Summary Descriptions of ESRP Themes and Projects

1. LTG 1 Decision Support

a. Decision Support Framework
b. Human Well Being

2. LTG 2 Monitoring, Mapping, Modeling

a. Monitoring
b. Mapping and Landscape Analysis
c. Modeling (forthcoming)

3. LTG 3 Pollutant-Specific Studies: Nitrogen

a. Nitrogen

4. LTG 4 Ecosystem Specific Studies: Wetlands and Coral Reefs

a. Wetlands
b. Coral Reefs

5. LTG 5 Site - Specific Demonstration Projects

a. Future Midwestern Landscapes
b. Tampa Bay
c. Willamette River Basin
d. Coastal Carolinas
e. Southwestern US
f. Cross-Place Coordination

LTG 1 Decision Support

LTG 1: The Ecosystem Services Research Program will provide innovative, online decision support that offers EPA, Regions, States, local communities and resource managers the ability to integrate, visualize, and maximize use of diverse data, models and tools at multiple scales to generate alternative decision options and to understand the consequences of management decisions on the sustainability of ecosystem services, their value, and human well-being. This long-term goal integrates the products of the other four long-term goals.

a. Decision Support Framework

b. Human Well Being

Ecosystem Services Research Program
Decision Support Framework
Ann Vega
Status Report and Future Directions. June 24, 2009

1.1 Project or Theme Goal

By 2016, the Decision Support Framework (DSF) [1] will provide local, state, tribal and regional decision-makers an analytic-deliberative framework to help inform land and resource use decisions to sustainably maintain healthy ecosystem services and communities. The DSF will host and make available an array of tools designed for decision makers operating in different circumstances, communities, spatial scales, and levels of complexity and uncertainty.

1.2 Conceptual Model and Description

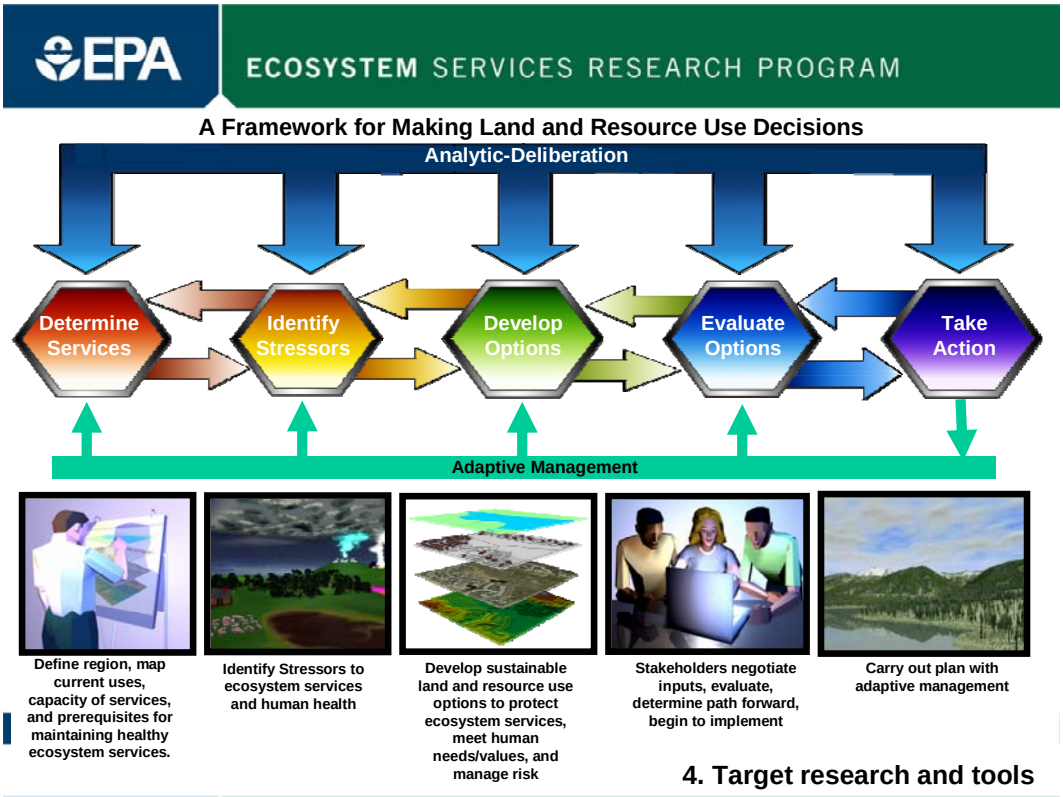


Figure 1 Current Decision Support Framework Conceptual Model

[1] The date has been changed to reflect the comments received from the SAB regarding the incorporation of products from other ESRP teams. The "Decision Support Platform" team (now the Decision Support Framework team) has been refocused over the last 6-8 months to concentrate not on an on-line platform, but on collecting information and understanding what decision-makers and stakeholders need/want. We have therefore renamed the team to remove the word "platform" and to focus on development of a decision support framework.

The draft conceptual model for the DSF is still evolving, but currently, it consists of five modules:

1. Determine Services (define area of interest, services of interest, condition/status and carrying capacity of services of interest, current land and resource use, etc.)
2. Identify Stressors (including type, magnitude, spatial and temporal effects of stressor/driver)
3. Develop Options (create desirable, feasible, and realizable land and resource use options to protect ecosystem services, meet human needs, and manage risk; use scientific data, computer based models, values of stakeholders, etc.)
4. Evaluate Options (stakeholders use agreed-upon measurement rules to score options; consider uncertainty, value of collecting additional information; evaluate tradeoffs, risks, opportunities, consequences)
5. Take Action (determine next steps and implement them; revisit periodically and adapt as needed)

As part of each of the modules, analytic-deliberation approaches are needed to engage stakeholders with decision-makers in a participatory decision making process. Once a decision is implemented, it is also advised to periodically evaluate the implementation to determine whether or not changes in data, models, or ecosystem conditions demonstrate the need for revisiting any steps in the process (adaptive management).

The current conceptual model guides our information collection. In response to an SAB quality reviewer, we are collecting information from stakeholders and decision-makers through workshops, existing documents (including survey results) and the literature. The conceptual model continues to evolve as additional information from ESRP stakeholders and decision-makers is collected. The most significant scientific uncertainties are:

- The conceptual model itself. Thus far, minimal information has been collected to inform the conceptual model. A refined conceptual model will be prepared in September 2009. It is anticipated that additional information will be collected in FY2010 and further refinement will be needed.

- Inputs to the DSF. These inputs (including data, maps, models, deliberative and valuation processes, evaluation of human-well-being) will come from others both within and outside of the ESRP. Uncertainty within and between inputs as we bring the DSF together is significant.

1.3 Expected Impact/Rationale

Land and resource use decisions are typically made by individuals, towns, counties, tribes, states and sometimes multiple states (regions) to increase economic viability of an area with little attention to the long term effects on human health and the environment. Improved decision-making includes awareness of the cumulative (and incremental) impacts of multiple local decisions (bottom-up) as well as the local consequences of regional environmental policy (top-down).

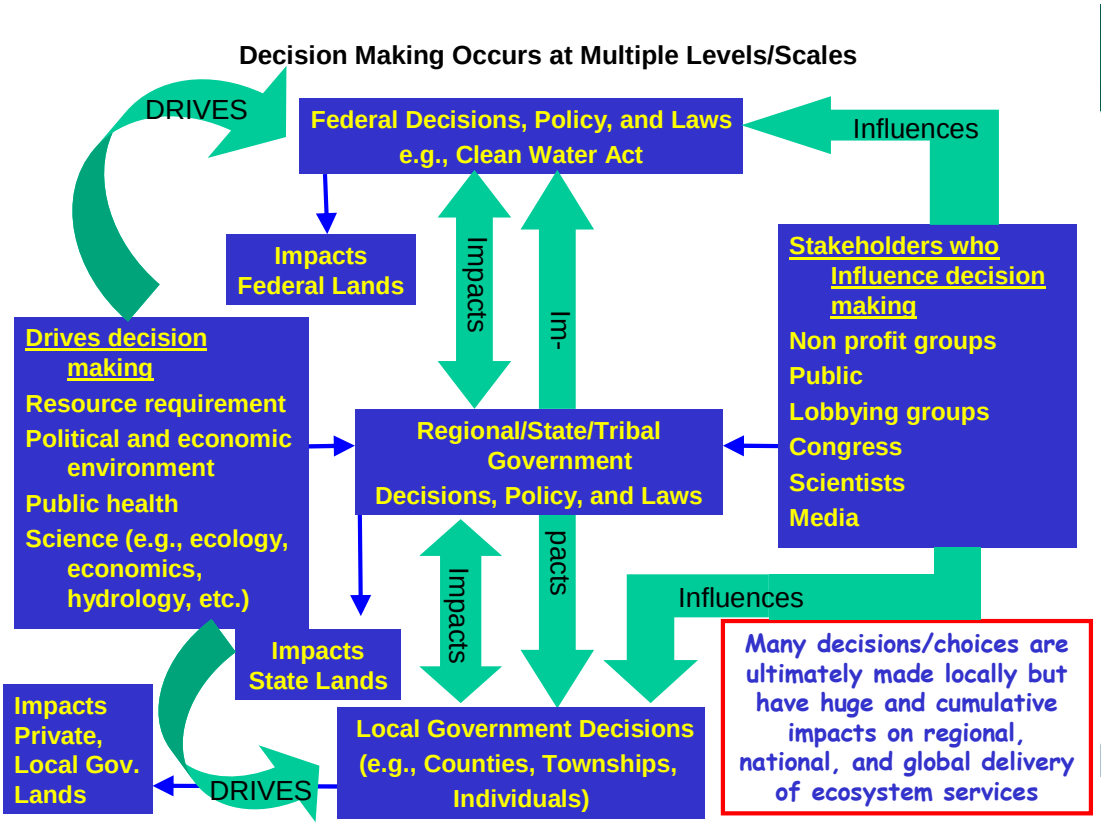


Figure 2 Decision-Making Occurs at Multiple Levels/Scales

Individuals and groups who typically make land and resource use decisions do not all currently have the capability to evaluate the impact that their decisions have on ecosystem services and socio-cultural needs. By 2016, the EPA and its partners intend to create a decision support framework (DSF) to help stakeholders and decision-makers involved in land and resource use decisions understand and evaluate the cumulative (and possibly incremental) impacts of their planned land and resource use decisions on ecosystem services, economic viability, and human well-being.

1.4 Current Status

1.4.1 Research Underway in FY 2009

In 2009, the DSF team is focused on meeting 3 annual performance measures (APMs):

APM 1 (372)	Produce a peer-reviewed decision support platform [framework] (DSP[F]) research and implementation plan.
APM 2 (374)	Develop a database of characteristics of existing information, tools, approaches and techniques both electronic and non-electronic in concert with stakeholder/user inputs via outreach and education and the E[S]RP teams (content developers) to assist in the design of the DSP[F] architecture.
APM 3 (375)	Develop conceptual model for the framework of the Decision Support Platform [Framework] (DSP[F]).

Table 1: List of DSF APMs.

For APM 1, the DSF team is working on finalizing the DSF Implementation Plan. We received comments on the Draft Implementation Plan at the end of 2008 and we are working on resolving those, in addition to the comments received from the Scientific Advisory Board (SAB). The Final Implementation Plan will be completed by September 2009.

For APM 2, the DSF team is developing a database of tools (e.g., guidance documents, websites, approaches/techniques, models, mapping tools, decision support systems, etc.) that already exist for supporting decisions related to ecosystem services. The database is currently about 80% complete. We are building the database to be compatible with the Ecosystem-Based Management (EBM) Tools Database in order to enable two groups of users (EBM's and ESRP's) to benefit from both efforts. The first version of the database will be completed by September 2009. Currently there are hundreds of tools (data, models, maps, approaches, decision support systems, information, etc.) available for environmental decision makers. Within the ESRP, additional tools are being developed. The ability to delimit the environmental issue under consideration, select the most appropriate decision support tools and use the tool(s) effectively, presents a universal and fundamental challenge. To address this challenge in the short-term, the DSF team is developing a means to manage this emerging information by developing a searchable database. This information management tool will make it easier for decision makers to effectively find appropriate tools for use in decisions affecting ecosystem services.

Concurrently with the development of the existing tool database, the DSF team is also working to collect information from all ESRP place-based, ecosystem-based and pollutant based projects, about what stakeholders and decision-makers want/need in order to improve decisions that impact ecosystem services. Additionally, the DSF team is documenting decision processes that decision-makers currently use. The DSF team has developed an approach to mine documentation from some of the ESRP projects who are further along, while eliciting the information via workshops from ESRP projects that are in earlier stages. For example, some members of the DSF team participated in a Coastal Carolinas workshop in Jan. 2008. The DSF team is also working with the Coral Reefs team to develop a series of workshops. The first Coral Reefs/DSF workshop is scheduled for June 17-19. Future workshops with the Coral Reefs team and the Nitrogen team are planned for FY2010.

Work on APM 2 informs a revised conceptual model which is APM 3. This also will be available September 2009. Note that the Decision Support Framework is in its very early stages. The goal is to have a completed framework by 2016.

1.4.2 Current Impacts, Critical Accomplishments and Innovations

Using extramural resources and resources available from the Environmental Modeling and Visualization Laboratory (EMVL), the existing tool database will be ready for internal review (ESRP project personnel, clients and partners) in June 2009 and ready for external review (clients outside of ESRP) in October 2009. This database, as stated above, is expected to guide decision-makers to tools of which they may not be aware. The ESRP database is being developed to be compatible with the EBM Tools Network database which contains approximately 400 additional tools. It is anticipated that by September, 2010, users will be able to easily search both databases to find applicable/appropriate tools.

Information regarding decision-maker needs was collected at the Coastal Carolinas and Wetlands workshops to help inform the current vision of the DSF. Additional information

related to needs and decision processes will be collected through Coral Reefs and Nitrogen workshops.

The DSF team has developed a preliminary conceptual model of the DSF which will continue to evolve over the next two years.

1.4.3 Publications and Papers Presented in 08/09 and forthcoming

March 25-26, 2008 (and pre-meeting LTG 1 (DSF) and LTG 2 (Modeling) on March 24), Athens, GA. DSF and Outreach and Education Workshop. Both teams participated. Multiple presentations and discussion.

June 9-12, 2008. Virtual ESRP Programmatic Meeting. DSF presentation given by Ann Vega.

July 22-23, 2008, Cincinnati, OH. NRMRL Decision Support Expertise meeting with Rick Linthurst. Multiple presentations.

August 3-7, 2008, Sydney Australia. 5th SETAC World Congress, Protecting Our Global Environment. Ecosystem Services: New Strategic focus for U.S. EPA's Ecological Research Program. Presentation given by Tim Canfield

August 12-14, 2008, Portland, OR. ESRP Programmatic Meeting. DSF presentation given by John Bolte and Mitch Small

October 2008. Fort Meade, FL. Biological Advisory Committee (BAC) Meeting: The Pursuit of Relevant Research in the ESRP. Presentation given by Walter Berry.

March 30, 2009. Cincinnati, OH. ESRP Seminar Series. DSF Presentation given by Ann Vega, Amanda Rehr, and Pat Bradley.

March 31, 2009. Cincinnati, OH. Decision Analysis: Supporting Environmental Decision Makers Workshop. "Decision Support Framework (DSF) for Planning Land and Resource Use to Sustainably Maintain Healthy Ecosystem Services and Communities." Presentation given by Ann Vega.

March 31, 2009. Cincinnati, OH. Decision Analysis: Supporting Environmental Decision Makers Workshop. "The Value of Technical Information in Environmental Decision Making Processes." Presentation given by Mitch Small.

May 31-June 4 2009. Goteborg, Sweden. SETAC Europe 19th Annual Meeting: Protecting ecosystem health: facing the challenge of a globally changing environment. Platform and Poster presentation. Presentations given by Tim Canfield.

June 25, 2009, Leipzig, Germany. Institutionalising Sustainability Assessment Workshop. "Decision Support Framework (DSF) for Planning Land and Resource Use to Sustainably Maintain Healthy Ecosystem Services and Communities." Presentation to be given by Ann Vega.

July 19-23, 2009, Boston, MA. Coastal Zone Management 09. "Building Capacity for Collaborative Decisions, Resilient Ecosystems, and Sustainable Practices: Water, Land,

Community and People in Estuarine Watersheds." Presentation will be given by Marilyn Tenbrink

September 29-October 1, 2009, Atlanta, GA. ESRP Programmatic Meeting.

1.4.4 Resources

The human resources identified here are estimated as of 03/17/09.

Lab	FTE
NRMRL	5.05
NERL	0.35
NHEERL	0.9
Expert	0.21
OEI	0.1
ORMA	0.1
contractor	0.65
partner	0.2
Total	7.56

Table 2: List of DSF Team FTE.

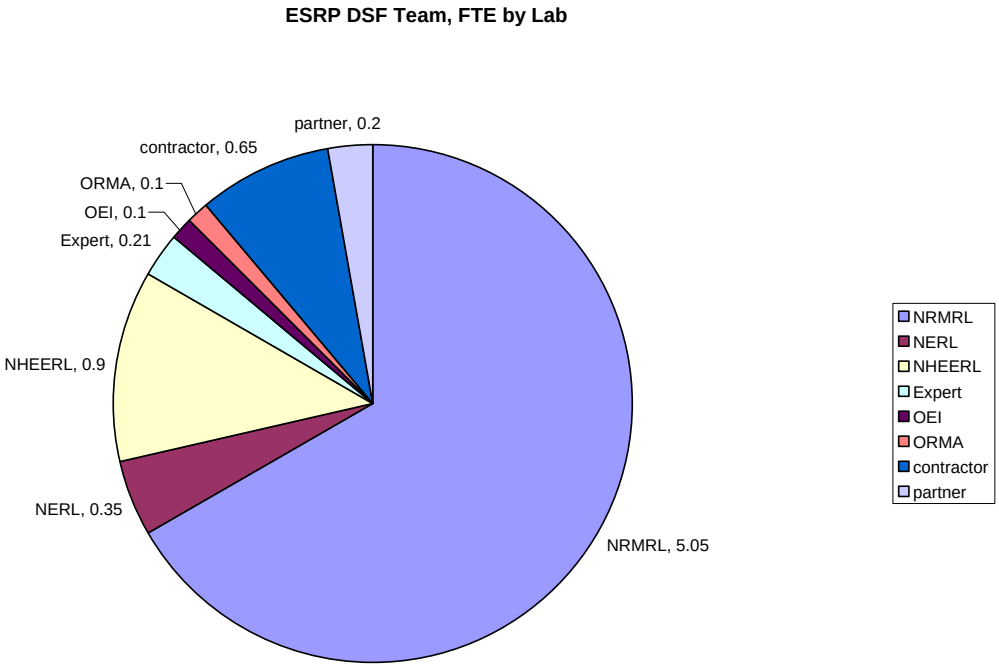


Figure 3: FTE by Organization.

In FY09, the DSF team was able to secure 87K of 08/09 extramural money and 500 hours of support from OEI's Center for Environmental Computing, Environmental Modeling and Visualization Laboratory (EMVL). It is anticipated that the DSF team will receive

approximately 180K of 09/10 extramural funding. This funding will be used to continue to support workshops and database development and for a new APM related to decision support for reactive nitrogen. The DSF team will also apply for additional EMVL hours to be used in FY10. The DSF team has created a "funding menu" detailing the funds which are needed to complete our efforts by 2016 (available upon request).

1.5 Response to Comments

1.5.1 Response to Program Office Comments

The "Decision Support Platform" team (now the Decision Support Framework team) has been refocused over the last 6-8 months to concentrate not on an on-line platform, but on collecting information and understanding what decision-makers and stakeholders need/want. We have therefore renamed the team to remove the word "platform" and to focus on development of a decision support framework (see draft conceptual model above).

We anticipate that the Program Offices and Regional Offices will assist the DSF team by providing team members to participate in conference calls and meetings and help guide DSF development. As indicated elsewhere in this document, the DSF team is actively seeking participation by decision-makers and stakeholders to work with us to help us develop what they need.

The DSF Implementation Plan is being revised to address all comments received.

1.5.2 Response to SAB Comments

The SAB provided several comments with regard to the Decision Support efforts put forth in the original MYP document. These comments were in 6 primary areas: 1. Lack of needed in house expertise; 2. Combining the DSF with Outreach and Education (OE); 3. Adequately describing how the DSF would work; 4. Concerns about feasibility of developing the DSF; 5. Developing connections and utilizing outside partners; and 6. Adequately defining potential clients. The DSF team considered all of the comments made by the SAB and addressed each area in the revision of the DSF plan.

- We recognized early on that we did not have all the expertise in house to ORD to accomplish all that was needed in the development and implementation of Long Term Goal 1 and especially the DSF. The SAB comments also pointed this out. We have been working hard to bring in outside expertise to fill in the gaps that exist that impede the development of the DSF. We have brought on two expert hires form Carnegie Mellon University to help us in the development of the DSF. We have set up a series of webinars from outside experts in the field of decision support to bring their perspectives to the table. The DSF team continues to identify gaps still unfilled in this process and search for outside experts to fill those gaps.

- The SAB suggested that the DSF and OE groups be combined into one team. We originally had these two groups combined but quickly found that the amount of work to be done in each of these areas necessitated the need for two full teams. We recognized that these teams still needed to be closely linked and to that end we have many areas where the DSF and OE have mutual efforts. This is no more apparent than the workshops that are being jointly conducted by the DSF and OE

to work with potential clients in the place based areas. We will continue the strong ties and collaboration between both of these teams to accomplish the ESRP goals.

- The SAB identified the need to provide greater detail on how the DSF would work. As indicated above, the "Decision Support Platform" team is now the Decision Support Framework team. We have refocused our efforts to concentrate not on an on-line platform, but on collecting information and understanding what decision-makers and stakeholders need/want. The DSF Implementation Plan (IP) is currently being revised to address this and all other comments and will be completed by August 2009.

- The SAB raised concerns regarding the feasibility of accomplishing Long Term Goal 1. This was based on the relatively short time for this goal to be completed, the lack of available expertise, the lack of resources allocated to this effort, and that this goal, being dependent on much of the other work being conducted concurrently, should be re-classified as a long-term objective. We agree with this assessment and have discussed these concerns with our upper management. This final decision is still being considered at that level. We have suggested pushing back the final deliverable of this effort to coincide with the intent expressed by the SAB. We are looking to partner with outside groups in an effort to leverage our resources with these groups and further the development of the DSF.

- The DSF Team has been working on developing interactions and connections with potential outside partners. These efforts have focused on academics, private sector companies, other governmental agencies, professional societies, and international professionals working in the area of Ecosystem Services. These were all areas identified by the SAB where we could do a better job in broadening the reach and expertise of the DSF effort. Through interactions with SETAC, DSF Team members are putting forth sessions at their annual meetings focused on Ecosystem Services, developing a Global Science Advisory Committee to provide a platform for researchers across the globe to share and exchange ideas and information regarding Ecosystem Services, and working with the steering committee to set up special symposia to discuss ecosystem service concepts in both Europe and the United States. This is a dynamic and ever evolving process that will continue throughout the life of the DSF effort.

- The process to adequately identify the potential clients is a constant challenge. The DSF Team plans to conduct workshops with all the place based areas as well as the coral reefs, nitrogen and wetlands groups to identify and incorporate these clients into the development process of the DSF. The first planned workshop is in mid June 2009 with the Coral Reefs group. These workshops will give us a better understanding of who the specific clients for the DSF efforts may be. While we can certainly identify groups that will help develop and use the products delivered by the ESRP and especially the DSF, it is more difficult to specifically identify names and individuals that will use these products. This can only be accomplished at this level by conducting these types of workshops and engaging these individuals and groups face to face.

The DSF Team is working hard to not only address the letter of the SAB comments but the spirit of these comments as well. This process will continue through the life of this effort

with the goal of providing a top notch DSF that will support the decision needs of our potential clients.

1.6 Challenges

The DSF team faces several challenges including:

- Lack of resources. We lack extramural money to support workshops for all ESRP projects (we can support a few each year). We lack sufficient travel money for in-house personnel to travel to workshops and/or meet with other ESRP stakeholders and decision-makers. We lack dedicated (i.e., full time) in-house personnel.

- Bounding our efforts: The ESRP is a very broad program. We have attempted to bound our efforts by focusing on land and resource use decision-makers; however, this is still very broad and will remain a challenge as the program evolves.

- Integrating science and human values/judgments: This is a common decision science challenge that we too must meet.

- Limitations imposed by EPA: Currently, EPA has limitations on some computer software that can be used. EPA also requires Information Collection Request approval to perform surveys, a tool that is typically used by social scientists to collect information from decision-makers and stakeholders.

- Ownership/Maintenance of the DSF: It is unlikely that the EPA will be able to own and maintain the DSF over the long-term. We must seek and obtain partnerships with others to help address this issue.

- Lack of in-house expertise in social and decision sciences: ORD is attempting to increase its capability in these areas, but it takes time.

1.7 Future Directions (resources permitting)

In order to inform the DSF architecture, we will:

- Continue to reach out to local and regional decision-makers and the public at large to identify how they make environmental decisions and what sorts of tools and data are needed by them to help them make better environmental decisions.

- Continue to evaluate existing tools from the ESRP, user and IT perspectives.

- Begin to evaluate different types of analytic-deliberative approaches

- Focus on what stakeholders and decision-makers need, rather than where we are coming from.

- Work closely with the modeling, mapping, monitoring, human-well being, outreach and education teams and the economics network in order to ensure our work is complementary and we can truly integrate science with decision-making.

- Continue to have workshops with stakeholders and decision-makers, working with the Outreach and Education group, as well as the Place-Based and other theme groups, e.g. Wetlands and Nitrogen.

- Continue to work with other groups outside of EPA developing these sorts of tools, such as the Ecosystem-Based Management (EBM) Tools Network, the Planning Collaborative, etc.

- Stay informed of new information technology and tools.

As to the development of products, we will continue working on the Tools Database and the Decision Support Framework conceptual model as indicated above. Also, see potential products in Appendix D.

1.8 Appendices

Appendix A: Hierarchy of services being addressed in research described, including units of measure

There are a multitude of ecosystem services that fall under the ESRP. Depending on the place where the efforts are being focused will determine what the priority services might be and thus what the hierarchy of the services to be addressed might be. For example the hierarchy of services in the Willamette and Southwest Place based areas may both include a focus on water quantity, but in the Willamette it may be for flood control while in the Southwest it may be for delivery of sufficient amounts of water to sustain population needs. With this in mind the DSF will not choose the hierarchy of services, but will develop a framework that is designed to be flexible, adaptable and inclusive of the hierarchical needs of the potential users of this decision support framework. Ultimately the hierarchical decisions will be made by the potential users and to provide this support, the DSF will allow the user to set the hierarchy a priori for their needs and develop decision support outcomes that maintain what is important to them while assessing the potential negative stresses that these decisions may have on the long term sustainability of the ecosystems services provided in their area.

Appendix B: Conceptual Model

This is addressed in Section 1.2.

Appendix C: Experts' Contributions

The DSF currently employs two experts from Carnegie Mellon University: Dr. Mitch Small and Ms. Amanda Rehr.

Mitch Small's responsibilities are to:

- Provide expert advice and council to the ESRP National Program Director (NPD) and to the ESRP Decision Support Framework (DSF) team in the area of decision support;

- At the highest program level, liaison between the DSF team and other ESRP teams to assist in the convergence of philosophies related to economics, decision analysis, risk analysis, and modeling;

- Provide guidance and assistance in planning, developing, and defending the ESRP DSF to peer scientists and to high-level EPA decision makers; and

- Identify and evaluate methods/approaches for:

    - predicting and valuing human health and ecosystem impacts,

    - sensitivity and uncertainty analysis (including scenario analysis, expert elicitation and probabilistic risk and uncertainty analysis),

    - generating management alternatives for environmental problems,

    - decision analytic evaluation of management alternatives,

    - determination of the value-of-information associated with new studies and research

Thus far, Dr. Small has:

- Provided valuable input into the first draft of the Decision Support Framework (DSF) conceptual model - ensuring that the team included "adaptive management" in its thoughts about the DSF.

