ACES: A Community on Ecosystem Services

December 6-9, 2010
Gila River Indian Community
Near Phoenix, Arizona

www.conference.ifas.ufl.edu/aces

ACES
A Community on Ecosystem Services

Welcome to ACES 2010

We want to take this opportunity to welcome you to ACES 2010. This is the second ACES Conference and the dialogue in the ecosystem services community has continued and expanded since we last convened in Naples, Florida in December 2008. A *Community on Ecosystem Services* (ACES) reflects more than a name change. It represents progress, which we will discuss over the next four days in workshops, plenary sessions, panel discussions, and presentations. We have expanded the format of the conference to include 5 concurrent sessions over 3 full days. This is not an effort to test endurance, but rather an indicator of the extraordinary interest in this topic.

ACES continues to highlight the broad interdisciplinary nature of research on and applications of ecosystem services and the need to combine ecological, geographic, socio-economic, and institutional information and models. This conference will once again provide a venue for synthesizing the research, methods, and tools needed to more routinely and effectively incorporate ecosystem services into resource management, conservation, restoration, and development decisions. Discussions and presentations on ecosystem services will identify and address successes as well as impediments to incorporating ecosystem services more effectively into resource management. Four themes – (1) landscapes, geography and mapping; (2) measures and values; (3) drivers of change; and (4) institutions and decisions – guide the ACES 2010 agenda.

We wish to specifically thank the conference partners and the Steering Committee for their efforts to make ACES 2010 a success. Their insights and support are greatly appreciated. In addition, we are grateful for the outstanding efforts of Jhanna Gilbert and the staff of the University of Florida, IFAS Office of Conferences and Institutes (OCI), in organizing the logistics for ACES 2010.

We look forward to another productive conference that sets the stage for continuing dialogue, sharing information, and progress. We encourage you to network, meet old friends, and make new ones.

Carl D. Shapiro, Ph.D., Conference Chair
Co-Director, Center for Science, Decisions, and Resource Management
U.S. Geological Survey

Greg Arthaud, Ph.D., Conference Co-Chair
National Leader for Ecosystem Services and Urban Forestry Research
Research & Development
USDA Forest Service

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

Iris Goodman, Conference Co-Chair
Acting Deputy National Program Director for Ecology
U.S. Environmental Protection Agency

Dianna M. Hogan, Ph.D., Program Coordinator
Research Physical Scientist
Eastern Geographic Science Center
U.S. Geological Survey

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Organizing Committee

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Agenda

ACES 2010 Agenda			
Sunday	***Sunday, December 5, 2010***		
5:00pm-7:00pm	Pre-Conference Registration Open - *Thunder 2 Foyer*		
Monday	***Monday, December 6, 2010***		
7:30am-5:00pm	Conference Registration Open - *Thunder 2 Foyer*		
7:30am-8:30am	**Morning Refreshments and Poster Set-Up** - *Kave Ballroom*		
	Morning Pre-Conference Workshops		
Location	**Komatke A**	**Komatke B**	**Komatke C**
Workshop Organizer	**Joseph Nicolette** ENVIRON International Corporation	**Florian Eppink** Helmholtz Centre for Environmental Research	**Coeli Hoover** USDA Forest Service
8:30am-10:00am	**Evolution and Valuation of Ecosystem Services**	**The Emperor's clothes? Addressing Consistency in Ecosystem Service Studies**	**Forest Carbon Estimation and Management: Techniques and Tools**
10:00am-10:30am	**AM Break -** *Kave Ballroom*		
10:30am-12:00pm	Morning Workshop Continued	Morning Workshop Continued	Morning Workshop Continued
12:00pm-1:00pm	**Workshop Boxed Lunch** - *Kave Ballroom*		
12:15pm-1:00pm	**Workshop Lunch Discussion- Akimel Two** ***Corporate Demand for Ecosystem Services*** Speakers from ENVIRON and World Resources Institute with Discussion to Follow		
	Afternoon Pre-Conference Workshops		
Location	**Komatke A**	**Komatke B**	**Komatke C**
Workshop Organizer	**Allegra Bukojemsky** Biohabitats, Inc.	**Doug MacNair** ENTRIX	**Tom Hastings** Michael Baker Inc.
1:00pm-2:30pm	**Qualifying and Quantifying Ecosystem Services: Tools for the Planned and Designed Landscape**	**A View from the Trenches: A Workshop on Estimating Ecosystem Services and Their Value**	**Major Domestic and International Ecosystem Restoration Initiatives - Lessons Learned**
2:30pm-3:00pm	**PM Break -** *Kave Ballroom*		
3:00pm-4:30pm	Afternoon Workshop Continued	Afternoon Workshop Continued	Afternoon Workshop Continued
5:15pm-7:15pm	**Networking Social -** *Akimel Lawn/ Mesquite Terrace*		

Tuesday	*Tuesday, December 7, 2010*
7:00am-5:00pm	Conference Registration Open - *Thunder 2 Foyer*
7:00am-8:00am	**Morning Refreshments and Poster Set-Up** - *Kave Ballroom*
8:00am-9:50am	**Opening Plenary Session** - *Komatke D-G*
8:00am-8:15am	**Opening Remarks - Carl Shapiro**, Co-Director, Center for Science, Decisions, and Resource Management, U.S. Geological Survey, ACES 2010 Conference Chair
8:15am-8:30am	**Welcome Address - Governor William R. Rhodes**, Gila River Indian Community
8:30am-10:00am	**Plenary Panel Discussion** ***Incorporating Ecosystem Services into Resource Management Decisions: A Policy-Level Discussion*** **Moderated By: Olivia Barton Ferriter,** Acting Director, Office of Policy Analysis, Department of the Interior **Panel Members** **Deanna Archuleta**, Deputy Assistant Secretary for Water and Science, Department of the Interior **Molly Macauley**, Research Director and Senior Fellow, Resources for the Future **Janet Ranganathan**, Vice President for Science and Research, World Resources Institute **Amanda DeSantis**, Leader - Sustainability Initiatives, DuPont **Harris Sherman**, Under Secretary for Natural Resources and Environment, U.S. Department of Agriculture -*invited* **Terrence "Rock" Salt**, Deputy Assistant Secretary of the Army, Civil Works
10:00am-10:30am	**AM Break -** *Kave Ballroom*
10:30am-12:00pm	**Plenary Session** - *Komatke D-G* **Plenary Panel Discussion** ***Advances and Challenges in Ecosystem Services Research, Applications, and Institutions: Changes since ACES 2008*** **Moderated By: Sally Collins,** Director *(retired)* , Office of Environmental Markets, U.S. Department of Agriculture **Panel Members** **Mark Schaefer**, Deputy Executive Director of Environmental Conflict Resolution, Morris K. Udall Foundation **Rick Linthurst**, National Program Director for Ecology, U.S. Environmental Protection Agency **Gregory Biddinger**, Environmental Program Coordinator for ExxonMobil Biomedical Sciences, Inc. **Robert Costanza**, Director, Institute for Sustainable Solutions, Portland State University **Carl Lucero**, Acting Director, Office of Environmental Markets, U.S. Department of Agriculture
12:00pm-1:30pm	**Boxed Lunch -** *Kave Ballroom and Foyer*
12:15pm-1:20pm	**Special Lunch Session- Coyote/Buzzard/Eagle** ***"We Live By The River"*** A film by the Yukon River Inter-Tribal Watershed Council **Presented by Alaska Region Director, Jon Waterhouse**

	Tuesday, December 7, 2010 (Continued)				
	Concurrent Sessions				
	Session 1A	**Session 1B**	**Session 1C**	**Session 1D**	**Session 1E**
1:30pm-3:15pm	**National Ecosystem Services Partnership Session I: Quantification, Valuation, Tools and Metrics**	**Ecosystem Services and Urban Sustainability**	**Ecosystem Services and Indigenous Peoples**	**Ecosystem Services and The European Union**	**Business Initiatives to Mainstream Ecosystem Services**
Location	**Komatke D-G**	**Komatke A**	**Komatke B**	**Komatke C**	**Coyote/Buzzard/Eagle**
Moderator	**Lydia Olander**	**Susan Wachter**	**Robert Hall**	**Joseph Nicolette**	**Suzanne Ozment**
1:30pm-1:35pm	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
1:35pm-1:55pm	**Sara Vickerman** - Development of a National Framework for Habitat/ Biodiversity Metrics	**Diana Pataki -** The Role of Urban Metabolism Research in Optimizing Ecosystem Services and Advancing Urban Sustainability: Prospective Applications in California	**Robert K. Hall -** **S**WESP Tribal Ecosystem Services Pilot in Arid Southwestern North America	**Joke Van Wensem** - Ecosystem Services and the Dutch Situation	**David Carroll** - The Guide to Corporate Ecosystem Valuation & Lafarge's Ecosystem Valuation Initiative
1:55pm-2:15pm	**Kevin Summers** - The Relationships among Ecosystem Services and Human Well Being	**Eugenie Birch** - The Impact of Natural and Manmade Disasters on Urban Ecosystem Services	**Courtney Flint** - Perceptions of Ecosystem Services and Threats to Well-being from an Alaska Native Community	**Rita Gomes** - Ecosystem Services Inclusive Strategic Environmental Assessment	**John Finisdore** - A Review of New Methods to Link Ecosystem Services to Corporate Performance
2:15pm-2:35pm	**Spencer Phillips** - Climate Change and Ecosystem Services: The Contribution of Public Lands in the United States	**Arthur Nelson** - Urban Containment and Ecosystem Services Triage? Having your Cake while Eating it Too	**Sarah Gergel** - Long-Term Losses of Culturally Important Ecosystem Services in Coastal Rainforests	**Tom Campbell** - Ecosystem Services in U.S. NRDA Regulations and Incorporation into the EU ELD	**Diane Fitzgerald** - Ecosystem Services for Corporate Decision Making: An AEP Case Study
2:35pm-2:55pm	**Katie Arkema** - Predicting Provision and Value of Ecosystem Services for Use in Decision-Making	**Amy Lynch** - From Principles to Practice: A Survey of Public-Sector Green Infrastructure Planning in the United States	**Kamaljit Kaur Sangha** - Identifying Links Between Ecosystem Services and Aboriginal Well-Being and Livelihoods in North Australia	**Michele Bianco** - Application of Ecosystem Services within the ELD: Legal Framework	**Michele Schulz** - Ecosystem Services for Urban Landscapes: A Corporate Perspective
2:55pm-3:15pm	**Sissel Waage** - Emerging Ecosystem Service Tools & Relevance to Corporate Decision-Making	**Panel Discussion**	**Panel Discussion**	**Fabio Colombo** - Application of Ecosystem Services within the ELD Framework: Technical Application	**Jack Davis** - Advancing Markets for Ecosystem Services

	Tuesday, December 7, 2010 (Continued)				
3:15pm-3:45pm	**PM Break -** *Kave Ballroom*				
	Concurrent Sessions				
	Session 2A	**Session 2B**	**Session 2C**	**Session 2D**	**Session 2E**
3:45pm-5:30pm	**National Ecosystem Services Partnership Session II: Policy, Market Design, and Implementation**	**Marine and Coastal**	**Impacts of Invasive Species on Ecosystem Services**	**Urban**	**Remote Sensing and Spatial Classification**
Location	**Komatke D-G**	**Komatke A**	**Komatke B**	**Komatke C**	**Coyote/Buzzard/Eagle**
Moderator	**Lydia Olander**	**Terry Holman**	**Olivia Barton Ferriter**	**Greg Arthaud**	**Paul Young**
3:45pm-3:50pm	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
3:50pm-4:10pm	**Stephen Swallow** - Experimental Markets for Connecting Ecosystem Services to Consumers' Values and Decision Support	**Joey Bernhardt** - Human Impacts on Coastal Marine Ecosystems and Services	**Sarah Cline -** Measuring the Economic Impact of Invasive Species on Ecosystem Services	**Mark Buckley** - Getting Demand Right for Valuing Urban Ecosystem Services in the Pacific Northwest	**Molly Macauley** - Assessing Investment in Future Landsat Instruments for Ecosystem Management
4:10pm-4:30pm	**Jessica Fox** - How Payments for Ecosystem Services are being Stacked in the United States	**Jason Kreitler** - Interacting Coastal-Based Ecosystem Services in Puget Sound: Recreation and Water Quality	**Lars Anderson** - Impact of Aquatic Invasive Species on Ecosystem Services at Lake Tahoe	**Kathleen Wolf** - Ecosystem Services in the City: Urban Greening and Public Health	**Molly Reif** - Remote Sensing for Coastal Applications: Implications for Ecosystem Services
4:30pm-4:50pm	**Al Todd** - Forests to Faucets: Drinking Water as an Ecosystem Service	**Tomasz Zarzycki** - Spatial Visualization of Recreational Values Arising from Marine Biodiversity	**Cyndi S. Kolar** - Impacts of Invasive Asian Carps on Freshwater Ecosystems	**Dianna Hogan** - Water Quality Ecosystem Services in the Urban Environment	**Richard Bernknopf** - A Framework for Estimating the Benefits of Moderate Resolution Imagery in Environmental Applications
4:50pm-5:10pm	**Sally Duncan** - Policy and Practice: Emerging Lessons on Payments for Ecosystem Services	**Denise Reed** - Using Ecosystem Services to Define and Communicate a Vision for the Future of Coastal Louisiana	**Julio Betancourt** - Buffelgrass Invasion in the Sonoran Desert: What Do We Stand to Lose?	**Catherine Shields** - Modeling Linkages between Effective Impervious Surface and Urban Vegetation Productivity in Semi-arid Environments	**Shengli Huang** - Monitoring and Predicting Spatiotemporal Water Surface Dynamics of Topographic Depressions in the Prairie Pothole Region
5:10pm-5:30pm	**Amanda DeSantis** - The Business Relevance - Moving Beyond the Concept to the How, What and Why	**Panel Discussion**	**Panel Discussion**	**Matthew Skroch** - Landscapes, Geography and Mapping	**Chandra Giri -** Ecosystem Goods and Services and the Status and Distribution of Mangrove Forest of the World
5:45pm-7:45pm	**Welcome Reception -** *Akimel Lawn/ Mesquite Terrace*				
7:00pm-8:30pm	**National Ecosystem Services Partnership Town Hall Meeting - Coyote/ Buzzard/ Eagle** **Moderated By: Lydia Olander**, Duke University				

Wednesday	*Wednesday, December 8, 2010*				
7:00am-5:00pm	Conference Registration Open - *Thunder 2 Foyer*				
7:00am-8:00am	**Morning Refreshments** - *Kave Ballroom*				
8:00am-9:45am	**Plenary Session:** *Komatke D-G*				
8:00am-8:30am	**Keynote Address - David J. Hayes**, Deputy Secretary, Department of the Interior				
8:30am-9:45am	***U.S. National Ocean Policy - How Will it Affect Ecosystem Services?*** **Moderated By: Laura Davis**, Deputy Chief of Staff, U.S. Department of the Interior **Panel Members** **Sally Yozell**, Director of Policy, National Oceanic and Atmospheric Administration **Kameran Onley,** Director, U.S. Marine Policy, The Nature Conservancy **Suzette Kimball**, Deputy Director, U.S. Geological Survey **J.B. Ruhl**, Matthews & Hawkins Professor of Property, The Florida State University College of Law				
9:45am-10:15am	**AM Break -** *Kave Ballroom*				
	Concurrent Sessions				
	Session 3A	**Session 3B**	**Session 3C**	**Session 3D**	**Session 3E**
10:15am-12:00pm	**Informing Resource Management: A Panel on Ecosystem Services and Science-Based Decision Making**	**Models**	**Coastal and Marine Ecosystem Services in the Gulf of Mexico**	**Valuation I**	**A Discussion on Ecosystem Services as a Framework for Law and Policy**
Location	**Komatke D-G**	**Komatke A**	**Komatke B**	**Komatke C**	**Coyote/Buzzard/Eagle**
Moderator	**Ken Williams**	**Bill Labiosa**	**Cristina Carollo**	**David Brookshire**	**Ira Feldman and Mark Nechodom**
10:15am-10:20am	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
10:20am-10:40am	**Deanna Archuleta -** The Need for Science in Resource Management	**Bogdan Chivoiu** - Integrated Modeling Framework for Forecasting Ecosystem Services	**David Yoskowitz -** Gulf of Mexico Ecosystem Services Workshop	**Ryan Smith -** Water Banking: A Free Market Approach to Efficiently Managing and Incentivizing Conservation of a Natural Resource	*Session agenda not yet finalized when printed.*
10:40am-11:00am	**Ione Taylor -** Decision Science, Valuation, and Resource Decision Making	**Seth Soman** - An Agent-Based Model of Multifunctional Agricultural Landscapes Using Genetic Algorithms	**Sharon Hayes** - Impacts of Deepwater Horizon Oil Spill: An Approach to Valuing Ecosystem Services	**Austin Troy** - Estimating Ecosystem Service Values in Southern Ontario	
11:00am-11:20am	**Anne Kinsinger -** Linkage of Ecological Science and Ecosystem Services	**Rebecca Logsdon -** Development of a Methodology to Quantify Ecosystem Services Using Landscape Models	**Lauren Hutchison** - Prioritization of Habitat Management Areas Using Stakeholder Analysis of Ecosystem Services within a GIS Framework	**Simone Maynard** - Valuing Ecosystem Services through Participatory Processes for Policy and Planning in Southeast Queensland	

	Wednesday, December 8, 2010 (Continued)				
11:20am-11:40am	**Ben Tuggle -** Integrating Ecosystem Services into Landscape Conservation Cooperatives	**Shuguang Liu** - EcoServ: A Community and Web-Service Based Modeling System for Simultaneously Quantifying Multiple Ecosystem Services at the Landscape to National Scales	**Marc Russell** - An Operational Structure for Clarity in Ecosystem Service Values	**Paul Manson** - Role of Ecosystem Function in Measurement of Economic Aspects of Ecosystem Services	*Session agenda not yet finalized when printed.*
11:40am-12:00pm	**Carl Shapiro -** Incorporating Ecosystem Services and Adaptive Management into Sustainable Resource Decisions	**Azur Moulaert -** Applied Multidisciplinary Solutions for the Sustainable Development of the Térraba-Sierpe Region of Costa Rica	**Elizabeth Smith** - Finding Common Ground between Ecosystem Services and Environmental Systems	**Tomasz Zarzycki** - Contingent Valuation of Benefits Arising From Marine Biodiversity	
12:00pm-1:30pm	**Boxed Lunch -** *Kave Ballroom and Foyer*				
12:15pm-1:30pm	**Special Lunch Session- Coyote/Buzzard/Eagle** ***Ecosystem Services and Greening National Accounts*** **Moderator: Trista Patterson**				
12:15pm-12:20pm	Introduction & Overview				
12:20pm-12:40pm	**James Boyd** - Measuring Consumption of Environmental Public Goods: Theory and Practice of a Green Index				
12:40pm-1:00pm	**Kenneth Bagstad** - Contextualizing Ecosystem Services Supply and Demand for National Accounting Systems				
1:00pm-1:20pm	**Trista Patterson** - Demand Side Ecosystem Services				

	Wednesday, December 8, 2010 (Continued)				
	Concurrent Sessions				
	Session 4A	**Session 4B**	**Session 4C**	**Session 4D**	**Session 4E**
1:30pm-3:15pm	**When Ecosystem Services Cross Boundaries: Science and Governance**	**Ecosystem Services in Urban Areas: Tools, Conceptual Framework, and Policy Interventions I**	**Seaworthy Metrics for Ecosystem Services**	**Valuation II**	**Tools**
Location	**Komatke D-G**	**Komatke A**	**Komatke B**	**Komatke C**	**Coyote/Buzzard/Eagle**
Moderator	**Laura Lopez-Hoffman and Laura Norman**	**Ann Kinzig**	**Mary Ruckelshaus**	**Richard Bernknopf**	**Sissel Waage**
1:30pm-1:35pm	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
1:35pm-1:55pm	**Laura Lopez-Hoffman** - What Happens when Ecosystem Services Jump Across Boundaries?	**Ann Kinzig** - Understanding Off-Site Ecosystem Service Flows	**Becky Allee -** Approaches to Ecosystem Service Assessment and Valuation at NOAA	**David Bakter** - The Economic Value of the Mississippi River Delta	**Pieter Booth** - Case Study of Comparative Tool Application and Considerations for Corporate Land Management
1:55pm-2:15pm	**Laura Norman** - Ecosystem Services: the SCWEPM Bridge across Trans boundary and Environmental Justice Divides	**Thomas Elmqvist -** Analysis of Social and Ecological Values of Urban Green Spaces: Implications for Urban Planning	**Susan H. Yee** - Incorporating Ecosystem Services into Coastal and Watershed Management	**Maura Flight** - Valuing Ecosystem Service Tradeoffs of Wetland Management in Delaware	**John Ritten** - Linked Ecological and Economic State and Transition Model for Adaptive Management of Rangeland Ecosystems
2:15pm-2:35pm	**Olivier Petit** - Strengthening Cooperation on International Rivers: Trans boundary Ecosystem Services as a Policy Tool	**Linda Fernandez** - Dynamic Analysis of Open Space Using a Repeat Sales/Hedonic Approach	**Michael Papenfus** - Marine InVEST: Assessing Ecosystem Services in Marine and Coastal Environments	**James Klang**	**William Labiosa** - Integrated Ecological, Economic, and Quality-of-Life Evaluations for Land Use Planning Decision Support in South Florida: The South Florida Ecosystem Portfolio Model
2:35pm-2:55pm	**Chris Brown** - The Protection of Ecosystem Services in the US- Mexico Border	**Joshua Abbott** - Water, Water Everywhere: Hedonic Pricing of Residential Lakes in an Arid City	**Greg Guannel** - A Process-Based Model for Valuing Coastal Protection Services	**Billy Gascoigne** - Valuing Ecosystem and Economic Services across Land-Use Scenarios in the Prairie Potholes	**Nancy Musgrove** - HEA as a Tool for Evaluating Ecosystem Services and Restoration Options
2:55pm-3:15pm	**Gary Nabhan** - Payments for Damages to Ecosystem Services Related to the Gulf Oil Spill	**Pat Gober -** Using Watered Landscapes to Manipulate Urban Heat Island Effects	**Panel Discussion -** Mary Ruckelshaus, Buck Sutter, All Speakers	**Ilona Kaminska** - An Attempt at the Economic Valuation of Waste Bioremediation Service in Brackish Estuaries	**James Remuzzi** - LandServer: An Ecosystem Service Market Mapping and Assessment Tool
3:15pm-3:45pm	**PM Break -** *Kave Ballroom*				

	Wednesday, December 8, 2010 (Continued)				
	Concurrent Sessions				
	Session 5A	**Session 5B**	**Session 5C**	**Session 5D**	**Session 5E**
3:45pm-5:30pm	**Making Markets Work**	**Ecosystem Services in Urban Areas: Tools, Conceptual Framework, and Policy Interventions II**	**Modeling and Mapping Species for Assessing Ecosystem Services**	**Climate and Natural Hazards**	**Water Services, Pollution, and Values**
Location	**Komatke D-G**	**Komatke A**	**Komatke B**	**Komatke C**	**Coyote/Buzzard/Eagle**
Moderator	**Bobby Cochran**	**Ann Kinzig**	**Brenda Rashleigh**	**Barry Gold**	**Jay Messer**
3:45pm-3:50pm	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
3:50pm-4:10pm	**Bobby Cochran** - Making a Multi-Credit Ecosystem Market Work for Oregon	**Mary Ruckelshaus-** Valuing Changes in Ecosystem Services Under Alternative Futures	**Stephen Jordan** - Ecosystem Services of Coastal Habitats and Fisheries: Multi-scale Modeling	**Sharon Kahara** - Effect of Climate, Age and Management Intensity on Nutrient Storage in USDA Restored Wetlands in California's Central Valley	**Bryan Milstead** - Northeastern Lakes: Tradeoffs Between Aesthetics and the Attenuation of Anthropogenic Reactive Nitrogen
4:10pm-4:30pm	**David Primozich** - Getting Supply and Demand Moving at Scale: The Freshwater Trust's StreamBank Model	**Mary Cadenasso -** Strategies to Retain Nitrogen and Dissipate Heat in Baltimore, MD, USA	**Katie Arkema** - Using Maps and Models of Species to Quantify and Manage for Trade-offs Among Ecosystem Services	**Christopher Lant** - Climate Change, Hydrology, and Landscapes of America's Heartland: A Multi-scale Natural-Human System	**James McConaghie** - Nitrogen Retention as an Ecosystem Service is Linked to Land Cover Heterogeneity
4:30pm-4:50pm	**Jeremy Sokulsky** - Moving from Inputs to Outcomes to Markets	**Christine Alfsen** - The URBIS Partnership Proposal: Fostering the Ecosystem Approach in Urban Planning	**Brenda Rashleigh** - Modeling of Valued Fish Species in River Networks	**Jan Cassin** - Managing for Resilience in the Coastal Zone - Ecosystem Services and Climate Change	**Megan Lang** - Effectiveness of Wetland Conservation Practices for Pollutant Regulation
4:50pm-5:10pm	**Panel Discussion** - Extending Models to New Watersheds	**Charles Perrings -** Urban Ecosystem Services Science and Policy, the International Dimension	**John Rogers** - Dynamic Simile-Based Model for Predicting the Effects of Water Quality on the Growth of Thalassia testudinum in Tampa Bay	**Mark Buckley** - Building Risk and Uncertainty from Climate Change into Economic Valuation of Ecosystem Services	**Jay Messer** - Considering Ecosystem Services Co-benefits in Strategies to Restore the Chesapeake Bay
5:10pm-5:30pm	**Panel Discussion** - Extending Models to New Watersheds	**Panel Discussion**	**Panel Discussion**	**David Batker** - Flood Protection and Ecosystem Services in the Chehalis Basin	**Gustavo Perez-Verdin** - The Value of Water Under Different Altitude and Moisture Scenarios
5:45pm-7:45pm	**Poster Reception -** *Kave Ballroom*				

Thursday	*Thursday, December 9, 2010*				
7:00am-12:00pm	Conference Registration Open - *Thunder 2 Foyer*				
7:00am-8:00am	**Morning Refreshments & Poster Removal** - *Kave Ballroom*				
	Concurrent Sessions				
	Session 6A	**Session 6B**	**Session 6C**	**Session 6D**	**Session 6E**
8:00am-9:45am	**Drivers of Ecosystem Service Changes Can Go Both Ways: Economic Development, Technology and Population**	**Cultural Services: Interdisciplinary and International Perspectives**	**Payment for Ecosystem Services**	**Ecosystem Service Research and Management in the Southwest**	**Nitrogen Removal as an Ecosystem Service**
Location	**Komatke D-G**	**Komatke A**	**Komatke B**	**Komatke C**	**Coyote/Buzzard/Eagle**
Moderator	**Indur Goklany**	**Terry Daniel**	**Frank Casey**	**Darius Semmens**	**Jana Compton, Steve Jordan, and Anne Neale**
8:00am-8:05am	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
8:05am-8:25am	**Roger Sedjo** - Forest Adaptation to Climate Change: Management Options	**Robert Ribe -** Ecological Production Functions for Landscape Aesthetics.	**Kari Virgerstol** - Paying for Watershed Services: How do we Measure Impacts?	**Pamela Bailey -** A Comparison of Fragmentation Effects in Three Erigeron Pollination Networks	**Michelle Perez** - Connecting the Science to Water Quality Trading
8:25am-8:45am	**Braden Allenby -** Technology as a Driver of Ecosystem Service Change	**Adrienne Gret-Regamey -** Services Provided by Modified and Constructed Landscapes.	**Travis Greenwalt** - Payment for Ecosystem Services from the Carson River Natural Floodplain	**Kenneth Bagstad -** Ecosystem Services in Decision Making for Public Lands in the Southwest and Beyond	**Judy Denver** - Using Hydrologic Landscapes to Predict Nitrogen Removal in Wetlands
8:45am-9:05am	**Bruce Peacock -** The Economic Feedback Loop for Ecosystem Service Policy Changes	**Thomas Elmqvist -** Cultural Ecosystem Services and Urban Green Spaces.	**Evan Mercer** - Payments for Forest Based Ecosystem Services in the US	**Matt Weber -** Using Focus Groups to Understand Ecosystem Services of an Impacted Southwestern River	**Stephen Jordan** - Wetlands as Sinks for Reactive Nitrogen at Continental and Global Scales
9:05am-9:25am	**Billie L. Turner II** - Change in Environmental Services in Southern Yucatán: Balancing Proximate and Distal Drivers	**Courtney Flint -** Scientific Methods for Cultural Service Assessments	**Todd Gartner** - The Northern Forest Watershed Incentives Project	**David Brookshire** - Integrated Modeling and Ecological Valuation: A Framework for the Semi-Arid Southwest	**Paula Allen** - Does Nutrient Retention Increase with Hydrologic Complexity?
9:25am-9:45am	**Indur Goklany** - Drivers of Ecosystem Service Changes Can Go Both Ways: Economic Development, Technology and Population	**Marianne Penker -** Evaluating Cultural Ecosystem Services: The Perspective of European Social Sciences	**Panel Discussion**	**Carrie Presnall** - Market Development for Rangeland Ecosystem Services	**Alex Echols -** Greenhouse Gas Benefits from Agricultural Nitrogen Managed for Water Quality
9:45am-10:15am	**AM Break & Poster Removal -** *Kave Ballroom*				

	Thursday, December 9, 2010 (Continued)				
	Concurrent Sessions				
	Session 7A	**Session 7B**	**Session 7C**	**Session 7D**	**Session 7E**
10:15am-12:00pm	**The Economic Valuation of Ecosystem Services on American Indian Tribal Land**	**National Programs to Deliver Ecosystem Service Payments and Jump-start Markets**	**Will Ecosystem Services Render Ecological Risk Assessment Obsolete as a Tool for Informing Decisions? An Expert Debate**	**Spatial and Temporal Dynamics of Ecosystem Services**	**Carbon and GHG**
Location	**Komatke D-G**	**Komatke A**	**Komatke B**	**Komatke C**	**Coyote/Buzzard/Eagle**
Moderator	**James Caudill**	**Sara Vickerman**	**Anne Rea and Wayne Munns**	**Darius Semmens**	**Jonathan Smith**
10:15am-10:20am	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
10:20am-10:40am	**Tom Blaser**, Attorney-Advisor, Department of the Interior Office of the Solictor, Washington DC	**Sara Vickerman -** National Policy Options to Encourage Credible Ecosystem Service Markets	**Rochelle Araujo and Gregory Biddinger -** Ecological Risk Assessment Is a Flawed Paradigm and Has Outlived Its Usefulness in Informing Environmental Management	**Gary Johnson -** Service Path Attribution Networks (SPANs): Spatially Quantifying Ecosystem Service Flows	**Sandra Kling** - The Ecosystem Services of Urban Forests: Enhancing Carbon Storage with Carbon Offset Projects in the City of Tampa, Florida
10:40am-11:00am	**Barbara Harper -** Valuing the Priceless: Valuation of Tribal Resources and Services	**Lynn Scarlett** - Connecting Landscape-scale Conservation with Ecosystem Markets and Programs	**Lisa Wainger and Larry Kapustka -** There Is Merit in Understanding Risk to Ecosystem Services in the Context of Environmental Management Decisions	**Miroslav Honzák** - Application of Artificial Intelligence for Ecosystem Services (ARIES) for Assessing Flows of Freshwater Services in the La Antigua Watershed, Veracruz, Mexico	**Stephen Faulkner** - Ancillary Effects of Carbon Sequestration Strategies on Ecosystem Services
11:00am-11:20am	**Bruce Peacock -** Cultural Resource Valuation: State of the Economics	**Sally Duncan** - Public Utilities and Payments for Ecosystem Services: New Connective Tissue?	**Dale Goble and J.B. Ruhl** Ecological Risk Assessment Should Focus on Ecological Condition and Not on Human Well-being	**Brian Voigt** - Modeling Temporal and Spatial Flows of Ecosystem Service in Chittenden County, VT, USA	**Lydia Olander** - Stacking Carbon Payments with Land Use Policies, Programs, and Markets
11:20am-11:40am	**John Vitello -** Tribal Forest Management Inherently Results in Sustainable Ecosystem Services	**Albert Todd** - Eco-Enterprise: Market Innovations in Ecosystem Services	**Panel Discussion**	**Jay Diffendorfer** - Accounting for migration in ecosystem services assessment	**Ralf Seppelt** - Global Land Use Change Dynamics, Green House Gas Emissions, and Ecosystem Services (GLUGS)

	Thursday, December 9, 2010 (Continued)				
11:40am-12:00pm	**Panel Discussion**	**Bobby Cochran**- Measuring Ecosystem Services – Transitioning to an Efficient and Integrated Approach	**Panel Discussion**	**Julia Michalak -** Seed Dispersal Services and Urban Development Influence Garry Oak Regeneration Patterns	**Aaron Jenkins** - Supplying Ecosystem Services: Conservation and Management Decisions of Farm Operators in Eastern North Carolina
12:00pm-1:30pm	**Poster and Booth Strike -** *Kave Ballroom*				
12:00pm-1:30pm	**Boxed Lunch -** *Akimel Foyer & Pre-Function*				
12:15pm-1:30pm	**Special Lunch Session- Coyote/Buzzard/Eagle** ***Forests and Forest Management*** **Moderator: Robert Deal**				
12:15pm-12:20pm	Introduction & Overview				
12:20pm-12:40pm	**Susan Alexander -** Mushrooms, Boughs and Money: Non-timber Forest Products in the United States				
12:40pm-1:00pm	**Tong Wu -** Tradeoffs Between Forest Ecosystem Services Under Differing Socioeconomic Conditions				
1:00pm-1:20pm	**Adrienne Gret-Regamey -** Tradeoffs Between Ecosystem Services for Sustainable Land Use Management				
	Concurrent Sessions				
	Session 8A	**Session 8B**	**Session 8C**	**Session 8D**	**Session 8E**
1:30pm-3:15pm	**Using Ecosystem Service Credits in Public Policy and Restoration Programs**	**Effects of Biofuels Production on Ecosystem Services**	**Ecosystem Service Endpoints for Decision Making**	**Implementation and Institutions**	**Synthesis of Indicators and Information**
Location	**Komatke D-G**	**Komatke A**	**Komatke B**	**Komatke C**	**Coyote/Buzzard/Eagle**
Moderator	**Jeremy Sokulsky**	**Betsy Smith**	**Dixon Landers and Lisa Wainger**	**Amy Daniels**	**Barry Rosen**
1:30pm-1:35pm	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview	Introduction & Overview
1:35pm-1:55pm	**Adam Davis** - The Potential for Private Capital Funds to Serve Conservation and Restoration Public Policy Goals	**Randy Bruins** - Evaluating Ecosystem Service Trade-offs Associated with Biofuel Feedstock Production in the Midwest	**Paul Ringold -** ESRP Approach to Using Final Ecosystem Services	**Bruce Jones** - The State of Ecosystem Services Implementation	**R. Jan Stevenson** - Integrating Indicators of Ecological Condition and Services into a Policy Framework
1:55pm-2:15pm	**Dan Nees** - Payments for Watershed Services: Leveraging Public Funding to Expand Restoration Success	**Terry Sohl -** Development of a Spatially Explicit Land-use Model for the Assessment of Biofuels	**Lisa Wainger -** Bringing Principles to the Practical Measurement of Ecosystem Service Endpoints	**Anne Neale -** National Atlas of Ecosystem Services	**Lisa Smith** - Conceptualizing Human Well-being and Ecosystem Services in Context of Economic and Social Aspects

	Thursday, December 9, 2010 (Continued)				
2:15pm-2:35pm	**Alex Echols -** The Commoditization of Intangibles: Overcoming Impediments to Reducing Pollution through Markets	**Yingxin Gu** - Dynamic Modeling of Ecosystem Performance to Identify Land Suitable for Biofuels Development	**Jeffrey Kline -** Defining the Role of the Ecosystem Services Concept in Public Lands Management	**Jim Henderson** - Ecosystem Services and the Corps of Engineers: We Identified Them and Now We're Waiting	**Simone Maynard** - Synthesizing Qualitative and Quantitative Information: Support for Ecosystem over Land Use Approaches to Ecosystem Services Assessments
2:35pm-2:55pm	**Jeremy Sokulsky -** Using Ecosystem Service Credits to Increase the Effectiveness of Publicly Funded Restoration & Water Quality Regulatory Programs	**Virginia Dale -** Regional Changes in Water Quality Associated with Switchgrass Feedstock	**Kevin Halsey -** Measuring Ecosystem Services at Multiple Scales	**Robert Deal** - Integrating Ecosystem Services into a Management Framework for Public Lands	**Kenneth Boykin** - Mapping Biodiversity Metrics at Regional and National Landscape Scales
2:55pm-3:15pm	**Tracy Stanton -** State of Watershed Payments: An Emerging Marketplace	**Laurence Eaton -** The Economic Effects of Biofuel Feedstock Production on Game fish Distribution	**Panel Discussion**	**Maggie Clary** - Lessons from Case Studies of Collaborative Watershed Management	**Jeff Ranara** - Integrated Social-Ecological Network Analysis of User-managed, Avian and Invertebrate Species - Inhabited GreenER Roofs and Walls Providing Expanded Urban Ecosystem Services
3:15pm-3:45pm	**PM Break -** *Komatke Pre-Function*				
3:45pm-4:55pm	**Closing Plenary Session** - *Komatke D-G* ***Progress and Future Directions for Ecosystem Services: A Synthesis of ACES 2010*** **Moderated By: Marina Moses,** Director Roundtable on Science and Technology for Sustainability, The National Academies **Panel Members:** **Mark Nechodom**, Natural Resources and Environment, U.S. Department of Agriculture **Barry Gold**, Program Director, Marine Conservation Initiative, Gordon & Betty Moore Foundation **Sissel Waage**, Consultant, Business for Social Responsibility **Lydia Olander**, Director of Ecosystem Services Program, Nicholas Institute, Duke University **Frank Casey**, Center for Science, Decisions, and Resource Management, U.S. Geological Survey				
4:55pm-5:00pm	**Closing Remarks - Carl Shapiro**, Co-Director, Center for Science, Decisions, and Resource Management, U.S. Geological Survey, ACES 2010 Conference Chair				
	Conference Concludes				
5:45pm-9:30pm	**Optional Post Conference Tour** - *ASU Decision Theatre*				

Poster Directory

Poster #	First Name	Last Name	Organization	Abstract Title
1	Emily	Cloyd	US Global Change Research Program	Integrating Existing Networks to Detect Future Shifts in Ecosystem Structure and Function Due to Global Changes
2	Romorno	Coney	Jackson State University	The Applications of Spatial Information Systems in Ecosystem Restoration: The Case of the Colorado Rocky Mountain Arsenal
3	Michael	Lewis	USEPA	Fate and Effects of Anthropogenic Chemicals in Coastal Plant-Dominated Ecosystems: A Comparative Review
4	Kristie	Maczko	Sustainable Rangelands Roundtable	Assessing Effects of Climate Change on Rangeland Ecosystem Goods and Services
5	Gregory	McCarty	USDA-ARS	Wetlands as Carbon Sinks within Agricultural Ecosystems
6	Ivelisse	Ruiz-Bernard	University of Florida	Effects of a Catastrophic Forest Fire on the Trophic Parameters of an Outstanding Florida Water
7	Zhengxi	Tan	ARTS at USGS EROS Center	Impacts of Corn-based Biofuel Production on Soil Fertility and Ecosystem Sustainability
8	David	Batker	Earth Economics	Towards Creating a Watershed Investment District to Align Policy, Planning and Funding for Salmon Habitat Restoration and Flood Protection in Washington State
9	Peter	Edwards	National Oceanic and Atmospheric Administration	The Role of Ecosystem Services Valuation in Coastal Habitat Conservation
10	Ted	Gilliland	Arizona State University	A Challenge for Ecosystem Service Bundling: Joint Production of Services and Free-Riding
11	Kenna	Halsey	Parametrix	The Role of Ecosystem Services in Sustainability Planning
12	Marisa	Mazzotta	EcoBenefits Research	A Simplified Decision Support Approach for Evaluating Wetlands Ecosystem Services
13	Doug	Parker	University of Maryland	Defining the “Product” in an Ecosystem Marketplace
14	V. Kelly	Turner	Arizona State University	Ecosystem Service Provisioning in Sustainable Planned Communities in the United States
15	Claudia	Young	USGS EROS Center	EcoServ: an Online Ecosystem Services Modeling System using Open Geospatial (OGC) Consortium Standards
16	Esther	Duke	Colorado State University	Designing a Pro-Poor Payment for Ecosystem Services Program in Western Panama
17	Kelly	Brands	American Forest Foundation	Voluntary Gopher Tortoise Habitat Crediting System
18	Stephanie	Beadle	Portland State University	Value of Streamside Visits in Southeast Arizona
19	John	Carriger	US Environmental Protection Agency	Modeling Ecosystem Services with Bayesian Networks
20	Kevin	Halsey	Parametrix	Measuring Ecosystem Services at a Site Level

Poster Reception, 5:45pm-7:45pm, Wednesday December 8, 2010
Kave Ballroom, Sheraton Wild Horse Pass Hotel

Poster #	First Name	Last Name	Organization	Abstract Title
21	Mark	Judson	Environmental Monitoring Sensor Intelligence Corp	Towards Predictive/Operational Assessment of Beach Closures using Remotely Sensed Data
22	Dixon	Landers	US Environmental Protection Agency	A Systematic approach for quantifying Final Ecosystems Services at Regional and National Scales
23	Leslie	Massey	Arkansas Water Resources Center	A Volunteer Water Quality Monitoring Program in the Upper Illinois River Watershed, Northwest Arkansas
24	Monobina	Mukherjee	University of California, Riverside	Analysis of Factors Influencing Open Space Values using a Spatial Hedonic Model
25	Ronald	Raunikar	US Geological Survey	Ecological Integrity as an Economic Variable: The Need for Aggregated Landscape Scale Indices
26	Vineeta	Shukla	Maharshi Dayanand University	Fish as an Indicator of Heavy Metal Pollution in Aquatic Ecosystem
27	Nancy	Steele	Los Angeles & San Gabriel Rivers Watershed Council	The Feedback Loop: Monitoring and indicators of Watershed Health in Greater Los Angeles
28	Christina	Wong	Arizona State University	Evaluating Water Ecosystem Services from the Yongding River Restoration Project
29	Sapana	Lohani	University of Arizona	Evaluating Ecosystem Services at LCNCA using State and Transition Models
30	Nicole	Davis	Texas A&M University, Corpus Christi	Linking Riparian Width to Ecosystem Services on a Coastal River in Texas, USA
31	Ray	Finocchiaro	US Geological Survey	Greenhouse Gas Flux of Grazed and Hayed Wetland Catchments in the Prairie Pothole Region
32	Jeffrey	Hollister	US Environmental Protection Agency	Geospatial Tools for Evaluating Ecosystems Services in Lakes and Ponds of the Northeastern US
33	Kristen	Hychka	US Environmental Protection Agency	Improved Mapping of Riparian Wetlands using Reach Topography
34	Russell	Mizell	University of Florida	Vegetation Plots Provide Regulating and Cultural Ecosystem Services
35	Darius	Semmens	US Geological Survey	A GIS Tool to Assess Social Values for Ecosystem Services (SolVES)
36	Benjamin	Sleeter	US Geological Survey	Development of National Land-use/Land-cover Scenarios for Ecological Impact Assessment
37	Elisa V.	Wandelli	Embrapa Amazonia Ocidental	Ecosystem Services of Second-Growth Vegetation Among Rural Settlers in Central Amazonia
38	Sarah	Kiger	University of Michigan	Linking an Ecosystem Process Model to Ecosystem Services
39	Carrie	Presnal	University of Arizona	Ecosystem Services In NEPA – Exciting New Tool, Weak Buzzword, or Another Burden?
40	Heather	Sander	US Environmental Protection Agency	Potential Impacts of Cropland Biofuel Production on the Provision of Avian Habitat

Poster Reception, 5:45pm-7:45pm, Wednesday December 8, 2010
Kave Ballroom, Sheraton Wild Horse Pass Hotel

About the Abstracts

The abstracts submitted for the ACES 2010 Conference were reviewed for their relevance to the ecological, economic, geographic, institutional, and management aspects of ecosystem services. Because of the constraints of time and conference topics, fewer than 200 submissions were able to be accepted as oral presentations. Our remaining contributions have been accepted as poster presentations; and all accepted submissions are found in this document.

Abstracts have been organized in alphabetical order by the presenting author's last name. In addition to the detailed conference agenda and poster directory preceding this introduction, an author index is located at the end of the book to facilitate the search for abstracts.

The ACES 2010 abstracts reflect the diversity of the topic of ecosystem services and the exciting future it holds. Thank you to all of the authors who have agreed to share their work.

Conference Abstracts

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

Water, Water Everywhere: Hedonic Pricing of Residential Lakes in an Arid City

Joshua K. Abbott[1] and *H. Allen Klaiber*[2]
[1]School of Sustainability, Arizona State University, Tempe, AZ, USA
[2]Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University, State College, PA, USA

Water provides a wide array of ecosystem services to urban dwellers. In addition to basic life-support functions, conveyed water also allows residents to derive aesthetic, recreational and cultural benefits from mesic and oasis landscapes that would not be sustainable on local rainfall alone. This is especially true in many cities of the U.S. desert southwest, where a combination of landscape preferences derived from less arid regions and heavily subsidized water supplies have led to surprisingly green landscapes and high per-capita water consumption. While the predominance of such landscapes suggests they provide important services to urban dwellers, they do so at considerable social cost – in terms of the (frequently hidden) costs of conveyance infrastructure, the scarcity value of the water itself and the increased vulnerability from long-distance importation of water. It is therefore important to gain an understanding of the relative benefits and costs of such "conspicuous" water usage.

As a case study, we examine the value of the recreational and aesthetic services provided by a series of private residential lakes in the Phoenix metropolitan area. Using hedonic price regression models, we utilize an extensive database of residential transactions preceding the recent housing "bubble" to examine the price premium attached to houses within lake communities versus comparable homes in non-lake communities. Furthermore, we examine how this premium varies across properties with varying degrees of lake access (i.e. adjacency vs. proximity) and across lakes whose characteristics (e.g. size, water quality) allow for more or less intensive recreational use. We then combine our estimates from this analysis with data on lake volume and evaporation rates to calculate the implicit unit value of an acre-foot of water in residential lakes. We then compare these estimates to 1) the rates paid by communities to water providers and 2) estimates of the full social cost of the associated water. These comparisons enable us to determine if the widespread consumption of water in residential lakes in Phoenix is primarily driven by strong homeowner preferences for aquatic landscapes or, conversely, the generally low price of water. Answering this question provides insight into how changes in water policy (i.e. through the more efficient pricing of water) may or may not spur changes in the intensity of water usage in residential landscapes.

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Mushrooms, Boughs and Money: Nontimber Forest Products in the United States

Susan J. Alexander[1]*, Sonja Oswalt*[2] and *Marla Emery*[3]
[1]US Forest Service, Alaska Region, Juneau, AK, USA
[2]US Forest Service, Southern Research Station, Knoxville, TN, USA
[3]US Forest Service, Northern Research Station, Burlington, VT, USA

The United States has joined 11 other countries in the Montreal process, so as to reach consensus on ways to assess national progress toward the sustainable management of forest resources. These twelve countries comprise over 90 percent of the world's temperate and boreal forests, and 60 percent of all forests. Each country assesses its own forests using a set of criteria and indicators agreed on by all member countries.

Indicators in the Montreal process focusing on measurements of nontimber forest products (NTFPs) can be found in two general areas, or criteria. One criterion focuses on productive capacity of forest ecosystems. The NTFP indicator in this criterion seeks to measure annual harvest of NTFPs nationwide. The other criterion examines the "maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies." Indicators in this criterion focus on value, consumption, international trade, employment, wages, and subsistence uses of NTFPs. NTFPs include medicinal plants, food and forage species, floral and horticultural species, materials used in arts and crafts, and game animals and fur bearers. Fuelwood, posts and poles, and Christmas trees are wood products, but are included in the U.S. NTFP indicator analyses. These products and the social and ecosystem services they provide are frequently overlooked in conventional forest products analyses.

The harvest of NTFPs is a significant activity in the U.S. The retail value of commercial harvests of NTFPs from U.S. forest lands is estimated at $ 1.4 billion annually. In the northwestern U.S., significant commercial products include evergreen boughs, floral greens, moss, and wild edible fungi. In the northeastern U.S., evergreen boughs, maple syrup, wild blueberries, and medicinal plants such as wild ginseng are important to local economies. In the southwest, posts and poles, medicinal plants, and forage are important to local communities. Medicinal plants such as saw palmetto, floral greens such as galax, and pine needles for nursery applications are harvested for commercial use in the southeast. NTFPs are exported from the U.S. to countries all over the world, including pecans, foliage, wild blueberries, wild ginseng, and wild edible fungi. Both legal and illegal harvest of medicinal plants in the United States has expanded considerably in the past twenty years, prompting protective measures for many species. Foods from native plants and fungi constitute a small percentage of foods consumed by Americans, but are often culturally significant. Native wild-harvested plants, fungi and game are important in traditions and culture, and can provide food security in lean times. NTFPs are important to many people throughout the country for personal, cultural, and commercial uses, providing food security, beauty, connection to culture and tradition, and income.

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The URBIS Partnership Proposal: Fostering the Ecosystem Approach in Urban Planning

Christine Alfsen and *Laura Dickinson*
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Currently, many urban regions are striving to incorporate innovative ecosystem focused approaches into long term planning for sustainability. All of these approaches are site specific but provide lessons that are relevant to other local and global urban planning efforts. Several of these ongoing initiatives in metropolitan regions have been studied and several approaches consolidated over the last 10 years by the UNESCO (United Nations Education Science and Culture Organization) New York Office. Findings from this ongoing research indicate the need for comprehensive regional ecosystem approaches which integrate education and outreach in all steps of participatory planning, and incentives and recognition of sustainable urban efforts. During this presentation, findings from this research effort will be illustrated through examples from metropolitan regions including Montreal, Stockholm, Chicago, and South Africa. This presentation will also describe the proposal of the URBIS Partnership, which will provide support for and recognition of using the ecosystem approach in planning and serve as platform for creating more resilient and equitable urban regions. The URBIS Partnership will serve as a network and forum for representatives from local governments to share their sustainable management practices and document the process of linking science, education, and policy while protecting and enhancing urban ecosystem services for more resilient urban regions. This partnership approach includes a proposed designation process to recognize urban areas' efforts to engage in participatory and comprehensive approaches to social and ecological urban planning for sustainability. The proposed steps of this designation foster conservation, restoration, and social equity using the ecosystem approach, constant dialogue among stakeholders, and adaptive governance. Throughout this process, sustainable management practices will be developed and then cataloged for sharing and dissemination as part of a global knowledge network.

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Does Nutrient Retention Increase with Hydrologic Complexity?

Paula E. Allen*, Maliha S. Nash* and *Ann M. Pitchford*
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Hydrologic complexity of a watershed can be thought of as the number, type, spatial arrangement and connectivity of water bodies on the landscape. Despite difficulties in measuring highly variable spatial and temporal de-nitrification rates within and among water body types, the type of water body and it's connectivity with others affects water residence time and therefore nutrient processing and retention. The development of indices for determining the relative nutrient processing among watersheds for making nutrient management decisions and gauging tradeoffs among other ecosystem services is therefore an important research goal. Towards this end we developed an index of hydrologic complexity based on metrics that describe the number, type, and spatial arrangements of different water body types on the landscape and evaluated the extent to which the index and the metrics they are based upon can explain the variability in stream nutrient concentrations and watershed nutrient retention. We used data collected from streams from third order watersheds covering four Midwestern states (MN, WI, IL, and IA). Our index, is a compilation of metrics scaled to 1.0 and added together, giving each metric equal weight. Using regression analyses we tested *the null hypothesis that hydrologic complexity has no influence on stream nitrogen concentrations or N retention.* Results from this research can be expanded to other areas in the Midwest and Nationally.

