomes and enhanced human well-being.

However, the theory of ES must be made relevant to a wide range of contexts if it is to reach its full potential. This paper compares experience in two countries in Asia, investigating ecosystem production functions; discussing ways to cope with data gaps and other issues with valuing ES; examining the institutional, policy & sociopolitical contexts and the barriers to implementation; and asking what types of science, economic and institutional analyses are needed.

China: Existing conservation incentive programs in China include planned investment in the Natural Forest Conservation Program and the Grain to Green Program of around \$100 billion. These schemes are based on top-down government decisions; there is potential to improve results through the use of market-based mechanisms that explicitly link service providers with service users.

CI has developed a pilot ES study in Yujiashan Nature Reserve, Sichuan province, home to the Giant Panda (*Ailuropoda melanoleuca*), and the watershed for 28,000 people. The study estimates the values of various ES from the Reserve, including water provision, carbon sequestration and biodiversity. Four projects to tackle threats to these ES are identified, and it is demonstrated that ES benefits are likely to exceed costs. An Ecological Compensation Fund is proposed, funded through existing water fees and external funding.

The context for this pilot changed following the tragic earthquake in May 2008; the implications for ES policy are being assessed. Lessons from this study will be shared with other policymakers in China and elsewhere.

Cambodia: Eleven hydropower facilities are being fast-tracked in the Cardamom and Elephant Mountains. The highlands also provide drinking water to 3,500 villages and towns, and are a biodiversity hotspot.

This study projects the impacts of poor watershed management on hydropower facilities' revenues and profits. Firstly, variations in water flows directly impact their ability to generate energy; assuming a modest 10% reduction in energy generation during the region's periodic droughts equates to a loss of at least \$24 million p.a. during these periods.

Secondly, sedimentation caused by poor watershed management can cause hydropower facilities to close prematurely; the lost revenues are estimated to total up to \$4 billion. It would be in facility operators' interests to finance investments in forest conservation in order to protect their revenue streams and as a risk management strategy.

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EPA's Ecosystem Services Research Approach

Rick A. Linthurst

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Conservation of ecosystems services is increasingly becoming common ecological currency for measuring environmental protection. In the Environmental Protection Agency, this evolution has significant ramifications for current regulatory actions that are not targeted at goods and services per se. While ecosystems services are explicitly or implicitly embedded in some of the environmental legislation, it has not yet become a significant driver for decision making by the Agency.

The Ecosystem Services Research Program (ESRP) will expand the conservation and enhancement of the goods and services our natural resources provide, and on which our continuing well-being depends, by establishing the scientific foundation required to make informed trade-offs in land management decisions and, in some instances, creation of financial markets for these services. These services include clean air, water quantity and quality, food, fuel, productive soils, recreation, and culturally important natural areas. EPA clients use the results of this research to conserve and enhance services even in the face of intensified resource use, population pressures, and a wide variety of other human stressors, including climate change.

ESRP is focused on six overarching questions: 1) how do we identify, measure, monitor and map ecosystem services to document changes, 2) what is the relationship among ecosystem services within and among ecosystems, 3) how do these services respond to alternative management actions, 4) what are the thresholds below which ecosystems cease to effectively provide important services, 5) what is the relationship between ecosystem services and human well-being, and 6) what is the monetary and non-monetary value of these services?

ESRP is currently developing methods to: 1) assess how reactive nitrogen affects the amount, type, and quality of ecosystem services in terrestrial and aquatic systems, 2) quantify ecosystem services provided by freshwater and coastal wetlands and by coral reefs, including nutrient cycling, flood mitigation, storm surge protection, wildlife habitat, fisheries, recreation, and tourism, and 3) forecast changes in ecosystem services under alternative management options in five place-based studies range in size from an urban area to broad regional studies. These are: Tampa Bay, FL; a multi-state area of the Southwest, the Coastal Carolinas, NC & SC; the Willamette River Basin, OR; and a 12 state area in the Midwest with an emphasis on biofuels development scenarios.

This presentation will briefly describe the ESRP and the desired outcome. The ESRP is being planned not as an EPA activity but as a multi-institutional opportunity that is seeking partners in its implementation. Current partnerships and possibilities will be highlighted.

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Integrated Monitoring and Forecasting of Ecosystem Services in the Prairie Pothole Region of the United States

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Ecosystem structure, functions, goods, and services are constantly changing under the impacts of human activities, natural disturbances, and shifting ecological cycles. There is a critical need to build integrated, spatially explicit, models to simultaneously monitor, quantify, and predict the changes of ecosystem goods and services. We present our efforts towards the development of such a modeling system for the Prairie Pothole Region of the United States. There are three major components of the modeling system. First, disciplinary models are developed and tested at the plot scale, based on information from field and remotely sensed datasets. These datasets include a long-term (>40 yrs) study of wetland processes and climate-induced changes in hydrology and chemistry on wetland biota at the Cottonwood Lake Study Area (North Dakota). Second, disciplinary models are integrated and further developed for landscape and regional applications that are constrained by remote sensing observations from various satellites (e.g., Landsat, MODIS, and AWIFS) and by data from ground monitoring networks through the use of data-model fusion techniques. Finally, the modeling system is staged on the Internet using open-source data and model sharing technology to accommodate a variety of users and purposes. Ecosystem services to be quantified include; carbon sequestration, biomass production, nutrient retention, topsoil conservation, flood water storage, and habitat suitability for amphibians, birds, and agricultural pollinators. When complete, the model can utilize monitoring signals or data from specific land-uses (e.g., Conservation Reserve Program) as input. It can generate performance reports and/or practices for agencies, and to facilitate agency-specific adaptive management and policy goals. The model also can be used to forecast change in diverse ecosystem services in response to proposed policy or other changes of interest, such as climate change and land conversion for biofuel production.

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On-Site Consequences of Biomass Production for Bioenergy: Spatially Explicit Monitoring, Forecasting, and Optimization

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Bioenergy industry calls for a monitoring, forecasting, and optimization system for biomass production that is spatially explicit and quantifies land use and climate change consequences for ecosystem productivity and sustainability. Here, we present our effort to develop such a modelling system to meet this critical need. This model is built upon our existing General Ensemble biogeochemical Modeling System (GEMS). To satisfy the need for near-real-time monitoring, we are developing a data-model fusion capability to take advantage of various satellite observations and in-situ field measurements. With the addition of this monitoring capability, GEMS can always start with the best estimate of initial conditions for forecast. This adaptive modeling and forecasting capability is essential for supporting adaptive precision management practices to address emerging issues in the field. Production sustainability under any given set of management practices can be quantified using GEMS. Biomass production can be optimized by examining various feasible management practices, including tillage, fertilization, and harvesting. Using stochastic ensemble simulations, GEMS can generate uncertainty maps on desired outputs (e.g., biomass production, greenhouse gas emissions, and soil fertility), enabling the optimization of resources to reduce uncertainty. As a case study, GEMS is applied to simulate the spatial and temporal details of biomass production under various management practices in Iowa.

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Ecosystem Services Across Borders: A Framework for Transboundary Conservation Policy

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International political borders rarely coincide with natural ecological boundaries. Because neighboring countries often share ecosystems and species, they also share ecosystem services. When countries share ecosystem services, drivers of ecosystem change in one country may affect the delivery and quality of ecosystem services in another country. We use the Millennium Ecosystem Assessment (MA) to elucidate how drivers in one country can affect ecosystem services and human well-being in other countries. We present three case studies of ecosystem services shared by the United States and Mexico. The examples are: the *provisioning service* of shared groundwater provided by the All-American Canal in California; the *regulating service* of agave crop pollination by long-nosed bats; and the aesthetic value of the North American monarch butterfly, a *cultural service*. We suggest that the concept of ecosystem services as articulated by the MA could be used as an organizing principle for transboundary conservation because it would meet many criteria of successful transboundary policy: it would frame conservation in terms of mutual interests between countries, consider a diversity of stakeholders and provide a means for linking multiple services and assessing trade-offs between uses of services.

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Considering Ecosystem Services in Restoration Decisions on the Upper Mississippi River System

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Since 1986, ecosystem restoration on the Upper Mississippi River System has primarily been conducted under the auspices of the Environmental Management Program. This multi-agency partnership will likely evolve soon into a new program, the Navigation and Ecosystem Sustainability Program (NESP), which will provide more funding and a broader set of restoration perspectives, projects and tools. A Science Panel that has been promoting an adaptive management approach under NESP has also been reviewing river ecosystem services and the advantages and disadvantages of considering these services as planning and evaluation criteria. The potential exists for ecosystem services to be factored into several kinds of decisions, ranging from restoration project design and ranking, to the formulation of ecosystem goals and objectives at multiple scales. Thirteen ecosystem services provided by the river have been identified and grouped under categories used during the Millennium Ecosystem Assessment (cultural, provisioning, and regulating). The services have been described in sufficient detail to allow non-scientists to distinguish them from river processes and functions that do not provide obvious benefits to humans. Existing quantification and valuation tools have been reviewed. An evaluation framework that recognizes the need to assess ecological production and economic value functions has been adopted. Much work remains, but the general need for continuing communications between scientists and economists is clear, as is the need to evaluate existing Corps' Principles and Guidelines and planning steps to determine where ecosystem services can and should be addressed most effectively.

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Enhancing Market Based Approaches to Ecosystem Services: USDA Leadership for Federal Guidelines and Methods

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Market based approaches are an innovative way to stretch resources and take conservation beyond the boundaries of the farm, ranch and forest, while preserving productivity, maintaining and enhancing landowner livelihoods, and producing environmental benefits, including protection and restoration of ecosystem services. Market based solutions provide flexibility to undertake actions that have the lowest cost and result in more cost-effective achievement of natural resource conservation and environmental goals compared to traditional command and control approaches.

The efficient operation of a market is based on an understanding of credits, trading, and banking as well as the interaction of society and our natural resources. Effective markets require consistent, well-defined, and quantifiable environmental goods and services. Currently, there are many challenges facing the expansion of market based solutions but none more important than the need for consistency. Uniform standards and metrics, uniform definitions, and credible models and verification protocols are all necessary for environmental markets to succeed.

To address these challenges, USDA will use the new authority provided in the 2008 Farm Bill to establish technical guidelines and science-based methods to measure the environmental services benefits from conservation and land management activities in support of emerging environmental services markets.

USDA is embarking on a new initiative that involves looking at markets and the philosophy behind their success. It will use the principles of the marketplace to leverage Federal funds and services with private funds to address nonpoint source problems and achieve enhanced environmental outcomes.

This presentation will describe USDA's policy for an organized approach to enable markets to expand. It will describe USDA's procedure to leverage expertise and ensure consistency across the federal government. It will discuss the establishment of government-wide guidelines and methods for quantifying the air quality, water quality, greenhouse gases, wetlands and endangered species benefits of conservation and land management practices. The presentation will also detail the tools and reference materials USDA has developed to enhance an efficient operation of markets for environmental improvement.

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A Conceptual Framework & Monitoring System for Rangeland Ecosystem Goods, Services & Processes

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To explore importance of commodity and amenity values, Sustainable Rangelands Roundtable (SRR) conducted two national workshops on rangeland ecosystem goods and services. Workshops captured varied stakeholder perspectives, developed categorization frameworks, and integrated rangeland ecosystem goods, services, and core processes into SRR's *integrated social, economic, and ecological concept for sustainable rangelands (ISEEC)*. Outcomes address the nation's reliance upon rangeland resources and SRR's contribution to rangeland stewardship and conservation through comprehensive monitoring of natural stocks of goods and services and the core ecosystem processes that support them.

The workshop incorporated extractable goods derived from rangelands, tangible and intangible rangeland ecosystem services, and core ecosystem processes that underlie these goods and services. While rangeland amenity values matter to some individuals, profit potential may motivate many others to engage in conservation and/or provision of rangeland ecosystem goods and services. SRR participants identified *criteria for evaluating public and private programs that offer conservation incentives*, specifically conservation easements and credit trading. Participants also developed an *applied evaluation method* suitable for use by ranchers, technical service providers, and other land managers who seek to identify and consider the income potential of rangeland ecosystem goods and services provided by their lands.

To address broader issues, the conceptual framework (*ISEEC*) developed by SRR was expanded to depict integration of social, economic, and ecological elements of rangeland sustainability via the bridge of rangeland goods and services. The Texas Leon River Restoration Project illustrates utility of SRR's model to successfully address multiple desired uses associated with traditional ranching operations, national security military uses, and critical species habitat requirements.

Comprehensive monitoring is also foundational to successful rangeland management for ecosystem goods and services. Managers and scientists need baseline data to detect changes that may be due to management actions, disturbances, or longer term processes like climate change. Actions and reactions in social and economic systems also must be monitored to obtain a complete picture of sustainability. SRR's *ecological, social and economic indicator set for rangeland inventory, monitoring, and assessment* may be applied at multiple spatial scales. A case study of ecosystem services affected by the Idaho Murphy Complex fires illustrates potential applications of indicators to track fire regimes, changes in productivity and vegetation patterns, and impacts on critical sage grouse habitat.

Workshop participants concluded by *recommending future research* and efforts to better inform management and conservation of the nation's rangeland resources, as well as the goods and services that these valuable lands provide. The *Oregon Multi-Agency Pilot Project* highlights evolving interest in comprehensive rangeland resource monitoring to track trends in natural capital and core ecosystem processes. Better information leads to better decisions, culminating in sustainable management of rangeland ecosystem goods and services to satisfy wants of current populations while also conserving the nation's rangelands for future generations.

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Value of Ecological Services Provided by Restoring Gravity-Driven Flow to the Everglades

John Arthur Marshall

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The dollar value of ecological goods and services provided by restoring gravity-driven flow from Lake Okeechobee to the Everglades ecosystem down the Governor's "missing link" path is calculated. The *missing link* is also addressed as *Plan 6*, in the US Army Corps of Engineer's 1994 *Recon Study*, in the 1993 Science Subgroup preceding the Task Force Science Coordination Team, and in the 1981 "Marshall Plan" to *Repair the Everglades*. All of the above reports indicate that the *Plan 6* approach will maximize ecological benefits; however none of the reports attempt to place an economic dollar value on the ecosystem services of a *Plan 6* implementation. This presentation will go in the direction of breaking that tradition. An energy cost spreadsheet model is developed to provide a first order estimate to analyze trade-off's between gravity-driven flow and pumping alternatives, specifically flow v. surface storage and aquifer storage (below ground storage) and recovery. An estimate of the dollar value "swing" will be provided regarding the ecosystem services delivered if gravity-driven flow is restored, verses the cost to society if flow to the Everglades is not restored down the missing link.

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Guaranteed Sustainability Label: Is it a Way of Promoting Sustainable Agriculture?

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Although there is political and institutional recognition that extensive farmland provides a wide range of environmental services beside food and fibre production, promoting sustainable local economies based on extensive agriculture is still a challenge for the agents involved, both farmers and policymakers. The key question remains how to convert such environmental services into an income stream, and how to convert this stream into a foundation for sustainable rural development. Achieving rural development via private markets, within the current European rural development paradigm, would imply the creation of new, or differentiated, products and services and the associated development of new markets. Information labelling might be a way of communicating the attributes not visible in the product, namely in agri-food products. If there is demand for such differentiated products and consumer's willingness to pay (WTP) is higher (or equal) than the price listed by producers a market solution can be featured for sustainable rural development.

In this paper we address whether consumers are willing to pay a price premium for *Guaranteed Sustainability Labelled Beef*, an emerging label type being developed in Portugal within the EU funded EXTENSITY project (<http://extensity.ist.utl.pt/>). The *Guaranteed Sustainability label* is meant to be a voluntary labelling mechanism. Farmers will adopt the label if it becomes a mechanism that effectively facilitates them capturing the rewards of their superior performance in relation to the conventional production process.

In recognition of the importance of revealing consumer preferences for such differentiated products a contingent valuation survey was carried out. Respondents were sampled across meat consumers that were approached at or nearby food stores located in the metropolitan area of Lisbon (Portugal).

We concluded that on average consumers are willing to pay an extra price premium of 3.5  per kilogram of sustainability labelled beef (having the conventional beef as baseline). Our findings also indicated that demand for sustainability labelled beef will decrease 0.8 kg per a price increment of one Euro per kilo. Although further analyses are needed our findings suggest that Guaranteed Sustainability Label can play a role in promoting agricultural sustainability in Portugal.

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Forest Management Strategies for Atmospheric CO₂ Mitigation

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A recent review (Canadell and Raupach 2008, Science 320:1456-1457) summarized four possible forest management strategies for climate change mitigation: increase forested land area through reforestation and afforestation; increase carbon density of existing forests at both stand and landscape scales; expand the use of forest products that sustainably replace fossil fuel CO₂ emissions; and reduce emissions from deforestation and degradation. This talk will review biological, climatic and management influences on forest carbon sequestration, and will discuss these four climate change mitigation strategies within the context of southeastern U.S. forest management.

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Integrated Ecosystem Assessments: A Tool for Bridging Science and Ecosystem Management

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Humans use and are affected by the ecosystems of which they are a part in multiple ways. Those responsible for managing ecosystems for the benefit of society are often limited in their responsibility or focus to a single sector or subset of the goals established for each of those multiple uses. Even worse, the goals for each use may be unknown or so vague that it is difficult to determine if success is achieved. As a result, managers struggle to balance goals for the non-human components of ecosystems in the face of desired multiple uses of the system. The difficulties are exacerbated by the lack of comprehensive, holistic, integrated science examining or predicting the ecosystem changes that may result from multiple use coupled with natural variation. In short, we lack scientifically based measures of ecosystem health that can be used to predict the effects of one manager's decision on decisions made by other managers.

Integrated Ecosystem Assessments (IEAs) formally bridge science and management, applying the best existing scientific information to provide an improved scientific basis for managing competing uses for the holistic benefit of an ecosystem. They can drive a paradigm shift from considering impacts of a single use in isolation (e.g., changing land use, ocean and coastal uses, or fisheries) to considering how a collection of proposed uses will affect each other. This talk applies an IEA framework to a hypothetical ecosystem to demonstrate its utility in addressing how three competing human uses will affect the system's health.