- Delivered, with John Bolte (OSU), a well-received presentation which assisted in the translation of information across different areas of expertise including economics, decision analysis, risk analysis, and modeling.

- Provided significant input into the Decision Support Framework (DSF) Implementation Plan - providing documentation of the cutting-edge research of the DSF Team.

- Provided expert input at a dry run of an analytical hierarchy process workshop for the Future Mid-Western Landscapes project.

- Presented “The Value of Technical Information in Environmental Decision Making Processes” at the Decision Analysis: Supporting Environmental Decision Makers Workshop.

- Developed a Value-of-Information Exercise for our up-coming Coral Reefs/DSF workshop.

Amanda Rehr was recently brought on as an expert. Her responsibilities are to:

- Provide expert advice and council to the ESRP Decision Support Framework team in the area of decision support.

- Liaison between the Decision Support Framework team and a subset of other ESRP teams (e.g., place-based, ecosystem-based, pollutant-based) to evaluate and document the decision landscapes (using Bayesian Belief Networks) in those projects.

- Devise models for assessing the decision landscapes of environmental management problems.

- Demonstrate decision landscape models using case study examples and real use cases of decision processes that are elicited from decision makers during workshops. Provide documentation and visual demonstrations of both case study examples and real use decision processes.

Thus far, Ms. Rehr has:

- Introduced the concept of a decision landscape and Bayesian Belief Networks during the ESRP seminar series DSF presentation (March 30, 2009)

- Developed a presentation capturing the Coral Reef's DPSIR (drivers, pressures, state, impact, response) framework and how it relates to decision landscapes, which she will present at the upcoming workshop.

- Developed a decision landscape/DPSIR exercise for use at the workshop.

Appendix D: List of Future Products (resources permitting)

Ecosystem Services Tools Database

The Ecosystem-Based Management Tools Network (NatureServe 2008) has developed a database of tools that consider bundled ecosystem services emphasizing coastal and marine systems. The Ecosystem Services Tools Database (being developed by the DSF team) augments the scope of ecosystem services in the broad sense of decision support related to the USEPA's Ecosystem Services Research Program. The purpose is to provide an evolving searchable database of tools, approaches, and techniques that can be applied in analytic-deliberative decision support processes accounting for improving decisions that may affect ecosystem services.

Lessons Learned from Workshops

As a result of the Coral Reefs/DSF workshops, we will be collecting information regarding what worked and what didn't work in terms of the analytic deliberative processes used at the workshop. Additionally, a value-of-information exercise will be used to determine whether or not the workshop had any impact on participants' beliefs regarding relationships between environmental pressures and outcomes and/or preferences for different outcomes.

Flow Charts of Decision-Making Processes

An expected outcome of the Coral Reefs/DSF workshops is a series of flow charts of decision-making process and key decisions from coral reef decision-makers. This information will be collected as part of the workshop process. Additionally, we will collect

information about different data and tools that are used by decision-makers and map these into the flow charts.

Review of Social-Networking Tools

A variety of social networking tools (social networking analysis, FaceBook, MySpace, etc.) are being investigated for their potential to demonstrate gaps in communication between and among stakeholders and decision-makers, to bring stakeholders and decision-makers to a common understanding about a topic, and to determine how they learn from each other. In addition to using a social networking analysis tool at the Coral Reefs/DSF workshop and documenting results, it is anticipated that a literature review will be performed in order to summarize lessons learned from other uses of these different tools.

Ecosystem Services Social-Networking Tool

This tool would use an existing social networking tool (such as FaceBook or MySpace) to bring ecosystem services stakeholders and decision-makers together in a social network to discuss common issues, learn from each other, and direct them to more robust, scientific websites. This is a potential outreach and education tool.

Appendix E: Cross Cuts

The connection and linkage between global climate change and nitrogen, wetlands and land/resource use is a complicated issue. Climate change affects land and resource use potentials, but changes in land and resource use has an impact on the process of global climate change. This presents all ESRP groups with the "chicken or the egg" conundrum. Both nitrogen and wetlands issues are integrally aligned with each other as well as the global climate change issues. The mechanisms and interactions of nitrogen and wetlands with global climate pressures is complex and require discussions, interactions and collaborative development of programmatic plans between the nitrogen and wetlands groups. The resulting interactions and paths forward from these interactions will be the guiding boundaries that the ESRP DSF will utilize to develop the appropriate decision support framework to meet the needs of the nitrogen and wetlands clients and users.

The DSF effort truly cross cuts all the ESRP efforts. Workshops/document reviews are planned with all the ESRP groups to identify the needs of the stakeholders and potential users of those efforts. But time, workshop planning and implementation logistics and resource limitations prohibit the DSF team from conducting these workshops/document reviews with all groups in the first year. Due to programmatic level priorities, the DSF group will begin working more closely with the nitrogen and wetlands teams. DSF leads in collaboration and coordination with the nitrogen and wetland leads are discussing plans to conduct a joint workshop effort with all three groups to maximize the potential overlap and collaboration for information gathering and programmatic development. The best way to link efforts it to jointly develop the plans for identifying needs and implementing outputs.

Ecosystem Services Research Program
Human Well-Being Theme
Lead: Laura Jackson – jackson.laura@epa.gov; 919-541-3088
Status Report and Future Directions, June 22, 2009

1.1 Theme Goal

To understand and document how the provision or disruption of specific ecosystem services contributes to direct measures or indicators of human health and well-being.

1.2 Conceptual Model and Description

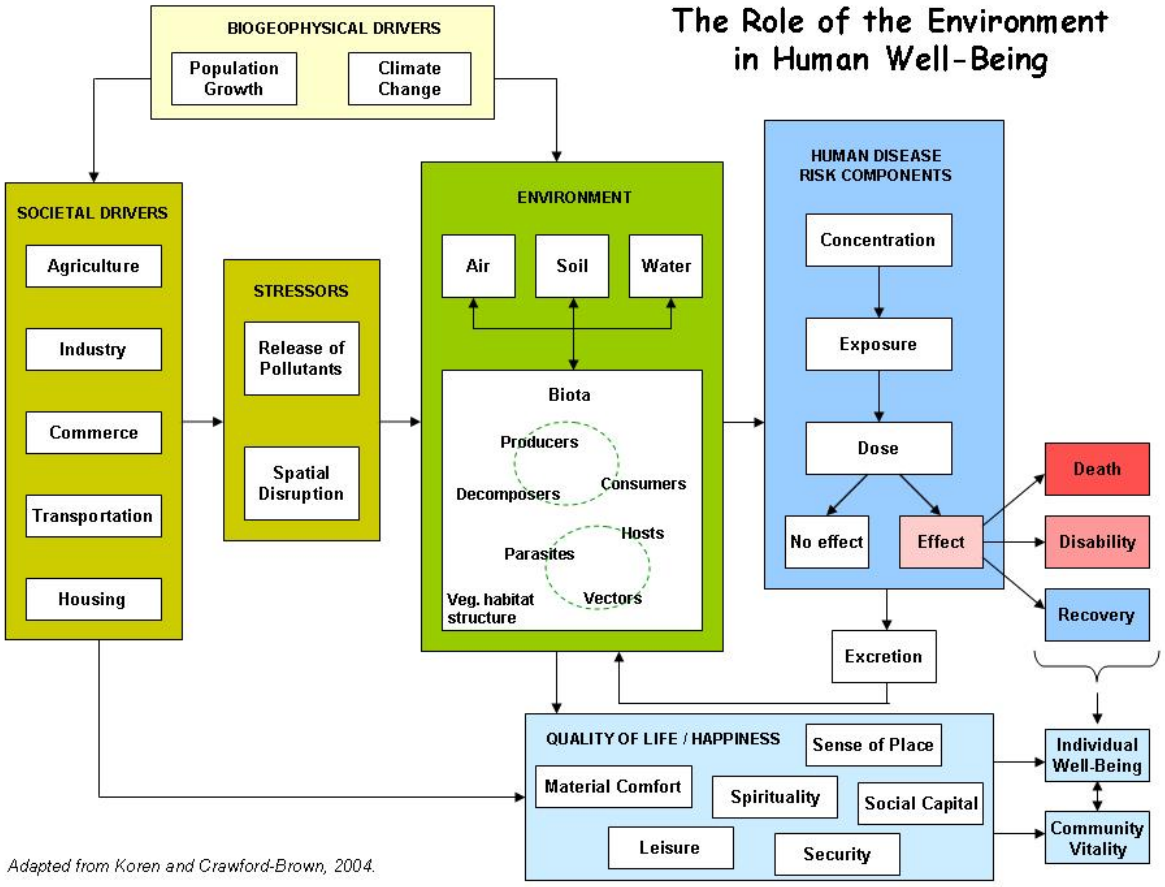


Figure 1.2 Top-level conceptual model of the role of ecosystem services in human well-being.

Figure 1.2 illustrates the general conceptual relationship among ecosystem services and human well-being. ESRP research to address the health component of human well-being is developing examples of specific hypothesized relationships at various spatial scales. ESRP research addressing overall well-being will ultimately include these health examples; the approach here is to start holistically to envision well-being. Additional conceptual models that provide more detail to guide the research under each approach are provided in Appendix B.

1.3 Expected Impact/Rationale

Research results will provide meaningful societal consequences, in terms of human health and well-being outcomes, of unit changes in the extent and condition of the ecosystem services under study. Expected services and management impacts to be studied include strategic habitat protection and restoration as a means to mitigate air-quality criteria exceedance, drinking-water contamination, storm damage, infectious disease risks, and adverse spiritual/cultural effects. Air research underway is expected to assist OAR and the Regions with the Smartway and Clean Cities programs. Ongoing research to minimize vector-borne disease through land management and biodiversity conservation is of interest to OPPTS as an integrated pest management strategy, to OW as a highly-valued societal consequence of wetlands protection and restoration, and to the EPA Regions as an additional societal benefit of smart growth and brownfields redevelopment.

As an ESRP Theme, Human Well-Being research is integrated into most of the program projects and several sister themes. Among other linkages, the Future Midwestern Landscapes project will compare population respiratory health benefits between its biofuels and multiple-services scenarios using OAR's BenMAP model. The Willamette and Tampa Bay projects are applying the USDA iTree model to quantify air filtration services of urban tree cover. The National Atlas will include measures of urban green space and estimates from the literature of associated benefits to respiratory health, physical activity, and mental health. Sense of place has been identified through client outreach as a high-priority ecosystem service for research in the Coastal Carolinas project; the Southwest project plans to include a focus on Tribal culture. The Index of Well-Being will be applied to Wetlands, Coral Reefs, and Tampa Bay. See also Appendix E.

1.4 Current Status

1.4.1 Research underway in FY 2009

<u>Effects of vegetative buffers on ambient near-roadway pollutant concentrations</u>
Data analysis is underway following FY08 mobile and stationary field monitoring in Research Triangle Park, NC (n = 50 rush-hour periods). Parameters include concentrations of CO, black carbon, and the spectrum of PM from ultrafine to PM_{10}, measured downwind of roadside vegetation of varying type, height, and thickness. Computational fluid dynamics modeling is beginning that will simulate ambient concentrations under vegetation characteristics not sampled in the field. Wind-tunnel research will address particulate behavior under diverse meteorological conditions beyond those captured in the field. Leveraged FY09 field sampling in Las Vegas will contribute additional data from un-vegetated conditions. An FY10 field season will take place in Detroit. The expected outcome is a statistical model of the reduction in ambient pollutant concentrations that is provided by gradients in near-roadway vegetation across a range of biological and meteorological conditions.

<u>Forest fragmentation, biodiversity loss, and associated risk of Lyme disease</u>
Landcover pattern metrics were previously linked to Lyme disease rates in ~500 tiled landscapes across 15,000 km^2 in central Maryland. The biological mechanisms suggested by the literature are reductions in native biodiversity, leading to raised wildlife infection rates; and increased human exposure to degraded forest habitat through very low-density housing development. To evaluate predictive ability, ORD staff applied the model to ~500 Pennsylvania landscapes of similar spatial extent. In FY09, goodness-of-fit analysis is underway; preliminary results indicate an 80% match of predicted risk categories to the empirical data. Work is underway to

convert three scenarios of future housing density from ORD's Global Change Research Program to landcover classes in order to create alternative futures of Lyme disease risk at the Census tract scale across the northeastern U.S.

Development of an Index of Well-Being

The literature of well-being and index construction is under review. The result will be two foundation review papers: (1) The elements of human well-being and their relation to the environment, and (2) The construction of indices of well-being – review and potential application to the United States. The first manuscript will examine the roles of basic human needs, economic well-being, environmental conditions and services, and subjective happiness (cultural, aesthetic, or other sociological values) on overall well-being. The second manuscript will review the existing indices of well-being, assess the applicability of their elements to U.S. conditions, and develop a strawman approach for index development for the U.S. Targeted for Frontiers in Ecology, these manuscripts will provide the basis for an analysis of the relationships of the elements of a well-being index to specific ecosystem services and the potential predictive value of ecosystem service information for an assessment of human well-being. Applications to ESRP projects will be determined through these analytical results and predictive relationships.

Please see Appendix B for conceptual models of the above studies. Proposals for the near-roadway and Lyme disease studies underwent internal review as part of the cross-EPA Group on Earth Observations (GEO) Advanced Monitoring Initiative. The plan to develop an index of well-being was reviewed as part of the research portfolio of the ORD/NHEERL Gulf Ecology Division. The Human Well-Being Theme does not currently have an implementation plan (IP). This research is a very small component of the overall program, with insufficient staff to address the suite of research planning activities appropriate for a fully operational, funded research initiative. Work is exploratory and opportunistic in nature, leveraging existing environmental health studies across EPA and externally where an ecosystem services perspective is mutually beneficial. Human well-being research that is fully integrated within other ESRP Projects and Themes is addressed in the IPs of those components. The Human Well-Being Theme Lead is a Ph.D. scientist in the intersection of landscape ecology, public health and urban planning, with 19 years of research and management experience in EPA's Environmental Monitoring and Assessment Program (EMAP).

1.4.2 Current impacts, critical accomplishments and innovations

EPA Regional scientists in the eastern U.S. are interested in land management for biodiversity as a tool to minimize Lyme disease risk. Planning is underway for an OSA/ORD/Regional workshop on this topic in the Region 1 lab during Sept. 22-23, 2009.

The ESRP/GEOSS initiative on near-roadway vegetation as pollution buffers has catalyzed NRMRL research on this issue. In addition to contributing significant additional funding, NRMRL is planning a state-of-the-science workshop involving ORD, OAR, OECA, EPA Regions, other Federal agencies, and academia on the potential of vegetative buffers to mitigate respiratory health risks and inform policy.

The Healthways/Gallup Poll on Well-Being in the U.S. has expressed interest in the potential for inclusion of the ESRP index of well-being in their web-based product.

1.4.3 Publications and papers presented in FY 08/09 and forthcoming

Publications

"Environment and Lyme disease risk" *In:* Lyme *Disease: Symptoms, Diagnosis, and Treatment.* Nova Publishers (in press)

"The concept of well-being and its relationship to the environment" *Frontiers in Ecology* (in prep.)

"Towards the development of an index of well-being for the U.S.: a review" *Frontiers in Ecology* (in prep.)

"Assessing the influence of vegetative and structural roadside barriers on near-road particulate matter concentrations using a mobile sampling platform" *Atmospheric Environment* (in prep.)

"Validation of regression model to estimate Lyme disease risk by landscape attributes" *International Journal of Epidemiology* (in prep.)

Conferences

Annual Meeting of the Society for Human Ecology, September 10-13, 2008 – Bellingham, WA
"Going Green Does a Body Good: Transdisciplinary Approaches to Defining Relationships between Ecosystem Services and Human Health and Well-Being" (session chair)
"Identifying What Really Matters: What Constitutes Well-Being" (platform)

Society for Environmental Toxicology and Chemistry, November 16-20, 2008 – Tampa, FL
"Assessing Ecological Services" (session chair)
"USEPA's New Ecological Research Program: Ecosystem Services" (platform)
"The Relationship between Forest Degradation and Lyme Disease" (platform)
"Components of an Index of Well-Being: Identifying What Really Matters" (poster)

EPA Regional Science Workshop – Green Infrastructure: Linking People, Nature, and Landscapes through Sound Science. February 9-11, 2009 – Annapolis, MD
"Human Health and Well-Being" (plenary)

International Association for Landscape Ecology, April 12-16, 2009 – Snowbird, UT
"Ecosystem Services and Human Well-Being" (session chair)
"The Role of Landscape Ecology in Assessing Ecosystem Services and Human Well Being" (platform)

International Association of Landscape Ecology in Europe, European Landscapes in Transformation – Challenges for Landscape Ecology and Management" July 12-16, 2009 – Salzburg, Austria
"The Emerging Importance and Interactions of Ecosystem Services, Ecosystem Condition, Landscape Functioning and Human Well-being in the United States: Lessons from 70 Years of Progress in Europe" (invited platform)

National Conference on Ecosystem Restoration, July 20-24, 2009 - Los Angeles, CA
"Ecosystem Restoration, Ecosystem Services and Well-Being" (session chair)

"The Relationships among Ecosystem Services, Restoration and Human Well Being and the Construction of an Index of Well-Being" (platform)
"The Appropriate Role for Ecosystem Services in Ecosystem Restoration and Environmental Decision-Making" (panel discussion)

Annual Meeting of the Ecological Society of America, August 2-7, 2009 – Albuquerque, NM
"Ecosystem Condition, Ecosystem Services and Human Well-Being" (session chair)
"Use of Existing Well-being Measures in the Development of an Index of Well-Being (IWB) for Ecosystem Services Research" (platform)
"Forest degradation and Lyme disease risk" (platform)

CDC National Environmental Public Health Conference, October 25-28, 2009 – Atlanta, GA
"The Role of Ecosystem Services in Environmental Public Health" (proposed session chair and five invited talks by staff from four Federal agencies)

Coastal and Estuarine Research Federation Biennial Symposium, November 1-5, 2009 – Portland, OR
"Ecosystem Services and Human Well Being: Theoretical and Practical Challenges" (Day-long session chair)
"Estuarine Ecosystem Services & Well-Being" (session chair)
"Estuarine Ecosystems and Human Well being: Introduction to Symposium" (platform)
"Relationships among Ecological Processes, Ecosystem Services and Human Well-Being" (session chair)
"Quantification of Estuarine Ecosystem Services and Case Studies" (session chair)
"Valuation of Ecosystem Services" (session chair)

Greenbuild International Conference and Expo, November 11-13, 2009, Phoenix, AZ
"Towards Guidelines for Designing Green Space to Reduce Community Health Risks" (session chair)
"Air Purification Services and Cardiopulminary Health" (platform)
"Residential Forest Pattern Affects Risk of Lyme Disease" (platform)
"Mental Health and Accessible Green Space" (platform)

SETAC Annual Meeting, Human-Environmental Interactions: Understanding Change in Dynamic Systems, November 19-23, 2009 – New Orleans, LA
Session proposal under review

1.4.4 Resources

EPA: estimated 4 FTE from 8 permanent staff and 2 term employees
Non-EPA: estimated 3 FTE under contract

Budget and personnel are needed to maintain and strengthen this research theme. In particular, significant funding is essential to access large databases of medical and pharmaceutical records, as well as Healthways/Gallup data bases on well-being, in order to advance and quantify suggested linkages between ecosystem services provision/ degradation and human illness and disease, and human-well-being (both individual and societal) in ESRP Places and at regional and national scales.

1.5 Response to Comments

1.5.1 Response to Program Office comments N/A

1.5.2 Response to SAB comments

In its review of the draft ESRP multi-year plan, the SAB acknowledged the critical importance of linking ecosystem services to human health and well being. While lauding the program's vision in featuring both health and social-science research elements, the SAB recognized that the ESRP lacks sufficient in-house expertise and funds to launch major initiatives in these areas. Instead, the SAB advocated case studies at multiple spatial scales to demonstrate proof of concept, and to focus on developing external partnerships. As a result, the ESRP is no longer representing human well-being and its valuation in health, economic, or other social metrics as its ultimate measures of success. The program concurs that it does not have sufficient resources to meet this goal. Instead, the ESRP accepts the SAB's recommendation to pursue exploratory and opportunistic case studies to connect ecosystem service endpoints to quantifiable health and well-being outcomes, as illustrated in this report. These studies will seek to demonstrate, to decision-makers and potential partners within the Agency and externally, the relevance, importance, and feasibility of this transdisciplinary research approach.

ORD has not yet committed the financial or human resources needed to expand the social-science portion of the ESRP. As a result, the ESRP has reconceived the Valuation component within the program's organizational structure. Originally conceived as a separate research initiative within Long Term Goal 1: Decision Support, Valuation is now incorporated within each of the place-based, ecosystem, and other ESRP projects, and implemented through term appointments of "expert hires." The skills required for ecological economics research are both radically distinct from, and more mature than, those required for eco-health integration and the study of well-being. Therefore, the ESRP has chosen to incorporate valuation within the other parts of the program, rather than merging the Valuation and Human Well-Being components, in response to SAB comments.

1.6 Challenges

Challenges include the nascent state of the science, transdisciplinary nature of the problems, minimal resources, and steep learning curve for potential ESRP participants.

1.7 Future Directions

Increased effort will be directed towards incorporating HWB endpoints into ecosystem service layers of the National Atlas. ESRP staff are exploring "benefits transfer" from the literature to express respiratory and physical fitness benefits of urban green space in terms of average days of life extended. Data mining efforts are currently determining the potential to seek associations between green space and mental-health outcomes in children. Discussions are also underway on including degradation of the night sky (i.e. light pollution) as an impaired ecosystem service, with documented and projected links to breast cancer and other diseases of the endocrine system. An important future component of the respiratory work will be scaling the findings from the near-roadway field and modeling studies to the municipal and national levels. Research will also address transferability of findings to diverse near-roadway conditions in non-study sites.

Partial or full application of a constructed index of well-being is anticipated for the Wetlands and Coral Reefs ecosystems and Tampa Bay pilot, although the exact nature of these applications is dependent upon data availability and project needs. Continuing discussion with the Healthways/Gallup Well-Being Survey will likely provide the opportunity for the addition of question(s) to their survey and a broad database for use in index development and applications.

Increased effort is needed to address HWB in the research still being planned for the Coastal Carolinas, Southwest, Wetlands, and Nitrogen Projects. Global climate change is a likely issue through which to link ecosystem services with human health and well-being in these Projects. The HWB Lead will continue to participate in planning workshops and outreach to potential partners. Benefits to society will be integral to the research developed for these Projects; however, additional staff or funding will likely be required to quantify specific health or well-being endpoints.

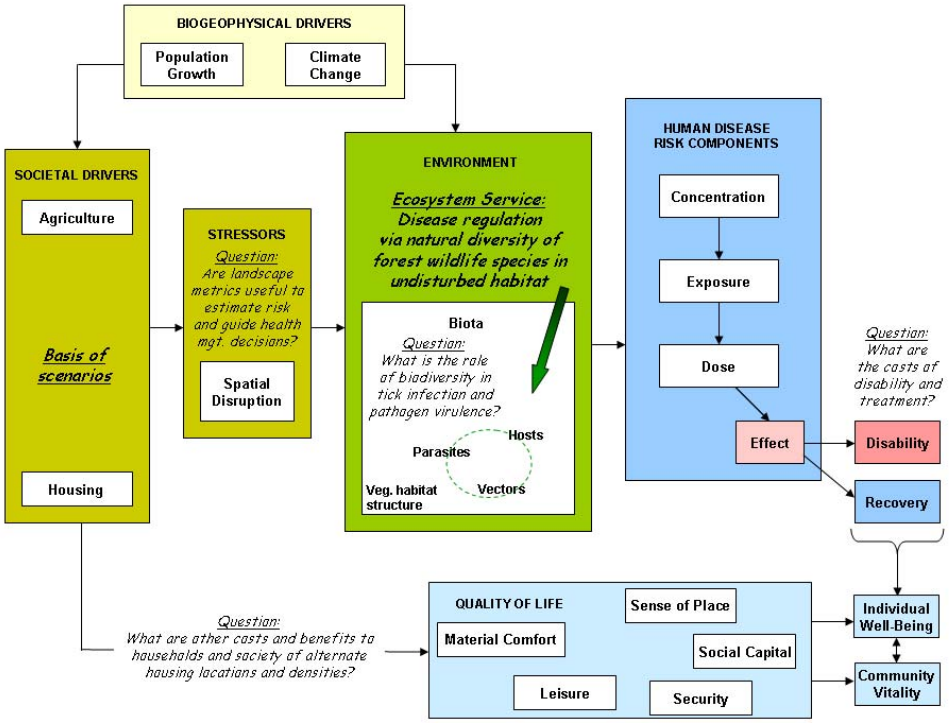
1.8 Appendices

Appendix A: Hierarchy of services being addressed

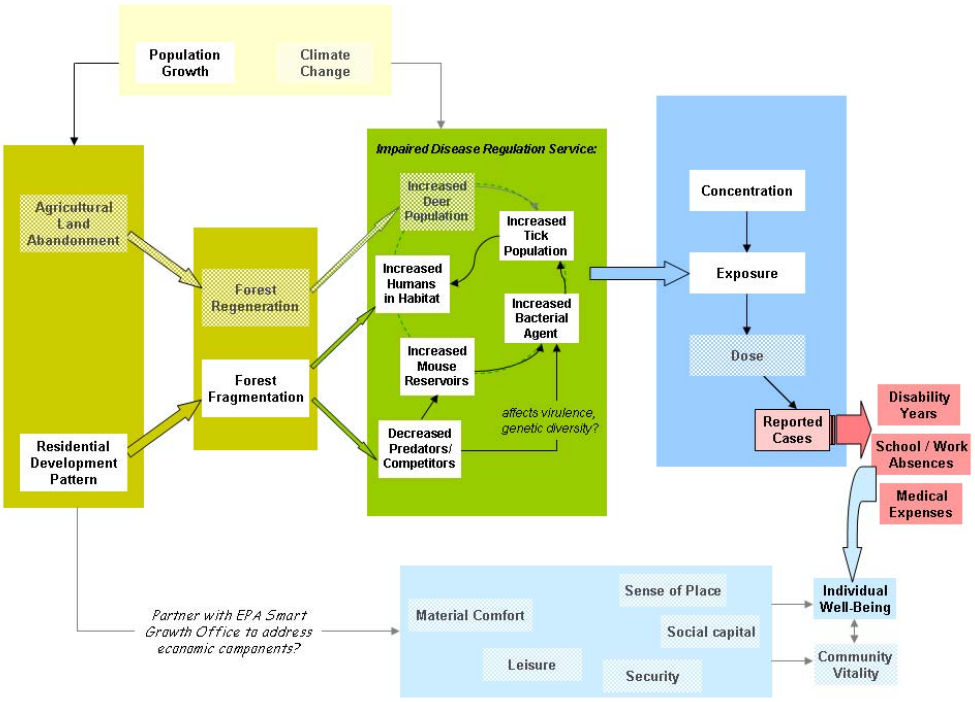
<u>Lyme disease study</u>	
Ecosystem measures:	Forest habitat extent and configuration
	Wildlife community composition (partner research)
	Tick infection rates (partner research)
Intermediate eco service:	Biodiversity (if you consider that a service)
Final ecosystem service:	**Disease regulation**
Units of societal value:	Total number of cases and cases per pop. (rate)
	Estimated average medical costs
	Estimated average lost productivity (days of work/school missed)
<u>Near-roadway study</u>	
Ecosystem measures:	Vegetation type, height, depth and porosity
	Ambient concentrations of PM, CO, black carbon
Final ecosystem service:	**Air purification**
Units of societal value:	Grams of pollutants removed per year
	Estimated average days of life extended
	Estimated average medical costs averted
	Estimated average productivity gained (days of work/school)
<u>Index of Well-Being</u>	
Ecosystem measures:	Air Quality
	Water Quality
	Contaminant Concentrations (Sediments & Tissues)
	Health Statistics
	Economic Values
	Biodiversity
	Nutrient Recycling and Use
	Landscape Characteristics
	Ecosystem Condition
Non-Ecosystem Measures:	Basic Human Needs
(related to Eco-Services)	Human Health Statistics
	Economic Welfare
	Cultural, Spiritual and Aesthetic Needs
	Happiness
Final Eco-services:	**Air purification**
	Water purification
	Water provision
	Reduced risk from toxins
	Increased well-being