Key Words: hydrologic complexity, landscape metrics, watershed mass balance
Notice: Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

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Technology as a Driver of Ecosystem Service Change

Braden Allenby
Center for Earth Systems Engineering and Management, Arizona State University, Tempe, AZ, USA

The coming of the anthropogenic Earth, called by some the Anthropocene, poses unprecedented design, engineering, and management challenges. Technological change, poorly understood and frequently underestimated by most disciplines, is a potent driver of earth system change, and an important aspect of the emerging earth systems engineering and management paradigm. This talk will use historical examples of technological evolution, such as the railroad, to illustrate relevant implications of new technology systems, and use these examples to suggest that existing intellectual frameworks are entirely inadequate to understand, much less ethically and rationally manage, emerging technologies such as the Five Horsemen: nanotechnology, biotechnology, robotics, information and communication technology, and applied cognitive science.

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Impact of Aquatic Invasive Species on Ecosystem Services at Lake Tahoe

Lars W.J. Anderson
US Department of Agriculture, Agricultural Research Service, Davis, CA, USA

At least 20 non-native invasive plants, invertebrates and fish have become established and now proliferate in the littoral and pelagic habitats of Lake Tahoe, a beautiful, deep, alpine lake, designated an Outstanding National Resource Water (ONRW) under the Clean Water Act. This paper describes some of the most detrimental AIS species that affect ecosystems services at the lake, and provides a summary of the recent multi-agency response to the problem. Of primary concern now is preventing the introduction of quagga and zebra mussels (none have been found in Lake Tahoe to date), reducing populations and spread of Eurasian watermilfoil and curlyleaf pondweed, removal of Asian clams and reduction in populations of non-native warm-water fish. Over the past several decades, a variety of survey and detection methods have been effective in monitoring AIS, including, regular plankton sampling, SCUBA surveys, sediment samples, hydroacoustic surveys, videography and side-scan sonar surveys as well as physical point-sampling to determine presence/absence of macrophytes. Boat traffic (within the lake and via launches), water currents and mechanical removal (harvesting) have facilitated both the introduction and dispersal of AIS at Lake Tahoe. A newly approved Aquatic Invasive Species Plan and associated actions such as mandatory boat inspections at all launches over the past three have begun to curtail new introductions and should eventually reduce ecosystems impacts from existing AIS. However, continued funding and access to other resources will have to be assured for this effort to be sustained successfully and for long-term protection of Lake Tahoe.

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Ecological Risk Assessment is a Flawed Paradigm, and has Outlived Its Usefulness in Informing Environmental Management

Rochelle Araujo[1] and *Greg Biddinger*[2]
[1]U.S. EPA, Office of Research and Development
[2]ExxonMobil

In Support of the Proposition: Rochelle Araujo

Ecological risk assessment and ecosystems services are central concepts in a set of divergent and ultimately incompatible approaches to the environment and the management of environmental problems; namely, those of solving problems vs managing issues. Ecological risk assessment has led to the development of risk-based policies, in which ecological "bads" are to be minimized. This overly simplistic view not only fails to consider trade-offs between risks and benefits, it leads to environmental management policies that careen from solution to solution, reaction to reaction. Moreover, risk assessment is both reductionist and determinate, predicated on notions of stressor-response and control – with humans as initiators of (many) stressors and possessors of control (or the ability of control) – in both cases placing humans outside of the centrality of ecosystems.
Ecosystems services, in the other hand, by constructing benefits to humans of ecosystems functions, fully integrates humans into the fate of ecosystems in a multifaceted and, admittedly, brinksmanlike role. That is, the transformation of ecosystem functions into services is largely a function of the proximity to or interactions of humans with ecosystems in a way that, at the same time, endangers them, thus subverting any attempts to construct an ecosystems services-based stressor-response function that would be required to apply risk assessment methodologies to ecosystems services. That makes of risk assessment a paradigm lost – and invites us to take up a path towards holistic management of environmental issues.

Against the Proposition: Greg Biddinger

Managing human behavior to sustain the biological and physical integrity of our natural world requires a broad range of tools and supporting information. The Ecological Risk Assessment (ERA) paradigm and the tools and data that support it are, or at least can be, valuable components in an environmental management system. I would agree with a number of points raised regarding the ineffective or inappropriate application of ERA, but would not agree that the premise of ecological risk management is wrong or that the basic structure of the ERA paradigm is flawed. Rather I would contend that the trouble with the application of the ERA paradigm is that it needs to be connected to a contextually relevant performance objective to achieve its intended purpose of informing environmental management decisions. If that were done then the promise of performing risk-risk and risk-benefit trade-offs would be more likely fulfilled.

In my opinion ERA and Ecosystem Services (ESS) should be coupled, along with other tools, into a broad robust environmental management system. The ecosystem service concept helps frame those structural and functional attributes of the natural world that provide value. It is in this understanding of value that we can move from simply managing risk to natural systems by avoidance to defining actions that will be linked to performance objectives.

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Predicting Provision and Value of Ecosystem Services for Use in Decision-Making

Stephen Polasky[1] *and* ***Katie Arkema***[2]
[1]University of Minnesota, St. Paul, MN and Natural Capital Project
[2]The Natural Capital Project, Stanford University, Stanford, CA, USA

Human society depends on vital goods and services provided by ecosystems. But human actions threaten to erode the ability of ecosystems to provide these ecosystem services. In market economies, firms are rewarded for producing commodities but not for protecting environmental quality necessary for sustained provision of ecosystem services. Consumers pay market prices that do not necessarily reflect the full costs of their production and consumption. Unless society fixes this imbalance and begins to properly account for the value of nature we are unlikely to see fundamental change necessary to sustain ecosystem services. Addressing this imbalance requires addressing three tasks:

1) Improved understanding of the likely consequences of human actions on ecosystems and their ultimate impacts on ecosystem services and biodiversity ("ecological production functions")

2) Improved understanding of the value of changes in ecosystem services or biodiversity ("valuation")

3) Design of institutions and policies that provide correct signals of values to producers and consumers ("incentives")

InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) is a spatially explicit modeling approach being developed by the Natural Capital Project that integrates ecological production functions, valuation, and incentive mechanisms to study the value of ecosystem services provided at a landscape scale under different policy or management regimes. Examples of the application of InVEST to analyze policy or management alternatives will be shown using data from Hawaii, Minnesota and Oregon. Quantifying ecosystem services in a spatially explicit manner, and analyzing tradeoffs among them, can help to make more effective, efficient and defensible land use and resource use decisions.

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Using Maps and Models of Species to Quantify and Manage for Trade-offs Among Ecosystem Services

Katie Arkema*[1]*, *Anne Guerry*[1] and *Mary Ruckelshaus*[2]
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Changes in the distribution and abundance of animals and plants can modify the delivery of benefits from nature of value to people. Understanding the relationship between ecosystem components, such as species, and ecosystem services is an increasingly important and challenging task in the face of human population growth and climate change.

We have developed a scenario assessment tool called InVEST, which stands for Integrated Valuation of Ecosystem Services and Trade-offs. The tool is made up of a suite of process-based models that quantify how changes in the distribution of animals and plants can lead to changes and trade-offs in the delivery of multiple ecosystem services. InVEST consists of models for both terrestrial and marine ecosystems that require information about species occurring in these environments. In this talk we will focus primarily on marine environments. For example, models for mapping recreation services such as whale watching and SCUBA diving, are informed by data on cetacean sitings and the distribution of kelp forests. Fisheries models require some measure of the abundance of target fish species. Coastal protection models, which map and value the ability of the environment to protect human and natural communities from erosion and flooding, require maps of the density and extent of key structure-forming species of coral, seagrass, and mangroves.

In this talk we will first, explain the overall structure of the ecosystem services models, which include steps to quantify the supply, demand and value of each service, in both biophysical (e.g., landed biomass) and economic (e.g., net present value of fish) currencies. Next, we will demonstrate how maps of the distribution and abundance of species are used as inputs to models of ecosystem services (such as those mentioned above) and discuss how ecosystem services outputs vary with different levels of data quality and resolution. Finally, we will explain how outputs from models that forecast species distributions for various scenarios of climate change and management strategies are particularly important for informative assessments of ecosystem services. We will provide example output from sites where we are applying the marine InVEST models (e.g. West Coast of Vancouver Island in British Columbia, Belize, and Puget Sound) and discuss how this information is, and can be, used in various decision-making and planning processes (e.g., marine spatial planing, coastal zone management, ecosystem-based climate adaptation, and payments for ecosystem services).

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Storm Runoff Sampling and Water Quality Data in the Kickapoo Watershed

Viswatej Attili
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The potential effects of Atrazine and other pesticides on human beings, aquatic life, fish-eating wildlife, and the whole ecosystem are still poorly understood. Recent studies conducted by USGS concluded that the concentrations of Atrazine commonly found in agricultural streams and rivers caused reduced reproduction and spawning, as well as tissue abnormalities in laboratory studies with Fathead minnows (Pimephales Promelas).

Kickapoo Environmental Office in collaboration with EPA and USGS has been monitoring ten streams on the Kickapoo Watershed (Part of the Delaware Watershed, Northeastern Kansas) in 2007, 2009, and 2010. While the use of herbicides and pesticides has benefited in controlling weeds, insects, and other pests, and increased food production and reduction of insect-borne diseases; their use would also have affected the water quality and the fish habitat. This report is going to mainly focus on comparisons of the data from all the three years and analyze the impacts based on the obtained results. Results mainly indicated high concentrations of pesticides, nutrients, and E-coli in the streams during the monitored years.

In many streams, particularly those draining the agricultural areas, Atrazine was found at concentrations that may affect aquatic life or fish-eating wildlife. The concentrations of Atrazine in all streams remained below 2 µg/L in 2007; in 2009 the concentrations were relatively very high throughout the study area in most of the monitoring sites. Very high concentrations of E-Coli and total Phosphorus were recorded in both 2007 and 2009 monitoring seasons. Studies of the effects of Atrazine on the ecosystem are still in the early stages, and it may take years before major advances in understanding the actual potential effects.

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Contextualizing Ecosystem Services Supply and Demand for National Accounting Systems

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National accounting systems demand a rigorous approach to ecosystem services valuation in order to correctly assign and sum the value of natural capital relative to other components of national income. This needed rigor poses several challenges to ecosystem services researchers, including accurately conceptualizing and measuring the units of ecosystem services, properly valuing these units, and avoiding double counting. Emerging approaches to conceptualize ecosystem services, beyond the popular Millennium Ecosystem Assessment approach, offer a better way forward by valuing only the economic endpoints associated with nature's economic contributions. The built and human capital contributions toward economic value are then properly accounted for as compliments to natural capital, with double counting correctly avoided.

In this talk, I will discuss this approach in contrast to past efforts to value ecosystem services. In particular, ecosystem services researchers in the past have too rarely considered the demand side of ecosystem services when assigning value, have relied too heavily on value transfer, and have inconsistently classified ecosystem services using dated and confusing typologies. Some emerging approaches to map, assess, and value ecosystem services are doing a better job of addressing these common problems. I will demonstrate some of these alternative approaches and discuss their strengths and shortcomings, along with future research needs. Given the potential for ecosystem services research to better inform national accounting practices, this talk will thus provide ecosystem services researchers with a better understanding of how their work can help contribute to improved environmental accounting systems.

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Ecosystem Services in Decision Making for Public Lands in the Southwest and Beyond: A BLM Case Study

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Emerging approaches to assess and value ecosystem services offer the promise of better accounting for the value of goods and services derived from public lands. These public goods, traditionally valued as free, have often been degraded by decades of extractive resource use. In this study, we evaluate the outputs and utility of a series of emerging valuation methods and assessment tools toward assisting decision making for the Bureau of Land Management (BLM).

Our case study site, the San Pedro River in Sonora and Arizona, is internationally recognized for its high biodiversity and ecological significance. A long history of scientific research in the watershed exists to support ecosystem services research. Much of the Upper San Pedro's riparian corridor is managed by the BLM's San Pedro Riparian National Conservation Area, yet the perennial flow supporting these reaches is threatened by groundwater withdrawals.

We evaluated four groups of ecosystem services identified as important by local stakeholders and scientists, including those derived from water, biodiversity, carbon, and cultural values. We also applied a series of scenarios to evaluate the sensitivity of varying methods to various environmental changes, including mesquite removal for native grassland restoration, urbanization, and proposed water augmentation via the Central Arizona Project. We used primary economic valuation, value transfer, and the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) and Artificial Intelligence for Ecosystem Services (ARIES) tools to map and value ecosystem services. Other emerging ecosystem services tools are being evaluated in a parallel effort led by Business for Social Responsibility, with a focus on corporate decision making. We evaluated the utility of each approach based on a series of criteria relevant for public land managers, such as resource requirements, scalability and generalizability, and the ability to incorporate multiple valuation perspectives (e.g., monetary and non-monetary).

Our results are intended as proof of concept rather than to support specific management alternatives for the San Pedro. They provide a snapshot of the current "state of the science" for ecosystem services methods for use in BLM decision making both within the San Pedro and agency-wide. These findings could also inform public land managers of other agencies as they seek to improve resource management using an ecosystem services framework.

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A Comparison of Fragmentation Effects in Three *Erigeron* Pollination Networks

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Pollination has been identified as a critical ecosystem service for native ecosystems. Habitat loss due to fragmentation is increasing every year in the U.S. and is resulting in biodiversity loss particularly in endemic and rare populations of animals and plants. Army bases are increasingly becoming isolated areas of biodiversity with many endemic and rare populations of animals and plants, surrounded by development. Understanding how fragmentation affects pollination mechanisms and gene flow in plant species is a critical issue to reduce the “island effect” with which many of our military bases are challenged, and is critical to prevent the extinction of plant and pollinator species. Our findings will have wide application for resource management on military bases and other natural areas that are islands of diversity.

This on-going study is a pioneering effort to study network properties of pollination networks in relationship to a genetic analysis for 3 species of *Erigeron* affected by fragmentation. Few studies have investigated how plants evolve with pollination networks in fragmented habitats, one of the most influential interactions affecting plant demography and genetic viability. We will be applying network approaches to understanding how plant species subjected to fragmented and sparsely vegetated habitat have adapted pollination network strategies to ensure adequate gene flow. Our study will focus on three species of *Erigeron* (Fleabane Daisies), one adapted to naturally sparse cliff wall habitat in one canyon fragmented by topography (*E. lemmonii*) and two others (*E. arisolius and E. neomexicanus*) adapted to more diverse habitat conditions in a larger range. Innovative aspects of this study are to develop and publish genetic microsatellite markers for the three species of *Erigeron,* which are the first microsatellite markers to be identified for the genus of *Erigeron,* currently underway. New botanical information is being observed and recorded for the endemic *Erigeron lemmonii,* which will add important knowledge for the management of this rare and endemic plant. Genetic fingerprinting will be used to demonstrate the role of selfing and the extent of gene flow of an endemic rare plant species, growing in a natural canyon fragmented landscape, in relation to other more widely spread species growing in a range of habitats affected by manmade fragmentation. Additionally, this work will further network science application by combining pollination networks with genetic analysis as an indicator of fragmentation. We will compare and contrast the pollination networks of three species of *Erigeron* by recording pollinator/ plant interactions and construct quantitative plant visitation graphs and adjacency matrices of links to determine pollinator network relationships using PAJEK and UCINET software.

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The Economic Value of the Mississippi River Delta

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Countless people value the Mississippi Delta, and many depend on it to sustain their livelihoods. However, until recently the economic value of natural systems in the Delta had never been fully measured, and because of this could not been incorporated into regional economic planning. In 2007, Earth Economics, in partnership with the Gund Institute and Louisiana State University, began an ecosystem service valuation study of the Mississippi River Delta. The objective of our study was to use benefit transfer methodology to determine a dollar value range for the ecosystem services provided by the Delta, which include hurricane buffering, water supply, fisheries support, waste treatment and other previously unaccounted for natural goods and services that contribute to the local and regional economy. Our report was publicly released in June 2010, in the wake of the Deepwater Horizon oil disaster. The report found that (pre-spill) the Mississippi River Delta ecosystems provide at least $12 – 47 billion in benefits to people every year. If this natural capital were treated like an economic asset, the present value of the Mississippi River Delta would have a value of between $330 billion and $1.3 trillion. It was found that wetlands, which include freshwater, saltwater, estuaries, tidal bays, and cypress swamps, account for more than 90% of the estimated total value of ecosystem services provided in the Mississippi River Delta. The report examines three future scenarios: continued wetland loss; minor wetlands restoration efforts; and a major wetlands restoration. The study shows that large-scale wetlands restoration is a good financial investment for the Gulf region and the nation, bringing in an annual net benefit of $62 billion, by producing benefits with an estimated present value of at least $21 billion and avoiding $41 billion in damages.

The Deepwater Horizon oil spill in the Gulf of Mexico provides economists and ecologists with an opportunity to educate decision makers and garner public support for better governance and accounting of Gulf ecosystems and the goods and services they provide.

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Flood Protection and Ecosystem Services in the Chehalis Basin

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Since 1970, the Chehalis River Basin in western Washington State has experienced seven catastrophic flood events. A storm in 2007 brought floods to Lewis County that caused an estimated $166 million in damage to personal property, agricultural land, local businesses, and transportation systems such as Interstate 5. Understanding how flood protection is provided within the Chehalis Basin is vital for making good private and public investment decisions.

To inform decisions on flood protection in the basin, Earth Economics completed a study for the Chehalis River Basin Flood Authority in May 2010. The study identified and estimated the economic value of natural systems in the Chehalis River Basin using benefit transfer methodology. The results indicate that Chehalis Basin ecosystem services provide between $1.3 and $11.6 billion in economic benefits to citizens every year. One of these critical ecosystem services is flood protection.

Earth Economics worked with the Gund Institute at the University of Vermont to use the newly developed Artificial Intelligence for Ecosystem Services (ARIES) tool, a web-based tool for ecosystem service mapping and modeling. Preliminary maps were generated to show where flood protection and other ecosystem services are provisioned, who benefits from these ecosystem services, where flood protection and other ecosystem services are being impaired, and how the service of flood protection is transferred to beneficiaries.

Project highlights included: 1) Designing comprehensive project criteria for flood protection, 2) Applying the ARIES modeling framework to flooding, and 3) Calculating an asset value of natural capital in the basin, thus allowing traditional (flood) project cost/benefit analysis to incorporate ecosystem services.

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Towards Creating a Watershed Investment District to Align Policy, Planning and Funding for Salmon Habitat Restoration and Flood Protection in Washington State

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Healthy watersheds and the salmon populations they support are essential to the health of the Pacific Northwest's economy. Since 2005, Earth Economics has worked with local groups in the Green/Duwamish Watershed (near Seattle) to protect and enhance watershed health by assessing the value of the watershed's ecosystem services. One completed report led to the unanimous approval of the $5 million North Winds Weir Project, a salmon habitat project with associated flood protection benefits. Our work broadened local understanding of the economic benefits associated with riparian restoration, brought focus on the often competing initiatives of flood protection and salmon habitat restoration and advised local jurisdictions to align funding and focus on projects that benefit both salmon and flood protection- and potentially a number of ecosystem services.

Initially focused on helping the Seattle area Water Resource Inventory Area 9 (WRIA 9) to develop independent funding mechanisms for the watershed's Salmon Habitat Plan ($200-300 million over ten years), we identified 21 possible funding mechanisms. From these, three were selected in collaboration with WRIA 9, to be introduced in a three-phased approach.

In May 2010, the WRIA 9 Watershed Ecosystem Forum took a significant step and voted unanimously in favor of adopting the first phase, involving a King County Flood Control District levy increase. The second phase will entail the creation of a new taxation district for salmon and flood protection, funded through either a small per parcel assessment or fee, or a new property tax. The third phase, and ultimate goal of this process, is to develop "Watershed Investment Districts" at the State level. These tax districts would be formed at the watershed scale, ensuring that watershed goods and services (such as stormwater conveyance, flood control, and salmon production) are managed in a coordinated way that reduces overall costs and increases overall benefits.

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Value of Streamside Visits in Southeast Arizona

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The purpose of this study is to estimate the recreation-use value of riparia visits, including bird watching and hiking, in the San Pedro Watershed and two private nature preserves. The study proposes to collect data from three key locations: Bureau of Land Management's San Pedro Riparian National Conservation Area (SPRNCA), The Nature Conservancy's Ramsey Canyon Preserve, and The Nature Conservancy's Patagonia-Sonoita Creek Preserve. Each location provides ecological and recreation-use value information of riparia. The SPRNCA is a semi-arid watershed that covers 57,000 acres of land along 40 miles of the Upper San Pedro River and is home to over 100 species of breeding birds and 84 species of mammals. The Patagonia-Sonoita Creek Preserve encompasses the first two miles of perennial flow of Sonoita Creek and is considered one of the richest riparian habitats in the Southwest dominated by senescent Fremont cottonwood trees. Patagonia-Sonoita Creek is visited by thousands of people every year. Ramsey Canyon is located in Apache Highlands which is composed of a mountainous region intersected by semi-arid grasslands. Ramsey Canyon receives visitors from all over the world each year. These three locations are a sample of what remains of a once vast riparian network in the American Southwest. The data collected will investigate visitation trends and potential application of travel cost models to quantify consumer surplus per visitor day value. Additional social and natural science data from census and GIS sources will be tested for increased model explanatory power. Results will be compared with other nonmarket valuation figures calculated in the region. Values estimated will provide a lower bound of the total nonmarket value that can be compared appropriately to other competing values.

Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

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Human Impacts on Coastal Marine Ecosystems and Services

Joey R. Bernhardt and *Katie K. Arkema*
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The delivery of marine ecosystem services, such as shoreline protection and recreation, depends on nearshore habitats such as eelgrass beds and kelp forests. We are developing a model of habitat quality, which provides a way to assess how human activities and climate change impact the functioning of nearshore ecosystems, and consequently the production of marine ecosystem services. We assess the susceptibility of nearshore habitats to human activities such as coastal development and finfish aquaculture by considering the spatial overlap between the activity and the habitat, as well as the frequency and intensity of the activity. Similarly, we also consider the vulnerability of habitats, which is a function of their resilience to each activity (their ability to resist disturbance and recover quickly, as well as their ability to adapt to changing conditions over time). The outputs from the model include maps of the relative impact of each activity or climate stressor on several nearshore habitat types, an assessment of the cumulative impact of all activities and climate stressors on each habitat type, and maps of the change in habitat quality under future scenarios of human activity and climate change. The outputs from this model are then used in a suite of ecological production functions, (part of Marine InVEST, a new ecosystem services scenario assessment tool) which reflect these changes in habitat quality in terms of changes in the production of valuable ecosystem services such as food from fisheries, and recreation.

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A General Framework for Estimating the Benefits of Moderate Resolution Imagery in Environmental Applications: A Case Study in Non-point Source Pollution of Groundwater Resources

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We propose that moderate resolution land imagery (MRLI) is crucial to a more complete assessment of the cumulative landscape level effect of agricultural land use and land cover on environmental quality. If this improved assessment yields a net social benefit then that benefit is due to the value of information (VOI) from MRLI. Environmental quality and the capacity to provide environmental services evolve because of human actions, changing natural conditions, and their interaction with natural physical processes. The human actions, in turn, are constrained and redirected by many institutions including agriculture, energy, and environmental policies. A general framework for bringing together all relevant processes (i.e. sociological, biological, physical, hydrological, geological) to interpret environmental implications of MRLI is presented. We set out a specific application using MRLI observations to identify crop planting and thus estimate surface management over a landscape that is the source for groundwater resources. We tailored the application to the characteristics of groundwater pollution hazards in Iowa to illustrate the general framework in a land use-hydrologic-economic system. In the example, MRLI VOI derives from both reducing losses to agricultural production and reducing mitigation and treatment costs necessary to avoid human health and other consequences of contaminated groundwater.

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A Land Valuation Model for Protecting Ecosystem Services: South Florida Case Study

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South Florida, especially the Miami MSA, has seen tremendous growth in the form of urban and suburban sprawl over the last several decades. Some of this development has encroached on a fragile ecosystem, the Everglades. The research tests for the efficacy of protective land use controls on the probability of development.

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Buffelgrass Invasion in the Sonoran Desert: What Do We Stand to Lose?

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Southern and central Arizona are on the verge of losing the Arizona Upland of the Sonoran Desert, the ecological backdrop for two large cities (Tucson and Phoenix) that host major universities, a profitable tourism industry with world-class resorts, multiple national and regional parks, and award-winning conservation efforts. Invasion by *Pennisetum ciliare* (buffelgrass) and other non-native grasses threatens to transform this mostly fireproof and diverse ecosystem into an impoverished and flammable savanna. Risks to biodiversity include not just rare and endangered species, but also to more dominant and iconic ones like the saguaro. There are obvious compromises to conservation efforts. Simple purchase and setting aside of “pristine” desert is no longer effective without the resources needed to manage invasive grasses and associated wildfires. Likely impacts to basic ecosystem services, including food webs, nutrient cycling, and the transport, supply and quality of water and sediment, remain virtually unstudied. Economic impacts include market-based costs (e.g., decreased property values in infested and increasingly fire-prone areas, losses in tourism revenues with a decaying ecological backdrop, and escalating weed control and fire suppression budgets across all jurisdictions) as well as nonmarket based costs not easily expressed in dollar terms (i.e., aesthetic values). Urban areas now have to plan growth, development and protection of public safety around a fast-evolving fire risk.

We must choose between saving the desert or resigning ourselves to these novel and combustible grasslands. What decisions must we make, who makes them, and how will they be implemented across complex physical and cultural landscapes? The Arizona state government has declared buffelgrass a noxious weed, and in Pima County, local governments are drafting ordinances to encourage utilities, developers, and private landowners to control it on their properties and right-of-ways. A non-profit organization, the Southern Arizona Buffelgrass Coordination Center (SABCC: see www.buffelgrass.org), was established in late 2008 to coordinate across the public and private sectors. Control efforts have accelerated, culminating in treatment of >1500 acres on public lands and right-of-ways in 2008 and 2009. Public awareness and participation is on the rise. Over 100 volunteers pull buffelgrass each month in the Tucson area and similar volunteer efforts are under way in Phoenix. A vulnerability and risk assessment was recently completed for the Tucson area, and is being integrated into a state-and-transition, decision analysis framework parameterized for habitat suitability, invasion rates, dispersal dynamics, and treatment costs and effectiveness. Congressional field hearings focused on buffelgrass invasion on federal lands were held in Tucson on April 10, 2010. If the federal government, by far the largest landowner in the state, allows buffelgrass to overrun suitable habitat on its lands, mitigation efforts will be compromised on other adjacent public and private lands. An interagency mitigation and planning effort across 5 different federal agencies and 14 federal units is under consideration.

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ELD and the Ecosystem Services: Application to a Case in Italy

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Part 1: The selection of the resources and services that have a key role in the ecosystem is a useful tool to evaluate and mitigate for environmental damage. The European Directive 2004/35 “on environmental liability with regard to the prevention and remedying of environmental damage” provides for the use of resource-to-resource or service-to-service equivalency approaches for priority criterion reporting: “when determining the scale of complementary and compensatory remedial measures, the use of resource-to resource or service-to-service approaches shall be considered first”. The same approach is used by the American Legislation. These equivalency approaches are based on the principal concept that the public can be compensated for injured resources and services through a replacement project providing additional resources and services of the same type.

Part 2: The present study is a qualitative exercise of the application of resource-to-resource equivalency approaches to quantify potential environmental damage in a site located in the North of Italy with river and lake sediments contamination of POP’s. To define the potential Ecological Services Loss the Habitat Equivalency Analysis focused on the effects of the POP’s concentration on the benthos community. To define the potential Human Use Service Loss, the Visitor – User Days Analysis focused on limitation of sport fishing caused to POP’s concentration in fish tissues has been used.

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Moving Industry's Management of the Environment from Risk Avoidance to Performance through use of Ecosystems Services

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The promise of the Ecosystem Services (ESS) concept is that it shifts the focus of environmental management from one of avoiding behaviors that may result in an environmental injury, to one that assures such activities support the continued productivity of nature systems in which industry operates. For industry, and likely regulatory agencies, this is an important and possibly difficult technical culture shift. It's important in that by using ESS as a management focus we have a greater ability to incorporate the value and therefore the benefits of environmental protection or controls investment into project design and economic evaluation. Additionally, Industry, as does the average public, often struggle with the actual economic value and social benefits achieved by simply reducing risk through traditional control or remedial strategies. The shift to a focus on ESS will enhance all parties understanding of the direct links between the management actions taken to protect environmental condition and their direct benefits to the public at large.

As valuable as such a shift might be, it may be technically difficult. Today managing operational integrity is focused on avoiding failure by equipment and the people that operate those processes and facilities. Such a focus on avoiding failure and the risk associated with such failure is one that starts with a severe inward focus. To a great degree it is a bottom-up process that builds from the purpose of manufacturing and then looks to how the process can safely interact with the environment. Such an approach is not holistic in that it focuses on a single or limited number of separate single points of environmental contact and test the probability of those separate contacts being problematic. Shifting to starting from an understanding of the performance attributes of the natural system(s) in which are about to construct and operate an industrial your environment

The intent of this presentation will be to provide an overview of how ESS assessment can be incorporated into the design, construction and management of industrial production systems. The use of ESS in the Oil & Gas and petrochemical industries for project design, site development and facility management will be discussed. How this would impact the information needs and tool sets will be evaluated.

It is important to remember that industrial systems produces goods and services just as ecological systems do and our sustainable objective to integrate these systems in such a way as to assure that both have the freedom to produce and maintain their operational integrity into the future.

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The Impact of Natural and Manmade Disasters on Urban Ecosystem Services

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Urban ecosystem services become damaged in the face of natural and manmade disasters. Thoughtful rebuilding after such occurrences can insert resilience, help mitigate against the future calamities and strengthen or improve existing urban ecosystem services. Examples from Japan and elsewhere provide evidence of the application of protective disaster management approaches employed in the restoration and/or amplification of urban ecosystem services after a disaster.

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Legal Issues in Valuing Tribal Natural Resource Damage Claims

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Several federal statutes, including the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Oil Pollution Act of 1990 (OPA), and the Clean Water Act (CWA), authorize federal, state, and tribal governments to act as trustees on behalf of the public and bring money damages claims against potentially responsible parties for injury to natural resources caused by discharges of hazardous substances or releases of oil. Trustees use recovered damages to restore, rehabilitate, replace, or acquire the equivalent of the injured natural resources.

Tribal natural resource damage claims may involve unique and/or culturally sensitive issues in terms of distinguishing legally cognizable injury from other, non-compensable harms caused by a discharge or release; demonstrating interim loss of natural resource services, including religious, medicinal, and subsistence uses; and translating natural resource injury into a claim for compensation. Recent amendments to federal regulations for conducting natural resource damage assessments include additional, restoration-based methodologies for valuing interim loss of services, which may facilitate successful resolution of tribal natural resource damage claims. However, difficulties with valuation may remain in situations where replacement or acquisition of the equivalent resources is the only practical outcome.

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Case Study of Comparative Tool Application and Considerations for Corporate Land Management

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Corporations can benefit from evaluating Ecosystem Services on their land holdings. Benefits to landowners and managers can be tangible (e.g., financial and license to operate) and intangible (goodwill and reputation). In order to successfully manage ES on corporate lands, it is important to understand how habitat management, biodiversity conservation, and sustainability are related to ES; what tools are available for helping incorporate ES into land management decision; and how best to apply these tools. In the fall of 2010, the Environmental Services, Tools, & Markets Working Group of Business for Social Responsibility (BSR) convened a meeting of tool developers and end users for the purpose of comparing and contrasting tool functionality, data requirements, user interface, outputs, and application costs. Several tools, developed by universities, non-governmental organizations and consulting firms, were applied using environmental and social data sets for the San Pedro watershed in Arizona as a case study to evaluate water provisioning, carbon sequestration, biodiversity, and cultural services. The results of BSR's roundtable workshop will be presented to provide an overview of how existing tools can facilitate ES-based land management decisions. In addition, this presentation will include example results of tool application, including a framework for screening and cataloguing ES attributes of properties and comparing ES attributes among various properties as well as exploring the effect of various development decisions (e.g., preservation, development, and restoration) on the flow of ES .

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The Multiscale Integrated Earth Systems Model (MIMES): The Dynamics, Modeling and Valuation of Ecosystem Services

Roelof Boumans
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Ecosystem services are defined as those functions of ecosystems that support (directly or indirectly) human welfare. They occur at multiple scales, from climate regulation and carbon sequestration at the global scale, to flood protection, soil formation and nutrient cycling at local and regional scales (Kremen 2005).

The MIMES project aims to integrate participatory model building, data collection and valuation, to advance the study of ecosystem services for use in integrated assessments. MIMES builds on the GUMBO model (Boumans /et al./ 2002; Costanza /et al./ 2006) to allow for spatial explicit modeling at various scales. The three major objectives are:

- A suite of dynamic ecological economic computer models specifically aimed at integrating our understanding of ecosystem functioning, ecosystem services and human well-being across a range of spatial scales;
- Development and application of new valuation techniques adapted to the public goods nature of most ecosystem services and integrated with the modeling work;
- Delivery of the integrated models and their results to a broad range of potential users.

The MIMES outline was constructed after the Millennium Assessment Synthesis report on "Ecosystems and Human Well-being: General Synthesis". The MIMES at this stage represented a general model scalable in time and space applied in global, regional and local models.

Ecosystem services are the interface between the natural spheres and the anthroposphere, where natural amenities are evaluated for their contributions to the economies and well-being of human cultures. When MIMES is used to represent a spatial explicit model (multiple locations), exchanges between locations can be coded to represent not only flows of water, air and people but also the spread of species.

Subject-specific models (subject models) relevant within the MIMES outline were studied and translated for representation within the SIMILE declarative modeling language. MIMES development requires an "interaction matrix" to link outputs and inputs among the subject models. This matrix is a dynamic feature within MIMES development for developers of subject models to interact with modelers of other parts in the model (asking for model input and providing model output when asked)*.

MIMES is applied to an array of case studies, to include a global implementation, land-use changes within the Albemarle Pamlico watersheds in Virginia and North Carolina, the Willamette basin in Oregon USA, and in the United States to guide ecosystem based , management decisions in Stellwagen Marine reserve, Massachusetts.

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Measuring Consumption of Environmental Public Goods: Thoughts on the Theory and Practice of a "Green Index"

James Boyd
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The talk will discuss the institutional status of Green GDP initiatives in the US and abroad, alternative approaches to environmental indices and their relative merits, and illustrate one particular approach focused on place-based consumption of environmental public goods.

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Mapping Biodiversity Metrics at Regional and National Landscape Scales

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It is widely understood that the human condition is intrinsically linked to the quality of the environment and the services it provides. Ecosystem services, i.e., "services provided to humans from natural systems," have become a key issue of this century in resource management, conservation, human well-being, and environmental decision analysis. Mapping and quantifying ecosystem services have become strategic national interests for integrating ecology with economics to help explain the effects of human policies and the subsequent impacts on both ecosystem function and human welfare. Aspects of biodiversity are valued by humans in many ways, and thus are important to include in any assessment that seeks to identify and quantify the value of ecosystems to humans. Some biodiversity metrics clearly reflect ecosystem services (e.g., abundance and diversity of game species), whereas others reflect indirect and difficult to quantify relationships to services (e.g., relevance of species diversity to ecosystem resilience, cultural value of native species). Wildlife habitat has been modeled at broad spatial scales and can be used to map a number of biodiversity metrics. In this evaluation, we use USGS Gap Analysis Program data including land cover, land stewardship, and deductive habitat models for terrestrial vertebrate species to map metrics reflecting ecosystem services or biodiversity aspects valued by humans over large areas. Metrics will be derived from species-of-greatest-conservation-need, threatened and endangered species, harvestable species (i.e., upland game, migratory birds, and big game), total species richness, and taxon richness. The project is being conducted at multiple scales in a phased approach, i.e. place-based watersheds to multi-state regional areas that eventually culminate in a national-level product for the conterminous U.S. Preliminary results for the San Pedro watershed (southeast AZ) and the Southwest region (AZ, NM, NV, UT, & CO) are provided as first-level examples of this incremental approach.

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Dynamic Modeling of Ecosystem Performance to Identify Land Suitable for Biofuels Development

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Our ecosystem performance modeling method separates the climate signal from the effects of management and ecological disturbances. Using this approach, we can display ecosystem performance anomalies (EPAs), or areas where the ecosystem performed significantly better or worse based on weather expectations. The objective of this study is to identify areas in the Greater Platte River Basin that could be suitable for conversion to a biofuels grass.

We trained our model on more than 16,000 pixels identified by the National Land Cover Database as grassland. The modeling process incorporates three main components: 1) Long-term ecosystem performance, or site potential: 9 years of integrated growing season Normalized Difference Vegetation Index (NDVI) data, geophysical data, biophysical data, and climate data incorporated into a regression tree model determine the ecosystem's site potential. 2) Ecosystem performance (EP): an annual integrated growing season NDVI serves as a proxy for annual ecosystem performance, or productivity. 3) Expected ecosystem performance (EEP): site potential combined with seasonal weather data and incorporated into the regression tree generates the expected ecosystem performance.

We define targets for potential conversion to a biofuels grass as areas with moderate or high site potential and: 1) where croplands persistently underperform based on our grass model—if this occurs then this area would likely be more productive as grassland; and 2) where grasslands normally performed or persistently overperformed based on our grass model—if this occurs then this area would likely maintain similar productivity levels as a biofuels grass.

Target areas should undergo further study before any conversion to a different crop type occurs to insure that the change in land use is appropriate and to avoid any undesirable and irreversible land cover changes.

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Global Quantitative Assessment of the Value of Ecosystem and Biodiversity Conservation

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It is well established that human well-being is dependent upon ecosystem services provided by natural systems (MA 2005, TEEB 2008). Ecosystems face a variety of pressures resulting from population growth, urbanisation, and climate change but due to the public good characteristics of many ecosystem services, they are typically under-valued in both private and public decision-making relating to their use and conservation. As a result, most ecosystems are continually being degraded causing the provision of ecosystem services to decline. This paper presents the results of a global assessment of the value of ecosystem services under a range of alternative future scenarios. The research has been conducted as part of The Economics of Ecosystems and Biodiversity (TEEB) study.

The methodology applied combines land use modeling and economic value transfer in the following steps: 1. Spatial modeling of changes in ecosystem extents and quality under alternative conservation strategies using the GLOBIO model; 2. Estimation of biome specific value functions through meta-analyses of the economic valuation literature on ecosystem services; 3. Valuation of ecosystem services under alternative conservation strategies by substituting spatially explicit ecosystem changes into the value functions. The biomes included in the analysis are: temperate forests and woodlands; tropical forests; grasslands; rivers and lakes, inland wetlands; coastal wetlands, mangroves; and coral reefs. The results are presented at the regional and global level.

The analysis presented in this paper raises a number of important issues for economic valuation of ecosystem services. Firstly, the study addresses the challenge of scaling up value information on ecosystem services to a global scale by applying a spatially explicit approach to value transfer. Secondly, through comprehensive meta-analyses of the valuation literature on ecosystem services from each major biome, the study provides an overview of the available stock of knowledge and the gaps that remain to be filled. Some biomes are well represented in the valuation literature (e.g. rivers and lakes, wetlands, forest) whereas for others information is scarce (e.g. grasslands). Similarly, some ecosystem services are better covered (e.g. recreation, provisioning) than others (e.g. cultural and non-use values).

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Voluntary Gopher Tortoise Habitat Crediting System

Todd Gartner and ***Kelly Moore Brands***
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Fire-maintained longleaf pine stands once occupied 90 million acres in the Southeast, but today have declined to roughly 3 million acres as a result of habitat conversion and fire suppression. Lack of fire on the landscape has resulted in limited habitat for a variety of species. Consequently, many species have experienced population declines including the gopher tortoise. With over 80% of land in private ownership in the Southeast, the greatest potential for conservation, restoration and management of habitat for declining species lies in the hands of family woodland owners.

To address these issues, the American Forest Foundation is developing a market-based voluntary habitat crediting system for the gopher tortoise and associated species in portions of Georgia and Alabama. The incentive-based framework will complement other efforts in the region to help preclude the need to federally list the eastern population of the gopher tortoise.

Under the program, interested family woodland owners become eligible for habitat management assistance and conservation credit payments through a process that considers the potential habitat contribution of the property in combination with the landowner's bid requirements. Landowners selected to participate will be issued credits for verifiable gopher tortoise habitat and agreed upon management activities. These credits can be voluntarily purchased by federal, state or county governments, or private companies to offset impacts on gopher tortoise habitat and populations. These credits may also assist the credit holders in meeting their regulatory obligations should the eastern population of the gopher tortoise become federally listed in the future.

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Engaging Landowners in Watershed-Scale Nutrient Management Projects in Wisconsin

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Based on its own project's outcomes and those of other organizations, Sand County Foundation has concluded that targeting conservation practices in specific watersheds has the most potential for demonstrating meaningful links between changes in agricultural land management and improvements in water quality. In three new Wisconsin projects taking this approach, Sand County Foundation and its partners are seeking to test the hypothesis that engaging landowners at the beginning of the project will minimize resistance to the project, while allowing project goal setting, monitoring, choice of practices, and adaptive management to draw on local farmers' superior knowledge of their local watershed.

Project watersheds were chosen in different regions of Wisconsin. Landowners in each were consulted on identification and adoption of changes to management systems for critical sites like to contribute high levels of nutrient loss; identification and adoption of practices which take into account the importance of timing nutrient applications to reduce losses during critical runoff periods; and identification of suitable sites at which to monitor water quality, both at the edge-of-field and in waterways. Crop consultants and other key advisers to farmers in each watershed were also engaged early in the process, and community leaders from outside agriculture were offered opportunities to comment.

Early experience in each project strongly suggest that time invested engaging local landowners and farm operators early at a project's onset can help avoid many difficulties, from wasted effort identifying critical sites without the benefit of local experience to unintentional involvement in preexisting local controversies between agriculture and the non-farm community. Projects that advertise intent to find out, and to document, "what is really going on" with water quality appear able to bypass sources of resistance to many current approaches to conservation on agricultural land.

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Integrated Modeling and Ecological Valuation: A Framework for the Semi-Arid Southwest

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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 was 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 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 developed a similar framework for the Middle Rio Grande of New Mexico (MRG).

The non-market techniques of Choice Modeling (CM) and Contingent Valuation (CV) were conducted for each site allowing for benefit-transfer tests. 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. Our modeling framework began with the identification of factors that influence spatial and temporal changes in riparian vegetation on the two rivers. We used 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. Preliminary results will be discussed.

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Evaluating Ecosystem Service Trade-offs Associated with Biofuel Feedstock Production in the Midwest

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U.S. EPA's Future Midwestern Landscapes Study is quantifying ecosystem services in a 12-state area of the Midwestern US. This study will be generating detailed landscape coverages representing a Base Year (2002) and two alternative futures (2022). The 2022 Biofuel Targets (BT) Landscape approximates the landscape expected in the year 2022 given current policies which set targets for increases in biofuel production through the Energy Independence and Security Act of 2007 (EISA); this landscape is characterized by increases in corn acreage and utilization (removal) of corn stover. By contrast, the 2022 Multiple Services Landscape will be one in which practices such as conservation tillage, wetland restoration and addition of riparian buffers are significantly increased. For the Base Year and alternative future landscapes, projected changes in various environmental endpoints are being modeled; these include soil carbon and soil productivity; stream loadings of runoff, sediment, nutrients and pesticides; composition of fish communities; wildlife habitat; and air quality. These changes are being estimated using either off-the-shelf, adapted, or in some cases newly-developed models. Changes in these endpoints will be related to ecosystem services using a level-of-service approach that considers both supply of and demand for public-friendly ecological endpoints. Outcomes will be provided via a web-based "Environmental Decision Toolkit" that will allow users to visualize and compare the Base Year and alternative future landscapes by examining tradeoffs–that is, changes in the provision of a variety of ecosystem services–at both local and regional scales.

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Building Risk and Uncertainty from Climate Change into Economic Valuation of Ecosystem Services

Ernie Niemi, ***Mark Buckley*** and *Sarah Reich*
ECONorthwest, Portland, OR, USA

On-going and anticipated changes in climate alter the economic value of many ecosystem services by reducing the ability of ecosystems to provide them, increasing society's demand for them, and raising the volatility of both supply and demand. In some cases, decisions about how to manage ecosystems in the face of climate change can be supported using conventional analytical tools because the expected effects of climate change on the supply of and demand for ecosystem services can be predicted with enough certainty to support the calculation of the expected net benefits (costs) likely to result from different management alternatives. Moving into situations with less predictable outcomes due to climate change provides new challenges to appropriately estimating values and tradeoffs between policy options involving ecosystem services. Available science indicates there is uncertainty and ignorance concerning how climate change might alter an ecosystem, but raises the possibility of threshold events that would have catastrophic economic consequences if they should occur, and will be expensive to prevent. We illustrate practical approaches for addressing these situations with examples involving policy decisions for water resources in the Pacific Northwest and Southwest, including salmon and beaver restoration.

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Getting Demand Right for Valuing Urban Ecosystem Services in the Pacific Northwest

Mark Buckley and *Tom Souhlas*
ECONorthwest, Portland, OR

States and communities in the Pacific Northwest are implementing major programs to restore ecosystems in urban/suburban areas. Justification for these efforts and the tradeoffs they require focuses on informing decision-makers and the public about the value of the ecosystem services that will be protected or enhanced. While the quality of the supply of ecosystem services from small and imperfectly connected areas typical of urban areas does not often meet that of pristine remote systems, the demand for the urban services can be much greater. Therefore it is particularly important to fully and carefully characterize the demand for urban ecosystem services. The scarcity and direct accessibility of urban ecosystems increases the value of the services to public and private users, such as water utilities, commercial fishers, homeowners, and recreating residents. Consequently, while the total supply of ecosystem processes and functions from an urban site might be less than a more remote site, the value of the resulting services in urban areas per-area can be greater. The high level of demand can justify spending scarce funds on restoration and conservation in urban and suburban areas. Similarly, the opportunity costs of providing these services can be greater (than remote systems) due to the competing demands for urban lands and waters. Aligning existing and potential ecosystem services with demands on these services can identify urban areas that justify conservation and restoration. We present examples from the siting of urban parks and green corridors in Portland, Oregon, the protection of agricultural lands adjacent to peripheral urban centers on the Skagit River, and levee setbacks in one of Seattle's industrial districts. We find values comparable to required expenditures for acquisition and restoration when considering the full demand for urban ecosystem services.

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The Sustainable Sites Initiative: Quantifying the Sustainability of Designed Landscapes

Allegra Bukojemsky
The American Society of Landscape Architects' Sustainable Design and Development Professional Practice Network

As part of the workshop on Qualifying and Quantifying Ecosystem Services: Tools for the Planned and Designed Landscape, this section discusses the details of the Sustainable Sites Initiative, a new rating system developed to guide and measure the sustainability of designed landscapes.

Green building standards, such as the U.S. Green Building Council's LEED® rating system, are driving environmentally superior building design and construction through voluntary market-based incentives. Measurable benefits - environmental, economic, and quality of life - result when people have the necessary information and tools to guide their design decisions and when commitment to excellence is recognized. By extending this approach beyond buildings to the planned landscape, we can realize even greater gains.

Developed through the partnership of the American Society of Landscape Architects (ASLA), the Lady Bird Johnson Wildflower Center, and the US Botanic Garden, the Sustainable Sites Initiative (SITES™) is a first attempt to systematically apply the wealth of ecological knowledge to the design and management of anthropogenic systems. Launched in November 2009 and currently in Pilot Project phase, the rating system is based on the principles of ecosystem services. Specific credits were derived with the intent of protecting and restoring clean air and water, diverse microclimates, healthy ecosystems, and human health and well being. Credits ranging from stormwater management and hydrodynamics, soil health, air and water pollution reduction and abatement, and human wellbeing are designed to be applicable to a range of landscape based projects such as large campuses, public parks, conservation areas, recreation areas, and transportation and utility corridors.

This presentation will provide an overview of the certification system with a focus on ecosystem health, and the potential of market and industry transformation with this new tool. More information on the program can be found at www.sustainablesites.org.

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Strategies to Retain Nitrogen and Dissipate Heat in Baltimore, MD

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The urban ecosystem can be designed and managed to provide numerous ecosystem services. In metropolitan Baltimore, nitrogen retention and heat dissipation are two services that are particularly important for the biotic and human populations in the region. Nitrogen, specifically in the form of nitrate, is a critical water pollutant causing eutrophication that results in algal blooms and reduction of oxygen in the water column. This adversely affects aquatic organisms and compromises water quality. Therefore, it is critical that nitrogen be retained in the landscape, thereby preventing it from entering receiving waters. Excess heat in urban areas is a known risk factor for human populations. Cities are typically 3-5 degrees C warmer that surrounding rural areas due to heat generating processes that occur in the city and materials used in city structure that absorb heat and reradiate it back out to the atmosphere slowly. Consequently, urban areas are characterized as an urban heat island and mitigation strategies to reduce the risk of excess heat to biological and human populations are needed.

Ecological, physical and social processes that occur on land influence nutrient and pollutant input to streams. These inputs are often difficult to control through regulation because a significant proportion may not come from one identifiable source. The Baltimore Ecosystem Study (BES) Long Term Ecological Research program has focused on quantifying locations of nitrogen retention and release in the Gwynns Falls watershed. This watershed drains portions of Baltimore County and City and empties into the Chesapeake Bay. The Chesapeake is an important feature for ecological and social identity in the region, but it is a threatened water body. The US Environmental Protection Agency has declared it an impaired water and has mandated a 40% reduction in nitrogen loadings into the Bay. The riparian zone, which is the boundary between land and water, plays an important role in retaining nitrate. Ecological understanding of how riparian zones mediate landscape-stream interactions has developed from research in agricultural and forested systems. In these systems, the soils and vegetation in the riparian zone retain nitrate preventing its release into the adjacent stream. These processes may be altered, however, in urban landscapes. In fact, research by BES has found that riparian zones do not retain nitrate as expected. Therefore, traditional management strategies to increase the width of riparian zones may not be an effective way to prevent nitrate from entering streams in urban landscapes. Strategies that are more spatially distributed throughout the watershed may be needed.

Such a strategy is to increase tree canopy throughout the watershed, not just in the riparian zones, in an effort to increase nitrogen uptake by plants and reduce water draining the terrestrial system. Baltimore City has responded to these results by passing an administrative policy to double the City's tree canopy by 2036. This strategy, guided by a desire to increase the capacity of the system to retain nitrogen, may provide additional ecosystem services to urban residents. Increasing tree canopy should facilitate the dissipation of heat and reduce heat stress experienced by biotic and human populations.

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Legal Framework: Ecosystem Service Valuation in the United States and Incorporation into the EU ELD

Thomas Campbell, Esq.
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Mr. Campbell will discuss the legal framework in which ecosystem services are currently being used in the United States and are now being integrated into European Law. Within the United States, these applications began within the natural resource damage assessment arena and expanded to uses in evaluating remedial alternatives (e.g., net environmental benefit analyses, NEBA). Within the EU, these applications are expanding to also include environmental damage assessments and net environmental benefit analyses, etc. The use of methods to quantify ecosystem services such as habitat equivalency analysis (HEA), resource equivalency analysis (REA) and human use service valuation have thus expanded from the U.S. regulatory applications within the United States and are similarly being incorporated into the European Liabilities Directive (ELD). The overall similarities between the use of ecosystem services within the U.S. and ELD frameworks will allow the European countries to benefit from the development and use of the ecosystem service valuation methods developed and used in the U.S. This information will provide the foundation to discuss specific applications in European countries such as Italy and Denmark.

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Modeling Ecosystem Services with Bayesian Networks

John F. Carriger*, Susan H. Yee, Leah Oliver* and *William S. Fisher*
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Incorporating ecosystem services into the decision process requires an approach that links alternative decisions and the pressures they create to changes in ecosystem condition, function, and the provision of ecosystem services. This complex task requires integration of expert opinion, stakeholder concerns, data, and models, as well as a rigorous approach for handling uncertainty and incomplete information. To maximize relevancy to decision-makers, approaches must have the ability to quantify the tradeoffs between the services humans derive from ecosystems and the socio-economic costs associated with protecting them.

Bayesian networks (BNs) offer opportunities for decision support and knowledge representation of ecosystem services. Bayesian networks reflect cause and effect relationships among variables and can incorporate a variety of data from expert opinion to model output. The qualitative (conditional independence) and quantitative (probabilistic) aspects of BNs are understandable to both scientific experts and stakeholders alike. The ability of BNs to communicate and integrate knowledge on ecosystem services makes them particularly advantageous for environmental management problems.