The process begins with identifying an overarching question, in this case: *What is the likelihood that Ecosystem X will remain healthy, (assuming it is healthy)? If it is not healthy, what is needed to make it healthy?* Implementation involves: 1) documenting the status and trends of ecosystem and cultural resource conditions; 2) relating those trends to their environmental and economic causes and consequences; 3) delivering ecological forecasts and scenario developments under changing ecosystem conditions as well as different management actions; and 4) reviewing means, including costs and benefits, to implement those alternatives. The IEA approach provides, for the first time, basic decision making tools to support an ecosystem approach to management. It facilitates analysis of the role of upland uses in maintaining or improving coastal ecosystem function, the delivery of goods and services, and the health of high priority, at-risk species. A successful IEA is responsive to policy-relevant questions, based on peer review and public participation, broadly integrated and synthetic, based on high-quality existing information, and predictive. It is a process and a product that results in managers and regulators having the scientific know-how and political will to restore and maintain coastal ecosystems so that they support desired functions and uses.

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The South East Queensland Ecosystem Services Project: Turning Concept into Practical Application for Land-Use Planning and Policy

Simone Maynard

South East Queensland Catchments, Brisbane, Australia

The South East Queensland (SEQ) Ecosystem Services Project aims to identify, measure, value and incorporate ecosystem services into natural resource management and decision making in SEQ by developing an agreed framework for ecosystem services. The SEQ Ecosystem Services Framework consists of descriptions and definitions of four main components: Ecosystems, Ecosystem Functions, Ecosystem Services and Human Well-being; a semi-quantitative description of the relationships between these in the form of matrices; and a series of maps identifying spatially where ecosystems, ecosystem functions and ecosystem services occur or are derived from in SEQ. The maps produced to support the Framework provide a spatial representation of where particular suites of ecosystem services are being generated and provides key information on: (a) areas that provide a high level of service requiring protection or management to maintain their ecosystem service provision (b) areas that provide specific ecosystem functions or services and (c) changes in ecosystem service provision over time.

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Screening Criteria for Assessing Opportunities for an Ecosystem Services Approach

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There is growing interest in incorporating ecosystem services into conservation projects, but the success of an ecosystem services approach is dependent upon a set of supporting conditions. Explicit consideration of these conditions can help a) to understand whether an ecosystem services approach is likely to succeed, and b) to design an effective approach. The existing literature typically assumes an ecosystem services approach will be taken and explores enabling conditions for various types of approaches, particularly payments for ecosystem services (Van Noordwijk et al 2007, Swallow et al 2007). It does not specifically help conservation practitioners to assess whether conditions are favorable for using an ecosystem services approach to achieve conservation goals. Our research aims to address this gap.

We describe the ten most important criteria that influence the likelihood of success for an ecosystem services approach to conservation. In a screening matrix, we present the 'best case' for each criterion and a set of supporting questions that can help users to gather relevant information. The 'Top Ten' screening criteria were selected on the basis of a review of existing literature, an analysis of case studies and the practical experiences of The Nature Conservancy, WWF-US and The Natural Capital Project. We find that the ten most important criteria fit within two categories: a) the cost-effective and verifiable delivery of ecosystem services and conservation benefits; and, b) various legal, institutional, social and economic conditions.

The criteria have important implications for the conditions under which ecosystem service based conservation projects should be undertaken, and how they should be designed. Further research is required to refine these criteria, in particular to determine which criteria matter most, how the criteria interrelate, and how different conditions affect the choice between alternative instruments for providing ecosystem services. Future work is planned to test the criteria in screening potential ecosystem service approaches for conservation projects of WWF-US, The Nature Conservancy and The Natural Capital Project. The aim is to address the abovementioned research questions and further evaluate the practical application of the screening tool.

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Measuring Ecosystem Services within the Context of the Montreal Process Criteria and Indicators for Forest Sustainability

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Indicator 27, which was recently added to the Montreal Process Criteria and Indicators for Forest Sustainability roster, calls for the measurement of revenues from Environmental Services (ES). This paper describes our experiences and findings so far in attempting to address this indicator, as well as the issue of ES at large, in the upcoming 2010 National Report on Sustainable Forests. We identify several major revenue streams that can be readily measured and directly associated with ES. We also describe a much broader realm of activity where the provision of ES is pursued through novel financial arrangements that are much less liable to strict categorization or routine measurement.

Indicator 27 raises a number of conceptual questions regarding the definition of ES and relationship between value and revenue, and we discuss these at length. Moreover, given the breadth of values that may be encompassed by ES, potential linkages to other indicators in the National Report must be considered. We identify several of the most important of these linkages both in terms of their ability to help us quantify the actual provision of ES and as a vehicle for exploring a more general relationship between biophysical measures and measures reflecting human values.

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A Tool for Optimizing Site Designs to Mimic Pre-Developed Ecosystem Services

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Stormwater runoff is a major environmental concern particularly in developing and urban environments. The transition from a native landscape to a built environment, known as urbanization, increases the amount of impervious cover with roads, parking areas, sidewalks, rooftops, and other forms of hardscape. These characteristics of urban environments reduce, disrupt, and eliminate pre-existing vegetation, upper soil layers, natural depressions, and native drainage patterns that originally existed to intercept, evaporate, store, slow, and infiltrate stormwater. As a result, the volume and timing of stormwater runoff is changed thus adversely impacting water bodies downstream by transferring harmful pollutants into the water and accelerating channel erosion with an increase in flow. Aquatic biological communities that exist downstream of stormwater discharges are also impacted by urbanization. This impact on both the quantity and quality of aquatic life has been recorded at levels above 10% watershed imperviousness.

In an effort to help mitigate the adverse impacts that urbanization has on the environment, many developers are turning to alternative methods of site planning and stormwater design such as low impact development (LID). LID is a site development strategy which seeks to control stormwater runoff on-site as opposed to moving stormwater offsite through a conveyance system and into receiving waters downstream. The goal of LID is to maintain the natural, pre-developed conditions of a site through innovative techniques known as best management practices (BMPs). Despite its concept nearly twenty years ago and its gain in popularity throughout the country, LID is still not a widely used practice for managing stormwater runoff – particularly in the Southeastern United States. The study described in this paper focuses on design and consulting firms located in southern Alabama, Louisiana, and Mississippi.

To gain a better understanding of the perception of LID and BMPs in the study area, the Department of Landscape Architecture at Mississippi State University developed an online questionnaire aimed at assessing the industry's perception and adoption of LID/BMP techniques and technological needs for implementing these strategies into site plans. Topics of investigation included demographics, firm and project information, familiarity with LID/BMPs, client understanding, marketability, cost feasibility, availability of hydrologic modeling tools, and interface preferences. The survey was designed to be taken in 15 minutes or less and distributed via e-mail to design professionals throughout the study region. Responses were compiled, compared, and analyzed based on the industry's needs and preferences for a tool capable of modeling both pre- and post-developed hydrologic conditions of sites designed with and without LID/BMP solutions.

Survey results initiated the development of a user-friendly, Microsoft Excel spreadsheet-based tool tailored for counties within Alabama, Louisiana, and Mississippi. In its current phase, the model is capable of estimating runoff based on pre- and post-developed site conditions. The first step in the model requires user input of project information, site dimensions, and precipitation data. Precipitation data is model-generated by selection of state and county, or the data can be manually entered by user-defined values. Upon completion of site specific information and selection of a design storm, the user must characterize the site based on its land use and land cover for each respective hydrologic soil group (HSG), cover type, and size. After characterizing the site, a runoff curve number is generated and printable results are displayed. Model results include pre-developed versus post-developed conditions; storm event peak flow, runoff, and hydrographs; and annual runoff volumes. Future development of the model is expected to include water quality computations, a database selection of BMPs, and a cost component. Together, these components will assist designers in calculating and communicating the effectiveness that LID/BMP strategies have on reducing water quantity and improving water quality for optimizing site designs to mimic pre-developed ecosystem services.

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Restoring Waterfowl Habitat and Potential Flood Storage Services on Wetland Reserve Program Lands in the Mississippi Alluvial Valley

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The Mississippi Alluvial Valley (MAV) is comprised of approximately 10 million hectares and is considered a continentally significant wintering area for North American waterfowl. However, approximately 90% of the forestland within the MAV has been cleared and converted to agriculture. Large scale clearing was in part driven by successful flood control resulting from the Mississippi River and Tributaries project that was authorized under the Flood Control Act of 1928. Flood control work has resulted in impaired fish and wildlife habitat, flood storage, and floodplain hydrology and other wetland functions and values. The United States Department of Agriculture's Wetland Reserve Program (WRP) was initiated to restore wetlands within marginal agricultural landscapes. Lands enrolled in WRP have aided in returning land-use patterns to those that occurred prior to conversion to agricultural use and have helped restore functionality of wetland systems. The top three states in terms of WRP enrollment are Louisiana, Arkansas, and Mississippi, who's combined acreage totals over 202,342 hectares and of which nearly 85% is located within the MAV.

The objective of this study was to evaluate the effectiveness of restored WRP lands in providing waterfowl habitat and potential flood storage. We performed analyses to estimate the contribution of restored WRP lands toward waterfowl foraging habitat objectives for the MAV, and assessed the location of WRP restoration sites relative to the active flood plain within the states of Arkansas, Louisiana and Mississippi using a High Frequency Natural Flood Model developed by Ducks Unlimited.

Current WRP projects provided an estimated 6.7% to 13.0% of the waterfowl foraging objectives for Arkansas, Louisiana and Mississippi combined. This represents an increase of approximately 25.95 to 49.85 million duck-energy-days resulting from restoration activities as compared to the assumed prior condition of marginal, frequently flooded agricultural land. More importantly, active management of hydrology units alone could increase foraging value provided by WRP by 78-96%, which would increase carrying capacity by approximately 266,000-427,000 waterfowl each winter. In addition, approximately 69.7% to 77.7% of land enrolled in WRP across the three states appears to fall within the 24 month flood frequency. Through 2005, the model suggests that 120,115 acres of 172,326 analyzed have a flood frequency of 0-24 months, and 125,672 acres were predicted by the model to have at least some natural flooding.

This analysis provides evidence that restoration programs like WRP are beneficial in restoring some wetland values at landscape scales in systems like the MAV. Given that a large proportion of WRP lands fall within the 24-month flood frequency, these lands should provide significant flood storage capacity as well as additional wetland functions and values as their plant communities mature. In addition since the majority of these lands are perpetually protected, the long term benefits to waterfowl, forest wildlife, flood plain fisheries, water quality, nutrient and carbon sequestration and other functions and values should be significant.

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Understanding Key Conditions for Success: The Nature Conservancy's Approach to Ecosystem Services

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The ecosystem services approach presents an opportunity to achieve conservation in places where traditional conservation approaches may not work. It can enhance conservation strategies by providing access to new sources of long-term financing, supporting greater impact at a wider scale, and opening new avenues for advancing conservation with institutions that do not traditionally consider the environment in their decision-making. However, an ecosystem services approach may not always be the best way to achieve conservation. Success depends on an enabling context and effective project design.

The Nature Conservancy (TNC) has identified ecosystem services as an important strategy for achieving conservation objectives. Recognizing that there are many challenges to achieving success with an ecosystem services approach, TNC is focusing its efforts around research & development, testing & implementation, and learning & guidance. Under research and development, TNC is developing tools to help screen for enabling conditions and understand the science that links conservation to service delivery. In the field TNC is testing and implementing ecosystem services approaches. TNC is then taking lessons learned and sharing them with broader audiences both within and outside the Conservancy.

With a focus on two case studies, this presentation will describe the Nature Conservancy's work using ecosystem service approaches. In so doing, it will outline some of the opportunities and constraints with an ecosystem services approach and some of the potential overlaps with DoD approaches.

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Identifying and Analyzing Rural Residential Development

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Changing land use dynamics has lead to the increase in rural residential development – specifically, the spread of people and housing into more remote areas of the landscape (i.e. traditionally forested/natural environments and agricultural lands). In many instances, the dispersed nature of this development and its invasion into non-urban landscapes results in conflict with ecosystem preservation, wildlife management, emergency response provision, and community services (e.g. schools, transportation, communications, etc.).

In an attempt to identify, analyze, and guide rural residential development patterns, a geospatial method has been developed to map non-urban residences on the landscape. Utilizing GIS and both traditional and semi-automated aerial photo interpretation techniques, a point map and a variety of spatial statistics can be quickly derived.

This poster will briefly depict the technical methodology needed to map these rural residences and, more importantly, illustrate a number of examples where University researchers have worked in an outreach capacity to employ this data/analysis to assist community decision-makers. Examples will include wildfire risk assessment and management plans, infrastructure estimates and build-out analyses, development of urban growth boundaries, greenways mapping, etc.

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The Non-Native Red Rimmed Melania (*Melanoides tuberculatus*) in Biscayne Bay National Park, Florida, and the Potential for the Future

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The non-native gastropod *Melanoides tuberculatus* (Family Thiaridae: common name Red-Rimmed Melania) was identified by USGS researchers working in Biscayne National Park (BNP) in 2003. In its native habitat of Southeast Asia and parts of Africa *M. tuberculatus* is a freshwater snail, however we have collected it live in salinities up to 30 parts per thousand (ppt) salts, (typical marine waters are 30-35ppt). This finding initiated a study to determine the distribution, genetics, salinity tolerance and threat to the native species that compete for a similar niche as *M. tuberculatus*. The presence of *M. tuberculatus* is significant to the visitors in BNP because it is an intermediate host for several human parasitic trematode worms including *Clonorchis sinensis*, *Opisthorchis spp.* (liver flukes) and *Paragonimus westermani* (lung fluke). Additionally, it is an intermediate host for other digenic trematode parasites including, *Philophthalmus megalurus* that affects the eyes of birds and *Centrocestus formosanus*, that is a serious pathogen of fish, crustaceans, and some mammals. *Centrocestus formosanus* is also known to occasionally infect humans and is a documented parasite in Florida. All intermediate host stages of these trematode lifecycles are present in BNP and new cases of lung and liver fluke have been documented in the Miami area. The proximity of BNP to a landfill, a sewage treatment center, and multiple septic systems may increase the potential for infections.

M. tuberculatus can spread very quickly because it can reproduce asexually and broods internally so the offspring are live born; this strategy increases the overall survivability of the young. Surveys within BNP over the 2004-2006 time periods show an increase of *M. tuberculatus* in the Black Point area located on the west-central edge of BNP. The estimated numbers of *M. tuberculatus* per square meter (based on raw counts using three petit ponar samples from each transect (TR) site) approaches 60,000/m², in 2006 at the BP transect location 4 (TR4), an increase from 696/m² in 2004, at approximately 1400 meters from shore. The numbers, at the seaward most point of the transect (TR6, approximately 2200 meters from shore) increased from 87/m² in 2004 to 3826/m² in 2006. These numbers support our experimental salinity tolerance data conducted on specimens collected from BNP. *M. tuberculatus* may be adapting to higher saline waters eliminating the marine barrier and increasing its habitat range. This will increase the competition with the native species that utilize a similar food source. It may also increase the potential of the parasites to begin to infect native species increasing the parasite threat in BNP and surrounding waters. South Florida water temperatures are very similar to the water of Southeast Asia and with the IPCC Global Climate Change Forecast the range of *M. tuberculatus* is likely to expand northward.

Resource managers and the general public need to be aware of this non-native/invasive snail and take steps to monitor its parasite host status and prevent its spread and additional introductions.

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Status of the USEPA's National Atlas of Ecosystem Services

Anne Neale and *Jim Wickham*

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The US Environmental Protection Agency's (USEPA) Ecosystem Services Research Program (ESRP) is focused on transdisciplinary research to develop tools to enable decision-makers at all levels of governance to proactively conserve ecosystems services. A major product from the ESRP will be a National Atlas of Ecosystem Services. This Atlas will use principles of landscape ecology to extend the frontiers of ecoregional assessment and spatial analysis in order to display the sources and beneficiaries of ecosystem services. Services to be included in the Atlas are water quality and quantity, carbon sequestration, services provided by wetlands, food and fiber, soil regulation, and aquatic and terrestrial habitat. We anticipate that this Atlas will eventually provide national coverage of these multiple ecosystem services. This Atlas will be a product developed by EPA's ESRP in collaboration with many other organizations, notably the National Geographic Society and the USGS. The Atlas will be a digital product, will be available for multiple spatial units, will include a historical perspective, and will be updated as new spatial data become available and as ecosystem services science matures. This presentation provides a status of the Atlas design and implementation.

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Reforming Urban Development Patterns to Facilitate Production of Ecosystem Services

Arthur C. Nelson

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The interface between urban and nonurban land uses is skewed favoring urban development over resource land uses for at once obvious and surprising reasons. The result is that more resource land is lost to urban development than is efficient.

This paper reviews the theory and empirical evidence of inefficient land use outcomes to the current land use regulation and development regime. It then poses regulatory and economic approaches to offsetting those inefficiencies.

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Achieving a Win-Win in Restoring Ecosystem Services

Kurt Nelson

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The Tulalip Tribes have occupied the Puget Sound Region since time immemorial and are part of what are known as the Coast Salish people. Historically the Tulalip Tribes sustained a flourishing subsistence-based economy rooted in fish harvest, shellfish harvest, hunting, gathering, and trading of resources. Today, the Tribes have adapted and diversified their economy but still remain closely connected to the land and water and depend upon natural resources for economic and cultural purposes. The Tulalip Tribes continue to serve as natural resource stewards and seek to preserve, protect, and restore Treaty-reserved natural resources within their ancestral lands.

The restoration of Treaty-reserved natural resources using ecosystem services, partnerships and environmental services decision making can best be shown through three recent projects the Tulalip Tribes have been coordinating; the Qwuloolt Estuary Restoration project, Skykomish Biogas Demonstration Project, and the Coho Creek Restoration Project. All three projects integrate aspects of ecosystem services and involve significant levels of cooperation between project partners.

The Qwuloolt Estuary Restoration project is a Tribal, Federal, State, and local partnership to reintroduce tidal processes and salmonid access to 360 acres of former agricultural land. A goal of the project is to allow the tidal processes to modify the landscape. The project is currently being designed with a target date for construction of August 2009.

The Snohomish Basin Biogas Project is a cooperative effort between the Tulalip Tribes and local dairy farmers. The purpose of the project is to reduce the environmental impact to Tribal lands from the dairy operations by demonstrating the viability of a dairy-waste digester system to reduce nutrient and bacteria loading into the Snohomish River while producing renewable energy and marketable by-products. This project focuses on the reuse of a waste product, reduction of the carbon foot print from local dairies, the reduction of greenhouse gas emissions, and a reduction of bacteria and nutrient loading into the local river system.

The third project is a Tribal effort to reestablish streams and wetlands to a former military ammunition depot. Topography, remnant conditions, and the stories of elders suggest the location of this project was formerly wetland and streams. Using the existing topography, hydrology, and vegetative communities, a stream and wetland restoration plan was developed which includes 1.7 miles of new channel and initially 2 acres of new and enhanced wetland. This project is currently under construction.