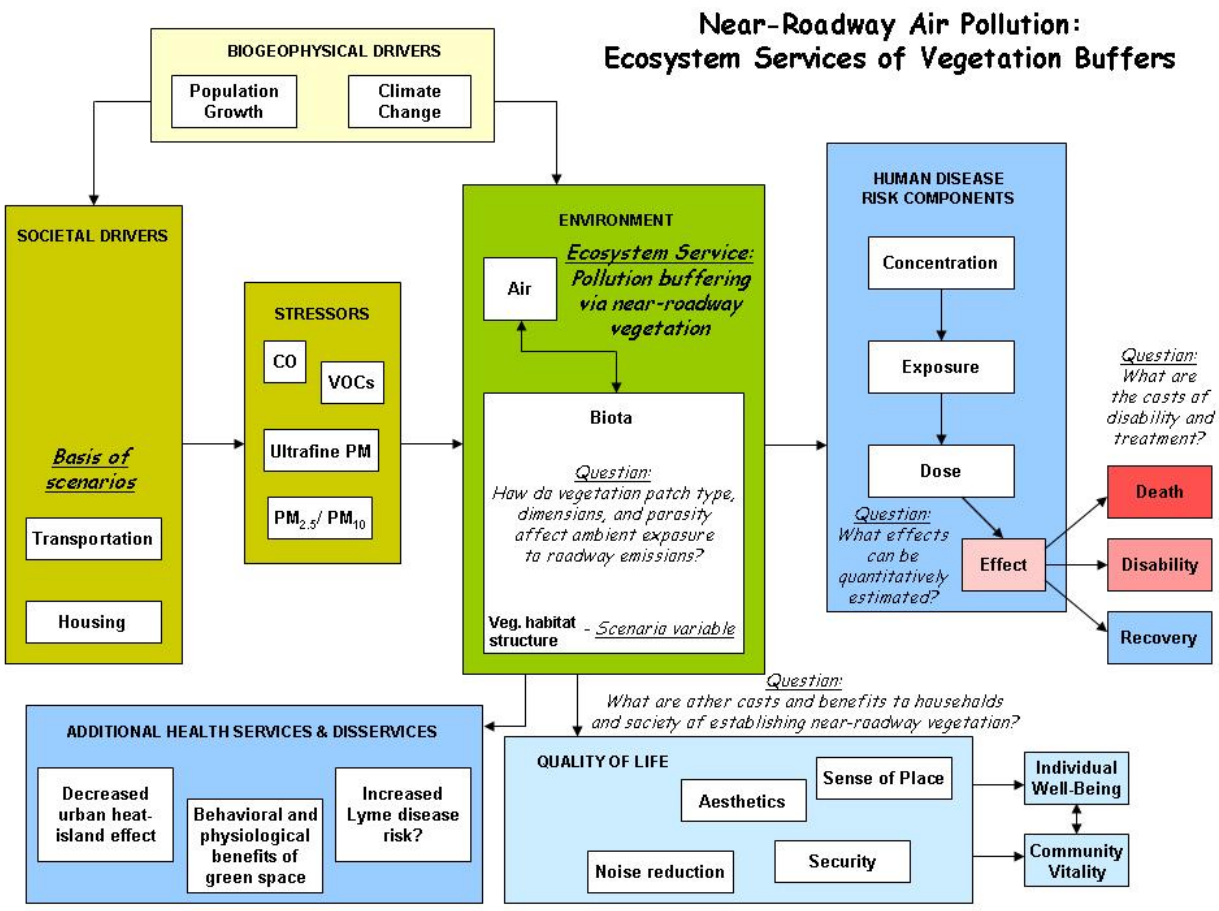
Appendix B: Conceptual model and most significant scientific uncertainties

The Role of Ecosystem Processes in Regulating Lyme Disease



Greater level of detail (shaded boxes: issues that ESRP and partner efforts are not currently addressing)

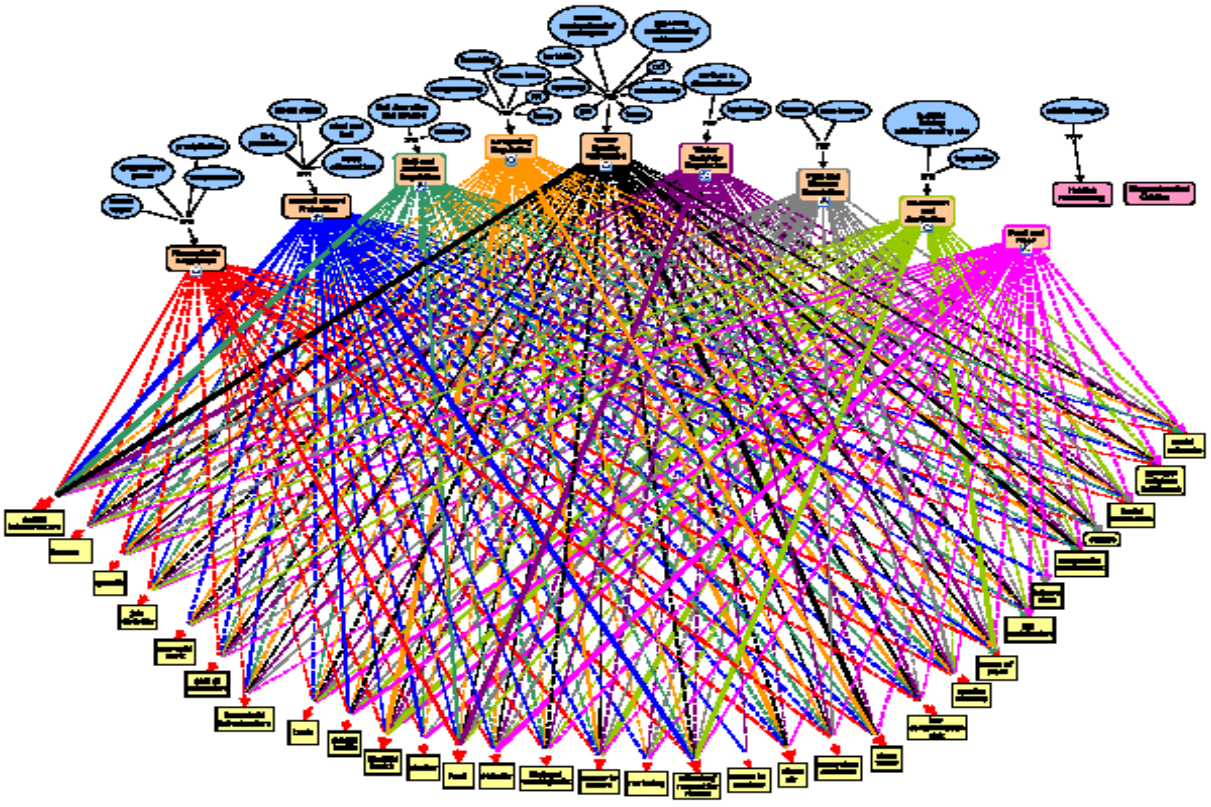



Near-Roadway Air Pollution:
Ecosystem Services of Vegetation Buffers
BIOGEOPHYSICAL DRIVERS
Population Growth
Climate Change
SOCIETAL DRIVERS
Basis of scenarios
Transportation
Housing
STRESSORS
CO
VOCs
Ultrafine PM
PM2.5/ PM10
ENVIRONMENT
Air
Ecosystem Service: Pollution buffering via near-roadway vegetation
Biota
Question: How do vegetation patch type, dimensions, and porosity affect ambient exposure to roadway emissions?
Veg. habitat structure - Scenario variable
HUMAN DISEASE RISK COMPONENTS
Concentration
Exposure
Dose
Question: What effects can be quantitatively estimated?
Effect
Question: What are the costs of disability and treatment?
Death
Disability
Recovery
Question: What are other costs and benefits to households and society of establishing near-roadway vegetation?
ADDITIONAL HEALTH SERVICES & DISSERVICES
Decreased urban heat-island effect
Behavioral and physiological benefits of green space
Increased Lyme disease risk?
QUALITY OF LIFE
Aesthetics
Sense of Place
Noise reduction
Security
Individual Well-Being
Community Vitality

Conceptual Model of Human Well-Being

We have developed a conceptual model of human well-being in which 30 drivers, 9 ecosystem services, and 31 indicators of well-being are identified and interconnected. While the model is too large to read at this page size, it is reproduced here to suggest its complexity and state of development.

The fact that nearly all services are related to some aspect or indicator of well-being is not unexpected. In fact, if this conceptual model did not show the innate complexity of well-being, it would hardly be believable. Unfortunately, describing and quantifying this complex set of relationships is both impractical and largely intractable. Our approach will be to complete the conceptualization of the relationships by adding the interactions among the indicators of well-being, and then assess the level of importance and uncertainty associated with each linkage. Using that conceptualization, we will disassemble the model by eliminating all interactions that are determined to be of minor consequence, either individually or in composite. Our expectation is this will reduce the complexity of the model by a substantial amount (up to 60%), while only impacting the index a small amount (<20%). If indeed this is the case, we will then use existing data to parameterize each interaction and then populate the model and index. Examinations of co-linearity or other measures of joint variation can then be used to economize the variables of the index. Initial testing, validation and application will be done using data from one or more of the ESRP place-based projects.



Appendix C: Experts' contributions

Not applicable.

Appendix D: List of future products

- Mapped projections of Lyme disease risk at the Census-tract scale under alternative scenarios of forest fragmentation due to housing development. Targeted region includes multiple northeastern and mid-Atlantic states comprising the U.S. endemic zone of highest risk.

- Video simulations of downwind ambient pollutant concentrations under alternative scenarios of near-roadway vegetative buffers.

- Two research papers on Lyme disease model validation in Pennsylvania and New York, including economic valuation of projected disease incidence.

- Two papers describing the results of modeling—computational fluid dynamics and wind tunnel studies—on the effectiveness of vegetation as near-roadway pollutant buffers.

- Literature review of the influence of green space on mental health, with obstacles and opportunities for testing published findings across sites and spatial scales.

Appendix E: Cross cuts

An index of well-being will be applied within the Wetlands project. Discussions are underway with the Wetlands and Nitrogen projects on feasible and appropriate research to translate ecosystem service gain or loss into human-health endpoints. Ecosystem services to be evaluated by the Wetlands project include water filtration, storm-water buffering, carbon storage, and the provision of wild food and recreation. Nitrogen research will encompass atmospheric nitrogen, runoff into surface and ground water, and transformations within these media. The wetland services, and the role of nitrogen in disrupting the provision of clean air and water safe for drinking, fishing, and swimming, each have links to human-health outcomes. However, it is unclear to what extent these outcomes will be estimated from the biophysical endpoints under development. Global climate change is perhaps the strongest policy driver for incorporating specific human health measures into the research for these two projects. There is growing interest across EPA in the connections between climate change and human health. Since climate-related health effects are mediated by ecosystem services, additional resources and incentives may emerge for ESRP research in this area. Examples include how changes in wetlands affect risk of mosquito-borne disease; and how changes in precipitation and flow modify N concentrations, which in turn affect risk of harmful algal blooms and nitrates in drinking water. Climate change is also relevant to the projections of Lyme disease risk under alternative future scenarios.

LTG 2 Monitoring, Mapping, Modeling

LTG 2: The Ecosystem Services Research Program will deliver a publicly accessible, scalable, national atlas, an inventory system, and models for selected ecosystem services that can be quantified directly or indirectly.

a. Monitoring

b. Mapping and Landscape Analysis

c. Modeling (forthcoming)

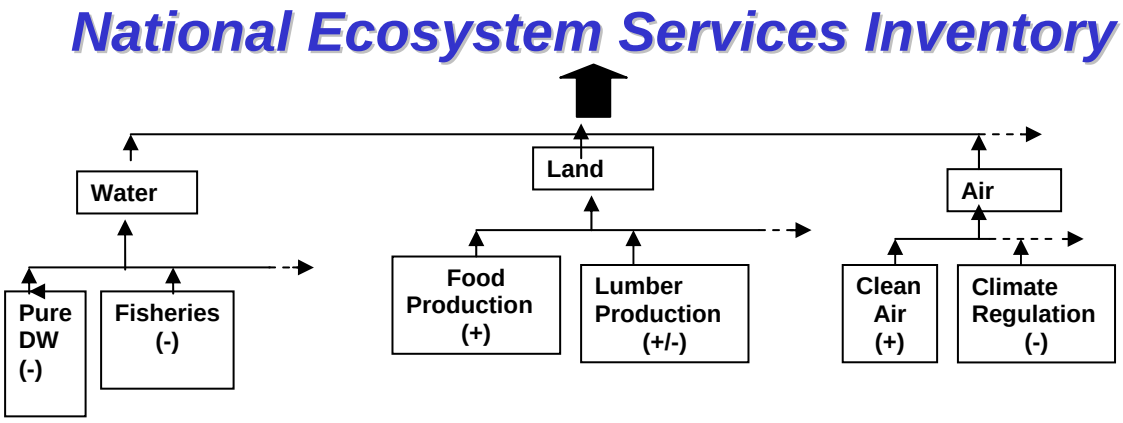
Ecosystem Services Research Program
National Monitoring for Ecosystem Services
Contact: Michael McDonald (919/541-7973: mcdonald.michael@epa.gov)
Status Report and Future Directions. June 18, 2009

1.1 Project or Theme Goal

National Monitoring for Ecosystem Services (ES) provides policy-makers with necessary information about changes in the quantity and quality of ecosystem services due to regulation, use, and trading at state, regional and national levels. . We will design a monitoring system for inventorying ecosystem services. This will move from the more traditional condition assessments of current monitoring programs to ecosystem services monitoring at the appropriate scales.

1.2 Conceptual Model and Description

Figure X



We envision a comprehensive inventory of ecosystem services across at least the key human survival elements. Because of clear statutory mandates and our monitoring expertise, we will initially focus on water-related ecosystem services.

1.3 Expected Impact/Rationale

We will develop monitoring designs and indicators that will allow current ecosystem services (ES) for aquatic ecosystems to be estimated on a national and regional basis. This approach will yield unbiased and representative regional/national inventories, and through time, allow for assessment of ES trends associated with management decisions. We also envision the use of these data for the empirical parameterization of models to allow scaling to more local levels and/or for developing associations with regional/national remote sensing data. Monitored ES data will also allow model hindcasting to assess predictive accuracy of these models.

Within the next five years we will determine whether ES produced by aquatic ecosystems can be estimated from current condition monitoring programs. For existing monitoring programs to be useful for ES, they must provide high quality, consistent, representative, and spatially distributed data of sufficient record length to assess status, changes, and trends in ES with time. This requires examination of both the monitoring designs and indicators to determine if they will allow for ES estimates at local to national levels. If they do not, we will determine what additional information is needed or whether entirely new ES indicators and designs are needed. Further, we will examine the response of ES to anthropogenic stressors and determine whether ES response thresholds exist for selected ES. We will also develop approaches to combining data from different spatial units, monitoring designs, and ecosystem types.

1.4 Current Status

1.4.1 Research Underway in FY 2009

Estuaries – We are currently analyzing and synthesizing data to estimate ES and habitat data from Humboldt Bay (CA), Lagoon Pond (RI) and Weeks Bay (AL). We are refining a broadly applicable framework for spatially explicit rendering of ES produced within an estuary. We are examining the valuation of estuarine ES through the use of a biodiversity discount rate concept (with pilot application to analysis of oyster genetic diversity), and refining and generalizing a simple travel cost model. We are also in discussion with the Nature Conservancy (their Ecoregional Assessment Program) to explore parallel research interests for coastal systems in support of more rapid mapping of ES.

We have observed reductions in contaminant concentrations in estuarine fishes at the national level (National Coastal Condition Report III, draft report). We have estimated the economic value of this reduction in contaminants to an improved national recreational fishery.

Streams and Rivers– We have estimated the number of stream miles nationally and regionally that have reduced nitrogen assimilation capacity.

We have developed an approach to estimate the value of the loss of ES associated with recreational fishing in the Mid-Atlantic. This is potentially applicable to the nation.

We are examining changes in water quantity ES by examining the changes in the miles of perennial streams in the landscape through time on a regional and national basis.

We are developing a GIS tool to better represent and model the stream network, including previously unmapped headwater streams.

We are examining nitrogen removal by streams and rivers in the Mississippi River Basin, and the contribution of floodplain forests to the N balance around large, floodplain rivers.

Lakes – We are **c**urrently analyzing the data for lakes collected in the EPA Office of Water National Aquatic Resource Survey (NARS), to determine whether ecosystem services can be determined from condition. .

We are developing data visualization tools that allow scaling from national to local levels using NARS Lakes data for ES.

Wetlands – (reported elsewhere)

Corals – (reported elsewhere)

1.4.2 Current Impacts, Critical Accomplishments and Innovations

Increased estuarine recreational fisheries associated with decreased fish contaminant levels may have resulted in $13.5M increase in recreational revenue nationally (linked to OW NARS).

The relationship between percent forest cover in source water watersheds and reduced costs for drinking water treatment was found for a number of large cities (linked to ESRP Mapping).

Improved human life expectancy in a number of large cities is associated with the reduction of PM2.5 by urban forest canopy (linked to USFS and ESRP Mapping). .

More than 50% of the nation's streams have lost moderate to major capacity for nitrogen assimilation (linked to OW NARS).

We have been able to estimate the reduction in recreational angling due to impairments in the streams and small rivers of the Mid-Atlantic Highlands using condition monitoring data. The economic impact of this loss was estimated to be $148M/y (linked to OW NARS, ESRP modeling).

1.4.3 Publications and Papers Presented in 2008/09 and forthcoming

Journal articles

Paul, J.F., M.E. McDonald, and S.F. Hedtke. 2008. Stream condition and infant mortality in U.S. Mid-Atlantic States. Human Ecol. Risk Assess. 14:728-741.

Manuscripts

Jackson, L. E., B. Rashleigh, M.E. McDonald. Submitted. Estimating lost recreational benefits from regional stream degradation. Ecol. Econ.

O'Higgins, T.G. Submitted A pragmatic approach to evaluating biodiversity loss. Ecol. Econ..

Presentations

O'Higgins, T.G, Rumrill S., Helms, A & deMarzo, A. 2008 Concurrent Detection of the Pacific Decadal Oscillation in Multiple Estuaries: Ocean-Estuary Coupling within Padilla Bay (WA), South Slough, (OR), and Elkhorn Slough (CA) National Estuarine Research Reserves: Proceedings of The Pacific Estuarine Research Society 31st annual meeting. Hatfield Marine Science Center Newport, OR.- poster

O'Higgins, T.G. .2008. Ecosystem Services of Algae in Estuaries on the west coast of North America: The Almighty Dollar. Proceedings of the 22nd NorthWest Algal Symposium, Oregon Institute of Marine Biology, Charleston, Oregon

O'Higgins, T.G. 2008. Estuary-wide Habitat Specific Estimates of Fisheries Ecosystem Services in a Pacific Northwest (USA) Estuary. A Conference on Ecosystem Services. Naples, Florida

Economic evaluation of selected fisheries in the Yaquina Estuary Oregon. National Centre for Ecological Analysis and Synthesis- Marine Valuation Working group. 4/24/2008

Cumulative effects of habitat alteration on ecosystem services in estuaries. EPA ecosystem services group telconference 8/6/2008

Seasonal and long term patterns of physico-chemical parameters in South Slough, Oregon:eutrophication or ocean estuary coupling. Oregon Institute of marine Biology. Invited talk 5/8/2008

Cumulative effects of habitat alteration on ecosystem services- fisheries services and biodiversity value. EPA Atlantic Ecology Division. Naragansett (RI) 10/28/2008

1.4.4 Resources

ESRP Monitoring team has 19 EPA NHEERL FTE and a part-time external expert, Dr. Jim Boyd. Budget beyond salary is not expected. However, if additional funds were available more rapid development of a topological model for watershed characteristics related to ES could be accomplished.

1.5 Response to Comments

1.5.1 Response to Program Office Comments

1.5.2 Response to SAB Comments

The SAB clearly understands the daunting research task required to develop ecosystem services monitoring designs and indicators. We appreciate their view that EPA has extensive experience in the development of national inventory and monitoring programs (e.g. EMAP), and we intend to capitalize on that experience. The design options for determining ecosystems services will not be constrained by our prior ecosystem condition monitoring designs, as monitoring for the quantity and quality of ecosystem services often must be considered at multiple temporal and spatial scales. Selection of the most

appropriate monitoring design(s) (e.g. targeted, census, probability) will depend on the questions to be addressed and which ecosystem service endpoints are measured. A workshop to identify final ecosystem service endpoints is currently planned for July 2009 and will include both economists and ecologists. The development of responsive, low variability indicators for estimating ecosystem services will be a very difficult task. Following the workshop we will examine whether existing indicators (or the deconstructed information) from national condition monitoring programs will be sufficient for estimating final ecosystem services, or whether additional information will need to be collected, or whether entirely new ecosystem service indicators will be necessary. This initial workshop will focus on final stream ecosystem service endpoints since much of ORD's previous condition research has focused on streams (see future directions below for additional information on the workshop)._

The focus of the ESRP monitoring is to provide a national monitoring framework to inventory the current quantity and quality of services that the nation's ecosystems are providing. As the inventory is taken through time, it will also allow for changes and trends in these services to be detected in response to management or policy decisions. For this to be accomplished it will be imperative to coordinate and partner with other federal agencies conducting national monitoring programs.

We believe it is essential for data collected by an ecosystem services monitoring program to be tightly linked to the development of empirically-based forecasting models and to the national mapping efforts. Landscape associations with monitored ecosystem service data may provide a key approach for scaling ecosystem service information from the local to the national level. Monitored ecosystem service data will also be needed for parameterizing empirical forecasting models, and also for scaling national services to a more local level. Monitoring data could provide a comparative test for the predictive capabilities of ecosystem service forecasting models when applied to other locations or by hindcasting to previous times

1.6 Challenges

The most significant organizational challenge is the spread of peoples' time across a number of Multi year Plans (MYPs) and projects. Many of these disparate efforts are related and could be integrated, bringing more overall FTE to bear on national problems.

1.7 Future Directions

Research on ESRP monitoring at the national level requires establishing both the monitoring designs and the indicators necessary to allow ES estimates from the local to national levels. The initial key question for national ESRP monitoring will be to determine whether ES produced by aquatic ecosystems can be estimated from current condition monitoring programs.

Design - There 138 estuaries that represent over 90% of the estuarine surface water and freshwater inflow of the coastal regions of the contiguous US, and only about 92 of these

are not currently being monitored by NOAA's National Estuarine Research Reserve System (NERRS) or EPA's National Estuary Program (NEP). Thus, a census approach may be possible, and even desirable, for estuarine ES.

- Potential for new design frame for freshwaters may be based on watersheds (e.g., NHD+ basins or HUC 12-14) to provide the basis and scale for integration of ES locally, and to allow for aggregation to regional and national scales.

Indicators - We are convening a workshop (mid-July 2009) with economists and ecologists to focus on identifying indicators of final ecosystem services – ecological features, quantities, and qualities that directly result in a service to humans – in stream ecosystems. From these final ecosystem services we will determine whether this information can be provided by our current condition indicators, whether additional information is needed, or whether entirely new ES indicators will have to be developed.

- Examine the response of final ES indicators to anthropogenic stressors and determine whether response thresholds exist for selected ES.

Watersheds - If watersheds become the future design frame for national to local ESRP monitoring, then development of a topological relationship between the ecosystems that make up a watershed and the ES that the watershed provides would be undertaken. Such a topological relationship would allow estimation of ES trajectories for watersheds with various ecosystem compositions and changing anthropogenic stressors to be determined. Such a tool could be developed nationally, but would provide significant local insights into various management decision options within a watershed.

1.8 Appendices

Appendix A: Hierarchy of services being addressed in research

Our focus is initially on aquatic ecosystems. The Clean Water Act defines final ecosystem services which have already been codified (e.g., provision of drinking waters, provision of swimming waters, provision of fishing waters, sufficient quantity of water). Our research will begin with the production of these ES.

Appendix B: Conceptual Model and most significant scientific uncertainties

Conceptual model - see above.

A significant uncertainty surrounds how to combine all of these disparate data types from different spatial units, monitoring designs, and ecosystem types.

Appendix C: Experts' Contributions

Jim Boyd has provided his expertise in identifying final ES as significant issue in monitoring for ES for valuation. He has been key as a co-leader in the development of the ES endpoints workshop for streams.

Appendix D: List of Future Products

Percentage of the freshwaters of the US in which natural N assimilative capacity has been exceeded and ecosystem services (including drinkability and recreational fisheries) have been lost.

Economic loss associated with diminished recreational fisheries in the streams and small rivers of the US.

Estimate the average increase in life expectancy for the people in each city in the US with a population greater than 100,000 due to a reduction of PM2.5 associated with urban tree cover.

Estimate the reduced cost for drinking water in the US due to tree cover in the source water watersheds.

Estimate the ES provided by the various ecosystems w/in a watershed. Show how these ES can be bundled within a watershed and show how watersheds with different kinds of ecosystems and services can be compared to other watersheds. This would allow better decisions about the ecosystems making up watersheds based on the gain and loss of ES.

Appendix E: Cross Cuts

The monitoring team has direct links to ESRP wetlands and coral teams since both of these are national aquatic resource types requiring ES monitoring. Also, direct links to nitrogen as a nationally significant stressor across all aquatic ecosystems. Global warming impacts on ES, both direct and indirect, may also be estimated with national ES monitoring through time.

Ecosystem Services Research Program
Mapping and Landscape Ecology
Anne Neale, 919.541.3832, neale.anne@epa.gov
Status Report and Future Directions. June 22, 2009

1.1 Project or Theme Goal

The goal of the Mapping and Landscape Ecology Theme is to produce an accessible, digital National Atlas of Ecosystem Services while also providing landscape ecology and mapping support to other projects and themes contained within the ESRP program. The Atlas will use the principles of landscape ecology and spatial analyses to extend the frontiers of eco-regional assessments in order to display the sources and beneficiaries of ecosystem services. Services to be included in the Atlas are water quality and quantity, carbon sequestration, food and fiber, soil regulation, and aquatic and terrestrial habitat. The Atlas will allow displays of services for multiple spatial configurations, overlays and graphics of multiple services, data downloads, and the ability to place a spatial unit in context with those surrounding it.