We present a case study for U.S. Virgin Islands coral reefs, assessing the impacts of anthropogenic stressors on reef condition and the provisioning of ecosystem services. A key issue is the ability of the BN to assess the levels of stressors (e.g. coastal development) and indicators (e.g. richness, coral cover, fish biomass) needed to achieve desired levels of ecosystem services (e.g. habitat, tourism, fishing) and the data gaps in knowledge and understanding of these relationships. Probabilistic relationships for the Virgin Islands BN were developed from field survey data, landcover data, and literature reviews.

Bayesian networks offer an integrated modeling process to manage and communicate risks to ecosystem services. The probabilistic framework allows uncertainty in outcomes to be quantified, and can be used to prioritize high impact decisions or attributes to monitor when assessing ecosystem condition. By linking the ecosystem with socio-economic concerns, BNs can effectively be used to evaluate alternative decisions, and their consequences for provision of ecosystem services.

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The Guide to Corporate Ecosystem Valuation & Lafarge's Ecosystem Valuation Initiative

David Carroll
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The goal of the World Business Council for Sustainable Development's Ecosystem Valuation Initiative is to strengthen the business license to operate, innovate, and grow by using ecosystem valuation to manage risks and opportunities related to ecosystem change. A new publication entitled *The Guide to Corporate Ecosystem Valuation* (to be released October 2010) helps managers apply ecosystem valuation tools and methods to inform business decisions.

Lafarge piloted the *Guide to Corporate Ecosystem Valuation* during its development. The team focused their valuation initiative at the 5,000-acre Presque Isle Quarry, located on the western shore of Lake Huron in Michigan. Lafarge has made a commitment to establish biodiversity management plans at quarry sites, annually monitor the sites, and report the status of implementation in Lafarge's Sustainability Report. In order to become better stewards of the environment, Lafarge is working to adapt ecosystem services modeling tools to suit business purposes and enhance biodiversity.

This project assesses various ecosystem services tools on their usefulness in improving biodiversity management and land use planning by Lafarge and other corporate landholders. Tools tested by Lafarge include the Corporate Ecosystem Services Review, InVEST, and the Wildlife Habitat Benefits Estimation Toolkit. Ecosystem services assessed at the quarry site include freshwater requirements, erosion requirements, and recreation, ecotourism, and education.

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Managing for Resilience in the Coastal Zone – Biodiversity, Ecosystem Services, and Climate Change

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Marine ecosystem based management seeks to manage human actions to maintain resilient ecosystems with the capacity to sustainably provide the ecosystem goods and services that people depend on. Our economic well-being and quality of life are highly dependent on marine biodiversity and ecosystem services – benefits we receive from coastal ecosystems in the form of food (fish and shellfish), storm protection, climate regulation, wind and wave renewable energy, recreation, and aesthetic and spiritual inspiration. Maintaining resilience is a challenge – coastal and marine ecosystems are under increasing pressure from multiple threats including overharvest of fisheries, pollution/nutrient enrichment, habitat conversion, and biodiversity loss. Climate change also affects ecosystem function and impacts ecosystem services in coastal zones, adding to the on-going loss and/or degradation in these services globally. The strategies we use to adapt to climate change may influence our ability to maintain coastal ecosystem services into the future – alternative strategies for adaptation can either negatively or positively affect the provision of ecosystem services.

To evaluate alternative strategies for climate adaptation and marine ecosystem based management, we need better tools for evaluating marine ecosystem services We provide a conceptual framework for understanding relationships among biodiversity, climate change, climate change adaptation, ecosystem function, and ecosystem services in coastal and marine systems. We first discuss a conceptual model of biodiversity and ecosystem function used to develop indicators of ecosystem services at ecosystem-wide (Puget Sound) and local (drift cell) scales. We then present the results of a review of effects of climate adaptation strategies on ecosystem services and how coastal ecosystem services are being considered (or not) in climate change adaptation around the world. Then using regional data on shoreline conditions in Puget Sound, we present a decision support tool and model for applying ecosystem services in project-specific and longer-range planning for climate change adaptation and ecosystem resilience in coastal zones of the Pacific Northwest.

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Integrated Modeling Framework for Forecasting Ecosystem Services

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The Lower Mississippi Valley (LMV) has experienced extensive loss and conversion of forests and wetlands in the past and there are now large-scale conservation efforts targeting the restoration and enhancement of ecosystem structure, functions, and services. These efforts need both patch- and landscape-level management, assessment, and monitoring. Landscape-scale decision-support tools are necessary to assess both direct and ancillary effects of conservation practices on ecosystem services and to simultaneously evaluate the impacts of future management actions while considering potential changes in land use and climate.

We have developed a frame-based ecosystem services modeling platform to explore the relationships between site and landscape variables and specific ecosystem services, such as wildlife habitat (bird species richness, duck energy days, amphibian occupancy rates), climate regulation (carbon sequestration), and water quality (potential nitrate retention, soil erosion potential). The framework allows the integration of several modeling components and displays the dynamic outputs for each of these models simultaneously. The platform provides data flow for individual models, the execution of external models, real-time running of internally implemented models, data transfer between co-dependent models, and a visualization component for the landscape maps, graphics, and text outputs.

The user designates a spatially explicit study area (e.g., a county, basin, or a landscape around a restored area of interest) that the model then represents as a raster land-use, land-cover (LULC) map (at various grid cell sizes). This initial base map then changes with each time-step according to LULC change scenarios, which can be user-defined, outputs from a land-use change model, or a set of economic or policy transition rules. In the LMV, we are using the model to explore the effects of changes in LULC and climate in areas comprised mainly of agriculture, restored riparian forest (mostly Wetland Reserve Program patches), water features, and mature bottomland hardwood forest. The creation of new restored forest patches, or the transition back to agriculture, creates a dynamic landscape which affects the estimates of ecosystem services based on the size, age, condition, and configuration of LULC patches, and on the total number of specific cells.

We are currently using Forest Vegetation Simulator (FVS) to model forest growth and development on the restored forest and natural forest cells and to estimate carbon stocks. Hierarchical Bayesian statistical models are the basis for quantifying bird species occupancy and richness, and frog species occupancy components. Habitat suitability models will be used to model the potential habitat for specific bird species depending on structural variables at the patch scale and landscape metrics. Impacts on ecosystem services sensitive to hydrologic changes are being modeled with PRMS and SWAT.

We will present an example of the model application for estimating impacts of LULC change on ecosystem services metrics for the Tensas and Yazoo basins in the LMV.

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Can Local Ecosystem Services Valuation Studies be Upscaled for Use in Global Assessments?

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In recent years, there have been several attempts to estimate the economic value of ecosystem services derived from global biodiversity (Costanza et al, 1997; TEEB, 2008, 2010 forthcoming). Generally, these global assessments aggregate / upscale local valuation studies. However, local studies tend to: utilise a wide variety of valuation approaches; address different ranges of ecosystem services; and be of varying quality. Arguably, this variation makes it difficult to extract synthesis conclusions to feed into global assessments. This paper examines the likely robustness of global assessments that upscale local studies. Our discussions are based on the results of two biodiversity / ecosystem services valuation studies.

The first study aimed to explore the robustness of ecosystem service value transfers within a consistent case study: a choice experiment that assessed the value of ecosystem services associated with the UK Biodiversity Action Plan. The study was administered across 12 UK regions using an identical survey instrument. A series of value transfer tests were undertaken across the regions. The results demonstrate that even when controlling for observable differences between the study and policy sites, large variations in transfer errors were found. Given this finding, it is likely that even larger variations in transfer errors will be found in Global assessments, particularly given the likely differences between study and policy sites. On a more positive note, the research also found that making use of more information by pooling data across several study sites generally (but not always) reduced transfer errors.

The second study evaluates the potential of monetary valuation techniques to value biodiversity and ecosystem services in developing countries. The research hypothesis here is that most valuation methods have been developed for use in a developed country setting, and thus these approaches may not be directly applicable in developing countries. The evidence collected in this review supports this hypothesis. The review also highlights the fact that currently there are only a limited number of studies that have set out to value biodiversity / ecosystem services in developing countries. The implication of these observation for global assessments is that (i) there is currently a lack of developing country data to input into global assessments and (ii) given the differences in the way that valuation should be applied between developed and developing countries, it is unlikely data from developed countries can be readily transferred to developing countries to fill this data gap.

The paper then concludes by making a number of recommendations on how local studies might be improved to allow them to be more robustly inputted into global assessments.

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Lessons from Case Studies of Collaborative Watershed Management

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We conducted a study of policy instruments used in land use planning for the provision of water-related ecosystem services. In particular we focused on the mismatch of watershed and jurisdictional boundaries, which can lead to management conflicts and inequities in the costs and benefits of watershed protection. Policymakers across the country have designed various forms of collaborative watershed management to respond to this challenge, with mixed results. This study seeks to identify the factors that contribute to the successful integration of watershed science into the development planning process. We synthesized general insights about the efficacy of collaborative watershed management arrangements for four case studies: the New Jersey Pinelands (NJ), Upper San Pedro Partnership (AZ), Willamette Ecosystem Marketplace (OR), and the Ohio Balanced Growth Program (OH). For each case, we consider the origin of the arrangements, financial and regulatory enabling conditions, policy instruments for co-management, and the success of the projects as a management process and in terms of environmental outcomes. The synthesis aims to assist stakeholders by broaching the questions that might naturally arise in attempts to implement similar policy measures, and highlighting elements of each case that could be exported to other regions. Overall, the synthesis provides a summary of the state-of-the-art in collaborative watershed management. We found that a variety of policy instruments are utilized to navigate the mismatch between watershed boundaries and political jurisdictions. The collaborative efforts range from providing information to decision makers, to the establishment of mandatory zoning requirements. Most cases have some sort of enabling legislation and multiple funding sources. They also implement a variety of innovative financing mechanisms, including markets for ecosystem services, tradable development rights, and prioritization of funding based on conservation goals. All of the cases involve planning; however, the timing and level of stakeholder involvement in the process vary. The major barriers cited were slow implementation of the planning process and lack of enforcement authority. While it is difficult to assess what the planning and environmental outcomes might have been in absence of the collaborative effort, it appears that these efforts have led to greater awareness and integration of watershed science into development planning.

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Measuring the Economic Impact of Invasive Species on Ecosystem Services

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Invasive species can affect all categories of ecosystem services as defined by the Millennium Ecosystem Assessment including provisioning services, regulating services, cultural services, and supporting services. Economic research on invasive species can help to quantify these impacts in monetary terms. Accurate information on the economic value of damage caused by invasive species is important for benefit-cost analysis of different management options and for prioritizing projects competing for limited funding.

Economic valuation derives estimates for a range of invasive species damages that can be categorized as direct use values (including consumptive and non-consumptive values), indirect use values, and non-use values. Direct uses are related to human uses of natural resources, indirect uses support human uses or the resources being used, and non-use values are related to the existence of the resource and not on any service that it provides. Direct use values affected by invasive species include consumptive uses such as agriculture, water supply, and electric generation as well as non-consumptive uses such as recreation. Consumptive use values are often derived from market data, while non-consumptive use values are usually obtained from non-market valuation methods. Examples of indirect use values that can be lost due to invasive species damage could include increased water usage, increased wildfire risk, and reduction in greenhouse gas mitigation. Individuals place non-use values on natural resources or ecosystems based on their existence regardless of whether they will use the resource directly or indirectly.

This talk provides an overview of economic valuation of lost ecosystem services caused by invasive species. Economic valuation techniques and applications from the literature are discussed, followed by an assessment of gaps in the literature and areas for further research.

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Integrating Existing Networks to Detect Future Shifts in Ecosystem Structure and Function Due to Global Changes

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Terrestrial and aquatic ecosystems supply goods and services of vital importance to humanity. These can be categorized as provisional (e.g., food, fiber, fresh water, biodiversity), regulating (e.g., air quality, water quality, climate feedbacks, biogeochemical cycling, erosion), and cultural (e.g., aesthetic, education, recreation, spiritual) services. Human activities, including anthropogenic climate change, are affecting the structure, function, productivity, and resilience of ecosystems in ways that challenge their ability to provide ecosystem goods and services. The ecosystems research element of the US Global Change Research Program (USGCRP) seeks to better understand the relationships between long-term sustainability of ecosystem function and global changes (e.g., land use change and climate change).

A fundamental understanding of the structure and function of ecosystems and the potential for global change to affect these begins with characterizing the present state of ecosystems and developing or adopting key indicators that allow early detection of future changes that signal approaching ecological thresholds. Such indicators may also allow us to model potential future trajectories of ecosystems to test system sensitivities and management adaptations. In order to quantify the effects of changing climate on ecosystems, we need to re-examine ecological observing and monitoring systems for their ability to capture climate change-induced responses, identify gaps in capabilities, and coordinate these systems with climate observations. As a first step toward this coordination and integration, the Ecosystems Interagency Working Group is holding a series of workshops to inventory existing monitoring and observation networks and to develop a plan to integrate and augment these networks, where needed.

This poster reports on the first of those workshops, convened in November 2010, and describes plans for further workshops and products. In this first workshop, participants will:

1. Examine the goals and infrastructure of existing monitoring and observation networks in order to identify redundancies and gaps;

2. Articulate broader, cross-agency goals for an integrated climate change monitoring network;

3. Suggest approaches for prioritizing endpoints to monitor and elements to consider, such as geographic extent, density, placement of sites, spatial and temporal scales necessary for change detection, etc.; and

4. Suggest approaches for integrating and augmenting existing monitoring and observing networks to better detect global change effects.

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Making a Multi-Credit Ecosystem Market Work for Oregon

Bobby Cochran
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The Counting on the Environment project was launched in 2007 to document a model for stakeholder decisionmaking through a consensus based process. The project has worked through outreach and convening, market design, and now market operation. This continues to include building trust among diverse stakeholders, defining methods for assessing the functions of local ecosystems, and designating trading areas for new kinds of ecosystem credits. A presentation on stakeholder agreement for the multi-credit market now operating in Oregon will be the foundation for participants to discuss their own successes and challenges with market development. The objective of discussion on consensus-based stakeholder processes is to advance decision making tools such as Counting on the Environment that help communities and stakeholders overcome barriers to functioning, credible and transparent local ecosystem service markets.

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Measuring Ecosystem Services – Transitioning to an Efficient and Integrated Approach

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The Willamette Partnership has been working to develop a multi-credit market for ecosystem services for about five years. The Partnership began this process by focusing on water quality trading in Oregon's Willamette Basin, but soon discovered that it is not cost-effective to develop market infrastructure and protocols to serve such a limited geographic region, and has since expanded to serve emerging market-based programs throughout the Northwest, and coordinates closely with practitioners around the country. For example, the Partnership and Bay Bank on the East Coast jointly developed an ecosystem crediting platform to support similar but locally specific ecosystem markets.

The Natural Resources Conservation Service awarded a grant to the Partnership for a project called Counting on the Environment. This project involved facilitating tentative agreement from 25 public and private stakeholders to use consistent methodology to measure for ecological values: wetlands, water temperature, salmon, and upland prairie. The first three are arguably compliance markets (driven by obligations under the federal Clean Water Act and Endangered Species Act). Upland prairie is habitat to the endangered Fender's Blue Butterfly, but is otherwise unprotected by regulations and will depend largely on voluntary conservation investments. This process represents substantial progress, but is structured along existing siloed government programs. Continuing along this fragmented path will likely be more expensive, confusing, and time-consuming for buyers and sellers of multiple services than an integrated streamlined approach and could inhibit expansion of outcome-based incentive and market-based programs.

Oregon's 2009 legislation directed a work group to consider how an integrated approach to the measurement of ecosystem services might be accomplished. The work group drafted critera for such a system, then assessed several different tools to determine which ones might be appropriate. Although none of the systems met all criteria, the Partnership's approach received the highest scores.

The criteria follow: Multi-scaled, and applicable to landscape scale and site level assessments; address landscape context; applicable to all land and water types; quantifies ecosystem services individually and holistically; easily applied with low transaction costs; uses best available ecological information; compatible with existing methodologies where appropriate; transparent; repeatable; informs monitoring of cumulative effects; and posted in the public domain for use by anyone. Coordinated investment by the public and private sectors could support the development of such a system, and ultimately be much more cost effective than the current duplicative and poorly coordinated system.

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The Applications of Spatial Information Systems in Ecosystem Restoration: The Case of the Colorado Rocky Mountain Arsenal

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The vast network of abandoned contaminated sites scattered across the United States during the Cold War era continues to be a national concern today for federal government agencies charged with the task of initiating the ecological restoration of these hazardous sites to their pre-land use form. One of the largest contaminated sites from the Cold War era, the Rocky Mountain Arsenal, a 17,000 acre U.S. Army facility in Adams County, Colorado was established in 1942 to manufacture chemical weapons at the height of World War II. During that period also, private corporations leased facilities at the Arsenal to manufacture pesticides. Before the government acquired the land through eminent domain, the Arsenal was originally prairie and farmland, located only 10 miles northeast of downtown Denver. Decades of chemical weapons and pesticide manufacturing at the Arsenal has caused extensive contamination and ecosystem damage to areas on-site and beyond its boundary. No longer operational, the Arsenal was placed on the National Priorities List by the Environmental Protection Agency (EPA) in 1987 to clean up the contaminated soils, structures, and groundwater. Coincidentally, officials discovered that the arsenal also provided habitat for the bald eagle and more than 300 species of birds, mammals, reptiles, and fish and other wildlife in its surrounding buffer and encouraged conservation. Accordingly, Congress passed a bill in 1992 that will change the Rocky Mountain Arsenal to a national wildlife habitat upon completion of the cleanup and restoration. Notwithstanding these efforts, no serious attempt has been made to apply spatial information systems in the on-going ecosystem recovery efforts in the area.

In light of that, this paper presents a case study that applies mix scale methods of geospatial analysis involving historical aerial photographs connected to GIS, and statistical analysis of regression to analyze the ecosystem trends and restoration in the study area between the time period of 1942 and 2007. Emphasis is placed on those factors responsible for the problems, ecological change analysis of several environmental variables and mapping of the land use trends, mitigation efforts and the viability of the study area as a potential national wildlife refuge and future lines of action. This approach not only allows for a better understanding of how land-use change analysis helps track negative impacts, but it also offers a road map for proper management of the surrounding ecology of the Rocky Mountain Arsenal and Denver metropolitan areas. The expectation is that the study would provide managers of various agencies with support tools to make more informed and ecologically sound decisions with clearly defined restoration goals in the reuse of contaminated public lands.

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Regional Changes in Water Quality Associated with Switchgrass Feedstock

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The establishment of bioenergy crops will affect ecological processes and their interactions and thus have an influence on ecosystem services provided by the lands on which these crops are grown. The regional-scale effects of bioenergy choices on ecosystem services need special attention because they often have been neglected yet can affect the ecological, social and economic aspects of sustainability. A regional-scale perspective provides the opportunity to make more informed choices about crop selection and management, particularly with regard to water quality and quantity issues, and also about other aspects of ecological, social, and economic sustainability. We give special attention to cellulosic feedstocks because of the opportunities they provide. Within this regional framework of scientific inquiry, improving prediction and management requiring addressing four pressing research needs: (1) understanding data and knowledge requirements, (2) quantifying effects of biofuel production on the many aspects of sustainability, (3) improving bioenergy feedstock management at a regional scale, and (4) developing and applying landscape perspectives at regional scales in order to develop an understanding of relationships among diverse processes. It is only with the full system perspective at appropriate scales for considering effects and decision making that sustainability of the bioenergy system can be addressed.

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The Potential for Private Capital Funds to Serve Conservation and Restoration Public Policy Goals

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While mitigation banking under section 404 of the Clean Water Act and conservation banking under sections 7 and 10 of the Endangered Species Act have existed for decades, organized private capital has more recently begun to invest in conservation and restoration projects at a larger scale. Private and institutional investment in projects that develop government sanctioned 'credits' that can be used to meet regulatory requirements is no longer limited to these CWA and ESA programs either. Credits have now been sold to meet legal obligations under Natural Resource Damage Assessment provisions of CERCLA, Total Maximum Daily Load obligations under the CWA, and a host of state regulations addressing issues ranging from urban sprawl to climate change.

This presentation will address the questions: "What are investors looking for in an 'ecosystem services' related fund or project?" "How can policy goals be served through private investment?" and "What are the responsibilities and obligations of regulatory agencies if environmental markets are going to be able to live up to their potential?"

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Advancing Markets for Ecosystem Services: A Corporate Perspective

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New corporate tools for ecosystem assessment and valuation such as *The Corporate Ecosystem Services Review* and *The Guide to Corporate Ecosystem Valuation* often uncover new market opportunities for companies. Markets for ecosystem services can offer companies cost-effective opportunities for regulatory compliance, new revenue streams for landowners, and incentives for motivating sustainability best practices in a corporate supply chain.

Some companies are taking leading roles as market developers to generate needed ecosystem service credits on their own, while others have benefited by selling credits. This presentation will describe several strategies companies can use to benefit from markets for ecosystem services, and will provide insights about future market developments.

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Linking Riparian Width to Ecosystem Services on a Coastal River in Texas, USA

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Riparian corridors are essential ecotones that provide a connection between terrestrial and aquatic ecosystems. They are long, linear mosaics comprised of complex environmental factors, ecological processes and plant communities adjacent to lotic and lentic systems. Ecosystem services are the direct and indirect benefits provided by functioning natural ecosystems to the human population. The goods and services provided by these ecosystems are important for the health and survival of humanity and yet threats to these indispensable ecosystems are rising. The purpose of this study is to increase awareness of the importance of riparian ecotones by highlighting their functions and corresponding goods and services along the Mission River located in the semi-arid climate of the South Texas Coastal Bend. Development of required data for applying ecosystem services to these habitats and raising general awareness enables state agencies, watershed groups, and stakeholders to implement more informed decisions on land management practices. The overall objectives of the study are to 1. Define the riparian zone for a semi-arid, coastal environment; 2. Apply ecosystem service practices to the large riparian corridor habitat and the microhabitats provided by varying geomorphology within that riparian corridor; 3. Use Geographic Information Systems to develop site specific riparian maps utilizing remote sensing, location data (Land Use/Land Cover, effluent sites, etc.), and field established assessment sheets. The linear configuration of riparian systems provides an easily derived measurement that can be related to their function and therefore the produced goods and services. Buffer widths have been linked to the four categorical functions that comprise ecosystem services; regulation, habitat, production, and information. Depending on the ecosystem function, recommended riparian widths have been defined. Using GIS, the Mission River riparian corridor widths were measured and linked to various ecosystem services. More specific services can be linked to community vegetation characteristics (i.e. native vs. invasive species, evergreen vs. deciduous, proportion of vegetation classes, etc.). For example, on the Fennessey Ranch in Refugio County, Texas, potential riparian widths range from 0 m located on elevations higher than 7 m to 1,255 meters located on elevations less than 5 m. Areas where riparian widths were less than 3 m did not meet the criteria for any of the four designated ecosystem service functions. Using riparian characterization data, areas performing multiple ecosystem service functions were spatially defined along the riparian corridor. These maps will be useful in land management and serve as an ecologically-derived database where ecosystem service valuation can be added.

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Integrating Ecosystem Services into a Management Framework for Public Lands

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The concept of *ecosystem services* has emerged as a way of framing and describing the comprehensive set of benefits that people receive from landscapes. These include commodities like timber and fresh water, as well as processes like climate regulation, soil production, preservation of genetic diversity and esthetic, spiritual and cultural assets. The USDA Forest Service has been exploring use of the framework of ecosystem services as a way to describe forest values provided by federal lands and to attract and build partnerships with other government entities and non-government organizations to implement needed projects. More recently, the Agency has sought placed-based example applications of the ecosystem services framework to national forest management to better illustrate the concept for policymakers, managers, and potential national forest partners. To demonstrate this framework, the Deschutes National Forest and the Forest Service's Pacific Northwest Research Station are collaborating to explore how an ecosystem services approach can enhance forest stewardship in central Oregon. This includes (1) describing the ecosystem services provided by the forest; (2) examining the potential tradeoffs among services associated with proposed management activities; (3) assessing the relationship between supply and demand for services and strategies for sustaining ecosystem services over time; and (4) attracting and building partnerships with stakeholders who benefit from particular services the forest provides.

We synthesize the first phase of this effort, which includes: (1) defining ecosystem services from a management perspective; (2) describing how management actions support the provision of those services; (3) compiling existing forest-level data that can be used to illustrate some of these services; (4) identifying partners with potential to plan, fund, or implement projects to enhance ecosystem services; and (5) suggestions for future research. We also provide an overview of new efforts to incorporate social sciences research into this framework, the decision making process of forest management, and an integrated ecosystem services model that includes carbon, water and other key services into a draft optimization modeling framework.

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Using Hydrologic Landscapes to Predict Nitrogen Removal in Wetlands

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Available geographic data relevant to wetland formation, shallow subsurface hydrology, and nitrogen transport were used to delineate Hydrologic-Landscape Regions (HLRs) within the Coastal Plain in the Mid-Atlantic Region (MIAR) as part of the Conservation Effects Assessment Project (CEAP) of the USDA. The HLRs are intended to provide a foundation for understanding spatial variability in nitrogen transport and transformation and the resulting variability in the effectiveness of wetlands at mitigating nitrogen transport from agricultural areas to streams. This, combined with land-use information, will improve understanding of potential nitrogen removal by wetland ecosystems located in different natural settings common to the MIAR.

Groundwater provides more than half of the water (as base flow) and most of the nitrate that enters streams in the MIAR Coastal Plain. The local groundwater-flow system, therefore, is particularly important to the natural function of wetland ecosystems and to locating wetland restoration to reduce nitrogen transport. Wetlands may intercept nitrogen in areas where groundwater recharges, such as through poorly drained soils in fields (prior-converted cropland or restored wetlands); where groundwater discharges, such as in riparian zones; or where surface water moves through wetlands. The relative importance of these functions depends on the distribution of wetlands in the landscape and the local hydrologic and geochemical conditions that determine potential for nitrogen removal.

HLRs were developed using an approach previously applied in other settings, including at a coarser scale for the conterminous United States. Fundamental landscape units were delineated in two ways, including uniform grid cells and individual watersheds delineated from available hydrography (NHDPlus). Available geographic data were used to define for each fundamental unit metrics specifically relevant to shallow hydrology and wetland function in a coastal plain setting, including land-surface form, the permeability and geochemical conditions in soil and aquifer sediments, and climate characteristics. Principal components analysis and cluster analysis were then used to group the fundamental landscape units into common HLRs, which were interpreted with respect to the distribution and types of wetlands likely to occur within each cluster and the resulting expected effectiveness of wetlands at nitrogen mitigation.

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The Business Relevance – Moving Beyond the Concept to the How, What, and Why

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The concept of ecosystem services has expanded the ways that companies think about environmental performance in many facets from product development and capital projects to operational resource needs. The concept is understandable but applying it, particularly at a practitioner level, is challenging.

From a global perspective, DuPont has identified mega trends of unprecedented growth in developing countries, the need for increased food production, a drive for renewable energy and materials, and a demand for greater safety and security. Couple these with increasing scarcity of natural resources and disasters, and the demand for greater transparency from businesses underscores the inter-linkages of human well being, economic development, and the environment. It is the intersection of these inter-linkages that sheds the light on ecosystem services.

These global trends present both potential downsides if a resource is scarce or degraded (ex. water constraints) and opportunities if a service is provided or enhanced (ex. products that require less consumer water usage). But simply the pace of population growth and scale of economic activity to sustain and create opportunities means increasing scarcity of resources that may be less easy and more costly to secure. There is a need to go beyond traditional environmental footprint reductions to also capture sustainable and environmentally improved products that have less reliance on water, land, and depletable resources to meet the global environmental challenges.

This presentation will provide an overview of the challenges and opportunities of determining if, how, what, and why to incorporate into decision making processes and environmental performance.

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Accounting for Migration in Ecosystem Services Assessment

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Many authors have described corridors or stopover sites that are "critical" to the survival of migratory species, suggesting that these areas are disproportionately important to migratory populations and thus have high value. Although much current research is devoted to identifying and quantifying the importance of these areas in terms of species biology, a conceptual framework for assigning them value within an ecosystem services context has not been established. Owing to the transient nature of migratory species, discrepancies can exist between the areas that most support a species' population viability – and hence their long-term ability to provide services – and those areas that benefit most as a result of services provided by the species. In effect, some areas can be subsidizing or subsidized by others. The net value of goods and services provided by migratory species can therefore only be quantified at any one location by considering the dynamics of services they provide and environmental support they receive throughout their ranges.

We present a simple model that distinguishes the value of ecosystem services an area supports from that which it receives, permitting estimation of the net value of an area resulting from migratory species. We also describe a method for estimating the net payment, or subsidy, owed by or to a location that balances benefits received and support provided by locations throughout the migratory range of one or more species. Using examples of economically important migratory species we will demonstrate our method and quantify the interdependence of geographically distant ecosystems. It is anticipated that this approach can serve as a foundation for the establishment of markets that would facilitate cross-jurisdictional cooperative management and conservation of migratory species. It can also provide a mechanism for resolving natural resource conflicts over the sustainable and equitable allocation of exploited migratory species. The information requirements to fully realize the potential of this approach are substantial; new data, data-integration, and assessment methods are necessary. We argue, however, that the utility of ecosystem services as a framework for environmental management and conservation is limited without the capacity to explicitly account for the spatial dynamics of migration and ecosystem services provided by migratory species.

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Designing a Pro-Poor Payment for Ecosystem Services Program in Western Panama

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Human society depends on healthy ecosystems. Payments for ecosystem services (PES) have emerged as an incentive-based tool to protect and restore ecosystem-service flows, which are being degraded at regional and global scales. Through PES, users of ecosystem services pay landowners who supply these services through land management. This study focuses on PES programs as a possible means to achieve ecosystem-service conservation on private lands, which are playing an increasingly important role in conservation efforts. Specifically, this study examines potential for PES program development to address conservation and livelihood issues in the buffer zone of the La Amistad Bi-national World Heritage Site in Western Panama. Although Panama does not currently have a national or regional PES program, there is widely recognized potential for program development.

This study reports results from a survey of 344 farmers and ranchers about their interest in participating in a potential future PES program. While respondents reported a lack of familiarity with the PES concept, after being provided with an explanation, many expressed interest in participating; interest was greatest for scenarios related to agroforestry and forest conservation. Using logistic regression analyses we found that farm size, participation in other conservation programs, the number of conservation organizations with which the farmer has worked, and total income were all significant predictive factors of willingness to participate for at least one of three program scenarios with a positive relationship. Land tenure security and age were significant explanatory factors with a negative relationship for one or more scenario. Several of these factors are related to a household's socioeconomic status.

The second part of this study investigated how PES program design factors would affect the potential eligibility of low-income households, an increasingly important target of PES programs, particularly in developing countries. Using eligibility requirements based off of Costa Rica's national program, and also generally in-line with programs elsewhere, we found that respondents who ranked lower on our constructed socioeconomic scale were less likely to be eligible to enroll in a Panamanian PES program despite that many are willing to participate.

PES land enrollment requirements, tenure, and land characteristics (e.g. slope) result in participation trade-offs. For example, higher land enrollment requirements result in a rapid decline in potential participants. This research contributes to a key piece of the PES design puzzle: how to proactively explore ways to ensure that landowners across the socioeconomic spectrum (particularly the poor) are able to participate. Understanding trade-offs is important for guiding PES program design to achieve rural development and poverty alleviation goals in tandem with conservation.

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Policy and Practice – Emerging Lessons on Payments for Ecosystem Services

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Ecosystem services – the subject of considerable study by economists and ecologists for the past three decades – have arrived with considerable fanfare in the conservation and land management arenas during the past 5-10 years. Regardless of how they are defined or their outputs measured or their credits paid for, their newly emerging role represents a full-fledged, multifaceted *challenge* to our thinking about how to manage our natural resources. How can we best integrate the multiple facets into dynamic solutions that give landowners, governments, and businesses *choices*, and simultaneously produce positive ecological and economic results on the ground?

Numerous interested parties each approach that question from their own perspectives: mitigation, endangered species, habitat metrics, quantitative tools, credit markets, Farm Bill programs, rural sustainability, ecological function, macroeconomic trends, emerging policy issues, and more. The broad-based concept of payments for ecosystem services must encompass all these issues, and the noise of early development should not divert us from the need to think innovatively while not reinventing wheels.

Lessons learned at the site level are still developing around the country as diverse practitioners put into place innovative ecosystem services-based projects. The social issues emerging from the focus on ecosystem services, however, are already coming clear. First, the spectrum of types of payments for ecosystem services must remain broad: it is critical to provide choices to all actors – landowners, government agencies, and businesses – involved in ecosystem services-related activities. Second, those choices are all potentially nested within the natural resource management and conservation opportunities provided by a restoration economy. More specifically, the social acceptability of ecosystem services is tied up with selling the economic basis of changed approaches. Third, there continues to be an important and substantial role for non-market solutions such as those offered by the Farm Bill and grant-making by local/regional intermediaries, and fourth, we should not underestimate the importance of both landscape- and site-level data analysis to guiding future policy directions. The conclusions will include a number of questions that can form the basis of both immediate action items and a longer-term research agenda.

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Public Utilities and Payments for Ecosystem Services: New Connective Tissue?

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Across the country landowners with acreages of all sizes are becoming interested in the economic and ecological potential of programs that provide payments for ecosystem services. To date however, opportunities for restoring and enhancing ecosystem service functions across agricultural and forested resource lands far outnumber the actual projects undertaken by landowners, with projects and programs typically fragmented across the landscape. The multiple barriers to optimal landowner participation in these programs include high transaction and opportunity costs (particularly the preparation time and paperwork required), lack of acceptable metrics for ecological improvement, financial risks, lack of technical and financial knowledge, and low buy-in. Such concerns demonstrably reduce participation in incentive programs, constrain economic and ecological benefits on the ground, and thus hamper overall program success. This context undermines the potential for strengthening local economies around restoration-driven income sources. In addition, current policies do not support the sort of organizational and landowner cooperation—at the landscape level rather than the current project-by-project approach—that could provide greater opportunities and economic and ecological payoffs.

However, experience to date suggests that the promise of diversifying income sources through ecosystem service payments still has much to deliver, and could be improved through strategic and integrated design, implementation, and management of restoration and conservation projects across the landscape. In particular, public utilities could play a pivotal “connective tissue” role. With their existing customer bases and the ongoing need to protect source waters and improve energy conservation measures, they have both their own and customers’ motivations to reduce ecological footprints as drivers of change, and they “cover the map” in a way no other institutions do. Innovative approaches designed to assist public utilities in their service provision as well as their outreach can help examine watershed-scale opportunities for coordination of ecosystem service delivery, monitoring and feedback to strengthen landowner opportunities.

To explore the reach of public utilities, we will review a number of ground-breaking projects developed by the Eugene Water and Electric Board in Oregon’s McKenzie River Valley that implement the ecosystem service concept and could lead to longer term institutional changes. For example, an Ecosystem Service District administrative framework could adopt the utility’s service boundaries and potentially address a broader range of services. The potential role of federal agencies in supporting these local innovations will be discussed.

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The Economic Effects of Biofuel Feedstock Production on Gamefish Distribution

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Increased ethanol production from biofuel crops has elicited concerns from the inland fishing community because of the intensification and expansion of corn production on cropland. This suggests that bioenergy mandates may influence utility generated from water quality and related fishing opportunities. We present a travel-cost method 1) to estimate recreational use values for watersheds in the Arkansas-White-Red River basin and 2) to generate a welfare-relevant measure of ecological quality using fish species richness forecasts based on changes in water quality. Assuming the challenges facing valuation of large spatial extents using second-best surveyed estimates, the authors take an approach that estimates resource use as a function of population and fishing privilege patterns within proximity to watersheds. We used the Agricultural Policy Analysis Model (POLYSYS) to forecast future changes in land use, including starch and cellulosic bioenergy crops. We used this information to forecast changes in water quality using the Soil Water Assessment Tool (SWAT) model. Water quality, combined with future landuse, was used to predict changes in fish richness. Finally, this recreational component is combined with non-use values to suggest a more comprehensive approach that could be suitable for evaluating welfare implications of future bioenergy landscapes at the water-shed and fuel-shed (e.g. biorefinery specific) level.

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The Commoditization of Intangibles: Overcoming Impediments to Reducing Pollution through Markets

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Through law-making and regulations point source pollution control has advanced substantially in the United States. However, non-point source pollution has been more difficult to address through regulation. Issues like nutrient loss to waters from agriculture, greenhouse gas emissions and availability of clean reliable sources of water will be the key environmental challenges of the 21st Century.

Development of innovative conservation strategies, like ecosystem service markets and performance based market driven incentives for Farm Bill and other conservation programs will be essential in meeting key environmental challenges. Such strategies that reward actual performance of deliverables offer to improve the environment, improve taxpayer and private environmental return on investment and put environmental quality and economic opportunity into alignment instead of opposition. However, there are many essential impediments that impede moving to these new conservation delivery strategies. Key impediments need to be overcome including reliably anticipating performance, price, property rights and ownership so that buyers can rely on the delivery of critical services through land based ecosystem service approachs instead of technical or engineering solutions.

The Sand County Foundation has undertaken the development, deployment, testing and valuation of a market-based incentive program for farmers that can be replicated on a large scale throughout the US and in other nations. These strategies can address a variety of conservation challenges such as reducing hypoxia, improving water supplies and reducing greenhouse gas emissions. This work provides first order documentation of environmental performance of specific management practices, documentation of costs, establishing common metrics that may be used by “producers” and “consumers”, and opening forums between producers and consumers for discussion of exchange of ecosystem services.

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Greenhouse Gas Benefits from Agricultural Nitrogen Managed for Water Quality

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The Millennium Assessment and recent USDA Conservation Effects Assessment Initiative (CEAP) have identified loss of nitrogen from agricultural production to the nation's waters as one of the key unmet environmental challenges of this century. Likewise, development of cost effective strategies to address greenhouse gas emissions is one of the key environmental challenges of our time. Sand County Foundation has piloted an initiative to assess the cost and effectiveness performance of a variety of nitrogen management techniques to reduce loss from agriculture to waters. These practices can provide significant reduction (and in some cases increases) in greenhouse gas emissions, and may be low cost strategy to reduce greenhouse gas emissions.

The Sand County Foundation has undertaken the development, deployment, testing and valuation of a market-based incentive program for farmers that can be replicated on a large scale throughout the US and in other nations. These strategies can address a variety of conservation challenges such as reducing hypoxia, improving water supplies and reducing greenhouse gas emissions. This work provides first order documentation of reductions in nitrogen and greenhouse gasses of specific management practices, documentation of costs, establishing common metrics that may be used by "producers" and "consumers", and opening forums between producers and consumers for discussion of exchange of ecosystem services.

Applied GeoSolutions LLC and Winrock have worked with Sand County Foundation to model the auxiliary greenhouse gas reductions associated with enhanced nitrogen management for water quality. N_2O is an extremely powerful greenhouse gas, with each molecule having almost 300 times the effect of a molecule of CO_2 on warming. Agricultural soil management is the largest anthropogenic contributor of N_2O to the atmosphere. Developing low cost strategies to reduce N_2O lost form agriculture could be a significant factor in implementing climate strategies. This is also a case where there is significant potential to stack multiple ecosystem benefits from specific actions.

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The Role of Ecosystem Services Valuation in Coastal Habitat Conservation

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Part of the National Oceanic and Atmospheric Administration's (NOAA) mission is to promote stewardship through science-based conservation and management. Promoting stewardship requires that NOAA demonstrate the contribution of its products and services to the economic value of: (1) the nation's stock of coastal and marine resources; (2) commercial and non-market economic activities; (3) changes in the health and safety of the nation's citizens.

Ecosystem service valuation techniques have the potential to provide information that can be used to demonstrate the economic benefits of habitat conservation. Ecosystem services are the direct or indirect contributions that ecosystems make to the well-being of human populations. Social science provides the basis for understanding human behavior. Thus social sciences and economics can be used to demonstrate how NOAA products and services affect decisions and outcomes related to the human safety and health and to the economy. Natural science can be better integrated into NOAA decision making if consideration is first given to the users of information, the processes by which information is used to make decisions and the level at which decisions will be made; e.g. policy, emergency response, or households.

The estimation of economic benefits can assist NOAA with decision making, as well as increase the public's general understanding of the economic importance and value of habitats. The end goal of ecosystem service valuation is to be able to demonstrate the tradeoffs in ecosystem services resulting from policy decisions. This can include incorporation of a monetary metric into cost-benefit analyses or other quantitative or qualitative means of assessing the losses and/or gains of ecosystem services to society.

NOAA has embarked on a number of initiatives that will incorporate the concepts of Ecosystem Services Valuation and Ecosystem Services and Markets. The agency is currently developing a number of pilot projects should provide information that can be used to better demonstrate the economic value of ocean and coastal management and assist with prioritization and planning. NOAA is also involved in a number of federal interagency efforts currently underway that support the incorporation of Ecosystem Services, Valuation and Environmental Market to meet the needs of federal, state partners and the general public. This poster presentation will highlight these initiatives and explore opportunities for future collaboration.

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Analyses of Social and Ecological Values of Urban Green Spaces: Implications for Urban Planning

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Ecosystem services can be understood as:"*a heuristic device for making human-ecology interaction more visible in decision making*" and knowledge about the spatial *distribution* of ecosystems services is important for identification of legitimate stakeholders and where to focus management intervention. In urban areas in particular, we have a poor understanding of the spatial distrubution of ecosystem services. As one approach to address this, we here present a framework for spatial analyses of ecological and social values of open spaces. Stockholm is unique in having pioneered extensive, though separate, surveys of the human and environmental values in the urban landscape. User-perceived values of open spaces such as parks and other green areas have been documented in a sociotope map, while a biotope map documents ecological values throughout the city and their importance for biodiversity. We applied explicit spatial analysis and correlation based on data from the sociotope aand biotope maps and included residential income data and a property rights/management database

We addressed the following questions: Are areas of high social value (e.g. recreational or cultural-historical spaces) frequently associated with high ecological values? Are areas of low ecological value associated with particular kinds and levels of social value? What patterns and characteristics are revealed in areas of low social *and* ecological value? How can we translate an integrated map of social and ecological values into a map of spatial distribution of ecosystem services?

Such analysis may provide helpful input to urban policymakers to navigate sustainable urban development paths that balance social, cultural, and environmental values. For example, identifying possible actions in targeted areas of both low social and ecological values - e.g. ecological restoration and a transformation of recreation and other cultural ecosystem services will require in-depth investigation of these areas' current and historical environmental and social context and involve key stakeholders in a participatory, scenario planning process that envisions possible futures and discusses concrete steps for realizing them.

The whole process, from the initial surveying and mapping of social and ecological values and their correlation with economic and institutional data, translation of these data into a map of distribution of ecosystem services, could serve as a model for urban development for most cities in Sweden as well as cities in many other countries.

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Cultural Ecosystem Services and Urban Green Spaces

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The concept of ecosystem services has proven useful in describing how biodiversity and ecosystems are linked to human well-being, but there are considerable knowledge gaps about urban ecosystem services. Millennium Ecosystem Assessment covered almost every ecosystem in the world but did barely mention urban systems. On the other hand, the World Development Report the world's largest assessment of urbanization, barely mentioned ecosystems.

Cities provide a range of critical Ecosystem Services that are enjoyed by most urban residents, where cultural services, i.e. the nonmaterial benefits obtained from ecosystems, like spiritual enrichment, cognitive development, recreation, and aesthetic experiences, are specially important. There are multiple social effects of green spaces and in a recent review links were noted between access to green spaces and e.g. healthy cognitive development of children, strategies to reduce crime and aggression, strengthened communities, and increased sense of well-being and mental health. The distribution and accessibility of green space to different socio-economic groups, however, often reveals large inequities in cities contributing to inequity in health among socio-economic groups, although confounding effects are not always possible to separate.

Stockholm is unique in having pioneered extensive surveys of the social values of green spaces in the urban landscapes. User-perceived values of parks, open spaces, and other green areas have been documented in a sociotope map. I will present spatial analyses of how social values co-vary with data on residential income and property rights/management and discuss the challenges and difficulties in the methodology and attempts to map cultural ecosystem services in the urban landscape.

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Ancillary Effects of Carbon Sequestration Strategies on Ecosystem Services

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Based on current trends, cumulative U.S. greenhouse gas (GHG) emissions are projected to double by 2050 and increase by a factor of three to four by 2100. Terrestrial U.S. land sinks sequester approximately 30% of the annual fossil-fuel emissions and a key climate mitigation strategy is to maximize the natural carbon storage processes in order to enhance ecological carbon sequestration. The effects of increasing ecological carbon sinks through changes in land-use and/or land management on other ecosystem services are not known. Quantifying these ancillary impacts on other ecosystem services is critical to the overall evaluation of potential climate mitigation strategies.

We used the spatially explicit simulation model FORE–SCE (FOREcasting SCEnarios of land-cover change) to provide forecasts of land use and land cover (LULC) from 2001 to 2050 for Tensas Parish, LA and Claiborne County, MS. These two areas are representative of landscapes where ecological carbon sequestration strategies have been implemented. We used a downscaled version of the IPCC A1B emission storyline to parameterize and constrain the spatial allocation of future LULC. The A1B storyline assumes a future world of very rapid economic growth, low population growth, and a balanced mix of technologies and energy supplies. Under this set of assumptions, a reference LULC and land management scenario devoid of any direct carbon or GHG mitigation policies or actions was developed as a baseline. An enhanced ecological carbon sequestration scenario was developed that included increased afforestation, no deforestation, no freshwater wetland loss, increased forest cutting cycle period from 25 to 45 years, and reduced rates of clear-cutting by 50 percent. Outputs from the reference and enhanced scenarios were used to as inputs to ecological and biogeochemical models to quantify a suite of ecosystem services: carbon sequestration, timber production, GHG reduction, sediment retention, wildlife habitat, and nitrate retention. Both current and potential market and social benefits and management activity costs for these simulated values were calculated using a discounted cash flow (DCF) analysis.

The enhanced scenario resulted in increased woody wetlands and mixed forest LULC types at the expense of crop land. This was expected and consistent with the enhanced carbon sequestration actions. These changes in LULC translated into expected increases in carbon sequestration and wildlife habitat, and a reduction in greenhouse gas emissions and sediment erosion. Timber production, however, was much lower in the enhanced scenario compared with the reference scenario and there was no change in nitrate retention between the two scenarios. The net present value of the mitigation activity (the difference between present values of benefits and costs) ranged between -$18.2 million assuming marketable timber value only and $436.9 million assuming all potential and social values for the ecosystem services are realized. Depending on the assumptions and valuation of the ecosystem services, the return on investment in the mitigation activity could be significant.

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Dynamic Open Space and Housing Values: A Novel Repeated Sales/Matching Approach

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This research employs a novel quasi-experimental method to value proximity to open space for habitat values in Riverside County. Research on the value of proximity to open space typically uses cross-section or repeated cross section data where open-space areas are fixed and constant over the time period of the sample. This type of analysis could result in biased estimates of value because open space proximity could be correlated with unobservables that influence house values.

We use house sales data from Western Riverside County (in Southern California). This county maintained an active program of open space acquisition from 1988 through the end of our sample period in 2004. The addition of new open space reserves allows us to test whether creating nearby open space adds to the value of a residence. The addition of the open space reserves can be viewed as an experiment with a treatment group where proximity to open space changes and a control group. We use a repeat sales approach that measures whether the rate of house price appreciation is greater in a time period where the proximity to open space declines for that house. The repeat sales methodology allows us to control for all time-invariant house characteristics, whether observed or not.

It is possible that open space preserves were placed in areas where home values were increasing more rapidly than other areas in any case. For instance, perhaps people are more motivated to improve their houses if they are close to open space. One method we use to diagnose this effect is a false treatment dummy. Our data contains many houses that sold several times over the period and where the proximity to open space changed in one sale pair, but not in others. In these cases, we create a false treatment dummy that is positive for an observation if : 1) the house had a change in proximity to open space at some transaction pair; and, 2) this particular observation (transaction pair) did not have an open space proximity change. If the coefficient on the false treatment dummy is positive and significant, it suggests that open space preserves are placed in areas where house values are appreciating in any case. Results show insignificance.

We also use a matching methodology to test whether the control and treatment groups are similar. We employ a variety of propensity-score based matching techniques to obtain weights for control and treatment groups. Using these weights we re-examine our baseline and find that the match-based-weighting has little effect on our overall results.

Our results appear robust to a number of different specification tests and we believe they are the first results to rigorously identify open-spaced proximity values based on quasi-experimental methods. In addition, the results are particularly policy applicable because they apply to open space preservation on the wildland-urban frontier. This frontier is often where the ecological value of open space is high because there is room to maintain contiguous habitats. Our research suggests that there are significant benefits to residential use values in addition to these ecological benefits and measuring these values over time is important.

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A Review of New Methods to Link Ecosystem Services to Corporate Performance

John Finisdore
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Ecosystem change is highly relevant to business because companies not only impact ecosystems and the services they provide, but also depend on them. Several methods are emerging to help companies develop strategies that enhance ecosystem services and corporate performance. These include *The Corporate Ecosystem Services Review* (WRI, 2008), *Ecosystem Services for Corporate Decisions Making* (WRI, forthcoming), and *The Corporate Ecosystem Valuation Guide* (WBCSD, forthcoming).

Since publication of *The Corporate Ecosystem Services Review* (ESR) in 2008, an estimated 200+ companies have used the method. They report that the ESR helped identify new risks and opportunities that their existing environmental management and due diligence systems did not reveal.

The forthcoming guidelines *Ecosystem Services for Corporate Decision Making* provides a framework for integrating ecosystem services considerations into business management systems, particularly 1) Environmental Management Systems, 2) Sustainability Reporting, and 3) United Nations Global Compact's Performance Model. The guidelines contain:

- A list of systems, tools, and procedures in which managers can address ecosystem services
- Key concepts for integrating ecosystem services into priority systems
- A framework for developing ecosystem services-based corporate performance metrics

The Corporate Ecosystem Valuation Guide is a resource for companies to translate environmental assets or risks into monetary or non-monetary values. Fifteen companies around the world piloted the guidelines and results will be released in the coming year.

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Greenhouse Gas Flux of Grazed and Hayed Wetland Catchments in the Prairie Pothole Region

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Wetland catchments are major ecosystems in the Prairie Pothole Region and play an important role in the flux of greenhouse gases (GHG). Information about land use influence on fluxes of GHG from these catchments is limited. We examined the effects of haying and grazing, two common land uses in the region, on GHG fluxes from wetland catchments during the growing seasons in 2007 and 2008. Fluxes of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), along with soil moisture and temperature, were measured along an elevational gradient every other week from April through approximately September near Ipswich, SD. We used closed, opaque chambers to measure fluxes from catchments in native prairie that were moderately grazed or left idle, and from catchments recently (less than 3 yr) converted from cropland to grassland (i.e., restored by seeding to native species) that were hayed once during the growing season or non-hayed. Catchments of contrasting land uses were in adjacent areas and had similar soil series, soil nitrogen and organic carbon content, precipitation, and vegetation. Catchments were divided into upland and wetland zones for analyses. When compared with idle catchments, grazing as a land use had little effect on GHG flux. This may be related to the gradual and selective effect grazing has on plant productivity. Haying, on the other hand, having a more immediate and comprehensive effect on plant productivity had significant effect on CO_2 flux, but not CH_4 and N_2O. Additionally, haying may have indirectly influenced soil water filled pore space, which may affect CH_4 and N_2O fluxes under different hydrological conditions than were present during this study.

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Ecosystem Services for Corporate Decision Making: An AEP Case Study

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The electric power industry relies on ecosystem services such as sustained water supply, water purification through wetlands, and a stable climate for daily operation of power plants. Recognizing the importance of these services, AEP recently conducted a Corporate Ecosystem Services Review (ESR) for a facility in Rockport, Indiana, in collaboration with the World Resources Institute and Electric Power Research Institute.

The ESR helped identify new risks and opportunities that existing environmental management and due diligence systems did not reveal. AEP is assessing how to embed the ESR's core concepts into the company's existing corporate decision making systems and procedures, such as ISO standards for Environmental Management Systems (ISO 14001).