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Demonstrating the Net Benefit of Site Cleanup: An Evaluation of Ecological and Economic Metrics at Two Superfund Sites

David Nicholas

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In response to Agency-wide efforts to improve techniques for ecological benefit assessment, the EPA Office of Solid Waste and Emergency Response (OSWER), Policy Analysis and Regulatory Management Staff (PARMS), is exploring alternative approaches for valuing and quantifying the net environmental impacts from OSWER programs. In this PARMS-sponsored study, the ability of alternative ecological and economic valuation metrics to demonstrate the net benefit associated with site cleanup was explored at two sites, Homestead Air Reserve Base (HARB), FL, and Rocky Mountain Arsenal (RMA), CO. The four metrics evaluated were as follows: ecological service value in service-acre-years, ecosystem service value in dollars, human recreational use value in dollars, and real estate and community impact value in dollars. The purposes of the study were to (1) explore the ability of the four metrics to demonstrate the benefits of site cleanup; (2) identify and quantify new benefit streams; (3) identify data gaps that could be addressed in the documentation process at active sites so that net benefit metric calculations can be supported by the available site data; and (4) understand more fully how these metrics may be used at sites to identify, prior to remediation, the cleanup and reuse alternatives that provide the greatest net environmental benefit. Results of the study will be presented.

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Use of Ecosystem Services in Evaluating Biodiversity Offsets and Demonstrating Environmental Sustainability

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This presentation provides an overview as to how ecosystem service values and metrics, as discussed and presented by speakers earlier in this session, can be used within a net environmental benefit analysis (NEBA) framework to demonstrate environmental sustainability. Ecosystem service metrics as they pertain specifically to biodiversity offset projects are reviewed and incorporated into a sustainable development assessment framework (SAF). An overview of biodiversity offsets is followed by an overview of a NEBA approach incorporating ecosystem service metrics.

The overview of the NEBA approach provides the context from which ecosystem service metrics can be evaluated to demonstrate sustainability from a biodiversity perspective. A NEBA is an approach that provides a *formal quantification* of the change in ecosystem service values (a combination of ecological, social, and economic values) that would be associated with the implementation of a specific action. The goal of a NEBA is to support decision-making for the selection of actions that maximize ecosystem service benefits back to the public. In evaluating actions, it is important for stakeholders to understand the potential benefits (i.e., gains in ecosystem service values) and costs associated with various alternatives in order to support decisions.

A case example of the use of the ecosystem service values in a biodiversity context to demonstrate environmental sustainability will be presented. The pros and cons of using various ecosystem service metrics in evaluating biodiversity will also be addressed.

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Sustainable Forest Management in the Face of Rapid Urbanization

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The forests in Florida are urbanizing and rapidly changing due to increases in human population. The state's current rate of growth is more than twice the national average with most of this occurring within existing metropolitan regions. The human population within the Tampa Bay watershed has doubled since 1970 and is now in excess of two million.

To address the challenge of forest sustainability in the Tampa Bay watershed a consortium of interested parties that includes local, state and federal government agencies, research universities, nonprofit organizations and private industry formed the Tampa Bay Watershed - Forest Working Group in 2006. The group presently includes a unique collaboration of forestry practitioners and researchers, land use planners and arborists whose professional disciplines span the urban - rural forest continuum.

Current projects include the long-term ecological assessment, quantification and valuation of ecosystem services of the urbanizing forest within the Tampa Bay watershed; assessment of the effectiveness of government forest conservation policy; social survey to determine urban homeowner valuation of trees; and a cooperative project with the U.S. Geological Society to determine how changes in the distribution, composition and structure of the urbanizing forest influences water quality and flows.

Information from the long-term ecological assessment, quantification and valuation of ecosystem services of the urbanizing forest has been incorporated into the City of Tampa's comprehensive land use plan. The Forest Working Group is now assisting the Mayor's Office of the City of Tampa with a series of workshops and interagency planning sessions to develop a plan for urban forest sustainability.

The non-binding structure of the Forest Working Group facilitates cooperative research, education and management activities, while supporting individual members to continue to focus on work within their chosen areas of expertise. This arrangement has encouraged creativity, cross discipline learning and the integration of work in the social, biological and physical aspects of forest sustainability. The group's success is one model for how to begin solving problems associated with sustainable forest management in the face of rapid urbanization.

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Estuary-Wide, Habitat-Specific Estimates of Fisheries Ecosystem Services in a Pacific Northwest (USA) Estuary

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This study was conducted to explore the feasibility of synthesizing existing data to evaluate fisheries ecosystem services provided by major habitats within a single estuary and to identify data gaps limiting our ability to develop practical tools for communicating the distribution of ecosystem service values to local resource managers and environmental management decision makers.

The ecosystem services selected were recreational and commercial fisheries for Chinook salmon, Dungeness crab, Pacific oysters, bay clams and the bait fishery for burrowing shrimp (*Neotrypaea californiensis* and *Upogebia pugettensis*). The study site was Yaquina Bay, Oregon. The habitats were subtidal, oyster, eelgrass (*Zostera marina*), unvegetated sand, *Neotrypaea*, *Upogebia*, and mixed *Neotrypaea-Upogebia*.

Ecosystems service values were calculated using benefit transfer and travel cost methods. Relative values for each fishery were assigned to each of the 7 major habitat types based on extensive review of published studies, grey literature, expert knowledge and unpublished data. Habitat specific monetary values were calculated based on the relative values and area of each habitat type. Service values were then mapped for each habitat type within the estuary.

The total value of commercial fisheries for Pacific oyster, Chinook salmon and Dungeness crab was between $\$0.7\text{m.y}^{-1}$ and $\$2.5\text{m.y}^{-1}$. The value of recreational fisheries for Dungeness crab, Chinook salmon, burrowing shrimp and clams was between $\$2.1\text{y}^{-1}$ and $\$4\text{m.y}^{-1}$. Uncertainties in the commercial fisheries were due to the lack of information on oceanic catch of Chinook salmon derived from Yaquina populations. Uncertainties in recreational fisheries came largely from assumptions about effort and catch per unit effort. The best estimate mean $\text{acre}^{-1}\text{yr}^{-1}$ value for each of the habitat types was, oyster habitat $\$3.2\text{k}$; subtidal habitat $\$2.0\text{k}$; mixed $\$1.6\text{k}$; bare habitat $\$1.5\text{k}$; *Neotrypaea* habitat $\$1.4\text{k}$; *Upogebia* habitat $\$1.4\text{k}$ and eelgrass habitat $\$1.2\text{k}$. There were significant differences between the value of bay clam and burrowing shrimp stocks in different habitat types, but their recreational use values appeared to be controlled by ease of human access to resources rather than stock size.

While it was possible to estimate ecosystem service values for the 7 habitats within Yaquina Bay using existing data the confidence intervals of those estimates for the most highly valued fishery, Chinook salmon in particular, were large. Furthermore, the best estimates for Dungeness crab were based solely on the habitat preferences of sub-adults and do not take into account ontogenic shifts in their habitat preferences. Nevertheless, the values reported here are best first order estimates.

The results of this study identify important data gaps with respect to the commercial and recreational fisheries value of major Pacific Northwest estuarine habitats. Additional habitat-specific research is needed to fill the data gaps so that practical applications can be developed to aid resource managers and environmental decision makers.

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Factors Influencing Economic Value of Ecosystem Services: A Comparison between Mediterranean Wetlands and Forests

Elisa Oteros-Rozas, Berta Martín-López, José A. González and Carlos Montes

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Mediterranean ecosystems provide a wide range of services that have been largely studied and economically valued. Wetlands and forests, in particular, have received special attention in the ecosystem services economic valuation framework since the early '80s. The need to include economic criteria in the conservation policy decision-making process is behind the spread of economic valuation studies. However the accuracy and suitability of assigning economic values to ecosystem services is being widely debated. The purpose of this study is to identify and compare methodological and ecological factors influencing the economic value of ecosystem services in two of the most commonly valued ecosystem types of the Mediterranean basin: wetlands and forests.

More than 120 economic valuation studies, not only from well-known databases but also from grey literature, have been quantitatively analyzed using a meta-analysis approach. First, we described the distribution of studies by ecosystem type, ecosystem services valued, geographic area, publication type, language, main purpose, and time, providing a comprehensive overview of ecosystem services valuation in the Mediterranean basin. Second, the relationships between some methodological variables and the resulting economic values were analyzed. Finally, we characterized the differences in the economic value attributed to ecosystem services provided by Mediterranean wetlands and forests.

Our results reveal some gaps in the existing body of valuation studies and suggest future research directions. A wide range of economic values was found among the reviewed literature. Several factors influenced valuation, particularly the geographic location of the study, the ecosystem services valued and the methodology used. Differences in methodologies used and resulting economic values were also found between wetlands and forests.

We conclude that several methodological, ecological and socioeconomic factors highly influence the economic values assigned to Mediterranean wetlands and forests. Finally, suggestions are made for caution in using the results of economic valuation studies for benefit transfer and different conservation policies such as payments for ecosystem services.

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Mapping Ecosystem Services: Current Trends

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Recently many scientists have urged the scientific community and managers to analyse the spatial patterns of ecosystem services and to map them. Although there have been many advances in the field, like those that show how to include spatially explicit information of ecosystem services (maps) for conservation planning, a standardized, commonly accepted method for the mapping of ecosystem services has not been yet developed. Our objectives are: (1) to analyse all publications related to the mapping of ecosystem services, and (2) to suggest some indications about what could be done to improve the research in this field.

First we selected from the literature the most commonly used words to refer to ecosystem services and their spatial dimension, and proceeded the search in the ISI Web of Science (www.isiwebknowledge.com/). We obtained a total of nearly 400 articles of which we analysed all that included a map of ecosystem services (more than 30). The analyse method included several variables like: year of publication, scale, services mapped, type of ecosystem studied, purpose of the study, and methods used.

We found that although ecosystem services approach is a very prolific field, the mapping of these services is still at the early stages of development. Most of the studies that apparently mapped services have mapped ecosystem functions instead. This shows the confusion that still exists between ecosystem functions and services. Related to this, we also found that nearly in all cases the study did not mapped the distributions of the beneficiaries of these services, which is essential to characterize the flow of ecosystem services and the potential social conflicts. We also found that most of the articles had global scales (the whole World) and just some local ones. Regulation services were the ones that were mapped more frequently, instead of production or cultural ones.

We concluded that some basic, standardized guidelines for the mapping of ecosystem functions and services are needed. This cartography should include the flows of ecosystem services by including the beneficiaries of these services, and might be complemented with an analysis of the stakeholders involved, like the institutions responsible of the management that affects ecosystem services. This cartography might be the basic tool for planning the territory, showing, clearly the links between Natural Capital and human societies.

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Ecosystem Service Trading Programs: Lessons from Mid-Atlantic Water Quality Markets

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The use of markets and market-like programs to reduce pollutants and provide ecosystem services is receiving increased attention. Markets can provide flexibility for regulated entities that are trying to meet environmental goals. But, markets are not a substitute for regulation. Without an enforceable cap or environmental standard, most markets will not produce significant environmental improvements. This presentation will compare water quality market program development and implementation in three Mid-Atlantic States; Pennsylvania, Virginia and Maryland. Each state has different goals, leading to differences in market development and market institutions. Most market-based programs focus on the supply side of the market, creating the potential for a large supply of water quality credits. These programs have created limited demand for credits. How regulations and baselines are set will affect the scale and scope of water quality markets.

Pennsylvania's program was designed to promote trading. Thus, the supply-side baselines in Pennsylvania are set low to encourage participation. Also, Pennsylvania underestimated public interests in trading and, initially, had very little public participation in the program's design. This led to delays in implementing the program as the state agency had to open its proposal to public comment and change.

In Virginia, the water quality credit trading market was created through legislation. This approach limits the flexibility that oversight agencies may have. Thus, the program is more unwieldy. This may end up increasing the price of credits.

Maryland's water quality credit trading program tries to lower the cost of meeting a pollutant loading cap. But, from a broader perspective, Maryland has missed out on the most significant sources of cost savings. Maryland is upgrading nearly all of its waste water treatment plants to a very high level of technology. They will then cap loads at each plant and use the trading program to offset any new loads that occur due to population growth. While the program has the potential to provide a cost effective method to offset growth, the large gains that could have been realized had they allowed plants to trade in lieu of the technology upgrades were lost.

All three mid-Atlantic water quality credit trading programs demonstrate the importance of public/stakeholder involvement in program creation. Programs need to demonstrate to the public that they will lead to real environmental change or preservation. Issues of equity and fairness are also important to stakeholders. Furthermore, when creating programs, it is important to consider both the supply and demand sides of the market. Too often programs are designed with the idea that merely creating the program will bring about economic activity. In most cases, demand for water quality credits is created through government regulation or control. While most program designers assert that they are creating market or trading programs, market-like programs are more commonly the result. These market-like programs rely on performance based goals. Example programs include targeted cost-share programs, reverse auctions, and controlled or managed markets. Though water quality credit trading programs are limited to just one environmental resource, they can be very complex in design. Using water quality trading as a model for ecosystem trading, leading to a factor increase in the number of environmental resources and goals, will be challenging.

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Tools and Lessons for Community Engagement in Ecosystem Protection: Land Suitability Mapping and Growth Management in the Sandhills of North Carolina

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Sustainable Sandhills is a nonprofit organization with a focus in the eight county region surrounding Fort Bragg, in southeastern North Carolina. This region contains the entire Sandhills Longleaf Pine Ecosystem; one of the 21 most endangered ecosystems in the nation. Fort Bragg and associated Pope Air Force Base form one of the largest military complexes in the country and are seeing major growth in the military population, which in turn is driving substantial development in surrounding communities. The mission of Sustainable Sandhills is to serve as a model for regional sustainability planning, improving the quality of life for current and future generations through consensus, cooperation, shared visions and collaborative actions.

This presentation describes the regional situation, including pressures on ecosystems and communities resulting from growth of the military installations. Sustainable Sandhills has responded with a variety of programs, and entered into partnerships for innovative planning efforts with the military and a broad array of stakeholders. The presentation addresses the realities and challenges of community engagement and planning around ecosystem protection and sustainable development, among which is the fact that most stakeholders don't think in ecosystem service terms.

One of the key tools of Sustainable Sandhills and its partners is land suitability mapping, which uses geospatial analysis and community input to identify, across the region, the suitability of land for different purposes, and reveals where conflicts between potential land uses may occur. Sustainable Sandhills piloted this tool with funding from EPA. This presentation explores how a team of planners, sustainable growth proponents and GIS professionals worked with the community to develop, implement and refine a series of six land use suitability models for the region. It will show how planners are utilizing the results to develop and implement regional growth management plans. Specifically, the results of the models have been incorporated into the Comprehensive Regional Growth Plan that was recently published by the Base Realignment and Closure (BRAC) Regional Task Force, as well as the 2008 Joint Land Use Study that was recently adopted by the Fort Bragg/Pope Air Force Base Regional Land Use Advisory Commission. As for the process and tool, land suitability modeling has been taken up for Strategic Lands Inventory studies by the Southeast Regional Partnership for Planning and Sustainability (SERPPAS), a joint effort between DoD and other state and federal agencies covering North Carolina, South Carolina, Georgia, Alabama, and Florida. The presentation highlights lessons learned from the experiences in the Sandhills region.

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Incorporating Demand for Ecosystem Services into Payment Schemes

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A literature review and general systems analysis of current approaches to payments for ecosystem services (PES) reveal a common weakness, a missing feedback that could strengthen PES toward the goal of balancing human needs with the adaptive capacity of ecosystems. In absence of this feedback, in situations of rising demand for ecosystem services and limited means for producing them, the likelihood that payment systems effectively shift, but do not preclude ecosystem service losses is high. We propose that explicit price and information signals to ecosystem services consumers are necessary to “closing the loop”, and thus necessary to sustaining ecosystem services. In addition, this information is valuable to spatially and temporally targeting conservation and restoration activities. To date, attention paid to this (demand-side) feedback loop has been more casual than concerted. By incorporating demand for ecosystem services, PES can be improved as an overall tool to reduce the growing deficit between rates of ecosystem service supply and consumption or impact.

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Bioenergy and Sustainability – Why Woody Biomass

Marcia Patton-Mallory

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One of the greatest challenges facing forest managers in the United States on both public and private land is restoring, maintaining and enhancing the health and resilience of forest ecosystems. In many forests, this requires the removal of large quantities of small-diameter and low quality material that currently has little or no commercial value. Furthermore, climate change is likely to exacerbate the forest health problem in many parts of the country. A warmer climate could increase the risk of uncharacteristic and destructive wildfires and increase the susceptibility of forests to large-scale insect and disease epidemics. Climate change increases both the magnitude of the effort needed and the urgency of taking action.

Increasing the utilization of woody biomass from forests through hazardous fuel reduction, forest restoration, and other vegetation management activities on public and private lands can help offset the costs of these activities, provide economic opportunities to rural communities, and enhance environmental benefits for the American public. When the woody biomass is converted to energy and energy products, there are the additional benefits of air pollution offsets, renewable energy and associated displacement of fossil fuels.

Utilization of woody biomass is most successful when local needs and interests are matched with the local forest resource issue. Local forest resource issues generating biomass can be the result of forest fuels reduction, major insect outbreaks, significant storm damage, treatments for invasive species, and general forest health restoration activities. Communities benefit by increased rural jobs, new industry, renewable energy for schools and administrative facilities, alternative to landfills for urban forest management, and diversification of their economic base.

The use of wood-based energy lowers greenhouse gas emissions over fossil fuels, because carbon dioxide released when woody biomass is burned is balanced out by new, carbon- sequestering biomass growing in its place. For this reason, developing renewable systems such as growing trees for energy crops on private lands has gained considerable attention and support. Maintaining healthy working forests and utilizing by-products of forest management actions allows both sequestration and biofuels production to occur on the same acres.

National, State and local activities in different regions of the United States are presented along with a summary of the public dialog about energy from woody biomass and sustainability of forests.

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National Policies and Legislation for Woody Biomass Utilization

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For over a decade, drought, wildfire, insects and disease on our Nation's forests caused environmental degradation and significant economic impacts to States, Tribes, rural communities, and industry. These impacts, compounded by the effects of climate change and rising fuel costs, prompted Congressional attention and new legislation to meet these issues with a focus on woody biomass utilization.