1.2 Conceptual Model and Description

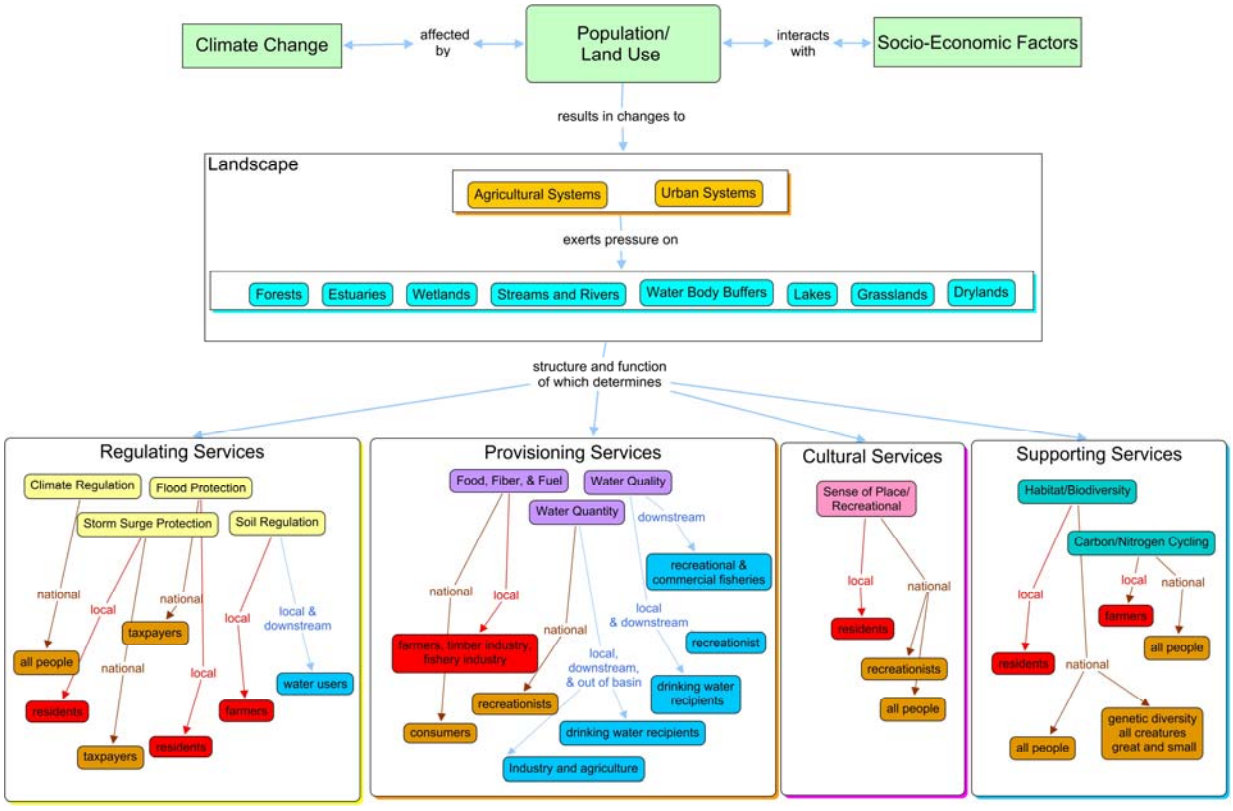


Figure 1 Conceptual Model for National Atlas of Ecosystem Services

The foundation for research and development of the National Atlas of Ecosystem Services is primarily the landscape. The structure and function of the various components and patterns of the landscape are providing the services which, in this figure, are broadly categorized into regulating, provisioning, cultural, and supporting. This conceptual model also recognizes the importance of identifying the beneficiaries of the services.

1.3 Expected Impact/Rationale

Ecosystem services mapping is a critical component of the ESRP, as it provides decision-makers and other key users with a visual and comprehensible method for interpreting and understanding how the delivery of multiple ecosystem services can be conserved and enhanced, while maintaining the use of ecosystem resources. Accordingly, ecosystem services models/maps will provide users the ability to assess choices in a spatially explicit context. We also envision that the National Atlas will include the ability to enable users to explore the aggregate consequences of explicit or implicit management choices (i.e., land use, climate change, and policy). Where possible, the National Atlas will identify the beneficiaries of services, who may reside locally, downstream or in an area remote from the production site of the services.

We anticipate that information provided by the Atlas will provide the foundational data to help guide newly forming schemes for valuation of and payment for ecosystem services. The data presented in the Atlas can help guide where best to preserve or restore ecosystems to maximize the provision of services. In some cases, this may be the restoration of natural systems or it could also pertain to ecosystem creation such as constructed wetlands to mitigate the effects of agricultural tile drainage. We believe that the Atlas can also help identify where Best Management Practices involving land use could be applied or improved. We also envision that a major impact of the Atlas will be to raise awareness of the importance, magnitude, and fragility of a natural system's ability to provide ecosystem services.

From initial informal discussions we have held in multiple venues, we anticipate that decision-makers at multiple levels from EPA Program Offices to county planners, other stakeholders, as well as the general public will use the Atlas. It is being designed towards a target audience with "Google Earth" type capabilities but will also provide datasets and additional functionality for those with GIS expertise. We will seek formal user input after we have developed a demonstration application.

We believe that over the next 3 to 5 years, as the science of ecosystem services becomes more robust, as partnerships with other agencies and programs within EPA develop, and as technology improves, the Atlas will evolve and will become more sophisticated and more widely used. During the evolution of the Atlas, the technology to disseminate the Atlas products will also improve. We anticipate that as the Atlas evolves, more entities will utilize as well as contribute data, realizing one of the key goals of linking the needs of individuals and communities with ecological goods and services.

1.4 Current Status

1.4.1 Research Underway in FY 2009

Development of the Atlas is progressing in a multi-faceted and phased approach. Several broad types of efforts are ongoing simultaneously:

- Creation of science-based products using today's knowledge in the short-term to further the use of ecosystem services in decision-making.
- Conducting research to better quantify ecosystem services towards an end goal of national mapping.
- Partnership development with other agencies, NGOs, academia, and others.
- Development of an Atlas demonstration using ArcGIS Server with Flex technology.
- Development of national data sets necessary for conducting ecosystem service assessments.

Specific projects currently ongoing include:

- Conducting a Green Infrastructure Analysis for all forested and wetland land cover 30 m pixels across the nation. This has great potential for showing where habitat connectivity can be restored at the same time as restoring / preserving water quality. Also has potential for showing where important habitat is at risk from urban/suburban development. We are planning a similar analysis including all natural land cover types (e.g., grasslands, shrublands).
- Developing new landscape metrics to quantify pollutant attenuation by riparian buffers and wetlands. These new metrics combine landcover patterns with flow path which links stream directly to pollutant sources.
- Developing models/coefficients to quantify pollutant attenuation by riparian buffers and wetlands.
- Conducting a drinking water sustainability analysis by evaluating the source area of thousands of surface water intake locations across the country and relating that back to intake water quality and cost of treatment.
- Developing a national land cover classification that expands the ability of the National Land Cover Data (NLCD) to evaluate many ecosystem services. One expectation of this data set, which will include crop type, is that it will be able to better predict nutrient and pesticide loading over the landscape. Interagency agreement with the USDA National Agricultural Statistics Service is in development.

- Developing a method combining remote sensing data and other predictor variables such as presence/absence of hydric soils, climate, topographic information, and vegetation type to better identify locations of wetlands. Currently there is no good national coverage of wetlands and this is a necessary data layer for evaluating ecosystem services in wetlands. We are collaborating with the USGS EROS Data Center on this effort.

- Conducting a change detection analysis for coastal wetlands.

- Conducting research to quantify storm surge reduction provided by coastal wetlands.

- Conducting an in-depth literature review of the State of the Science for Ecosystem Service Mapping.

- Conducting national assessments of impervious surface cover and stream buffer metrics and relating these to ecosystem services. This is being conducted using 30 m National Land Cover Data and NHDPlus stream hydrography. Currently completed for all US 12 digit HUCs.

- Conducting scale assessments investigating impacts of use of different scale and resolution data.

- Conducting research using the SCS Curve Number method to predict runoff discharge and amount of precipitation retained on landscape. We have applied method to state of South Carolina; runoff for a 10 and 25 year storm event is calculated for each 30 m pixel and then summarized by 12 digit HUC. Research is ongoing investigating changes between 1990s and 2001 using NLCD and between the potential given the biophysical settings and 2001 using the LANDFIRE biophysical settings data layer and the 2001 NLCD.

- Conducting research to quantify nitrogen loads across the nation. Includes developing a data layer for animal feeding operations for the nation, developing a data layer for point sources as well as load from fertilizer application using Crop Data Layer mentioned previously. See Nitrogen Update for more information.

- Evaluating multiple models for predicting nutrient and sediment load and export including SPARROW, WARMF, AnnAGNPS, SWAT, L-Thia, and RUSLE. Although many of these models are too heavily parameterized to be run for the entire US at any kind of meaningful resolution, we will be able to derive important information from running a model on a subset of watersheds within a given region (e.g., ecoregion) which can then be applied using a series of rules derived from the model output to an entire region.

- Developing an interagency agreement with the USGS Eros Data Center to compile and create national seamless 10 or 30 m resolution coverages of soils

variables critical to the calculation of ecosystem services. Includes modeled variables as well as those available through the SSURGO and STATSGO data bases. This work is being developed in consultation with the Natural Resources Conservation Service (NRCS) National Geospatial Development Center and will be served via the USGS seamless server. Soils information is critical to the calculation of many ecosystem services and this data base will be made widely available for multiple purposes.

- Investigating the use of modules of the Natural Capital Project InVEST tool for calculation of ecosystem services across the nation.

- Developing a tool to conduct dasymetric population modeling for the US census data. Tool will allow us to calculate population estimates for 30 m pixels allowing for better estimation of beneficiaries.

- Partnering with USGS GAP program and US Fish & Wildlife to map metrics related to habitat and maintenance of biodiversity. Meeting scheduled for Fall 2009.

- Development of an urban component to Atlas using the USFS UFORE and UFORE-Hydro model to calculate air, water, and macro-climate services for all large urban areas. Also will include development of metrics for availability of green spaces and heat island effects. Will be developed in collaboration with the USFS. We are planning an urban ecosystems workshop which will kick off this effort.

- Linking ecosystem services, especially urban services, to human health including environmental justice metrics.

- Developing a web-based tool to allow upstream as well as downstream navigation of 12 digit HUCs. Tool will be incorporated into the Atlas.

- Updating the Analytical Tools Interface for Landscape Assessments (ATtILA) to run in the ArcGIS environment. Evaluating feasibility of incorporating ecosystem service calculation capability into the tool. This would give users the capability to calculate metrics we display in the Atlas using their own data which may have a much finer resolution. A comment that we have heard repeatedly from potential users is that they would like the ability to use their own data.

A draft version of the Implementation Plan is currently undergoing revision. Three peer-reviews of initial plans for the national atlas were completed in support of, and in advance of, its development. The reviews, conducted at Arizona State University, Tempe, Arizona, Rutgers University, New Brunswick, New Jersey, and the Christian-Albrecht-University of Kiel (Germany) included a seminar type presentation followed by a critical review by a group of faculty and graduate students, and also by international leaders in the field of ecosystem services during the University of Kiel review. The

review comments, which were particularly helpful in developing and refining the Implementation Plan, are included as an appendix to the plan. Additional reviews were also held at the Bren School of the Environment, University of California, Santa Barbara and at the National Center for Ecological Analysis and Synthesis (NCEAS) a research center of the University of California also in Santa Barbara. The plan will be distributed for external review in summer, 2009 and will be finalized before the end of 2009. The plan has been written by EPA staff with a broad range of scientific backgrounds including landscape ecology, wetland ecology, hydrology, and zoology. It has also undergone review by Dr. Charles Vörösmarty who contributed significant content. Members from collaborating organizations will be asked to review and contribute to the document prior to its external peer review.

1.4.2 Current Impacts, Critical Accomplishments and Innovations

We have developed a partnership with the National Geographic Society who will be distributing many of the maps we create on their *LandScope America* web site. This provides an exceptional opportunity to have our work published in a venue that generates a tremendous amount of interest. We feel this is a great opportunity for outreach and education.

We have been successful at developing partnerships and at this point the Atlas seems to have gained enough awareness that other organizations have heard of it and are enthusiastic about participating.

The Green Infrastructure Analysis has been completed and has generated much interest. Many states are using Green Infrastructure in decision-making and thus, this data layer should be immediately useful to states. This data has been delivered to the National Geographic and will soon be included on their conservation web site, *LandScope America*. This data layer can be used in combination with other data layers to best identify sites for protection or restoration. For example hub and corridor data can be overlain with stream hydrography data which can help identify stream corridors where restoration would not only improve water quality but would also restore connectivity to hubs. Like wise, areas critical for maintaining connectivity can be protected.

There is a growing general awareness and interest in how Ecosystem Services can broadly be used across the agency for multiple purposes. One example of this is a recent proposal submitted by a Region 2 Superfund person to use Ecosystem Services for prioritizing contaminated sites for clean up. In essence, how could the Region get the most “bang for the clean-up buck”? There is an emerging awareness of how ecosystem services can be used as part of a prioritization scheme for addressing 303d listed impaired water bodies. One of the comments received during the OW review of the MYP stated that “the ecosystem services theme of the ERP provides us an innovative framework to better communicate the meaning of the watershed approach. We have begun to demonstrate how the Approach can be linked to ecosystem services and thereby inform permit and restoration decisions”.

1.4.3 Publications and Papers Presented in 08/09 and forthcoming

Neale, A.C. and J.D. Wickham. 2008. Status of the US EPA's National Atlas of Ecosystem Services. Presented at A Conference on Ecosystem Services, Naples, FL.

Neale, A.C., and J.D. Wickham, 2008. Building a U.S. National Atlas of Ecosystem Services. Presented at Ecosystem Services – Solution for problems or a problem that needs solution? Kiel, Germany

Allen, A.E., et al., 2008 Mapping Ecosystem Services: What is the State of the Science? 2008. Presented at A Conference on Ecosystem Services, Naples, Fl.

Allen, A. E., et al., 2009. The Landscape Framework for the Spatial Characterization and Mapping of Ecosystem Services: What is the State of the Science? In prep, to be submitted to Landscape Ecology.

Allen, A. E., et al., 2009. Presented at the International Association of Landscape Ecology Meeting, April, 2009.

Wickham, J.D. et al., 2009. A US. National Assessment of Green Infrastructure and Change using Morphological Image Processing. Submitted to Landscape and Urban Planning.

Neale, A.C., et al., 2009. The National Atlas of Ecosystem Services: Spatially Explicit Characterization of Ecosystem Services. Invited abstract submitted to Coastal and Estuarine Coastal and Estuaries Research Federation 20th Biennial Conference, Estuaries and Coasts in a Changing World - 2009, Portland, Oregon, November 2009.

1.4.4 Resources

There are currently 16 EPA FTE housed in the Landscape Ecology Branch, Environmental Sciences Division, National Exposure Research Laboratory, and working on the ESRP mapping theme in some capacity. Approximately 30 % of their time is currently devoted to the Atlas. Approximately another 40 % of their time is devoted to other projects within the ESRP. There are also other EPA FTE outside of the Landscape Ecology Branch working on the Atlas component of the ESRP amounting to approximately 3 FTE. There is also an Intermittent Expert Employee, Dr. Charlie Vörösmarty, Professor of Civil Engineering at the City University of New York, who has been hired by EPA to work on this project, we have 420 hours available for FY 2009 and hope to renew this for 2010.

Currently the Atlas group has access to approximately $400,000 of EPA funding to compile spatial data necessary to develop a National Atlas of Ecosystem Services. Two national data sets, in particular, will be completed with this funding. One of these is the NASS Crop Data Layer which will be completed for the nation for 2009 with a $175,000 investment from EPA. This data base which provides a crop coverage at a 56 m pixel resolution will be extremely beneficial in estimating nutrient and pesticide loads based on

the crop information derived from the data. We are also investing $100,000 in an effort through USGS Eros Data Center to compile soils information for the nation.

We have contract dollars available to hire two students through the Student Services Contract and limited contract dollars available to process GIS data, develop tools, and conduct literature reviews.

Budget for 2010 -- unknown. We anticipate requiring a substantial influx of extramural funding to complete our plans for the National Atlas. We also anticipate a substantial investment in travel dollars to support the effort. Meeting with partner organizations and presenting the Atlas at professional meetings are a critical to the success of the Atlas.

1.5 Response to Comments

1.5.1 Response to Program Office Comments

The Mapping Team appreciates the Office of Water review of the ESRP MYP and is planning on visiting OW to present the current approach for developing the National Atlas. This approach for the Atlas has progressed significantly since the OW review of the Draft MYP and is at a point where it would benefit from a much more rigorous OW review. The mapping team would like to work with OW to help ensure that the Atlas is developed as a useful product meeting their needs as well as the needs of the States.

The OW review of the MYP included the comment that "an approach to bring increased certainty and predictive power about the ecosystem service benefits of ecosystem restoration and protection is needed now". The mapping team agrees with this statement and is working towards this target. Specifically, the work quantifying and mapping the benefits of riparian buffers and wetlands will contribute to this knowledge. The comment goes on to say "Over time, we should build a collaborative science program to demonstrate how we can partner with others to mitigate any adverse future change to our aquatic environment, including those attributed to climate change". Again, we agree with this suggestion and are actively pursuing these partnerships.

The OW review also included comments related to including environmental justice issues in the Atlas. The mapping team is planning an urban component to the Atlas and is planning on including environmental justice issues as part of this effort.

The OW review also raised concerns about the willingness of other agencies to participate. We have devoted a considerable amount of effort to engaging other partners as we believe their expertise and access to data are vital to the success of the Atlas. To date, we have received very positive feedback from other agencies and are continuing to pursue partnerships.

1.5.2 Response to SAB Comments

We agree with the SAB comment that empirical data are needed to test hypotheses regarding why changes in ecosystem services are occurring, and at which scales. We are

using existing empirical ecological data and are working with the monitoring theme to evaluate nationally available data sets for their ability to predict changes in ecosystem services.

We believe since the MYP was initially drafted, there is more clarity in the program concerning what the Decision Support Framework will deliver versus what the National Atlas will deliver, thus responding to the SAB concern on this issue. We anticipate the Atlas will be just one tool included in the Decision Support Framework suite of tools. Our initial focus of the Atlas was on our ability to calculate and map ecosystem services but as we get further along in our development of a demonstration application, we will seek and welcome the input of the decision support theme.

The SAB review stressed the importance of collaborations and partnerships with other organizations including other federal agencies, NGOs, and academia. We agree with this recommendation wholeheartedly and have been actively pursuing partnerships with others. We currently have entered into a memorandum of Understanding with the National Geographic as previously mentioned, are in the process of funding two interagency agreements, and have held positive discussions and meetings with the NRCS, USFS-multiple groups, USGS-multiple groups, NASS, NCEAS, FSA, Natural Capital Project, EPRI, USDA's new Office of Ecosystem Services and Markets, and others. Our vision is to establish an Ecosystem Services National Atlas Consortium of contributors much like the Multi-Resolution Land Cover (MRLC) consortium. We will consider ourselves successful when the access page for the National Atlas contains the logos of many organizations. We recognize that the expertise related to many of the services resides in other organizations and we are doing what we can to incorporate this knowledge.

The mapping team also agrees with the SAB's recommendation not to define ecosystem services too narrowly and is making a conscious attempt not to do that. In some cases, we are referring to benefit categories to avoid the controversy that comes with defining a particular value as an ecosystem service (e.g., biodiversity).

We will use monitoring data derived from the national monitoring programs such as EMAP, the National Lakes Assessment, the National Wadeable Streams Assessment, and others to develop predictive models for ecosystem services. We have held multiple discussions with the monitoring group with whom we are coordinating but are still fairly early on in this endeavor. We are also using data collected and compiled by USGS in their SPARROW modeling efforts to develop predictive tools. Specifically, we are using these data which are collected during multiple flow regimes for multiple years to assess the pollutant attenuation capacity of riparian buffers.

We are hopeful that as the Atlas becomes more viable, a regular high-visibility assessment of ecosystem services in time and space will take place. Obviously, this will be dependent on continued availability of resources and Laboratory management priorities.

1.6 Challenges

The organizational structure of the ESRP constructs a challenging environment for a research program housed within ORD. ESRP Leads are generally not EPA managers and as such, have no authority over resources. They are dependent on their managers to assign appropriate resources to the ESRP program. This works well as long as supervisors are supportive of the ESRP but has the potential to fall apart with shifts in management or when other Laboratory priorities take precedence.

We strongly feel that partnering with other organizations is critical and although absolutely worth the investment, is time-consuming and therefore challenging.

Developing methods to map beneficiaries is a challenge we are facing as is providing a mechanism for valuation. The term, valuation, as used by the mapping team does not imply dollars.

Developing methods to quantify uncertainty continues to be a challenge, both as a result of the underlying data and in the modeling of ecosystem services from the underlying data. The underlying data, by their nature, are flawed and contain inaccuracies and inconsistencies (i.e., NHDPlus, DEMS, NLCD) but they are the best data available and we have no choice but to use them. The challenge remains of how to quantify the uncertainty.

Linking the ecosystem functions to actual ecosystem services remains a challenge. As an example, we can map nitrogen attenuation by the landscape, we can quantify the reduction to stream nitrogen loading, but still have to determine how to tie these values to improvement in sport and commercial fisheries, designated uses, etc. We are relying on many of the other components of the ESRP to fill in some of these gaps.

Relating production of ecosystem services to beneficiaries of ecosystem services also remains a challenge.

Computing power is a continual challenge. Our ability to develop a National Atlas in the ArcGIS Server environment is severely limited by our computing resources. We are exploring multiple avenues to overcome this obstacle.

1.7 Future Directions

We are continuing with a phased approach for developing the Atlas. We are producing national maps indicating ecosystem services that we are able to deliver with current knowledge, technology, and data availability while simultaneously researching and developing more robust methods for which we will be able to produce national maps in the future. We are also continuing to develop data sets that are critical to the development of maps of ecosystem services. We are developing a demonstration project.

We will be incorporating the results of the other ESRP projects and themes linking ecosystem function with ecosystem services into the Atlas.

We are also continuing to develop partnerships with other agencies and groups as we believe this needs to be a multi-organization product.

A main future focus will be on developing the means to incorporate future scenarios into the Atlas. We currently anticipate using the ICLUS scenarios but would also like to give users several additional options. These are currently under discussion.

1.8 Appendices

Appendix A: Hierarchy of services

A complete hierarchy of services to be included in the Atlas is still under development. Table A-1 presents the hierarchy in its current state.

Benefit Category	Measurement	Proxy (indicator)
Water Quality	Quantity of nitrogen, phosphorus, and sediment attenuated by the landscape, related to loading. Changes in	% imperviousness, % naturally vegetated stream buffers
Water Quality	Modeled stream and lake water quality	
Water Quantity/Timing	Discharge anticipated from design storm event, quantity of precipitation retained on the landscape. Changes in	% imperviousness
Carbon Storage	Quantity of carbon stored in soils and in above and below ground biomass	
Storm Surge Protection	Wave height reduction	
Food and Fiber	Under discussions with partner agencies on how to represent	

Habitat / Maintenance of biodiversity	Under discussion with partner agencies, considering species richness for different groups of fauna, suitability of habitat for species of high conservation value, and others.	% natural vegetation Connectivity of habitat % in protected lands status % imperviousness
Soil Regulation	Quantity of soil retained on landscape (RUSLE), still under discussion	
Cultural/Recreation	Still under discussion	

Table A-1 Hierarchy of Ecosystem Services

Figure A-1 below highlights ecosystem-ecosystem services categories for which we have ongoing projects. This figure also identifies areas in which there are research gaps.

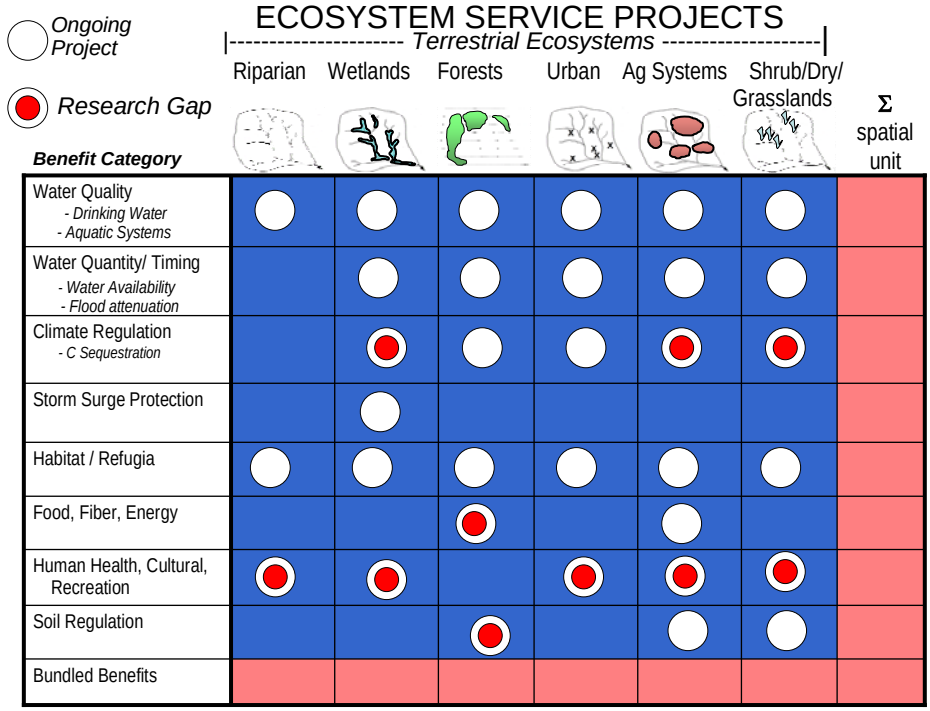


Figure A-1. Ongoing projects within the Atlas work group.

Appendix B, Conceptual Model

The Conceptual Model for the Atlas work was shown in Figure 1 at the beginning of this update. The following series of figures outlines our research framework. It has been useful to consider ecosystem services in this framework considering ecosystem impact on service, the current knowledge base, and suitability for intervention. A composite scoring of these three functions may be helpful to guide potential investments in research, protection, and mitigation.

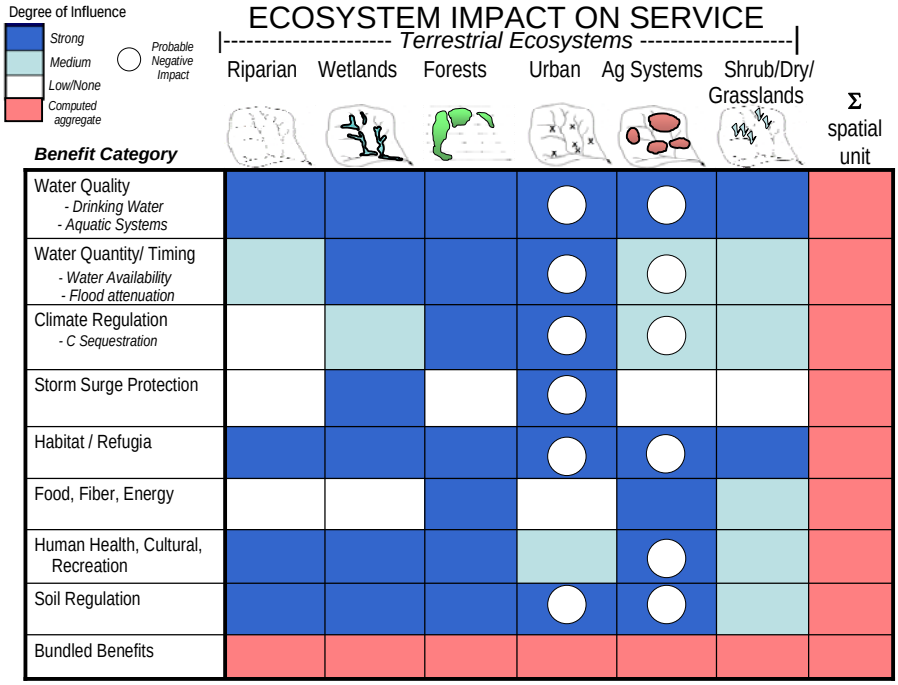


Figure B-1. Ecosystem impact on services. Colors of boxes are arguable but figure provides a context in which to discuss. Figure is being updated to include aquatic systems.