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Valuing Ecosystem Service Tradeoffs of Wetland Management in Delaware

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Wetlands cover over 30 percent of the State of Delaware. These ecosystems are being threatened, in particular, by development associated with the growing state population. Wetlands serve a variety of ecosystem functions, including surface water detention, nutrient transformation, coastal storm surge detention, species habitat, and carbon sequestration. Our analysis links wetland functions in Delaware to ecosystem services - the contributions that these functions make to the well-being of human populations - for purposes of economic valuation.

There is little disagreement that wetland ecosystem functions provide valuable services. The relationship of some services, such as recreation, to wetlands is more apparent than others, for example, flood protection. From a social welfare perspective, failure to incorporate the values of as full a suite of ecosystem services as possible may result in inefficient resource management (i.e., the total value of goods and services provided by the landscape is not maximized). Our analysis demonstrates a framework designed to evaluate tradeoffs in multiple ecosystem services of land and resource management scenarios. Specifically, we apply the Natural Capital Project's Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) tool to quantify changes in carbon storage and sequestration, water purification, flood protection, and biodiversity associated with alternative wetland management scenarios in Delaware. For each service, InVEST employs multiple, integrated, spatially-explicit models. The results of our analysis, both biophysical and economic endpoints, provide additional information regarding less transparent ecosystem services of wetlands to support efficient landscape-level land use planning.

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Perceptions of Ecosystem Services and Threats to Well-being from an Alaska Native Community

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Culminating three years of research on traditional knowledge and local berry resources in Point Hope, Alaska, focus groups were conducted with youth ages 12 to 18 and with adult community members to explore and compare their perceptions of ecosystem services and threats to well-being. Aerial photos were used to prompt discussion regarding spatial extent of ecosystem services. Numerous provisioning and cultural ecosystem services were highlighted along with current and potential change drivers or threats perceived to challenge. Regulating services were more implied than explicit. Connections with traditional knowledge were highlighted, with youth being far more concerned about maintaining traditions and local subsistence food harvesting than adults perceived them to be. Sharp differences were also found between youth and elders regarding socio-behavioral changes in the community, particularly drugs and alcohol. This participatory exercise highlights the value of a grounded approach to ecosystem services assessment beginning from the point of view of local residents and including the next generation of community decision-makers. This paper will discuss challenges and opportunities associated with conducting this type of engagement for ecosystem services assessment.

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Scientific Methods for Cultural Service Assessments

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In the many efforts to articulate an ecosystem services framework, a common theme is the lack of clarity regarding how to measure cultural ecosystem services. Cultural ecosystem services are by nature social constructions by people interacting with the biophysical world. As such, measuring such benefits requires engagement with people to understand their values, perceptions, experiences, and actions. These dimensions are outside the common realm of biophysical science, thus it is no surprise that ecologists, biologists, and others from physical science disciplines struggle with measuring human processes and outcomes or how to integrate such measures and indicators into their models and assessments. Assumptions are often made that measurements of human values or social systems are less quantifiable, less reliable, or less valid. This paper will contradict these assumptions, highlighting an array of well-tested methodologies to quantitatively and qualitatively assess cultural ecosystem services for a clearer view into cultural values and benefits from ecosystems that can be integrated with biophysical ecosystem indicators. A discussion of data quality and confounding factors associated with social science inquiry will be included. Our general conclusion is that a transdisciplinary, integrated methodological approach to cultural ecosystem services moves beyond disciplinary divides to bring together the most rigorous assessment tools available, capitalizing on technological innovations in modeling and simulation as well as evolving economic and multi-attribute valuation techniques and inclusive participatory approaches.

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How Payments for Ecosystem Services are Being Stacked in the United States

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During the last decade, various market-based opportunities to buy and sell credits representing ecosystem services have emerged. The majority of these markets are focused on selling credits to those needing mitigation for natural resources impacts. These markets include wetland mitigation banking, species conservation banking, water quality trading, and greenhouse gas credits. While the markets have organized the credit types into discrete markets, the ecological reality is that many of these services are linked. For example, when a forest is replanted to support endangered species, it may produce both species habitat as well as sequester carbon. In an effort to maximize financial returns, interest has arisen in selling multiple credits types for the same conservation action. For example, selling species conservation banking market as well as carbon offset credits for the same forest restoration project. The selling of credits in multiple markets using the same conservation action is referred to as “credit stacking.”

While there is significant interest in credit stacking, there has not been an assessment of the definitions, protocols, or case studies. The objective of this work is to provide a comprehensive review of the current state of carbon, species, water quality, and wetland credit stacking in the United States. This project will summarize national opinions on the definition of credit stacking; current involvement in credit stacking by credit banks, purchasers, and regulatory agencies; identification of credits that are currently being stacked and their respective scenarios; legal issues and opportunities to stack credits for the carbon, species, water quality, and wetland credit markets.

We completed the review through an email query sent to credit banks, associations, and regulatory agencies in the United States. The e-mail query resulted in more than 300 regulators, researchers, bankers, and practitioners. In this presentation, we will summarize the results of the research, the first comprehensive assessment of credit stacking in the United States. We envision that this work will lay a foundation for further research as well as developing an ecological appropriate protocol(s) for credit stacking.

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The Northern Forest Watershed Incentives Project

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The Northern Forest Watershed Incentives Project (NFWIP) is a pilot initiative aimed at developing an innovative and replicable market-based model that will incentivize private landowners to restore, enhance, and protect imperiled aquatic resources in two critical watersheds in the Northern Forest region of the United States: the Upper Connecticut River watershed in Vermont and New Hampshire, and the Crooked River watershed in Maine.

Identified because of their vital roles in providing essential watershed services to the population centers they serve, and their high vulnerability to a variety of pressures, NFWIP's two pilot watersheds are in critical need of protection. However, the capacity to protect these watersheds lies predominantly in the hands of private landowners who, for a variety of economic and ecological reasons, are finding it increasingly difficult to do so. AFF, along with four local partners in the pilot watersheds, is developing a cutting-edge incentive-based framework that helps landowners generate additional streams of income by ensuring they receive proper compensation for the watershed services their land confers to the many individuals, companies, and government agencies who benefit.

The framework is built upon a “payment for ecosystem services” model, in which private landowners sell the watershed services provided by their forests, such as water purification, flood abatement, accessibility of recreational resources, and habitat protection, to watershed beneficiaries, such as municipalities, government agencies, corporations, and the like. Through the brokering of these ecosystem services, NFWIP helps landowners cultivate the necessary resources to keep their forests and associated aquatic resources healthy and intact.

Markets have been proven to be more efficient at protecting watershed resources than command and control approaches. However, there still remain many questions that need to be answered before they can fulfill their full potential. Through its innovative approach, NFWIP will help transition these models from theory to widespread applicability. By implementing two parallel pilot projects that possess very different ecological and demographic characteristics, we will bring an entirely new set of data and lessons learned to the field, demonstrating how differing social, ecological, and political contexts affect a water market's likelihood for success.

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Valuing Ecosystem and Economic Services across Land-Use Scenarios in the Prairie Potholes

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In recent years, society has increasingly recognized the essential link between healthy ecosystems and human welfare. This altruistic viewpoint has led to increased efforts to identify, quantify, and value the services these ecosystems provide. However, in order for these values to be useful to resource managers there must be collaboration across many disciplines. This study uses biophysical values derived for the Prairie Pothole Region (PPR) of North and South Dakota, in conjunction with value transfer methods, to assess the environmental and economic tradeoffs under different policy-relevant land use scenarios over a 20-yr. time period. The ecosystem service valuation is carried out by comparing the biophysical and economic values of three focal services (i.e. carbon sequestration, reduction in sedimentation, and waterfowl production) across three focal land uses in the region (i.e. native prairie grasslands, lands enrolled in the Conservation Reserve and Wetlands Reserve Programs (CRP/WRP), and cropland). This study finds that CRP/WRP lands cannot mitigate (1 for 1) the loss of native prairie from a social welfare standpoint. Furthermore, land use scenarios in which native prairie loss was minimized and CRP/WRP lands were increased provided the most societal benefit. The scenario modeling projected native prairie conversion in the next 20 years results in a social welfare loss valued at over $2.5 billion, when considering the study's three ecosystem services, and a net loss of about $1.8 billion when reductions in commodity production are accounted for. With high ecological scores on native lands, along with significant economic dependence on the agricultural sector, it is important to measure how these land uses work with and against each other. By quantifying ecosystem and economic tradeoffs of future land use scenarios, this study aims to help policy makers and natural resource managers make more informed, efficient, and defensible decisions.

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Long-term Losses of Culturally-Important Ecosystem Services in Coastal Rainforests

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Mapping of ecosystem services (and trade-offs among them) has become an important goal for both managers and researchers. However, limitations of standard approaches impede our ability to understand long-term dynamics of ecosystem services. Rigorous quantification of culturally-important ecosystem services has remained particularly elusive. Here, we explore the utility of high resolution historical aerial photography for understanding trade-offs among ecosystem services of ecological, cultural and economic value. We focus on a forested landscape in coastal British Columbia where management has been contentious and power dynamics among First Nations communities and other forest managers are shifting.

The abundance of potential historic services across the landscape differed greatly based on tree species composition and size. The location of services across the landscape, as well the loss of many services, was linked to underlying topography and productivity patterns. Errors in the amount and location of different ecosystem services resulted from several challenges associated with historic aerial photographs; yet are likely more accurate than reconstructions based on coarser-resolution data. Estimates of the historic abundance of various ecosystem services can yield better estimates of the decline and recovery of services and aid in quantifying trade-offs among services in time and space.

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A Challenge for Ecosystem Service Bundling: Joint Production of Services and Free-Riding

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Multiple ecosystem services are often produced jointly by a single land use. For example, natural forest may sequester carbon, protect biodiversity and produce hydrological services simultaneously. As a result, there are several programs endeavoring to bundle ecosystem services. However, there are significant challenges for managing ecosystem services through bundling. One current example of efforts to protect multiple services illustrates the potential impact of joint service production on contributions to service protection. In Los Negros, Bolivia, there is a payments for ecosystem services program that provides in-kind payments for bird habitat and watershed protection. In its initial phases, the program was funded by an international conservation donor seeking to protect migratory bird habitat. However since its initiation, individual irrigators benefiting from hydrological services have been reluctant to contribute to the program. The authors examining this case state the problem concisely: "…using biodiversity payments to pump-prime the scheme may also have created a perverse incentive for downstream users—why should they pay when someone is already doing it for them?"[†]. In other words, because the benefits of jointly produced ecosystem services are frequently non-excludable (or exclusion would be costly), incentives to free-ride on actors protecting other services may impede efforts to bundle services. Using a game-theoretic model, this research will seek to provide a clearer understanding of the behavior of donors contributing to the protection of jointly produced services, especially as it relates to uncertainty about the joint production of the two services. It is my hope that this analysis will provide a starting point for an examination of the complex interactions that translate service user preferences into the protection of bundles of services on the ground, as well as create knowledge useful for designing institutions capable of managing for multiple jointly produced services.

[†]Asquith, N. M., M. T. Vargas, and S. Wunder. 2008. Selling two environmental services: in-kind payments for bird habitat and watershed protection in Los Negros, Bolivia. Ecological Economics 65(4):675-684.

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Ecosystem Goods and Services and the Status and Distribution of Mangrove Forest of the World

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Mangrove forests provide important ecosystem goods and services to human society including protection from natural disasters such as hurricanes and tsunami. It is estimated that the mangrove forests provide at least US $1.6 billion each year in ecosystem services worldwide. However, the forests have been declining at a faster rate compared to inland tropical forests primarily due to conversion to agriculture, aquaculture, and urban areas. Yet, our scientific understanding of the extent and distribution of mangrove forests of the world is inadequate. The available global mangrove databases, compiled using disparate geo-spatial data sources and national statistics, need to be improved. Here, we mapped the status and distributions of global mangroves using recently available Global Land Survey (GLS) and the Landsat archive.

We interpreted approximately 1,000 Landsat scenes using a hybrid supervised and unsupervised digital image classification techniques. Each image was normalized for variation in solar angle and Earth-sun distance by converting the digital number values to the top of the atmosphere reflectance. Ground truth data and existing maps and databases were used to select training samples and also for iterative labeling. Results were validated using existing GIS data and published literature to map “true mangroves”. Our analysis revealed that the total area of mangroves in year 2000 was 137,760 square kilometers in 118 countries and territories in the tropical and subtropical regions of the world. Approximately 75% of world’s mangroves are found in just 15 countries, and only ~6.9% is protected under the existing protected areas network (IUCN I-IV). Our study confirms earlier findings that the biogeographic distribution of mangroves is generally confined to the tropical and subtropical regions and the largest percentage of mangrove is found between 5^0N and 5^0S latitude. We report that the remaining mangrove forests of the world are less than previously thought. Our estimate is ~12.3% smaller than the most recent estimate by the Food and Agriculture Organization (FAO) of the United Nations. We present the most comprehensive, globally consistent, and highest resolution (30 m) global mangrove database ever created. We developed and used better mapping techniques and data sources and mapped mangroves with better spatial and thematic details compared to previous studies.

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Using Watered Landscapes to Manipulate Urban Heat Island Effects

Patricia Gober

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The prospect that urban heat island (UHI) effects and climate change may increase urban temperatures is a problem for cities that actively promote urban redevelopment and higher density development. One possible UHI mitigation strategy is to plant more trees and other irrigated vegetation to prevent daytime heat storage and facilitate nighttime cooling. We investigated the tradeoffs between water use and nighttime cooling in 212 Census block groups in Phoenix, Arizona, including the city center and areas of urban redevelopment, using a neighborhood-scale meteorological model. We found that increasing irrigated landscaping lowers nighttime temperatures, but this relationship is not linear; the greatest reductions occur in the least vegetated neighborhoods. Increasing density increased cooling and in most cases had little effect on water use. The takeaway message for practitioners is that no one urban design and landscape plan is capable of addressing both UHI mitigation and water conservation. Any one strategy will have inconsistent results if applied across all urban landscape features and may lead to an inefficient allocation of scarce water resources.

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Ecological Risk Assessment Should Focus on Ecological Condition, and not on Human Well-being

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In Support of the Proposition: Dale Goble

Ecological risk assessments are structured to separate decisions on the effects of a proposed action on ecosystems from decisions on the acceptability of those effects. The fact that the dichotomy may be elusive is a poor reason to abandon the conceptual distinction by incorporating consideration of ecosystem services, an explicitly utilitarian valuation scheme.

Ecological risk assessments seek to characterize the nature and magnitude of risks to ecological systems caused by environmental stressors such as chemicals, land change, disease, invasive species, and climate change. Procedurally, the assessment is a preliminary step that provides information on adverse effects. This information can then be used by the risk manager to decide whether the adverse effect(s) are acceptable given other factors such as economic or legal concerns.

Introducing consideration of ecosystem services undermines this dichotomy between determining the effects and the acceptability of those effects because the concept of ecosystem services was crafted to provide a market-based value for biodiversity. Ecosystem services are thus one measure of some of the "other factors" that the risk manager relies upon to decide whether the risk is acceptable.

Against the Proposition: J.B. Ruhl

Ecological risk assessment's historical focus on ecological conditions to the exclusion of human well being has led to an increasingly technical but ultimately incomplete account of the impacts of environmental degradation to sustainability. Including threats to the flow of ecosystem services to human populations within the scope of ecological risk assessment will provide a more robust platform for sustainable decision making.

The purpose of any risk assessment is to improve decision making by supplying the decision makers important information about the status, trends, and uncertainties of risks bearing on whatever it is we care about assessing. The scope and intensity of the risk assessment-how wide we set the lens and the power of focus-are critical design issues for ensuring robust and reliable information. Ecological risk assessment methods, though by all means vital to natural resources management decisions, have set too narrow a lens by leaving out an important question-what risk to humans does risk to ecosystems pose? The discipline of ecological economics, with its building body of knowledge about natural capital and ecosystem services, focuses precisely on that question. We should, therefore, use that new knowledge to develop a new method of ecological-economic risk assessment.

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Drivers of Ecosystem Service Changes Can Go Both Ways: Economic Development, Technology and Population

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Among the major drivers of changes in demand for ecosystem services and the nature's ability to meet that demand are economic development, technology and population. In the ecological literature these drivers of change were frequently considered, either explicitly or implicitly, to be operating in one direction only, namely, in the direction of deteriorating and diminishing ecosystem services. Nowadays this view has been tempered somewhat for the technology driver and, to a lesser extent, economic development. This presentation will present arguments and examples that the effect of all three of these drivers can be complex, and that each can, under the right circumstances, relieve pressures on ecosystem services, just as easily as they can increase those pressures. A more nuanced understanding of these drivers of ecosystem service changes and their effects could help expand the research agenda in searching for ways to increase the ability to sustainably meet the human demand for ecosystem services.

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Ecosystem Services Inclusive Strategic Environmental Assessment

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The purpose of this paper is to elaborate on the importance of, and on methodological approaches to, considering biodiversity issues, and priorities, in strategic environmental assessment (SEA), in particular through the assessment of ecosystem services. The paper will share research advances on how ecosystem services can be incorporated into SEA as a fundamental component of the strategic assessment in support of decision-making, and will particularly explore its relevance in municipal spatial planning.

Safeguarding livelihoods is a major driver in SEA in its effort to promote trajectories for sustainability. The Convention on Biological Diversity and Millennium Ecosystem Assessment offer a consistent framework to address biodiversity, ecosystem services and their societal values in SEA. As an impact assessment approach SEA is highly versatile and has shown evidence of a large spectrum of applications. Rather than keeping only a control, and mitigation, role on the impacts of development, SEA has the potential to highlight development opportunities that are inclusive of environmental and sustainability priorities. The development opportunities provided by ecosystem services can be explored in SEA through strategic approaches that can contribute to avoid impacts of human actions on ecosystem services.

The SEA research team at IST-Portugal has been advancing and advocating a strategic-based and collaborative oriented approach in SEA which purpose is to engage stakeholders in collaborative assessment of strategic development options based on opportunities and risks for the environment and sustainability. Based on the work developed by other sources, a method to allow the consideration of ecosystem services in SEA at municipal spatial planning levels has been developed and will now be tested in different cases. Results will be used in support of local decision-making and in directing the consideration of biodiversity in policy choices.

Many studies along with the Millennium Ecosystem Assessment point to the urgency in considering actions that can revert the process of degradation of biodiversity values and its supporting ecosystems. Human activities, as direct and indirect drivers, are the crucial targets and SEA can have a strategic contribution in influencing priorities by showing strategic reasons for change. The paper will conclude on the reasons that support biodiversity and ecosystem services inclusive approaches in SEA and on how methods so far developed can be extended to other applications, highlighting benefits and challenges to be faced. Recommendations for its practical implementation will be issued based on policy arguments concerning the incorporation of economic benefits of ecosystem services as well as the opportunity to achieve international priorities where they are national commitments.

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Payment for Ecosystem Services from the Carson River Natural Floodplain

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The Carson Water Subconservancy District (CWSD) and the Carson River Coalition (CRC) River Corridor Working Group are interested in preserving the ecosystem services of the natural floodplain along the Carson River and enhancing the viability of agriculture in these floodplain areas. One potential approach is to pay landowners for the ecological services provided by land in the floodplain areas. ENTRIX and Environ worked with the CWSD and CRC to develop economic information to assist in determining an appropriate payment assuming the payment structure was to be annual lease payments.

The ecosystem functions provided by the natural floodplain of the Carson River provide many benefits to the region, including habitat values, flood protection, and watershed preservation. The purpose of this research is to provide information about the monetary value of these functions using different approaches.

Three approaches were used to explore potentially appropriate payments. The first was to consider what costs might be avoided by maintaining the floodplain. For this, restoration costs in the Truckee River provide an excellent comparison to the Carson River. Several ongoing restoration projects in the Truckee watershed are attempting to mimic the functions provided by a natural floodplain. The second approach was the use of HEC RAS flood event simulations to quantify the magnitude of flood impact differences between the natural floodplain, and the same floodplain with development. A final approach was to evaluate comparable payment programs elsewhere in the country, including market based approaches such as Tradable Development Rights (TDR) regimes.

The results of the study point out differences based on approach, and differences within each approach based on the sensitivity to parameters such as the discount rate, the period of time, flood frequencies, and other. The results also point to a range of values that are appropriate for the CWSD and CRC to consider as they move forward with their payment for ecosystem services (PES) strategy.

Conclusions of this research will focus on factors that influence the ultimate determination of appropriate payments such as: development pressure in the region, flexibility inherent in the mechanism, term length for the mechanism, uncertainty associated with participation, and others.

Recommendations from this research will emphasize the importance of floodplain- and policy-specific analyses to assess appropriate ecosystem service payments.

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A Hint of Risk: Tradeoffs between Ecosystem Services for Sustainable Land Use Management

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Future land use and climate change scenarios will most likely strongly impact the provision of ecosystem goods and services in the Swiss Alps. Adapted land use management as well as the thorough consideration of tradeoffs between ecosystem goods and services are needed to mitigate the degradation of ecosystem services under such conditions. Especially forest management practices have an important influence on the sustainable provision of ecosystem services provided by Alpine regions.

Taking into account the high uncertainties decision-makers have to deal with and the need for a coherent system to compare tradeoffs, a model is developed which combines the probabilistic mathematics of a Bayesian Network with a risk approach to support decision-making for sustainable land use management. We illustrate the approach with a case study from a Swiss Alpine region – the Landschaft Davos – in which forest ecosystems are especially significant for avalanche protection, wood production, and carbon sequestration. We calculate ecosystem service benefits and related uncertainties in a spatially explicit manner under climate and land use change scenarios including risk attitudes of stakeholders. Preliminary results show how such an approach can be used to prioritize forest management options under uncertainty. The presented framework provides a starting point for more sustainable land management, and a useful tool for better informed and participatory decision-making.

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Services Provided by Modified and Constructed Landscapes

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The ecosystem services concept is currently embraced as a bridge between the natural environment and human well-being. Yet, many studies on ecosystem services consider only the natural landscape as being the environment's contribution to human well-being and neglect explicit consideration of the contribution of modified or constructed landscapes. Many ecosystem services, especially cultural services, are however not exclusively derived from "natural" ecosystems. Consensus seems to have been reached that no classification scheme will adequately meet all the demands from all the different contexts in which ecosystem service research is potentially utilized. Rather, multiple services classifications should be developed which are each useful for distinct purposes.

In this presentation, we first contribute to this 'pluralism' of service typologies and suggest a framework that provides the conceptual background for a classification of services for landscape researchers and practitioners addressing the value of ecosystem services provided by modified or constructed landscapes. We then demonstrate that built and modified environments are important and legitimate contributors to cultural ecosystem services using a new approach organized around the 3D visualization of different landscapes. The semantic, parametric, and shape grammar driven digital 3D model is integrated in a collaborative platform and helps determine tradeoffs between services and key variables strengthening the cultural value of a landscape. Especially spatial planners might benefit from such an approach that allows addressing the ever more important trade-off decision making between 'building' and 'conserving'.

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A Process-Based Model for Valuing Coastal Protection Services

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Faced with the conflicting challenges of increased human use of coastal areas and potential intensification of coastal hazards caused by climate change, ecologists, engineers and economists have been developing new ways to account for and value the protective services provided to communities by marine ecosystems. The mitigating effects of biogenic habitats (e.g. mangroves, coral reefs) on coastal erosion and inundation have been demonstrated in field and laboratory experiments, as well as with complex hydrodynamic models. Similarly, various efforts have put dollar values on the services provided by specific marine ecosystems, and contrasted them to the economic value of other competing anthropogenic uses of the environment. However, few models have been developed to take into account the way in which the distribution and abundance of biogenic habitats modify wave transformation and wind-generated storm surge processes, and thus reduce coastal erosion and inundation.

Marine InVEST quantifies and values the ability of biogenic habitats to provide coastal communities with protection from erosion and flooding, using process-based methods and the best-available science. The coastal protection model, which consists of 1-dimensional wave transformation and wind-generated storm surge models, incorporates the processes by which biogenic habitat (e.g., kelp forest, seagrass, oyster reefs or dune-grass) and non-biogenic habitats (e.g., coastal dunes), reduce coastal erosion and inundation. These habitats are then valued by comparing the relative difference between modeled erosion and inundation with and without their presence. Outputs from the models have been designed to evaluate (in both economic and social terms) the services provided by these ecosystems. They include biophysical (e.g., area of beach or land eroded or flooded), monetary (e.g., beach nourishment costs or damages to property), and social (e.g., number of people affected) currencies for use in various decision-making contexts.

In this talk, we will describe our theoretical approach and the innovative methods we have developed to quantify the reduction in erosion and inundation provided by vegetation. Additionally, we will show how impacts of “hard” man-made structures are represented, and how outputs from the model can be used to compare trade-offs between coastal management options that favor hard structure (“grey”) - or ecosystem-based (“green”) solutions, or a combination of both. Finally, we will present our approaches for economic valuation and how metrics for coastal protection can be used to inform ecosystem-based approaches to climate adaptation, marine spatial planning, and coastal management strategies such as restoration of habitats for mitigation purposes.

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SWESP Tribal Ecosystem Services Pilot in Arid Southwestern North America

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The sustainable flow of natural resources and ecological services is required to meet the nutritional, cultural, societal and economic needs of First Nation communities. Governments, tribal leaders and citizens within the North American arid southwest face environmental and economic challenges of ensuring people have access to clean water and sanitation while vital ecosystems are protected without undermining economic growth. The objectives of the US Environmental Protection Agency Ecosystem Services Research Project (ESRP) is to provide information and tools allowing communities, planners, and policy makers to evaluate holistically the impacts of water- and land-use decisions. Understanding the linkages among traditional knowledge, locally evolved management systems and human health and well-being will enhance the evolution of ecosystem services sciences. The USEPA and USGS are proposing a pilot Tribal study in collaboration with San Xavier District (SXD), of the Tohono O'odham Nation (TON) to understand the impact that water and land management will have on the goods and services derived from natural and cultivated ecosystems. The goals of the Tribal pilot study are to investigate the feasibility of using an ecosystem services approach to assess the ecological, economic and social ramifications of alternative water allocation and land-use scenarios with emphasis on historic ties tribal populations have to the land, their unique cultural and dietary practices and ecosystem services. We understand that one size does not fit all, nor are decisions made at one scale suitable at another. Ecosystem Services science in the southwestern United States (e.g., Southwest Ecosystem Services Project, Santa Cruz Watershed Ecosystem Portfolio Model, AGAVES) will investigate how traditional, existing, and evolving methods and tools may be used implemented at multiple scales (e.g. watershed, sub-watershed and community) with decision makers. In addition, in this time of limited funds and personnel, that we must pool the talent, experience and resources of Federal, State, Tribes, NGOs and the public to investigate how the science of ecosystem services can be applied to assess the ecological, economic and social ramifications of alternative water allocation and land-use scenarios. Ongoing hydrology research into the benefits of in-channel recharge and restoration of a riparian area at the SXD provide the environmental setting upon which identification and quantification of ecosystem services can be examined to explore the non-monetary value to the SXD. Accordingly, ecosystem services, in alignment with current classification methods, were derived from the SXD's Vision Document that is based on the SXD's image of tomorrow. This research will provide data and materials to help the SXD holistically evaluate ecosystem service impacts and will be used as a demonstration study on ecosystem services that benefit Tribes.

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The Role of Ecosystem Services in Sustainability Planning

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There are many facets to the broad concept of sustainability. Energy efficiency, recycling, reducing consumption, and reducing GHG emissions are just some of the ways people think about and seek to address sustainability. All of those things are important and should be part of the sustainability conversation. However, the concept of ecosystem services provides a unique and valuable framework for understanding how we manage a landscape to achieve regional sustainability goals.

The presentation will describe the link between ecosystem services and sustainability. The presentation will then outline some of the necessary obstacles that need to be overcome in order to use ecosystem services as an analysis framework. The presentation will conclude with a proposed approach for more fully and effectively integrating ecosystem services into land use and land management planning to make sustainability the end goal. The discussion of the proposed ecosystem service integration approach will be highlighted with examples of specific aspects of the approach that are already being implemented in various locations.

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Measuring Ecosystem Services at Multiple Scales

Kenna Halsey, ***Kevin Halsey*** and *Paul Manson*
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An ecosystem services-based approach is increasingly recognized as an effective way to quantify the relationship between an organization's environmental performance and the health of the landscape. Using ecosystem services to understand and quantify organizational influences on the landscape integrates ecological, economic, and social considerations into a single measure that vastly improves decision-making processes.

To effectively use an ecosystem services approach, we must be able to measure ecosystem performance at multiple scales: the regional landscape, the organization, and the individual project. Further, we must be able to relate these scales to each another to understand how project-level decisions can ultimately affect the sustainability of organizations and the regional landscape.

This presentation will demonstrate the benefits of measuring ecosystem services at multiple scales. The presentation will illustrate how the ability to relate the measurements at the different scales improves both our project decision-making and our efforts to achieve organizational/regional sustainability. On the project side, we will illustrate how projects can better incorporate important landscape context factors and regional ecosystem priorities into their decision-making. On the organizational/landscape side we will show how organizations can better understand the effect individual project decisions have on an organization or region's progress towards sustainability goals.

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Measuring Ecosystem Services at a Site Level

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Many of the tools being developed to measure, value, or evaluate ecosystem services are focused towards landscape scale measurement. These landscape level measurement systems are increasingly providing good decision-support tools for high-level and regional planning activities. However, eventually land use and land management decision-making progresses to site-by-site, project-by-project determinations. Accordingly, it is important that decision-makers have access to decision-support tools for site- or project-level decisions.

This presentation would provide a demonstration of EcoMetrix, a non-proprietary tool developed to measure ecosystem services at a site scale. While the primary application of the tool thus far has been in support of ecosystem market transactions (EcoMetrix is integrated into both The Freshwater Trusts online Streambank system and the Willamette Partnerships credit calculation toolbox), the system is equally useful for integrating ecosystem services into planning processes. The presentation will highlight the results of this year's Businesses for Social Responsibility (BSR) Roundtable pilot study in the San Pedro Basin, which includes EcoMetrix as one of the tools being tested.

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Valuing the Priceless: Valuation of Tribal Resources and Services

Barbara Harper and *Stuart Harris*
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Tribal valuation of ecosystem services is in its infancy, and premises and definitions are being discussed at contaminated tribal sites that are engaged in natural resource damage assessment. When a formal valuation is necessary, we believe that two prior steps are crucial: (a) proper description and quantification of tribal services before the valuation step, and (b) reconsideration of value, worth, and currency in subsistence economies. Subsistence currencies are based on labor (time, energy), skill, and knowledge, but also store value in networks (accounts) of reciprocity, obligation, and trust that accrue interest over generations and that determine how materials, services, and information flow within the community. CTUIR is developing methods for tribal service quantification that should prove useful for eventual conversion into various types of credits (say, eco-cultural quality of life units).

A number of tribal sites have bypassed formal valuation of lost services in lieu of simply restoring the resource to baseline conditions. Replacement of land has been suggested, although place-specific cultural aspects of a site or resource cannot be replaced; a multiplier on replacement might be logical based on a cultural HEA (cultural acre-years). Willingness to accept dollars or projects for lost use has been used, but we doubt that it is really equitable for tribes or individuals with little money and low expectations. The choice may be presented as offering nothing versus offering a little for a decision they can do nothing about in any event. In those cases, decision authority is a kind of currency that is withheld from tribes. Another kind of currency might be blood currency, through a revealed preference of willingness to die to protect the homeland. Many other creative equivalents can be envisioned.

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The Impacts of the Deepwater Horizon Oil Blowout: Valuing Lost Ecosystem Services

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The authors illustrate an innovative methodology for calculating relative dollar values for ecosystem services to estimate the ecosystem services lost to the recent oil spill. The effects of the oil released to the environment from the Deepwater Horizon well off the Louisiana coast continue to grow in economic, noneconomic, and ecological terms. British Petroleum (BP) has placed $20 billion in escrow to cover economic and ecological damages. Ideally, good public policy would ensure that compensation would be tied to the social damages associated with the spill, which at this point are not yet known.

NOAA's National Resource Damage Assessment (NRDA) process has been used in the past to estimate the damages associated with oil spills and to identify the projects that will restore the lost and damaged resources. Although NRDA does a good job of characterizing the lost ecological services (primarily habitat) associated with a particular incident (e.g., acres of wetlands and seagrass, and the quantity and type of terrestrial, estuarine, and marine life affected), the total impact of the Deepwater Horizon blowout, said to be the largest environmental catastrophe in the nation's history, presents huge challenges in terms of the vast geographic scale and extensive duration of damages. Because non-market damages, and ecosystem service losses in particular are often time-consuming and expensive to calculate using traditional economic methods, NRDA often employs replacement value to calculate the impact of a spill, which can underestimate true ecological damages. Identification of mitigation strategies is based on cost-effectiveness, but isn't necessarily based on projects that yield the greatest ecological benefits. Consequently, NRDA estimates can often underestimate the true social cost.

This presentation will briefly examine the NRDA process, and postulate an alternative approach to estimating relative ecosystem services lost as a result of the blowout. The views expressed in this paper are those solely of the author, and are not necessarily the views of the Council on Environmental Quality, the Environmental Protection Agency, Harte Research Institute or Texas A&M.

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Using Landscape Vegetation to Sequester Carbon and Reduce Greenhouse Gas Emissions

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As part of the workshop on Qualifying and Quantifying Ecosystem Services: Tools for the Planned and Designed Landscape, this session introduces the urban forestry modeling tools available to both quantify and maximize the greenhouse gas mitigation benefits of landscape vegetation.

Meeting institutional sustainability initiatives and reducing the level of climate change associated with greenhouse gas emissions requires a multi-faceted approach. Current sustainability efforts tend to focus upon "grey" infrastructure and enhanced energy efficiency. Opportunities exist, however, to leverage natural capital assets and manage the landscape "green" infrastructure to both reduce energy consumption and offset existing emissions. This presentation examines the current scientific models available to quantify the atmospheric carbon reduction associated with both remnant woodland vegetation and landscape tree cover.

Landscape trees impact atmospheric carbon levels in two main ways. They directly sequester carbon in both plant biomass and the forest soil, while they also, if properly sited, reduce the energy consumption demands associated with the cooling of human structures. Understanding how to quantify the net benefits associated with this vegetation allows for a fuller integration of the green infrastructure into the design process and can help organizations and institutions meet their respective carbon reduction goals.

(This session is part of a preconference workshop: "Qualifying and Quantifying Ecosystem Services: Tools for the Planned and Designed Landscape")

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Ecosystem Services and the Corps of Engineers: We Identified Them and Now We're Waiting

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Efforts taken to improve the Corps of Engineers (Corps) assessment of its ecosystem restoration efforts have included investigation of ecosystem services as an approach to provide greater information for ecosystem decisions. During 2008 fourteen ecosystem services were identified as affected or influenced by the Corps.

Incorporation of the identified ecosystem services in Corps activities (ecosystem planning, design, and operations) requires identifying how the services are reflected in current practice, how services could be addressed in the future, and how Corps actions will be influenced by the experience with ecosystem services by Corps stakeholders and other agencies.

A number of actions are ongoing to clarify how ecosystem services can be addressed by the Corps. Discussions with Corps planners have produced suggested refinements and revisions to the identified services. The complexity of applying the fourteen identified services in the systems affected by the Corps has produced a recommendation for some sort of organization of the services, perhaps a hierarchy, showing relationship or dependencies of the services (e.g., biodiversity is frequently seen as a foundation or necessary for other services).

Some clarification of the definition of ecosystem services would assist in knowing where in Corps processes to consider ecosystem services. The academic and applied literature looks at services either as components of nature or as benefits or outcomes. Corps policy of restoring degraded structure, function, and dynamics reflects the ecosystem services as components of nature literature; services would be considered as problem identification and plan formulation concerns. The benefits or outcomes viewpoint of services would put them with the project evaluation component – which alternative is preferred-for planning and operations. Clarification is needed on how providing ecosystem services would interact with the need to provide a sustainable project; using resources to produce services could overwhelm a project's ability to be sustainable.

Action on ecosystem services in the Corps awaits the Corps' interpretation and resulting regulations to the "Account for Ecosystem Services" principle included in the 2009 revision of Federal water resources planning policy – the Principles and Standards (P&S). Preparation of this guidance is underway by Corps Headquarters.

While awaiting Corps guidance on P&S implementation, other agencies are considering how to use ecosystem services as a way to respond to public needs and to develop their projects. Corps participation in other agency efforts can help define the Corps response to ecosystem services. The ecosystem services identified in 2008 can be reformulated or reorganized to reflect Corps guidance, processes, and institutional arrangements. As the Corps works to become more conversant in ecosystem services language, projects should be identified that could help define the Corps' role and response to the incorporation of services.

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Water Quality Ecosystem Services in the Urban Environment

Dianna Hogan and *JV Loperfido*
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Urban development generates impervious surface cover, alters watershed flow patterns, and increases the amount of pollutants produced and transported through a watershed, greatly reducing the ability of the landscape to provide important ecosystem services including water quality regulation and habitat provision. Conversion to urban land use is increasing in the Chesapeake Bay watershed even as the Bay is already listed as an impaired water body under the Clean Water Act due to poor water quality and habitat conditions related to nutrient and sediment pollution. Maintaining and improving the health of the Bay requires removal and retention of excess nutrients and sediment originating in the watershed. As land is converted to urban land use, stormwater Best Management Practices (BMPs) are used to try to replace the ecosystem functions of water quality (nutrient and sediment removal and retention) and water quantity and timing once provided by the predevelopment natural landscape.

This work characterizes and evaluates the ability of anthropogenic water quality mitigation protocols to provide ecosystem services in comparison to how the same ecosystem services are provided in natural landscapes. Local level impacts and mitigation need to be mapped and interpreted to improve the ability to scale ecosystem service production and flow up to the regional or landscape level. This project (1) constructed detailed maps of land use and stormwater mitigation practices, (2) identified different BMP implementation patterns and connectivity related to different mitigation policies and practices, (3) initiated stream monitoring and analysis for nitrogen (N), phosphorus (P), and sediment pollution originating from natural and urban watersheds, and (4) is identifying a suite of watershed anthropogenic indicators that may be important in producing the ecosystem service of water quality regulation in urban watersheds.

This presentation will provide an overview of the state of the knowledge on this topic and report on case studies being conducted in Montgomery County, MD and Fairfax County, VA that compare natural and urban areas and different watershed mitigation protocols designed to replace the ecosystem services of water quality regulation and habitat provision in urban environments. This work relates stormwater management policy and resultant mitigation protocol to the provision of ecosystem services in anthropogenic environments. Understanding the ability of structural water quality mitigation facilities to replace water quality functions historically provided by natural wetland and floodplain ecosystems prior to landscape development is essential for improved land use decision making in support of service availability.

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Geospatial Tools for Evaluating Ecosystems Services in Lakes and Ponds of the Northeastern US

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Northeastern lakes benefit residents and visitors by providing valuable ecosystem services such as nutrient retention, recreational opportunities, and aesthetic value. Concurrently, however, complex changes such landscape change, population growth, and management decisions influence lake services both positively and negatively. To better understand and manage these systems, we are developing a database and geospatial tools to explore the association between lake condition and the provisioning of ecosystem services.

The database provides unique identification numbers for over 28,000 geographically referenced lakes which allows us to combine data from the National Lake Survey, the New England Lakes and Ponds Survey, the USGS SPARROW model, aircraft based hyperspectral data of select lakes as well as other datasets. These data include standard physical-chemical measures of water quality and subjective assessments (e.g., appeal, integrity) of lakes.

The geospatial tools are built with ArcGIS server, Oracle, SAS, R, and other applications and are served in an online application that enables mapping and analysis of lake ecosystem services that are sensitive to variations in predicted nitrogen and phosphorus loading. With this online application, we provide access to: 1) lakes monitoring database; 2) modeled nutrient fluxes; 3) state-specific data sets; 4) analytical tools and scripts for exploring associations between nutrients and lake ecosystem services, 5) tools for mapping lake ecosystem services, and 6) prototype ecosystem service production functions, sensitive to variations in predicted nitrogen and phosphorus loading.

These efforts will provide managers and researchers a better understanding of links between management decisions affecting nutrient fluxes and selected ecosystem services; support other novel research questions such as examining the link between ecological condition and human health; and provide our many partners with reproducible research that enhances understanding of our work, and encourages using similar approaches and analyses in novel ways.

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Application of Artificial Intelligence for Ecosystem Services (ARIES) for Assessing Flows of Freshwater Services in the La Antigua Watershed, Veracruz, Mexico

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The purpose of this research was to demonstrate an application of the Artificial Intelligence for Ecosystem Services (ARIES) model platform for assessing flows of freshwater provision in the La Antigua watershed in Veracruz, Mexico. ARIES is a new methodology developed for making environmental decisions easier and more effective through a web based application.

The main aim of the work was to map and quantify the actual physical flow of freshwater services across the landscape from the provision of the service to their beneficiaries. Namely we examined the following beneficiary groups: agricultural water use for livestock and crops, municipal drinking water supply, industrial power and water supply, and recreational rafting and fishing uses.

In order to map and quantify the services for each beneficiary we developed explicit conceptual models that logically describe the linkages of the relevant spatial variables. This framework incorporates both well understood deterministic models and, where deterministic models are unavailable, expert consensus. Secondly, using these principles, we modeled the sources that provide and the sinks (i.e., regions of runoff, infiltration, and evapotranspiration) that impact the delivery of fresh water. Thirdly, using the above relationships and artificial intelligence techniques (i.e., machine reasoning, pattern recognition) deployed via ARIES, we built ad-hoc probabilistic Bayesian models to define our networks. Lastly, we used an agent-based spatial flow model, also deployed via ARIES, to simulate the magnitude of the freshwater services flows across the landscape. This approach allows for the explicit linkage between ecosystem service source areas and the users deriving benefits from that region.

Finally, by presenting the results (e.g., freshwater service density plots, uncertainty maps) to local decision-makers in Mexico we hope to demonstrate the usefulness of this approach for guiding future landscape planning decisions. In the presentation we will report on the feedback and recommendations we receive during a workshop planned for the Veracruz region in October 2010.

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Monitoring and Predicting Spatiotemporal Water Surface Dynamics of Topographic Depressions in the Prairie Pothole Region from Remote Sensing and Hydrological Models

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With an area of about 715,000 km^2, the Prairie Pothole Region (PPR) of North America extends from north-central Iowa to central Alberta. The landscape of the PPR is dotted with many small wetlands created during the last glacial retreat approximately 12,000 years ago. The inter- and intra-annual water surface change is a key factor in regulating many ecosystem services, including carbon sequestration, floodwater retention, waterfowl production, and pollution reduction. However, the spatiotemporal water area dynamics of each wetland in the PPR has not been well monitored and modeled for several reasons. First, most of the wetlands in the PPR are small and thus cannot be detected by conventional remote sensing data at a resolution of 30-60m, such Landsat Enhanced Thematic Mapper Plus (ETM+) and ResourceSat-1 Advanced Wide Field Sensor (AWiFS) sensors. Second, most of the region is relatively flat and the current Digital Elevation Models (DEM) with resolution up to 10 m are usually inadequate to capture those small wetlands. Third, the PPR is very large, and spatiotemporally limited high-resolution aerial photos are not practical to cover large areas. To counteract these deficiencies, we are developing a system to monitor and predict the spatiotemporal water area change of each wetland by combining remote sensing and hydrological models. Some of the features/highlights are: (1) Small bodies of water can be mapped with moderate-resolution satellite data using methods that map water as subpixel fractions using field measurements or high-resolution images as training datasets. A method that uses a regression tree technique and 30-60m ETM+ and images for training the regression tree that, in turn, is applied to the same image to map subpixel water. (2) We developed a 0.5-m bare earth model from Light Detection And Ranging (LiDAR) data which was freely available at http://lidar.cr.usgs.gov/. In combination with National Wetlands Inventory (NWI) data, we subsequently delineated wetland catchments and their spilling points. From the delineated catchments and spill points, we calculated the water storage capacity of each individual basin. We also modeled the water routing by considering connectivity among basins. (3) We have been developing water mass balance models, considering climate, soil, land cover, snowmelt, surface runoff, evapotranspiration, and groundwater, to estimate the time-series change of water volume of each wetland. (4) In each wetland, we have been modeling the water surface dynamics from water volume and wetland morphology. The modeling results of big lakes are being compared and regulated by the results from remote sensing classification, which is being used to calibrate small depressional wetlands. (5) The water dynamics are compared to multiple aerial photos for accuracy validation of the water surface area.

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Prioritization of Habitat Management Areas using Stakeholder Values of Ecosystem Services within a GIS Framework

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Ecosystem-based management is a holistic approach to natural resource management that incorporates data analysis of interactions between humans and the environment on both a temporal and spatial scale. An Ecosystem-based Habitat Management Plan (EBHMP) was developed by determining priority areas and projects for habitat conservation, preservation and restoration within the Corpus Christi/Nueces Bay area in the Coastal Bend of Texas. This study focused on answering three questions: 1) What ecosystem services are provided by targeted habitats 2) What is the relative importance of the ecosystem services provided by these habitats, and 3) How do priority areas designated by stakeholders relate to the perceived value of habitats within the study area? Stakeholders of the EBHMP represent state, federal, and local governments, non-governmental organizations, academia, and industry and development. Survey data was used to measure perceived ecosystem services based on empirical knowledge from local stakeholders, and relative values of ecosystem services was assessed and incorporated into a stakeholder value matrix (SVM). Spatial application of habitat values derived from the SVM was visualized using GIS and integrated into a “heat map” that highlights the values of each area. The “heat map” allows for easy identification of priority areas for habitat management and conservation. Results of the SVM and GIS analysis were incorporated into an adaptive management plan to enable stakeholders to make informed decisions regarding priority areas for conservation and/or active management. To facilitate active and adaptive management practices, data relevant to the study area are incorporated into an online database.

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Improved Mapping of Riparian Wetlands Using Reach Topography

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Riparian wetlands provide a suite of ecosystems services including floodwater retention, biogeochemical processing, and habitat provisioning. However in one mid-Atlantic watershed the National Wetlands Inventory was shown to underrepresent these systems by greater than 50%. These hydrologically and physically complex floodplain systems occur where there is vertical, horizontal, and longitudinal hydrologic connectivity between the floodplain and the stream and groundwater systems. Stream reaches that have floodplain and wetland habitats typically are unconstrained latitudinally and longitudinally where overbank flooding can occur, and where there is regional, groundwater discharge at the toe-of-slopes. Building on this knowledge, the goal of this study was to improve the spatial prediction of headwater riparian wetlands through identification of suitable reach settings that allow for this three dimensional exchange of water. In the Shaver's Creek drainage, a small watershed in the Ridge and Valley Physiographic Province of Pennsylvania, known locations of mapped, non-open water National Wetlands Inventory (NWI) wetlands, field-identified non-NWI wetlands, and non-wetland locations (n=40, 30, and 35, respectively) were used to build a predictive partition tree. Predictive variables were Digital Elevation Map-derived topographic indices for the stream reaches: valley width, mean stream slope, and contributing area. The partition tree resulted in a 5-node tree with classes ranging from very high to very low likelihood of wetland occurrence or least constrained to most constrained. The overall R^2 of the tree was 0.61, however two of the classes (very high likelihood and very low likelihood) comprised ~70% of the study reaches and were classified with accuracy >94%. This classification is a useful approach to characterizing likely floodplain wetland and non-floodplain wetland supporting reach settings, especially in screening out the least likely wetland-supporting or most constrained reaches within a watershed. This approach could be developed in other physiographic settings, and could be useful in identifying unmapped wetlands for field study, siting potential restoration efforts, and scaling up findings from site-level to watershed-wide inferences.

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Supplying Ecosystem Services: Conservation and Management Decisions of Farm Operators in Eastern North Carolina

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The purpose of this research is to examine how market-based incentives through conservation programs and/or environmental markets could be utilized to enhance ecosystem service (ES) production on private land in eastern North Carolina (NC). The research was carried out in two phases: a farm operator survey and a cash flow analysis of farm operation management options. The mail survey was administered in six NC counties from August to October 2008 and resulted in 295 usable returned questionnaires. The survey revealed that fifty percent of respondents had participated in conservation programs in the past and were generally satisfied with their experience. Although there was some unfamiliarity with ES terminology (e.g., carbon storage), a majority of respondents were interested in future payment-for-ecosystem-services (PES) programs, especially those involving wildlife habitat or water quality. Employing choice experiments in which respondents selected among hypothetical PES programs, we found that payment level exerted a positive, statistically significant influence on respondents' decisions to enroll, whereas program contract length and program administration by a conservation NGO or private company had significant negative effects. Overall, these insights into landowner preferences for conservation programs could assist the design and marketing of new programs to more effectively engage landowners and thus enhance privately supplied ES.

Using a cash flow analysis approach, the costs of supplying ES on private land were estimated by assessing farmer land management decisions with regard to profitability of different management options. Drawing on data from the USDA and the abovementioned survey, hypothetical, representative farms were formed for the two agricultural zones in the study area, as was a baseline scenario reflecting conventional management (e.g., growing corn with conventional tillage) of the farms. For comparative purposes, the following four scenarios were created: conservation low, conservation high, carbon low, carbon high. The conservation scenarios depict two levels of participation, expressed in number of acres, in USDA conservation programs. Positing low ($5 per ton of CO_2) or high ($30/t$CO_2$) carbon prices, the carbon scenarios assume that the farmer "grows" and sells carbon stacked on top of the conservation programs. For each scenario, the net present value per acre of farm profits was calculated over a forty-year time horizon. We found that economic returns are similar for the baseline, low conservation, and low carbon scenarios, somewhat greater for high conservation, and by far the most attractive for high carbon. These results indicate that management alternatives like conservation programs and growing carbon can be combined profitably with conventional management, or potentially supplant it altogether.

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Service Path Attribution Networks (SPANs): Spatially Quantifying Ecosystem Service Flows

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Ecosystem services are the effects on human well-being of the flow of benefits from ecosystems to people over given extents of space and time. The Service Path Attribution Network (SPAN) model provides a spatial framework for quantifying these flows, providing a new means of estimating these economic benefits. Each ecosystem service is defined in terms of the flow of some form of matter, energy, or information, known as the service medium, from an ecosystem source to a human user. The service may be realized either by providing a measurable positive flow of this medium to the user, or in those cases where the medium is considered harmful (flood water, unwanted sediment or nutrients, wildfire), the service may be provided by an ecosystem preventing such a flow to vulnerable human groups.

A 4-tuple (S,K,U,F) of functions describe the spatial distribution of the service's main interacting components.

Symbol	Name	Description
S	Source	service medium production capacity by landscape
K	Sink	service medium absorption capacity by landscape
U	Use	human demand for or vulnerability to the medium
F	Flow	movement algorithm from source to use locations

The landscape under study is then projected onto a network of locations, and the Flow algorithm is applied iteratively until all of the service medium has been moved from sources into either sinks, uses, landscape flow traps, or out of the study area. A weighted graph of the service medium flow routes is then constructed and analyzed to calculate the additionality and related marginal utility provided by each landscape source or sink to each use location. Route topology is also assessed to identify bottlenecks in medium flow and areas critical to its preservation (or likewise most effective at blocking it). This approach discovers dependencies between provision and usage endpoints, spatial competition among users for scarce resources, and landscape effects on ecosystem service flows. Particularly novel is the model's ability to identify the relative density of these flows throughout landscapes and to determine which areas are affected by upstream flow depletion. span models have been developed for a number of services(aesthetic viewsheds, proximity to open space, carbon sequestration, surface water provision, flood mitigation, nutrient cycling, and avoided sedimentation/deposition), which vary in scale of effect, mechanism of provision and use, and type of flow. Results have been derived using real world data from case studies in VT, Madagascar, and the US Puget Sound region.

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Issues Associated with Downscaling National Ecosystem Services Assessments to Local Scales: A Case Study from a National Assessment of Riparian Ecosystems of the U.S.

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An important issue in assessing ecosystem services across broad areas is the degree to which nationally consistent biophysical data, such as land cover, and models can be used to assess local scale conditions in ecosystems services and visa versa. Downscaling of national biophysical data often lack spatial and thematic resolution needed to be informative at local scales. Models established at national scales often are too general to capture processes at local scales. Conversely, models developed at local scales often poorly represent biophysical, economic, and social processes at regional and national scales. Moreover, very detailed biophysical data (e.g., spatial and attribute resolution) constructed at local scales may be logistically impossible to construct over broad scales. A framework is needed that permits logical levels of upscaling and downscaling to assess ecosystem processes and associated services. We discuss these issues within the context of a recently completed national-scale assessment of riparian habitat changes. We use this study to illustrate problems with upscaling and downscaling and discuss issues and possible solutions.