The woody biomass utilization initiative aims to restore forest health resiliency, provide economic opportunities, reduce hazardous fuel reduction costs, generate thermal energy, mitigate carbon emissions through wood substitution, and provide feedstock for biofuels. These activities provide jobs for rural communities, Tribes and States; decrease firefighting costs; and offset fossil fuel dependency while mitigating effects of climate change.

The presentation provides an overview of the following key policies and legislation focused on woody biomass utilization:

Policies:

- The 2000 National Fire Plan
- The 2001 National Energy Policy
- The 2002 Healthy Forests Initiative

Legislation:

- The Biomass Research and Development Act of 2000
- Sections 9006 and 9008 of the 2002 Farm Bill
- The 2003 Healthy Forests Restoration Act
- Energy Independence and Security Act, 2007
- Food, Conservation, and Energy Act, 2008 (2008 Farm Bill)

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Clean Water Act Compensatory Mitigation Scaling Incorporating Uncertainty

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This paper presents an approach for determining compensatory mitigation requirements for Clean Water Act compliance. This process is often referred to as scaling. Compensatory mitigation is intended to replace the ecological services that are lost as a result of unavoidable impacts to natural resources affected by a development project. Ecological services refer to the beneficial functions performed by natural resources, such as the provision of food and refuge for fish populations. Lost ecological services are defined as the reduction in the provision of these beneficial functions resulting from project implementation. The amount of compensatory mitigation needed to replace lost ecological services depends, in part, on the ability of the affected resources to return to their baseline conditions. The amount of compensatory mitigation also depends on the ability of the selected compensatory mitigation measures to replace lost services. A critical factor in the ability to replace lost services is the uncertainty involved in mitigation success.

These concepts are illustrated by a case study of compensatory mitigation scaling in Guam involving the construction of a wharf in coral habitat. The range of compensatory mitigation measures appropriate for replacing lost ecological services in this case was restricted by the type of natural resources affected by the project, and by the limited mitigation possibilities within Guam. The compensatory mitigation project recommended for this project was characterized by significant uncertainties with regard to quantifiable success measures. Therefore, a scaling approach was needed that could incorporate these uncertainties in a meaningful analysis.

An adaptation of Habitat Equivalency Analysis (HEA) was selected for this approach. Two features of this adaptation included the analysis of a mitigation project of fixed size and the incorporation of mitigation uncertainty. These features are rarely if ever incorporated in more standard applications of HEA. The use of HEA in this case provided a readily available methodology that was transparent to resource experts and the public.

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Economic Approaches to Valuing Ecosystem Services in Natural Resource Damage Assessments

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This presentation describes the various economic approaches that are available to place monetary values on the provision of ecosystem services in the natural resource damage assessment context. Traditionally, those approaches have been categorized as “revealed preference” methods such as the travel cost method, and “stated preference” methods such as conjoint analysis. However, recently promulgated revisions to the CERCLA damage assessment regulations expand the list of recognized methods that may be used to determine compensable value, which includes the value of ecosystem services. Those revisions also include “restoration-based” methods such as habitat equivalency analysis. These different approaches will be arrayed to illustrate their similarities and differences, and to suggest implications for valuing ecosystem services.

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Watershed Age of Development and Watershed Management

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Watershed management often includes some aspect of landuse/landcover analysis to estimate human impact on receiving waters. Unfortunately, looking strictly at landuse as interpreted from aerial photography hides attributes that make each polygon unique. Intuitively, one such characteristic is age. Age adds a temporal scale to development's impact on receiving waters. In relation to watershed management, it can be used to highlight regulations in place at the time of construction.

Age itself can be determined in several ways. As many municipal seals illustrate, the year a city or town is settled is the beginning of the picture, but more importantly, the year a particular parcel is built upon is stored in databases maintained by the tax assessors' offices. Within a Geographic Information System (GIS), the parcel dates become the building blocks with which to analyze different scales of the landscape regarding human alteration.

Within Sarasota County, these data were utilized for two projects in which watershed characteristics were needed for interpretation. Through the development of the Tidal Creek Condition Index, a partnership between Sarasota County and Mote Marine Laboratory, a GIS analysis was completed to compare different watersheds to index values. A spatially-weighted average age of development was calculated from the parcel data for each of those areas of the basins. Although this analysis did not correlate with the tidal creek index, it was significantly correlated with benthic diversity and another index, based on landuse, the Landscape Development Intensity Index.

Another project was the development of a pollutant-loading model for the county by Jones Edmunds and Associates. Here, the average age of development was calculated for plat boundaries to represent neighborhoods. It was found that the average age and property values corresponded with landscape maintenance practices as observed in the field. This provided another attribute for medium-density residential landuse category regarding irrigation properties as an input to the model.

Human alteration of the landscape as defined by the manipulation of a parcel's built upon date was found to be a new and useful watershed attribute. Further evaluation as an indicator within other jurisdictions and against other indices is warranted as its use was limited to Sarasota County. As we struggle with limited funding available for watershed projects at a local scale, development of indicators such as watershed age of development is becoming increasingly important for targeting funding and effective watershed management.

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Location Affects Protection: Observable Characteristics Drive Park Impacts in Costa Rica

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To support conservation planning, we ask whether a park's impact on deforestation varies with observable characteristics that planners could use to prioritize sites. Using matching methods to avoid common biases in impact estimation, we find that deforestation impact varies with site characteristics. Avoided deforestation is greater on parks located closer to the capital city, on land closer to a national road, and on flatter land. In allocating scarce conservation resources, policy makers have to consider many factors, such as ecosystem services provided by a site and the costs of acquiring a site. Holding such factors fixed, Pfaff et al. 2004 conjecture that impact can be raised by protecting first, in a sequencing of protection, the sites less likely to survive outside parks. We provide empirical support for this argument in the context of Costa Rica's renowned park system. This insight, combined with information on eco-services and land costs, should guide investments.

Keywords: forest, protected areas, parks, reserves, Costa Rica

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Payments for Environmental Services: Empirical analysis for Costa Rica

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Evaluating its impact using the deforestation observed in matched untreated areas, we find that Costa Rica's 'PSA' program of payments for environmental services had little effect on 1997-2000 forest clearing. Reasons include: a low national rate of deforestation; no targeting of those locations more likely to change land usage; and a goal of transferring surplus to landowners. This pioneering effort could save much of its budget, or greatly increase forest impact from current funds, if it could avoid enrolling lands which would remain forested even without such payments.

Keywords: forest, ecosystem services, payments, Costa Rica

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Mapping Spatial Relationships of Two Exotic Species Relative to Forest Disturbances and Climate

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Invasive species and climate are the two most important drivers of change influencing Florida's landscape, particularly forested ecosystems. Florida has become the national epicenter of alien plant introductions in recent years. Florida's unique and changing climate and its impact on natural systems are of constant research interest. Forest disturbances and climate together play a central role in determining future introduction, spread patterns and invasion dynamics of invasive species. *Imperata cylindrica* (cogongrass) and *Lygodium japonicum* (Japanese climbing fern) are two known most notorious invasive species of the southern forests. We evaluated the spatial relationship of forest disturbances with the establishment and spread of *I. Cylindrica* and *L. japonicum* and role of climate in predicting their future geographic invasion potential at the Blackwater River State forest, a 195,000 acres forest in northwestern Florida. Spatial relationships between species occurrence and its abundance in relation to anthropogenic disturbances (road/trail network and prescribed fire) and natural disturbance (caused by hurricane Ivan) were mapped using spatial analysis in a geographic information system. Species' future geographic invasion potential as determined by climatic variables were mapped using MAXENT, an ecological niche modeling framework. Results indicated that anthropogenic and natural disturbance events resulted in significant expansion of both species compared to undisturbed areas. Growth patterns of both species were mostly affected by precipitation, indicating significant expansion potential with increase in precipitation.

Keywords: Invasive species, Climate, Disturbance, Drivers of change, Spatial relationships, Blackwater River State Forest, Japanese climbing fern, Cogongrass.

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Implementing a Nature's Services Infrastructure: The Case of a Million Trees Los Angeles

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Urban forestry is being seen as a means to improve urban environments through the biophysical functions of trees. One might term this the implementation of a biogenic infrastructure. This presentation will present research on the implementation of the million tree planting initiative in Los Angeles that includes research on water and energy costs and benefits of one million new trees in the city. Our research methods include qualitative interviews, observations and analysis as well as the deployment of monitoring instruments in the urban forest and economic analysis. This presentation will be an overview of our interdisciplinary research, and a discussion of the institutional complexities in implementing a large scale forestry program which began as a campaign promise, but exhibits all the requirements of an infrastructure program. It will examine the promise of nature's services in the context of a conventional city management structure.

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Climate, Land Use Land Cover and Migratory Bird Habitat Requirements

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The important bird habitat of the Great Plains is among the most threatened landscapes in North America. The Conservancy has identified sites for conservation action based on conservation priority and level of threat. Climate change and shifts in land use to supply biomass for energy are expected to alter the climate regimes, habitat types and other factors that influence the survival of species and health of populations in these landscapes. These alterations can be expected to change the scope, severity, and impact of various threats to biodiversity, which in turn may change the relative value of virtually all conservation strategies employed by the Conservancy. Our assumptions about how long a habitat or species may persist once protected may no longer be reasonable over time. We must revisit the networks of priority sites identified through ecoregional planning and the potential responses of these landscapes to climate changes and other large scale agronomic practices such as biomass expansion. A unified framework is essential to assess the current conservation portfolio and prioritize alternative strategies for conserving and identifying functioning habitats, species, and changes in ecosystem services.

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Understanding the Costs and Benefits of Carbon Management and Sequestration

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The creation of new markets to encourage environmental stewardship and provision of ecosystem services from private lands has become a common approach to the increasingly complex challenges associated with allocation of scarce resources worldwide. Growing concerns about future global warming point to the establishment of new carbon sequestration strategies that can help mitigate the negative effects of climate change. The State of Florida has a unique and valuable opportunity for the development of new strategies for carbon sequestration. However, rapidly escalating land values, competing interests in alternate land uses, and relatively low returns from land uses such as agriculture and forestry operations, together present significant challenges to the development of carbon sequestration strategies from agricultural and forested lands in this state. This paper provides an overview of the literature on carbon markets and the state of research on ecosystem services associated with carbon sequestration in order to help inform the development of these approaches in Florida.

The State of Florida has enormous carbon sequestration potential, but the rapid urbanization of the state continues to reduce this potential. The emergence of carbon markets worldwide illustrates the potential of the use of markets to encourage and enhance environmental stewardship on private lands. Through a review of carbon market literature, this paper provides information on the basics of carbon markets, how they function in other states and countries, and how costs and benefits of provision of carbon sequestration strategies can be estimated. Many ecosystem services are associated with carbon management, but the values of these services are often not captured in traditional markets. This paper also provides an overview of natural resource economics approaches to the estimation of these nonmarket values. The information presented will provide insights for the development and enhancement of carbon markets in Florida and will illuminate some of the knowledge gaps in economics and policy that need to be filled to help Florida advance its national and global role in carbon management and sequestration.

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Economic Valuation of Improved Ecosystem Services of Kol Wetland

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Wetlands are one of the most important natural ecosystems, which help in sustaining human life by providing diverse goods and services. But unfortunately the benefits of these valuable resources are often unaccounted or undervalued due to the intangibility nature of the same. This guided the indiscriminate exploitation of these resources which resulted in the large scale destruction and degradation of the same. Urban wetlands or wetlands lying adjacent to the urban centres offer multiple benefits to the urban society. It acts as the source of drinking water and also as a source natural waste water disposal. But these wetlands are the most vulnerable to degradation. Kol wetland is a good example for the same. Kol wetland is the part of the largest Ramsar site in India known as Vembanad-Kol wetland. It simultaneously provides benefits for the urban society and ensures the livelihood options for thousands of rural population comprised of farmers and fishermen. It is also known as one of the important rice producing areas in Kerala state of India. Its ecological significance being an important habitat of water fowls and migratory birds is widely acknowledged. The wetland is also endowed with natural beauty with a long stretch of backwater zone, which enhances the recreational value of the same. But due to the ever expanding population pressure and the unsustainable practices followed by the stakeholders including the farmers, the wetland is facing the threat of degradation.

A contingent valuation study has been undertaken to assess the willingness to pay of the urban stakeholders for the improved conservation and management of Kol wetland. Findings demonstrate a higher level of interest and willingness to pay among the majority of the urban stakeholders for the improved conservation and management of the wetland. But the farmers, a large component of rural stakeholders of the wetland, expressed their financial difficulties to follow sustainable agricultural practices, hence, requires financial assistance for the same. This information will help the policy makers in making appropriate policies for the better conservation and management of the wetland.

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Using Ecosystem Services in the National Ambient Air Quality Standard Setting Process

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The U.S. Environmental Protection Agency (EPA) is currently conducting a joint review of the existing secondary (welfare-based) National Ambient Air Quality Standards (NAAQS) for oxides of nitrogen (NO_x) and sulfur (SO_x). EPA is jointly assessing the science, risks, and policies relevant to protecting the public welfare associated with nitrogen and sulfur due to both their atmospheric interactions and ecological effects. As discussed 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”. Adverse public welfare effects are based on an assessment of how ecologically adverse impacts translate into adverse impacts on the public welfare. While adversity is not explicitly defined in the CAA, it can be inferred that adverse ecological impacts may have some corresponding impact on the well-being of human populations, through reductions in ecosystem services that might include direct services (e.g., flood control) or indirect services (e.g., provision of habitat for endangered species).

Currently, we are assessing the exposures and risks for ecological effects associated with atmospheric nitrogen and sulfur deposition. The main ecological effects include aquatic and terrestrial acidification and aquatic and terrestrial nutrient enrichment. Case study analyses in areas with known sensitivities to these effects are underway. We are exploring how ecosystem services may be used to characterize the levels of adverse effects associated with current deposition of nitrogen and sulfur, and how ecosystem services may be used to inform the standard setting process by demonstrating the links between an adverse ecological effect and the level of an associated ecological indicator. For example, ecological effects associated with nitrogen and sulfur deposition are related to the ecological indicator, acid neutralizing capacity (ANC). We are evaluating the extent to which we can link ecological effects as shown by ANC with potential measures of adversity to public welfare, by characterizing impacts to ecosystem services. Some examples of these ecosystem services include recreational and subsistence fishing, recreational lake use, natural habitat provision, and tourism. The value of these ecosystem services related to alternative levels of ANC will be assessed as the review progresses. We recognize that economic valuation of ecosystem services can be difficult, and non-monetary valuation can also be used to value ecosystem services. Valuation may be an important step from a policy perspective to compare the costs and benefits of altering versus maintaining an ecosystem (i.e., it may be easier to protect than repair ecosystem effects).

The first draft risk and exposure assessment and other documents associated with this review are available at: http://www.epa.gov/ttn/naaqs/standards/no2so2sec/cr_rea.html

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Everglades as Carbon Reservoir: Role of Management and Restoration

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Wetlands provide a range of goods and services including flood control, biogeochemical cycling and retention of nutrients and contaminants, water quality, carbon storage and sequestration, water storage and aquifer recharge, shoreline protection and erosion control, habitat for diverse wildlife, and many other ecological and economic benefits. Wetlands are one of the most productive ecosystems and have the ability to store large stocks of carbon in soil. Globally, wetlands occupy approximately 4 to 6% of the earth's land area. Because of their relatively high primary production and low decomposition rate, relative to upland ecosystems, wetlands are considered net sinks for organic carbon and nutrients. Hydrologic alterations resulting from water level drawdown or drought can result in reversal of anaerobic conditions to aerobic conditions, resulting in loss of carbon as carbon dioxide. However, the major effect of drainage in the ecosystem occurs belowground, where organic matter decomposition by heterotrophic microorganisms is significantly greater under drained than flooded conditions. Thus, wetlands that sequestered carbon would release carbon back to the atmosphere upon drainage. In addition, wetlands can be sources or sinks for greenhouse gases such as methane and nitrous oxide. In this presentation, Everglades ecosystems as carbon reservoir and the role of management and restoration on carbon sequestration will be discussed.

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Gulf G.A.M.E. (Geospatial Assessment of Marine Ecosystems) – Data Discovery

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One approach to ecosystem based management of oceans and coastal resources is the formation of a geospatial framework that identifies ecological similarities in marine habitats and enables the application and development of new tools and programs.

Ecoregions are spatial frameworks of ecological similarities and provide a very powerful tool for use in environmental protection. Their identification can provide multiple benefits such as identifying information gaps, locating appropriate monitoring and study sites, expand site-specific information to larger areas or interpolating to a finer scale, and predicting effects of various management or development scenarios. This can further research by identifying critical infrastructural relationships, assessing cumulative impacts, identifying habitats that should receive additional resource protection or conservation to sustain ecosystem health, biodiversity, and species of importance for fisheries. Marine ecoregions present special challenges since they are not easily compartmentalized and generally present a continuum of overlapping, often interdependent systems.

The Gulf GAME project is intended to support the “Gulf of Mexico Alliance Governors’ Action Plan, Identification and Characterization of Gulf Habitats Priority Issue”. The aim of this project is to develop an inventory of habitat-related information within the Gulf of Mexico. In particular, the project will provide database infrastructure for “identification, inventory and assessment of nearshore and offshore Gulf habitats to inform resource management decision”. This will serve as a foundation to develop a spatial framework for ecosystem-based management associated with regulatory and planning programs and areas of government coordination. Information gaps will be identified and footprint maps produced; the initial focus being on seagrass beds, identified by EPA as being a critical concern. The availability of updated maps derived from a spatially organized database can allow rapid access to the information needed to enhance the understanding and protection of habitats and their associated marine resources.

The work completed here will develop an inventory of habitat-related data within the Gulf of Mexico that will serve as a foundation to develop a spatial framework for ecosystem-based management associated with regulatory and planning programs and areas of government coordination. By providing data layers to illustrate the current spatial extent of seagrass beds, oyster reefs, coral reefs, and other benthic or deep-sea habitats as well as other habitats associated with the water-column, managers will be able to investigate loss or degradation of these habitats, protect and/or conserve them, and help maintain the ecological integrity of Coastal areas in the Gulf of Mexico.