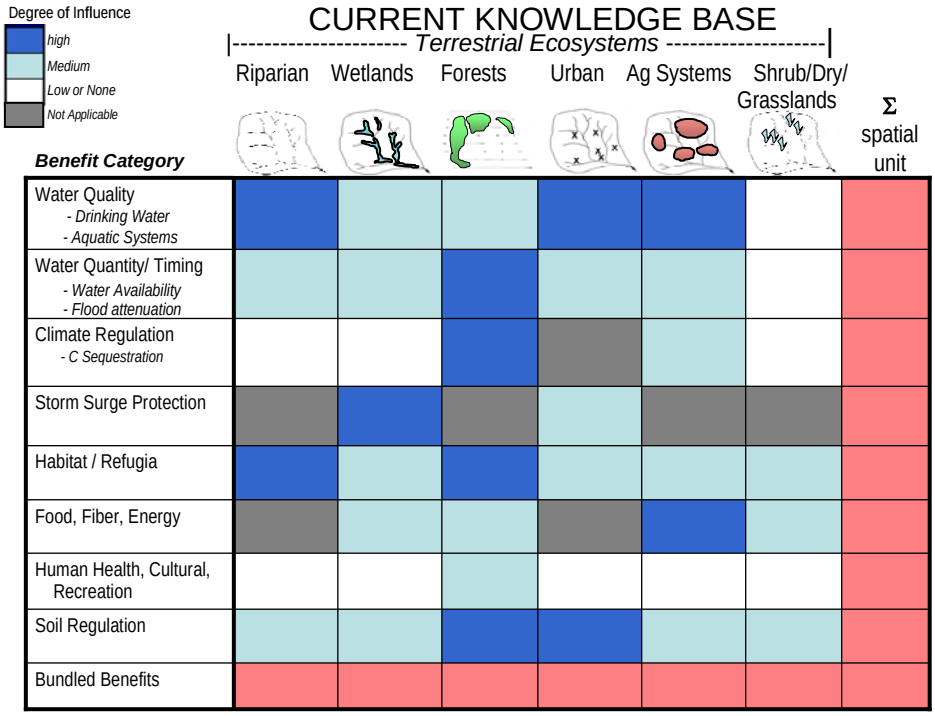


Figure B-2. Current knowledge base for mapping ecosystem services.

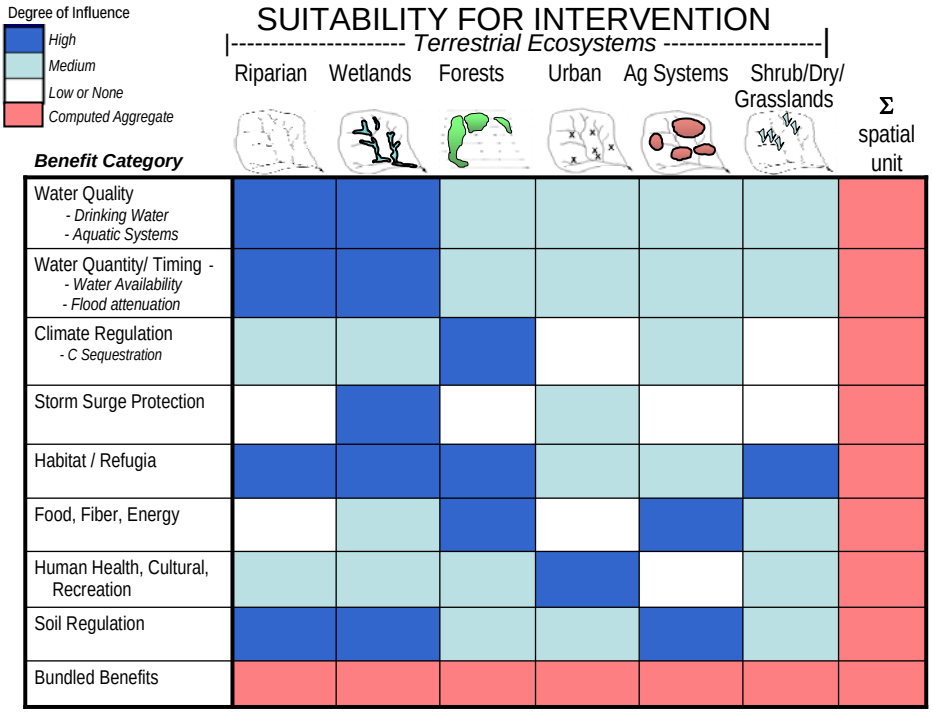


Figure B-3. Suitability for intervention.

Appendix C: Experts' Contributions—

Dr. Vörösmarty has been instrumental in helping develop the Research Framework and with development of the Implementation Plan. He has brought his experience authoring the Millennium Ecosystem Assessment to our group, has provided significant comments on the Implementation Plan and has advised on water-related ecosystem services.

Appendix D: List of Future Products

Online access to ecosystem service maps, ancillary information, and interactive features.

An example (still incomplete) of some of the items that will appear in the online Atlas Table of Contents for each Ecosystem Service Benefit Category:

Ecosystem Service Benefit Category

- □Water Quality
  - □Water Quality Index
  - □Build Your Own Water Quality Index
  - □% stream buffer with 30 m natural cover
  - □% stream buffer with 60 m natural cover
  - □% pervious surface
  - □Quantity of nitrogen removed by landscape
  - □Quantity of phosphorus removed by landscape
  - □Quantity of sediment kept in place by landscape
  - □Who are the Beneficiaries?
    - □Economic
    - □Other
  - □Who is paying for the Service?
  - □What are the stressors?
    - □Nitrogen Loading
      - □Total
      - □Atmospheric (CMAQ output)
      - □Agricultural
      - □Urban
      - □Point Source
    - □Phosphorus Loading
      - □Total
      - □Agricultural
      - □Urban
      - □Point Source
    - □Sediment Loading
      - □Total
      - □Agricultural
      - □Urban
      - □Point Source
    - □Pesticide Loading

Total

□Habitat, Maintenance of Biodiversity
□Climate Regulation
□Water Quantity
□Food, Fiber, & Fuels
□Storm Surge Protection
□Flood Protection
□Cultural/Recreational
□Soil Regulation

In addition to the ecosystem service maps and associated information, the user will also have ability to display the following background data layers:

- State Boundaries
- County boundaries
- Congressional Districts
- Ecoregions
- Population
- Land Cover
- NHD Plus
- Street maps
- Satellite imagery
- Protected Areas
- Roads

Application will also allow user to change layer transparency to view multiple layers at one time and will include advanced graphing capabilities to view multiple services, multiple scenarios, and multiple spatial units at one time. The graphics will also allow the user to view one spatial unit in context of others in a particular region.

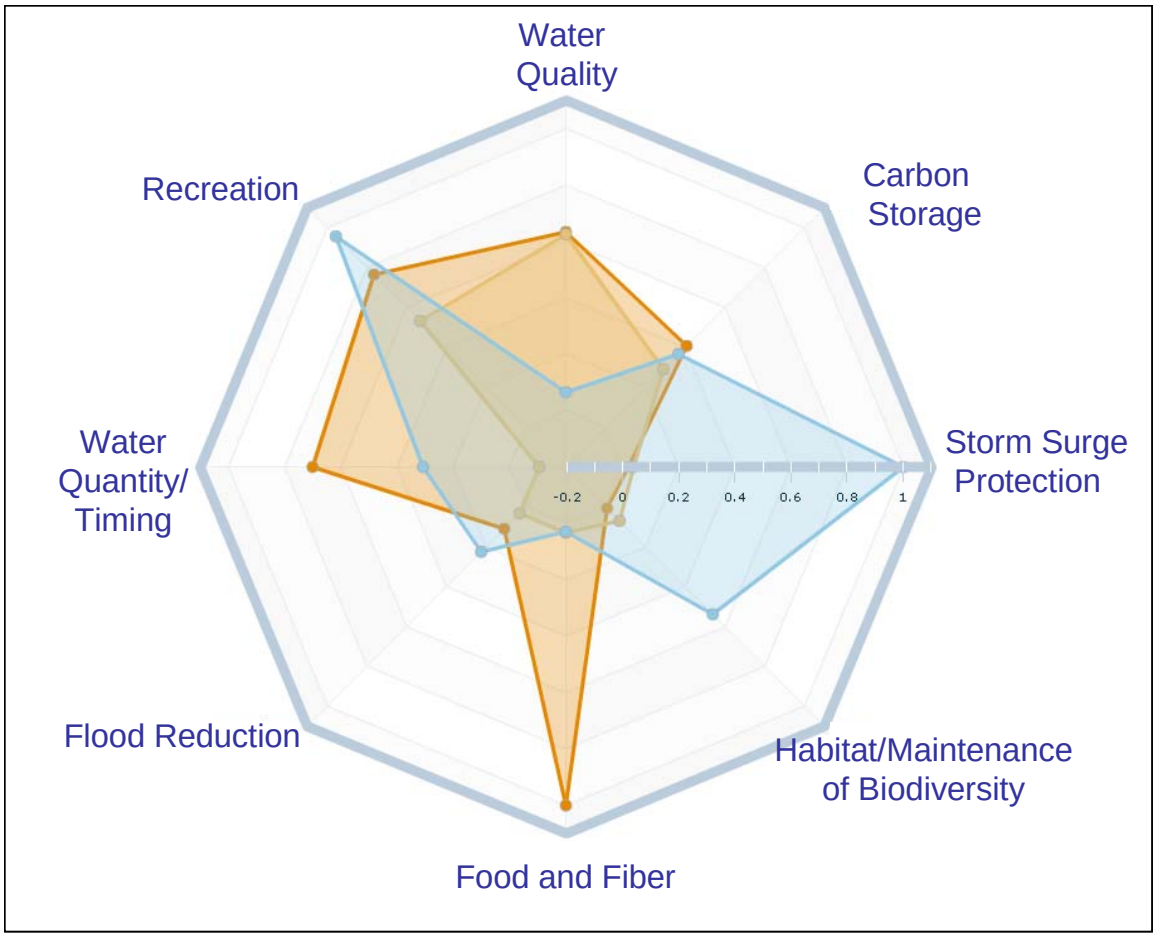


Figure D-2. Example of graphic showing potential, present, and one alternative future for multiple services for 1 spatial unit (e.g., 1 12 digit HUC).

Appendix E: Cross Cuts

The research undertaken by the Mapping and Landscape Ecology group is very much integrated and interactive with the ESRP Nitrogen and Wetlands groups. The Mapping team is working with the Nitrogen Team to develop national maps of nitrogen loads and of the landscape's ability and potential for attenuating some of those loads. These are outlined in the Nitrogen write-up. The Mapping Team is working with the Wetlands Team to develop methods to better identify wetlands and wetlands types and to develop methods to quantify and map services from wetlands. The Nitrogen Team, the Wetlands Team, and the Mapping Team are all working together to investigate how best to quantify and map nitrogen attenuation by wetlands.

The Mapping Team is also working with the Place-Based Teams in a mutually beneficial relationship to develop methods for better quantifying and mapping ecosystem services. In some cases, methods that have been developed for a place will be applicable for the nation. In other cases, data that are being developed in a place will be used to validate coarser-scale data that are being presented for the nation. An example of the former is the improved Land Cover Classification that was done for the Future Midwest Landscapes study using the National Land Cover Data (NLCD), NASS Crop Data Layer, and LANDFIRE. This data set, which has much potential for ecosystem services will likely be developed for the nation. An example of the latter is that carbon storage and sequestration data being collected on a very fine scale in the Willamette study will be used to verify/validate much coarser methods being proposed for the nation. To the extent possible, the Mapping Team is developing their methods to be applied for the entire nation in the "Places" to best further the goals of place-based research as well those of the National Atlas.

Eventually we will incorporate climate change scenarios into the Atlas. We have not yet focused on climate change as a forcing variable with the exception of sea level rise changes related to coastal wetlands. Two of the issues with basing future scenarios on climate model changes are the coarseness of the predicted climate change data and the large number of climate change models from which to select. An additional challenge is that the current suite of ecosystem service models available does not lend itself well to detecting differences above noise with only small changes in climate change. We recognize that this will potentially be a very important topic for the Atlas in the future and we will revisit when other aspects of the Atlas are a little more developed. We plan to coordinate this aspect of the work with ORD's Global Change Program. and will bring a climate change expertise into the group. One aspect of climate change that we are currently incorporating is carbon storage and sequestration. Carbon storage and sequestration will be one of the ecosystem services included in the Atlas.

LTG 3 Pollutant-Specific Studies: Nitrogen

LTG 3: The Ecosystem Services Research Program will provide an assessment of the positive and negative impacts on ecosystem services resulting from changes in nitrogen levels at select locations and within select ecosystems.

a. Nitrogen

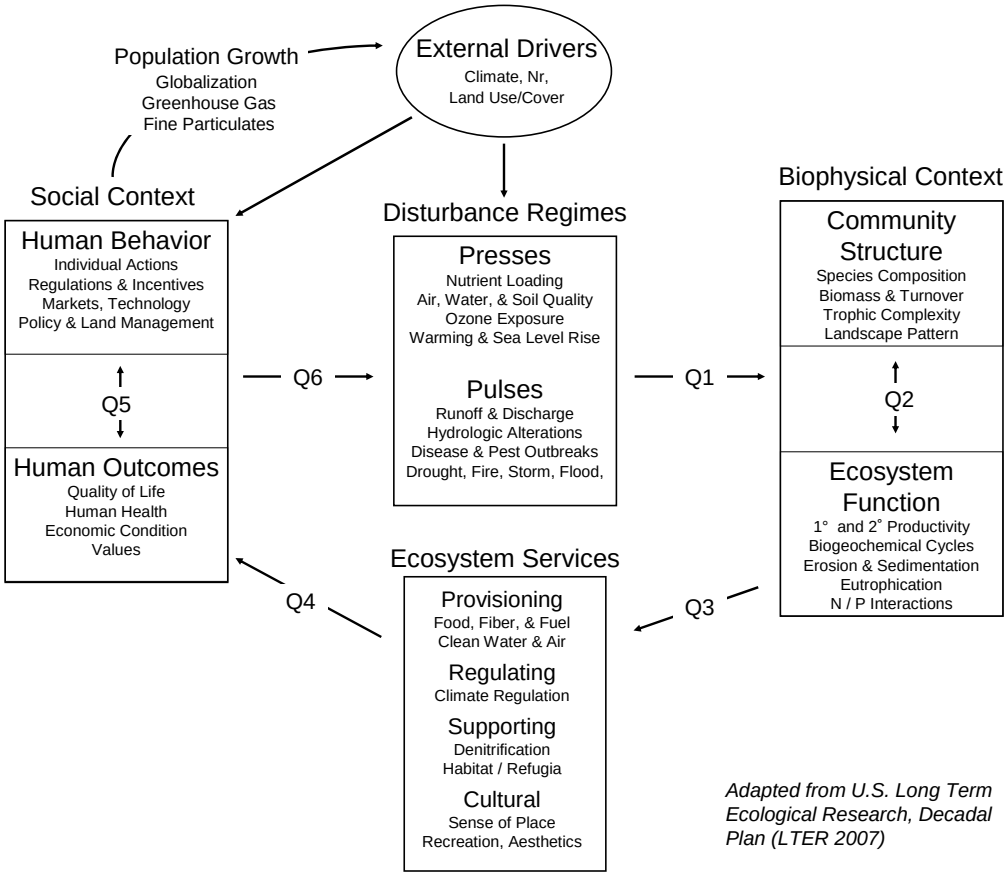
Ecosystem Services Research Program
Pollutant-based studies: Nitrogen Theme
Jana Compton, ORD-NHEERL-WED
Status Report and Future Directions. June 22, 2009

1.1 Project or Theme Goal

Supply decision-makers with comprehensive, reliable information and predictions about the effects of changing inputs of nitrogen (N) on ecosystem services.

1.2 Conceptual Model and Description

Figure 1. Ecosystem Services Research Program-Nitrogen (ESRP-N) Conceptual Framework (modified from LTER 2007).



In order to integrate research within the ESRP-N program, we use a general conceptual framework (Figure 1), adapted from the National Science Foundation's Long Term Ecological Research (LTER) Program Decadal Plan. This framework clearly relates drivers of change and disturbance regimes to ecosystem structure and function (the biophysical context) and ultimately to ecosystem services. The "pulses" and "presses" refer to stressors and disturbances at different temporal and spatial scales. This

conceptual framework is flexible and can be adapted to different ecosystem types, geographic regions, spatial scales and specific stressors. We used this conceptual framework to identify questions that address direct and indirect interactions among the model components as well as feedbacks related to policy and planning. Question sets associated with each "Q" on the diagram are contained within our implementation plan. Mapping research questions onto this framework has exposed potential gaps in our research plan and emphasizes areas where collaboration may be needed.

1.3 Expected Impact/Rationale

This research will provide decision-makers and environmental managers with comprehensive, reliable information and predictions about the sources and effects of N on ecosystem services, considering atmospheric and waterborne sources, terrestrial and aquatic ecosystems, and multiple geographic scales. Our overall goal is to provide quantitative information on the impacts of changing N inputs to ecosystem services. We have identified three key areas where research is needed to improve the knowledge base for regulation of N and management of its impacts.

1. Quantitative information on the response of ecosystem services to N inputs. Which ecosystems are sensitive; where are ecosystems/services at risk?
This work will yield analyses of the impacts of anthropogenic N inputs on US ecosystems and will be summarized into a state of the science report. This will include information on critical loads to these ecosystems and tipping points that can be used in future assessments of N deposition effects. This work will support the air quality standards review and risk assessment process.

2. Better accounting of N sources, fate and transport to US ecosystems at national, regional and local scales. What sources are responsible for the effects/risk?
We will provide wet plus dry inorganic N deposition rates via CMAQ (Community Multiscale Air Quality model) for the entire country; better quantification of ammonia deposition in CMAQ; better accounting of N in agricultural landscapes; new ways to link land use and N inputs; GIS layers and tools that can be used in national, regional and local assessments, management and regulation. This work will contribute to a national nutrient inventory, TMDLs, and water quality criteria. Our work will lead to estimates of N removal across the nation as a measure of ecosystem services from terrestrial ecosystems, riparian areas, wetlands, river networks and estuaries. Estimates will be derived at multiple spatial scales: by ecosystem class, ecoregion, and major river basin. The ecosystem service of N removal (water purification) within wetlands, streams and riparian buffers are key components of this work. We will generate new tools and approaches for quantifying N removal by wetlands, riparian areas, and stream networks. This will be useful for restoration prioritization, regulation, and management.

3. How will ecosystem services change in response to increases or decreases in N loads? What are the impacts of management and policy?
We will generate tools that link ecological response to ecosystem services and human benefits, and models of N flow through US ecosystems and models of N impacts on ES. These tools are in development, through collaboration with mapping, modeling and decision support specialists. Our efforts will provide better information on the spatial distribution of N sources and removal, which is expected to improve decision making with respect to restoration, best management practices and improving condition of waters

that do not meet their designated use because of nutrients. Outcomes will aid federal agencies (USFS, NPS, EPA-OAR) assessment efforts, policy, regulations and resource management, by complimenting and extending critical loads modeling.

1.4 Current Status

1.4.1 Research Underway in FY 2009

Our broad goal of connecting N to ecosystem services will be approached through a two-pronged effort that includes national-scale work where possible, and smaller scale studies tackling specific problems and ecosystem types. The ESRP-N overall approach is shown in Appendix B ("the Road Map"). We can begin on the Road Map by identifying the ecosystem services impacted by N and developing ways to measure and bundle these services. This will be formalized in 2009-2010 with a state of the science paper on the impacts of N on a set of ecosystem services. Then using research from the place-based and system-based studies, as well as other relevant work, we will construct ecological response functions (ERFs), which are comparisons of N inputs with changes in key community structure/ecosystem functions that link to ecosystem services (e.g., N loading vs. algal production). From these ERFs, we will identify a key set of ecosystem service response functions (ESRFs; see the upper left diagram in the "road map") that relate ecosystem changes (e.g. algal growth) with ecosystem services (e.g., recreation, fisheries). The ERFs will also allow us to identify sensitive ecosystems, particularly when we overlay the critical loads on current N loading data (air deposition, fertilizer inputs). In 2009-2010 we will also compile national-scale data on N sources, including atmospheric deposition, fertilizer input, wastewater treatment and animal operations. We will then be able to map ecosystems at risk and develop management tools, based on the ESRFs, to quantify the impact of changes in N loading on bundles of ecosystem services.

Status of implementation plan (IP). Our implementation plan was sent for external review and comments were received in May 2009. We are currently revising the plan in response to the comments received, to be completed in July 2009. The reviews and response will be made available to the SAB committee.

1.4.2 Current Impacts, Critical Accomplishments and Innovations

The current ESRP-N effort directly supports the ecosystem services approach adopted by OAQPS for their process of reviewing the secondary National Ambient Air Quality standards for NOx and SOx. The ESRP-N focus on N lays a foundation for assessments of future air and water quality regulations related to N. This effort is bringing CMAQ dry deposition into critical loads work used by Office of Air programs to assess their effectiveness.

1.4.3 Publications and Papers Presented in 08/09 and forthcoming

Compton, J.E., T. Greaver, R. Dennis, W.E. Hogsett, B. Hill and J. Beaulieu. 2008. Ecosystem services altered by changes in reactive nitrogen: A new perspective for

decision making. Poster presentation at ACES: A Conference on Ecosystem Services. Dec. 8-12, 2008, Naples, FL.

Milstead, B. 2009. The benefits of protecting and restoring Northeastern lakes: An ecosystem services perspective. March 18-20, 2009. Invited presentation at The 33rd Annual Meeting of the New England Association of Environmental Biologists. Westbrook, Connecticut.

Walker, H. 2009. Reproducible research: Human health and environmental applications. March 18-20, 2009. Invited presentation at The 33rd Annual Meeting of the New England Association of Environmental Biologists. Westbrook, Connecticut.

Kiddon, J., and H. Walker. 2009. Reproducible research: Human health and environmental applications. April 2009. 22nd annual Enhancing the States' Lake Management Programs Conference. On the edge: Enhancing ecological integrity of shorelines. Chicago, IL.

Compton, J.E., T. Greaver, R. Dennis, W.E. Hogsett, B. Hill and J. Beaulieu. 2009. Ecosystem services altered by changes in reactive nitrogen: A new perspective for decision making. Invited presentation at Ecological Society of American special session. August 2009.

Compton, J.E., T. Greaver, R. Dennis, W.E. Hogsett, B. Hill et al. Nitrogen effects on ecosystem services. State of the science paper to be ready for EPA clearance in 2009.

1.4.4 Resources

Currently we have 14 staff members on the nitrogen team, 11 of whom devote half or more of their time to the program. From this team we have approximately 8 FTE, plus one expert who will devote 0.25 FTE. OAQPS, OAR and NCEA staff do not necessarily have a proportion of their time allocated to the Ecology Multi-Year Plan, however, they are spending of their time on very related and pertinent issues (6 more FTE) that contribute in important ways to the success of ESRP-N. We have funding to hire another expert, and hope to garner more funds to aid in linking ecological responses via critical loads to ecosystem services and human benefits. In fiscal year 2009, we received $700K of direct funding, and we will use this to expand our work in national data collection, modeling and linking N to ecosystem services. We are proposing to use a part of this funding to hire three post-doctoral FTE over the next year.

1.5 Response to Comments

1.5.1 Response to Program Office Comments

The Office of Water comments on the ESRP MYP related to N included concerns that the N program was not considering a broad spectrum of N sources, in particular non-deposition sources and request for an explanation of why we are not considering phosphorus. We have added research focusing on a wider spectrum of N sources.

Although the ESRP-N effort will focus on N, and the regulatory process generally addresses stressors one at a time, ecosystem responses to N often are influenced by the availability of multiple nutrients (P in aquatic ecosystems, base cations in some terrestrial ecosystems) thus, N loadings and effects need to be considered in this larger context.

1.5.2 Response to SAB Comments

Summary of SAB EPEC comments: Long-term Goal 3 calls for an assessment of the positive and negative impacts on ecosystem services resulting from changes in N levels at select locations and within select ecosystems. The Committee finds that this is an important area of ecological research. However, given the relatively modest effort that can be undertaken with available resources, we have some concern about what can be accomplished in this important area, and how EPA's contribution will complement what is being done in other agencies. In particular the SAB had three major recommendations: a more detailed description and justification of the research should be developed; opportunities for coordinated research across place-based studies and wetlands should be pursued, and that EPA partner with other federal agencies conducting research on N so that research is complementary and not duplicative.

Response to SAB EPEC comments: Since this MYP was written and reviewed by SAB, the ESRP-N research group has expanded and prepared a more detailed implementation plan. This ~80-page implementation plan is anchored by a conceptual model which outlines the relationships between human actions, ecological processes and ecosystem services. The justification and rationale is described in the ESRP-Nitrogen Implementation Plan. The plan completed external review in May 2009 and a revised, externally-reviewed implementation plan will be available in July 2009. There are national, regional, place-based and system-based research themes addressing questions that range from N loading rates to different ecosystems, to approaches to evaluate the effects of changes in N loading on multiple ecosystem services. We developed a conceptual framework to represent such a perspective, illustrating the positive and negative impacts of N on important ecosystem services, across an N loading gradient. Developing a defensible accounting framework for ecosystem services would allow managers and regulators to see the range of N effects, and is an important objective of ESRP-N. We have established several key collaborations with other agencies at this point.

The place-based studies working on both agriculture and N have teamed with USDA to examine N sources, cycling and leaching in those systems using a variety of approaches and models. We are also involved in the Interagency Critical Loads research (led by USFS) through EPA's Office of Air and Radiation. In addition, we are establishing collaborations through a fall 2009 workshop with USGS SPARROW team because we feel that there are many common interests, in particular ways in which SPARROW would be modified to determine N removal by different ecosystem types. We have also brought on Dr. John Harrison, our expert hire and lead of the US component of the Global NEWS modeling, to advise us and to downscale this model for use at the national and regional scales, as part of a "weight-of-evidence" modeling approach in N sources, loading and transformations.

ESRP-N Response to other recent SAB panels: There are three additional SAB reviews that relate to ESRP and the N program. We are responsive to the SAB Ecological Risk Assessment committee recommendations because we will examine uncertainties associated with sources of stressors, we will address issues of the proper scale at which our data and findings are appropriate for decisions, and we are developing a program to address climate change interactions with N. The SAB Committee on Valuing the Protection of Ecological Systems and Services recommended an identification of the services that most interests decision-makers; our initial work identifying ecosystem services impacted by Nr addresses this issue. Most relevant to ESRP-N are the SAB recommendations from the SAB Integrated Nitrogen Committee (INC), which released a draft report in March 2009, and tentatively recommends that EPA should pursue an integrated approach to develop the understanding needed for science-based policies, regulations and incentives to address the impacts of excess Nr on the environment, human health and climate and that in order to do so, EPA is advised to form an intra-agency task force that builds upon existing Nr work within the agency. The ESRP-N program will address both of these recommendations, and we pay close attention to this committee's findings. In addition, the INC committee recommends further examination of the impact on and restoration of ecosystem services, and thus our work addresses a number of vital needs in this area.

1.6 Challenges

Organizational Challenges for the Office of Air include the ecological need to consider the holistic effects due to total reactive nitrogen, although the current listed criteria pollutant is oxides of nitrogen. The Office of Air is also interested in establishing a relationship between ambient air concentrations (the regulated criteria pollutant) and ecological effects, responses and services associated with atmospheric deposition. Also, air and water regulation and ecological effects are often viewed as separate, but nitrogen has cascading effects (one molecule of N can affect air, land and water in ways contrary to human benefit) thus considering all sources and effects could lead to better and more efficient regulation. There is the recognition that traditional water quality criteria may not work for nutrients, however, the appropriate alternative is not clear. We view this as an opportunity to successfully apply the ecosystem services concept.

Scientific challenges include the need to create links from N to ecosystem services – e.g., there is no ES model to plug into an ensemble model like FRAMES. Nitrogen effects are a cross-media, cross-scale problem.

Administrative challenges include building a program across EPA labs, which are physically separate, such that it is difficult to build and direct teams across the agency.