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The State of Ecosystem Services Implementation

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The objectives of this presentation are to illustrate the various approaches that are being used to formulate ecosystem services projects and the state-of-the-art processes through which projects are implemented. Multiple methods were used to achieve these objectives. First, we conducted an internet search to identify ecosystem service project websites and other downloadable information. Content from the internet search was analyzed to identify the range and frequency of conceptual approaches and implementation strategies used. Second, we conducted a survey of international organizations known to be involved with strategic planning to implement ecosystem services concepts. The survey was developed in and conducted online using Key Survey software. Key Survey sent each potential respondent a unique link to the survey, followed up automatically with email reminders to those who had not yet completed the survey, and eliminated data entry errors. We present methodologies used to evaluate the state-of-implementation of the ecosystem service concept. The degree of project implementation ranged from early stage planning and conceptualization to implementation of an adaptive management phase. Discussion will also highlight results from the survey, including motivations for conducting projects and characteristics of projects that have successfully implemented ecosystem services concepts.

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Ecosystem Services of Coastal Habitats and Fisheries: Multi-scale Modeling

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Coastal commercial fisheries for species such as shrimp, crab, and oyster are associated with valuable provisioning and cultural services in addition to their direct economic benefits. These fisheries, in turn, are supported by critical shallow water and shoreline habitats, in large part because these habitats are essential to survival of early life stages. Although the supporting functions of habitats operate at very small spatial and temporal scales, their contributions accumulate over space and time to produce fishery resources that extend over large, multi-state regions. Likewise, depredations that reduce the extent of critical habitats accumulate spatially and temporally, thereby reducing the services and values of coastal ecosystems. We have developed models of blue crab and penaeid shrimp fisheries in the northern Gulf of Mexico to project the long-term, spatially extensive consequences of marginal losses or gains in coastal habitats. The models can be scaled to scenarios at multiple spatial scales. We present examples of simulations at Gulf-wide and individual estuary scales.

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Wetlands as Sinks for Reactive Nitrogen at Continental and Global Scales

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Wetlands support physical and ecological functions, including removal of reactive nitrogen (Nr) from surface water and groundwater, that result in valuable services to society. We compiled published data from wetland studies worldwide to estimate total Nr removal and to evaluate factors that influence removal rates. Over several orders of magnitude in wetland area and Nr loading rates, there is a positive, near-linear relationship between Nr removal and Nr loading. Total Nr removal by major classes of wetlands in the contiguous U.S. is ~20-21% of the total anthropogenic inputs of Nr to the region. Worldwide, Nr removal by wetlands is roughly 17% of anthropogenic Nr inputs. Historical loss of 50% of native wetland area in the U.S. and globally suggests an equivalent loss of Nr removal capacity. Expanded protection and large-scale restoration of wetlands should be considered in strategies to re-balance the global nitrogen cycle and mitigate the negative consequences of excess Nr loading.

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Towards Predictive/Operational Assessment of Beach Closures Using Remotely Sensed Data

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Partnering with the EPA on NASA Earth Science on **R**esearch **O**pportunities in **S**pace and **E**arth **S**ciences (ROSES 2008), EIM Sensor has demonstrated the company's ability to design and develop a comprehensive coastal water observation solution. EIM Sensor has worked on several environmental projects which engage stakeholders with Federal, State, and local agencies participating in research and ecological model development activities. Our goal is to optimize ecological forecasting capabilities to perform near real-time assessments related to coastal environmental conditions to maximize the benefits of ecosystem services and reduce risk to the public.

EIM Sensor is performing research and model development to create improved forecasting tools to enhance the value of ecosystem services provided to the public and coastal regions. By improving monitoring efficiency data collection activities, it is envisioned that these new tools will be leveraged to enhance policy and decisions making at multiple scales.

By combining NASA Earth Science products with empirical models of beach contamination, EIM Sensor aims to provide decision-makers with operational tools to gain a better situational awareness of potentially hazardous conditions in beach ecosystems. Better forecasting tools will maximize the extremely valuable ecological services to humans that many urban coastal regions provide and enhance the revenue base to their associated communities.

Week old toxicology reports and data sets are currently the only indicators beach managers, activity coordinators, and the general public use in decision making about potential risks along beaches and coastal areas. Their understanding of the levels of hazards such as *Enterococcus* and *Fecal Coliform* has a direct impact on decision making at multiple levels and the potential for maximizing the usefulness of the beach resource.

The ongoing research is being conducted in Pensacola Beach, Florida with current beach management activities in order to make potential users a part of the development cycle. The monitoring sample sites were strategically selected via collaboration with EPA scientists, regional planners, and decision-makers. This research therefore provides better environmental data for decision-makers and maximizes the benefits of ecosystems services against the benefits of manmade development projects.

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Effect of Climate, Age and Management Intensity on Nutrient Storage in USDA Restored Wetlands in California's Central Valley

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Natural wetland ecosystems perform critical services that support human activities. Among these, water quality protection and improvement and atmospheric stabilization are counted among the most important. Historically, the degradation of wetlands has been more rapid than any other ecosystem. In California's Central Valley (CCV), over 90% of the historic wetlands were destroyed to make way for agriculture and urban expansion. In the early 1990s, the United States Department of Agriculture initiated the Wetland Reserve Program (WRP), one of several programs that have protected hundreds of thousands of acres of previously cultivated cropland. In addition to assessing program effectiveness, our work aims to provide strategic science based support for managers. Nutrient enrichment of streams from agricultural runoff is a serious problem in the CCV. Recent studies indicate that nutrient loading poses a threat to drinking water supplies and already endangered fish species. Nutrient uptake by wetland plants may mitigate this to some extent. We evaluated nutrient storage in WRP vegetation along climatic, age and management gradients. Our data indicates that climate plays a significant role in carbon, nitrogen and phosphorous storage. Sites in the drier southern CCV sequestered significantly less than those in the Sacramento and San Joaquin River basins further north. Furthermore, intensive management practices may be detrimental to nutrient storage. Based on our results, WRP in the CCV stores about 63 tons of nitrogen, 2400 tons of carbon and 525 tons of phosphorous in the wetlands shallow marsh vegetation alone. However, management strategies may impact benefits accrued over time.

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An Attempt at the Economic Valuation of Waste Bioremediation Service in Brackish Estuaries (Gulf of Gdańsk - the Southern Baltic Sea)

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The ocean bottom is the most widespread habitat in the world. It is characterized by a vast biodiversity and it performs numerous, crucial ecosystem services. In the same time it is the place where a large amount of organic and inorganic waste materials are accumulated. The mentioned waste materials undergo a natural bioremediation which consists of many processes like decomposition, storage, accumulation, dilution, assimilation, chemical decomposition and redistribution. The role of benthic habitats in removing pollutants and regulating the quality of water is undisputable. The benefits of ecosystem regulating services for people are still remaining unmeasured.

The aim of this work is to identify sedimentary habitats (sea grass beds, blue mussels beds, soft-bottom habitats) and shore habitats (beaches, reed fields) which supply the service of waste bioremediation. In relation to the fact that decreased biodiversity of habitats is followed by ecosystem's reduced ability to process the waste materials it is aimed to estimate the efficiency of these habitats to perform the bioremediation of waste materials as well. In the project a real participation of particular habitats in waste bioremediation will be shown. The rates that should be taken into consideration while evaluating this ecosystem service (the reduction of nitrogen/phosphorus concentration; increase in water transparency; BOD_5/day and others) will be analysed as well.

The above analysis will allow to indicate these habitats from Gulf of Gdańsk which play a major role in performing the bioremediation service and point out their effectiveness in removing waste materials.

The quality of water in sea ecosystems is the result of many interweaving processes. Various habitats supply the bioremediation service of waste materials and take part in it at a different degree. It is necessary to concentrate on these habitats which contribute the most in discussed environmental service, choose one type of the waste material and unify fixed degrees of reduction that were established for different habitats.

The best way to estimate the economic value of waste bioremediation is the replacement cost method. Under certain conditions it can be used for evaluating the indirect use values. In addition a the Contingent Valuation Method will be applied in order to reaffirm the economic value that was estimated while using the replacement cost method.

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Identifying Links between Ecosystem Services and Aboriginal Well-being and Livelihoods in North Australia: Applying the Millennium Ecosystem Assessment Framework

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The livelihoods and well-being of Aboriginal and non-Aboriginal communities in remote and rural northern Australia are dependent upon the ecosystem services provided by tropical ecosystems. The well-being of all Australian citizens is measured by the Australia Bureau of Statistics (ABS) using socio-economic indicators. In this study we investigated the importance of non-market benefits derived from ecosystem services for Aboriginal well-being. Through a case study with the Mullunburra-Yidinji people in the Wet Tropics, Queensland, we applied the Millennium Ecosystem Assessment (MA) framework to identify the links between ecosystem services and the MA's six constituents of human well-being. The study demonstrated that cultural and provisioning services were key determinants of community well-being, and these are not currently measured by the ABS. We adapt the MA framework to include the ABS indicators and explore the potential strengths and weaknesses of the approach for measuring the well-being of contemporary remote and rural Aboriginal communities.

Keywords: Aboriginal people, human well-being, ecosystem services, livelihoods. Millennium Ecosystem Assessment, Wet Tropics.

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Linking an Ecosystem Process Model to Ecosystem Services

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Current research on the spatial mapping of ecosystem services tends to rely on statistical or correlation data of land use or land cover (LULC) characteristics and patterns. While this method captures the current state of services closely linked to LULC, it is unable at present to account for the integrated ecosystem processes that drive the presence, amounts, and flows of many ecosystem services. We propose that utilizing ecosystem process models in combination with traditional methods of ecosystem service mapping can be used to explore the relationship between ecosystem function and services. Our study site is the exurban landscape of southeast Michigan, which is characterized by a mixture of residential housing, agriculture and natural ecosystems. We use the ecosystem process model BIOME-BGC in the context of a human dominated system. BIOME-BGC uses climatic drivers and vegetation parameters as inputs to calculate productivity and nutrient flows within a given ecosystem. These outputs could then be used to estimate patterns and flows of ecosystem services in the landscape. By linking spatially explicit data to an ecosystem process model we increase our ability map certain ecosystem services over space and time.

We have found that the strengths of linking ecosystem processes to ecosystem services with BIOME-BGC are that some regulating and supporting services can be directly calculated such as nitrogen retention, carbon sequestration and soil fertility. BIOME-BGC can also be used to help quantify and map services such as local climate regulation, water quality and harvestable biomass. The weaknesses we have found include the inability to improve models of cultural services since these are driven more by human values than ecological processes. However, more detailed research on ecosystem service bundles may allow for ecosystem process models to indirectly inform cultural services in the future. Also, BIOME-BGC does not incorporate vegetative structure and thus services such as wildlife habitat can't be inferred using this method.

Linking an ecosystem process model with ecosystem services can improve our current methods of mapping the location and quantity of ecosystem services. This technique can also be used to simulate the ways human management may alter flows of services, the relationships services have to one another, and how feedbacks within ecological systems can affect ecosystem services. This method could also be used to predict the location of ecosystem services in the future under different management, development, and climate scenarios.

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Understanding Off-Site Ecosystem Service Flows

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Following the Millennium Ecosystem Assessment it has become conventional to describe the human interest in the biophysical world in terms of a set of services that directly or indirectly contribute to wellbeing. These comprise benefits that people exploit both directly (the provisioning and cultural services) and indirectly (the supporting and regulating services). The rapid evolution of coupled human-natural systems changes the flow of the ecosystem services, and hence the way that landscapes should be managed. Yet many significant changes in ecosystem services are neither identified nor taken into account by land users. Particularly problematic are ecosystem services that affect people at some distance, but whose value is not reflected in market prices. Indeed, understanding ecosystem service flows of this kind is identified as among the key research challenges posed by the Millennium Assessment (Carpenter et al, 2009). The research reported addresses the following question: If the full array of (spatially and temporally distributed) ecosystem services delivered by specific landscapes, and the full set of (spatially and temporally distributed) beneficiaries of those services are taken into account, how should this affect landscape management?

The research is designed to extend existing work in three ways. First, identification and mapping of the land use-contingent ecosystem services provided by a reference landscape is extended in space and time. We identify the biophysical transport mechanisms (e.g. hydrological and atmospheric transport systems) and socio-economic networks (e.g. trade routes) that distribute ecosystem services and disservices off-site, find measures of the associated ecosystem service flows, and test the sensitivity of these flows to variations in economic and environmental conditions. Second, we identify the off-site beneficiaries of those distributed ecosystem services for which there are no market prices (or where market prices do not reflect social opportunity costs), and estimate the value of services to distinct sets of beneficiaries. Third, we identify governance mechanisms – institutions and incentive systems – that have the potential to induce optimal provision of ecosystem services at the landscape scale. Specifically, we will consider landscapes that deliver a range of ecosystem services at different geographical scales, and investigate the relationship between the scale of landscape management and the scale of the effects of landscape management. We investigate how inclusion of a range of services with widely varying temporal and spatial impacts affects the sustainability of conservation and use strategies.

The research is illustrated by reference to the ecosystem services flows associated with the Panama Canal Watershed, which is currently being investigated in partnership with the Smithsonian Tropical Research Institute.

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Defining the Role of the Ecosystem Services Concept in Public Lands Management

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The USDA Forest Service has embraced the concept of ecosystem services as an organizing framework for characterizing the range of benefits that public and private forest lands provide to people. The concept of ecosystem services links ecosystems to human well-being. It can facilitate forest planning and management by: (1) defining the goods and services that result from policy and management actions; (2) describing how actions lead to outcomes in terms of changes in these goods and services; and (3) describing the tradeoffs inherent in management of public lands to assist in garnering public input and making decisions.

Although appealing from a theoretical perspective, using the ecosystem services concept as a basis for landscape analysis and management decisions presents many challenges in practice. Meeting those challenges will require the combined efforts of researchers from a variety of disciplines (e.g. ecology, economics, sociology) to devise methods for characterizing ecosystem services in a manner that suits the perspectives and informational and analytical objectives of forest managers and the public. In this study, we propose a conceptual framework—including a common language and set of conceptual elements—around which collaboration can take place. We will: (1) present an intuitive conceptual framework for describing the ecosystem services provided by forest landscapes and their influence on human welfare; (2) outline key steps involved in using the framework as a basis for landscape analysis, including data and analytical requirements; and (3) discuss in detail the complexities of implementing such a framework in practice, and provide suggestions for ways to implement the framework with minimal primary data collection and modeling, while maintaining scientific integrity. Our overarching objective is to improve understanding and discourse among policymakers, managers, stakeholders, and the public, and to facilitate the development of cost-effective and timely landscape analyses and decision-making processes that consider ecosystem services outcomes and their values as key criteria of management choices.

Our conceptual framework is strongly rooted in the work conducted by environmental economists during the 1970s and 1980s regarding multiple use forestry (e.g., Bowes and Krutilla, Peterson and Randall, Brown). We view ecosystem services largely as an expanded choice set of variables under consideration when managing public lands. Our framework defines and characterizes tradeoffs among ecosystem services in ways that allow ecological and socio-economic models to be effectively linked and applied to forest planning and management decisions using both quantitative and qualitative characterizations of tradeoffs. We acknowledge, however, that characterizing tradeoffs is not a sufficient condition for conducting sound management. Public acceptance of a chosen management alternative also depends on fostering trust among the public and stakeholders that public land management agencies are acting in the best long term interests of the public and their preferences regarding public lands. Our framework includes consideration of how to present information to the public and stakeholders to highlight the long term effects of management actions envisioned by managers regarding forest and ecosystem health.

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The Ecosystem Services of Urban Forests: Enhancing Carbon Storage with Carbon Offset Projects in the City of Tampa, Florida

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This paper examines how carbon offset projects might be used to enhance urban forest programs. These projects have the potential to enhance the ecosystem services of trees in the urban setting that include carbon storage, improved air quality, storm water runoff mitigation, animal habitat, and a better quality of life.

In 2008 and 2009, urban forest carbon offset projects were designed to offset greenhouse gas emissions from the University of South Florida's Annual “Going Green” Expo. In 2008, trees were planted in a City of Tampa public park, and the carbon offset project was evaluated one year after the tree plantings to identify successes and failures in an effort to improve upon the 2009 tree planting program. In 2009, a City of Tampa neighborhood was selected to plant trees through the City of Tampa’s Tree Planting Program. Volunteers from EcoAsset Solutions, LLC, the City of Tampa’s Beautification Program, and a University of South Florida fraternity were utilized to plant trees throughout the city neighborhood. A geospatial database was constructed for the trees planted in 2009 and a data management and carbon sequestration tracking system was developed to monitor the trees through time.

This paper summarizes the approach for each year’s carbon offset project; presents the methods used to quantify greenhouse gas emissions from the environmental expo and to track carbon sequestration from annual tree growth; and, provides lessons learned and recommendations for governmental and/or organizational entities interested in developing future carbon offset projects. This research demonstrates that there are benefits to urban forests and ecosystems services that can result from carbon offset programs.

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Impacts of Invasive Asian Carps on Freshwater Ecosystems

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Asian bighead and silver carps have been introduced around the world for human food and for biological control of undesirable plankton. These large-bodied planktivores sometimes become abundant and dominate fish biomass. Such has been the case in parts of the USA where these fishes have become established. Bighead and silver carps were introduced in the country in the 1970s and quickly escaped into waters beyond their original intended uses. They have continued to spread into new areas, are now established throughout much of the Mississippi River basin, and are poised to enter the Great Lakes. In this talk we will discuss some of the documented impacts Asian carps have had on ecosystem services where they have become established outside of their native range, including in the USA.

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Interacting Coastal-Based Ecosystem Services in Puget Sound: Recreation and Water Quality

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Coastal recreational opportunities and water quality are major contributors to human well-being in Puget Sound. These ecosystem services also interact, creating opportunities for ecosystem based management and ecological restoration that could positively affect people and the environment. Yet the effect of environmental quality on human behavior is poorly quantified. To clarify this effect we investigate a water quality dataset for evidence that environmental condition partially explains variation in recreational visitation, our indicator of human behavior.

We test for the effect in both travel cost method (TCM) and fixed effects (FE) models. The TCM relates annual recreational visitation to environmental conditions, park characteristics, travel cost, and recreational demand. Our proxy for perceptions of environmental condition was *E. coli* surveys at each park. We estimated travel time from Seattle to each State Park via a road and ferry transportation network dataset. With a subset of the data containing origins and destinations of park visitors we constructed a demand function that relates the visitation rate to the distance traveled. We then used this function to aggregate population within Puget Sound around each park according to the empirical distance decay relationship. This function allowed the inclusion of the effect of population size around a park on visitation rate. Using the FE technique we controlled for all time-invariant unobserved variables and compared monthly variation at the park level to determine how water quality affects visitation during the summer season.

Using 57 State Parks throughout Puget Sound, our TCM model explains nearly 70% of the variation in mean annual visitation. Seven significant variables were retained in the best model through an AIC model selection process. The variables that increased visitation include the number of campsites at a park, the park size, and the number of possible park activities. Variables that negatively affected visitation included a dummy variable for limited accessibility, the aggregated population surrounding each park, travel time, and *E. coli* counts. In the FE analysis, monthly visitation was negatively related to *E. coli* counts while controlling for monthly visitation trends. This indicates people are responding to changes in water quality, and an improvement would yield an increase in the value of recreation. Together, these results could help in prioritizing water quality improvements, could assist the creation of new parks or the modification of existing infrastructure, and provide quantitative estimates for the expected benefits from potential changes in recreational visitation and water quality improvements. These results could also be monetized to determine the changes in ecosystem service value among scenarios or for a given restoration or management action.

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Integrated Ecological, Economic, and Quality-of-Life Evaluations for Land Use Planning Decision Support in South Florida: The South Florida Ecosystem Portfolio Model

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The U.G. Geological Survey (USGS) **Ecosystem Portfolio Model (EPM)** is an online multicriteria decision-support tool created to support land use and ecosystem restoration planning. There are currently three applications of the EPM: the South Florida EPM, the Puget Sound EPM, and the Santa Cruz Watershed EPM (Arizona/Sonora). In the current versions of these applications, the EPM evaluates changes in ecological values (ecosystem services, valued ecosystem components, and other ecological criteria), economic criteria (land price), and community quality-of-life criteria (natural hazard risks and vulnerability of human populations related to ecosystem services, housing affordability, and others) for scenarios of land-use management, water resources practices, and climate change impacts, mitigation and adaptation, where each individual application focuses on a subset of these criteria specific to the case study. Our Department of the Interior-centric place-based strategy is to focus only on regional land use/natural resources planning case studies involving the intersection of priority ecosystems issues that are of direct interest to Department of the Interior agencies and missions that also have substantial interest from local partners. The place-based approach allows us to create custom web interfaces that are easy to use (little GIS or specific model expertise required) for simultaneously creating and evaluating land-use scenarios and exploring ecosystem services and community quality-of-life. The multicriteria framework and use of scenario building promotes the integration of diverse expertise and interdisciplinary models, while recognizing the large uncertainties involved.

This talk focuses on the South Florida EPM, which is designed to be used by land-use planners and ecosystem restoration planners at the county and regional scales. As currently formulated, it focuses on the regional planning interests of the National Parks and Refuges in South Florida. 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. The current prototype focuses on Miami-Dade County, but plans are underway for extending the model suite to other Counties and possibly the region, starting with Broward County. Furthermore, new efforts on characterizing sea-level rise vulnerability within integrated land-use/sea level rise scenarios of interest to County agencies are underway. To tailor the South Florida EPM application to its particular planning context, we have worked with local potential users and stakeholders to scope the issues, management questions, performance criteria and metrics related to the questions, values placed on criteria, time horizons, and spatial contexts specific to that context. As the case study develops and the modeling tools are iteratively improved, user and stakeholder values (expressed using multiattribute utility approaches) will continue to be explored and refined.

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A Systematic Approach for Quantifying Final Ecosystems Services at Regional and National Scales

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Since the development of the Millennium Ecosystem Assessment (2005), there have been a myriad of proposals regarding how to apply ecosystem services concepts in routine, systematic ways to support standards, markets and assessments of ecosystems services. The key question being addressed by multiple groups world-wide is “what where and when do we measure ecosystem service in order to facilitate quantification and, ultimately, human well being in space and time?” Quantification is the key issue relating to natural science, while human well being is the key issue relating to social/economic science. It is in the solutions to this quantification question that the nexus of modeling, monitoring, mapping and decision science must be integrated into a single focused effort. Key issues to be resolved include identifying the sampling units and the indicators, determining how they are arrayed over the landscape, and identifying what measurements to make relating to the ecosystem services. With current technology, it is doubtful that a census of all ecosystem services can be provided at regional to national scales. Therefore, two major pillars of research are needed (a) the capacity to quantitatively link biophysical features and patterns to human well being , and (b) probability approaches to sampling and estimation of the ecosystem services within defined reporting units, consisting of a finite number of sampling units.

The concept of Final Ecosystem Services (FES), those services important to humans and requiring little further explanation, appears to be an emerging and unifying concept that directly resonates with the general public and, when approached from the perspective of the user of particular ecosystem categories, cleanly avoids the dilemma of double counting. Leading from FES it is possible to identify key user groups for FES derived from a specific ecosystem category (e.g. streams, wetlands, forests, etc.) and to select those indicators of FES that are most robust, informative and economical. One fundamental requirement for applying this approach is to make sure terms are clearly defined and that methods are clearly articulated and systematically followed.

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Effectiveness of Wetland Conservation Practices for Pollutant Regulation

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Due to the substantial effect of agriculture on the extent and ability of wetlands to function, the U.S. Department of Agriculture (USDA) serves a key role in wetland conservation and restoration. The USDA has implemented several different conservation programs (e.g., the Wetland Reserve Program) with the aim of enhancing the delivery of key wetland ecosystem services (e.g., pollution control and habitat provision). In order for the USDA to best allocate funds, a better understanding of the impact of wetland conservation practices on the delivery of ecosystem services is necessary. Initiated in 2007, the Choptank Watershed Wetland Conservation Effects Assessment Project (CEAP) brings together an interdisciplinary group of experts and resources from multiple federal agencies, including the Natural Resources Conservation Service, the Agricultural Research Service, the U.S. Geological Survey, and the U.S. Forest Service, and the University of Maryland to assess the ability of wetlands with native vegetation, wetlands where conservation practices had been applied (i.e., wetland restoration and shallow water management areas), and prior-converted croplands to improve water quality in the Choptank River – a tributary of the Chesapeake Bay with high nutrient and sediment loads originating from agriculture. *In situ* observations, including samples of water quality and quantity collected from shallow piezometers, deep core drilling, and surface water, were combined with maps derived from remotely sensed imagery to estimate pollutant regulation services (e.g., nitrate transformation) being provided at nine study sites. Findings demonstrate, not only the ability of restored wetlands and shallow water management areas to reduce pollutants, but also the importance of prior-converted croplands (i.e., historic wetlands) to the improvement of water quality. Shallow ground-water flow paths were found to be critical vectors for nitrogen transport between croplands, wetlands and adjacent streams. Remotely sensed imagery, including LiDAR and radar, show considerable potential for the mapping of key wetland parameters controlling the provision of pollutant regulation services, including the mapping of wetness and wetland-stream surface water connectivity. Project findings will be used to assess and improve the effectiveness of conservation practices and Farm Bill programs affecting wetlands and associated lands in the Mid-Atlantic Coastal Plain.

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Climate Change, Hydrology, and Landscapes of America's Heartland: A Multi-scale Natural-Human System

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A lynchpin between nature and society, agricultural landscapes are finely adapted to socioeconomic forces and climate, yet both are now in flux. Building on earlier research conducted under the Virtual Watershed project, This NSF-funded Coupled Natural and Human Systems project will investigate the effects of anticipated climatic change on the agricultural heartland of the central United States and how adaptations to climate change will generate new landscape patterns. As a coupled natural-human system with climatic, agro-technology, market, and policy feedbacks, future landscapes will differ from current patterns in terms of water quantity, water quality, and agricultural production. Three central research questions that will be studied are: 1) How will 21st Century climate change, together with changing market and policy environments, affect land use patterns at various scales, from the central U.S., to macroscale regions such as the "Corn Belt," to mesoscale watersheds, to individual farms and fields? How will this change the geography of agricultural production? 2) Under what policies and prices does landscape change induced by climate change generate a positive or a negative feedback through changes in carbon storage, evapotranspiration, and albedo in agricultural landscapes? 3) Will climate change expand or diminish the agricultural production and ecosystem service generation capacities of mesoscale watersheds representative of agricultural regions? These questions will be answered using linked methodologies including downscaling of greenhouse gas emissions scenarios based on the 5th Assessment Report of the IPCC for 2020-2025, 2030-2035, 2060-2065, and 2095-2100 that will drive agent-based models of farmer behavior. From these, land use change models utilizing the NASS/USDA Cropland Data Layer will generate most-likely landscapes for the American agricultural heartland. The SWAT watershed model will then be used to derive estimates of stream flow, sediment, and nutrient loads, and, along with EPIC to estimate carbon storage, will be used in a genetic algorithm to derive ecological-economic production possibility frontiers for each representative watershed for each time period for each climatic scenario. We anticipate that climatic change will diminish agricultural and ecologic potentials in some regions, such as through reduced water availability, while expand it in other areas, such as through lengthening of the growing season. However, these effects will be greatly influenced through market and policy developments such as biofuel production and carbon credits.

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Fate and Effects of Anthropogenic Chemicals in Coastal Plant-Dominated Ecosystems: A Comparative Review

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Plant-dominated ecosystems such as coastal marshes, mangrove forests/swamps and seagrass meadows provide as many as 45 natural products and 21 ecological services. These include water quality and shoreline protection, and serving as a habitat for a diverse biota. Approximately, 80% of the commercial fishes in Florida rely on these habitats for their survival. The annual economic value (USD) of each of these ecosystems is between 9000 and 28000 /ha. Despite their ecological and economic importance, these complex and often interconnected habitats have decreased globally by as much as 50% due to a variety of stressors that include the presence of chemical contaminants such as petrochemicals, herbicides and metals. However, the fate and effects of these contaminants is not well understood for the biota associated with these shoreline ecosystems. Therefore, a literature review was conducted to determine the state of the knowledge and to identify data gaps. The chemical fate and effects database for shoreline plant-dominated ecosystems is scattered. Bioaccumulation information predominates the non-nutrient chemical literature, particularly for trace metals. Bioaccumulation results have been specific to species, tissue analyzed, life stage and season. Toxic effect concentrations are restricted to a few single chemicals and species determined using a variety of techniques. As many as 23 response parameters have been monitored in toxicity tests ranging in duration from 3h to 6 months. Sensitive life stages and effect parameters and mixture toxicities are unreported. Toxic effects data are more limited for mangroves and salt marsh plants than seagrasses. The lack of toxic effect levels and exposure information, even for herbicides, hinders regional to larger scale assessments and resource restoration activities. Conclusions and research recommendations for the flora (and fauna) in the three ecosystems are similar. Information is needed describing the magnitude, temporal variability and biological significance of common shoreline contaminants measured in near-coastal areas. The availability of these data will reduce the current scientific uncertainty concerning the contribution of anthropogenic chemicals alone or in combination with other anthropogenic and natural stressors. The data will also provide perspective on the ability of current numerical criteria and guidelines for water and sediment to protect these shoreline ecosystems and their species at risk.

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EcoServ: A Community and Web-Service Based Modeling System for Simultaneously Quantifying Multiple Ecosystem Services at the Landscape to National Scales

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Simultaneously quantifying multiple ecosystem services is required for making informed management and policy decisions. Often, this requirement cannot be met because of the lack of adequate model simulation systems. In addition, developing such a modeling system is challenging, requiring participation and collaboration of scientists and practitioners from many different disciplines. In order to address these issues, we developed an Ecosystem Services (EcoServ) model. EcoServ development is a community effort, and the modeling system is staged on the Internet using open-source data and model sharing technology to accommodate a variety of algorithm developers, data providers, and users. It also relies heavily on existing disciplinary models, web services and visualization technologies, and datasets from the ground and satellites. Disciplinary models within EcoServ are integrated and tested (and modified if necessary) for landscape and regional applications. Data-model fusion techniques are implemented in EcoServ to automatically improve the modeling system and to constrain model simulations using observations from spaceborne and airborne remote sensing and ground monitoring networks. EcoServ can be used for diagnostic analysis (e.g., how have ecosystem services been affected by historical land use practices and climate?). It can generate performance reports for specific land use practices and policies to satisfy agency reporting requirements and facilitate agency-specific adaptive management and policy goals. EcoServ can also be used to forecast change in diverse ecosystem services in response to future changes in policy, climate, and land use change (e.g., biofuel production).

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Development of a Methodology to Quantify Ecosystem Services Using Landscape Models

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Humans depend on products and services provided by the environment, yet many human activities destroy or severely damage those services that humans depend on. Although the idea of ecosystem services and the effects that humans have on them has been recognized for many years, there has not been much work to develop a method that can quantify how much ecosystem services are provided by a given area of land. The dynamic, unpredictable, and non-linear nature of ecosystem processes has been a main source for problems in quantifying ecosystem services. We will present a methodology to quantify ecosystem services using the Soil and Water Assessment Tool (SWAT) and the DayCent models. The definition of ecosystem services that was used to influence the modeling is any feature of an ecosystem that is actively or passively consumed or used to promote human welfare. The model can be used as a decision-making tool or a predictive model to understand the effect of land-management decisions on ecosystem service values. We will present the application of the model using data from the Wildcat Creek Watershed, an agricultural watershed located in central Indiana. Once a quantification method has been established, we plan to link the services to an economic model to attach a specific market price for each ecosystem service.

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Evaluating Ecosystem Services at LCNCA Using State and Transition Models

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Ecosystem services have garnered much interest in the past decade. These services include all the benefits that humans get from ecosystems, be it in the form of tangible goods or intangible services. Quantifying these goods and services is a crucial topic for protecting ecosystem services. However, market prices are usually not able to capture the opportunity costs of using natural resources. Ecosystem services from rangelands are even less well-understood since rangelands are themselves extensive, complex, and sometimes underrated ecosystems. Identifying and valuing ecosystem services from rangelands in the western US could be an important step in land management decision making. As a prototype study, we propose the valuation of ecosystem services from the rangeland at the Las Cienegas National Conservation Area (LCNCA). The LCNCA (170 km2) is a high profile multiple use property for the Bureau of Land Management, which is highly valued by the local population. Performance of ecosystem services can be assessed within each ecological site, which refers to areas with the potential to produce a specific vegetation community. For economic decision making, the key question is: does the cost of transitioning from one state to another exceed the increase in expected flows of ecosystem services? We identified six different ecosystem services - forage production (animal unit months), water supply (mm of runoff), soil stabilization / protection (kg of soil loss), water quality regulation (kg of sediment / peak flow), climate regulation (kg of carbon sequestered), and recreation (days). We will present preliminary results from evaluating ecosystem services based on the different management practices. We will also discuss the practical difficulties, as well as the potential benefits, of linking the concepts of ecosystem services and state and transition models in the rangeland at the LCNCA.

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What Happens when Ecosystem Services Jump Across Boundaries?

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When neighboring jurisdictions share ecosystems they also share the ecosystem services that jump across boundaries. Administrative borders rarely coincide with natural ecological boundaries, but instead, frequently traverse ecosystems crossing both watersheds and airsheds. Many species of mammals, reptiles, birds, and insects unknowingly migrate across international borders. In transboundary situations – when ecosystem services span boundaries – drivers of change on one side may affect the delivery and quality of ecosystem services, and consequently human well-being on the other side. This talk will explore the scientific and governance challenges of sharing ecosystems and their services across administrative boundaries. Using examples from migratory species that cross the US-Mexico border, this talk will frame the scientific and management challenges of studying transboundary ecosystem services and then suggest ways that the ecosystem services approach can be used to strengthen the governance of transboundary species and environments.

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From Principles to Practice: A Survey of Public-Sector Green Infrastructure Planning in the United States

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In recent years, *green infrastructure planning* has emerged as a way to elevate lands supporting ecosystem services in the development process. So far, there has been no systematic study of whether green infrastructure planning principles are being put into practice and, more specifically, of the level of connection between so-called *green infrastructure planning* practice and the principles that theoretically define the strategy. A survey, based upon responses by nearly 100 public planning organizations fills that gap, finding that the theoretical principles that distinguish green infrastructure planning from other environmental planning efforts *are* being integrated into public planning practice in both name and deed. The presentation briefly reviews the theory and rationale behind green infrastructure planning before discussing the results of the national survey.

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Assessing Investment in Future Landsat Instruments for Ecosystem Management

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We estimate benefits from public investment in new remote-sensing instruments that provide data about ecosystems. We consider the longest-operating US satellite-based land-observing program, Landsat. We analyze the case of using Landsat to observe global forest carbon sequestration. Improving measurement of the role of forests in storing carbon has become a prominent concern in climate policy. By characterizing the value of Landsat data in forest measurement, we can help inform public investment decisions in the satellite system. In our approach, we make explicit the sensitivity of the selection of instruments for the next generation of Landsat instruments, thus linking instrument choice explicitly to ecosystem services and policy design.

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ESValue: A Collaborative Tool for Estimating Ecosystem Services and Their Value

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The multitude of demands on our water resources present scientific, legal, economic, and social challenges that make it difficult to develop long-term, sustainable strategies for providing the public with reliable, high quality water supplies while protecting ecosystem services. Decision makers and stakeholders need to be able to understand the trade-offs, both ecological and economic, among competing objectives. However, information about ecosystem services and their values is often incomplete, which makes it difficult to fully incorporate them into the decision-making process. The purpose of this workshop is to provide participants with a working knowledge of the challenges and opportunities in measuring and valuing ecosystem services associated with different water management strategies. Through a hands-on case study, participants will engage in a collaborative valuation process using tools to quantify and value ecosystem services.

The workshop provides the opportunity to “test drive” a decision support tool that provides a framework for estimating the impact of alternative water management decisions on ecosystem service values. The workshop will use the ENTRIX ESValue tool, which is a decision support tool that helps managers and stakeholders systematically, transparently, and cooperatively assess and value the key ecosystem services that are affected by alternate natural resource management strategies. ESValue combines expert consensus, site-specific data, and literature-derived data to develop an ecosystem services production function. The production function specifies relationships among the physical environment and ecosystem services as well as relationships between key ecosystem services and human-induced environmental stressors (e.g. human population growth affects water quantity which affects habitat suitability). It provides the scientific and economic basis for assessing the trade-offs and synergies in selecting and prioritizing resource management options. Based on best available science and stakeholder preferences, ESValue then specifies the relative values that society, managers, and stakeholders place on ecosystem services. The ESValue tool thus facilities the comparison of what CAN be produced (i.e. production function) with what participants WANT to be produced (i.e. the valuation function) to help determine the most appropriate natural resource management strategy.

In addition to gaining exposure to scientific and economic methods, this workshop will benefit researchers looking for methods to foster engagement and collaboration amongst diverse stakeholders. A foundation of the ESValue quantification and valuation tool is stakeholder input, and this workshop will highlight the stakeholder engagement process integral to this approach. Many natural resource decision analyses do not breakdown because of a lack of data or scientific expertise. More often, they flounder because they do not adhere to a robust protocol for systematically synthesizing data, building consensus among stakeholders, and establishing priorities through sensitivity analysis. The workshop will explore how systematically eliciting and organizing manager and stakeholder intuition can aid in evaluating alternate strategies.

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Assessing Effects of Climate Change on Rangeland Ecosystem Goods and Services

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Debate continues about many aspects of climate change. However, most agree that climate change is bringing increased uncertainty for rangeland management. Risk, uncertainty and vulnerability are core themes in climate change discussions. Atmospheric CO_2 concentrations have been rising and are projected to continue increasing. It is anticipated that temperatures will be warmer and precipitation more variable, both of which can have profound effects on rangeland ecology. Such changes in rangeland ecology should instigate changes in business planning and land management.

In order to assess effects of changing climate on rangeland ecosystems, and to develop coherent adaptive management strategies, standardized inventory and assessment systems are needed to characterize soils, water, plants, animals, and productive capacities of landscapes. Economic and social systems and processes are inextricably linked with ecological systems and processes; therefore, data must be collected to identify and clarify those linkages. Indicator selection is both an art and a science, with indicator data driving subsequent analyses, adaptations and decision-making processes.

The connectivity among ecological, social and economic systems is embodied in rangeland ecosystem goods and services. These inter-relationships must be considered in the development of effective management and mitigation strategies to adapt to climate change. Ranchers and land managers in Colorado and Wyoming have begun to utilize periodic assessment of environmental data to optimize their management practices in the face of variable weather. Such adaptive strategies provide insight into how we might approach the added uncertainty climate change brings to rangeland management.

By incorporating monitoring into conservation, management and business plans, land owners and managers can more readily identify and respond to change. Responses may include altered grazing season or rotation, change in stocking rate, change in grazing animal class, creation of grass banks for additional forage, and business diversification to spread risk across enterprises.

To enhance our understanding of these complex environmental and ecological interactions, the Sustainable Rangelands Roundtable developed a framework to illustrate inter-relationships among social, economic, and ecological sub-systems. This framework enables a more meaningful discussion among land managers, policy-makers, and mainstream society regarding how climate change will impact availability, quality and quantities of rangeland ecosystem goods and services desired by the general public.

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Role of Ecosystem Function in Measurement of Economic Aspect of Ecosystem Services

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Ecosystem services are often used to understand the connection between nature's benefits and our economy. Accordingly, measurement of ecosystem services often consists of an economic valuation using one of many potential economic approaches (contingent valuation, hedonic pricing, replacement costs, etc.). The purpose of this presentation is to advocate that measurement of ecosystem services always begin with a thorough assessment of the underlying functions providing the services. Only after the ecological context is understood should the economic valuation be performed. This is a perspective argued for in literature, but with limited use in practice (Costanza and Folke 1997). Much of the challenges for economic valuation system stem from the assumption that the public has clear preferences to establish pricing or valuation of ecosystem services. However, in most cases, the public has yet to fully consider ecosystem services and has not yet formed preferences. Function-based measures of ecosystem services allow the public to identify and form preferences that are the first step needed in valuation.

The presentation will provide examples of how the failure to integrate functional performance evaluation into an ecosystem service valuation can adversely affect the valuation results. The presentation will also propose a preferred approach through which a sequential, but integrated, ecosystem assessment and economic valuation should occur. Examples of this approach will be presented including ecosystem service-based planning in Nevada and Oregon.

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A Volunteer Water Quality Monitoring Program in the Upper Illinois River Watershed, Northwest Arkansas

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Understanding how water quality conditions change along a land use gradient and over time is important for sustainable watershed management. The Upper Illinois River Watershed, located in northwest Arkansas, experienced a rapid population growth over the past decade which has resulted in a shift in land use from forest and grassland to urban and pasture. A volunteer monitoring program was established to compare current water quality conditions with conditions prior to the land use changes. The Illinois River Watershed Partnership, a non-profit organization, subcontracted with the Arkansas Water Resources Center, a water research institution at the University of Arkansas, to manage the volunteer monitoring project, train volunteers, and analyze the collected samples. The AWRC trained volunteers to collect water samples following EPA approved methods at 37 sites that were previously sampled in 1993 and 1994. Samples were collected during base flow conditions during September and December 2008 and February and May 2009 and analyzed for PO_4-P, NO_3-N, SO_4, Cl, F, TP, TN and TSS. Mean concentrations were calculated and compared to the concentrations observed during the 1993-1994 study. Overall, TP and SRP concentrations significantly increased at 14% and 11% of the sampled sites, respectively, between the previous and current studies, while respective concentrations significantly decreased at 8% and 16% of sampled sites. The greatest reductions in phosphorus concentrations occurred at sites downstream of effluent discharges, and both TP and SRP concentrations were positively correlated to pasture and urban land use within the catchment (R^2=0.11, P=0.045; R^2=0.16, P=0.15, respectively). Similarly, both TN and NO_3-N concentrations were positively correlated to urban and pasture land use (R^2=0.38, P<0.0001; R^2=0.29, P=0.0006, respectively), and 5% and 14% of the sampled sites significantly increased in TN and NO_3-N concentrations, respectively, between the two study periods. Overall, very few significant changes in water quality (i.e., water chemistry) were observed over the last 15 years; the most notable changes resulted from either improvements in phosphorus management of wastewater treatment facilities or the introduction of new effluent discharge into a receiving stream. Volunteer monitoring programs are an excellent way to promote environmental education and stewardship, and they can be useful to document changes in watershed conditions over time.

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Synthesizing Qualitative and Quantitative Information: Support for Ecosystem over Land Use Approaches to Ecosystem Services Assessments

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South East Queensland Catchments (SEQ Catchments) is a non-government body with responsibilities for catchment and natural resource management in the SEQ region, Australia. Over the last few years SEQ Catchments has been coordinating a major project to develop an ecosystem services framework for SEQ. Modeled closely on the Millennium Ecosystem Assessment, the SEQ Framework comprises four inter-connected components: ecosystem categories (32 in total), ecosystem functions (19), ecosystem services (28) and constituents of well-being (15). The main aim of the project has been to identify, measure and value ecosystem services in the SEQ region to support a wide range of policy and planning applications, including meeting ecosystem service requirements stipulated in statutory plans and natural resource management strategies.

Development of the Framework has involved more than 140 technical experts and stakeholders, participating in guided workshops to compile the relevant information. Two parallel approaches have been applied to develop information to support the Framework. One approach was based on expert local knowledge and qualitative analysis, using scoring systems and matrix methods (rather than absolutes as metrics) to identify the relationship between all the ecosystem categories and ecosystem functions in the Framework. The other approach has relied on GIS data sets and developing maps to spatially identifying where ecosystems and ecosystem functions are occurring across the SEQ region.

Comparing the information developed under each of these approaches is important to synthesizing information within the Framework. Results from this comparison show high correlation between expert panel scores and the spatial information provided in the maps. Of the 532 relationships assessed 83% of results correlated. Differing results was far greatest in human managed systems providing stronger support for adopting an ecosystem over a land-use approach in ecosystem services assessments. The SEQ case study provides valuable lessons for those who may wish to go down a similar path elsewhere. This paper gives a general description of the parallel approaches applied to develop information, results from the comparison analysis and key areas for improving such processes.

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Valuing Ecosystem Services through Participatory Processes for Policy and Planning in South East Queensland

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There are two parallel schools of thought regarding methodologies for valuing ecosystem services. One is based on the application of economic valuation techniques, aimed at deriving monetary values. The other aims simply to determine the relative values or relative importance of ecosystem services, relying on participatory processes involving stakeholders and/or experts, applying scoring or ranking systems similar to those used in multi-criteria analysis.

Over the last few years, South East Queensland Catchments (SEQC), a non-government body with responsibilities for catchment and natural resource management in SEQ, has been developing an ecosystem services framework for the region. The SEQ Ecosystem Services Framework aims to identify, measure and value ecosystem services for incorporation into natural resource planning and management. Development of the Framework has involved more than 140 participants, comprising a wide range of technical experts, government agencies and community representatives.

The interconnections between ecosystems, ecosystem functions, and ecosystem services have been exhaustively explored and documented by ecological and environmental experts, using scoring systems and matrix methods. More recent work has focused on determining the relative values or relative importance of ecosystem services in the SEQ context. This component of the Framework has been modeled along similar lines to the Millennium Ecosystem Assessment, which identifies the benefits of ecosystem services in terms of constituents of wellbeing. To identify these benefits and establish their relative values SEQC has been working with local governments, conducting participatory workshops in which community representatives directly attribute value scores to ecosystem services. In addition SEQC has engaged social science experts to explore the relationships between ecosystem services and the constituents of wellbeing, again making use of workshop procedures and scoring systems. As a result of the Framework, a policy aimed at protecting ecosystem services has recently been incorporated into statutory planning and other natural resource management documents for the region. This paper explains why qualitative methods rather than monetary valuations have been applied in the case of SEQ and describes the work and results that have so far been achieved.

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A Simplified Decision Support Approach for Evaluating Wetlands Ecosystem Services

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State-level managers and restoration advocates have expressed a desire for approaches that address wetlands services and benefits for two purposes: to demonstrate the benefits of money budgeted for restoration, and to compare proposals when awarding restoration funds for specific projects. Many wetlands functional assessment tools have been developed (e.g, WET, HEP, HGM, and others). While a number of these implicitly address ecosystem services and associated benefits, few address ecosystem services and benefits explicitly. Many of the existing tools are not routinely used, or are used only in very specific situations requiring in-depth analysis, because of the complexity of data collection required. In some cases, a comprehensive tool that addresses the inherent complexity of wetlands is needed, but there are many situations where a simplified approach can facilitate communication and decision making. We will be presenting a simplified approach to evaluating ecosystem services provided by freshwater wetlands restoration. Our approach is based on an existing functional assessment approach developed by Golet and Miller for the State of Rhode Island, and modified by Miller for application by The Nature Conservancy in Wisconsin. The approach is based on extensive research on existing functional assessment tools, and can be applied relatively easily using GIS measures and minimal field work. In addition to being used in demonstrating the benefits of money budgeted for restoration, and in comparing restoration proposals, our approach may also be used for preliminary screening of projects that require further evaluation, as a template for discussion when making mitigation decisions, and to develop watershed “report cards” used to educate the public about the benefits from wetlands in a watershed, and about where these benefits may be at risk.

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Wetlands as Carbon Sinks within Agricultural Ecosystems

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Tillage operations on cropland generally cause substantial redistribution of soil within the landscape by a combination of tillage and water erosion processes and often wetlands associated within agricultural ecosystems trap upland sediment moving down gradient. Such wetlands frequently have a high potential to soil organic carbon (elevated organic carbon content) was well as high net primary productivity associated the wetland vegetation. The impact of low carbon upland sediment on wetland ecosystem carbon dynamics has previously not been well characterized. Recent studies have demonstrated that carbon sequestration and storage in wetlands are stimulated by the dilution of ecosystem carbon from imported low carbon sediment. Using a combination of radionuclide tracers as chronological markers, we measured the rate of new soil carbon formation resulting from sedimentation and demonstrated that pedogenic processes associated with carbon sequestration are stimulated within the ecosystem. These finding also indicated that rates of carbon accretion in some wetlands may be linked to mineral soil deposition over the ecosystem history.

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Nitrogen Retention as an Ecosystem Service is Linked to Land Cover Heterogeneity

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We examined the effect of fine-scale variation in land cover on the ecosystem service of NO_3 retention in 21 residential sub-watersheds in metropolitan Sacramento. Linking landscape heterogeneity with the provisioning of ecosystem services in urban areas is important for building scientific understanding and for improving management. A key ecosystem service in urban systems is the retention of nutrients. This service is reduced by high rates of non-point source (NPS) loading of nitrogen (N), especially as nitrate (NO_3), which can adversely affect aquatic environments. Previous NPS studies have primarily compared urban to rural areas, often only weakly explaining variability in stream NO_3 using measures of landscape heterogeneity. Additionally, high variability in NO_3 export has been documented within urban systems. There is a need to begin developing ecological models specific to urban landscapes, and to identify opportunities for management to enhance ecosystem services, such as N retention, within urban systems.

To address this, we classified land cover for 21 sub-watersheds using HERCULES (High Ecological Resolution Classification for Urban Landscapes and Environmental Systems). HERCULES classifies high-resolution aerial photographs into 5 land cover elements: buildings, pavement, herbaceous and woody vegetation, and bare soil. All these sub-watersheds are residential in land use, but they differ substantially in land cover, as identified by HERCULES. Focusing on land cover may better explain observed variability in NO_3 export from urbanized watersheds. Streams were sampled for NO_3 concentration and discharge for 12 months, through both the wet and dry seasons. Partial correlation analysis and multivariate models were used to describe the relationships between land cover elements and stream NO_3 in the sub-watersheds.

Our results indicate that the proportion of pavement in the sub-watersheds, a commonly used indicator of urban intensity, did not strongly correlate with increased levels of NO_3 in streams. Instead, high proportion of building cover was associated with greater stream NO_3 content while high proportion of fine vegetation cover was associated with reduced NO_3 content. The use of fertilizers or enhanced N cycling through summertime watering subsidies surrounding residential buildings is a possible source of this increased NO_3. Lawn irrigation in the dry season resulted in shifting these streams from ephemeral to perennial flows. Pavement and infrastructure likely play a role in moving nutrients from surrounding land into streams by increasing flow during storms. However, areas of higher building cover specifically are associated with increased stream NO_3 in the Sacramento ecosystem. These results indicate that building cover should be further evaluated for possible mechanisms that increase NO_3 sources or delivery to streams. Conversely, fine vegetation cover may be associated with mechanisms which support ecosystem services of N retention, such as immobilization or denitrification by plants and soil microbes. Management activities seeking to reduce aquatic enrichment of NO_3 from urban systems may be best directed toward identified NO_3 sinks and sources associated with specific land covers, such as fine vegetation or residential buildings, and not focused solely on the minimization of impervious surface cover.

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Payments for Forest Based Ecosystem Services in the US

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Payments for producing ecosystem services have recently been promoted as an important, evolving "market" for forestland owners and potential policy lever for "keeping forests in forest." Over the last two decades, a variety of federal and state programs have applied a combination of regulations, extension services, and incentives to encourage private landowners to implement forest management, conservation, and restoration activities. Most of these programs have relied on payments from the government to landowners (usually in the form of cost-shares) to encourage specific types of land management. Although programs that subsidize tree planting for timber production in the US South have a long and successful history, programs specifically designed to enhance the production of ecosystem services such as water and air quality and biodiversity conservation are newer and their impacts uncertain. More recently, payments from additional sources have begun to emerge, including payments for forest carbon offsets, biodiversity conservation, and watershed management. In this paper, we use data collected for the USFS 2010 National Report on Forest Sustainability and data from the Ecosystem Marketplace report, "State of the Voluntary Carbon Markets" to produce an historical, statistical, and spatial analysis of the payments forest land owners receive from government agencies, non-government organizations, and private firms.