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The Spatial Lands Registry: A Tool to Facilitate Market Transactions

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Land use decisions made by private landowners will ultimately decide the future health of the Chesapeake Bay watershed. It is estimated that by 2030, residential development alone will impair an additional 40% (9.5 million acres) of privately-owned forestland in the Chesapeake watershed. New incentives, and the tools to deliver them, are needed to slow the spread of development by encouraging landowners to retain their land and become better stewards of it. One such tool, the Spatial Land Registry (SLR), will provide an online mapping and analysis function to help private farm or forest landowners determine their eligibility for various incentive programs and ecosystem service markets. Specifically, the SLR will employ user-friendly technologies to allow landowners to locate, register, map, and assess their land value relative to both regional and site-specific incentive programs/markets. Ultimately, this tool will link ecosystem service credits generated by a land owner's stewardship practices to markets via the *Bay Bank* (www.thebaybank.org), an on-line marketplace that will connect sellers (landowners) with buyers (polluters). The SLR will serve multiple purposes such as reducing transaction costs, increasing landowners understanding of the value of their land, and aggregating smaller landowners to help make market transactions more viable and secure.

A diverse group of stakeholders including state, private, and federal partners are working together to develop this innovative tool. Project partners will pilot the tool in Maryland and Delaware in early 2009.

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Modeling Multiple Ecosystem Services and Tradeoffs at Landscape Scales

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In this paper we describe InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs), a new spatially explicit modeling tool that predicts the consequences on land-use and land-cover (LULC) change on the production of multiple ecosystem services, biodiversity, and commodity production. Unlike the benefits transfer approach, InVEST uses ecological production functions and economic valuation methods to make production predictions. We apply InVEST to three alternative scenarios of LULC change in the Willamette Basin, Oregon, USA. We show how these different scenarios affect two hydrological service levels, soil conservation, rates of terrestrial carbon sequestration, biodiversity, and market returns to landowners.

We find no evidence of significant tradeoffs among ecosystem services and biodiversity across scenarios. The one tradeoff in the Basin is between market value, which is higher under the two scenarios that do not change development policies in the Basin, and all other ecosystem services and biodiversity, which are higher under the scenario that implements policies to more closely regulate development (the Conservation scenario). However, we find that the economic value of the Conservation scenario is higher than the economic value of the other two scenarios when reasonable values for ecosystem services produced by the landscape are added to market value estimates.

We also present initial InVEST analyses of other landscapes, including the Eastern Arcs watershed, Tanzania, the northern plains of Minnesota, USA, the Sierra Nevadas, California, USA, and a rural landscape in Ghana.

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Putting Ecosystem Services on the Map: The Natural Capital Project

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Nature provides a wide range of economic benefits to people. Accounting for these ecosystem services can improve resource decisions, provide powerful arguments for conservation, and lead to novel sources of funding through markets and other payments. However, information is typically lacking on where ecosystem services are generated, what they are worth, and to whom. As a result, governments, businesses, NGOs, and others are unable to make ecosystem services operational in their day-to-day decisions.

The Natural Capital Project is developing tools to make assessing ecosystem services easy. We are demonstrating and refining these tools in several contrasting regions around the world, and are engaging leaders both in these regions and globally to incorporate ecosystem services into decision-making. The Project is a partnership among Stanford University, The Nature Conservancy, and World Wildlife Fund, working together with many other institutions (www.naturalcapitalproject.org).

We have developed a mapping tool for quantifying ecosystem service values across landscapes, called InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs). Examples of questions that InVEST can help answer include:

- Which parts of a watershed provide the greatest carbon sequestration, biodiversity, and tourism values?
- Where would reforestation achieve the greatest downstream water quality benefits?
- How will climate change and population growth impact these effects?

InVEST is designed for use as part of an active decision-making process. It uses scenarios of alternative land use and other variables to map various ecosystem services. The mapped outputs provide information about costs, benefits, tradeoffs, and synergies of alternative investments in ecosystem services. We have developed InVEST through test applications in Oregon, Hawaii, Tanzania, Colombia, and China.

In this talk I introduce the Natural Capital Project and the InVEST tool, presenting recent results from several demonstration sites. I illustrate how ecosystem service maps can inform a wide range of policies, markets, and decisions. And I outline the important scientific and practical challenges we've identified along the way, as well as future directions for both research and policy.

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Using Remote Sensing to Estimate Ecosystem Services in the Prairie Pothole Region

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A goal of the U.S. Geological Survey's Integrated Landscape Monitoring Initiative - Prairie Pilot is to monitor the patterns and dynamics of ecosystem services over time. Remote sensing can provide a multiscale, multitemporal, synoptic view of ecosystems and ecosystem responses to natural and anthropogenic processes. We have developed methods for modeling ecosystem components and services using imagery available from Landsat and MODIS sensors. Archival data from these satellite sensors provide a record of past and current ecosystem responses to a range of climatic conditions and management scenarios. Local datasets and field data supply necessary calibration information. In one application, we use spectral data from vegetated areas to estimate biomass production for grasslands and crop types under normal, above normal, and below normal precipitation years. This information is important for modeling biogeochemical processes. The results are aligned with U.S. Department of Agriculture crop maps and are adjusted to crop statistics from the National Agricultural Statistics Service. We also developed an approach that flags pixels when the spectral signature of vegetation phenology indicates a significant departure from past behavior, as characterized from long-term phenology records. Such changes in vegetation performance can signal alterations in land use or management, soil conditions, hydrology, pest and disease outbreaks, climate, or other ecosystem processes. A third application uses time-series images to capture and quantify surface water dynamics and then classify the hydrologic function of prairie wetlands with respect to groundwater interactions (e.g., recharge, discharge, and flow-through systems). Differences in such functions are associated with characteristic differences in water chemistry and wetland biota. At a broader scale, we use satellite data of coarse spatial resolution, but fine temporal resolution, to study seasonal and interannual regional surface water dynamics. These data offer a potential opportunity to estimate geographic patterns of wetland dynamics that can be related to specific ecosystem services such as waterfowl migration and breeding habitat. This suite of remote sensing applications can contribute input for integrated models that quantify multiple and simultaneous outcomes of conservation practices, programs, and land management activities in the Prairie Pothole Region.

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Translating Policy Decisions into Ecological Service Impacts for Cost Benefit Analysis

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A major effort by the US EPA's Office of Research and Development to inventory and value those products and services humans receive from the environment is taking place in the Tampa Bay Region. It is the goal of this project to provide local to regional decision makers with new and augmented tools for considering the impacts that past, present, and future decisions will have on the cumulative combined ecological services generated by the landscape surrounding and including the Tampa Bay estuary. Much research into the functions of the various ecosystems of the Tampa Bay landscape has been completed or is ongoing. This past knowledge base will be integrated and augmented by selective research projects to refine models of ecological service production, delivery, and consumption. A systems dynamics modeling framework is being developed in the SIMILE environment by linking together numerous sub-models defining the relationships between defined stressors and different ecosystems production of valued ecological services. Here we present our progress on developing these sub-models as an example of how we are translating current and projected stressor conditions through ecological functions to ecological service endpoints that are clear, relevant, and valued by decision makers and the general public.

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Use of Fused Hyperspectral and LIDAR Airborne Data to Map Offshore Stamp Sand Migration in Keweenaw Peninsula, Michigan

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A major multi-faceted field data collection and sampling effort was conducted to examine the migration of copper mining waste sands (stamp sands) at two sites along the Lake Superior shoreline. The CHARTS (Compact Hydrographic Airborne Rapid Total Survey) airborne Light Detection and Ranging (LIDAR)/hyperspectral sensor system, jointly operated by the Corps, National Oceanic and Atmospheric Administration (NOAA) and the Navy, collected imagery and LIDAR data over two copper mining waste sites along the Keweenaw Peninsula in Lake Superior to support a study examining the transport of the black copper-bearing stamp sands by natural processes. Corps of Engineers researchers coordinated with local study participants at Michigan Technological University (MTU) to develop a week-long sampling effort to provide ground truth during the CHARTS overflight. Measurements were taken of spectral reflectance of terrain and lake bottom surface, light reflection and extinction characteristics within the lake water, acoustic bottom typing of the lake bottom near the stamp sands deposits, water quality parameters, and bottom samples. These data will aid in processing the data collected by the CHARTS system and will delineate the progressive spread of the stamp sands. These data will also assist in the development of algorithms for the calculation of water quality parameters from CHARTS data. Study conclusions will assist the Corps' Detroit District in developing plans for stamp sands remediation. This study represents one of the first major studies using CHARTS for environmental analysis purposes and is funded by the System-Wide Water Resources Program under a work unit targeted at the development of data fusion techniques.

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Our Growing Need to Understand Relationships between Human Activities, Global Change, and Ecosystem Services

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Agricultural production, urbanization, energy production, road building, mining, manufacturing, and other activities that satisfy human needs collectively change the structure and function of ecosystems. These changes reduce the capacities of ecosystems to provide services crucial to humans, such as maintaining water quality and availability, reducing floods, generating and maintaining productive soils, sequestering carbon, controlling climate, and generating and maintaining biodiversity. The dynamics between interacting elements of human-induced global change and ecosystem services are complex, variable in space and time, and difficult to describe well or simplify. Yet, humanity requires a much better understanding of these dynamics to assess intentional and unintentional tradeoffs between human activities and ecosystem services in the face of increasing demands on the environment. Tradeoffs on agricultural landscapes provide a good example of why this is so. Agriculture is profoundly important for feeding the rapidly growing human population and to the global economy, and, more recently, for providing alternative sources of energy. We know the benefits of agricultural production come with costs in the form of reduced ecosystem services. However, we have not described these relationships well in terms of how various stressors interacting on agricultural landscapes impact ecosystem services across space and time, which limits our ability to make informed decisions regarding tradeoffs. For example, habitat loss and reduced habitat quality are the primary factors contributing to the loss of biodiversity globally. Agricultural practices are the principal causes of such losses in the forms of habitat destruction from planting crops and contamination from applications of pesticides and fertilizers. Thus, at a coarse level of understanding, the generation and maintenance of biodiversity in and downstream of agroecosystems are reduced substantially to produce crops, but how so relative to specific activities and resultant environmental stresses, impacts on other related ecosystem services, and sustainability? Production of crops for biofuels and other emergent elements of global change add further to the complexity of these questions and the urgent need for useful information. Our research in the midwestern U.S. suggests interdisciplinary teams studying multiple stressors and ecosystem responses across scales using complementary methods are necessary to produce such information. This approach requires strong collaborations and partnerships with substantial leveraging of resources. It potentially could provide a broad range of stakeholders essential information for understanding and limiting tradeoffs between human activities and vital ecosystem services.

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Towards an Understanding of the Interactions between Drivers of Agricultural Production and Their Potential to Direct the Development of Sustainable Systems

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American agriculture has changed dramatically during the previous century as the result of social, political, economic, environmental, and technological drivers operating both internal and external to the agricultural system. Through an examination of farming operations, we identified how these drivers interacted to create the production systems predominant in US agriculture today. The highly specialized systems common to today's agriculture are more vulnerable to change, making development of adaptive capacity essential to address future challenges of food and energy production and develop sustainable systems. The success of industrialized agriculture has had the unintended consequence of decoupling the production and consumption processes, as fewer people are directly involved in agriculture. This has contributed to the societal view of farming as the problem in overconsumption of natural resources, and development of the notion that sustainable production systems alone will solve problems of natural resource overuse and contamination. Though there has been an increasing cognizance of the impact of human activity on natural resources, balancing natural systems requires an examination of both production and consumption. Closing the circle of consumption and production can serve to reduce the ecological footprint by more completely integrating the entire system. To become sustainable, we need to rethink our view of agriculture and modify production practices to enhance ecosystem services that agriculture can provide beyond traditional production. Knowledge of drivers and their interactions and influences on production systems will allow us to orient farming systems towards environmental sustainability, while maintaining economic feasibility.

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Standardized, National Ecosystems for Ecosystems Services Assessments

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Ecosystems provide the goods and services (food, fuel, fiber, climate regulation, water provision and purification, soil fertility maintenance, etc.) necessary to sustain humankind, and as such are considered the essential life-support units of the planet. Ecosystem services assessments are increasingly appearing in the scientific literature and a recent major assessment of global ecosystems (Millennium Assessment, 2005) concluded that many ecosystems are compromised in their ability to provide these benefits. By definition, ecosystems are the service-provider units of ecosystem services, and as such merit consideration for use as geographic accounting (spatial) units in ecosystem services assessments. An effort to map standardized, robust, national ecosystem distributions is described, and the use of these mapped ecosystem occurrences for ecosystem services assessments is discussed.

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Ecological Services and Land Use Codes: Evaluating the Effects of Municipal Policy on Environmental Outcomes

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In the United States, significant planning and regulatory effort has focused upon the adoption of ordinances to reduce non point source pollution. The United States Environmental Protection Agency (EPA) has recognized non point source pollution as the largest source of water quality problems. A complex array of laws and regulations affect water quality beginning with the federal government's role and the requirements of the Clean Water Act. Since the 1987 Clean Water Act amendment, states have been required to implement non point source pollution control programs. Recent discussion has focused on the trade-offs between ecological services and human services (Alberti and Marzluff 2004, Pickett and Cadenasso 2008) and the relationships between policy and ecosystem services. We present the initial results of a study funded by the National Oceanic and Atmospheric Administration (NOAA) which was aimed at creating a methodology to explore the impact of ordinances and regulations on water quality. The initial phase of this study examined four gulf coastal watersheds, one each in Florida, Alabama, Mississippi and Louisiana. Trends in water quality were correlated with ordinance characterizations. Our initial results indicate that in most cases, water quality data is not complete enough to evaluate ordinances at the municipal scale. However, in one case, Covington, LA had comprehensive water quality data that allowed more scrutiny of water quality policy. We concluded that current policy in Covington is insufficient to insure that ecosystem services are left intact to provide for minimum standards in measured water quality parameters.

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Applying the Ecosystem Services Concept for Environmental Management in the Upper San Pedro Basin, Arizona

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The Upper San Pedro River flows intermittently north from Sonora, Mexico into southeastern Arizona and is one of the last few large unimpounded rivers in the American Southwest. The remaining perennial reaches support a desert riparian ecosystem that is a rare remnant of what was once an extensive network of similar riparian systems throughout the Southwest, and is thus of critical ecological and cultural importance. The river serves as a corridor between the sky islands of the Madrean Archipelago in Sonora and Arizona's Central Highlands that is the most significant migratory flyway in the Southwest. It provides habitat for nearly 70% of the currently known avian species in the U.S. and has the highest mammalian diversity of anywhere in the U.S. The San Pedro River is threatened on numerous fronts by landscape change resulting from climate change, mining activities, the border fence, rapid human population growth and associated urban development, and unsustainable water use. These threats collectively require systematic analysis to fully understand the implications of management and policy actions for the basin's communities and ecosystems. A comprehensive approach based on applying the conceptual framework of an ecosystem services assessment has been adopted to identify the costs and benefits associated with scenarios based on different combinations of stressors.

Well-organized stakeholders, substantial long-term investment in monitoring, and a long history of multi-disciplinary, interagency research in the San Pedro Basin make it an ideal location to conduct a comprehensive ecosystem services assessment. These factors facilitated the establishment of a research enterprise between the USGS, USDA, USEPA, University of Arizona, and local stakeholders to assess and value ecosystem services in the San Pedro. Conceptual modeling of ecosystems within the basin, interactions between and the effects of the different stressors is being used to identify the most sensitive and locally relevant services, resulting in developing an implementation plan for their assessment and valuation. The importance of resident and migratory fauna within the basin poses important challenges in terms of defining the temporal distribution of services consumed and provided locally, as well as the geographic extent of services rendered elsewhere that depend on the existence of the corridor.

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On the Value of the Ecosystem Services Concept: An Idiosyncratic Synthesis of Regional Studies Their Methods, Results and Promises

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Placed at the interface of science and policy, modeling and management, measuring and valuation, ecosystem services have been the focus of hundreds of studies over the last 20 years. The concept has been seen as point of unification of so-far disparate fields of environmental research. Its considerable charm is due to the rather holistic approach. Thereby land-use management can be evaluated not only with respect to food production or water purification, but for all ecosystem processes in concert, investigating impacts of any policy change. In this paper we seek to investigate which promises the ecosystem service concept holds and to which extent current studies for regional environmental management have been able to live up to this promise. From our review of 174 studies boasting the label “ecosystem service” in title, keyword or abstract, the vast majority is concerned with only one or two ecosystem services. Furthermore, a substantial proportion (40%) of these studies is concerned with the monetarisation of ecosystem services, without actually being able to quantify them in the first place. Finally, considerable journal space has been devoted to discussing definitions of what to ecosystem services are, and specify which benefits and values can actually be attributed to them. The results can be summarized as follows:

(1) Ecosystem service accounting might provide information for regional decision making; external effects outside the focal region are frequently neglected. The failure of politicians to anticipate the disastrous effect of European bioethanol policy on the rain forests of Indonesia and Central Africa serve as an example on why a holistic and global perspective has to be taken even for national ecosystem service decisions.

(2) Biophysical models provide a specification of ecosystem services; allow analysis of trade-off, non-linear and dynamic pattern by scenario studies. All this is rarely found in recent studies. Instead of that, tables giving financial value to certain land-use types produced for the USA are used to monetarise study sites throughout the world.

(2) Valuation and accounting increase awareness of ecosystem goods and services. As long uncertainties – in the underlying data, the model as well as the valuation methodology - isn't considered correctly, uncertainty of economic constraints overlays all other.

(4) There is an enormous diversity in understanding, implementation and methodologies of stakeholder involvement. What are the success stories and why?

The ideal, and possibly utopian, ecosystem service for regional studies comprises six key features: describes the process behind the service, is multi-dimensional by considering several services, dynamic (allows for changing conditions), context-specific (with labor, environment and technology conditions specific to the site in question), policy- and economy-linked, considers external effects outside the focal region. After 20 years of ecosystem service research, it is still early days. Only through a common set of consistent methodological approaches and coordinated initiatives, open exchange of data and methods, and highly interdisciplinary research can the concept of ecosystem services continue to rise.

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Resource Assessment: Terrestrial Carbon Sequestration

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This paper discusses an economic framework for a terrestrial carbon sequestration resource assessment (CRA). The framework is a preliminary step to facilitate a wide and robust carbon market, and to establish a system consistent with property rights. The natural science components include the estimation of the physical capacity of the environment for carbon sequestration, as well as knowledge of carbon stocks and flows, and their uncertainty. The economic and policy components include the estimation of flows of services and associated economic values.

An assessment of carbon ecosystem sequestration differs from a traditional resource assessment, in part, because a nonrenewable resource is extracted, while carbon sequestration introduces carbon in a form that can be stored either biologically or geologically. Thus the total resource “availability” or maximum sequestration potential depends both on management practices that can enhance or detract from carbon sequestration, and also on naturally occurring events such as wildfires and volcanic eruptions that may interrupt or disturb ongoing carbon sequestration efforts.