1.7 Future Directions

In the coming year, we hope to establish a foothold on characterizing nutrient loading for the nation, including better estimates of total atmospheric N deposition, and quantifying N removal as an ecosystem service for riparian areas and wetlands. We also will complete a review of literature linking the effects of changing N loading to ecosystem

services. This review will target a number of key services related to water purification, crop and forest production, fisheries, biodiversity and greenhouse gas emissions. We will strengthen our ties to the Office of Air by jointly conducting research and analyses linking N deposition and ecosystem services. Our efforts will facilitate a cross-agency research program in nutrients, by increasing connections with the Water Quality and Climate-change related research within EPA, and providing useful information for Office of Water and EPA Region efforts to solve problems related to nutrients.

1.8 Appendices

Appendix A: Hierarchy of services being addressed in research described, including units of measure

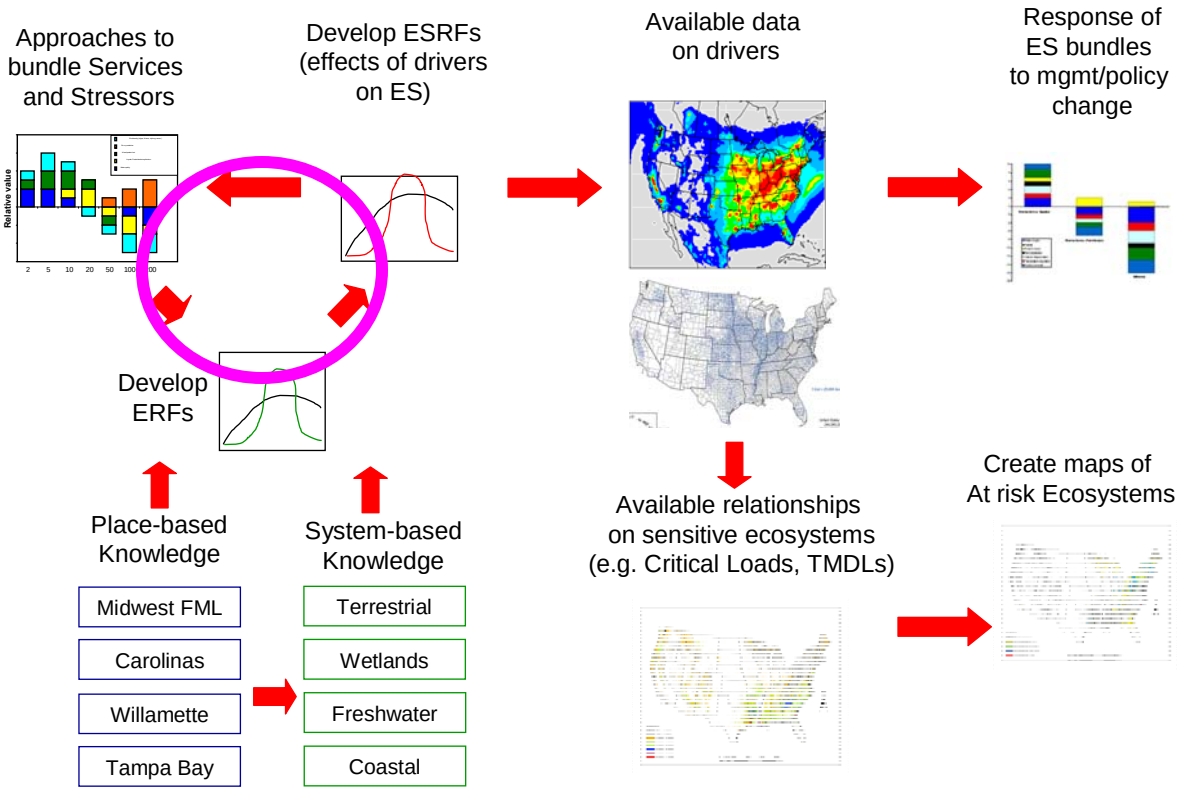
Our group is currently working on a set of tables that would apply to several different system types (wetlands, coastal and terrestrial). Below is an example of such a table, illustrating the pathway between N enrichment and consequences for human benefits in river networks.

Draft hierarchy of services for the influence of N enrichment on river networks.

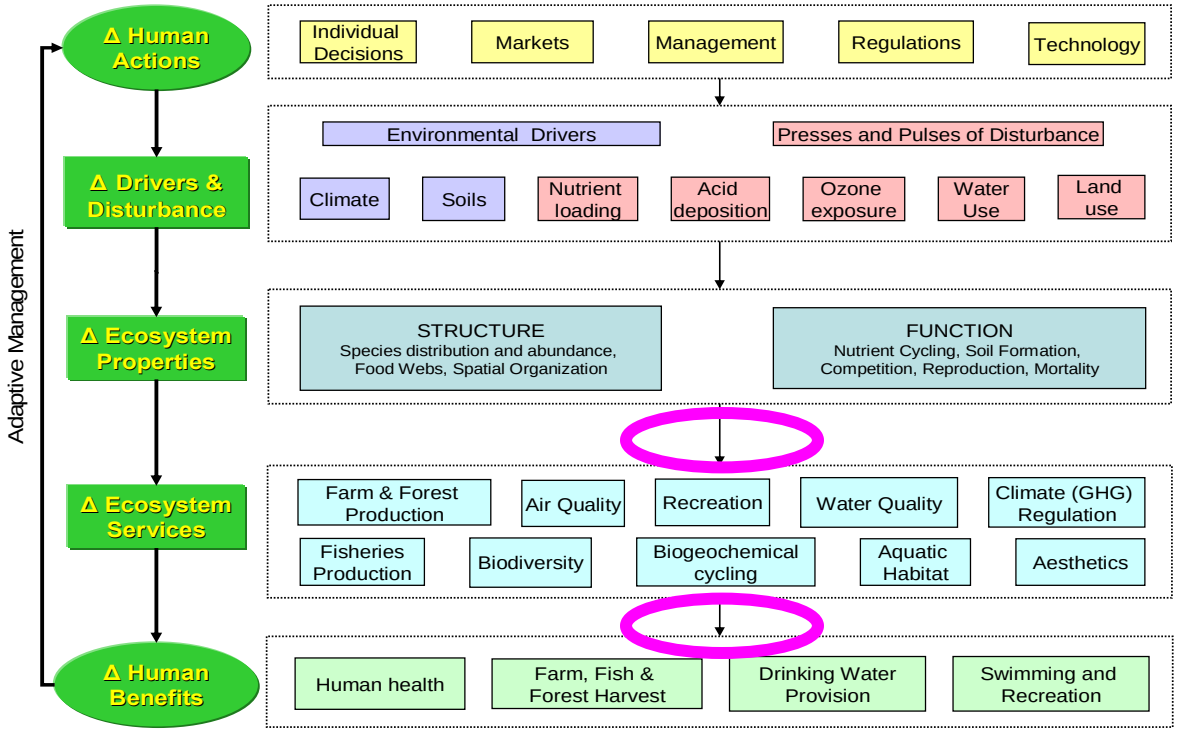
Primary Symptom	Secondary Symptom	Ecological Indicators	Impact on Ecological Endpoints	MEA ecosystem services	Economic-Related Indicator or Affected Ecosystem Services
Increased primary production	Increased ecosystem metabolism (DO depression)	Increased diel changes in dissolved oxygen; increased biomass of primary producers	Fish kills, changes in fish and invertebrate assemblages	Provisioning, Cultural	Decline in recreational fishing yields and variety
	Reduced diversity/quality of primary producers through competition/physiological tolerance	Composition of algal and macrophytes assemblages	Decline in species richness, increased dominance (e.g., *Cladophora*, *Typha*)	Cultural	Decline in aesthetics, decline in recreational fishing and boating
	Increased homogeneity of habitat	Cover of algae and macrophytes, reduced complexity of river habitat (e.g., speed up succession of oxbows, particularly in systems with dams)	Changes in biotic assemblages, increases in secondary production associated with simplified food web.	Provisioning, Cultural	Decline in aesthetics, decline in recreational fishing and boating, biofouling?
	Decreased water clarity (reduced light transmission)			Provisioning, Cultural	Decline in aesthetics, decline in recreational fishing and boating
Decreased nutrient use efficiency (or increased export downstream), so less relative N uptake			Higher levels of N in water downstream	Provisioning	Increased cost for drinking water treatment; anoxia in estuaries; human health risks
Toxicity to fish (NH_3-N)			Fish kills	Provisioning, Cultural	Decline in recreational fishing yields and variety

Appendix B: Conceptual Model and most significant scientific uncertainties, currently—critical path

The ESRP-N Road Map. The most critical links here are developing the approaches to quantify services and N loads (circled in pink below).



ESRP-N Organizational Model. Critical uncertainties lie in the links between the traditional ecological measures, ecosystem services and human benefits (pink circles).



Appendix C: Expert Contributions

Currently ESRP-N has hired one outside expert: John Harrison, Washington State University, Vancouver, WA. Dr. Harrison is a co-chair and US lead for the UNESCO-formed Global NEWS program (Global Nutrient Export from Watersheds). Within ESRP-N, we have asked John to run Global NEWS DIN model at the national scale to yield spatially explicit information on N input sources and DIN export for the nation, and for a downscaled regional version. The candidate study area for the downscaled version is the Mississippi Basin, due to the availability of data, importance to EPA, and ability to compare with SWAT and SPARROW outputs. He will advise the Ecosystem Services Research Program Nitrogen Team, and determine how the research program being developed can be improved and streamlined to aid in air quality and water quality decision making related to nutrients. For one or more of the place-based studies, he will take a leadership role in assessing the utility and accuracy of N source information at national and local scales. In addition to the NEWS modeling, we have asked John to develop a written plan for modeling N removal by lakes, streams and reservoirs at national and local scales. Include an approach for testing this plan, using a combination of field research and existing data.

Appendix D: List of Future Products.

APM 2009: Report on the quantification of ecosystem services associated with N removal and regulation.
APM 2010: Report incorporating ecosystem service response functions (ERFs) generated across place-based studies within ORD.
APM 2011: Report identifying sensitive ecosystems to increased Nr for US, based on regional and national critical loads work and other related work.
APM 2012: Report on the value of ecological services provided by Nr and costs associated with the services affected by Nr within the place-based demonstration projects based on alternative management options.
APM 2013: Demonstration of decision-support tool for examining ecosystem service response to and effects on Nr for place-based studies.

Appendix E: Cross Cuts

***Coordination with Wetlands*.** We are working to summarize values from the literature for (a) effects of Nr on wetlands services, (b) Nr removal by wetland ecosystems; coordinating this work with ESRP Tampa Bay and Wetlands projects. We are also working with the wetlands group to initiate coordinated cross-site research on N-removal for wetlands across the US. This work will be done in conjunction with NSF's Denitrification Research Coordination Network such that the data are comparable with this larger multi-organization effort.
***Coordination with Mapping*.** ESRP-N has a close connection with the Mapping group, with emphasis on quantification of N removal as an ecosystem service at a national scale. We will work together on national data layers of N sources and model inputs. Together, we are developing a riparian buffer project to quantify and map N removal by the nation's riparian areas and wetlands.
Coordination with Modeling. We view modeling related to N as having three main goals: 1) a tier-one (simple, near term) model that links ecosystem processes to services to human benefit and valuation; 2) a model comparison exercise which would yield a "weight of evidence" for the magnitude and effects of increase in anthropogenic N loading to air, land and water; and 3) a tier-three (more complex, longer-term) modeling framework which would link N fate and transport to ecosystem response and changes in ecosystem services. The tier 1 model would collate the ERFs and ESRFs to examine scenarios associated with Nr. The model comparison exercise would include SPARROW, SWAT and GlobalNEWS. We are currently hiring an expert to conduct national scale models of N removal by various landscape components (terrestrial, wetland, stream, lakes). This model, along with SPARROW output, could feed into a more complex and integrated tier 3 modeling effort such as FRAMES. We'd also like to create a visualization tool to examine N loads for a particular landscape. OAR's Clean Air Markets Division is doing this already, but we could provide assistance and perhaps testing. OW is developing a nutrient inventory and we hope to contribute to and collaborate on this. This is a great place to build a multi-media approach.
Climate change – N linkages. We will examine links between climate change and ecosystem services related to N by addressing the following issues:

1) Influence of atmospheric N deposition on production of N_2O, CH_4, and CO_2 production (review paper); 2) Interactive effects of N, CO_2 and climate change on net primary production (and C sequestration) across changing landscapes (review paper identifying key uncertainties); 3) Relationship between land use, flow regimes and hydrologic conditions and nutrient flux (data mining and analysis from long-term stream chemistry data bases); this can also be explored through model runs under different climate and land use scenarios, and we will expand this work in the next year.
In addition, we are proposing to hold a workshop co-led by EPA's National Center for Environmental Assessment on N-related research gaps and climate change will be an important component of that workshop.

LTG 4 Ecosystem Specific Studies: Wetlands and Coral Reefs

LTG 4: The Ecosystem Services Research Program will provide guidance and decision support tools to target, prioritize, and evaluate policy and management actions that protect, enhance, and restore ecosystem goods and services at multiple scales for two specific ecosystem types: wetlands and coral reefs.

a. Wetlands

b. Coral Reefs

Ecosystem Services Research Program
ESRP-Wetlands
Lead: Janet R. Keough, ORD NHEERL
Status Report and Future Directions. June 22, 2009

1.1 Project or Theme Goal

The Wetlands Ecosystem Services Research Program (ESRP Wetlands) will supply the fundamental scientific basis for using ecosystem services information in guidance and decision support to target, prioritize, and evaluate policy and management actions that protect, enhance, and restore ecosystem goods and services at multiple scales for wetlands.

Research will begin with identification, characterization, and assessment of wetland ecosystem services from data on conditions and functions, at local and landscape scales, as well as factors that influence the delivery of ecosystem services from wetlands.

1.2 Conceptual Model and Description

The conceptual model for the Wetlands research within the Ecosystem Services Research Program (Fig. 1) represents both the environmental dynamics of the wetlands ecosystem, as well as the information flow through the ecosystem from the perspective of a manager in support of decision-making. The main components of the conceptual model are the direct and indirect drivers, stressors, wetland system, ecosystem services, and human well-being. Indirect drivers include economics, demographics, and sociopolitical decisions that affect direct drivers (i.e., resource consumption, climate change, land use change, and invasive species). Direct drivers regulate stressors or pressures (e.g., flow and physical alterations and sediment and pollutant loading) that affect wetland ecosystems at multiple spatial and temporal scales. The wetland system is represented at multiple spatial scales 1) regional/national, where wetland condition (outermost circle) can be determined through GIS/landscape ecology approaches with the knowledge of distribution, abundance, and hydrogeomorphic setting of the wetland; 2) landscape scale (inner circle), where the wetland is recognized to be imbedded within a hydrologically-connected ecosystem that includes components of the landscape, surface water, and groundwater systems; and 3) wetland (smaller circles) scale, where processes and dynamics within the wetlands are represented explicitly in time and space. Changes in the wetland ecosystem affect the delivery of services at multiple scales which, in turn, impact components of human well-being. A feedback loop between human well-being and indirect drivers represents how changes in the components of human well-being influence socioeconomic decisions and policies.

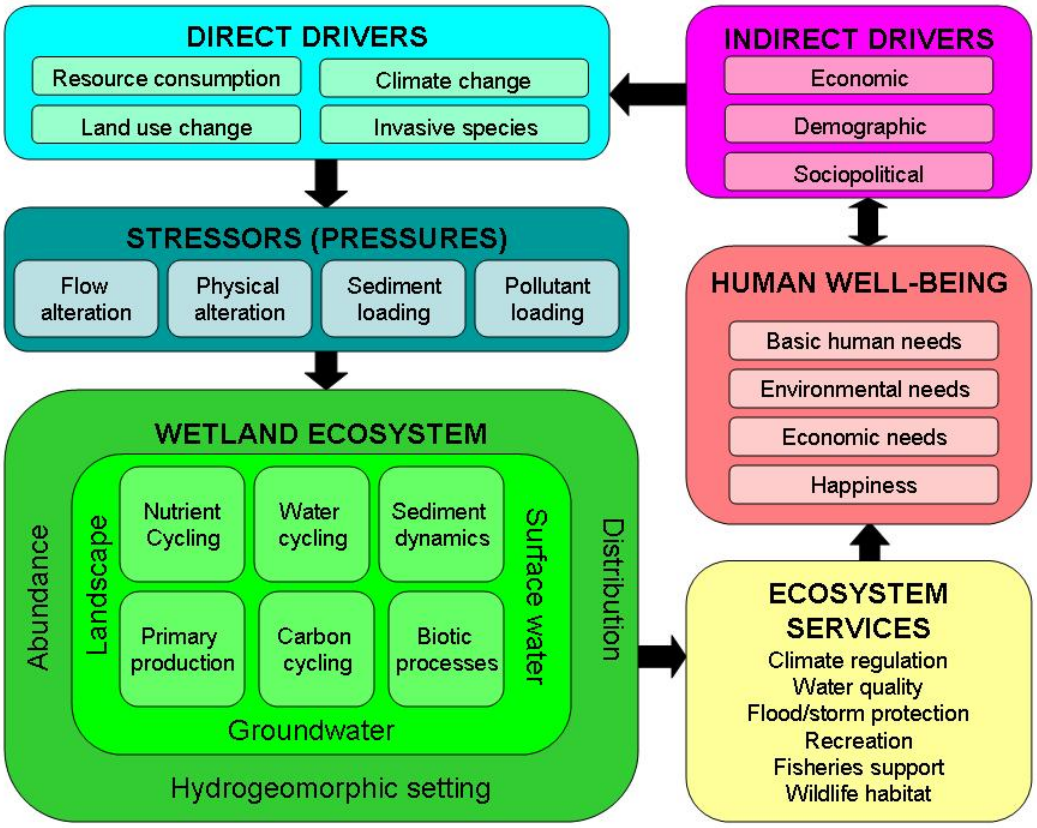


Figure 1: Conceptual Model of Wetland Drivers, Stressors, Features, Services and links to Human Well-being

1.3 Expected Impact/Rationale

Incorporation of ecosystem service and benefit information into decisions that involve wetlands is challenging because many North American wetland types have temporal and spatial variation in hydrology and other functions associated with delivery of services. Production functions, such as carbon sequestration, nutrient retention, wildlife and fisheries production, are dependent on local hydrology and habitat structure and extent. The ESRP-Wetland research will address these production functions in many types of wetlands across the ecoregions of the US.. Often such estimates are wanted at landscape scales, so a large emphasis will be at regional scales for ecosystem services and for estimates useful to decision makers.

ESRP Wetland research is integrated into the larger program in several ways (see Appendix E). Some of the wetland research in this program is being conducted within some of the Place-based efforts (Coastal Carolinas and Tampa Bay, for instance). Monitoring wetland services is being addressed by a partnership with the Office of Water's National Wetland Condition Assessment and planned within the ESRP Wetland program. Landscape-scale research on wetlands is tied closely with the National Atlas of Ecosystem Services. Most of the research within ESRP Wetlands is examining nutrient (including reactive nitrogen) functions and services.

At this point, we see applications of wetland research results in several EPA-relevant areas. Examples include: informing implementation of the 2008 wetland mitigation rule by the EPA and US Army Corps of Engineers that calls for consideration of services; informing remediation efforts under the Clean Water Act section 303d in addressing TMDL plans; and regional application of guidance on protection of watersheds and ecosystems.

1.4 Current Status

1.4.1 Research Underway in FY 2009

Appendix B illustrates the critical path for ESRP Wetland research. Over the next 5 years, research will seek to resolve scientific issues associated with estimating ecosystem services from wetland condition and function data at watershed and regional scales. By partnering with other major themes within the ESRP, we expect to contribute to advances in monitoring, mapping, and valuing the services and benefits of many types of wetlands in North America.

The Implementation Plan for ESRP Wetlands has been reviewed by an external peer panel, which provided valuable feedback on both science and science applications of the planned research. Revisions to the Implementation Plan should be completed by July, 2009, at which time, the plan will be publically available on the ESRP Environmental Science Connector.

1.4.2 Current Impacts, Critical Accomplishments and Innovations

The following are selected examples of how the ESRP wetland work has influenced activities within EPA and other organizations.

- Inserted ecosystem service endpoints into the FY10 EPA Great Lakes Restoration Initiative

- Inserted ecosystem service considerations into the Upper Lakes Study by the International Joint Commission (US and Canada)

- In the process of introducing ecosystem services endpoints into an interagency effort on the environmental effects of biofuels development

- Two EPA STAR grants are being awarded in 2009 for “Forecasting Ecosystem Services from Wetland Condition Analysis”

- A STAR grant will likely be granted in 2009 (or early FY10) to support ecosystem services research associated with the OW National Wetland Condition Assessment

- Co-proposed NCEAS Working Group with Tim O’Higgins (NRC) and Murray Rudd (Memorial University of Newfoundland) on the integration of landscape ecological models of coastal wetland functions and services for the

purposes of improving community decision making in the vicinity of coastal wetlands (including estuaries in several areas of the conterminous US, including those in the SwESP and Coastal Carolinas). This work is cross-linked with the National Atlas', Coastal Carolinas, and SwESP and is supported by NERL.

1.4.3 Publications and Papers Presented in FY 08/09 and forthcoming

Allen P. E., M.S. Nash, R.D. Lopez, J.R. Christensen, N.G. Tallent-Halsell, L. Butler, A.M. Pitchford, and A.C. Neale. 2009 in review. The Landscape Framework for the Spatial Characterization and Mapping of Ecosystem Services: What is the State of the Science? *Landscape Ecology.*

Brazner, J.C., N.P. Danz, A.S. Trebitz, G.J. Niemi, R.R. Regal, T. Hollenhorst, G.E. Host, E.D. Reavie, T.N. Brown, J.M. Hanowski, C.A. Johnston, L.B. Johnson, R.W. Howe, and J.J. Ciborowski . 2007. Responsiveness of Great Lakes wetland indicators to human disturbances at multiple spatial scales: A multi-assemblage assessment. *Journal of Great Lakes Research* 33 (Special Issue 3):42-66.

Hoffman, J.C., D.A. Bronk, and J.E. Olney. 2008. Does terrestrial carbon subsidize production of estuarine fish larvae? *In: Biological production in aquatic ecosystems connecting forests, rivers and coastal waters, Y. Yamashita, Ed., Fisheries Research Series, Koseisha-koseikaku, Tokyo, Japan,* 157:35-45.

Hoffman, J.C., D.A. Bronk, and J.E. Olney. 2008. Organic matter sources supporting lower food web production in the tidal freshwater portion of the York River estuary, Virginia. *Estuaries and Coasts* 31:898-911.

Hoffman, J.C., D.A. Bronk, and J.E. Olney. 2007. Tracking nursery habitat use in the York River estuary, Virginia by young American shad using stable isotopes. *Transactions of the American Fisheries Society* 136:1285-1297.

Jordan, S. J., L. M. Smith, and J. A. Nestlerode. 2009. Cumulative effects of coastal habitat alteration on fishery resources: toward prediction at regional scales. *Ecology and Society* 14(1): Article 16.

Jordan, S. J., et al. Accepted, in revision. Accounting for natural resources and environmental sustainability : linking ecosystem services to huyman well-being. To be resubmitted to Environmental Science and Technology.

McKinney, R.A., Raposa, K.B., and Kutcher, T.R. in review. Use of urban marine habitats by wading birds (Ardeidae) foraging in a North Atlantic estuary. *Biological Conservation.*

McKinney, R.A., Charpentier, M.A., & Wigand C. 2008. Assessing the wildlife habitat value of New England salt marshes: I. Model and application. *Environmental Monitoring and Assessment,* 142, xxx-xxx. http://dx.doi.org/10.1007/s10661-008-0375-6

McKinney, R.A., Charpentier, M.A., & Wigand C. 2008. Assessing the wildlife habitat value of New England salt marshes: II. Model testing and validation. *Environmental Monitoring and Assessment,* 142, xxx-xxx. http://dx.doi.org/10.1007/s10661-008-0403-6

McKinney, R.A., and Charpentier, M.A. 2008. Extent, properties, and landscape setting of geographically isolated wetlands in urban southern New England watersheds. *Wetlands Ecology and Management* 16, xxx-xxx. http://dx.doi.org/10.1007/s11273-008-9110-x

Peterson, G.S., M.E. Sierszen, P.M. Yurista, and J.R. Kelly. 2007. Stable nitrogen isotopes of plankton and benthos reflect a landscape-level influence on Great Lakes coastal ecosystems. *Journal of Great Lakes Research* 33 (Special Issue 3):27-41.

Raheem N., J. Talberth, S. Colt, E. Fleishman, P. Swedeen, K. Boyle, M. Rudd, R. Lopez, T. O'Higgins, C. Willer, and R.M. von Boumans. 2009 manuscript in preparation. The Economic Value of Coastal Ecosystems in California. Report to the California Ocean Protection Council from the National Center for Ecological Analysis and Synthesis Working Group on Valuation of Marine Ecosystems. 26pp.

Trebitz, A.S., J.C. Brazner, A.M. Cotter, M.L. Knuth, J.A. Morrice, G.S. Peterson, M.E. Sierszen, J.A. Thompson, and J.R. Kelly. 2007. Water quality in Great Lakes coastal wetlands: Basin-wide patterns and responses to an anthropogenic disturbance gradient**.** *Journal of Great Lakes Research* 33 (Special Issue 3):67-85.

Trebitz, A.S. and D.L. Taylor. 2007. Exotic and invasive aquatic plants in Great Lakes coastal wetlands: Distribution and relation to watershed land use and plant richness and cover. *Journal of Great Lakes Research* 33:705-721.

Wigand, C., Smith, H., Spears, C., Keith, B., McKinney, R.A., Chintala, M., and Raposa, K. in press. Relationships of watershed landuse and nitrogen loadings with salt marsh fish in the Narragansett Bay Estuary. *Rhode Island Natural History Survey.*

Wigand, C. 2008. Coastal Salt Marsh Community Change in Narragansett Bay in Response to Cultural Eutrophication (Chapter 17), pages 499 – 522. Eds., B. A. Costa Pierce and A. Desbonnet; In: Science for Ecosystem-based Management: Narragansett Bay in the 21st Century. Springer Publishing, NY.

Wigand,C., McKinney, R, Chintala, M., Lussier, S., and Heltshe, J. 2009.Development of a reference coastal wetland set in Southern New England (USA). Environmental Monitoring and Assessment, DOI 10.1007/s10661-009-0770-7 (online).

Wigand, C., Brennan, P., Stolt, M., Holt, M., Ryba, S. In review. Soil respiration in coastal marshes subject to increasing watershed nitrogen loads in southern New England (USA). Submitted Wetlands.

1.4.4 Resources

General estimate of wetland FTE in FY09:

NHEERL:21.5 science FTE (1/3 to ½ of these are Principal Investigators, the rest are science administrators (such as Branch Chiefs) and support scientists

NERL: Portions of 5 FTE are Principal Investigators, unknown number of support scientists

NRMRL: 0.3 FTE of one Principal Investigator, unknown number of support scientsts

ORD experts as Special Government Employees: up to 600 hours/year of a non-market economist (Dr. Marisa Mazzotta) and support from Dr. Charles Vorosmarty is working on approaches to mapping wetland services.

Funding Resources:

Contract support is currently at approx. 2 FTE for wetland-related work, funded by ORD's National Exposure Research Laboratory.

The Wetland program needs additional funding for contract GIS support; FTE or partner support for valuation and decision support; and travel funding for federal staff.

Non-EPA FTE:

The three STAR grants, mentioned previously, will provide significant partnerships with academic teams for elements of the ESRP Wetland program.