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Considering Ecosystem Services Co-benefits in Strategies to Restore the Chesapeake Bay

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Pursuant to a recent Executive Order to restore the Chesapeake Bay, the EPA has set targets for reducing nutrient and sediment loading to its tidal waters. The Bay States must submit plans for achieving these targets. The plans include improvements to both “gray infrastructure” (e.g., wastewater treatment plant and municipal stormwater management system upgrades that reduce point-source loadings), and “green infrastructure” (e.g., agricultural and development best management practices that reduce non-point sources of pollutants). EPA’s Ecosystem Services Research Program conducted a preliminary analysis to determine the most cost-effective mix of green and gray infrastructure improvements that would achieve the loading targets of nitrogen, phosphorus, and sediment to the Bay, and also the levels of “bonus” ecosystem services (i.e., those services not directly associated with improvements in water quality in the Bay) that would be delivered by this mix of improvements. An important objective of this analysis was to evaluate how different state and federal policies could affect the cost of meeting nutrient and sediment reduction goals and the level of ecosystem services derived from actions taken to meet those goals.

The analysis indicates that the least cost solution tends to favor a mix of green and gray infrastructure improvements (leaning toward green infrastructure), and that the cost of achieving nutrient and sediment loading targets for the Bay could be partially offset by the value of ecosystem services such as carbon sequestration, hunting, and freshwater angling associated with green infrastructure improvements. The analysis demonstrates that policies and regulations that require maximum achievable technology for gray infrastructure upgrades both increase the costs of achieving the loading targets and provide fewer of the bonus ecosystem services important to Bay residents. This analysis does not consider socioeconomic (e.g., market) barriers to implementing green infrastructure improvements, and is based on very preliminary estimates of the extent and value of bonus ecosystem services delivered. It nonetheless demonstrates the desirability of considering ecosystem service co-benefits when optimizing gray and green infrastructure investments to reduce nutrient and sediment reductions.

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Seed Dispersal Services and Urban Development Influence Garry Oak Regeneration Patterns

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In Western Washington, Garry Oak (*Quercus garryana*) woodlands are the focus of intensive restoration and management efforts in both urban and non-urban landscapes. Steller's jays, Western and Eastern gray squirrels disperse and bury acorns, providing a potentially important ecosystem service. These species preferentially cache acorns in areas with forest cover and sparse understory cover. Urban development may influence regeneration patterns by altering the abundance and behavior of dispersal species. My research asks the following questions: 1) do patterns of oak seedling and sapling abundance reflect the dispersal preferences of Steller's jays and gray squirrels; and 2) are seedling and sapling abundance different in urban versus non-urban landscapes?

I conducted vegetation surveys in 157 ten meter radius plots within 30 oak woodlands with natural understory distributed across a gradient of urban development. I collected diameter at breast height (DBH) and basal area for canopy tree species, sapling counts for canopy tree species, oak seedling counts in one meter subplots and estimates of canopy and understory cover at the plot and subplot levels. Land-cover composition, including urban cover, was quantified within a half kilometer buffer surrounding each oak woodland. I also planted 360 acorns in one urban and one non-urban site under oak, non-oak forest, and no forest cover and monitored germination, acorn removal by potential seed predators and seedling emergence. Data were analyzed using mixed effects regression models.

Seedlings were more common in understory grass and open/herb cover and were most abundant under oak then non-oak forest canopy and least abundant under no forest canopy reflecting jay and squirrel cache preferences. Seedling abundance showed no significant relationship with urban development. In contrast, saplings showed a negative relationship with open/herb cover and no relationship to grass cover. The youngest sapling class showed a negative relationship with landscape urban development and strong positive relationship with landscape forest cover. Older saplings showed no relationship to forest or urban land cover as a continuous variable. However, there were significantly fewer older saplings in woodlands surrounded by greater than 40% urban cover. Acorns planted under non-oak forest canopy were significantly more likely to be removed by seed predators and those planted under oak canopy were more likely to germinate. Seedling emergence did not differ between sites or groups indicating that acorns are capable of producing seedlings regardless of canopy cover type.

These results suggest that seed dispersers significantly influence seedling spatial patterns, but that this influence is greatly reduced in later life history stages. Importantly, although seedling production does not appear to differ in urban versus non-urban landscapes, sapling abundance was significantly lower in urban landscapes. This finding has important implications for urban oak forest regeneration and highlights the need for greater research into how urban development alters the mechanisms driving transitions between plant life history stages. Improved understanding of how landscape spatial structure influences forest regeneration processes is needed in order to create adequate forest restoration and management plans and to improve the ecological sustainability of future land use decisions.

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Northeastern Lakes: Tradeoffs between Aesthetics and the Attenuation of Anthropogenic Reactive Nitrogen

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Historically, lakes have played a major role in the industrial, agricultural, and urban development of the northeastern United States though the provisioning of fresh water and hydropower. Although lakes continue to be important sources of freshwater, technological changes have reduced dependence on water as a source of power. Expanding populations and increases in affluence have raised the demand for cultural ecosystem services such as the provisioning of recreational, housing amenity, and existence value benefits from lakes. At the same time, lakes are also valued for the dilution, processing, and transport of anthropogenic wastes such as reactive (fixed) nitrogen from agricultural & urban runoff, sewage, vehicle emission etc. The proportion of reactive nitrogen attenuated through denitrification and plant uptake can be estimated based on models derived from published lake studies. For northeast lakes, estimated nitrogen removal rates are high (median = 20-40%) but these numbers need verification. The use of lakes to process nitrogenous waste may conflict with cultural uses as these are highly influenced by people's perception of water quality and aesthetics. We use data for actual and perceived water quality from the 2007 EPA National Lake Assessment and nutrient concentration estimates from the draft USGS SPARROW model for New England and the Mid-Atlantic regions to model lake aesthetics. Random forest modeling indicates that reactive nitrogen concentration is an important predictor of lake aesthetics and their potential to deliver cultural ecosystem services. We evaluate the changes in cultural and nitrogen removal services predicted to occur under various nitrogen reduction and increase scenarios for northeastern lakes.

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Vegetation Plots Provide Regulating and Cultural Ecosystem Services

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Ecosystem services are 'emergent properties" provided by the complex functional interactions that occur between the ecological components of natural resources. These services contribute to the productivity, stability and sustainability of landscapes. "Regulating services" provided by arthropods include such functions as biological control of pests, pollination and food chain augmentation. "Cultural services" are aesthetic-related such as bird watching, butterfly gardening, and accompanying nature appreciation and inspiration.

Natural ecosystem services are important but they do not always occur where or when they are most needed. A growing body of research suggests that functioning plant communities can be assembled, strategically placed within the landscape and managed to provide specific services. Our interests lie with the development, augmentation and demonstration of "regulating" and "cultural" ecological services across a range of crop production and natural resource systems including urban homeowner yards and gardens and agroecosystems of all scales and philosophies, including organic.

Previously, we developed a trap cropping system for stink bugs whose plant species provide an array of other ecological services. Services that can be obtained from these plantings include control of stink bugs through trap cropping, increased biological control of arthropod pests, and augmentation of pollinators and wildlife by provisioning of nectar, pollen, extrafloral nectaries, seeds, alternate hosts and shelter, etc. By evaluating a variety of individual and specific assemblages of plants and cultivars, we aim to provide recommendations to consumers for use at any time of year near cash crops or natural habitats to provide pest suppression and enhance other functions. Recommendations emphasize the selection, culture, and management of plant species and cultivars with critical ecological attributes and will assist consumers in the selection of appropriate plants, timing of management activities, and proper size and location of plantings to meet specific objectives. We describe our progress to date.

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Applied Multidisciplinary Solutions for the Terraba-Sierpe Region of Costa Rica

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The protected area of the "Humedal Nacional Terraba-Sierpe" (TS) presently marks the end of the development boom and the start of the Osa peninsula, one of Costa Rica's best preserved wilderness areas, boasting one of the planet's greatest concentrations of biodiversity. The TS mangrove forest, the largest on the pacific coast of Central America, is a keystone ecosystem within this complex system. Limited access has played a large part in protecting this area from runaway development. Until fairly recently the government was planning to build the largest airport in Central America, capable of landing 2000 tourists a day; there are plans for many traditional marinas; the Pan-American Highway is slowly creeping forward and a massive power plant looms on the planning horizon.

In 2008 we launched the ECOTICOS Project (Education, Communication, Technical, Institutional and Conceptual Solutions http://www.uvm.edu/cdae/ecoticos) whose primary goal is to identify the threats, examples, and opportunities to promote the sustainable development of the TS mangroves. The core objectives of the ECOTICOS Project are:

(A) Technical Lever Solution - Ecosystem Services Green Map: over the course of the project a series of GIS and Google Earth maps were generated to capture the good, the bad, the ugly and most importantly the possible. This was done with a combination of site visits, recognizance flights, personal interviews and on the ground training.

(B) Institutional Lever Solution - Ecosystem Services Valuation: during this first stage of the project two community meetings were convened to capture their views on what they see and would like to see across the landscape. These meetings allowed fine tuning both an Ecosystem Services Valuation Exercise and a Multi-criteria Analysis.

(C) Conceptual Levers Solution - Habitat, Water Quality, and Fishery Baseline: during the initial phase of this project, substantial efforts were made towards the development of multiple baselines to assess habitats, water quality and the current status of fisheries.

Embedded in these three levers are the two most important pieces of the puzzle: Education and Communication. A series of exercises ranging from green mapping, photojournalism, storytelling and bio-monitoring were undertaken.

Keywords: Ecosystem Services, Valuation, Costa Rica, Mangroves, Multicriteria Analysis, Ecological Economics, Community Development.

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Analysis of Factors Influencing Open Space Values using a Spatial Hedonic Model

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Open space in this study refers to parks, areas with wild habitat and residential lot size. The focus of this study is on Inland Empire region which is a large metropolitan area located in southeastern California, comprised of Riverside and San Bernardino counties. The data offer a nice experiment of two neighboring counties where Riverside has implemented a policy directed at open space preservation (RCIP) and San-Bernardino has not. This study will also investigate how open space variables influences home value before (1996-99) and after (2000-04) a conservation policy for open space is implemented in Riverside County.

The data used in this study contains residential sales information from 1996-2004 for almost 69 cities within Riverside and San Bernardino counties. This study will use a hedonic model which would take into account both spatial and temporal variation in the impact of both structural features and open space variables on sale value of residential property. Few studies explicitly consider both temporal and spatial dynamics of open space values in the open space literature (Cho et al. 2009). An Ordinary Least Square model (OLS), a Spatial Error Model (SEM) and a Spatial Autoregressive Model (SAR) will be used in this analysis which would take into account spatial correlation in error terms and home values.

Here is a preliminary glance at two zones out of 12 total zones from two counties as the analysis is still undergoing. Following are few important observations out of a variety of interesting results obtained from the analysis: It is seen that SEM provides the most efficient estimators amongst the three models for Zone1 (cities in Riverside county) and Zone2 (cities in San-Bernardino County).Zone1 has the maximum amount of open space than the other zones in Riverside County and a policy for conservation of open space with wild habitat. This might be a reason the variable measuring proximity to wild habitat areas indicate that this amenity do not have a scarcity value in Zone 1 whereas it does have this value in Zone2 that has no conservation policy. Proximity to parks has a higher amenity value in Zone1 than Zone2. It is also seen that home value goes down more in Zone2 compared to Zone1 with percentage of urban density around it during (2000-04) compared to(1996-99).This may be because people feel less densely packed in Zone 1 because the policy provides them with more open space during (2000-04). In Zone 2 the sense of feeling of urban density might be more pronounced as this region do not have a policy and the housing market is on the upswing during this time period.

This ongoing study will be able to decipher the value of open space and how open space variables influence housing market in a County which has a policy versus the County which does not have one.

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HEA as a Tool for Evaluating Ecosystem Services and Restoration Options

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The Washington Department of Natural Resources (WDNR) manages approximately 1300 acres of upland and nearshore habitat as part of the Woodard Bay Natural Resources Conservation Area (NRCA) and adjoining state-owned aquatic lands in Henderson Inlet, near Olympia, WA. Although the majority of the site is undeveloped and supports a rich array of native species and habitats, the NRCA was the site of the former South Bay Log Dump operated by the Weyerhaeuser Company for over 50 years. Accumulation of wood debris, shoreline filling, and release of toxic chemicals associated with creosote pilings and other in-water structures associated with the log dump were thought to have adversely affected the nearshore areas through alteration of nearshore processes and degradation of riparian and benthic habitats.

WDNR and its partners sponsored a feasibility study to identify and evaluate alternative restoration actions that addressed their management goals for the site. Determining the best approach to restoring the nearshore ecosystem while balancing the needs of the diverse biological communities was challenging. The development and comparison of alternatives relied on the Habitat Equivalency Analysis (HEA) tool to quantify and aggregate ecological service flows (detrimental or beneficial) of various restoration actions on more than a dozen target resources or ecosystem services. The net changes in the habitat value or ecological services provided by each action were weighted according to the consensus restoration priority for each species or service. Costs associated with each restoration alternative were used to standardize the relative change in habitat value and ecosystem services. The FS identified a preferred alternative for the restoration of the Woodard Bay NRCA by identifying the most cost-effective restoration approach. The HEA provided decision makers with a valuable tool for optimizing the benefits to multiple natural resources.

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Payments for Damages to Ecosystem Services Related to the Gulf Oil Spill: Trans-Boundary Issues and Potential Solutions

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The Deepwater Horizon oil spill that began in April 2010 has not been contextualized either as a transboundary water quality issue or as an ecosystem services issue. That is unfortunate since a) roughly half of the Gulf of Mexico shoreline lies along the Mexican and Cuban coasts rather than exclusively in the U.S., and b) the fisheries and migratory bird stopovers of all three countries depend upon the ecosystem surfaces provided by coastal wetlands. More than 120 species of commercially marketed fish and shellfish, as well as millions of individuals of waterfowl, shore birds and wading birds depend upon the Gulf and its adjacent bayous and wetlands for parts of their life cycle. Both commercial and recreational fishermen in addition to recreational hunters rely upon these wetland habitats and their species as well. Tar balls, oil slicks and dispersants can potentially contaminate these birds, fish and invertebrates, but can also affect their habitats which provide provisioning, support and buffering services to the entire Gulf. To date, BP has focused on payments only to those whose incomes are directly affected by fisheries area closures, but there are legal precedents for looking at all those negatively impacted by diminished ecosystem services. We propose novel mechanisms to compensate not only U.S. citizens impacted by the spill but Mexican and Cuban citizens as well.

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The National Atlas of Sustainable Ecosystem Services: Work in Progress

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The US Environmental Protection Agency's (USEPA) Ecosystem Services Research Program (ESRP) along with its many partner organizations is developing a National Atlas of Sustainable Ecosystem Services. In 2008 the Atlas was presented at the first ACES meeting in Naples, Florida at which time the product was in the early stages of development. Two years later, the Atlas project has made significant progress towards providing science-based outputs in an interactive, web-based application. The Atlas currently allows mapped displays of 25 indicators of ecosystem services for the conterminous US, each summarized for approximately 83,000 12-digit Hydrologic Unit Codes (HUCs). Mapped indicators can be displayed over satellite imagery, topographic maps, or street maps. These indicators reflect supply of ecosystem services as well as demand for and drivers of services. The Atlas also contains multiple biophysical data layers such as stream hydrography, protected land status, and connectivity of natural land cover. Political and ecological boundaries are also represented. Ecosystem service categories currently contained within the Atlas include clean water for drinking; clean water for recreation and support of aquatic habitat; food, fuel, and fiber; recreation, cultural, and aesthetic value; climate regulation, clean air, protection from floods; and habitat for maintenance of biological diversity. Additional future elements of the Atlas include the addition of another 25 indicators within the next year, future scenario mapping, dynamic modeling, incorporation of high-resolution metrics for selected urban communities, and integrated index building capabilities. The planned public release date for the Atlas is late 2011 or early 2012.

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Payments for Watershed Services: Leveraging Public Funding to Expand Restoration Success

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Historically, Chesapeake Bay restoration efforts have faced the duel challenges of insufficient public funding and the difficulty of addressing pollution from “non-point” sources, such as agricultural lands, not currently subject to traditional industrial discharge permit limits. The Chesapeake Fund is designed to address both of these vexing issues. In short, the Fund obtains critical pollution reductions from non-point sources using a framework that stretches federal dollars to achieve more pollution benefit then that of current approaches. It is estimated that Bay restoration will cost $15 - $30 billion dollars. Moreover, the majority of certain key pollutants (such as nitrogen, phosphorus, and sediment) come from non-point sources such as farmlands and other non-industrial sources. Clearly, the path forward for Chesapeake Bay restoration must leverage public funding to accomplish more pollution reduction per dollar spent, and those reductions must come from non-point sources.

The Chesapeake Fund’s framework will stimulate private funding of pollution reduction projects, and leverage federal funds to obtain more reductions per federal dollar spent when compared to traditional grants. Specifically, the Fund will seek private funding for the initial stages of each pollution reduction project, through a specified completion date for the individual project. At that completion date, the privately funded project would have the option to present the verified pollution offsets to the Project and receive an agreed upon price, which would represent the typical amount paid by federal grants for Chesapeake Bay pollution reduction. However, if the privately funded project decides instead to sell the verified pollution offsets to an entity seeking to retire offsets or to bring new economic activity to the watershed, the federal funds remain unused for that project, and will be reallocated to other projects that will achieve even more pollution reductions for the Bay. This presentation will outline the Chesapeake Fund’s efforts to leverage public funds, in a safe and prudent manner, to stimulate private funding of land management practices that will measurably reduce pollution from non-point sources such as agricultural lands. In addition, we will discuss the design framework expected to obtain significantly more pollution reduction per federal dollar spent.

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Urban Containment and Ecosystem Services Triage? Having Your Cake While Eating It Too

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Urban containment attempts to prevent urban development from sprawling into agricultural lands, sensitive landscapes, and other open spaces. On the surface, urban containment works to maximize the preservation of ecosystem services, but does it? For instance, if growth is concentrated inside urban containment boundaries (UCBs), sensitive landscapes within the boundaries are put under pressure for development. In effect, a kind of "triage" could occur whereby ecosystem services inside the UCBs are sacrificed to preserve them outside. This presentation summarizes the theory and application of urban containment, reviews recent research on the triage effect, and synthesizes theory and literature to pose an outline for preserving ecosystem services both inside and outside UCBs using market-based land value techniques in combination with innovative land use regulatory approaches.

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Ecosystem Services: the SCWEPM Bridge across Transboundary and Environmental Justice Divides

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Administration and ownership of the Santa Cruz Watershed (SCW) is divided between the four governing Nations of Mexico, the Tohono O'odham Nation, the Pascua Yaqui Tribe, and the United States. This geography has historically made transboundary management contentious and created actual and perceived environmental justice imbalances. A modeling tool is being developed to recognize internationally shared ecosystem services. The Santa Cruz Watershed Ecosystem Portfolio Model (SCWEPM) is a map-based multi-criteria evaluation tool that stakeholders can use to explore tradeoff-scenarios between valued ecosystem services at multiple scales for use within a participatory decision process. The SCWEPM will help all stakeholders voice their priorities and concerns, realize mutual benefits and tradeoffs for transboundary cooperation, foster management coordination of priority ecosystem services, and bridge the environmental justice divide.

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The Protection of Ecosystem Services in the US-Mexico Border

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Ecosystem services as defined by the Millennium Ecosystem Assessment are the benefits ecosystems provide for human well-being, and can be classified as provisioning, regulating, supporting and cultural. Provisioning services cover natural resources and products derived from ecosystems, and represent the flow of goods. Regulating services are the life-support functions ecosystems provide and are determined by the size and quality of the ecosystem. Cultural services are the non-material benefits obtained from ecosystems such as spiritual and religious significance. Binational watersheds are ideal study areas for the exploration of ecosystems services, because they may function as split-plots where many natural variables are similar, but where the contrasting economies and social dynamics may operate differently, imposing divergent pressures on shared natural resources.

In our initial research into ecosystem services on the US-Mexico border, we explored the potential of sustainable landscapes in the region from an ecosystems services perspective. The study employed watershed subareas as the basic areas of analysis, because impacts on these areas sensitive to human activities may affect hydrologic cycles and water availability. Data used were analyzed for each subarea through the use of a spatial pressure index composed of four variables with the following formula: Pressure index = Urban area + urban patches + population – population density. Data were normalized to each subarea so they could be compared and converted to a value between 0 and 1 to be used in the formula.

The traditional approach for conservation of natural resources is the establishment of Natural Protected Areas. However, other types of land ownership systems also preserve natural resources. Common property regimes such as Mexican offer protection of ecosystems services, as does private land ownership in the US. Thus, in this research, we explore the contribution of institutional conservation in the sense of natural protected areas (federal, state or county), and ejido land to the protection of ecosystem services.

In order to asses our objectives we used data produced by the U.S.-Mexico Border Environmental Health Initiative (BEHI) on urban and natural protected areas, and by the Instituto Nacional de Geografia y Estadistica on ejido land, within the major subareas (groups of basins) along the U.S.-Mexico border. Our results suggest that approximately 330 protected natural areas cover around 20% of the border subareas. More than 79% of the natural protected areas are on the U.S. side of the border, and most of these lie in the western portion of the border. Ejido land accounts for almost 40% of natural vegetation area of Mexico, considering grasslands, and 12.6% of the whole border area; these lands are concentrated mainly in the midwest.

Recommendations - In order to preserve ecosystem services, land use administration must be taken into account, but this varies considerably between the US and Mexico. Within Mexico, preservation of ecosystem services would benefit from land use planning that better examines future scenarios, includes more active public participation, and explores the linkages of land use markets and regulation (natural resource markets are an example of such linkages). Within the US, land use policy should better evaluate public policies and their impacts and focus more on the specifics of implementation and administrative efficiency. An overarching shortcoming to protecting ecosystem services in the border region is that planning efforts in both nations stop at the border, and future efforts should explore means by which a more coordinated protection strategy can be advanced. Public agencies in both countries are encouraged to coordinate protections efforts across the border are warranted; an area with the potential for such integration is that of the Big Bend region where US efforts at ecosystem services preservation in the Big Bend National Park could be linked with the emerging conservation efforts in Mexico that seek to protect the Maderas del Carmen, a sub-region of the Sierra del Carmen mountain range that lies across the Rio Grande River of the U.S. national park.

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Stacking Carbon Payments with Land Use Policies, Programs, and Markets

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Many policy makers are asking whether landowners should be able to participate in multiple environmental markets (stacking) and how new markets should interact with other programs or laws that impact the same ecosystem services. The fundamental reason for asking these questions is to design a policy or program that best achieves its environmental objective. If a landowner would have undertaken the same activity if he was participating in one environmental market or two, then there is an additionality problem. Stacking can, however, be a way of aggregating a number of small, insufficient funding streams into one sufficient to trigger environmental conservation or restoration.

When rules are not clarified, stacking may go forward in an unstructured way, undermining environmental outcomes. Having policies in place earlier rather than later can avoid this risk. Also, programs currently enrolling lands under contracts and easements, may not be able to retroactively change landowner rights once the stacking question is resolved. Recognizing these challenges, we reviewed examples from other environmental markets and programs to consider how a new environmental market, a carbon market, based on a mandatory climate policy, would interact with existing markets, laws, and programs to help inform the development of state, regional, and hopefully some day, federal policy. We consider regulatory-driven programs: (1) regulations such as buffer requirements, (2) regulatory markets such as water quality trading and wetland mitigation banks, and (3) the case of state mandated management plans in California. We also consider incentive-based programs: (1) direct payment programs such as the Conservation Reserve Program, (2) tax incentive programs such as conservation easements and tradable development rights, and (3) voluntary markets in carbon or other ecosystem services. We find that by considering whether specific programs and markets should be stacked, it is possible to assess whether stacking would significantly harm or help the environmental objectives of the programs. This may be one approach to develop guidance on stacking for a new regulatory market.

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Marine InVEST: Assessing Ecosystem Services in Marine and Coastal Environments

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Marine and coastal ecosystems provide humans with a range of goods and services that are important to our well-being. Examples of these ecosystem services include seafood, protection from storms, and recreational opportunities. In order to properly protect and manage these resources, we need to improve our ability to measure and value changes in ecosystem services. These ecosystem service metrics can then be used in a variety of policy contexts including marine spatial planning and natural resource damage assessment.

Marine InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) is a decision-support tool that integrates ecological, economic, and social information in a framework that is designed to help natural resource managers and other policy-makers incorporate the value of ecosystem services into decision-making. The Marine InVEST modeling approach assesses scenario-driven changes to ecosystem services by coupling processed-based, biophysical models of ecosystem change to appropriate valuation methods. Our models use both economic valuation and other non-monetary approaches to evaluate the predicted changes to the marine and coastal environment. Ecosystem services currently modeled in Marine InVEST include: the role of biotic and abiotic habitat in providing coastal protection; food from commercial fisheries and aquaculture; wave energy; the provisioning of aesthetic views; and marine and coastal recreation. InVEST is designed to compare the flows of services across alternative future scenarios, highlighting potential trade-offs, and win-win situations. Because the outputs of our models are based on an ecosystem services framework they can provide a transparent and objective means to guide and support management strategies and improve communication among stakeholders with diverse set of goals and interests. We will demonstrate our suite of models with outputs from model runs on the West Coast of Vancouver Island (WCVI), where we are partnered with a local public-private partnership charged with developing a comprehensive marine spatial plan.

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Defining the "Product" in an Ecosystem Marketplace

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Markets rely on well-defined goods and services to operate. Market participants require a level of certainty concerning the attributes of the good or service being purchased. In ecosystem service markets the product or good being purchased is often ill-defined.

This paper will assess the information needed to define ecosystem service products. Using the Chesapeake Bay as an example, it will discuss the ecosystem service characteristics that must be measured to confidently describe the ecosystem service product. The paper will discuss points of scientific uncertainty in ecosystem service characterization and measurement. It will also discuss stochastic uncertainties that may arise due to unforeseen events (weather, fire…).

Different ecosystem service markets will need to quantify the ecosystem services being produced in different ways. In water markets, the good may be pollution reduction. This may be measured directly through monitoring or indirectly through models. Monitoring may require baselines such that the Change in the Ecosystem is equal to the New Condition minus the Previous Condition. Estimating modeled water quality pollution load reductions from BMP adoption may require measurement and estimation of several parameters such as; Base Loads, BMP Efficiencies and Delivery Ratios. In carbon markets, Carbon Sequestration may be modeled using Acres and Carbon Sequestration Rates. In all of these markets, each of these parameters possess some scientific and some stochastic uncertainty. This paper will discuss how these uncertainties have been addressed in the Chesapeake Bay region. It will emphasize the stakeholder driven process whereby scientific uncertainties are considered.

In addition to assessing how we measure and model ecosystem service characteristics, this paper will discuss issues that arise in ecosystem service market formation. The following questions will be address. How should markets be designed to recognize scientific and stochastic uncertainty? What other factors may markets want to consider? How should baselines be established to ensure that the "product" meets market expectations. How will markets ensure additionality?

Well functioning Ecosystem Service markets require institutions that can help define and standardize the "product". These institutions must address the science behind ecosystem service quantification in a manner that involves stakeholder input and acceptance.

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The Role of Urban Metabolism Research in Optimizing Ecosystem Services and Advancing Urban Sustainability: Prospective Applications in California

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Urban metabolism may be defined as “the sum total of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste” (Kennedy et al. 2007). The first part of the presentation presents metabolism methods and use of urban metabolism as a platform for research into energy use in California communities, and specifically the Los Angeles area. To date, urban metabolism, life cycle assessment, and urban ecosystem frameworks have been considered separately, but there are many advantages to linking these frameworks to understand the over -flows of energy and materials into, within, and out of urban areas. Research in the Los Angeles area is used to demonstrate these advantages. The second part of the presentation focuses specifically on the role of ecosystem services in urban metabolism. It uses the United Nations Millennium Assessment’s framework to explore the potential linkages between metabolism and the supporting, provisioning, regulating services provided by greenspace, wildlands, and aquatic ecosystems in urban areas.

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Cultural Resource Valuation: State of the Economics

Bruce Peacock
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This presentation describes the various economic approaches that are currently available to value cultural resources. Three questions are asked: what are cultural resources, how can they be valued, and what are the challenges facing cultural resource valuation. There are a number of economic methods that have been used in various contexts; however questions have been raised regarding their suitability if tradeoffs, which are essential to economic valuation, are not considered available by key stakeholders. This presentation will identify these issues and raise questions for additional research.

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The Economic Feedback Loop for Ecosystem Service Policy Changes

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This presentation describes how different types of economic analyses, when available, can be incorporated in a “feedback loop” that results in ecosystem service policy changes. This feedback loop describes how the analysis of direct and passive use values and regional economic impacts can influence the conditions of ecosystem services through governmental policy changes. The example of the Glenn Canyon Dam operations decision is presented as a case study.

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Evaluating Cultural Ecosystem Services – The Perspective of European Social Sciences

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Numerous scientists world-wide seek to evaluate eco-system services, mostly to provide decision support for the protection and sustainable use of the associated ecosystems. This contribution is based on the assumption that cultural services have been neglected so far in these evaluation efforts, despite a huge body of relevant research outside the ecosystem service community. Based on a review of the European literature and research activities, the contribution will pose the following questions:

1. What relevant research does exist for the evaluation of cultural ecosystem services?

2. Why do we need knowledge on the values and preferences associated with cultural ecosystem services?

Economists, geographers, sociologists, experts from planning studies and other social scientists have already shed considerable light on recreational, aesthetic or heritage values of ecosystem features. Most of this research, however, is not labelled as cultural ecosystem service evaluation. The models, methods and data result from other perspectives on the relation of humans with nature, such as natural resource management, multifunctional agriculture, multifunctional landscapes, landscape amenities, or positive environmental externalities. Common valuation methods include replacement cost, travel costs, hedonic prizing, contingent valuation or choice modelling. Europe, however, also has a long tradition of group evaluation tools and participatory methods. They are generally based on the assumption that public decision making should result from public debate and not only from the aggregation of separately measured individual preferences.

For profound decision making support, knowledge on the full range of values associated with ecosystems is needed. This would help decision makers to take account of trade-offs between competing services and rank different bundles of provisioning, regulating, supporting and cultural services. One of the major advantages of the eco-system service approach is the integration of both, commercial valuables - such as timber or food – as well as non-marketable commons, such as recreational values or water purification effects of woodland. In contrast to private provisioning services and common regulating or supporting services, many cultural services are directly perceived and experienced by many groups, including also non-land holders and non-experts. Cultural services are associated with places people feel attached to, feel responsible for. By taking account of the broad appreciation of cultural values, the ecosystem service agenda can secure the support of the general public. This is another argument for the pressing research need regarding the evaluation of cultural ecosystem services in general, and more specifically, the integration and elaboration of the relevant knowledge already existing.

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Connecting the Science to Water Quality Trading: Methods for Estimating Nonpoint Source Nitrogen Reductions and Future Science Needs

Mindy Selman -- Presented by ***Michelle Perez***
World Resources Institute

Water quality trading is gaining traction in a number of watersheds around the world. It is a market-based approach that works alongside water quality regulation to improve water quality. Our research has identified nearly 60 water quality trading programs worldwide, the majority of which focus on trading nutrients like nitrogen. In addition, nearly all water quality trading programs allow trades between regulated point sources and unregulated nonpoint sources. Because nitrogen losses from nonpoint sources are difficult to measure, designers of water quality trading programs are faced with the challenge of selecting a methodology for determining nitrogen reductions from nonpoint sources like agriculture. Some of the methods for determining nonpoint source nitrogen losses have included direct measurement through monitoring, modeling approaches, and standardized reduction values. Each of these methods presents unique advantages and disadvantages in terms of accuracy, transaction costs, and feasibility. Furthermore, these methods can be improved through integration of improved scientific information and adaptive management approaches.

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The Value of Water under Different Altitude and Moisture Scenarios: A Review of Willingness-To-Pay Studies in Mexico

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Water resources are highly valuable in environments where the liquid is restricted to groundwater or flash floods occurred in short periods of time. These types of environments are usually located in arid, semiarid, or high-altitude areas. In this paper, we present a case study where water is physically and economically valued through a water balance model and a non-market valuation technique. A follow-up review of similarly-conducted study cases in Mexico was carried out to test the hypotheses that elevation, moisture index, and human development index, affect the economic value of water. We concluded that the main factors influencing the value of water in our case study are income, education, age, family size, and water bill. We also concluded that there is no a significant relationship between water value and elevation, but there is some relationship between water value, moisture index, and human development index. Dryer areas and more developed communities tend to pay more for an improvement in current water resources conditions. These results can help decision-makers to consider regional policies aimed to improve water management conditions in arid and less-developed communities in Mexico.

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Understanding Off-Site Ecosystem Service Flows

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Following the Millennium Ecosystem Assessment it has become conventional to describe the human interest in the biophysical world in terms of a set of services that directly or indirectly contribute to wellbeing. These comprise benefits that people exploit both directly (the provisioning and cultural services) and indirectly (the supporting and regulating services). The rapid evolution of coupled human-natural systems changes the flow of the ecosystem services, and hence the way that landscapes should be managed. Yet many significant changes in ecosystem services are neither identified nor taken into account by land users. Particularly problematic are ecosystem services that affect people at some distance, but whose value is not reflected in market prices. Indeed, understanding ecosystem service flows of this kind is identified as among the key research challenges posed by the Millennium Assessment (Carpenter et al, 2009). The research reported addresses the following question: If the full array of (spatially and temporally distributed) ecosystem services delivered by specific landscapes, and the full set of (spatially and temporally distributed) beneficiaries of those services are taken into account, how should this affect landscape management?

The research is designed to extend existing work in three ways. First, identification and mapping of the land use-contingent ecosystem services provided by a reference landscape is extended in space and time. We identify the biophysical transport mechanisms (e.g. hydrological and atmospheric transport systems) and socio-economic networks (e.g. trade routes) that distribute ecosystem services and disservices off-site, find measures of the associated ecosystem service flows, and test the sensitivity of these flows to variations in economic and environmental conditions. Second, we identify the off-site beneficiaries of those distributed ecosystem services for which there are no market prices (or where market prices do not reflect social opportunity costs), and estimate the value of services to distinct sets of beneficiaries. Third, we identify governance mechanisms – institutions and incentive systems – that have the potential to induce optimal provision of ecosystem services at the landscape scale. Specifically, we will consider landscapes that deliver a range of ecosystem services at different geographical scales, and investigate the relationship between the scale of landscape management and the scale of the effects of landscape management. We investigate how inclusion of a range of services with widely varying temporal and spatial impacts affects the sustainability of conservation and use strategies.

The research is illustrated by reference to the ecosystem services flows associated with the Panama Canal Watershed, which is currently being investigated in partnership with the Smithsonian Tropical Research Institute.

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Strengthening Cooperation on International Rivers: Transboundary Ecosystem Services as a Policy Tool

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A flood of newspapers and magazines have been threatening international water wars in the future. A critical look at the current and past situation on international watercourses shows that cooperation between States is, most of the time, the rule, and military conflicts the exception (Wolf, 1998). Nevertheless, to meet the challenges of global change, it will be critical to design resilient socio-ecological systems in transboundary watersheds and create mechanisms for adaptively and collaboratively sharing water. How can this be done? We apply international regime theory to transboundary cooperation on watercourses (Lindemann, 2008) to answer this question. We argue that a part of the answer leans on the ability to assess and integrate transboundary ecosystem services (Lopez-Hoffman et al. 2010) as a challenge of adaptive management strategies. Moreover, framing transboundary cooperation in terms of cross-border ecosystem services may help strengthen cooperation between stakeholders on international watercourse. The issue is then methodological (integration of transboundary ecosystem services to the approach of international regimes) as well as political. The first part of this talk will address the challenges of governance on international watercourses. We will then try to understand how international cooperation on shared watercourses happens. Next, we will explore the challenge of designing adaptive management and adaptive governance systems on international watercourses. Finally, we will argue that transboundary ecosystem services can become a political as well as an analytical tool in building transboundary watersheds regimes that are resilient and adaptive to climate change.

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Climate Change and Ecosystem Services: The Contribution of Public Lands in the United States

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The Intergovernmental Panel on Climate Change (IPCC) (2007) reports a likely 2°C to 4.5°C temperature rise in the upcoming decades. This warming is likely to affect ecosystems and their ability to provide services that benefit human well-being. Ecosystem services valuation (ESV), meanwhile, has emerged as a way to recognize the economic value embodied in these services that is not currently reflected in markets. To contribute to better understanding of, and therefore decision-making regarding, the costs and benefits of climate change, other measures affecting the management of the wilderness and other public lands where many ecosystem services are harbored or produced in abundance. We combine GIS analysis with the benefits transfer method to estimate potential global-warming-induced changes in the economic value of ecosystem services produced by US conservation lands. Using conservative assumptions, the overall trend indicates that the majority of ecosystem services values decreases as temperature increases. While some ecosystem service values increase in the 2° scenario in several regions, the values markedly decreased in all but one region under the 4.5° scenario. These results are consistent with other major studies such as the IPCC and the Cost of Policy Inaction and indicate both the important role of public conservation lands in providing ecosystem services and the need for policy action to avoid major economic losses were climate change to impair the health of those lands.

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Ecosystem Services in NEPA – Exciting New Tool, Weak Buzzword, or Another Burden?

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The concept of ecosystem services is generating excitement in environmental circles around the world as a way of protecting public goods such as crop pollination, the capacity of wetlands to "clean up" water, and the climate buffering action of vegetation. In the United States, land managers and policy officials have begun to take notice of ecosystem services, and the idea is shaping policy guidance for the National Environmental Policy Act (NEPA), management initiatives, and dispute resolution. However, new concepts in policy discourse and guidance do not necessarily produce a different set of decisions or outcomes in resource management (Houck 1997; Blumm 1993). Government land management and other environmental agencies are constrained by political institutions (e.g., legislative authorization, appropriations and oversight) and the pressures of relevant laws and interest groups—both agency clients and critics (Farber & Frickey 1991; Mashaw 1997).

This research provides a systematic review of the use of ecosystem services in legislation and policy – with particular focus on how federal policy guidance on ecosystem services has or has not influenced environmental assessments under NEPA. The deeper contribution of this research explores the impact of the ecosystem services approach on how policy makers think and act. This study fills a critical gap in our understanding of U.S. environmental policy by examining how ecosystem services are being considered under NEPA. Further, this research demonstrates the capacity of science and scientists to create and promote tools useful for the real world of environmental decision-making and governance.

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Market Development for Rangeland Ecosystem Services

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Rangelands in the western United States are increasingly recognized as providing a diversity of ecosystem services to society. However, the changing economics of ranching and exurban land use may inhibit ranchers' ability to protect ecosystem functions and threaten the future of managed, working rangelands and the ecosystem services they provide, possibly forcing many to subdivide or sell their ranches. New mechanisms and funding streams are needed to raise the bottom line for ranching while at the same supporting wise land stewardship. Ecosystem markets are an increasingly useful, widely accepted tool for conserving ecosystems and the benefits ecosystem provide to human well-being, called ecosystem services. We reviewed literature on public funding and private markets for rangeland ecosystem services and worked with one ranching collaboration. We found many public payments for rangeland ecosystem services but few private funders outside of compliance based markets. Some obstacles to project implementation include lack of easy-to-use tools for rangelands; current public land use policy; and early adopters are investing considerable time to scope out market opportunities, find investors and develop projects. Finally, we make several recommendations to improve diversification of ecosystem markets to support ranchers and the continued and improved provision of rangeland ecosystem services.

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Getting Supply and Demand Moving at Scale: The Freshwater Trust's StreamBank Model

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The Willamette River basin in Oregon is a leading region for the advancement of ecosystem services and environmental markets. Quality standards and supporting infrastructure recently approved for use in Oregon make it possible for private landowners to efficiently restore rivers, wetlands, and upland habitats, document the benefits, and market a new ecological crop in the form of "credits" to buyers.

The Freshwater Trust (TFT), along with the Willamette Partnership, are demonstrating a model for fueling markets that gives traditional conservation funders (private foundations, agencies, etc.) the option of becoming "conservation buyers" of verified conservation outcomes in the form of credits. Using the StreamBank project planning, implementation, and monitoring platform, The Freshwater Trust will leverage the up the front, private investment needed to fund credit-generating stream restoration projects that meet rigorous eligibility, verification and registration protocols.

Developed by TFT, StreamBank is an innovative web-based software application that enables local landowners and restoration professionals to efficiently implement stream restoration projects on private land. In 2007, 2008 and 2009, TFT tested StreamBank with 25 restoration projects, completed, on average, 70% faster than if implemented through a traditional grant and permitting cycle. This dramatic increase in efficiency was possible due to StreamBank's ability to align the diverse requirements of various private, state and federal entities.

The methods demonstrated and actualized in the Willamette basin can be replicated in other regions where market activity may provide environmental benefits. While credit evaluation protocols are regional, the framework for developing them can be applied anywhere. The StreamBank platform is designed to be scalable for use on a regional and national level, incorporating region-specific information from existing data sources (watershed assessments, recovery plans, etc.). When utilized at scale, StreamBank has the potential to transform entire watersheds by meaningfully addressing current and mounting freshwater challenges, offering significant economic gains, especially to rural communities, and helping benefit municipal freshwater systems.

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Integrated Social-Ecological Network Analysis of User-Managed, Avian and Invertebrate Species-Inhabited GreenER Roofs and Walls Providing Expanded Urban Ecosystem Services

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Identification of the benefits of green roofs and walls have largely focused on their engineering functions such as storm water retention, climate mitigation and/or the aesthetic value of their plant life. By incorporating an understanding of ecological processes into the design and construction of green roofs and walls, the provision of habitats and/or foraging grounds for targeted species such as invertebrate pollinators, avian seed dispersers, or particular red-listed organisms is also possible. Taken individually, such habitats and foraging grounds would be isolated habitats, at risk for population extinction. However, a ***network*** of green roofs and walls, designed with an ecological understanding of species movements in and between fragmented habitats, could maintain viable species populations providing expanded ecosystem services such as pollination and seed dispersal in a wider urban landscape, especially when existing surrounding ground level habitats and foraging areas are incorporated into this ecological network. By further incorporating active citizen involvement and management in the use and maintenance of this fragmented ecological network, additional ecosystem services connected with educational, social, cultural, recreational, and health benefits are also possible.

The provision of these expanded greenER roof and wall ecosystem services can be studied by examining the interaction of user and management social networks with the plant, avian, invertebrate ecological networks on which they impinge, and vice-versa, as social-ecological networks. Such work builds upon studies that have begun to use a network perspective in understanding the resilience of social-ecological systems as well as a study sketching a typology of four approaches to integrated social-ecological network analysis. These four approaches are: (1) Analytical integration of separately examined social and ecological networks; (2) Analysis of the social network with ecological elements as node attributes, or vice versa ; (3) Integrated social-ecological network analysis removing social and ecological distinctions between network nodes and flows between nodes; and (4) Translating interactions between social and ecological entities into two-mode networks, possibly complemented by one-mode social and/or ecological networks.

Possible use of these four approaches in analyzing a hypothetical social-ecological network of green roofs, walls, and users in the area of Stockholm's Swedish Parliament and/or the Stockholm Albano/Frescati university area is examined.

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Modeling of Valued Fish Species in River Networks

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Riverine fish provide many ecosystem services in support of human well-being, including food, recreation, and biodiversity. Under future drivers of land use and climate change, inland waters are likely to be impaired, and conservation and protection of fish species and services in these systems will be a focus of environmental management. We developed a model that simulates the response of interacting populations of valued fish species – a metacommunity – to multiple stressors across a stream network. The model is spatially-explicit and age-structured, with three components: habitat suitability, based on exposure to multiple stressors; population dynamics, including species interactions; and movement across a spatial river network. Although this model is relatively simple, complexity can be built in as appropriate; for example, the representation of anadromy. We have linked this model to dynamic watershed inputs in an integrated modeling system for watershed assessment and prediction. The current application of the model is to the Willamette basin in Oregon, under alternative scenarios for climate and land management.

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Ecological Integrity as an Economic Variable: The Need for Aggregated Landscape Scale Indices

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Ecological integrity is part of the complete description of an economy and is thus as important to policy analysis and social research as any other economic variable. Because data describing ecological function are often localized with limited spatial and temporal comparability, investigations of the broad trends in landscape scale ecological integrity are limited. A standard calculation procedure is needed to integrate many sources of ecological data into an index that describes landscape scale regions. As the science of ecosystem and landscape ecology develop, the calculation procedures should evolve, just as other economic variables are recalculated as improved procedures develop. Despite somewhat arbitrary choices necessary for well accepted economic variables such as the gross domestic product and the consumer price index, the calculation procedures for these variables are transparent so they are quite useful. As an example of an index calculated using the Forest Inventory and Analysis (FIA) database of the USDA Forest Service, we developed an aggregate index that quantifies the closeness of a forested region to a natural state. This index was based on the diversity of native tree species and sizes for ecological subregions in a seral condition. We applied the calculation procedure to the 70 survey units of the southern U.S. for dates when survey data was available between 1961 and 2005. The index exhibited a significant increasing trend with time, per capita personal income and population.
Keywords: ecological indices, ecological diversity, policy analysis, economics, landscape.

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Using Ecosystem Services to Define and Communicate a Vision for the Future of Coastal Louisiana

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The loss of coastal wetlands in Louisiana and the degradation of the coastal ecosystem represent one of the greatest ecosystem restoration challenges in the nation. The coast is valued for its economic activity, including major ports and commercial waterways, the nationally significant oil and gas industry, and cities like New Orleans and Lafayette with their strong and unique cultural heritage. The ecosystem provides habitat to support nationally important commercial fisheries, harvest of alligators and fur-bearers, and millions of migratory waterfowl. The critical role played by the coastal landscape in attenuating storm surges and waves became even more clear after the hurricanes of 2005. To address the loss of these important services, the State of Louisiana (State) developed a Master Plan for a Sustainable Coast in 2007. The largely conceptual plan is now undergoing refinement in preparation for the 2012 Master Plan Update, which will include a plan for implementing, and funding, a series of prioritized coastal protection and restoration projects.

The 2007 Master Plan laid out a broad direction for restoration and protection in coastal Louisiana based on four objectives, and depicted implementation concepts on maps to give a general impression of where actions could be taken. To date, however, the planning process has been missing a single, comprehensive vision for coastal Louisiana, something that would make it clear to stakeholders where we are going and how we will know when we get there. Developing such a Vision is a key component of the 2012 Master Plan Update. Developing and then comparing restoration outcomes against a vision for the future of the coast enables the State to scale its investment effectively and ensures a common basis for discussing options for protection and restoration.

The visioning process builds on past planning efforts and principles, but looks toward the future by specifically acknowledging that the coast of the past is not achievable. By recognizing upfront that compromises are needed and that actions to achieve some desirable outcomes can have consequences (either synergies or conflicts) for other outcomes, the State will be equipped to make better funding and implementation decisions. The objective is to confront some of the legacy “tough questions” about the tradeoffs and find common ground to develop a shared vision. The Vision includes levels of protection appropriate for coastal communities and infrastructure, types of commercial and recreational activities that occur along the coast, and attributes of a sustainable ecosystem to guide the State in the future. The Vision must also be technically feasible in the context of a dynamic coast.

The Vision uses the concept of ecosystem services to characterize the aspects of the ecosystem which are considered broadly desirable. Nine groups of services have been identified: agriculture/aquaculture production, freshwater-dependent services, brown shrimp harvest, oyster harvest, saltwater commercial and recreational harvest, carbon and nutrient uptake, surge and waver attenuation, shoreline recreation and ecotourism. Levels of future service provision have been identified for each of these and benchmarked against current conditions. Predictive models are used to identify the change in level of service provision associated with the each project, or group of projects, allowing progress towards the vision to be used in project prioritization.

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Remote Sensing for Coastal Applications: Implications for Ecosystem Services

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The U.S. Army Corps of Engineers (USACE) administers the National Coastal Mapping Program (NCMP) for the collection of high-resolution airborne lidar and hyperspectral imagery in support of planning, engineering, construction, operation, and maintenance activities along U.S. coastlines. Using an integrated airborne sensor suite and ground-based processing system, topographic and bathymetric lidar and aerial and hyperspectral imagery are processed into a variety of Geographic Information Systems (GIS) data products. These include 1-meter Digital Elevation Models (DEMs), 1-meter bare earth DEMs, true color orthorectified aerial image mosaics, pre-processed hyperspectral image mosaics, basic land cover classifications, and zero-contour shoreline vectors.

Several studies have been conducted in response to an identified need to expand the use of and maximize the benefits of data resulting from this USACE program to support environmental project work at USACE coastal district offices. The focus of this presentation is to illustrate environmental application and product examples, such as new techniques for discriminating seagrass and macroalgae species in two Massachusetts harbors, identifying stamp sands containing copper and other toxic metals along Lake Superior, examining post-Katrina elevation and land cover changes along the south shore of Lake Pontchartrain, as well as other environmental research topics, including invasive species detection, wetlands and beach characterization, forestry parameterization, and ecological modeling. Through the illustration of these examples, the presentation will discuss the implications for ecosystem services, such as extracting spatially-derived ecosystem based information and classification accuracies. It will also explore key mapping techniques, data limitations and challenges, and other considerations important for extracting ecological data that are increasingly used in ecosystem service assessments.

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LandServer: An Ecosystem Service Market Mapping and Assessment Tool

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At the 2008 ACES conference, we presented the conceptual model of the LandServer tool. This year we are excited to present the working beta of the tool, currently live in Maryland and Delaware, with plans to expand to nationwide coverage. This workshop will discuss the concepts behind the tool, and demo the tools functionality to private landowners, State and Federal agencies, and non-governmental organizations.

What is LandServer?

A free online conservation assessment tool, LandServer enables private land owners, non-profit organizations, governments, and corporations to further their natural resource objectives by targeting landowners and operators willing to implement conservation actions.

LandServer provides landowners with a quick and easy evaluation of their property's potential to receive payments through ecosystem markets and traditional conservation programs. LandServer furthers organizations' conservation objectives by enabling working, conservation, suburban, and other rural lands to implement land practices that enhance and sustain ecosystem services.

What can LandServer do for me or my organization?

Raise awareness. LandServer is an educational resource that raises the awareness of the role of natural systems in providing valuable ecosystem services.

Increase participation. LandServer is a landowner's one-stop shop for natural resource information about their land. By translating complex program requirements into simple eligibility models, LandServer provides an efficient and comprehensive tool, educating landowners about their eligibility for ecosystem service markets; and enabling organizations to connect with landowners interested in implementing conservation actions.

Target priority conservation areas. LandServer can be loaded with any state or local GIS data, which is then used to produce a natural resource assessment report for the landowner. This GIS data can include Special Resource areas, wetlands, priority funding areas, wildlife action plan data, zoning, rural legacy, cost share programs, and other natural resource or priority area datasets.

Connect with landowners. LandServer directs eligible landowners to participate in relevant cost share, state, and local programs and conservation marketplaces like the Bay Bank. It enables organizations to specifically target and reach out to landowners who express interest in implementing conservation actions.

Learn more about LandServer at www.landserver.org

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Production Functions for Aesthetic Ecosystem Services

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Bearing in mind that aesthetic experiences are not the same as perceptions of value, it will be argued that the aesthetic experiences most needed from ecosystems are those which entail strong affects shared by many people and which are multi-dimensional in ways that comport with cultural appreciation of healthy ecosystems. The nature of these experiences will be discussed particularly in relation to both their reliable and anecdotal properties, and the strong, normative impacts they can have on the values held by people and cultures, and consequently upon ecosystems.

Bearing in mind that aesthetic experiences are not the same as descriptions of them, a range of potential affective perceptions, from both the senses and the intellect, that contribute to socially valuable aesthetic experiences will be discussed. Their relative power in producing positive or negative and intersubjective experiences will be explored by way of examples from theory and empirical evidence. A model indicating pathways for production of such experiences will be proposed. It will offer a sequential interplay of affects that is more likely to produce worthwhile aesthetic ecosystem services. The means for identifying and evaluating opportunities to create or maintain such experiences will be discussed in relation to the current state of the art of landscape scenery assessments, visual impact assessments, and the kind of empirical research that provides evidence to support these.