An assessment of carbon ecosystem sequestration also differs from a traditional resource assessment in economic terms. Some of these factors include the following: aggregation procedures; risk and uncertainty; benefits and costs; intra- and inter-generational equity and discounting; and technologic change. In addition, given the importance of human behavior and responsiveness to incentives that might be associated with increased sequestration efforts, the assessment will need to take into account market interactions. The paper outlines a possible methodology for a terrestrial carbon resource assessment and provides implementation recommendations.

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An Assessment of Vulnerability of Human Population Due to Loss of Mangrove Ecosystem Services in Africa

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Mangrove forests provide important ecosystem goods and services. These forests help stabilize shorelines and reduce the devastating impact of natural disasters, such as tsunamis and hurricanes. They also serve as breeding and nursing grounds for marine species, and are sources of food, medicine, fuel, and building materials for local communities. However, these forests have been declining at an alarming rate—perhaps even more rapidly than inland tropical forests—and much of what remains is in degraded condition. The remaining mangrove forests are under immense pressure from clear cutting, encroachment, hydrological alterations, chemical spills, storms, and climate change. Efforts are needed to curb the deforestation due to agricultural expansion while continuing efforts to reduce deforestation due to aquaculture development and urban development.

This paper presents a country by country analysis of changes in mangrove forests of Africa using time series Landsat data. Changes in population distribution within 20 km. of the coast line were also estimated. Then an integrated analysis was carried out to assess vulnerability of people due the loss of ecosystem services in African countries.

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Ecosystem Services of Florida Grasslands

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Ecosystem services of Florida grasslands go beyond providing a source of livestock feed, and in particular, they include those services that enhance environmental quality and ecosystem sustainability. The purpose of this presentation is to provide an overview of the range of ecosystem services provided by native and planted grasslands and to focus most intentionally on the role of Florida grasslands in carbon sequestration.

Ecosystems services of Florida grasslands include providing wildlife habitat, plant species conservation leading to greater biodiversity, preservation/enhancement of water quality, and preservation/enhancement of soil quality. In an increasingly urban state like Florida, grasslands provide habitat for nearly two thirds of our wildlife. Native grasslands are one of Florida's natural ecosystems, preserving many plants and animals. There are 332 native grasses in Florida, and more than 100 different plant species can be found on a single range unit of the longleaf-slash pine-wiregrass range type (biodiversity). Florida grasslands also play a major role in preserving water resources through water capture, minimizing particulate flow to surface water, filtration of potential pollutants from shallow ground water, and reduction in the likelihood of ground water contamination from agricultural, industrial, or municipal effluent irrigation. Soil quality is impacted by grasslands because they reduce soil erosion, increase water infiltration, and preserve topsoil. In addition, they increase soil fauna, soil carbon, and soil moisture.

An important aspect of enhancing soil quality is increasing soil organic carbon, or carbon sequestration. Unlike forestland, where a large percentage of carbon is stored above ground, in grasslands 90 to 95% of the carbon is below ground, most occurring as soil organic carbon. On a global basis, 22% of all soil organic carbon resides under grasslands. There are three primary ways in which carbon sequestration occurs. These include changes in land cover or land use, altered management within an ecosystem type, and altered ecosystem function. Focusing on the first of these three, bermudagrass establishment on previously continuously cropped land has been found to increase soil organic carbon in the top 6 cm of soil by 1.4 tons C ha⁻¹ yr⁻¹ when the grass was grazed. This was greater than when the grass was unharvested or harvested for hay (0.6 and 0.3 tons, respectively).

Grasses of warm-climate origin (C₄) have a photosynthetic pathway with twice the nitrogen efficiency compared to temperate grasses. This results in large carbon:nitrogen ratios in plant litter and especially in roots and rhizomes, thus degradation of these below-ground structures is slow. Existing soil organic matter has an even slower degradation rate than plant litter. Thus, soil organic carbon accumulates under C₄ grasslands because of the slow mineralization of existing soil organic matter, the high proportion of plant biomass that is belowground, and the slow rate of degradation of this high carbon:nitrogen material.

In conclusion, grassland ecosystems provide vital services to the Florida environment. Grasslands play a critical role in long-term carbon storage, sequester large amounts of new carbon, particularly following land-use changes, and carbon sequestration occurs regardless of grassland use, but it is greatest when the grassland is grazed by herbivores.

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Trade Offs between Agricultural Production and Ecosystem Services at a Farm Level

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Multifunctional agricultural landscapes are potentially important producers of ecosystem services, e.g., enhanced water quality, nutrient recycling, reduced sedimentation, carbon sequestration, and enhanced wildlife habitat, in addition to traditional agricultural commodities. The product mix of ecosystem services and commodity outputs from an agricultural landscape depends on the spatial pattern of land uses emerging from individual land use decision, called the economies of configuration by Gottfried et al., (1996). However, many empirical studies show that the production of ecosystem services on agricultural landscapes is in decline. This is consistent with social research conducted over the last few decades showing there is a narrow range of social circumstances under which farmers or landowners are willing to make personal investments in the present to achieve public benefits in the future through investing in natural capital (Firey 1963), i.e., investments that result in the greater production of ecosystem services. These services are frequently public goods from which the landowner derives virtually no income.

An integrative modeling approach (IMA) is developed in this study to generate a trade off curve between agricultural production and ecosystem services at a farm level. The methodology involves integrating a evolutionary algorithm with a hydrologic model AGNPS, a composite wildlife index model, and an economic model. The methodology developed in this research will help to identify the shape (competitive, complementary or supplementary) of the PPF curve of economic returns and ecosystem services. The integrated model is capable of identifying the optimal combinations of agricultural production and ecosystem services based on the available technology and resources at a farm level. This study also captures various ecosystem services provided by agricultural landscapes with riparian buffers such as increased water quality and wildlife benefits. The study area is the Big Creek watershed of the Cache River basin in southern Illinois, which covers an area of 1944km²

This comprehensive integrated modeling framework has important policy implications for the design of conservation stewardship programs such as the CRP, Conservation Security Program (CSP) and National Conservation Buffer Initiative (NCBI), which help target areas such as riparian buffers or land parcels that provide the maximum environmental benefits for the dollar spent. The anticipated results could serve as a tool in decision-making. This research offers interactive and spatially explicit models that will provide scientific information to policy makers and stakeholders that will aid in their planning and decision-making process regarding land use decisions and their impacts on ecosystem services from various policy scenarios and market conditions.

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Use of Ecosystem Services Analysis in Decision Making: Thoughts from a Newbie

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Ecosystem services analysis has been used by a variety of groups and organizations, and more so in the last 5 years. Most of this effort appears to have been directed at identifying services in a non-monetary fashion so that their “true” value is recognized. In addition, some have attempted to put monetary value on these same services to illustrate their importance to the flow of goods and services in the overall economy. For some companies the exposure to ecosystem services as a concept arises during the discussion with natural resource trustees under the natural resource damage assessment process. In general, the concept of ecosystem services analysis could have applicability to decision making in companies, but challenges exist. One application might be to obtain an additional measurement or estimation of the cost of doing business – either in terms of the environmental footprint, or under the wider umbrella of sustainability. The challenge for most companies is that the concept, outside the natural resource damage assessment process, is not well known. This lack of familiarity can be a major barrier to the concept being applied in decision making. Another challenge is how to translate these analyses into common language that can be understood by shareholders, employees and the business community at large. For now the use of this concept in decision making is limited, but the barriers to its wider use in the business community do not appear to be insurmountable.

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Use of Ecosystem Services Analysis in RUF – Restoration Up Front

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Ecosystem services analysis has been used by a variety of groups and organizations, and more so in the last 5 years. For many companies the exposure to ecosystem services as a concept arises during the discussion with natural resource trustees under the natural resource damage assessment process. Practitioners of natural resource damage assessment (NRDA) have developed simplified approaches that blend ecosystem services analysis with environmental toxicology, ecology, and a patina of economics. The simplified approach most widely used today to estimate the ecosystem (or ecological) services provided by a habitat or resource is called Habitat Equivalency Analysis, or Resource Equivalency Analysis. As more companies have become acquainted with these approaches, and what is needed to achieve timely, cost-effective NRD settlements, some have realized that their properties represent real assets that can be enhanced or restored, and used to help offset potential liabilities. These simplified approaches give them a way to estimate the potential value of the habitats on their property, and to determine what enhancements or restoration might allow the habitat to achieve even higher levels of services. The concept of undertaking restoration in this manner, especially in the absence of a quantified service loss is called restoration up front (RUF). In the past two years, companies, natural resource agencies, and now some in the insurance and conservation communities have become more knowledgeable about this concept and its potential use to increase restoration around the United States.

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Managing on a Landscape Scale for Woody Biomass

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Forest management tools have included thinning for growth and yield for many generations. More recently, thinning from below has been employed to improve the health and vigor of mature trees while simultaneously reducing the threat of wildfires. Biomass thinning using whole tree removal not only reduces smoke emissions, but gives the forest manager better control and precision over vegetation management treatments. Creating large scale, long term strategies also provides the opportunity to create new markets for small diameter products and bioenergy.

The presentation will provide an overview of commercial biomass thinning practices on federal lands with significant public involvement in landscape decision-making. Examples will include long-term projects designed for wildfire reduction and habitat improvement in California, endangered species habitat management in Georgia, and forest health and wildfire threat reduction in Oregon.

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Creating a Private Market for Ecosystem Services: Selling Hayfield Services for Grassland Birds to Ex-Urban Residents in Jamestown, Rhode Island

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Ecosystem services have long affected human quality of life, but modern economies frequently fail to adequately include some services. In particular, the modern economic systems are ill-equipped to integrate the value of public goods produced by ecosystems: The nature of public goods, particularly the inability of providers to exclude beneficiaries who have not paid compensation for provision, means that providers are generally unable to capture the value of many if not most or all beneficiaries. For example, a farmer who decides to incur costs to his or her business in order to protect grassland nesting habitat for birds provides aesthetic ecosystem services that impact the quality of life of nearby non-farm residents who like to see these birds or like knowing that the local ecosystem is functioning well-enough to sustain some breeding pairs. However, that farmer cannot leverage the values of his or her neighbors in order to afford to do even better for the ecosystem and nesting birds. Research reported here begins to challenge these limitations on private markets.

This project focuses on an experimental market in Jamestown, RI, where the investigators have tested rules of trade by which non-farm residents pay for farmers to avoid early-summer hay-harvests to enable successful nesting by bobolinks. Bobolinks, a neotropical migrant bird that over-winters in Argentina and breeds in North America is not endangered federally, but is noted as declining continentally and is listed as endangered by some state conservation departments. The project created the Nature Services Exchange of Jamestown, in collaboration with EcoAsset Markets, Inc. Investigators developed economic mechanisms for funding public goods, drawing on insights from experimental economics, enabling a test of two mechanisms designed to generate revenues for farmers and a third mechanism designed to measure the potential value of the public good to residents of Jamestown. The third mechanism satisfies theoretical criteria for incentive-compatibility, but usually does not generate revenues sufficient to provide the public good, yet it serves as a benchmark for evaluating the performance of revenue-generating mechanisms. All mechanisms involved a money-back guarantee if the total of offers from residents failed to meet the compensation necessary to cover the costs imposed on cooperating farmers. The mechanisms differed in the rules established for the disposition or rebate of funds collected in excess of the total needed to implement a farm-wildlife contract.

The market operated from approximately March through April in 2007 and 2008. In 2007, three of six available fields were protected under farm-wildlife contracts on which residents had paid some or all of the costs. In 2008, two of four fields were protected. Data show that one revenue-generating mechanism performed poorly relative to the other, but that modifications to the lower-performing mechanism increased offers for payment to be statistically similar to the other mechanism. Results also are mixed on the success of the incentive-compatible mechanism. Results also show that direct-mail marketing affected the decision of residents concerning whether or not to participate, as well as their payment offered once the individual had decided to participate.

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Ecosystem Services and Land Use in the Nebraska Sandhills Ecoregion

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Work performed under USGS contract 08HQCN0005.

The Nebraska Sandhills ecoregion, a grass-stabilized dune landscape, is considered one of the most distinct and homogeneous ecoregions in North America. The majority of the ecoregion consists of privately owned cattle ranches, punctuated with wetlands and hay crops. It is believed that the ecoregion enhances recharge of the Ogallala Aquifer as water from both precipitation and river channels moves easily through the porous soils. The U.S. Geological Survey's Land Cover Trends Project mapped land cover in the ecoregion between 1973 and 2000 to estimate amounts and types of land cover change. Estimates were derived from analysis of 28 randomly selected 10- by 10-kilometer blocks. The 28 blocks were analyzed with Landsat images, supplemented by historical aerial photographs, to interpret land cover for five dates from 1973 to 2000 (1973, 1980, 1986, 1992, 2000). Results show that only 4.2 percent (SE=1.0 percent; equates with an estimated $2,542 \pm 908 \text{ km}^2$) of the land cover changed during the study period. The largest changes overall include a decrease in grassland/shrubland (1.4 percent, SE=0.6 percent; $874 \pm 554 \text{ km}^2$) and an increase in agricultural land (1.5 percent, SE=0.6 percent; $926 \pm 551 \text{ km}^2$). The most common land cover conversion was grassland/shrubland converting to agricultural land, and the second most common conversion was agricultural land converting back to grassland/shrubland. During the study period, the greatest rate of change occurred during the 1973 to 1980 time frame. Also during this time frame, the ecoregion experienced an increase in agriculture as center pivot irrigation became popular. However, the topography and porous soils of the Sandhills made this kind of agriculture largely infeasible and, as a result, it began to decline in the 1980s. Overall, the land cover of the ecoregion has remained relatively stable and continues to provide grazing for livestock, deer, and antelope as an ecoregion-scale ecosystem service. To preserve ecosystem services, groups such as the Sandhills Task Force have been working on improved range management in an effort to boost both rangeland productivity and protect habitat for wetland and grassland species. At a broader scale, improved rangeland management helps to protect the groundwater resource that is vital to both the ecoregion and the Ogallala Aquifer.

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Everglades Restoration

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The Seminole Tribe of Florida has participated in the restoration of the South Florida Everglades since the early to mid 1990's. The Tribal connection to the ecosystems' plants, animals, birds, reptiles and water not only defines its culture, but directs its stewardship and future in these unique lands. Tribal partnerships with the U.S. Army Corps of Engineers, the South Florida Water Management District, and other Federal/State agencies have greatly expanded the Tribal understanding and life on its Reservations. The issues of water resources, wildlife protection, archaeological protection, natural resource conservation and restoration are incorporated into the main governmental functions of the Tribe. Religious, recreational, agricultural and commercial activities are closely tied to these lands in the Everglades.

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The USA National Phenology Network: Data and Tools for Ecosystem Services

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The USA National Phenology Network (USA-NPN) is an emerging and exciting partnership between federal agencies, the academic community, and the general public to monitor and understand the influence of seasonal cycles on the Nation's resources. The goal of the USA-NPN (www.usanpn.org) is to establish a wall-to-wall science and monitoring initiative focused on phenology, the seasonal pulse of the biosphere and thus the gateway to climatic effects on ecosystems and ecosystem services.

Periodic plant and animal cycles driven by seasonal variations in climate are the most fundamental biotic oscillations connected to human activities. They set the stage for dynamics of ecosystem processes, determine land surface properties, control biosphere-atmosphere interactions, and affect ecosystem services such as the production of food and water, carbon cycling, pollination, and wildlife habitat. Phenological data and models at local to national scales have applications related to scientific research, education and outreach, and can assist stakeholders, managers and scientists interested in agriculture, tourism and recreation, human health, and natural resource conservation and management. However, the predictive potential of phenology requires a new data resource—a national network of integrated phenological observations and the tools to access and analyze them at multiple scales.

The USA-NPN will (1) integrate with other formal and informal science observation networks (e.g., National Ecological Observatory Network (NEON), Long Term Ecological Research Network (LTER), Ameriflux, National Park Service Inventory & Monitoring, Organization of Biological Field Stations, public gardens, conservation groups) including regional phenology networks; (2) utilize and enhance remote sensing products, emerging technologies and data management capabilities; and (3) capitalize on myriad educational opportunities and a new readiness of the public to participate in investigations of nature on a national scale. This talk will illustrate how phenology is an emerging integrative science for assessing impacts of climate change and for increasing citizen awareness and participation in understanding environmental impacts of human activities on Earth systems.

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Spatial Analysis of Urban Forest Biomass Distribution in Five Southeastern U.S. Cities

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The trees growing in urban areas can be defined as urban forests. Urban forests are the mosaic of planted landscape trees and native forest remnants that have been either preserved or otherwise undeveloped. The composition and structure of urban forests is highly variable. The heterogeneity of urban landscapes and influential factors such as local environmental conditions, government regulations, socioeconomic, and held values can therefore drive urban forest structure and ecosystem services. Variables affecting urban forest composition and structure will also affect the urban forests' responses to environmental stresses such as temperature, drought, and wind. In the Southeastern United States, we are particularly concerned with urban forests' responses to extreme wind events such as tropical storms and hurricanes. Following a storm, timely prioritization, clean-up, and removal of tree debris and related tree hazards (i.e. downed and damaged trees, broken and hanging tree limbs, etc.) becomes a dangerous, costly, and time consuming process. Such storms can also cause extensive damage to urban forests and reduce the stream of ecosystem services. It is for these two reasons that we are attempting to quantify hurricane caused tree debris and its distribution in urban forest ecosystems.

Tree debris must be a percentage of the total amount of potential tree biomass. However the proportion of debris and the spatial distribution of it across the landscape have rarely been quantified. We used post-hurricane tree debris, land cover and street mile data to estimate ecosystem level debris amounts. We also used Geographical Information systems and permanent urban forest structure plots to spatially analyze the distribution of biomass across several urban ecosystems.

We estimated tree debris production for 10% of all communities affected during the 2004-2005 Florida hurricane season. We also estimate the spatial distribution of urban forest potential debris by determining the total amount of fresh weight aboveground tree biomass that exists for 5 given urban ecosystems: Miami, Tampa, Gainesville, Pensacola, and Houston, which had existing data on their urban forests' composition and structure. Results can be used to spatially analyze potential debris production and carbon storage across the urban ecosystem.

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What Can the Landscape Tell Us about Human Welfare? The Case of Píritu Lagoon in Venezuela

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The potential of remote sensing as a tool to study marine and land ecosystems has captured the interest of public managers and policy analysts. The link between physical measurements of parameters with standard theories of economic welfare is widely accepted, although the relationship between them is often unclear.