1.5 Response to Comments

1.5.1 Response to Program Office Comments

The ESRP Wetland Implementation Plan was sent to wetland scientists within the EPA's Office of Water, Office of Wetlands, Oceans and Watersheds. We also have added to our ESRP Wetland Team, Mr. Rich Sumner, the Regional Liaison to ORD from OWOW's National Wetland Program. Suggestions by OW reviewers have helped us focus on regional and national needs for ecosystem services applications with Clean Water Act programs administered by EPA. Mr. Sumner is actively working with ORD research staff to steer their results toward regional applications, such as EPA Region programs guiding wetland mitigation and wetland protection.

1.5.2 Response to SAB Comments

The SAB EPEC provided a number of useful suggestions and comments for the Wetlands theme of the ESRP. We have used these comments to improve the implementation plan for wetland research and outline here some of the changes made in response to the EPEC suggestions.

The ESRP Wetland Implementation Plan was subjected to peer review by wetland scientists from outside EPA in January, 2009. A number of excellent suggestions came from the review and the wetland team is in the last stages of revising the plan. Revisions include greater alignment of research with the management needs of EPA and its partners and increasing the clarity of where research can address elements of a wetland science concept (see Figure 1). We are seeking to describe with more specificity the focus and capacity of the staff and resources within ORD to address strategic portions of the universe of wetland ecosystem services science. The scope of research ranges from specific suites of services in regional wetland classes to a national approach of estimating services from the National Wetland Condition Assessment being carried out in 2010 by EPA's Office of Water.

The ESRP Wetland program has close ties with ORD's Water Quality Multi-year Plan, especially through the National Aquatic Resources Assessments (including the previously mentioned wetland assessment) by EPA's Office of Water. Since much of the "data" available for ecosystem service assessments will necessarily have to be derived from various environmental monitoring programs, we feel that a partnership with OW's monitoring and assessment programs can offer a suite of demonstrations on how well monitoring programs can be used in this way. ESRP Wetland research is placing initial emphasis on the relationships between ecosystem condition, ecosystem functions, effects of stressors, and delivery of ecosystem services; these are fundamental relationships that must be understood if the information is to be used in defensible decision-making.

We appreciate the SAB suggestion to begin with one or two simple pilot projects initially, so that tangible products can emerge early in the program. We agree that this approach offers proof-of-concept and stakeholder buy-in. ESRP-Wetland research will be conducted as a series of case studies that are scaled mainly for regional demonstration (the exception is the partnership with the NWCA). Even with the NWCA-related effort, we will have the opportunity to partition the results by wetland class, by ecoregion, by EPA region and provide a demonstration for state interests.

The SAB specifically mentioned the ecosystem services of salt marshes; our program will conduct a significant portion of our research on coastal salt (and fresh) marshes and will include estimations of storm surge services, as well as nutrient retention, wildlife and fisheries related services. At the present time, we are increasing our collaboration and coordination efforts specifically on transformation of reactive nitrogen in salt marshes.

1.6 Challenges

Research on wetland ecosystem services has begun in many types of wetlands and geographic places across the US. Considerable ESRP Wetlands work is/will be conducted in the ESRP Places (Coastal Carolinas, Tampa Bay, FML, Willamette, and Southwest) and additional work is being conducted in other geographic regions, with broad-scale work taking place in the coastal zone of the conterminous US in collaboration with research related to the National Atlas of Ecosystem Services. One challenge will be to integrate these geographically diverse efforts into a nationally cohesive program. The mapping and modeling programs may provide common ground among these research efforts. Also, we have begun a coordination effort within the ESRP to focus research on nutrient retention services, including retention of reactive nitrogen.

Mapping and scenario development (forecasting) requires significant synthetic analysis (estimating services in unmeasured / mapped sites, modeling services, etc) and the challenge is in developing capacity to map and model in many wetland ecosystem types and regions.

Travel funding limitations prevent significant face-to-face interactions needed for collaboration and synthesis

Many of the ESRP Wetlands staff have their FTE split between ESRP and the Water Quality MYP or between ESRP and previous commitments to EMAP and other ECO programs. Very few ESRP Wetlands staff are 100% ESRP Wetlands, including the Theme Lead.

Staff are still learning about ecosystem services science, how ecosystem services relate to human benefits and how ecosystem services are different or similar to typical ecosystem function / condition measures. The only expertise in economics within the ESRP Wetland program is via a part-time Special Government Employee; thus expertise in translating ecosystem services to values or in estimating relationships between wetland functions and human well-being are severely limited. In part, this limitation is a function of the distribution of research across wetland classes and ecoregions. We expect that initial steps to involve experts in valuation, ecosystem benefits, and other fields will accelerate understanding, leading to increased activity.

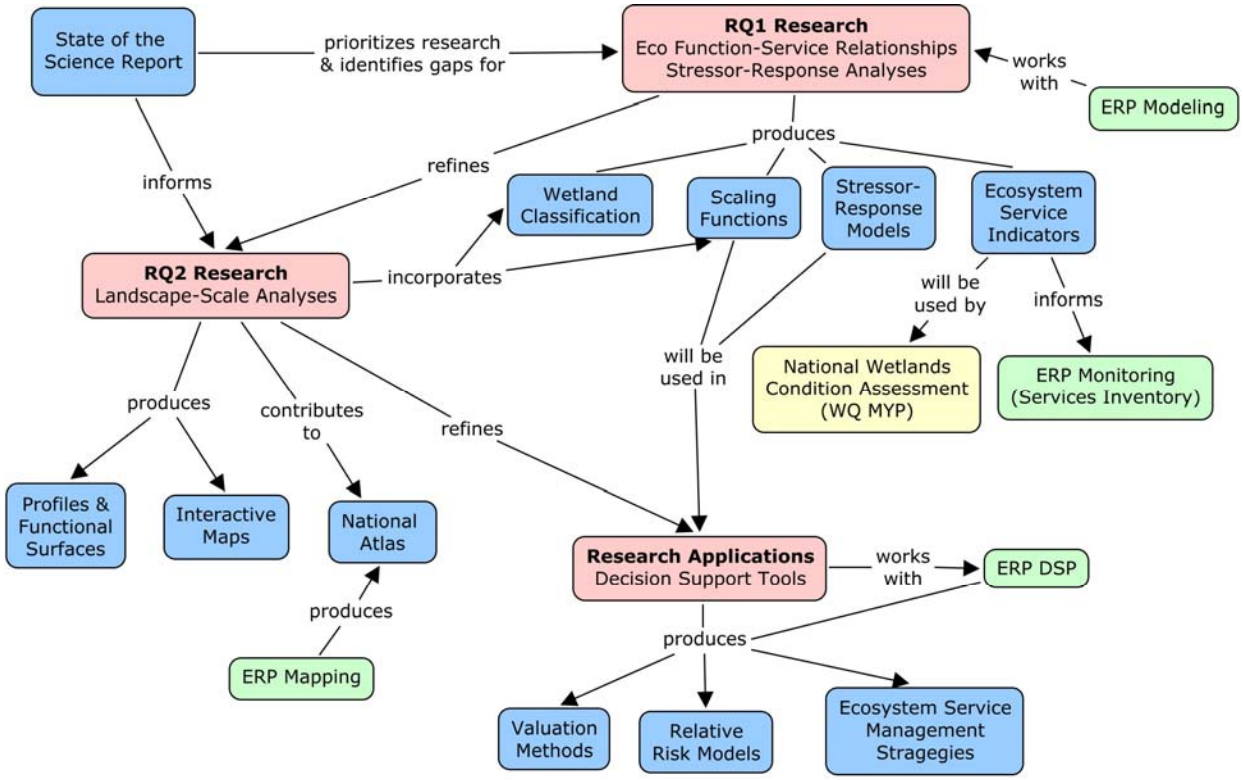
1.8 Appendices

Appendix A: Hierarchy of services being addressed in research described, including units of measure

Ecosystem Service	Units of Measure (general examples)
Carbon Storage	Carbon stocks in plants and soil (mT uptake/year): Flux of GHG (net release of C as g/m2/y)
Fisheries Support	Landings per unit area of wetland; Acres of suitable habitat; Feedstock for Commercial

	/ Recreational Fisheries (Kg/m2/y)
Flood Control / Storm Surge Protection / Water Storage Wave/Tide energy dissipation	Extent of Wetland Attenuation of Surge or Flood (m/event); Water Volume Capacity of Wetlands (regional m3 volume of water capacity)
Water Quality Improvement	Reactive N / Reactive P Removal (denitrification rate (N2 flux mmol/m2/d)); Equilibrium P Concentration ug/L P); Discussing N removal units with ESRP-N
Wildlife Support	Birdwatching Opportunities; Breeding Bird Community; Wildlife Prey Abundance

Appendix B: Critical Path



Appendix C: Experts' Contributions

Dr. Marisa Mazzotta has been hired by EPA as a Special Government Employee for approximately 600 hours/year. She will be advising and collaborating with ESRP Wetland efforts on non-market valuation of ecosystem services. She is beginning to apply her existing data on wetland values to ORD studies on the East Coast. She is

having discussions with the other wetland teams to seek opportunities for valuation in other wetland classes and other regions of the U. S.

Dr. Charles Vorosmarty has been on board and is continuing to consult with the Landscape Ecology Mapping/Modeling contributors (Neale, Christensen, Lopez) and contributing to the development of wetland ecosystem service mapping approaches and techniques, to the benefit of the ESRP-Wetlands Team

Appendix D: Examples of Future Products

- State of the science report on relationships among stressors, wetland functions, and ecosystem services at multiple scales (2009 APM)
- Report on nitrogen removal in wetlands as a function of wetland type, position in the landscape, and nitrogen loading rates at regional and national scales (2010 APM)
- Report on water quality ecosystem services in depressional isolated wetlands: water storage capacity of depressional palustrine wetlands (2011 APM)
- Report on the potential for using indicators of the ecological condition of wetlands to estimate delivery of ecosystem services.(2011 APM)
- Evaluation of ecosystem services associated with wildlife habitat provided by Great Lakes coastal wetlands using stressor-effects data (2012 APM)
- Report on the effect of nitrogen fertilization on the belowground structure, soil respiration and ecosystem service of carbon sequestration in selected east coast estuaries. (2013 APM)

Appendix E: Cross Cuts between Wetlands and other Themes

Wetlands X Place-based:

Coastal Carolinas: We will develop riparian wetland functions for the WASP model, we will work on representation of isolated wetlands in the GBMM for Cape Fear basin, and develop a proposal for modeling tidal creeks.

Future Midwest Landscapes: Research will be conducted on the capacity of isolated wetlands to provide nutrient removal and water storage in the Midwest region.

Tampa Bay: Research will support efforts to estimate wetland functions to retain / remove reactive nitrogen through denitrification and compare and contrast results with tidal marshes on the East and West coasts

Wetlands X Monitoring: Wetland team is involved in designing the National Wetland Condition Assessment and will use the data to assess wetland services

Wetlands X Nitrogen

Most wetland research in ESRP Wetlands will estimate nitrogen and phosphorus removal services. We are becoming engaged in discussions across the ESRP about appropriate units for estimating nutrient removal by wetlands. Funding in FY09 will supplement and accelerate estimations of retention / removal of reactive nitrogen.

Mining the scientific and technical literature for quantitative data on (1) the effects of nitrogen loading on various wetland classes, and (2) the capacities of various types of wetlands, under a range of environmental conditions, to remove reactive nitrogen from aquatic systems.

Wetlands X Modeling

The ESRP Wetland team is reviewing existing modeling approaches for wetlands. Communication of modeling needs between wetlands team and ongoing integrated modeling efforts in Coastal Carolinas led to three results: development of riparian wetlands functions for WASP, representation of isolated wetlands in GBMM for Cape Fear basin, and the development of a proposal for modeling tidal creeks.

Wetlands X Mapping

ESRP Wetlands research will be conducted within landscapes and will seek to provide information for spatial analysis

FY09 APM links with the National Atlas effort, by reporting on methods used to mapping wetlands for description of ecosystem services in piloted areas (focus is riparian wetlands and marine coastal wetlands)

Wetlands X Climate Change:

ESRP Wetlands will be conducting research on the ability of wetlands to sequester carbon

ESRP Wetlands will be conducting research on the relationships between sea-level and coastal wetland ecosystem services

Ecosystem Services Research Program

Coral Reef Project

Lead: William S. Fisher ORD/NHEERL, Gulf Ecology Division
850 934-9394; fisher.william@epa.gov

Status Report and Future Directions June 19, 2009

1.1 Project or Theme Goal

Coral reef ecosystem services are perceived as free and limitless under current policies and management; our goal is to provide the tools and information to ensure that the full value of coral reef services is routinely incorporated into all levels of management and decisions made in the reef watershed and coastal zone.

1.2 Conceptual Model and Description

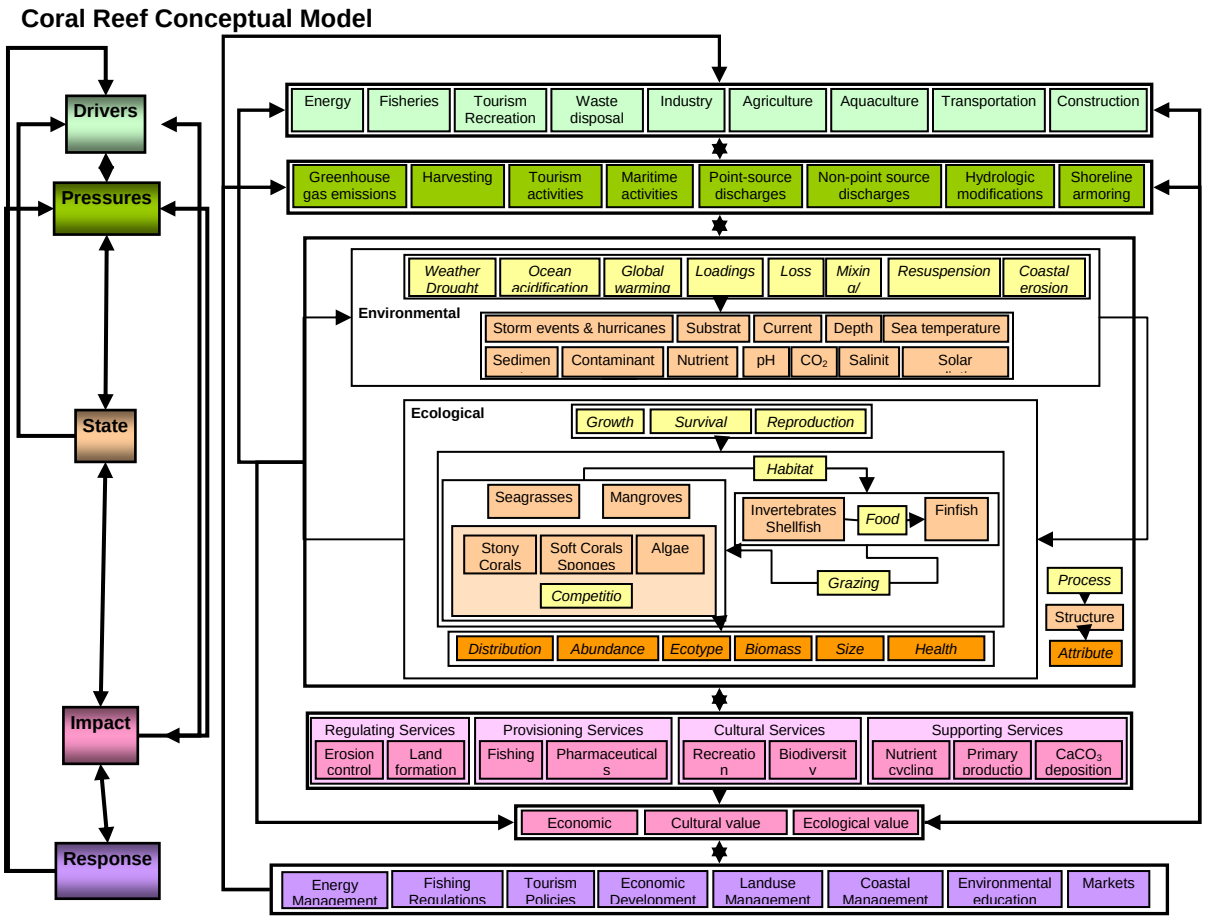


Figure 1. Human-centric DPSIR Model for Coral Reef Ecosystem

1.3 . Expected Impact/Rationale

Our short-term objective is to ensure that managers and decision-makers recognize the ecosystem services (ES) provided by coral reefs, and that they can be valued and considered when decisions are made. The long-term objective is that coral reef ES are routinely documented, valued and considered in watershed and coastal zone decisions. The short-term goal will be met through workshops with clients in Florida, Puerto Rico and U.S. Virgin Islands, our target jurisdictions. The workshops are designed to advance a common vision for sustainable reefs, describe obstacles and opportunities for achieving the vision, and document decision processes, information used in making decisions, and preferred vehicles for information delivery (decision support tools). Research in the project will be organized through a framework that characterizes relationships of human activities and coral reefs—including human benefits and adverse effects. The framework allows us to track the consequences of alternative decisions from human activities, through changes in ecological state and delivery of ES, to impact on value of the reefs. We will ultimately link research findings to the decision support tools already in use and work with clients to generate improved tools. The information we provide will directly benefit resource managers by squarely placing coral reef ES on the decision-making table. Moreover, regulatory protection through the Clean Water Act will be enhanced because coral reef values can be incorporated into designated uses for coastal waterbodies and protected through directed biological criteria.

1.4. Current Status

1.4.1. Research Underway in FY 2009

The ESRP Coral Reef Project Research Implementation Plan (IP) will be completed in 2009. To support the IP, we have adopted an organizational framework to link coral reef ecological and socioeconomic factors (DPSIR), and engaged five Focus Groups of coral reef experts from multiple federal, state, NGO and academic institutions. The DPSIR (Driving forces, Pressures, State, Impact, and Response) framework is specifically designed to link ecological and socio-economic factors. It demonstrates the connections among different human activities and the cumulative effects of different human activities on the coral reef environment. It is also being used as a decision support tool. The DPSIR concept is captured in annotated stock and flow diagrams (conceptual models) that are being linked to relevant information. When completed, several jurisdiction-specific diagrams will be loaded on the internet.

The Focus Groups serve to inform the framework, identify priority research questions and activities, integrate activities across disciplines and introduce the systems approach to potential research collaborators. They have also served to introduce our clients to the ESRP approach, our goals, and engage them in the process. Each Focus Group has submitted a final summary of their discussions, which will be included in and will inform our development of a research plan.

In close collaboration with the ESRP Decision Support Framework theme, four coral reef workshops are being planned for late 2009 and early 2010. These will be held in Florida (3) and Puerto Rico in collaboration with the Florida Keys National Marine Sanctuary, National Coral Reef Institute and Caribbean Coral Reef Institute. The workshops include reef managers and scientists to obtain information regarding:

- Visions for the coral reef ecosystem
- Suggested pathways for attaining that vision, and
- Obstacles and challenges

In addition, we will query managers on the decisions they make, their authorities and responsibilities, the decision process and the tools and information they use to make a decision. This information will be used to inform the 'Response' component (societal responses to changes in value) of the DPSIR framework. The workshops will include a demonstration of different kinds of decision tools to generate feedback for decision support approaches. The first workshop is in the Florida Keys June 17-19, 2009.

Central to the Coral Reef Project are the services provided by the coral reefs. A baseline assessment of coral reefs in U.S. Virgin Islands will be completed in 2009 using methods and indicators described in EPA's Coral Reef Rapid Bioassessment Protocol (and now used by The Nature Conservancy's Florida Reef Resilience Program). These studies are being performed with the active participation of EPA Region 2, U.S. Virgin Island Department of Planning and Natural Resources and The Nature Conservancy.

Laboratory studies are being performed at Gulf Ecology Division on the effects of sediment on coral using innovative photographic and laser technology to characterize small (short-term) changes in growth.

1.4.2. Current Impacts, Critical Accomplishments and Innovations

- DPSIR ecological-socioeconomic organizational framework—the first human-centric systems approach to be developed for coral reefs
- Annotated conceptual models to provide information on ecological, social and regulatory systems related to coral reef management
- More than 30 coral reef experts from multiple institutions participate on DPSIR Focus Groups
- Economists are examining methods to value both monetary and non-monetary values of coral reefs.
- Invitation from the inter-Agency Coral Reef Task Force for a presentation on the ESRP Coral Reef Project for its autumn 2009 meeting.
- Assessment of coral reefs in the U.S. Virgin Islands to establish baselines for development of biocriteria water quality standards
- Ongoing laboratory tests to evaluate the effects of sediment level on coral survival and growth
- Coral reef management workshops in Florida and Puerto Rico

1.4.3. Publications

<u>Recent (2008-2009)</u>

Barron, M.G., D.N. Vivian, S.H. Yee, and D.L. Santavy. 2008. Methods to estimate solar radiation dosimetry in coral reefs using remote sensed, modeled, and in situ data. *Environ Monitor Assess* 151:445-455.

Bradley, P., W. Fisher, H. Bell, W. Davis, V. Chan, C. LoBue and W. Wiltse 2009. Development and implementation of coral reef biocriteria in U.S. jurisdictions. *Environ Monit Assess*. 150(1-4):43-51

Bradley, P., W. Davis, W. Fisher, H. Bell, V. Chan, C. LoBue and W. Wiltse 2009. Development and implementation of coral reef biocriteria in U.S. jurisdictions. *11th International Coral Reef Symposium*. In press.

Fisher, W.S., L.S. Fore, A. Hutchins, R.L. Quarles, J.G. Campbell, C. LoBue and W.S. Davis 2008. Evaluation of stony coral indicators for coral reef management. *Mar Poll Bull.* 56:1737-1745.

Fisher,W.S., A.L. Hutchins, L.S. Fore, W.S. Davis C. LoBue and H. Bell 2009. Water quality standards for coral reef protection. *11th International Coral Reef Symposium.* In press.

Fore, L. S., J. R. Karr, W. S. Fisher and W. S. Davis 2008. Making waves with the Clean Water Act. *Science* (Letter to the Editor) 322:1788.

Fore, L.S., J.R. Karr, W.S. Fisher, P. Bradley and W.S. Davis 2009. Heeding a call to action for U.S. coral reefs: the untapped potential of the Clean Water Act. *Marine Pollution Bulletin*, In press.

Yee, S.H., D.L. Santavy, and M.G. Barron 2008. Comparing environmental influences on coral bleaching across and within species using clustered binomial regression. *Ecological Modeling* 218:162-174.

Yee, S.H. and M.G. Barron 2009. Predicting mass coral bleaching events in response to environmental stressors using eight years of global-scale data. *Environmental Monitoring and Assessment.* In press.

Zepp, R.G., C. Shank, E. Stabenau, K.W. Patterson, M. Cyterski, W. Fisher, E. Bartels and S.L. Anderson 2008. Spatial and temporal variability of solar ultraviolet exposure of coral assemblages in the Florida Keys: Importance of colored dissolved organic matter. *Limnol. Oceanogr.* 53(5):1909-1922.

Forthcoming (2009-2010)

ESRP Research Implementation Plan
Human-centric DPSIR framework to incorporate coral reef ecosystem services
Decision science and coral reef management
Probability surveys of coral reef condition in the U.S. Virgin Islands
Testing regulatory indicators in La Parguera, Puerto Rico
Testing regulatory indicators in St. Thomas, U.S. Virgin Isands
Manual for development and implementation of biocriteria for coral reefs

1.4.4. Resources

EPA FTE = 7
EPA expert hires = 2 x 400 h per year (economist and alternative futures scientist)

Budget beyond salary is needed to host and fund client travel to workshops; to support laboratory research (maintenance of cultured corals); and to support analysis of field samples (e.g., foraminifera, benthos).

Three weeks ship time per year on the OSV BOLD (EPA Office of Water) which has an estimated cost of $13,000 per day.

Non-EPA FTE is ~2 FTE through our partnerships in the Focus Groups, divers for bioassessment surveys, and client workshops.

Memoranda of Understanding are in process with The Nature Conservancy, NOAA, and National Coral Reef Institute, and have been agreed upon with Caribbean Coral Reef Institute, University of Virgin Islands and the U.S. Virgin Islands Department of Planning and Natural Resources.

1.5 Response to SAB comments

Summary from SAB: The Committee finds that, although coral reef systems are globally important, other more common "human dominated" ecosystems may provide services to more U.S. citizens, and greater opportunities for coordination and collaboration with other studies within the ecological research program. We therefore recommend that the Program consider undertaking projects in other more common "human dominated" ecosystems. If coral reef research is retained in the Plan, it should provide a better explanation of how studying the dynamics of ecosystem service flows in coral reefs will advance ecological sciences and ultimately help inform decision making.

Response: We understand the SAB concern that coral reef ecosystems, because of their wide geographic distribution, could appear to be less human dominated than other ecosystems. Yet, we elected to retain this ESRP topic for a variety of reasons. In particular, a coral reef focus has high scientific appeal and EPA-relevant outcomes that require significant collaboration with Federal, State, non-government and other ESRP programs. And, while coral reefs are widely distributed (7,607 square miles), they are under enormous anthropogenic pressures that threaten their existence—well over 10 million people are located near U.S. coral reefs, and human activities are a principal cause of reef decline. Coral reefs provide critical services not only to local populations (e.g., subsistence fishing and protection from catastrophic flooding), but benefit citizens across America (e.g., tourism, fishery harvests, aquarium fish, jewelry, and pharmaceutical products). Corals are also valued throughout the U.S. for non-consumable services such as natural beauty and biodiversity. Knowledge of the value of coral reefs has helped non-governmental organizations (e.g., The Nature Conservancy) to raise money for protection of coral reefs, and led the U.S. Government to establish and fund (over $200M yr^{-1}) interagency programs (e.g., Coral Reef Task Force), National Marine Sanctuaries, National Parks, local action strategies and legislation (e.g., Coral Reef Conservation Act) specifically for protection of coral reefs. Coral reefs are important to and valued by most American citizens, including those who do not live near them and those who may never visit them. In a 2007 poll of over 1000 American citizens by The Ocean Foundation, 80%

said that having healthy coral reefs is important to the overall health of the ocean and 69% said healthy reefs are also important to human well-being.

The objective of ESRP-Corals is to ensure the routine consideration of ecosystem services in local and regional decisions to support sustainable coral reefs. Inherent in this objective is linking anthropogenic stressors and reef attributes to ecosystem services and decision processes. ESRP-Corals is organizing these links between environmental and socioeconomic variables under the well-known DPSIR (Driver, Pressure, State, Impact, and Response) framework. This will advance our understanding of how decisions are made and the obstacles to decisions that support reef conservation. EPA-related decisions (e.g., Clean Water Act) will be prominent, but not exclusive. Research needs in both ecological and decision science far outstrip the ability of any one organization to achieve, so federal, state and academic partnerships will be fundamental to success of this project.

1.6 Challenges

Even with the organizational framework provided by the DPSIR model, it is a challenge to coordinate the various activities relevant and necessary to this project as we engage partners and attempt to take advantage of emerging opportunities (such as the recent national focus on ocean acidification). It is also a challenge to draw clients into the 'larger picture' that we offer—even if they agree with the overall concept, their responsibilities and authority are often narrowly defined. Scientific challenges include valuation of non-monetary services (especially important we think with coral reefs) and integration of multiple natural and human stresses on reefs. It is also a challenge to generate change in established long-term monitoring programs toward more effective regulatory indicators and monitoring designs.

1.7. Future Directions

Ecological research will pursue relationships and rate functions that link human activities with changes in ecological state and coral reef attributes. This includes characterization of coral reef extent, distribution and condition in target jurisdictions, laboratory-derived rate functions for sediment, nutrient (Nr), fishing and pH (ocean acidification from atmospheric CO_2), and a dynamic systems model for interactions among human activities and coral reef ecology. Socioeconomic research will provide methods to identify, characterize and value coral reef ES. These will include monetary and non-monetary values for services with initial focus on shoreline protection, fisheries, recreation/ tourism, and cultural services related to biodiversity. These methods will be applied to our target jurisdictions by incorporating results from reef characterizations (above). The dynamic model will be paired with changes in value for trade-off analysis of different decisions. Decision science research will investigate means to incorporate ES values into decision support tools that will be used by clients in our three jurisdictions. We will take the concepts and approaches of landscape ecology and move from the terrestrial environment, through the transitional coastal environments (e.g., mangroves, sea grasses, salt ponds, etc.) to the coral reef ecosystem. Finally, we will work with jurisdictions to identify means to routinely incorporate ES values into decisions and policies.