Finally, speculations about the nature and extent of gains or losses in welfare attributable to important aesthetic experiences will be offered. It will be argued that the value of these welfare effects is under-appreciated and warrants more attention. There are also potential pitfalls in incorporating aesthetic qualities in ecosystem service valuations. These can occur due to mismatches between the functional content of ecosystems and their primary sensible qualities, and also due to the fuzzy logic of aesthetic perceptions whereby the intentions of those who seek to produce them can go astray upon discovering the actual results. In either case, changes in ecosystems or information about them can impact aesthetic perceptions in uncertain ways with potentially problematic normative and cultural consequences.

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ESRP Approach to Using Final Ecosystem Services

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The U.S. Environmental Protection agency has developed the Ecosystem Services Research Program (ESRP) as one of its major research efforts. The goal of this program is to create “A comprehensive theory and practice for quantifying ecosystem services so that their value and their relationship to human well-being can be consistently incorporated into environmental decision making.” This goal requires that the ESRP program quantify ecosystem services in a manner that links ecosystems to human well-being. In pursuit of this quantification ESRP has supported a focused effort to identify practical indicators that can provide support for these linkages. In pursuit of this goal we have adopted the premises of Boyd and Banzhaf (2007) and the views embodied in the concepts of final ecosystem goods and services they developed. This focused effort has been built around workshops that identified metrics of final goods and services for streams, wetlands and for estuaries. The approach taken at these workshops was to identify a range of beneficiaries of each of these aquatic ecosystems. For each beneficiary we went through a series of thought experiments asking – How do these ecosystems directly affect the well-being of individuals in this group of beneficiaries, and what biophysical features, quantities and qualities require little further translation to make clear their relevance to human well being?

Results from these workshops have been provided in workshop reports. Continuing efforts will focus on evaluating these metrics for practical use among ecologists working in ESRP and elsewhere and translating the metrics for each beneficiary into indicators of potential final ecosystem services. The success of our continuing effort will be manifest in the testing and eventual adoption of these metrics and indicators in national and regional monitoring, modeling, and mapping programs and in improved linkages between natural and social scientists.

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Linked Ecological and Economic State and Transition Model for Adaptive Management of Rangeland Ecosystems

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Stewards of western rangelands manage increasingly complex social-ecological systems with few decision-making tools to assist them. Sources of ecological complexity include non- native invasive species, altered fire regimes, and climate change. Social complexity is increasing due to land conversion and rising land values, the changing demographics and character of rural communities, and shrinking producer profit margins. These accelerating ecological and social changes threaten the viability of ranches, sustainability of working landscapes, and well-being of rural communities. At the same time, natural resource management policies have transitioned away from “command and control” management and equilibrium-based scientific paradigms, towards land stewardship that applies adaptive management and collaborative learning to build ecological and social resilience. This shift in management philosophy has increased awareness of the importance of multiple ecosystem services, and the need to quantify and value both market and non-market services. Practical tools to help land managers in the transition towards adaptive management for ecosystem resilience are sorely lacking. This integrated research has developed and promoted one such tool, a linked ecological and economic state-and-transition model (STM), to help ranchers and land managers understand the effects of economic decisions on land health and ecosystem services, and the impacts of changing ecological conditions on ranch economic viability and profitability.

The model is parameterized for the Elkhead Watershed in Northern Colorado. The STM model was developed using both field collection and local knowledge as inputs. The STM model consists of three distinct ecological sites (Claypan, Mountain Loam, and Aspen), in addition to riparian habitat, hay production and pastures. Production estimates were determined for all potential states of the three ecological sites (the Claypan site consisted of four potential states, the Mountain Loam consisted of three potential states, and the Aspen consisted of two potential states). Once the states were indentified and transition probabilities were determined, a Stochastic Dynamic Programming (SDP) model was developed to determine the optimal cattle management decisions in order to maximize an infinite stream of returns to a “representative” ranch in the watershed in order to fully model overall land value. The “representative” ranch modeled represents the overall mix of ecological sites as observed across the watershed. Preliminary results show that both current ecological states and economic condition impact optimal behavior. Current ecological state conditions (and resulting transition probabilities) can have an impact on producer stocking behaviors. However, further refinement of transition probabilities, and their drivers, will likely improve the outcomes of the model. Future research will compare “optimal” decisions in terms of private and public values, enabling policy recommendations to ensure future viability of the ecosystem services provided by rangelands.

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Dynamic Simile-Based Model for Predicting the Effects of Water Quality on the Growth of *Thalassia testudinum* in Tampa Bay

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We describe a seagrass growth (SGG) model designed to predict the spatially-explicit growth of *T. testudinum* in Tampa Bay when nutrient, colored dissolved organic matter (CDOM) and suspended solids (TSS) inputs are altered by changing land use patterns in surrounding drainage basins. The SGG model functions on a daily mixing cycle based on tidally averaged exchange coefficients for each of 10 bay segments. Fresh water flow to bay segments was derived from gauged and ungauged drainage basins. Ungauged flows were estimated from a hydrologic model that included rainfall and four land-use categories (urban, agriculture, wetlands and forest). Changes in seagrass biomass were determined from daily rates of carbon fixation by photosynthesis, loss of carbon from respiration, and plant mortality. Seagrass growth rate was adjusted daily for day length, photosynthetically active irradiance (PAR) levels, and temperature and was bounded by biomass carrying capacity. Day length and PAR levels just below the surface of the water were provided by a simple spectral solar irradiance model. Irradiance at plant canopy depth was adjusted for water quality parameters (e.g. phytoplankton biomass, CDOM, and TSS). Phytoplankton growth was adjusted daily for PAR (integrated over depth) and temperature, and was bounded by cell death, nitrogen and phosphorus availability. Future versions of the model will include sub-models linking total seagrass biomass to commercial and recreational fishery production functions. Understanding this linkage will help in estimating the value of seagrass in supporting fisheries and how land use changes can impact fishery production through changes in seagrass communities.

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Valuing Changes in Ecosystem Services Under Alternative Futures

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Marine and terrestrial environments provide a number of important benefits to humans. However, a growing variety and intensity of human activities (e.g., energy production, fishing, development, transportation), coupled with the impacts of climate change, threaten the sustained delivery of these ecosystem services. Moreover, the processes and ecosystems that humans rely on for these services are poorly understood, scarcely monitored, and often only appreciated after they are lost. Land use, coastal planning and other approaches to ecosystem scale management require knowledge about tradeoffs between various services and about the true costs and benefits of policy decisions for humans and ecosystems. The Natural Capital Project, a partnership among Stanford University, The Nature Conservancy, World Wildlife Fund, and the University of Minnesota, is developing a suite of spatially-explicit ecosystem service models called InVEST (Integrated Valuation of Ecosystem Services and Trade-offs). InVEST 1) maps and values the services that flow from terrestrial or coastal and ocean environments under current and future management and climate change scenarios 2) is highly flexible for use with diverse habitats, policy issues, stakeholders, data limitations, and spatial and temporal scales 3) includes modules for a variety of services, 4) includes process-based models that consist of a biophysical step, where supply of the service is quantified, a use step where demand for the service is quantified, and an economic step for valuation in monetary terms. Models currently include food from agriculture, fisheries and aquaculture (and supporting pollination and nursery habitat services), non-timber forest products, water supply, protection from flooding, reservoir sedimentation, coastal erosion and inundation, recreation, carbon storage and sequestration, and energy generation. The models run in ArcGIS based on user-defined input layers that describe climate conditions and human use patterns in the form of alternative scenarios. We will highlight challenges and opportunities in developing and applying this approach in temperate and tropical areas around the world.

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Proposition 3: Ecological Risk Assessment Should Focus on Ecological Condition, and not on Human Well-Being

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In Support of the Proposition: Dale Goble

Ecological risk assessments are structured to separate decisions on the effects of a proposed action on ecosystems from decisions on the acceptability of those effects. The fact that the dichotomy may be elusive is a poor reason to abandon the conceptual distinction by incorporating consideration of ecosystem services, an explicitly utilitarian valuation scheme.

Ecological risk assessments seek to characterize the nature and magnitude of risks to ecological systems caused by environmental stressors such as chemicals, land change, disease, invasive species, and climate change. Procedurally, the assessment is a preliminary step that provides information on adverse effects. This information can then be used by the risk manager to decide whether the adverse effect(s) are acceptable given other factors such as economic or legal concerns.

Introducing consideration of ecosystem services undermines this dichotomy between determining the effects and the acceptability of those effects because the concept of ecosystem services was crafted to provide a market-based value for biodiversity. Ecosystem services are thus one measure of some of the "other factors" that the risk manager relies upon to decide whether the risk is acceptable.

Against the Proposition: J.B. Ruhl

Ecological risk assessment's historical focus on ecological conditions to the exclusion of human well being has led to an increasingly technical but ultimately incomplete account of the impacts of environmental degradation to sustainability. Including threats to the flow of ecosystem services to human populations within the scope of ecological risk assessment will provide a more robust platform for sustainable decision making.

The purpose of any risk assessment is to improve decision making by supplying the decision makers important information about the status, trends, and uncertainties of risks bearing on whatever it is we care about assessing. The scope and intensity of the risk assessment-how wide we set the lens and the power of focus-are critical design issues for ensuring robust and reliable information. Ecological risk assessment methods, though by all means vital to natural resources management decisions, have set too narrow a lens by leaving out an important question-what risk to humans does risk to ecosystems pose? The discipline of ecological economics, with its building body of knowledge about natural capital and ecosystem services, focuses precisely on that question. We should, therefore, use that new knowledge to develop a new method of ecological-economic risk assessment.

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Effects of a Catastrophic Forest Fire on the Trophic Parameters of an Outstanding Florida Water

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In nature, ecosystems are subject to subtle or gradual changes all the time, but sometimes nature provides periodic disturbance events or a single stochastic event that alter the ecosystem's relative "stability". Stochastic events such as wildfires can affect different ecosystem components such as changes in the hydrology, the nutrient budget and changes in water quality. Fire events have been a frequent and important mechanism of disturbance in Florida as well as the rest of North America for many centuries. The most visible effects of fire are the loss of vegetation and increase of soil erosion but the less obvious but equally important effects of wildfires occur after the fire is extinguished. For example, fires have the greatest potential to change nutrient losses from the watershed but few studies highlight its importance on the aquatic environment. In this study, the changes in trophic state parameters (e.g., phosphorus) due a wildfire event in 2007 are discussed for the Santa Fe lake group (Little Santa Fe, Santa Fe and Melrose Bay; outstanding Florida waters located in Alachua County). The availability of long-term data permits a documentation of the effect and duration of the 2007 Dairy Road fire that occurred in the Santa Fe Swamp. This study is of great importance for understanding the importance of stochastic events on Florida's water resources.

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Potential Impacts of Cropland Biofuel Production on the Provision of Avian Habitat

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Present laws and policies encourage the growth of corn for the production of starch-based and cellulosic ethanol on agricultural lands in the United States. This has been touted as an environmentally-friendly solution to problems of energy-independence, particularly in the Midwestern U.S. where much of the corn required to produce these biofuels is grown. However, the ongoing intensification of corn production (which was spurred by early biofuel policies and will be amplified by targets set by the 2007 Energy Independence and Security Act) is likely to negatively impact the delivery of a number of ecosystem services. This study explores how this production intensification is likely to impact one ecosystem service, habitat for bird species which provides opportunities for recreation via bird watching and hunting, in the Midwestern U.S.

This study focuses on Bird Conservation Region 22, the Eastern Tallgrass Prairie, which encompasses portions of eleven Midwestern states. These states are highly agricultural and are responsible for the production of much of the corn used in the generation of U.S. biofuels. As such, they are likely to experience significant intensification of agricultural production, particularly of corn, to achieve current targets. I use a highly detailed land-cover map and observation data from the North American Breeding Bird Survey to construct spatial models of habitat for breeding bird species identified as being of conservation concern in this region by the U.S. Fish and Wildlife Service. To assess the impact of these policies on the provision of habitat for these species, I then use these models to predict observations of these species on Breeding Bird Survey routes under landscape conditions predicted to exist in the region in 2022 under biofuel-driven agricultural production policies.

Results indicate that biofuel-driven intensification of corn production on Midwestern agricultural lands is likely to have a varied impact on the habitat of birds of conservation concern in the region. Habitat for a small number of species is predicted to improve while for others it is predicted to decline. For several species, habitat is predicted to experience only minimal change. These findings have conservation implications that differ for individual species, but suggest that, for the region as a whole, present policies encouraging the growth of corn for biofuel production will negatively impact the provision of habitat for key birds of conservation concern. As these species are already imperiled, further loss of habitat likely to occur under current policies may lead to species loss or reductions in abundance, at least locally, and thus to the loss of opportunities for bird watching and hunting. This illustrates just one of the ways in which the intensification of corn production for the generation of starch-based and cellulosic ethanol may negatively impact ecosystem services provision.

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Connecting Landscape-Scale Conservation with Ecosystem Markets and Programs

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Natural resource management and conservation have always played out in a context of ecosystem interconnections and challenges that transcend political jurisdictions. However, the focus on large landscape natural resource management to address these challenges has accelerated over the last decade in response to increasingly apparent cross-jurisdictional issues such as climate change effects, chronic drought, poor water quality and degraded watersheds, spread of invasive vegetation, poor forest health, and wildlife threats. Development and use of ecosystem services markets and related programs can contribute to landscape-scale conservation by: 1) providing non-traditional sources of funding, 2) facilitating generation of metrics to assess performance and results of natural resource management actions; 3) strengthening incentives for private landowners to engage in actions to protect and restore ecosystems, their components, and functions; and 4) providing mechanisms to link actions across jurisdictional boundaries.

While all natural resource management presents challenges that result from complexity and values trade-offs, these challenges are especially acute for large landscape natural resource management and conservation. Four hurdles, in particular, complicate large landscape natural resource management. These hurdles include: 1) difficulties in acquiring funding sufficient to provide resource protections at a large scale; 2) inadequacies and inconsistencies in data and information across jurisdictions and agencies; 3) varying motivations and interests in ecosystem protection across jurisdictions and land ownerships; and 4) limited legal and other authorities to coordinate action across jurisdictional and property boundaries at a landscape scale.

Ecosystem services market tools and related programs have demonstrated some potential to help address these four hurdles. My presentation will examine these four hurdles and how they have been partly addressed through development of ecosystem services markets and related programs. The presentation will also critique the adequacy of these tools, limits to their application, and possible ways to strengthen their use in the context of large landscape conservation.

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Ecosystem Services for Urban Landscapes: A Corporate Perspective

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John Deere, Syngenta, and the World Resources Institute are partnering to develop an ecosystem services framework for urban landscapes to improve the sustainable management of these landscapes. An ecosystem services framework is a structure for making informed decisions by considering a business or community's full dependence and impacts on a range of ecosystem services.

The first step of this project is to develop a scientifically defensible ecosystem services framework for turf in an urban landscape, initially focused on golf courses. The North American turf and turf-care industries generate a combined annual revenue of over $200 billion from the sales, installation and maintenance of equipment and landscapes. Recently, this industry has come under threat from the growing public perception that turf is an inefficient use of water, natural resources, and energy, with limited contribution to the urban ecosystem. However, as a dominant land cover in urban areas, turf holds considerable potential to enhance urban landscapes. An ecosystem services framework for turf would:

1) Categorize and quantify benefits that people derive from turf in urban areas

2) Define a standardized set of metrics for assessing ecosystem services-related inputs and outputs of turf

3) Align public policy incentives with urban landscapes stewardship

4) Inform decision making throughout the turf industry

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Forest Adaptation to Climate Change: Management Options

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One of the drivers of change that could affect the ability of forests to deliver various ecosystem services is climate change. Changing temperature and precipitation patterns and increasing concentrations of atmospheric CO_2 are likely to drive significant modifications in natural and modified forests. This paper reports on an examination of the effects of anticipated climate changes on forests and timber supply over the period roughly 2010-2050. It examines the question of the ability of the forest ecosystem, and particularly the industrial wood sector, to adapt the climate change over the period until about 2050. The focus is on the timber production component within the forest sector.

This study is part of a World Bank sponsored effort intended first to help decision makers in developing countries to better understand and assess the risks posed by climate change and to better design sector strategies to adapt to climate change. The study takes a broad overlook of issues relevant to climate change and its impact on forests. This is followed with three case studies – of Brazil, South Africa and China – of the impact of climate change on the forest and on their capacity to produce industrial wood. The presentation notes uncertainties associated with forest management in anticipation of a changing climate and makes suggestions as to future research directions.

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A GIS Tool to Assess *Socia*l *V*alues for *E*cosystem *S*ervices (SolVES)

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Ecosystems are facing continually increasing human pressures, which places ever more importance on research involving tools and methods that incorporate social values information into the broader context of comprehensive ecosystem services assessment. Tradeoff analysis among ecosystem services will be improved by including quantified and spatially explicit measures of social values. As a contribution to such research, the U.S. Geological Survey, Rocky Mountain Geographic Science Center (RMGSC) has developed a public domain, GIS application - *So*cia*l V*alues for *E*cosystem *S*ervices (SolVES). SolVES was developed with VB.NET as an ESRI®[1] ArcGIS toolbar and is available for download at solves.cr.usgs.gov. It is a tool to assess, map, and quantify the perceived social values of ecosystem services such as aesthetics and recreation through the derivation of a quantitative, social-values metric, the Value Index. The 10-point Value Index is calculated from a combination of spatial and non-spatial responses to public attitude and preference surveys. SolVES also calculates landscape metrics from spatial data layers describing the underlying physical environment, for example, average elevation and distance to roads and water, at locations along the Value Index. SolVES calculates kernel-density surfaces and zonal statistics to produce Value Index maps and to report landscape metrics associated with each index value. This can be repeated for various survey subgroups as distinguished by their attitudes and preferences regarding ecosystem uses such as motorized recreation or oil and gas drilling. The Value Index provides a basis of comparison within and among survey subgroups to consider the effect of social contexts on the valuation of ecosystem services. The Value Index also facilitates statistical analysis of relationships between index values and landscape metrics. Using a form of value-transfer methodology, SolVES can apply regression coefficients produced by such analyses to their corresponding landscape data layers to produce predicted social-value maps for similar areas where primary survey data are not available or as a complement to existing survey data.

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[1] Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Global Land Use Change Dynamics, Greenhouse Gas Emissions, and Ecosystem Services (GLUES): A Collaborative Research Initiative Based on Multiple Place-Based Assessment Studies

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The Millennium Ecosystem Assessment (MA) put ecosystem services as instrument to assess use of natural resources on the map. For all its success, the MA did not deliver explicit recommendations on either the scientific underpinnings of such assessments or on how to consolidate ecosystem service instruments within political structures. The project “Global Land Use change dynamics, greenhouse gas Emissions, and ecosystem Services” (GLUES), funded by the German Ministry for Science and Education, aims to address these issues.

GLUES will work with and support up to 10 Regional Projects (RPs) that will study ecosystem service management at local and national scales. With respect to scientific activities, GLUES has the overarching goals of synthesizing results from the RPs across the local to the global scales. To this end, the GLUES consortium will provide consistent global scenarios for the medium to long term which will provide frameworks in which the RPs can conduct their analyses. This consistency eliminates one source of variation that will inevitably exist between the RPs and thus one problem for the synthesis of their results.

GLUES will also provide the RPs with support for transferring results to and from international policy forums and science initiatives. By matching up the stakeholders and their conflicts from the RPs with the appropriate international forums, GLUES will facilitate a productive exchange of ideas and practical approaches. This exchange will give the programme and it’s results a long-term perspective beyond the funding period of the individual RPs and GLUES.

Supporting these two pillars is a GeoData Infrastructure (GDI). The GDI is a decentralized data management systems, where project partners from GLUES and the RPs as well as any other interested parties can make their data available for accessing by others. Envisaged data types range from socio-economic and ecological variables to information on institutional frameworks. The GDI makes it possible to request and quickly receive data in the desired format. The GLUES tasks of synthesizing scientific results and providing policy insights can benefit significantly from this easy flow of information.

By providing a synthesis and integration platform for place based studies GLUES does not only support regional projects within the funding measure of German ministry for Science and Education. It also may serve as a basis for synthesizing comparable place-based studies across the world.

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Modeling Linkages between Effective Impervious Surface and Urban Vegetation Productivity in Semi-arid Environments

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With a majority of the world's population now living in urban areas, their role as providers of ecosystem services warrants increased attention. While the expansion of urban areas undeniably has serious environmental impacts, it is possible that these impacts can be mitigated by maximizing the ecosystem services provided by developed areas. One potential service an urban area can provide is uptake of carbon (C) and nitrogen (N) pollution in its vegetated areas. A key component of maximizing uptake capabilities is an adequate supply of water, particularly in semiarid and water-stressed regions. However, reducing the impact of urban areas demands reducing reliance on water imports or groundwater resources. Given these tradeoffs, urban designs that maximize vegetation use of available water can make an important contribution to ecosystem services.

To gain insight into how landscape features influence vegetation productivity, we use a coupled ecohydrogic model to estimate impacts of the amount and arrangement of impervious surfaces on vegetation water use. We use the model to explore how concepts from decades of research in natural semi-arid ecosystems can be applied in the urban context. Ecological research in semi-arid ecosystems has shown that the arrangement of vegetated and bare surfaces plays a key role in regulating both runoff and ecosystem water use and productivity. Systems that include a mixture of bare and vegetated surfaces, for example, tend to show less runoff and more productivity than those with more homogeneous cover. In some instances, patchiness of bare and vegetated surfaces is more important than total vegetated area in determining rates of runoff and vegetation use of rainfall. In an urban context, impervious surfaces can be viewed as analogous to the bare surfaces present in undeveloped ecosystems.

Urban ecosystems are generally characterized by fragmented and heterogeneous land cover, with “bare” patches composed of streets, parking lots, roofs, and other impervious surfaces. While increases in total impervious area (TIA) have been widely shown to impact catchment hydrology, the role of effective impervious area (EIA) has been less extensively studied. Effective impervious area is defined as impervious area with a direct hydraulic connection to the drainage network. A consensus is emerging from the literature that EIA is as important or even more important than TIA as an indicator of catchment response to urbanization. Considering EIA in the design and evaluation of ecosystem services provided by urban areas is an important next step. Ecohydrologic models offer a tool to quantify the role of EIA on water availability and plant productivity and demonstrate the potential of urban areas to act as C or N sinks (and minimize the impacts such as increased storm runoff and degraded downstream water quality). We explore the relative roles of TIA and EIA on water availability and plant productivity in a semi-arid urban environment through a series of modeling exercises. The Regional HydroEcological Simulation System (RHESSys) is used to model a range of impervious surface and vegetation scenarios on a test hillslope in the Mission Creek catchment in Santa Barbara CA. Results indicate that reduced EIA can indeed act to mitigate the impact of TIA on water available to plants. We then implement a modification to the RHESSys model that incorporates patch scale estimates of EIA into simulations of the entire Mission Creek catchment, allowing us to quantify likely catchment-scale impacts of altering EIA.

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Fish as Indicator of Heavy Metal Pollution in Aquatic Ecosystem

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Industrialization and improvement in agricultural practices for better yield have contributed by various ways to the general deterioration of the environment, on which humanity is completely dependent for life. Numerous sources of industrial effluents lead to heavy metals enrichment of the aquatic environment during their mining and smelting operations. Heavy metals produce various physiological changes in the aquatic fauna particularly in fish. Among these physiological changes, energy metabolism has a key role as the animal is forced to expand more energy to mitigate the toxic stress. Heavy metals including cadmium are reported to induce changes in oxygen consumption, tissue respiration, histopathological changes, after accumulation in the tissues of fishes. Hence toxicity of cadmium to fishes has stimulated considerable interest in recent years. The present study was designed to observe the toxic effects of cadmium on freshwater teleost fish '*Channa punctatus*'. The hematological, biochemical, and enzymological alterations produced on exposure of *Channa punctatus* to LC_{50} (11.2mg/L) for 96h and to a sublegal concentration (1.12mg/L) of cadmium (Cd^{++}) for 15, 30, 60 and 120 days have been studied. For each enzyme, triplicate aliquots were incubated and incubations were repeated three times at 22°C. Cadmium in the samples of water, sediment, and fish tissues was analyzed by atomic absorption spectrometer(Perkin Elmer, 703). Enzyme analysis was made by standard methods as given by Bergmeyer. The students 't' test given by Wardlaw was employed to calculate the significance of differences between control and experimental means. The fish were hypoglycemic and hypolactemic. The pyruvate content of blood and liver decreased in acute and all stages of chronic exposures except for 30 days, where significant increase was recorded. Depletion was noted in the totoal protein and glycogen content of liver and muscle, and the level of lactate in liver in the two types of exposure. The levels of muscle lactate and pyruvate increased in both exposures. The activities of hexokinase, glucose 6-phosphatase and lactate dehydrogenase decreased in liver after 96 h and all stages of chronic exposure, except 30 days. The activities of hexokinase and lactate dehydogenase in muscle and glutamate-oxalacetate transaminase and glutamate pyruvate transaminase in serum, liver and muscles increased in all exposures. The activities of succinate and malate dehydrogenases in liver and muscles decreased after all exposures. Above results suggest that glycolysis and gluconeogenesis was impaired in liver but glycolysis prevailed in muscles. Aerobic oxidation is adversely affected in metal exposed fish, while proteolysis was increased.

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Ecosystem Services and Smart Growth Planning: Integrating Public Service Costs into Conservation Planning at the Urban Fringe

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Efforts to conserve biodiversity and other ecosystem services can conflict with policies that promote outward urban growth and increase the municipal tax base. The full costs of urban growth (loss of ecosystem services, costs of public services) are rarely considered in conservation *or* municipal land-use planning. Spatial analysis tools that facilitate the identification of important areas for the conservation of ecosystem services while also minimizing the costs of urban growth are critically needed to address the multiple challenges and land-use objectives that face rapidly growing urban areas. The goal of this research is to develop a conservation reserve scenario for eastern Pima County, Arizona that minimizes the costs of urban expansion while meeting targets for the protection of ecosystem services. We address four ecosystem services; soil productivity, aquifer recharge, recreation, and biodiversity by using a spatial optimization algorithm to find a "near-optimal" land matrix while satisfying targets pre-specified for each service. The cost surface model reflects an aggregated cost of providing public services across the study area, including sewerage, transportation infrastructure, municipal water supply, and public transit. The resulting reserve scenario depicts how multiple land-use goals – ecosystem service conservation and smart growth – may be integrated. The conservation reserve scenario we construct is evaluated beside an existing conservation lands system focused primarily on biodiversity protection using a different spatial design and cost surface. The resultant maps and analysis illustrate how considerations of public service costs and ecosystem services protection can be complementary when planning for land-use around the urban fringe. We discuss how our methodology may be used in new conservation planning exercises or as a prioritization technique in those that already exist.

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Development of National Land-use/Land-cover Scenarios for Ecological Impact Assessment

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Changes in land use and land cover (LULC) affect the ability of ecosystems to provide goods and services. Urbanization, agricultural intensification, and other anthropogenic disturbances alter landscape structure and function and the provision of ecosystem goods and services Natural disturbances from fires, storms, and insects, as well as impacts associated with climate change, can compromise the ability of ecosystems to support increasing demand for services. Understanding the complex impacts of such events is the subject of considerable ongoing research; however, there is little research to develop nationally consistent future scenarios of LULC change, consistent with global climate change assessments, at scales sufficient to facilitate ecological impact assessments.

Here we present ongoing work to develop a set of regional LULC scenarios for the United States. Scenario development is based on the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emission Scenarios (SRES). SRES scenarios include qualitative narratives and quantitative greenhouse gas emission scenarios based on future assumptions of population growth, economic development, energy use, social values, and rates of technological innovation. Climate variables for SRES scenarios are produced by Global Circulation Models and are used to inform LULC scenario construction. SRES scenarios were developed at the global and world-region scale, which has limited utility for regional ecological impact assessments. To facilitate such analysis we have developed a method to “downscale” SRES scenarios for the U.S., utilizing the qualitative SRES narrative storylines, LULC forecasts from quantitative scenarios produced by IPCC modeling teams, regional and national land-use histories, and expert knowledge. Downscaling from national to regional scales is based primarily on observed historical rates and patterns of LULC change and expert knowledge about the influence and interaction of drivers of LULC change at regional scales. Regional and national scenarios are designed to maintain consistency with world-region and global SRES storylines. Regional LULC scenarios serve as input, or “demand”, for the Forecasting Scenarios of Land Change (FORE-SCE) model, which allocates LULC annually at a 250-meter pixel resolution for ecological regions of the United States. Spatially explicit LULC provided by FORE-SCE, for the period 2000-2050, can be used in research requiring high-resolution scenarios of LULC for extended periods into the future, based on assumptions of changes in driving forces, including climate. Because our downscaled SRES scenarios are characteristically void of any assumed climate mitigation actions, our LULC scenarios can function as useful reference cases from which climate mitigation strategies may be constructed and evaluated for further impacts on ecosystem services.

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Finding Common Ground between Ecosystem Services and Environmental Ecosystems

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Ecosystem services are generally defined as the benefits people obtain either directly or indirectly from ecological systems. It is posited that these ecosystem services are free, but would be very expensive if people had to pay for them. From an economic standpoint, ecosystem goods and services are defined and applied to various natural and semi-natural ecosystems. From an ecological view, ecosystem functions and values should be well understood and, using that knowledge, applied to the ecosystem service framework. In addition, ecosystem processes are dynamic and the application of ecosystem service valuation should be flexible enough to include change.

Using riparian ecosystems as an example, we define ecological structures, functions, and values from an environmental perspective. We also provide a multi-scalar model to describe interactions within the riparian corridor and among adjacent systems. We then summarize recent efforts to use the ecosystem functions and services in riparian systems worldwide. Defining the Supportive Functions and Structures in the ecosystem services framework is an important step to providing the linkage between the environmental and economic/human approaches. It was helpful to also construct a matrix among ecosystem functions and services to define positive/negative relationships. For example, the Regulating Service of Raw Materials provides building and manufacturing materials; however, harvesting those materials from the riparian corridor would negatively impact the Gas Regulation service through carbon sequestration. We provide a discussion of the necessity of a feedback loop to ensure that goods and services can be produced or consumed without impacting the resilience of the ecosystem.

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Conceptualizing Human Well-being and Ecosystem Services in Context of Economic and Social Aspects

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Humans are dependent upon the services provided by nature, and unless we effectively account for the range of values from ecosystems in our efforts to protect the environment, we cannot sustain human well-being. In light of this dependence, a national measure of well-being is needed to link ecosystem services to the constituents of well-being in order to integrate the human condition into environmental protection. The USEPA Ecosystem Services Research Program (ESRP) vision is that a comprehensive theory and practice for quantifying ecosystem services, their value and their relationship to human well-being, is consistently incorporated into environmental decision making. A conceptual framework was constructed to develop modules that qualitatively link social, economic and ecological services to elements of human well-being. Results from these qualitative analyses provide a foundation for developing a composite index of well-being inclusive of ecosystem services for the U.S. Index construction will utilize objective and subjective data to integrate these modules into a weighted assessment of well-being. The determination of the impacts and gains in well-being associated with decisions that modify ecosystem services should reflect a “truer” measure for genuine accountability in ecosystem protection.

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Water Banking; A Free Market Approach to Efficiently Managing and Incentivizing Conservation of a Natural Resource

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A lack of coherent laws and regulation, combined with the inherent transient nature of water renders comprehensive water management a continual challenge. However, water stressed regions throughout the American West are beginning to experiment with water banking to address water shortages. Water banks serve as novel market-based approaches to efficiently transfer, allocate and drive the conservation of water. Some of these banks successfully juggle complex issues such as preserving rural economies, curbing the insatiable urban desire for water and augmenting environmental flows, while dealing with the increased uncertainty of water levels due to climate change. In 2010, with the support and guidance of WestWater Research LLC, a comprehensive graduate research and analysis of water banking throughout the United States was launched. Through literature research and in depth interviews 38 active and proposed water banks were identified. Of these, 32 banks were profiled and analyzed to understand their goals and market structure and evaluate their level of success as a management tool. This talk will provide insight into the most relevant and emerging themes in water banking as market-based model for managing and preserving ecosystem services.

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Development of a Spatially Explicit Land-Use Model for the Assessment of Biofuels

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The increased usage of biomass for biofuels has the potential to dramatically change the landscape of many parts of the United States. Utilization of corn for ethanol, and to a lesser extent soybeans for biodiesel, has already resulted in significant shifts in cropland extent and crop-type composition in parts of the Midwest and Great Plains. Likely utilization of cellulosic feedstock for biofuels has the potential to affect many other parts of the country. To understand the potential effects an expanded biofuels industry may have on land use and land cover (LULC), and ultimately on ecological systems, ideally we would have access to integrated modeling systems which account for drivers of LULC change operating at all pertinent scales. However, there is no one modeling system which provides such an integrated analysis of LULC response under an expanded biofuels scenario. Models such as the Policy Analysis System (POLYSYS) or Forest and Agricultural Sector Optimization (FASOM) models provide top-down policy and economic-based assessments of the agricultural sector, including potential effects of an expanded biofuel industry. However, these models typically only provide regional estimates of crop production, typically for states or large portions of states. While the simulation results from these models are extremely valuable, they cannot directly address ecological or agricultural system response at the site level.

The Forecasting Scenarios of Land-use Change (FORE-SCE) model provides spatially explicit forecasts of LULC response to a set of specific scenario conditions. The model is structured into distinct but linked components, the “demand” component which provides annual proportional estimates of LULC change, and the “spatial allocation” component which utilizes “demand” and creates annual LULC maps. Given the flexibility offered by the FORE-SCE framework, we can directly utilize regional estimates of agricultural production from models such as POLYSYS or FASOM as “demand”, and provide spatially explicit representations of biofuels scenarios as modeled by those aspatial models.

FORE-SCE applications to date include moderate resolution (250m) forecasts and backcasts of LULC patterns for the western Great Plains, and forecasts for the eastern United States. Such spatially explicit LULC forecasts can be used to examine impacts of LULC change on a variety of ecosystem services, such as effects of landscape pattern on biodiversity. Current research focuses on linkages of FORE-SCE with the General Ensemble Modeling System (GEMS), a biogeochemical modeling framework. Feedback between FORE-SCE and GEMS will allow us to examine site-specific soil characteristics under a specific biofuels scenario, allowing us to examine issues of biofuels sustainability at the site level. By linking the FORE-SCE LULC model with both top-down economic and policy models as well as with site-specific biogeochemical modeling frameworks, we are much better equipped to examine future biofuels scenarios, and the potential site-specific impacts of resultant land-use change under those scenarios.

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Moving from Inputs to Outcomes to Markets

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Using ecosystem services credits to invest public funds can 1) help agencies prioritize opportunities and expand the methods for investing in restoration, 2) be used to show the real value of government investments in the environment, and 3) demonstrate that ecosystem service credits are trustworthy, thus increasing stakeholder comfort in using credits in regulatory policy and private markets. The Lake Clarity Crediting Program motivates effective actions to restore Lake Tahoe clarity by informing the investment of federal, state and local funds and defining performance-based regulatory requirements. It also establishes the tracking and reporting infrastructure necessary to operate an ecosystem service market. This presentation will describe how water quality credits are strategically being used to underpin efforts to compete for national and state sources of public funds, address stakeholder concerns related to using offsets to meet regulatory requirements, and are leading the way to establish a market that will attract private capital to restoration of water quality and other environmental goals.

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Using Ecosystem Service Credits to Increase the Effectiveness of Publicly Funded Restoration & Water Quality Regulatory Programs

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Nearly $500 million has been invested to restore Lake Tahoe, yet lake clarity continues to decline, and there is little information to understand the effectiveness of these investments. Thus, regulators and restoration program managers have developed a broad set of performance measures to prioritize investments, report results and determine regulatory compliance. In particular, a Lake Clarity Credit has been developed within the context of the Lake Clarity Crediting Program which creates an accounting system for all efforts to meet the Lake Tahoe Total Maximum Daily Load (TMDL). This program increases the flexibility of meeting stormwater regulatory requirements by anchoring on meeting load-based performance targets and enabling water quality trading between municipalities in California and Nevada.

This presentation will show how ecosystem service credits create a new set of public policy options that can increase the effectiveness of the investment of public funds and avoid the stand-offs typical of regulatory posturing.

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An Agent-Based Model of Multifunctional Agricultural Landscapes Using Genetic Algorithms

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Agricultural landscapes are important producers of ecosystem services. The mix of ecosystem services and commodity outputs of an agricultural landscape depends on the spatial pattern of land uses emerging from individual land use decisions. However, many empirical studies show that the production of ecosystem services from agricultural landscapes is declining. This is consistent with research conducted over the last few decades showing there is a narrow range of social circumstances under which landowners are willing to make investments in the present to achieve public benefits in the future through investing in natural capital resulting in public goods which are frequently produced as ecosystem services.

This article describes the development and performance of a multi-agent-based model for the prediction of agricultural land-use decisions in a multifunctional landscape. Three agent types (profit-maximizers, satisficers, and conservationists) vary in their objectives and are geographically located based on land characteristics. Land-use choices in a southern Illinois watershed are simulated using genetic algorithms, a heuristic approach based on principles of natural selection.

As compared to land-use data derived from the USDA-NASS Cropland Data Layer, the three-agent model correctly predicts 73-87 percent of land uses over a three-year period compared to only 60 percent correct using a profit-maximizing agent alone, thus demonstrating the utility of the multi-agent approach. Genetic algorithms provide flexibility and out-perform linear programming in prediction accuracy with reasonable computational demands. When linked to the Virtual Watershed model, the multi-agent model can effectively evaluate the land use, commodity production, and ecosystem service outcomes of economic and policy scenarios in multifunctional agricultural watersheds.

Keywords: Multifunctional agriculture, Agent based modeling, Genetic algorithms.

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State of Watershed Payments: An Emerging Marketplace

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Driven by concern over unsustainable rates of freshwater consumption and recharge and the growth and severity of nitrogen-fueled dead zones across the globe, economists, policy makers, and environmental leaders have been experimenting with innovative solutions to managing water resources by working to capture a willingness to pay for watershed improvements, hoping to help maintain high-impact ecosystem services with a diverse set of payment mechanisms. Tracking the project-level activity of these nascent, often fragmented, and hard-to-find payments schemes led to a report focused on the current State of Watershed Payments designed explicitly to establish a baseline to inform a diverse group of stakeholders about where these schemes are being developed, in what context, and with what level of investment.

The focus of research is on two broad types of payment mechanisms: Payment for Watershed Services (PWS) and Water Quality Trading (WQT). Research is limited to those programs where transaction activity could be determined, defined as: A program is considered *active* if it has facilitated payments between entities seeking to improve watershed services. The key to the transaction is the exchange of money, or property (i.e., credits) from one entity to another.

Using 2008 as the baseline year, research identified 288 PWS and WQT schemes in varying stages of activity. Far fewer programs recorded actual transactions in 2008, numbering roughly 127. The transaction value in 2008 is estimated at US$9.3 billion, which may be conservative considering the number of programs where transaction activity could not be determined. Sophistication of program design, regulatory drivers, defined property rights, market structure, and monitoring and verification methodologies vary by program with each program unique to the local watershed conditions.

Tracking the payment activity of these nascent, often fragmented, and hard-to-find payments schemes establishes an important baseline providing transparency for all interested parties regarding where these schemes are being developed, in what context, and with what level of investment. These payment mechanisms are valuable project finance tools that can aid in the management of watersheds and in the sustainable use of ecosystem services. The global trends point to continued expansion of the use of market-based tools to aid in the improvement of water quality and ecosystem health. Practitioners are grappling with issues of quality, transparency, and the need for performance-based metrics to demonstrate real improvements in ecosystem health. These key features are sure to influence program design and thus how these tools will evolve in the coming decade. A growing constituency is arguing for valuing water-related ecosystem services as part of overall ecosystem health. That expanded lens would incorporate watershed services with other ecosystem services such as biodiversity, carbon sequestration and those associated with coastal and marine environments, further increasing the opportunities for these tools to work for water quality improvements, conservation, communities, and people.

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The Feedback Loop: Monitoring and indicators of Watershed Health in Greater Los Angeles

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Using a watershed-based approach for water resource management is well-established in scientific and policy circles throughout the world. In urban Greater Los Angeles, the Watershed Council is developing indicators and applying data from watershed monitoring programs to assess the economic, social and ecological health of this large region. Collaborative partnerships support indicator development and regional watershed monitoring while data and conclusions provide feedback for improvement. We will report on these two threads and how they feed into each other in the Los Angeles region, where the use of indicators for watershed health is relatively new, although beach monitoring has a relatively long history.

A research project to establish indicators of watershed health in Southern California is nearing the conclusion of a three year partnership between the Council, academics, and government agencies. We developed an indicators-based framework for assessing the health of the urban watersheds, drawing upon work of the US EPA (US EPA Science Advisory Board, 2002) to apply ecologic, social, and economic indicators to express watershed health. We completed a pilot assessment for a tributary of the Los Angeles River, the Arroyo Seco. Working with other organizations around the State, work is underway to design an system for aggregation of these regional products into a statewide reporting mechanism.

The watershed monitoring program focuses on the conditions the two major rivers of Greater Los Angeles, the Los Angeles River and the San Gabriel River. The State Water Resources Control Board initiated support for watershed-wide monitoring as a component of discharge permits. The program is managed by the Watershed Council yet designed in collaboration with the Regional Water Board, major water treatment dischargers (LA County Sanitation; Cities of Los Angeles and Burbank) as well as other regional stakeholders.

These watershed monitoring projects are addressing five questions about the watershed. 1) What is the environmental health of the streams? 2) Are the conditions at areas of unique importance getting better or worse? 3) Are receiving waters near discharges meeting water quality objectives? 4) Are local fish safe to eat? 5) Is body contact recreation safe? Answers to these questions are based on measurements of water chemistry/toxicity, physical habitat, biological integrity, water-borne bacteria and fish tissue toxicity. We report annually on both ambient and targeted-site conditions and will issue five-year State of the Watershed reports in 2011 for the San Gabriel River and 2013-14 for the Los Angeles River.

We will discuss the feedback between the monitoring programs, indicators development, and the statewide effort to develop a suite of indicators to be used in improving conditions in the extended watersheds that are intricately linked through large state and federal water transfer programs; we will briefly compare these programs to predecessor assessment systems from the region and nation, such as the independently designed and operated California beach report card.

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Integrating Indicators of Ecological Condition and Services into a Policy Framework

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Assessments of aquatic ecosystems can be refined to better inform management actions and to support human well being. Substantial improvements would be made by using similar frameworks for the assessment of streams, lakes, and wetlands and having common endpoints of assessment. Ecosystem services are common assessment endpoints that could be identified in all habitats and clearly related to human well being. However, many challenges stand in the way of transforming assessment programs of aquatic ecosystems, such as methods for assessing ecosystem services of diverse waters and harmonizing those methods with existing methods and water quality management policies. In this presentation, we provide solutions to many of these challenges by outlining an assessment protocol and relating results of assessment to a policy framework.

We propose a relatively simple framework to organize information gathered in assessments and to relate indicators of ecological condition and assessment. We organize indicator variables into five categories according to policy applications and a causal pathway linking human activities, the contaminants and habitat alterations (stressors) that they cause, valued ecological attributes, ecosystem services, and natural ecological factors that regulate interaction among the other four categories of variables. Human activities are often measured as proportions of watersheds or riparian zones that are altered by one type of human activity or another, i.e. land use. Contaminants and habitat alterations are measured with the physical and chemical attributes of waters and habitat structure, as well as invasive species. Valued ecological attributes is a category of attributes that are related to historic management endpoint of waters, such as biological condition, water clarity, and chlorophyll a concentration. We classify ecosystem services into supporting, regulating, cultural, and provisioning services as in the Millennium Assessment. One of the key differences in assessment of biological condition and ecosystem services is the comparison of observed condition to expected condition. Expected biological condition is near natural or minimally disturbed conditions. Expected ecosystem services, or the desired state, are the maximum possible. The expected biological condition and ecosystem services vary with natural hydrogeomorphic factors of the water body, so natural factors must be measured to determine expected condition for a water body. Water quality criteria can be developed using reference and stressor-response approaches for stressors, valued ecological attributes, and ecosystem services.

Tradeoffs will occur in management strategies for ecosystem services, including the support of biological condition. For example, many provisioning services are highest with modest nutrient pollution, however many cultural services (aesthetics and biological condition) may be compromised. Many states identify tiered uses of waters, which provide a policy mechanism for managing different waters for different uses, i.e. subsets of covarying ecosystem services. Different strategies for measure biological condition and ecosystem services, water quality criteria, and tiered uses will enable integrating assessments of ecosystem services into existing water management frameworks.

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The Relationships among Ecosystem Services and Human Well Being

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The Millennium Ecosystem Assessment produced a compelling synthesis of the global value of ecosystem services to human well-being. While the MEA was a critical, initial step to demonstrate the potential for assessing global trends in ecosystem services, it is important to note that the MEA did not attempt to down-scale such assessments to regional or even national scales of analysis, nor did it attempt to create methods and tools to support decision-makers at any level of governance, industry, or citizen action. A new research perspective focusing on ecosystem services is needed in which we define ecosystem services as the products of ecological functions or processes that directly or indirectly contribute to human well-being, or have the potential to do so in the future. This approach can easily be applied to an Index of Human Well-Being. The vision of this approach would be to contribute to a comprehensive theory and practice for characterizing, quantifying, and valuing ecosystem services and to ensure that their relationship to human well-being is consistently incorporated into environmental decision making. Building upon indicators linking ecosystem services to human and community health, both ecosystem and placed based information could be used to develop a U.S. measure of human well-being. This measure would expand the interpretation of ecosystem service indicators into an overall quality of life measurement for environmental decision support.

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Experimental Markets for Connecting Ecosystem Services to Consumers' Values and Decision Support

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This presentation will discuss the possibility of ecosystem service markets through which consumers may directly pay for ecosystem services, particularly public goods that benefit many people simultaneously. Many ecosystem services, including many recognized as cultural or aesthetic services, are public goods. Examples include the benefits people perceive from knowing that grassland nesting birds may be successful on farmland surrounding or near suburban, exurban, or rural-fringe homes. Land management decisions may affect more than one ecosystem service, such as may occur if landowners establish new grassland hayfields for nesting birds, a choice that may also increase carbon sequestration on the farm or capture more nutrients from rainwater runoff. Another example involves individuals paying to restore sea grass in coastal lagoons or shrubland important to fall-migrating birds in coastal stop-over habitats. The presentation will discuss example markets drawn from these example applications, and economic mechanisms designed to generate revenues, and drawn from literature of experimental economics. Challenges revealed in these examples will be identified, and potential advantages of a consumer driven market (rather than regulatory-based market like cap and trade) will be discussed. In addition, we will consider the use of economic choice mechanisms involving auction-based approaches designed for guiding management decisions when a conservation agency might face choices between methods that carry different costs and different spatial or temporal implications for on-the-ground results. Examples may be drawn from grassland birds in Rhode Island and Vermont, from the Virginia Coastal Reserve, or from Orange County, CA.

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A Program on Genuine Progress Accounts for the United States

John Talberth
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The Genuine Progress Indicator (GPI) is one of the leading candidates for a national headline indicator of sustainable economic welfare. The GPI begins with personal consumption expenditures adjusted for inequality, and then makes a series of credits or debits to account for additions to or loss of human, built, natural, and social capital and the service flows that emanate from these stocks. Additional adjustments are made to account for consumption financed by unsustainable debt. The GPI framework provides a way to incorporate changes ecosystem service values into the national accounting framework, however, methodologies to do so are still in their formative phase. This paper outlines a broad research agenda to establish a Program on Genuine Progress Accounts in the U.S. that relies on state of the art methods to marry real time satellite and ground-based monitoring data with GPI sub-accounts to produce annual and quarterly GPI estimates that can indicate the extent to which economic activity is building or drawing down natural capital stocks and their ecosystem service flows.

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Impacts of Corn-based Biofuel Production on Soil Fertility and Ecosystem Sustainability

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Promotion of using crop residue and other cellulosic biomass for biofuel requires quantitative information on the sustainability of cropping practices and their environmental consequences. It is a big challenge to develop cropping systems that can balance the demand for increasing biofuel production capacity with the maintenance of other critical ecosystem services. In this study, we took corn production as a renewable biofuel example to further our understanding of impacts of changes in land use and management caused by biofuel production on ecosystem sustainability. Our specific goal is to investigate how the levels of corn residue removal affect soil carbon and nutrient budgets at present and in the future under proposed corn-based biofuel production scenarios. Soil organic carbon (SOC), an important C component in the life cycle of biofuel production, is a strong indicator of cropping system sustainability. We used a soil carbon and nutrient balance approach developed from published experimental results to analyze historical USDA Agricultural Census data of yields and fertilizer usage associated with various management practices at the county scale across the United States. Our analyses show that ecosystem carbon flux demonstrates significant spatial variability, relying heavily on the total biomass production level and residue harvest intensity. We also found that SOC budgets depend mainly on the proportion of residue removal, tillage type, and previous SOC stock level. Furthermore, our results indicate that corn cob removal for biofuel has little influence on soil carbon and nutrient balances under conventional management practices, while necessary irrigation can contribute greatly to corn-based biofuel production and ecosystem sustainability.

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Eco-Enterprise: Market Innovations in Ecosystem Services

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As the needs and demands of society increase, it becomes ever more important to invest in the natural infrastructure that supports human life and economic development. Traditional conservation programs alone can't adequately safeguard the nation's land, water, or biodiversity and traditional markets do not provide sufficient economic incentives to retain open space. The value of ecosystems needs to be incorporated into individual and corporate decision-making and consumer choice.

Forest and agricultural lands are threatened by conversion and by land use decisions that can degrade their ecological value as well as their ability to provide critcal services to society. Local land use conditions often encourage the conversion of farm and forest lands to urban development or alternative uses. Because ecosystem services are not priced correctly or not priced at all, conservation and stewardship actions often cannot compete with other economic incentives.

The concept of an **Eco-Enterprise Zone** initative is to stimulate the development of workable multi-credit ecosystem service markets that could serve as tangible models in specific geographic areas of the US. The initiative would target areas with growing populations in need of both economic opportunities and ecological improvement. "Enterprise zones" have been used with great success for economic development purposes for decades. Tax incentives, tied with targeted grant opportunities, have resulted in job creation and wealth generation as well as rejuvenation of urban areas. This program could further this concept on a watershed or regional scale while adding the elements of both coordination of state and local land use planning authorities and development of ecosystem services markets at the local and regional scale. Landowners could receive new incentives to work collaboratively at the community and regional scale to improve water quality, provide climate mitigation benefits and conserve species habitat. New business enterprises could receive five-year tax credits and no interest loans for developing ecologically friendly and green industries that create additional jobs while providing re-investment opportunities for ecosystem services provision within the same zone.

A limited number (as many as 6-10) **Eco-Enterprise Zones** could be selected through a competitive process. Criteria for selection would include the potential to: demonstrate a comprehensive multi-credit approach to ecosystem services; deliver strong local alliances with capacity for action; create opportunities for new investments in conservation; engage local regulatory governance; define operational systems where land owners and managers can connect to the consumers that benefit from them; and, have ability to deliver new revenue streams directly to private landowners and/or incentives to keep forested land and other ecosystems intact. Implementation would consist of a dedicated 5 year commitment of technical and financial assistance investments.

Key elements of the program include:

1. State, local and federal cost-share share programs to incentivize coordination of local land use planning with state and federal environmental improvements
2. Tax credits to local business development within Eco-Enterprise Zones established through federal and state designation authorities
3. Development support for market design and infrastructure operation.
4. Development of ecosystem services markets and additional revenues for local land owners.

Economic benefits accrue in the same locality as ecological improvement. The **Eco-Enterprise Zone** initative encourages local businesses to pursue the triple bottom lines of economic development, ecological improvement and community well-being and stability. With business tax incentives tied to investments in land stewardship practices, rural wealth and ecological health could occur within the same communities and ecosystems.

The development process for newly emerging ecosystem service markets is characterized by adaptive learning; a process that benefits greatly from the lessons learned in early demonstrations. By capitalizing on existing regional or watershed-based projects and helping them reach maturity, overall ecosystem market objectives can be achieved in a more efficient and timely way.