The location of this study is the Píritu Lagoon in Venezuela, where field studies on environmental impacts are limited and there is a lack of information on resulting environmental changes. Geospatial tools were used to measure changes in landscape patterns over time, where these changes were linked to a simple two-factor, two-good general equilibrium (GE) model. This method was used in order to impute changes in human welfare arising from aquaculture effluent impacts, as well as other impacts on the lagoon ecosystem. Five Landsat images were used to determine 16 classes of habitat. Landscape metrics and patterns were retrieved from this classification and comparisons between them over time were assessed. Linkage to the GE model was made using the carrying capacity of the lagoon, as well as making assumptions for the model using other productive factors. Significant change was found in the Píritu lagoon, but the origin of the changes cannot be established with certainty. Nevertheless, linkages to the GE model show that if the changes did occur, then under reasonable assumptions used in such models, the population around the lagoon may have experienced a welfare decline. By using geospatial tools, this study provides a conceptual platform that links macroeconomic models to data generation from intermediate inputs within ecosystems. These approaches are applicable in other contexts.

Key Words: Landscape patterns, remote sensing, ecosystem goods and services, general equilibrium, environmental impact, welfare.

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NOAA Activities and Products in Support of Ecosystem Services

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Humankind benefits from a multitude of resources and processes that are supplied by natural ecosystems. These ecosystem services are distinct from other ecosystem products and functions because there is human demand for these natural assets. Services can be subdivided into five categories (Millenium Ecosystem Assessment Program, 2003):

Provisioning Services	Regulating Services	Supporting Services	Cultural Services	Preserving Services
Food, fiber, clean water, biochemicals, etc.	Carbon dioxide sequestration, oxygen production, flood prevention, etc.	Nutrient cycle, climate regulation, etc.	Spiritual, active recreation, education, cultural heritage, etc.	Biodiversity maintenance, refugia, etc.

These services are not free or infinitely available. As the human population grows, so does the pressure imposed on ecosystems. Consequently, society is realizing that ecosystem services are threatened and limited and we must balance conflicting uses.

The National Oceanic and Atmospheric Administration (NOAA) mission is “to understand and predict changes in Earth’s environment and conserve and manage coastal and marine resources to meet our Nation’s economic, social, and environmental needs”. To meet the Nation’s economic, social and environmental needs, one of NOAA goals is “to protect, restore and manage, the use of coastal and ocean resources through an Ecosystem Approach to Management (EAM)”. EAM is a holistic, evolutionary management strategy designed to improve the productivity of coastal and marine ecosystems. An ecosystem approach to management shifts current management practices from short-term perspectives, with humans independent of ecosystems to ecosystem-based, long-term perspectives with humans as an integral part of the ecosystems.

To accomplish this shift, NOAA is engaged in a wide variety of activities and is developing a suite of products to assist coastal managers in balancing the exploitation and the protection of our coastal resources in the ocean as well as in the Great Lakes. For example, NOAA is developing a wide variety of products, tools and technologies to insure healthy fish stocks and survival of endangered species, minimize the impacts of invasive species (e.g., lion fish, zebra mussels), explore ocean biodiversity and discover new products from new species, maintain coral reefs ecosystem productivity through assessment and evaluation of management decisions, minimize beach closure due precipitation runoff and bacterial contamination, minimize shellfish beds closure due to harmful algal blooms toxins, restore ecosystems after oil spills or vessel groundings and evaluate restoration efforts. In order to assist management and decision-making, NOAA is developing models, scenarios, forecasts and warning systems, integrated ecosystem assessments and other useful tools.

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Valuing Changes in Aquatic Ecosystem Services from Reductions in Nutrient Loadings

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Setting efficient ambient nutrient criteria requires knowledge of the benefits and costs associated with different standards, but Federal and state regulators often face difficulties when monetizing benefits. Our project will develop and demonstrate a generalizable framework for valuing the non-market benefits of fresh water nutrient reductions. In this paper, we describe the development of the framework. The framework starts with a eutrophication production function mapping quantitative measures of ambient nutrient levels to qualitative indicators of water body quality and suitability for designated uses. Next we will develop a combined revealed and stated preference model for valuation of the non-market benefits of nutrient reductions that is directly linked to the eutrophication production function. The model will provide a generalizable framework of data sources and analytical techniques designed to facilitate benefit transfer and scalability. The eutrophication production function and associated revealed and stated preference surveys will allow analysts to link chemical measures of water quality to ecosystem services to valuation.

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Who Decides? Combining Public Involvement and Ecosystem Services Valuation in Environmental Disputes

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In the United States, as in most modern democratic societies, some form of public participation in environmental decision-making is a legal requirement. At the same time, attempts to rationalize the trade-offs associated with environmental decision-making are increasingly quantified, using benefit-cost analysis and calculations of ecosystem benefits as a guiding principle for decisions. The impact of both the participation of stakeholders and the use of quantification strategies on the actual decision is usually unclear at the outset of any decision-making process.

Using theoretical perspectives from political science, science and technology studies and policy sciences, the stakeholder process used during the recent *Lower Mississippi Alluvial Valley (LMAV) Science Synthesis Conference* will be analyzed and interpreted. In response to the legal framework that requires public participation, and developments in political science and related academic fields, a broad variety of standardized participatory processes that can be used to organize participation, have been created by academics and civil servants. Public hearings, Joint Fact Finding, Deliberative Polling, World Café Discussions, the 20th Century Town Hall are only a few of the standardized processes that have been designed to organize public participation in decision-making. These processes differ in a number of meaningful ways. The way in which scientific information and other forms of expertise, such as ecosystem benefits valuation, is presented to, and used by participants in these processes varies widely. However, there is very little literature on how to design a decision-making process that is inclusive of a broad group of stakeholders, uses the best available scientific information in a sound manner, and leads to effective decisions. Most practitioners simply choose a process they are familiar with, or use guidance on this topic from their seniors. More recently however, a new type of organization has sprung up that specialized in assisting with the design and development of these processes. Organizations like MUSIC and the International Association for Public Participation help practitioners make decisions on how to design their decision-making processes. In this paper, the authors will analyze this development and how policy-makers and scientists in the LMAV can shape a public participation processes by incorporating this new type of organization.

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Urban Growth and Ecosystem Services: The Role of Land Regulation

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As America grows from a population of 281 m in 2000 to a population of 460 m by 2050, the issues of location, urban area expansion and the preservation of environmentally sensitive lands becomes a critical question. Under the Federalist system, states have devolved the common responsibility for managing this conflict to localities. Land use regulation can provide powerful incentives to individual actors to preserve valuable ecosystem services. We demonstrate the impact of regulation on incentives to develop urban uses to the environmentally sensitive Everglades.

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Using Amphibian Site Occupancy as an Indicator of Conservation Benefits

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The Wetlands Reserve Program (WRP) of the Natural Resources Conservation Service is a voluntary program that encourages landowners to restore and protect wetlands on their property. Usually these lands were previously used for agriculture. In the Lower Mississippi Valley there are numerous tracts currently enrolled in the WRP. The Conservation Effects Assessment Project (CEAP) was begun in 2003 as a means of evaluating the conservation benefits of the WRP program. In the lower Mississippi Valley, amphibian species occurrence is considered an ecological service of the WRP lands. Amphibians are excellent ecological indicator species in wetlands as they have a life-history tied to water and permeable skin sensitive to environmental contaminants. They are also often locally abundant and relatively easy to sample.

We have created a sampling protocol on WRP and agricultural lands in the Mississippi River delta region of northwest Mississippi to quantify the occupancy rates of amphibians as part of the CEAP program. Our method involves repeat sampling of sites to allow for estimation of site occupancy rates using site occupancy modeling. Models are constructed using observation data along with covariables measured at the sampling occasion, such as water depth and air temperature. This technique accounts for the problem of imperfect detection of species. Landscape variables and site characteristics are also modeled as site-specific covariables to improve estimates of the overall occupancy rate in WRP compared to agricultural lands. Identification of important landscape-scale factors in determining amphibian species occupancy can be performed through the use of information-theoretic model selection techniques. This technique should provide the basis for an evaluative tool to be used for decision support by program managers interested in increasing amphibian occupancy as an ecosystem benefit.

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LIDAR-derived Benthic Habitat Maps Enable the Quantification of Potential Dredging Impacts to Coral Reef Ecosystems

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An essential component to the analysis of ecosystem services is to characterize and define the major habitats within the area of interest. Aerial photography and/or satellite imagery coupled with geographic information systems (GIS) are frequently used to identify and quantify habitats in open terrestrial ecosystems. However, it is more difficult to successfully apply this methodology to deeper, <20 m, underwater environments. Light detection and ranging (LIDAR), a relatively new remote sensing technology that provides detailed bathymetry, can be used when adequate imagery is not available. This study uses LIDAR as the basis to characterize various benthic habitats in a coral reef ecosystem in order to quantify the habitats for a Habitat Equivalency Analysis (HEA) related to planned dredging activities to expand the Port Everglades entrance channel, Broward County, FL. As part of a regional mapping effort, marine benthic habitats were characterized for Broward County, FL. A mosaic of interpolated, sun-shaded, laser bathymetry data served as the foundation upon which acoustic ground discrimination, limited subbottom profiling and aerial photography, and groundtruthing data were added in a GIS to aid in interpretation of benthic habitats. Expert-driven visual interpretation outlined geomorphological features in the LIDAR data at a scale of 1:6000 with a minimum mapping unit of 1 acre. The map of Broward County yielded a high overall accuracy of 89.6%. To quantify the potential dredging impacts, the habitat layer was clipped in GIS to the boundaries of anticipated direct and indirect impacts of the proposed project. Then the area of each clipped polygon was totaled for each habitat by impact type. HEA and **Florida's** Uniform Mitigation Assessment Method (UMAM) were performed using these areas. This work would not have been possible using satellite imagery or aerial photography alone and illustrates the capability of relatively new remote sensing technologies to aid in the definition and quantification of habitats for ecosystem service analyses.

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Incorporating Systems Thinking into Landscape-Level Planning: Tools and Technologies

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One of the themes of ACES is “institutional structures and decision making.” The theme emphasizes “Tools and models, institutions, communities and stakeholders, and barriers.” This poster/paper/presentation presents systems thinking tools for engaging internal and external stakeholders in ecosystem management decisions. Tools presented are both actual (face-to-face) and virtual (web-based). The presentation features three recent or current landscape-level planning projects in Oregon, Washington, and Alaska, USA: (1) The Western Oregon Plan Revision Project (WOPR) conducted by the Bureau of Land Management Oregon/Washington State Office, (2) the Bridger-Teton National Forest’s landscape (forest) plan revision effort, and (3) Kenai winter recreation planning, directed by the Chugach National Forest and its Seward Ranger District.

The presentation focuses on both substantive and procedural aspects of systems thinking as part of ecosystem management planning and decision-making. It highlights such face-to-face tools as situation mapping and discussion guides and explains how these tools foster systems thinking.

The presentation also emphasizes the web-based tool used in WOPR, the “WOPR Web Forum.” About this technology, the Oregon/Washington BLM web site explains:

Public involvement efforts were aided by a contract through the U.S. Institute for Environmental Conflict Resolution. The Institute contracted with a private communication partnership, Daylight Decisions, to develop an interactive web site that allowed users to navigate the draft EIS and GIS-based maps of the planning area leaving detailed electronic comments tied to the document or locations on a map. The site also served as an information resource providing background information and detailed GIS mapping tools for displaying site-specific information about stand conditions and alternative land use allocations. (<http://www.blm.gov/or/plans/wopr/engagingpeople.php>)

The presentation illustrates how the systems thinking tools and technologies have been employed as part of the three featured projects.

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Partnerships Restoring the Yukon River Basin

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The Yukon River, over 2,200 miles long and draining an area of 330,000 square miles—about twice the size of California—supports the largest and longest inland run of Pacific salmon in the world. The watershed, which consists of the mainstem Yukon River and all tributaries, covers a vast portion of Alaska and the Yukon Territory in Canada and is the third largest basin in North America. Many of the Indigenous communities in the region are quite remote with no access to the primary road system and travel via airplanes, riverboats, dogteams and snowmachines. The River and surrounding lands provide over fifty percent of the Indigenous peoples' food and nutrition in the form of fish, moose, caribou, mountain sheep, rabbit, beaver, ducks, goose and other animals.

The Yukon River Inter-Tribal Watershed Council (YRITWC) is a coalition of 66 sovereign indigenous governments from the United States and Canada who have joined together to protect the watershed that serves them all. Native leaders noticed increased cancers and other health problems in human communities and game species within the Yukon River watershed. The Watershed Council was formed to restore the River and to protect it from further contamination. Indigenous communities are all connected and have a common interest in protecting the watershed, so an Inter-Tribal Accord was established to govern the YRITWC and commit the signatory indigenous governments to cooperate and consult with each other on all actions that could affect the environmental and cultural integrity of the region while respecting the inherent sovereignty of each individual Tribe and First Nation.

The long-term vision—and the guiding light for the organization—was articulated by Native leaders at the historic 1997 Summit that birthed the Watershed Council: to once again drink clean water directly from the Yukon River as our ancestors did for thousands of years before us. This is currently not possible without suffering significant health impacts due primarily to industrial and military contamination, mining, and poor municipal solid waste and waste water management.

This presentation will describe our model for restoring and conserving the watershed that sustains us. It will show the damage left by decades of military and other toxic waste disposal and human waste contamination. It will explain the challenges and importance of cleaning a large and remote watershed on which people depend for sustenance and transportation, economic and cultural well-being. It will show some of the successes—environmental, cultural and educational—that have come from the people of this area.

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The Use of Ecosystem Service Approaches in a European Public Policy Context

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Life on earth depends on the ability of the environment to provide essential services. The Millennium Ecosystem Assessment provided the most comprehensive assessment of the state of the global environment to date and classified ecosystem services in four categories:

1. Supporting services: the services that are necessary for the production of all other ecosystem services;
2. Provisioning services: the products obtained from ecosystems, including food, fuel, genetic resources, biochemicals, and fresh water;
3. Regulating services: the benefits obtained from the regulation of ecosystem processes, including air quality regulation, climate regulation, water regulation, erosion regulation, water purification, disease regulation, pest regulation, pollination, and natural hazard regulation;
4. Cultural services: the non-material benefits obtained from ecosystems through spiritual enrichment, cognitive development, reflection, and recreation and aesthetic experiences.

During the 1990s, attempts were made to quantify in monetary terms the benefits that the earth's ecosystem services provide. Costanza et al () devised a methodology to assimilate the work of over 100 valuation studies to generate estimates of the monetary value of 17 ecosystem functions for 16 habitat (or biome) types. This approach was applied in two European public policy cases:

1. An estimate of the ecosystem service values of Scotland's habitats, and,
2. An EU Scale assessment of the costs and benefits of Integrated Coastal Zone Management (ICZM).

Costanza et al estimated the annual flow of global ecosystem services to be \$33 x 10¹². The same methodology was applied to Scotland to derive a current annual ecosystem services value of approximately £17 thousand million (\$24 x 10⁹) as an initial estimate based on the available values. Some modifications to the model were suggested that could produce a more reliable value of Scotland's ecosystem services. In the assessment of Costs and Benefits of ICZM, an Ecosystem Service valuation approach was adopted to establish the value of effects on the flow of non-market benefits from the coastal habitats or biomes. This global information was used to devise a broad financial value for the impact of successful ICZM initiatives where they could be seen to slow or halt habitat degradation.

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Alternative Approaches to Valuation: An Anthropological View

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Using ecosystem services as a framework for research and decision-making requires valid and meaningful measures of value. Most commonly such measures have been derived through stated preference methods grounded in the marginal analysis of neo-classical economics. Yet using a monetary metric to compare alternative environmental actions can result in a loss of social context, information which may be needed for effective problem-solving. Furthermore, human well-being is socially mediated and symbolically complex, facts inconsistent with the methodological individualism and rational actor epistemology of mainstream economics.

This paper briefly examines some of the limitations of conventional economic measures in valuing ecosystem services. As an alternative to encourage interdisciplinary discussion, the paper then suggests some qualitative approaches to environmental value, grounded in anthropological theory, that avoid these shortcomings. Such approaches may contribute to a more meaningful characterization of ecosystem services.

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An Approach to Evaluating and Mapping Ecosystem Services for Conservation and Development in the Tully Catchment, Australia

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Effective landscape-scale conservation actions are dependent on an understanding of ecological processes and their condition at various scales. The ability to identify, evaluate and map these processes, the ecosystem services (ES) that they provide and their linkages to biodiversity, would deliver a potentially powerful method for prioritizing between conservation and economic activities across landscapes. An example is hydrological processes which deliver ecosystem services that are fundamental to both human wellbeing and the maintenance of a functional ecosystem for biodiversity. These processes are spatially distinct within catchments, making them amenable to examination, and their link between terrestrial and marine ecosystems provides opportunities to integrate planning in adjacent land and seascapes.

The case study area, the Tully catchment, is located in North Queensland, Australia; it both contains *and* connects to areas of high biodiversity and conservation values, one of 35 basins discharging into the Great Barrier Reef (GBR) World Heritage Area. The landscape, and in particular the floodplain area, has been altered extensively since European settlement. Over 80% of natural floodplain vegetation and over 60% of original riparian zones and wetlands have been converted, and this has resulted in significant changes in regional hydrology and drainage. The floodplain is highly productive and intensively farmed for sugarcane, cattle grazing, plantation forestry and horticultural crops. Recent satellite images have shown that sediment and nutrient discharges from the Tully do reach the GBR, potentially impacting biodiversity and the tourism industry that depend on the reef's condition.

We test and apply an integrated catchment-based approach to spatially map and model ES benefits and to understand trade-offs with other development priorities in the Tully catchment. The services provided by riparian vegetation and wetland habitats for biodiversity values and reduced sedimentation and nutrient deposition on the GBR are evaluated using a sedimentation transport model for four scenarios of riparian vegetation extent. We also assess the costs of replanting and foregone agricultural income for the same scenarios using a spatially explicit economic land use model.

We will present results of ES benefits and economic costs from the scenarios, and our initial assessment of the trade-offs towards meeting biodiversity and ES goals. We anticipate using the integrated results to solicit discourse with a diverse set of stakeholders from public and private sectors on trade-offs between ES and regional income. A possible outcome is to enable markets and mechanisms for ES, with the transfer of payments from marine reef tourism industries in the GBR to landholders in the Tully floodplain to mitigate water pollution as one potential policy tool.