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Forest to Faucet: Drinking Water as an Ecosystem Service

Albert Todd and *Emily Weidner*
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Drinking water is clearly one of the most vital ecosystem services flowing from healthy forested watersheds. Over 180 million people and thousands of communities in the US rely on surface water for their drinking water supply. Major urban centers, like Denver, Atlanta, and Los Angeles depend heavily on National Forests for their water. Other cities, like New York, Washington DC, Baltimore, Seattle and many small rural communities, rely on privately owned forests to provide clean water. Urban and suburban growth continues to convert watershed lands to development, increasing demand is further stressing water supplies, and new stresses like climate change are expected further strain the provision of these vital water shed services. Even so, in most cases, the public is generally unaware of their connection to the watersheds and forests that sustain their water supplies or the threats that they face now and in the future.

The future security of water supplies will not be ensured by a focus on water treatment alone. The connection between clean water and the condition of lands in source water watersheds is critical. Protecting, restoring, and managing forests in source watersheds is an essential part of future strategies for providing clean, safe drinking water that citizens can afford. Market-based financing of watershed management through Payment for Watershed Services (PWS) schemes is emerging as a promising instrument to connect the forest to the faucet in clear economic terms. Payments for watershed services can help incentivize watershed protection and lead to net increases in source water protection and improved management of ecosystems.

This presentation will present results and findings from a recently completed national assessment of drinking water supplies, illustrate the relative importance of sub-watersheds (at HUC-12 scale) in protecting water supplies, the role of forest lands in sustaining them and the future threats to those forests. The presentation will further look at the utility of this information in identifying potential PWS schemes and provide some examples of current PWS arrangements in the US.

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Estimating Ecosystem Service Values in Southern Ontario

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The presentation summarizes the results of a project conducted by Spatial Informatics Group, LLC (SIG) for the Southern Region Planning Unit of the Ontario Ministry of Natural Resources (MNR). MNR commissioned this study in order to:

- Better understand southern Ontario's natural heritage by adding a socio-economic value to MNR's existing natural heritage information
- Explore how ecosystem service information might support policy making and planning and allow for a fuller cost accounting
- Help identify key gaps in the literature
- Develop an economically defensible rationale for the conservation of southern Ontario's natural heritage and
- Fill the gap in information about ecosystem service values in southern Ontario.

SIG's primary objectives were to conduct a value transfer analysis for Southern Ontario and, based on this, share findings about the opportunities for and limitations to valuing ecosystem services in the study area.

The methodology for the entire study region included the following: determining study area boundaries; developing land cover and ecosystem service typologies that would be used for the value transfer function, in collaboration with MNR; conducting an extensive literature review and synthesis leading to the updating of the SIG Natural Assets Information System ™ with new valuation estimates classified by the customized ecosystem service and land cover typologies; creating a literature gap analysis cross-tabulated by ecosystem service and land cover type; mapping out southern Ontario according to the twenty one-class land cover typology using a set of custom-designed GIS utilities; calculating areas for land cover classes; cross-tabulating ecosystem service value flows by land cover and service type; reporting ranges of ecosystem service values by land cover, service, and study; and mapping ecosystem service value flows by geographic subunits (watersheds and hexagons). In a second phase, a slightly more detailed land cover typology was used for several small case study eco-districts located including significant amounts of Great Lake shoreline. This involved using aerial photos to digitize additional categories for beach dunes near structures and not near structures (which had significantly different values associated with them).

Based on the results of this analysis, we made an extensive set of recommendations about how ecosystem service valuation might be used in policy making and planning, and what the limitations are in general and specifically in Southern Ontario. A key finding was the importance of high precision in the land cover typology. In particular, it was found to be crucial to break land cover types such as forest, herbaceous, and wetland, into sub-categories based on proximity to urban areas (in the case of forest, there were separate categories, for urban, non-urban and suburban). Defining "urban" and "suburban", as well as choosing appropriate proximities proved to be challenging. It was also found that many categories required subdivision based on biophysical contextual factors, such as wetlands connected to the Great Lakes versus inland wetland.

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Change in Environmental Services in Southern Yucatán: Balancing Proximate and Distal Drivers

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Land or land system change is a major source of changes in environmental services worldwide. The causes, drivers, or forcing functions on land change have long been debated. The environmental sciences tend to focus on proximate drivers while the social sciences emphasize distal drivers. Both of these simplified positions err for a number of reasons, foremost generated by the specific questions posed. Longitudinal assessments of change in tropical forest demonstrate significant flux in the amount and pace of deforestation and tree-cover recovery. This flux is explored for the southern Yucatán over the past 25 years in which changes in population and regional economic policy have been profound, with impacts on environmental services. Proximate and distal drivers there have operated in concert; to ignore the full range of drivers leads to inaccurate assessments with potentially inappropriate policy implications.

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Ecosystem Service Provisioning in Sustainable Planned Communities in the United States

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Planned communities have become a dominant presence in residential landscapes across the United States. By instituting policies intended to maintain property values, these communities create social inequities through their ability to capture a disproportionate share of urban public services. Planned communities increasingly implement policies that regulate outdoor space with potential impacts on the provisioning of ecosystem services. A subset of these planned communities are intentionally developed to achieve a suite of sustainability goals including open space preservation, biodiversity conservation, compact development, energy efficiency, and organic agriculture. The extent to which these communities achieve their espoused goals and offer a viable mechanism for sustainable urban planning is unclear due to a lack of cogent empirical evidence. The ecosystem services perspective provides a guiding framework to empirically evaluate the ecological consequences of individual planned communities as well a means for consistent comparison of outcomes across planning schemes. This research identifies representative case studies of sustainable planned communities across different regions in the United States and identifies a suite of critical ecosystem services for evaluation of and comparison between projects through a review of the relevant literature. The goals and potential environmental outcomes are highly varied between different sustainable planned communities and these differences can be evaluated within the ecosystem services framework. A more systematic, empirically based platform can inform developers and advocates of sustainable planned communities in advancing their ability to meet espoused goals as well as the development of urban planning policies that incentivize ecosystem service provisioning.

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Ecosystem Services and Environmental Liability: The Dutch Situation

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It has been proposed that environmental damage in the context of the European Environmental Liability Directive (ELD) may be assessed by ecosystem services valuation. Question is how feasible this proposal is.

The ELD was incorporated into Dutch law by a modification the Environmental Management Act (EMA) in 2008 (VROM 2010).

Three different types of environmental damage are distinguished in the EMA:

- Any damage to protected species or natural habitats that has or may have significant negative effect on achieving or maintaining the favorable state of these species or habitats.
- Any damage to waters that has or may have significant negative influence on the ecological, chemical or quantitative condition or the ecological potential as described in the Water Framework Directive.
- Any soil pollution that poses a significant risk of negative effects on human health.

Damage is defined as measurable negative changes in natural resources or impairment of ecosystem functions, that occur directly or indirectly. Ecosystem functions are functions that natural resources fulfill for other natural resources, or for the society. Restoration measures may be targeted at recovery, rehabilitation or replacement of affected natural resources or ecosystem functions, or at creating equivalent alternatives for resources and functions. The authorities have to hold responsible the party that has caused the environmental damage and invoke an assessment of the magnitude of environmental damage. There is no indication in the EMA of how damage should be assessed.

The descriptions the EMA certainly provide possibilities to use ecosystem services valuation to assess damage and to investigate restoration measures. The concept of ecosystem services, however, has been relatively unknown in the Netherlands, especially in policy and management. Lately, the concept increasingly is gaining attention, mainly as a tool for communication. The Netherlands Environmental Assessment Agency (PBL) - the national institute for strategic policy analysis in the field of environment, nature and spatial planning - has published a first brochure on ecosystem services in spring 2010. The brochure states that it is important to include ecosystem services in decision making, but - unlike the international report “The economics of ecosystems and biodiversity” (UN 2010) - questions the feasibility of valuation of ecosystem services. Monitoring is not targeted at ecosystem services and values for the services are not (yet) available (PBL 2010).

Given the absence of indications of how damage should be assessed and how recovery/restoration should be measured, the statement of PBL makes it unlikely that in the near future ecosystem services valuation will be seen by authorities as a key instrument to assess damage in the context of the EMA.

VROM 2010. http://wetten.overheid.nl/BWBR0003245/geldigheidsdatum_03-07-2010 (in Dutch)
PBL 2010. http://www.rivm.nl/bibliotheek/rapporten/500414002.pdf (in Dutch)
UN 2010. http://www.teebweb.org/LinkClick.aspx?fileticket=I4Y2nqqliCg%3d&tabid=924&language=en-US

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Development of a National Framework for Habitat/Biodiversity Metrics

Sara Vickerman
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Defenders of Wildlife has a long-standing interest in securing new sources of revenue to support biodiversity conservation. For the purposes of this paper, biodiversity means the full spectrum of native plants and animals in functioning ecosystems. With the growing interest in programs that provide payments for ecosystem services and emerging markets for ecosystem services, biodiversity is often identified as a priority target, with the potential to attract private investment to supplement investments in conservation made by governments and non-profit organizations. However, most biodiversity is not regulated, so the drivers for biodiversity markets are weak and fragmented. It is also probably the most difficult resource to quantify consistently. It's difficult to sell what can't be reliably measured using accepted standards.

The Willamette Partnership in Oregon has secured several federal grants to support the development of infrastructure and protocols for a multi-credit marketplace. One project, called Counting on the Environment, facilitated agreement among a broad diversity of agencies and stakeholders to use consistent methodology to quantify credits for salmon, wetlands, water temperature and upland prairie. The upland prairie metric, except to the extent that it addresses the needs of the endangered Fender's Blue Butterfly, is the only one that addresses an unregulated resource.

With funding from the Bullitt Foundation, Defenders of Wildlife and the Willamette Partnership developed a proposal to create a national framework to quantify habitat and biodiversity, using the upland prairie calculator as a model. Each habitat-specific metric contains key indicators of habitat condition, function, ecological context, management security and other important values that are assigned numbers on a spreadsheet. Algorithms are developed and applied to generate a functional acre score for a site. The tool can be used to evaluate a site at baseline, under improved management conditions, and to quantify adverse impacts. The credit score is reported as a functional acre, which generally represents a percentage of optimum ecological functioning of a site relative to the needs of a group of focal species. The tool is policy-neutral, applicable to across all land uses, and should be compatible with similar tools applied to broader ecological scales.

For the national framework, stakeholders will initially select a set of habitats that are identified as ecological priorities, where there is a strong possibility that a voluntary, pre-compliance, or compliance biodiversity market will develop in the next few years, and where local experts are interested in being involved in the metric development. The cost of developing each one is in the $25,000 range.

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National Policy Options to Encourage Credible Ecosystem Service Markets

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Defenders of Wildlife and several other conservation organizations have been involved in the development and implementation of programs that promote public and private investment in ecosystem services. While the Willamette Partnership, Ecotrust, Pinchot Institute, American Forest Foundation, Pacific Forest Trust and Freshwater Trust have concentrated on the quantification and marketing of ecosystem services to regulated or voluntary buyers, Defenders focuses on improving policies that guide these markets, and will ultimately determine whether they succeed or fail.

Success of the programs should be measured using sustainability principles: ecological impact, economic efficiency, and social equity. Early experiences have revealed several systemic problems that inhibit the effective application of market-based approaches. These include 1) A lack of clear and integrated ecological goals at scales appropriate to critical resources like air and water, natural landscapes, fish and wildlife; 2) A series of federal statutes designed to address problems in isolation, that are not easily adapted to a more integrated approach; 3) Uneven regulations that appear to place higher value on some resources than on others; 4) Poorly developed measurement systems for ecological values, especially complex ones like biodiversity ; and 5) Chronic under-funding for many conservation programs, especially incentives for private landowners to conserve resources with public values.

Since it could take decades and considerable political strife to untangle the morass of natural resources laws and established funding mechanisms, one option would be for Congress to authorize, encourage, and help finance alternative approaches. For example, in one or more regions of the country, federal agencies and partners could be rewarded with extra funding and management flexibility to develop integrated conservation strategies that address multiple issues, especially water, habitat and carbon. The strategies should encompass public and private lands, provide incentives to private landowners, encourage private investment through market-based approaches, and include comprehensive third-party monitoring to document the effectiveness of the approach. Several successful examples of alternative approaches might convince skeptics and build support for more comprehensive changes to narrowly focused and administratively complex regulations. Other policy options that could be implemented include updating existing incentive programs to be more integrated, strategic and outcome-based, and increasing the relative amount of federal money allocated to infrastructure projects that enhance natural systems in place of more resource-intensive, hard engineering projects.

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Paying for Watershed Services: How Do We Measure Impacts?

Rebecca L Goldman[1]*, Silvia Benitez*[2] and *Alejandro Calvache*[3] ¨ *Presented by* ***Kari Vigerstol***
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Measuring the impact of our conservation work, particularly when the focus includes ecosystem services, is more complex than measuring a change in response to a given indicator as there are considerations of scale and of measuring the effectiveness of an interdisciplinary approach rather than a single intervention. We developed impact measures to test the effectiveness of such an ecosystem services approach: a set of payment for watershed services projects, called water funds, developed by The Nature Conservancy (TNC) and partners which are proliferating throughout the Northern Andean region of South America.

Water funds are based on the premise that natural ecosystems and conservation best management practices by people living upstream in a watershed can help provide a clean, regular supply of surface water to downstream users. These users (including water utility companies, hydropower companies, and other industries), who depend upon these services, should then pay for their maintenance and persistence. In the water funds in the Northern Andes, payments are voluntary and are invested in a trust fund providing a sustainable revenue source for conservation. Water users and stakeholders form a governing board to make decisions on where and how to spend the revenue.

Water funds include a governance structure, a financial mechanism, and various types of investments in people's well-being and in biodiversity protection and restoration. The impact of this combined strategy must be measured. To do this we first defined a set of clear goals and objectives for water funds. Second, we convened a multi-disciplinary team of experts to detail an experimental design including controls and treatments. Third, we developed a set of more detailed experimental questions and indicators. Finally, we compiled all of this into a guidance document which included extensive expert consultation and revision.

The guidance document includes a framework for monitoring and measuring the effectiveness of water funds where effectiveness depends on good governance, sustainable finance, functioning hydrological cycles, and healthy ecosystems. We address issues of scale and challenges of defining counterfactuals and controls, and we include a mechanism to relate small-scale indicator monitoring to measuring the effectiveness of the overall interdisciplinary approach.

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Tribal Forest Management Inherently Results in Sustainable Ecosystem Services

John R. Vitello
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Having been a practicing Forester, Silviculturist and Forest Manager on three different Indian reservations over the course of 22 years, I have witnessed and participated in some of the most remarkable forest stewardship being practiced anywhere in this country, and perhaps, in the entire world. Indian forestry is participatory by nature, and sustainable by both culture and statute. It is the Indian people that decide on the vision for their forest, which translates into the goals and objectives within their forest management plan. It is the Indian people that live within or near the forest, directly enjoying the cultural, spiritual, medicinal, sustenance, and other life-giving benefits that a perpetually in-tact forest provides. And it is the Indian people that work the forest, deriving economic benefits from the sustainable management of their forest for products that we all use.

Inherent in this management process of perpetuity is the provisioning of ecosystem services, the primary focus of this conference. While providing the lifeblood of economic, social, and spiritual sustenance to Indian people, their forests also innately provide for water, gas, climate and disturbance regulation; biological diversity and nutrient cycling; soil formation and retention; and a host of other vital services we tend to take for granted.

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Modeling Temporal and Spatial Flows of Ecosystem Service in Chittenden County, VT

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This paper presents the integration of ARIES (*AR*tificial *I*ntelligence for *E*cosystem *S*ervices) with the land use change model UrbanSim to explore impacts of current and future residential and commercial land use pattern on the provision of flood, recreation, and nutrient regulation ecosystem services. ARIES is an open source modeling platform developed at the Gund Institute for Ecological Economics. It is particularly well-suited for measuring, mapping, and modeling the temporal and spatial flows of ecosystem services across the landscape, explicitly linking the areas of provision (sources) with human beneficiaries. UrbanSim is an open source agent-based land use model that was designed to simulate a wide-range of future scenarios based on user-specified landscape conditions and behavioral assumptions.

Ecosystem services travel through time and space and are susceptible to disruption and destruction from both natural and anthropogenic perturbations. The conversion of natural or agricultural land to urbanizing uses is replete with a long history of hydrologic disruption, habitat fragmentation, and the impairment of sensitive landscapes. Development decisions are predicated on the presence of desirable landscape characteristics that meet the needs of developers and satisfy the desires of consumers, often at the expense of life-supporting natural capital. We demonstrate how the ARIES platform can be used for quantifying changes to ecosystem service provision under scenarios of alternative land use regulations, infrastructure investments, and population projections in Chittenden County, VT, USA. Stakeholder workshops were held to develop relevant scenarios related to issues facing the County as they attempt to plan for future growth. Chittenden County houses nearly 25% of the state's population and several employment centers that draw workers from throughout the region. Chittenden County is expected to maintain modest residential and non-residential growth over the next 30 years, and will continue to serve as the region's population and employment center.

The results of the Chittenden County UrbanSim model will be passed to ARIES (at five year intervals) to model flood, recreation, and nutrient regulation ecosystem services over time and space. Beneficiaries of interest for this application include homeowners, farmers, business property owners, and water-based recreational enthusiasts. We present Bayesian models of the ecosystem services as individual source, sink, and use components coupled with models of temporal and spatial flows of services across the landscape. Model outputs include maps depicting flow paths (linking sources to beneficiaries), hotspot locations that are critical to the movement of multiple services across the landscape, and the demand for and supply of services. Results will be shared with local and regional land use and transportation planners to inform decision-making and promote sustainable develop patterns.

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Emerging Ecosystem Service Tools & Relevance to Corporate Decision-Making

Sissel Waage
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There are increasing signals that a "game changing" paradigm shift in environmental thinking is underway—with the potential to significantly expand stakeholder expectations of corporate performance. Although the exact timing and geographic locations of uptake remain uncertain, the trend is becoming clear. Environmental thinking is broadening—from discrete issue management to inclusion of how business impacts may be affecting landscape-level ecological dynamics, such as the flows of ecosystem services.

If trends play out, then it is likely that stakeholders will demand that corporate reporting include not only specific impacts—such as waste flows, corporate greenhouse gas emissions, water usage, and other parameters—but also information that contextualizes this data within watershed, landscape, or even regional dynamics. Advocates assert that consideration of ecosystem services allows for understanding particular environmental impacts within the context of ecosystem structure, function, and flows of services.

As expectations begin to shift, corporate leaders have begun to make commitments related to ecosystem services and develop new practices. Concurrently, there are emerging government actions, as well as expectations of activists, investors, and other stakeholders. Ecosystem services initiatives have been launched in relation to the International Standards Organization (ISO 14,001), the Global Reporting Initiative (GRI) and the Global Compact's Performance Model (GCPM).

If momentum builds, then these efforts will, in turn, drive a need for identification, measurement, assessment, and potentially even valuation of both impacts and dependencies on ecosystem services within the landscapes in which businesses operate. In response to emerging demand, ecosystem services decision-making tools are in development.

This panel will offer a "point in time"' assessment of the ecosystem services tools domain as well as potential interface points with existing corporate governance, strategy, and operations decision-making processes.

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Bringing Economic Principles to the Practical Measurement of Ecosystem Service Endpoints

Lisa A. Wainger
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Ecologists and economists supporting the US EPA Ecosystem Service Research Program (ESRP) are working together to address the question: What do ecologists need to measure to support management decisions? Creating ecological endpoints that resonate with decision makers is an important step towards capturing the aspects of ecosystems that people most want to preserve and protect, even though such indicators do not directly measure benefits of changes in ecosystem services. While the ultimate ecosystem service metric for informing tradeoffs may be monetary assessments of social welfare, alternative metrics are routinely used when valuation cannot be successfully applied. As an alternative to dollars, ecological endpoints can be brought closer to measures of social welfare by considering the supply and demand conditions that make something valuable, including what is scarce or irreplaceable, and incorporating location conditions that affect how people value a gain or loss of ecosystem services. A case study for Midwestern agro-ecosystems will be used to demonstrate how economic concepts can be applied to create ecosystem service endpoints that can inform risk assessment and protection or restoration priorities. The approach quantifies supply and demand conditions for multiple ecosystem services to compare the *level of service* (LOS) by region, in order to suggest which services are scarce or vulnerable to disruption and which user populations are at risk of service loss. The analysis uses production functions to relate ecological quality and quantity to service provision, and evaluates the presence of complementary inputs necessary to realize service use (e.g., road access). Substitutability and irreplaceability are considered to establish whether a local shortfall in supply relative to demand is likely to be associated with a loss of social benefits. Further, spatial modeling of demand for services allows the *spillover* demand from more to less populated areas to be quantified. The case study will reveal how available ecological, physical and socio-demographic data can be combined and modeled using economic principles to assess whether current demand is fulfilled and whether services are likely to be sustained into the future.

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There Is Merit in Understanding Risk to Ecosystem Services in the Context of Environmental Management Decisions

Lisa A. Wainger[1] and *Mark S. Johnson*[2] -- *Co-presenter:* ***Larry Kapustka***
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[2]US Army Public Health Command, Health Effects Research Program, Aberdeen Proving Ground, MD , USA

In Support of the Proposition: Lisa A. Wainger

Risk assessment cannot fully realize its potential to inform decisions until it adopts ecosystem services as endpoints and links those endpoints, through economic models, to social benefits. Efficient use of our natural resources requires that we evaluate tradeoffs in terms of effects on multiple facets of our life support system and not as a piecemeal approach to eliminating a narrow set of human health risks, which is often the primary focus of risk assessment. It is clear that protecting human health is one of our highest priorities, however, that goal alone, is insufficient to protect many other aspects of social well-being, including economic well-being. Risk assessment needs to move forward by developing a wider set of evidence-based models that assess multiple facets of human welfare, present and future. Endpoints that measure ecosystem services are those that communicate harm to our natural resource base in terms that resonate widely because they capture uses of natural systems that matter to people. Effective ecosystem service endpoints can be incorporated in economic models to value changes and inform tradeoffs. Considering that much of the damage to natural systems occurs in small increments rather than as sudden losses, risk assessment may be the *only* appropriate tool to characterize potential damages to multiple aspects of human well-being, but only if the tool box is expanded to include a representative range of ecosystem services and the cumulative effects of many small changes are evaluated.

Against the Proposition: Mark S. Johnson

Risk assessment has been the primary vehicle to assist in environmental decision making. This choice has been driven in part by legislation focusing on specific stressor responses and in the current tools available to understand the impact of those stressors to values resources. However, current tools are limited in their ability to accurately characterize risk as few data are often available to make predictive inferences to population and community attributes. Some methods purport to quantify the values of specific natural resources in a common currency that is amenable to making equivalent comparisons (e.g. costs of remediation versus costs of resource loss); however, they often fail to capture an accurate representation of value given the complexity of many natural systems. Alternative methods are needed that incorporate a concern for aesthetics, ecosystem dynamics, and intrinsic values, in addition to handling uncertainties generated by complex system interactions that can cascade into important limitations on natural resources. These tangible (objective) and intangible (subjective and unknown) attributes can directly affect economic return (e.g. ecotourism, fishing, hunting, etc.). Currently, our understanding of these complex interactions is incomplete, as is our ability to provide an accurate metric to characterize them or to even capture the present and future value of these resources. Given these limitations, a precautionary approach is needed that places greater weight in pollution prevention and gathering of data in a proactive manner. Post hoc comparisons may need to be conducted qualitatively as well as quantitatively placing equivalent weight on intrinsic species values, rather than ecosystem services.

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Ecosystem Services of Second-Growth Vegetation among Rural Settlers in Central Amazonia

Elisa V. Wandelli
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Second-growth vegetation (*capoeira*) is an important part of the rural landscape in Amazon with ecological and social functions such as the recovery of soil fertility in agricultural land, protection of water and soil resources, maintenance of the biogeochemical cycles and as carbon sink through biomass accumulation. Although the temporary abandonment of agricultural land to natural regeneration in order to increase soil fertility is a common practice among rural people in Amazonia, this practice has been changing and could compromise the beneficial role these *capoeiras* in the areas. In this study we investigated the current use of *capoeiras* for agriculture and their role in accumulating biomass in 240 rural properties of urban-originated settlers in the Tarumã Mirim agrarian-reform Settlement, near Manaus Amazonas. Around 67 % of the families were not involved in agriculture activities prior moving to the settlement. Abandonment time of agricultural land was shorter than the average for rural people in Amazonia with the secondary growth vegetation being burned after only 1.9 (± 0,12) years of age. Of all *capoeiras* present in all properties, 89 % was burned before 4 years of age. The average area of *capoeira* vegetation in each family agricultural parcel was 0,89 ha (± 0,1) and 100 of the 240 lots did not have any *capoeira* vegetation. Eighty percent of the settlers interviewed did not relate *capoeira* vegetation to recuperation of soil fertility. Only 20 % of the *capoeira* species were named by the land owners and only 10 % of them knew of some use for those species. Average aboveground biomass accumulation was 4,7 t/ha dry weight and 17 t/ha dry weight for *capoeiras* aging up to 1 and 2 years of age, respectively. These averages are not enough to qualitatively increase ecological conditions in those properties. *Capoeiras* 4 or more years old had much higher biomass accumulation (30 t/ha). Government technical assistance for settlers is needed in order to implement sustainable management of *capoeiras.*

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Using Focus Groups to Understand Ecosystem Services of an Impacted Southwestern River

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Ecosystem services are difficult to classify, and terminology in use by scientists may not make sense to members of the general public. This research uses a series of focus groups and interviews to gain a better understanding of how people perceive riparian resources in southern Arizona, and the Santa Cruz River in particular. These conversations help scientists understand what is important to people about waterways, and thus how riparian ecosystem services research can be focused to be meaningful for public welfare. The Santa Cruz is an effluent-dominated waterway. Groundwater pumping has lowered the water table and in most areas the river flows only in response to storm events, or where fed by a continuous supply of treated wastewater. However the same water supports some of the last perennial surface water ecosystems in the region, and therefore its management has repercussions for rare terrestrial and aquatic wildlife, and vegetation. Continued effluent flow is uncertain, with changes possible due to water management in both the US and Mexico. As water resources become more scarce, tradeoffs regarding how to best manage the river and effluent face the region. The condition of the Santa Cruz makes it an interesting case study in contrast with less impacted riparian areas where public values are more studied.

Preliminary results will be presented from several focus groups planned at various zip codes in Tucson, AZ, representing a range of socio-demographic conditions, as well as various distances from the Santa Cruz River. Recruitment will include reimbursement to reduce self-selection bias, and will include Spanish translation. Additional focus groups will be convened farther upstream in the smaller community of Rio Rico, AZ, situated on a more ecologically robust reach of the Santa Cruz, to test responses under different ecological and socio-demographic conditions. Individual interviews will also be conducted with representatives of different river stakeholder groups in the region (i.e., industrial, agricultural, municipal, tribal, and environmental groups) to better understand aspects of the river important to them. Qualitative research results will also inform a future choice experiment survey designed to quantify the public value of changes in the Santa Cruz River.

This project is part of the Southwest Ecosystem Services Project (SwESP), a place-based study within the US Environmental Protection Agency's larger Ecosystem Services Research Program (ESRP). Water is a primary theme of SwESP, and the Santa Cruz River riparian area is hypothesized to supply significant ecosystem services to the public. This study seeks to identify indicators of these ecosystem services that will be relevant for riparian area management and public cost-benefit accounting.

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Ecosystem Services in the City: Urban Greening and Public Health

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The concept of ecosystem services (ES) represents a fundamental shift in how natural resources are defined and valued by human society. Natural assets, such as forests, agricultural lands, shorelines, and seas, have long been recognized as the sources of essential and economically valuable goods and services. The ES concept specifies additional sources of direct or indirect benefits and their economic consequences, such as flood protection, pollinator activity, natural filtering of potable water, and climate stability.

About 80 percent of the U.S. population now lives in cities and urbanized areas; the sum is at about 50 percent across the planet. Urban populations consume concentrated quantities of ES, extracting food, water, energy and the raw materials of goods from ecological systems, near and far.

Various ES classifications (such as the Millennium Ecosystem Assessment) sort and define derivations of natural capital, summarizing across extensive scientific evidence. Each also recognizes non-material, experiential benefits that people derive from natural systems, thereby considering the role of environment in human and social capital. An important array of ES is provided by nature that is located in the midst of the most populated urban environments. Decades of scientific studies demonstrate socio-cultural benefits that are provided by city trees, the urban forest, parks, community gardens, green roofs, rain gardens and micro-biotopes. Human health and well-being is a designation for an extensive array of social benefits – that in sum indicate a profound human need for nature in the everyday settings where people live, work, play, and learn.

A research outreach project is underway to make this body of science accessible to urban resource policy-makers and managers. A comprehensive review of science publications was the first step. In 2009 approximately 1,500 articles and reports were collected, and content analyzed, resulting in 12 themes of key findings. Narrative summaries are being prepared for each theme, to be completed in late 2010. Summaries are provided on a web site: Green Cities: Good Health - http://www.greenhealth.washington.edu. The entire collection serves as a timely compilation of knowledge about metro nature and human health and well-being.

The presentation will provide an overview of the project, including excerpts of key findings. Overall, the portfolio of summaries will: 1) capture and communicate the full range of knowledge about human health and well-being benefits provided by urban nature, 2) provide accessible outreach and teaching tools for use within urban communities, 3) enable a gap analysis of urban greening and social benefit research, and 4) serve as the basis for comprehensive planning and management of urban green spaces. While urban greening may not be widely regarded as a high priority in the discourse on ecosystem conservation and health, the published evidence justifies greater public and scientific support for nearby nature, including more extensive green infrastructure planning and implementation.

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Evaluating Water Ecosystem Services from the Yongding River Restoration Project

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The Yongding River, located in Northern China, is a major tributary of the Haihe River Basin, and is one of the largest rivers in Beijing. Given its great cultural and historic significance, the Yongding River is commonly known as the “Mother River” of Beijing. In the last 30 years, many stretches of the Yongding River have become dry due to upstream reservoirs, damming, diversion and channeling. In addition, rapid economic development, urbanization and population growth continue to exacerbate already complex water scarcity and water quality problems across the region. In 2010, the Beijing Water Authority and five southwestern districts enacted the *Yongding Green Ecological Corridor Plan*, with an estimated cost of $2.5 billion (US), which is expected to be completed in 2014. The corridor will be 170km long covering an area of 1,500 km^2, and will require 130 million m^3 of water. The plan aims to substantially increase aquatic ecosystems across the corridor (wetlands, lakes and streams), create connectivity between systems and enhance economic development through leisure and recreation services. We will evaluate the water ecosystem services imparted by the restoration by comparing ecosystem services before and after the restoration. Our study will assess the impact of ecosystem configuration changes on the delivery of ecosystem services by contrasting evolving configurations within and among three main sections of the corridor: i) mountainous, ii) urban plains and iii) outerurban plains. We hypothesize that the current ecological composition of the Yongding River limits its capacity to provide valuable water regulation, water purification, climate regulation, and flood regulation services. These ecosystem services could improve if the underlying ecological and hydrologic processes are considered and evaluated. This research seeks to advance river restoration efforts by evaluating the role of ecosystem configuration on ecosystem services.

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Tradeoffs between Forest Ecosystem Services under Differing Socioeconomic Conditions

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The ponderosa pine forests of the southwestern United States provide a diverse array of ecosystem services, from the supply of raw materials for consumption and production ("provisioning services") to microclimate control ("regulating services") to recreational and aesthetic values. The valuation of these ecosystem services are likely to have major influence on local forest management policy, especially regarding the implementation of ecological restoration. A coherent quantification of the economic benefits and costs of restoration can bolster the rationale for expanding restoration treatments, which are currently far from reaching the landscape scale necessary for securing long-term ecosystem health.

The existence of corroborative regional markets can facilitate restoration efforts by establishing baselines for the valuation of carbon sequestration and increased water yield, and by creating commercial outlets for restoration byproducts (primarily small-diameter wood from thinning). In our study, we analyze the tradeoffs between carbon sequestration, water yield, and timber provision under three landscape restoration scenarios facilitated by three hypothetical socioeconomic conditions: highly corroborative market (characterized by multiple firms with institutionalized transactions of payments for all three ecosystem services), moderately corroborative market (characterized by one or several firms with limited market mechanisms for ecosystem services), and non-corroborative market (no firms of sufficient industry or scale and no markets for ecosystem services). The last case represents a "business as usual" extrapolation of the present institutional and infrastructural setting. The analytical utility we use is the InVEST toolset for ArcGIS, a program developed by the Natural Capital Project.

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Incorporating Ecosystem Services into Coastal and Watershed Management

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Coral reefs provide valuable natural benefits that are often overlooked by social policies and human activities in the watershed and coastal zone. These benefits arise from ecosystem goods and services including harvestable fish and invertebrates, natural products like pharmaceuticals, unique biota to attract tourism, protection of shorelines from storms, and a diverse community of organisms for education, research and cultural fulfillment. Human activities and decisions heavily influence the type, quantity and the potential for sustainable delivery of these goods and services. Coral reefs are under increasing duress from human activities, both direct (fishing, tourism) and indirect (watershed pollution, climate change).

The U.S. Environmental Protection Agency Ecosystem Services Research Program (ESRP) is developing tools and information to better incorporate ecosystem goods and services into decision processes. A goal of the ESRP Coral Reef Project is to quantify and forecast changes in delivery of coral reef ecosystem services under different watershed and coastal management scenarios. This requires several areas of investigation, including 1) links between coral reef attributes and delivery of services, 2) links between human activity and coral reef attributes, 3) contributions of different policies, decisions and socioeconomic drivers in motivating human activities, 4) intended and unintended consequences of decisions on delivery of coral reef ecosystem goods and services and 5) methods to communicate and incorporate ecosystem goods and services information and analyses into future decisions.

The ESRP Coral Reef Project has engaged a commonly-used systems framework (Driving Forces-Pressures-State-Impact-Response, or DPSIR) to allow consideration of both ecological and socioeconomic factors. Ecological approaches include reef assessments that incorporate ecosystem service indicators, dose-response characterization of human-generated stressors on coral growth and survival, and empirical relationships between coral reef attributes and human watershed activities (such as fishing and land-based sources of pollution). Socioeconomic approaches include quantification of reef ecosystem goods and services (including fisheries, tourism, shoreline protection and potential natural products), legislative mapping, social network analyses, Bayesian Belief Networks, and decision scenario analyses.

One goal of the ESRP Coral Reef Project is to engage clients early and often so that information and methods developed will not only be useful to, but used by, the community. To achieve this, workshops have been held in three target jurisdictions (U.S. Virgin Islands, Puerto Rico, and Florida) to better understand threats to coral reefs, the management approaches and decisions, the types of information that contribute to those decisions and how it is currently disseminated. Simultaneously, concepts that are potentially useful to clients (such as the DPSIR systems framework, social network analyses and Bayesian Belief Networks) are introduced and used to develop collaborative projects. Client interactions shape the direction of research and influence the tools developed.

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Gulf of Mexico Ecosystem Services Workshop

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The first Gulf of Mexico Ecosystem Services (ES) workshop, as recommended by the Gulf of Mexico Ecosystem Services Collaboratory, was held in Bay St Louis, MS, June 16-18, 2010. The workshop, sponsored by the Gulf of Mexico Alliance (GOMA) Ecosystem Integration and Assessment Priority Issue Team, the Harte Research Institute, the Northern Gulf Institute, and the National Oceanic and Atmospheric Administration, supports multiple action items across issue teams in the GOMA Action Plan II. This workshop is also one of the actions outlined in the Louisiana-Mississippi Gulf Coast Ecosystem Restoration Working Group's "Roadmap for restoring ecosystem resiliency and sustainability". It supports the vision for successful restoration and sustainability as identified in the Roadmap, "Enhancing essential coastal processes and the ecological services they provide."

About thirty scientists, researchers, and natural resource managers from several disciplines (ecology, biology, oceanography, geography, fisheries, geology, and economics) attended the workshop and represented federal and state agencies, universities, NGO's, and the private sector. Although there was a broad array of interests and expertise, a consensus was reached on a common definition for ES and ES valuation applicable Gulf wide. Also, the ES most relevant to coastal and marine environments in the Gulf of Mexico were identified and prioritized by ecological type.

Several restoration projects within the Louisiana/Mississippi coastal geographic area were evaluated. One of the workshop goals was to identify a project to demonstrate a process to value ES. However, participants were not prepared to commit to a single project; rather, criteria for project selection were agreed upon. The criteria are: scale (e.g., 400-500 acres), transferability, regional relevance (i.e., one could foresee a similar project in each Gulf state), status (e.g., in planning but implementation soon enough to allow for before/after valuation), and leveraging opportunities.

The results of the workshop will support the GOMA Priority Issue Team actions focusing on (1) determining the socioeconomic and recreational values of critical ES in the Gulf region, (2) recommending policy revisions to consider benefits from habitats gain/loss, (3) characterizing impacts of nutrients on ES, and (4) assessing economic consequences due to climate changes and coastal hazards. Also, the outcomes of the workshop will inform the needs identified in the Roadmap. Ultimately, ES valuations will advise Gulf of Mexico coastal and marine decision-makers about the ecological and economic benefits and trade-offs associated with a variety of coastal and marine activities.

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EcoServ: An Online Ecosystem Services Modeling System Using Open Geospatial (OGC) Consortium Standards

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Ecosystems provide a wide range of goods and services. Maintaining sustainable ecosystem services to ensure provisioning of resources for future generations has become an explicitly stated goal for many agencies and, in some cases, has been legislatively mandated. Land use and climate changes affect myriad ecosystem services simultaneously. However, past practices have been quantifying only one or a few ecosystem services at a time, potentially producing unintended consequences since a management scenario that is optimal for one service can be disastrous for other services. Hence, there is a strong need to develop a modeling system to simultaneously quantify the impacts of land use and climate change on diverse ecosystem services for decision makers. We are developing EcoServ to meet this need. EcoServ simulates more than 12 major ecosystem services related to water resources, wildlife, plants, soils, and greenhouse gas (GHG) emissions. Using data and model sharing technology and web services to accommodate a variety of users and purposes, EcoServ has been implemented as a distributed geospatial model sharing platform based on Java Platform Enterprise Edition (J2EE) and open source geospatial libraries. The models on the EcoServ platform are accessible to applications over the Internet using Open Geospatial Consortium (OGC) data and processing services standards. Scenarios of land cover and land use can be created easily in EcoServ using the online Land Cover Editor. This feature allows users to modify the real land cover map to create their land cover scenarios and run EcoServ over those scenarios to evaluate the impact of land cover changes on the ecosystem services. EcoServ is especially suited for evaluating, understanding, diagnosing, monitoring, and forecasting changes of multiple ecosystem services in response to future changes in policy, climate, and land use (e.g., biofuel production).

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Contingent Valuation of Benefits Arising from Marine Biodiversity – a Case Study from Polish Part of the Gulf of Gdańsk (Southern Baltic Sea)

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Degradation and fragmentation of marine and coastal habitats cause biodiversity loss and consequently, a decrease in the provision of goods and services that arise from healthy marine ecosystems. Anthropocentric view on biodiversity leads to recognition of its economic importance to society. Most of the studies attempting at valuation of goods and services provided by marine ecosystems tend to examine systems with rather high biodiversity, such as coral reefs, mangroves etc. Marine ecosystems characterized by relatively low biodiversity i.e. coastal, brackish waters of the Baltic sea are underrepresented in such studies. This work was designed to fill this gap and to promote the values of ecosystem services provided by low-diverse areas.

Due to the incapability of most valuation methods capable of capturing non-use values of biodiversity, the Contingent Valuation Method (CVM) was employed. The set of two CVM studies conducted in 2007 and 2008 had two major aims:

- to assess the total economic value of goods and services arising from marine biodiversity of the Gulf of Gdańsk,

- to determine variability in economic values of different levels of loss in marine biodiversity of the Gulf of Gdańsk.

The findings from CVM study conducted in the year 2007 indicates that both visitors and residents of the Gulf of Gdańsk attach positive and significant values to the conservation of marine species. From the WTP values, coefficients and their relation to each other, it appeared that values allocated by the respondents, arrange examined marine taxa as follows: lowest values – group of algae and invertebrates, then birds, fish and most valuable – sea mammals. During CVM survey administrated in 2008, the richness of fish species was examined in terms of WTP stated for avoiding the loss in a number of species. Another scenario introduced in the survey aimed at detecting the WTP for avoiding the loss in overall marine biodiversity of the Gulf of Gdańsk. The results show that the WTP for fish conservation vary between 42,16 and 64,41 EUR and for overall marine biodiversity between 54,39 and 83,08 EUR. The willingness to pay for all the marine species in both CVM surveys (2007 and 2008) is higher than for any individual taxa. Nevertheless, it is not as high as it was *a priori* expected, having in mind point estimates for single taxa.

Scientific dispute highlights the need of incorporation of economic criteria in conservation policies. The main objective being to capture the economic value of marine biodiversity has been achieved in both studies; the WTP estimates were significantly greater than zero. Subsequently, such values, after appropriate aggregation procedure, should be invested in marine biodiversity conservation to maintain the flow of marine ecosystem services to the society.

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Spatial Visualization of Recreational Values Arising from Marine Biodiversity – Case Study from the Polish Part of the Gulf of Gdańsk (Southern Baltic)

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In full marine environments where the salinity level, tides and overall ocean characteristics promote high biodiversity the range of direct non-consumptive uses contains: wildlife watching, sea angling and scuba-diving. The Gulf of Gdańsk, located in the southern Baltic represents relatively low-diverse brackish estuary system. Watching sea mammals or marine birds in their natural habitats is rather uncommon and is of accidental character. The only recreational options which involve the number of people sufficient to examine preferences regarding these activities are sea angling and scuba-diving.

Sectors of the marine recreation business as well as sea anglers and scuba-divers themselves, depend on the presence and quality of natural resources. In order to provide the sets of arguments for the sustainable use of marine biodiversity, it is important to estimate the value of this ecosystem service.

The main aim of the studies was to assess the recreational value of the Gulf of Gdańsk biodiversity, by analyzing the preferences of sea anglers and divers. Moreover, spatial distribution of such value will be examined in order to indicate habitats that take part in the provision of the recreational service.

Two web-based questionnaires were developed, one for sea anglers and one for divers. Additionally, a number of face-to-face interviews was performed with anglers who have a limited access to the internet. Besides questions on species/habitat preferences, we also asked interviewees to choose the set of three grids on the map provided, in order to indicate the areas where they went fishing/diving most often in the year 2009. For the purpose of elicitation of monetary values we asked questions designed to reveal expenditures (travel, accommodation, equipment purchasing/renting, etc.) related to undertaken activities.

The results show that despite the niche character of sea angling and scuba-diving as a recreation types in the Gulf of Gdańsk area, the economic value of such non-consumptive use of biodiversity is significant for local economy and therefore worth incorporating in the assessment framework of ecosystem services provided by the Gulf of Gdańsk.

The GIS maps with presented values can contribute to coastal and marine spatial planning when different uses, sometimes competing with each other, are combined together. The assessment of the economic value of the ecosystem service can support the information available for environmental managers, while making decisions about the sustainable use of natural resources.

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A Green Infrastructure Approach to Stormwater Management

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As part of the workshop on Qualifying and Quantifying Ecosystem Services: Tools for the Planned and Designed Landscape, this session focuses on a green infrastructure approach to stormwater management.

Creating more sustainable green infrastructure requires transitioning from practices that may contribute to the degradation of the environment toward creating working landscapes that perform important ecological functions, including stormwater management. Green infrastructure calls for the integration of many of the following practices: planting and design decisions including converting turf to natural vegetation; managing, preserving, and restoring healthy forest stands and ecological corridors along streams and waterways; maintenance decisions; the integration of stormwater management features as part of a "functional landscape"; integrating vegetation into building architecture in green roofs and living walls; integrating cisterns and other water capture and reuse systems; permeable pavement and other alternatives to impervious surface; and natural outfall designs.

As a holistic approach to stormwater planning and design, green infrastructure provides a multitude of benefits including: reduced and delayed stormwater runoff, enhanced groundwater recharge, reduced stormwater pollutants, increased carbon sequestration, urban heat island mitigation, additional wildlife habitat and recreational space, improved human health, increased land values, lowered water consumption, reduced maintenance costs, natural habitat for diverse ecosystems; educational opportunities; and reduced overall operation and maintenance burden.

(This session is part of a preconference workshop: "Qualifying and Quantifying Ecosystem Services: Tools for the Planned and Designed Landscape")

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An Introduction to the Green Infrastructure Planning Approach

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As part of the workshop on Qualifying and Quantifying Ecosystem Services: Tools for the Planned and Designed Landscape, this session provides an overview and introduction to a green infrastructure planning approach.

As the need to recognize ecosystem services in land management decisions continues to grow, many struggle with the best way to apply those concepts in practice. Starting at the broad planning scale this presentation considers the applicability of planning for ecosystem services, through a holistic approach to landscape management: green infrastructure planning. This discussion provides an overview of the importance of addressing ecosystem services in urban and designed environments, discussing the many stacked benefits of a holistic green infrastructure approach to planning and design, including stormwater management, urban heat island mitigation, improvements to human health and well being, improved wildlife corridors and urban habitat patches, increased opportunity for community access and stewardship, increased land value, etc.

There are several widely held definitions of green infrastructure. The major difference between these is the issue of scale. This divergence in definitions is an opportunity to explore a more nuanced definition of green infrastructure as a regenerative design and planning approach which recognizes the importance of functioning natural systems at multiple scales, while providing a myriad of benefits. Green infrastructure provides a foundation for the restoration of more resilient natural systems. In practice this means embracing the notion that ecological preservation and conservation practices can be an integral part of the built landscape and that the design of those practices is directly informed by the natural processes and functions occurring on a site, as well as those occurring in the broader surrounding landscape.

Developing a strong and resilient green infrastructure network involves examining, interpreting and building upon the inherent patterns in the landscape, in an effort to build a site's capacity for regeneration. This approach involves a strong focus on connectivity, and designing for stacked benefits at multiple scales with an appreciation for historic function but an understanding that in highly urbanized areas, where natural function may not return in its original form, that a new functional living system with natural characteristics can be introduced.

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ADDENDUM

Valuing Ecosystem Services of Shellfish Aquaculture: What's Next for the Northwest

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Valuing ecosystem services is one way to monetarily value activities associated with a shared resource. In the case of shellfish aquaculture that shared resource is the marine environment encompassing shellfish farming and harvest activities. Estimating the economic value of resources is often an important element of preventing under-provision or overexploitation of public goods (Isaacs et al 2004). To address these issues for shellfish aquaculture, since late 2008 the Pacific Shellfish Institute (PSI) has overseen an investigation to assess the value of ecosystem services provided by shellfish in Washington State. The research sought to quantify the environmental, economic and social benefits and costs of shellfish production. Most notably, we demonstrate that harvest of farmed shellfish removes nitrogen at levels particularly notable for nutrient rich water bodies, and a monetary value can be placed on the nitrogen removal services provided by shellfish. In Oakland Bay, in south Puget Sound, shellfish harvest is estimated to provide a $77,000 to $650,000 annual water quality benefit. However, findings to date also indicate that the most substantial stumbling block in valuing ecosystem services provided by Washington shellfish is a lack of basic economic information on the value of the state's shellfish industry. Without a handle on the most basic economic indicator- the value of harvest- it is increasingly difficult to estimate the value of the ecosystem services provided by shellfish. Similarly, the economic costs and benefits of aquaculture activities are difficult to assess for property owners and recreational users of the near shore environment. To address this problem, PSI sought additional funding to fill critical socioeconomic information gaps related to the shellfish industry. In late 2010, PSI was awarded funding for that purpose and will begin to survey existing aquaculture operations in Washington, Oregon and California. The information gathered will provide tools to support the continuation of sustainable shellfish aquaculture along the West Coast. While the challenges and complexities associated with the shellfish industry are increasing, there is also a growing awareness among policy makers of the importance of maintaining a vital and sustainable domestic seafood industry. Socioeconomic information gathered, coupled with shellfish ecosystem services estimates, aims to assist informed decisions regarding shellfish aquaculture and restoration activities.

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The Conservation Marketplace of Minnesota (CMM)

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The Conservation Marketplace of Minnesota (CMM) is poised to deliver new conservation practices on the landscape that will cost-effectively compete with fence-row to fence-row corn. Delivery will be through innovative ecosystem service market applications that include pollination credits for new habitat, nitrogen reduction applications to protect municipal groundwater supplies, and other agricultural conservation practices that create nutrient and sediment reduction credits to surface waters, and carbon offsets for socially responsible businesses. A critical tenet of an ecosystem service market is its ability to meet buyers' needs. Ecosystem service credit value fundamentally rests upon reliable predictions of the environmental outcomes associated with credit exchanges, either for compliance programs or voluntary objectives. Sophistication of tools for reliable credit calculations must be pragmatically balanced with cost-effective transactions. Credit costs include capital investments, administrative overhead, routine operation and maintenance associated with the land use practices as well as credit tracking and reporting costs. Cost-effective implementation must focus on efficient crediting protocols, proper selection of credit generating sites and long-term management of practice and program expenses for delivering the credit. An illustration is when habitat is simply assumed to be provided within a vegetative cover application. Limited ecological value can result when seeding specifications do not protect or provide necessary attributes for the habitat. Specifying allowable dates and number of cuttings to provide protection from disturbances during nesting seasons is an obvious improvement. However, not supplementing plantings with a diversity of forbs that bloom across the whole growing season may fail to provide adequate pollinator habitat credits. Programs that provide minimal details in their specifications may not be realizing these necessary habitat attributes.

The Conservation Marketplace of Minnesota (CMM) is a collaborative team of local conservation organizations delivering detailed, cost-effective administrative services necessary to overcome these challenges in environmental markets. Knowledgeable of crediting protocols, local professionals can also use their client lists to leverage potential credit generator contacts making CMM a cost-effective broker or third party agent for these markets. CMM provides credit generators access to markets they may have missed or avoided because of uncertainty, unknowns or market complexities. CMM provides an environmental credit buyer acceptable crediting methods, contacts with potential credit generators, third party verifiers, documentation and reporting. To date, credit protocols have been developed for water quality trading (nutrients and sediment), wellhead protection, pollination and carbon. This presentation will document how crediting methods are used in the CMM setting, including field verification and specification techniques to define ecological uplift not previously provided in MN settings. The discussion will feature pollination credits, City investments in wellhead drinking water protection and surface water protection credits including methods applied to overcome challenges in this new market opportunity.

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An Operational Structure for Clarity in Ecosystem Service Values

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The ecosystem goods and services approach allows one to motivate and design policy based on the quantified social benefits received from ecosystems. The application of this approach to inform management requires tight integration of ecological and economic analysis. Thus far, however, this integration has been hampered on a broad scale by ambiguity in operational definitions of ecosystem goods and services. Specifically, the linked biophysical and economic analyses used to quantify and value "ecosystem services" often confuse final ecosystem goods and services (ecosystem outputs that provide direct human benefit) with broader ecological functions and intermediate services that provide only indirect benefit (e.g., through ecological relationships to other final services). Comprehensive categorizations of ecosystem services, such as that developed by the Millennium Ecosystem Assessment, do not ameliorate these challenges. What is lacking in these prior assessments and typologies is a comprehensive, unambiguous mechanism—or set of precise operational rules—that may be used to define final ecosystem goods and services, thereby promoting consistent and meaningful quantifications across disciplines and policy contexts. This paper proposes that the lack of clarity in separating final ecosystem goods and services from ecological functions stems from an attempt to define these goods and services for an overly generalized human beneficiary, resulting in double counting of some benefits and omission of others. Problems arise from using a generalized human beneficiary of ecosystem goods and services, for example, when what would be considered an ecological function leading to a final ecosystem good or service for one specific beneficiary would be considered the final ecosystem good or service for another beneficiary. These overlaps between final ecosystem goods and services for multiple different beneficiaries must be objectively resolved to avoid double counting when the total production and value of ecosystem goods and services benefits are calculated. This paper presents the first fully objective, operational, and universally applicable mechanism for determining whether an ecosystem biophysical feature, quantity, or quality is a final ecosystem good or service or should be considered an ecological function for an inclusive suite of "real-life" beneficiaries. We present several examples of application of this method for beneficiaries associated with the ecosystems in the Tampa Bay Estuary, Fl region. Through illustrations of the proposed operational structure, we demonstrate how the resulting typology averts double counting and other ambiguities implicit in prior attempts to quantify and value ecosystem services, and promotes operational ecosystem service definitions that are both ecologically and economically relevant.

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