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Performance Anomalies are a Relative Measure of Ecosystem Services

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Annual variations in weather impact ecosystems significantly, particularly in moisture limited systems. We seek to identify anomalous areas that are either more productive (overperforming) or less productive (underperforming) than expected, while accounting for long-term and short-term climate variability. Anomalous areas may result from management practices, fire, disease, ecosystem change, or other factors that influence ecosystem performance.

Methods

The growing season integral of the normalized difference vegetation index (gNDVI) serves as a proxy for ecosystem performance. We use MODIS NDVI at 250-m resolution or AVHRR NDVI at 1-km resolution to quantify gNDVI. A regression tree model is developed to predict gNDVI from 10,000 or more random pixels spanning multiple years (capturing climate variability) and a wide range of site conditions for a single land cover type. The regression tree then estimates gNDVI from these site condition indicators (site potential) and weather. Performance anomalies are defined as pixels outside of the 90-percent confidence interval around the model-estimated gNDVI regressed on actual gNDVI. Annual maps of expected gNDVI and performance anomalies are produced along with interannual maps of the trend and frequency of performance anomalies.

Results

Performance anomaly mapping of boreal forests in the Yukon River Basin aligned well with fire perimeters and field-based composite burn index (CBI). An area with a high-frequency underperformance with a negative trend was consistent with changes verified on Landsat imagery and might be related to an insect infestation. In rangelands of southern Idaho, separate models were constructed for shrub and grasslands. Rangeland performance anomalies aligned with fence lines in areas unburned in recent years. Actual grazing pressure agreed with grassland performance anomaly at the pasture level ($R^2 = 0.74$). Shrubland performance anomalies were mapped from 2000 to 2005 across Wyoming. These were compared with field-based percent bare soil estimated from Landsat. Percent bare soil was higher on underperforming areas 66 percent of the time relative to the percent bare soil from normal shrublands on similar sites. The North Slope of Alaska has been experiencing dramatic climate change impacts causing shrub expansion. Overperforming anomalous areas indicate ecosystems that may be in transition from grassland to shrubs.

Conclusions

Performance anomalies can be used to separate climatic variability from non-climatic variability by identifying areas that are above or below a climatically adjusted norm. This approach allows these variations from the norm to be tracked through time. This information will be useful to BLM land managers, USGS Integrated Land Monitoring projects, and other land managers.

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Valuation Issues of Ecosystem Services in the Coastal Zone

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Valuing ecosystem services in the coastal zone (here the term is used to loosely represent the nearshore, to bay, estuary, and upland environments) can be quite challenging. Many of the ecological features that produce services are hidden under water at least part of the time (oysters, seagrass, and other benthic organisms for example). Additionally, ecosystem services are impacted by what happens upstream. The quantity and quality of freshwater inflow into bays and estuaries can significantly impact ecosystems and the services they provide.

This study looks at the challenges of inventorying ecosystem services in the coastal zone and then valuing them. Discussion of the various valuation methods, including both market and non-market, that is most appropriate for coastal ecosystem services are discussed. Two case studies are presented with two different approaches to valuation: 1) Use of double-bounded dichotomous choice contingent valuation approach for valuation of freshwater inflow, and 2) Use of value transfer for valuing numerous ecosystem services in a defined area of the Coastal Bend of Texas. The results indicate significant value in the coastal zone for ecosystem services ranging from recreation to natural hazard and nutrient regulation.

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Author Index

Bold numbers indicate presenting authors.

Allen, Katherine.....	3	Cameron, Dick	142
Allen, Paula E.	4	Campany, Chris	150
Amos, Paul.....	88	Campbell, Elliott.....	21
Andam, Kwaw	131	Campbell, Tom.....	22
Anderson, Christopher M.	160	Carollo, Cristina	140
Anderson, Richard M.	5	Case, M. Chad	43
Andreu, Michael	6 , 40, 119	Celestino, Pedro	46
Archer, David W.....	72, 148	Chavez, E.	7
Arnold, Jeff.....	39	Chivoiu, Bogdan.....	42
Baerenklau, Kenneth A.	7	Christensen, Jay R.....	4
Bagstad, Ken	8	Claggett, Sally.....	141
Baker, Greg.....	9	Clark, M. W.	139
Baker, S.	105	Clevenstine, Bob.....	99
Baldwin, Michael J.	43	Coelho, Dana	125
Balvanera, Patricia.....	98	Cofer, C.....	110
Bann, Camille.....	93	Cohen, Matthew	82
Barko, John.....	99	Cole, Richard A.....	23
Barr, Ken.....	99	Compton, Jana.....	24 , 90
Barrow, Jr., Wylie C.	43	Conte, Marc	25 , 142
Bartell, Steve.....	99	Cooper, Suzanne T.....	26
Batistella, Mateus.....	46	Cosentino-Manning, Natalie.....	9
Beane, Julie	63	Coursey, Don	16
Bedford, David	47	Cropper, Jr., Wendell P.....	104
Beever, Erik	47	Cutrofello, Michele	29
Benedict, Karl.....	59	D'Andrea, Anthony F.....	32
Bernknopf, Richard	10 , 88, 153	da Silva, Marcos R.....	46
Binilkumar, A. S.	137	Dabrowska, K.....	27
Birch, Eugenie.....	11	Daily, Gretchen C.....	57, 58, 143
Blinn, Christine E.	12	David, Peter	28
Bohlen, Patrick.....	13	Davies, Jeremy R.....	61
Borum,, Jennifer.....	88	Davis, Christine.....	29
Boyd, James	14	Davis, Mike	99
Brand, L. Arriana.....	33, 59	Davis, Frank W.	87
Brawders, Sandra	62	Dawson, Terry P.	67
Breckenridge, Robert P.....	101	de Paula Pinto, Erika	46
Brenner, Jorge	15 , 178	Deal, Robert L.....	30
Brienza-Junior, Silvio	46	DeGroot, John.....	31
Broadbent, Craig D.	16 , 59	Dennis, Robin	24
Brooks, Matthew	47	Devoe, Nora.....	47
Brooks, R.	90	DeWitt, Theodore H.	32
Brookshire, David S.	16, 33, 59	DiGruttolo, N.	60
Brown, Jesslyn F.....	17	Dixon, Mark D.	33 , 59
Brown, Mark T.....	18 , 21, 82	Dobbs, Cynnamon	34
Browning, Zac.....	52	Dodge, Richard E.....	171
Brzuszek, Robert	150	Domingos, Tiago.....	103
Buckley, Mark	19	Dormann, C. F.	152
Burks-Copes, Kelly	20	Duarte, T. Kaeo.....	58
Buschinelli, Claudio.....	46	Duffy, Walter G.	35
Butler, J.....	176	Duke, Clifford E.....	101
Butler, Larry	4	Eason, Thomas.....	36
Callegary, James B.....	151	Ebert, D.....	90

Echols, Alex	37	Guerry, Anne D.	61
Eckles, S. Diane	38	Gumbricht, Thomas	82
Eldridge, Peter	32	Gunn, John	62, 63
Emmett, David	94	Hagan, John	63
Endale, D. M.	48	Haglund, Brent M.	64
Ennaanay, Driss	25, 39, 142	Hahn, Simeon	65
Eppink, F.	152	Halloran, J. M.	72
Escobedo, Francisco J	6, 34, 40, 92	Hannahs, Neil	58
Esnard, Ann-Margaret	88	Hanson, Jon D.	66, 72
Euliss, Jr., Ned H.	41, 52, 56, 96	Harrington, Richard	67
Faulkner, Stephen P.	42, 43, 76, 110, 168, 170	Harrison, Paula A.	67
Favara, Paul	118	Hatch, W. Randy	3
Feighner, Gordon R.	44	Hearn, Paul P.	68, 88
Feldman, Rebecca L.	45	Hedlund, Katarina	69
Feng, Ming	96	Heintz, H. Theodore	101
Ferraro, Paul	131	Hendee, James	50
Ferreira, Joice	46	Henderson, Jim E.	20, 70, 71
Finn, Sean	47	Hendrickson, John R.	66, 72, 148
Fisher, Dwight S.	48, 148	Hernandez,, Mariano	81
Fleming, Craig	49	Hidinger, Lori	101
Flessa, Karl W.	98	Hitzhusen, F. J.	27
Fletcher, Pamela	50	Hocctor, Thomas S.	73
Forney, Will	10	Hogan, Dianna	88
Fosnight, E.	177	Hogsett, W.	90
Fox, William E.	101	Hostetter, Leigh A.	86
Friedman, Melissa	6, 119	Hubbell, Bryan	138
Fulford, Richard S.	51	Hudier, Eric	165
Gala, William R.	86	Hummel, Ondrea C.	20
Galat, David	99	Humphries, S.	78
Gallant, Alisa	52, 53, 96, 97, 144, 147	Hyberg, Skip	74, 75
Ganz, David J.	54, 62	Iovanna, Richard	74, 75
Gillen, Kevin	88	James, J. Dale	110
Gillette, Shana	55	Jenkins, W. Aaron	76
Gilliam, David S.	171	Jenks, Melissa J.	77
Giri, Chandra	55	Ji, Lei	144
Gladwin, Hugh	88	Johnson, M.	90
Gleason, Robert A.	56, 96	Jones, Russell W.	78
Goddard, Kimball	47	Jordan, Steve	24
Goldhaber, Martin B.	41	Jose, Shibu	133
Goldman, Rebecca L.	57	Judson, Mark A.	79
Goldstein, Joshua H.	58	Kadiri, Medina O.	80
González, José A.	121	Kagawa, Aurora	58
González-Cabán, A.	7	Kahara, Sharon N.	35
Goodrich, David C.	33, 59, 81, 151	Kareiva, Peter	57, 143
Grabowski, Jonathan H.	5	Karl, Herman	168
Grammer, Paul	51	Kelty, R.	105
Grandy, Jake	59	Kepner, William G.	81, 151
Graves, Mark R.	146	Kermes, Kevin	96
Grêt-Regamey, Adrienne	84	Kiker, Gregory	50
Griffen, Blaine D.	32	Killeen, Tim	94
Grigulis, Karl	89	King, Danielle	82
Groop, Richard E.	112	Kitchell, Kate	47
Gruber, B.	152	Klein, Eduardo	165
Grunwald, S.	60	Kline, Jeffrey D.	83

Kline, Jr., Everette L.....	12	Mercer, Evan.....	108
Koellner, Thomas.....	84	Miller, David.....	47
Kraft, Steven E.....	85, 91, 156	Miller, Jason J.....	61
Kramer, Randall A.....	76	Miller, John.....	52
Krause, Paul R.....	86	Miller, Mark.....	47
Kreeger, Danielle.....	65	Milstead, Bryan.....	24
Kreitler, Jason.....	87	Mitchell, John E.....	101
Kreuter, Urs P.....	101	Montes, Carlos.....	121, 122
Labiosa, W. B.....	88	Moore, Austin.....	109
Lamarque, Pénélope.....	89	Moore, Lee.....	77
Landers, Dixon H.....	90	Moorman, Thomas E.....	110
Langley, Kenny.....	150	Morris, Belinda.....	107, 111
Lansey, Kevin.....	59	Moutinho, Paulo.....	46
Lant, Christopher L.....	85, 91	Moy, Jessica J.....	112
Larocco, Gina.....	30	Mullinix, Cassandra.....	68
Lautenbach, S.....	152	Murray, James B.....	113
Lavorel, Sandra.....	89	Murray, Brian C.....	76
Lawler, Josh.....	25	Mushet, David M.....	41, 96
Lawrence, Alicia B.....	92	Narayanan, Kannan.....	39
Lawrence, Keith S.....	93, 94	Nash, Maliha M.....	4
Lazar, B.....	78	Neale, Anne C.....	4, 114
Ledwin, Jane.....	49	Nelson, Arthur C.....	115
Lembke, Manuel.....	89	Nelson, Erik J.....	25, 142, 143
Lenihan, Hunter S.....	5	Nelson, Kurt.....	116
Li, Zhengpeng.....	97	Nicholas, David.....	117
Linthurst, Rick A.....	95	Nicolette, Joseph.....	118
Lite, Sharon J.....	33	Niemi, Ernie.....	19
Liu, Shuguang.....	53, 96, 97	Norman, Laura M.....	151
Lopez, Ricardo C.....	4	Northrop, Robert J.....	6, 40, 119
López-Hoffman, Laura.....	98	O'Gorman, Stefanie.....	93
Losleben, M.....	163	O'Higgins, Timothy G.....	32, 120
Lubinski, Ken.....	99	O'Neil, Maggie.....	29
Lucero, Carl F.....	100	Oetting, Jon.....	73
Lynch, Jason.....	138	Ogden, John.....	140
Lynch, Sarah.....	13	Olwero, Nasser.....	142
Macauley, Molly.....	10	Orcel, Audrey.....	89
Maczko, Kristie.....	101	Osborne, T. Z.....	139
Mansfield, Carol.....	29, 167	Oteros-Rozas, Elisa.....	121
Marques, Gonçalo M.....	103	Owens, Thomas.....	47
Marshall, John Arthur.....	102	Paez, C.....	7
Marta-Pedroso, Cristina.....	103	Palandro, David.....	140
Martin, Timothy A.....	104	Palomo, Ignacio.....	122
Martinich, J.....	78	Parker, Doug.....	123
Martín-López, Berta.....	121, 122	Parsons, Jon.....	124
Mathie, Amy.....	47, 88	Pataki, Diane.....	134
Matlock, Gary C.....	105	Patterson, Trista M.....	83, 125
Mattos, Luciano.....	46	Patton-Mallory, Marcia.....	126, 127
Maynard, Simone.....	106	Peacock, Bruce.....	128, 129
McCollum, Dan.....	101	Pearlstine, Leonard.....	88
McIntosh, Molly.....	59	Pellant, Mike.....	47
McKane, R.....	90	Perry, Jon S.....	130
McKenney, Bruce A.....	107	Peterson, Charles H.....	5
McKenzie, Emily J.....	107	Peterson, Mark S.....	51
Mendoza, Guillermo F.....	25, 39, 58, 142, 143	Pfaff, Alexander.....	131, 132

Phaneuf, Dannel.....	167	Shankle, S.....	110
Phillips, D.	90	Shepherd, Gemma	82
Phillips, Scott.....	68	Shepherd, Keith	82
Pieterse, E. Corrie	133	Simon, Benjamin M.	153
Pincetl, Stephanie	134	Simpson, Tom	118
Pitchford, Ann M.....	4	Singh, Ashbindu	55, 154
Plummer, Mark L.....	61	Small, Christine	36
Polasky, Stephen	53, 143	Sohl, Terry.....	53
Pool, Duane B.	135	Sollenberger, Lynn E.....	155
Powers, Sean.....	5	Soman, Sethuram	156
Prather, Dick	172	Spies, Thomas A.	83
Price, Will	62	Spivak, Marla	52
Prisley, Stephen P.....	12	Sprague, Eric	141
Pyke, David	47	Stachetti, Geraldo.....	46
Racette, Paul.....	65	Stahl, Jr., Ralph G.....	157, 158
Racevskis, Laila A.	136	Staudhammer, Christina L.....	92
Ramanathan, A.	137	Stewart, John	159
Rao, N.	176	Stewart, Steve	33, 59
Rea, Anne	138	Stoms, David M.....	87
Reddy, K. R.....	139	Stromberg, Juliet C.....	33, 59
Reed, Bradley	55	Strong, David	88
Reed, David J.....	140	Swallow, Stephen K.	160
Reeves, D. W.	48	Tallent-Halsell, Nita G.	4
Regetz, James	142, 143	Tallis, Heather	25, 39, 57, 142, 143
Remuzzi, James.....	141	Tan, Zhengxi	97
Ricketts, Taylor H.....	142, 143	Tanaka, John	101
Robalino, Juan	131, 132	Taylor, Janis L.....	161
Robertson, Guy.....	108	Tepper, Craig	162
Rockel, Mark	118	Thacher, Jennifer	59
Rodgers, C.	78	Thomas, K.....	163
Rogers, John E.	145	Thompson, Benjamin	164
Roth, Mark.....	147	Tidwell, Vincent	16
Rounsevell, Mark D.A.....	67	Tieszen, Larry	55
Rover, Jennifer	96, 144 , 177	Tilley, David.....	21
Ruckelshaus, Mary H.	61	Titus, Kim	172
Ruhl, J. B.....	85	Torregrosa, Alicia	47
Russell, Marc J.....	145	Travers, C.	78
Rygiewicz, P. T.	90	Tripathi, Nitesh	133
Saah, David S.	54, 62	Troy, Austin	8, 54
Saatchi, Sassan	134	Uchida, Emi.....	160
Sabol, Bruce M.....	146	Urdaneta, Deborah Febres.....	165
Sadinski, Walt	147	Vagen, Tor	82
Sanchez-Azofeifa, G. Arturo.....	131, 132	Valette-Silver, Nathalie J.	166
Santiago de Abreu, Lucimar.....	46	Van Houtven, George.....	29, 167
Saphores, Jean-Daniel.....	134	van Maasakkers, Tijs.....	168
Sassenrath, Gretchen F.	72, 148	van Riper III, Charles.....	151
Sayre, Roger	149	Varady, Robert G.	98
Schauwecker, Timothy	150	Vasques, G.M.	60
Schill, William B.....	113	Vizzini, Daniel G.....	44
Schomberg, H. H.....	48	Voigt, Brian.....	8
Schuler, Carol	47	Volk, M.	152
Semmens, Darius J.....	81, 151	Wachter, Susan.....	88, 169
Seppelt, R.	152	Waddle, J. Hardin.....	170
Seymour, Michael.....	150	Waite, Randy.....	138

Walker, Henry	24	Wolny, Stacie	39, 58
Walker, Brian K.	171	Wong, Grace Y.	176
Walker, Gregg B.	172	Wood, R.	105
Wardlow, Brian D.	17	Woodward, Andrea	47
Waterhouse, Jon	173	Wright, A.L.	139
Wein, Anne	88	Wright, Chris	144
Weltzin, J.	163	Wylie, Bruce K.	96, 144, 177
White, D.	90	Wynne, Randolph H.	12
Whitman, Andrew	63	Xaud, Maristela	46
Wickham, Jim	114	Yi, He	94
Wilcox, Dan	99	Yoskowitz, David W.	15, 178
Williams, Evan	174	Yuan, Wenping	96
Wilson, James	165	Zhao, Shuqing	97
Wilson, Tamara	10	Zhengpeng, L.	96
Wingard, G. Lynn	113	Zhou, Xiaoping	30
Winter, Thomas C.	41	Zhu, Zhiliang	55
Winthrop, Robert	175	Zipperer, Wayne	6, 40

Notes

Notes

Notes