1.8. Appendices

Appendix A: **Services of Coral Reefs**
The diverse communities that form coral reefs embody a natural beauty and mystique attractive to humans. Millions of tourists annually enjoy reefs in person and millions more enjoy reefs vicariously with reflection of a healthy, diverse, interactive community of unique marine organisms (as evidenced by sales of 'Save our Coral Reef' license plates and contributions to NGO reef conservation programs). But natural beauty and biological diversity are not the only values attributable to reefs. For the nearly 10 million people that live near them, coral reefs provide several essential services, including sand for beaches, shoreline erosion control, flood protection, construction material, subsistence fishing, recreation, economic opportunity and a sense of place, tradition and culture. Non-residents worldwide benefit from tourism opportunities, food products, aquarium fish, jewelry and curios, and pharmaceutical and cosmetic products now and in the future.

Several ES will be included in coral reef studies:
Shoreline protection (economic value of homes and land protected from storm events)
Fishing (economic value of reef fish harvested plus social/cultural value of subsistence fishing)
Tourism (economic value of recreational and tourism activities; willingness to pay to retain tourist attractions; intrinsic value of unique habitats)
Biodiversity (intrinsic value of unique populations, willingness to pay to protect biological diversity)
Pharmaceutical futures (value of human life from successful medicinal drugs such as AZT (from coral reefs); economic value of drug research and production; potential for future biochemical discoveries)

Others potential services are noted on the conceptual model (see Figure 1).

Appendix B: Conceptual Model and Scientific Uncertainties
The conceptual model follows a human-centric DPSIR framework to link ecological with socioeconomic factors (see attached Figure 1). A CMAP annotated model will be used to identify scientific, socioeconomic and regulatory uncertainties. A preliminary assessment indicates that much more is known about ecological interactions than about coral reef valuation, decision science and the pattern of legislation and authority for controlling human activities that affect coral reefs. Linked to the CMAP model will be: 1) a coral reef ecosystems bibliography, 2) a database of the legal and regulatory authorities relevant to coral reef ecosystems in the target jurisdictions, and 3) on-going ecological research activities. These will support analysis of scientific uncertainty (gap analysis).

Appendix C: Experts' Contributions
Expert 1: Dr. Jim Sanchirico, economist, University of California, Davis: Has led the "Impact" Focus Group and is developing a methods analysis for valuation of coral reefs
Expert 2: Dr. Carolyn Boggess, decision scientist with expertise in alternative futures scenarios, University of Oregon. Dr. Boggess is in the process of being hired and will

provide a comprehensive framework to consider effects and outcomes of alternative decisions.

Appendix D: List of Future Products

Report card for extent, distribution and condition of coral reefs in target jurisdictions
Landscape ecology models for watershed stressors (nutrients and sediment)
Bundled services valuation of coral reef attributes for the target jurisdictions
Development of CWA designated uses that recognize and incorporate ecosystem services
Annotated decision model to support managers with decision options and trade-off scenarios.
Coral reef decision analysis for Florida Keys National Marine Sanctuary, Southeast Florida, U.S. Virgin Islands and Puerto Rico.

Appendix E: Collaboration with other ESRP Projects

Collaboration with the Decision Support Framework Theme has already begun through development of client workshops. Collaboration with Nitrogen theme will be initiated through landscape characterization nutrient sources and coastal zone distribution of nutrients through analysis of satellite imagery in Florida (NASA-funded EPA project). Collaboration with wetlands will occur through the shared interest of wetland and mangrove protection by coral reefs and the shared ecosystem service of fish nursery areas.

LTG 5 Site - Specific Demonstration Projects

LTG 5: The Ecosystem Services Research Program will complete five site-specific demonstration projects that illustrate how regional and local managers can proactively use alternative future scenarios to conserve and enhance ecosystem goods and services to benefit human well-being and to secure the integrity and productivity of ecological systems.

a. Future Midwestern Landscapes

b. Tampa Bay

c. Willamette River Basin

d. Coastal Carolinas

e. Southwestern US

f. Cross-Place Coordination

Ecosystem Services Research Program
Future Midwestern Landscapes Project

Randy Bruins and Betsy Smith

Status Report and Future Directions. June 23, 2009

1.1 Project or Theme Goal

The Future Midwestern Landscapes (FML) Study will show how and where ecosystem services currently are being provided in the Midwest, and provide some alternative visions of how that could change in the future. We will make this information useful and accessible (as an online toolkit) to national policy-makers, EPA Regional Offices, farm groups, watershed organizations and others working to ensure both the ecological and economic viability of the region.

1.2 Conceptual Model and Description

The conceptual model developed for the FML (Fig. 1) forms the basis for a scoping exercise that is examining the available literature and using best professional judgment to hypothesize causal links, estimate the direction and magnitude of expected changes under our two alternative future scenarios, and identify the major gaps and uncertainties in the science associated with expected changes in the provision of ecosystem services. The conceptual model has allowed us to identify where we have EPA resources to address the research needs and where we need to seek assistance through collaboration with others (e.g. assessing changes in flood risk; we are exploring a collaboration with the Army Corps of Engineers through their Hydrologic Engineering Center). Economic principles are implicit in our conceptual model (economics are recognized as drivers of change through crop production, transportation, Conservation Reserve Program enrollment), improving decision efficiency by identifying the linkages between costs (e.g. as in an incentive program) and provision of services.

1.3 Expected Impact/Rationale

Long Term (3 – 5 years): Through our partnership with the USDA Farm Service Agency (FSA) we will **help frame new farmer incentive policies** that promote regional economic viability by showing how rural landscapes can provide a broader range of benefits to society. Additionally we expect to develop a new Ecosystem Services Index that will improve the FSA Environmental Benefits Index currently being used for decisions on land enrollment in the Conservation Reserve Program. We will also provide online support to illustrate trade-offs associated with alternative policies.

Through a partnership with the U.S. Fish and Wildlife Service (FWS) we will **identify critical habitat for sensitive species** and identify areas that with conservation practices will have a high probability of increasing the connectivity of habitat and providing stopover for migratory bird populations.

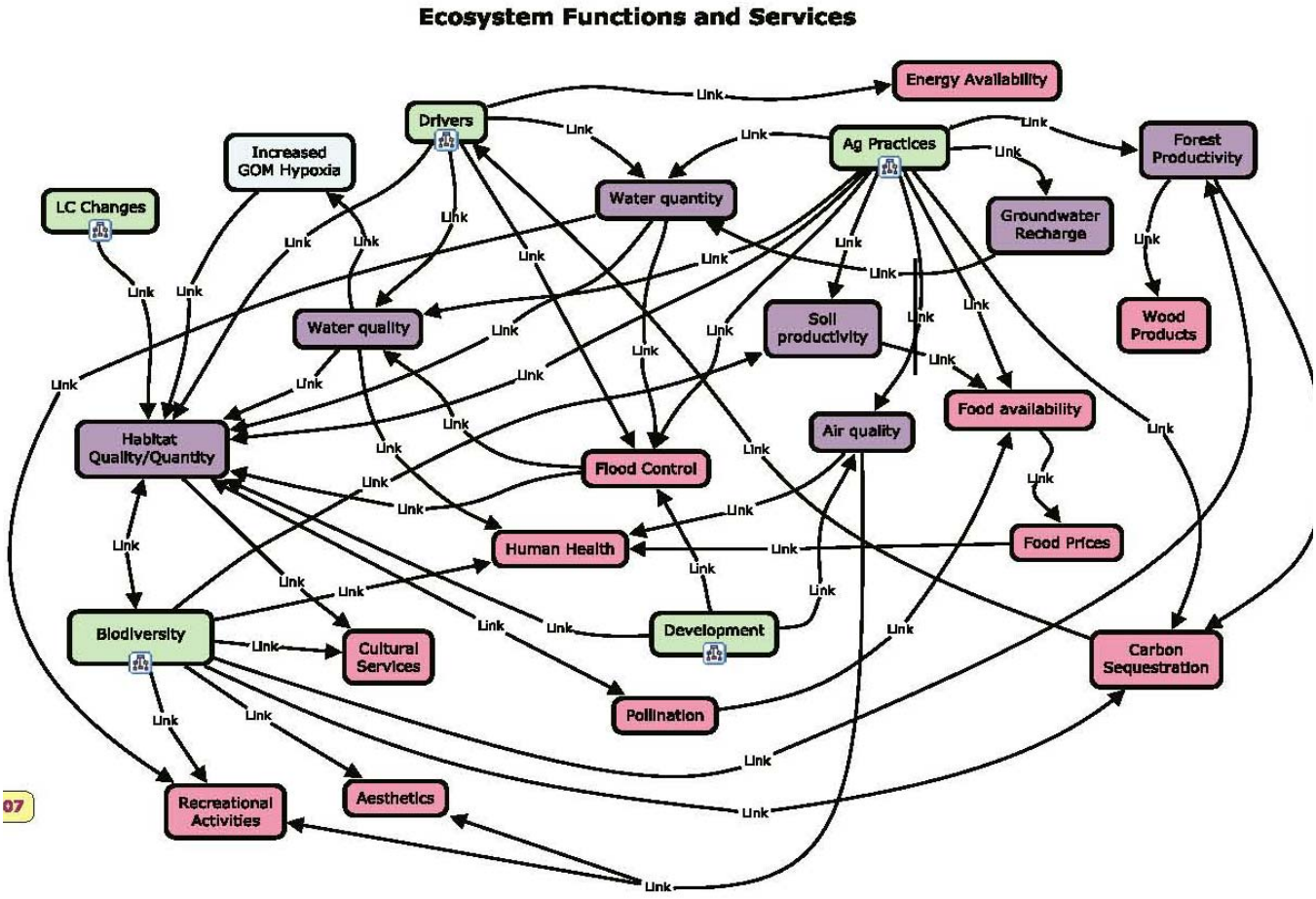


Figure 1. Simplified version of the FML conceptual model. (See Appendix B for more detailed version).

Through partnerships with farm, watershed and conservation groups we will **assist conservation planning and the development of markets** by identifying the potential provision of ecosystem services that could be obtained at specific places. We will integrate results of multi-scaled analyses that will link regional land use/ land cover patterns providing context, with local decision-making. Through the ESRP's Decision Support team, we also expect to provide fine-scale applications that will support local decision-making by regional land owners and managers.

The results of our assessment of changes in carbon sequestration resulting from alternative policy choices may inform EPA's Greenhouse Gas Rule. Site-specific assessment of cumulative impacts under the Biofuels Targets scenario will inform the National Pollutant Discharge Elimination System (NPDES) permitting by EPA's regional offices. Improvements in the Community Multi-Scaled Air Quality model in quantifying ammonia flux resulting from changes in fertilizer applications may inform future regulations on particulate matter.

Short Term (1 – 2 years): Our initial products will be **maps of our current and alternative-future landscapes**. Our recently completed Baseyear (BY) landscape is being viewed as a model that is likely to be emulated by other ESRP place-based studies and the national ESRP Landscape Characterization effort. It depicts actual crops planted along with chemical inputs typically associated with crop management. Our Biofuels Targets landscape, expected to be available later this summer, will depict an estimate of the results of the implementation of the Energy Independence and Security Act in 2022. We will use these maps as a vehicle for planning discussions with client groups concerning their visions of likely and desired futures, to strengthen our relationships with those groups and to assist in the design of our online FML- Environmental Decision Toolkit (FML-EDT). Metrics associated with these landscapes will be calculated and made available to our clients as interim products through the FML-EDT and should provide additional decision support immediately.

In support of the development of a conservation-focused Multiple Services (MS) future landscape, we have developed an **ecosystem services hierarchy** (see Appendix A) and a strategy for eliciting decision-makers values for the suite of services occurring throughout the Midwest. These values will be input into an optimization to identify a target MS landscape. An economic model that predicts response to land use policies will then be used to identify the realized landscape, which will then be spatially allocated using rule-based modeling. The integration of the economic modeling with land use modeling is a novel approach that can be used in other regions of the country.

1.4 Current Status

1.4.1 Research Underway in FY 2009

Implementation Plan – The FML Implementation Plan was completed in FY 08 and peer reviewed in early FY 09. Invitations to review the plan internally were extended to the Deputy Regional Administrators for EPA Regions 5, 7 and 8, and to the Deputy Assistant Administrators for the Office of Water and the Office of Air and Radiation. In addition, 7 external peer reviewers with backgrounds in economics, conservation, ecology, agriculture, and biofuels reviewed the plan.

Scoping – We are using conceptual models of ecosystem service delivery in the Midwest (see Appendix B) to develop a set of working hypotheses about how each kind of ecosystem service is likely to change under each of our future scenarios

Landscape coverages – We have recently completed the first part of the BY landscape by combining existing cropland data coverages for multiple years and data from the Landfire database (produced by NatureServe, USDA and USGS). The data associated with this coverage include estimates of chemical inputs and typical management practices for individual sites across the region. Through a Memorandum of Understanding (MOU) with FSA (signed 23 June 2009) we expect to have access to additional land use data that will further improve this landscape and provide necessary input to the development of ecosystem service production functions.

Coordinating models of the agricultural and energy sectors – Through iterative model runs, we are using EPA's MARKAL energy-emissions model and Iowa State University's FAPRI System agriculture-sector model to coordinate the specification of future conditions projected to result from the Energy Independence and Security Act's biofuel targets.

Values hierarchy for Midwestern landscapes – We are refining a values hierarchy (see Appendix A) for the MS landscape, which will be used to elicit values for services from decision-makers. A condensed version of the hierarchy will be incorporated into the FML-EDT to allow users to change the values on priority services and compare maps reflecting others' values.

Evaluating candidate conservation practices – We have compiled a list of ten agricultural conservation practices as candidates to be incorporated in our MS landscape, and we are evaluating their suitability for simulation.

Comparing watershed model performance – for selected 8-digit HUCs, we are conducting comparisons of watershed models (SWAT, AnnAGNPS and SPARROW) to determine the best approach for our study

Enhancing online toolkit – Working directly with Regional Offices and other clients, we are improving usability and analysis capabilities for the EDT. This new EDT will allow decision-makers to quickly obtain answers for specific assessment questions and will provide improved drill-down capabilities through the linkage with a GIS (ArcServer) backend Metrics for the BY landscape are currently being calculated and will soon be incorporated into the FML-EDT.

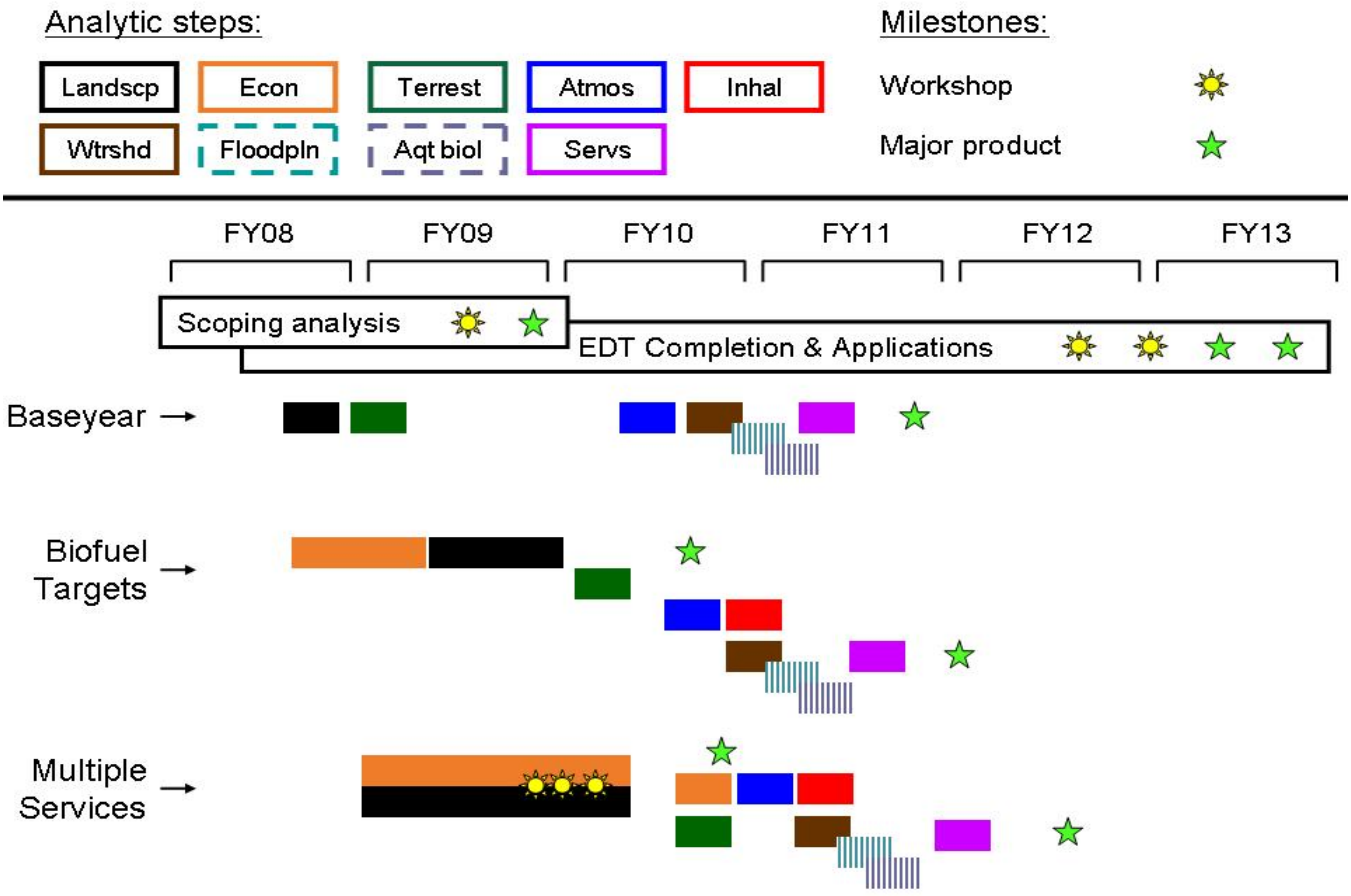


Figure 2. Timeline for the Future Midwestern Landscapes Study

1.4.2 Current Impacts, Critical Accomplishments and Innovations

- MOU with FSA recently signed, and interest in further developing decision support that will inform policy development and realization.

- In discussions with FWS on collaborative opportunities and anticipate a MOU within the coming months to allow collaboration on assessing impacts to habitat and identification of priority areas for conservation. A key factor in improving conservation decisions will include the integration of multiple scale assessments that link regional context with local decision-making.

- EPA's Great Lakes National Program Office (GLNPO) is using the current FML-EDT (and precursor, the EPA Region 5 EDT) to prioritize areas for management to improve water quality in Lake Michigan. GLNPO is using toolkit output in its outreach material. Michigan State University is using the Region 5-EDT to identify research support needed for improving water quality across the region.

- EPA Region 4 is currently evaluating the EDT as an aid to targeting watersheds for management actions through the development of a suite of watershed indices.

- Initial discussions are underway with the Army Corps of Engineers, Institute for Water Research (IWR) where, through their Hydrologic Engineering Center, we may be able to obtain assistance in modeling changes in flood risk associated with our alternative future scenarios. In return, EPA will provide access to the EDT and will work with IWR to include data and other information to assess the benefits associated with alternative watershed management options for areas they have responsibility for.

1.4.3 Publications and Papers Presented in 08/09 and forthcoming

Presentations made at the 2008 Symposium on Innovating for Sustainable Results: Integrated Approaches for Energy, Climate and Environment. Jan 7-10, Chapel Hill, NC:

"Future Midwestern Landscapes," Betsy Smith.

"ReVA's Environmental Decision Toolkit," Betsy Smith.

Presentations made at 2009 Biennial Meeting, US Society for Ecological Economics, May 31 - June 3, Washington DC:

"Estimating ecosystem service changes as a precursor to modeling," Bruins, Foster, Woodbury, Daniel, Franson.

"Spatially heterogeneous production functions: Concepts and applications to prioritizing restoration," Lisa M. Wainger.

"Ecological production functions: a theoretical and practical exploration." Alexander Macpherson.

Keynote presentation made at the European Commission Workshop on Ecosystem Services and Adaptive Management, June 25-26, 2009, Venice, Italy.

"Using ecosystem services to inform policy options: examples from EPA's Ecosystem Services Research Program" Betsy Smith

Publications:

Wainger, L.A. and J. Boyd. 2009. Valuing Ecosystem Services. Chapter 6 In: *Ecosystem-Based Management for the Oceans*. Karen McLeod and Heather Leslie (eds.) Island Press.

Manuscripts submitted:

Cooter, E.J., J.O. Bash, J.T. Walker, M.R. Jones and W. Robarge. "Estimation of NH_3 Bi-directional Flux from Managed Agricultural Soils." Submitted to *Atmospheric Environment*

Bash, J.O., J.T. Walker, G.G., Katul, M.R., Jones, E., Nemitz, and W. Robarge. "Estimation of in-canopy ammonia sources and sinks in a fertilized *Zea Mays* field. Submitted to *ES&T*.

Manuscripts in progress:

Bruins, R.J.F., et al. Hypotheses of direction and magnitude of change associated with ecosystem service provision under alternative policies affecting land use in the Midwest.

Mehaffey, M.A., R. van Remortel, E.R. Smith, and R.J.F. Bruins. Developing an augmented land cover classification for assessing ecosystem services.

Wainger, L.A., What do we need from ecological production functions to generate measures of social benefits?

Macpherson, A. and R. Iovanna, Targeting and evaluating conservation investments for on-site and off-site benefits using Data Envelopment Analysis.

Macpherson, A., et al., Ecological production functions: a theoretical and practical exploration.

Macpherson, A., et al. Using an Ecosystem Service Index to target conservation investments.

Manuscripts planned:

Regional ecosystem services assessment with linear programming - a case study of the extended Midwest region. (Tran lead author)

Hydrological analysis for ecosystem services assessment at regional scale - - a case study of the extended Midwest region. (Tran lead author)

Documentation (perhaps journal article) of the fertilizer scenario tool (Cooter lead author)

Journal article describing the revised bidirectional ammonia model as implemented in CMAQ (Jon Pleim lead author)

Journal article describing national bi-directional ammonia pilot analysis (Megan Gore lead author, NC State MS Student thesis)

Journal article describing mosaic dry deposition methodology (Donna Schwede lead author)

1.4.4 Resources

Estimated EPA contributors: ~6 FTE distributed over 20 individuals

Non-EPA FTE contributing to the project via partners/clients: ~1 FTE distributed over 5 individuals

Estimated budget requirements beyond EPA salaries (these are amounts being applied to support contracts):

	Spent in FY09	Need (cum. next 2 years)
Landscape development	125K	125K
Values workshops	75K	150K
EDT development	50K	250K
Watershed modeling support	50K	100K
Other modeling support		150K
Totals	300K	775K

1.5 Response to Comments

1.5.1 Response to Program Office Comments

There were no substantive comments from the program offices on our implementation plan or in subsequent discussions with them . We are continuing to interactive with both the Office of Water and with the Office of Air and Radiation on the development of the alternative scenarios and the quantification of ecosystem services and changes.

1.5.2 Response to SAB Comments

In its September 30, 2008 review of the ESRP Multiyear Plan, the SAB EPEC expressed surprise that the FML study (among other ESRP components) did not address transboundary pollution issues.

Transboundary application is difficult in a modeling study such as FML that relies on large existing data sets that frequently are national rather than international in scope. The modeling domain of the Community Multiscale Air Quality (CMAQ) Modeling System, which will be used in the Future Midwestern Landscapes (FML) Study, does indeed extend into Canada. However, EPA's MARKet ALlocation (MARKAL) energy system model, which the FML Study will be using to project future emissions, does not. Therefore, EPA's air modelers expect to work with the Canadians to apply some simple scaling up factors to Canadian emission inventories so that CMAQ can be used in the analysis of alternative futures. Transboundary watershed modeling also is greatly hampered by the lack of comparable land use coverages and therefore will not be attempted as part of this demonstration. For example, while we will estimate US loadings to the Great Lakes originating from the FML Study area, as well as export via the Red River of the North, we will not attempt to model water quality within the Great Lakes or Lake Winnipeg.

In its October 2007 commentary on ways to improve ecological risk assessments, the EPEC recommended describing ecological endpoints in lay terms, relating these endpoints to protection options and pursuing improvements in endpoint valuation. The SAB's May 2009 report on Valuing the Protection of Ecological Systems and Services touched on similar themes. The FML is using **decision science** (analytical hierarchy process or AHP) to elicit an initial set of weights for ecosystem services for creating an optimized Multiple Services scenario. This hierarchy **explicitly identifies ecological resources** that are expected to change under alternative policies. The MS scenario uses the best conservation science to **illustrate options** for conserving services which will be contrasted to an existing policy scenario where stresses associated with land management (e.g. agricultural chemical inputs and habitat loss) are anticipated to be greater. Both scenarios include **ongoing change processes** associated with increasing population and development at a **broad regional scale** (12 states) and for a 20-year time period. **Uncertainties** associated with modeling have first been estimated through our scoping process and will be augmented with sensitivity analyses for the models used to estimate endpoints for each model that does not estimate uncertainty.

The value of ecosystem services that are expected to change will be quantified using the **decision science** method (AHP), development of **benefits indicators** (reflecting scarcity/capacity indicators, benefit response curves, acceptable risk) and **spatially explicit biophysical rankings** (an ecosystem services index) that reflect a land parcel's current provision of services, as well as the capacity for provision of services under a viable incentives program. The results of our assessment, including **net environmental benefits** (e.g. ecosystem services index) will be communicated to decision-makers though an online environmental decision toolkit (EDT) that **combines the best of a web-based statistical package (SPlus) with a GIS package (ArcServe)**. The EDT provides advanced visualization and synthesis capabilities, multi-scale analysis, and linkages to other applications that provide assistance to landowners.

We expect that **the results of this study can be used by EPA** to inform the Greenhouse Gas Rule and future climate-related air regulations, future regulatory decisions on particulate matter, and decisions regarding water quality for the Gulf of Mexico. At a regional scale, the results of this study should be able to inform NPDES permitting by capturing estimates of cumulative site-specific stresses. **Outside EPA, we hope that the results of this study will be used** to inform future conservation policies by the Farm Service Agency and the US Fish and Wildlife Service. Additionally, study results could inform local decision-makers, particularly when paired with other finer-scaled assessment and management applications that are linked to the online decision toolkit.

1.6 Challenges

Significant scientific challenges:

Selecting future scenarios that are tractable in number (for example, two) yet nonetheless capture the critical decision variables for our clients.

Gathering and integrating information on conservation practice effectiveness and adoption rates, along with decision-makers' values, to simulate the MS scenario

Developing a rules-based spatial model to appropriately place those conservation practices onto the MS landscape is an important challenge, given the various ways that both the immediate and expanded spatial contexts of a pixel/parcel must be examined, considering the dependence of wildlife-based services (and potentially others) on large-scale spatial arrangements.

Significant organizational challenges:

Maintaining ongoing coordination among members of a multi-location project team

1.7 Future Directions

Most important ongoing tasks:

Solidify FSA and FWS working relationships and MOUs

Complete BY & BT landscape coverages

Clarify watershed and aquatic community modeling approaches

Complete and pilot values hierarchy

Select conservation practices to be included in MS landscape

Next set of tasks:

Use BY and BT landscapes as part of an outreach effort to initiate product-focused dialogue with several major clients, including GLNPO Lake Michigan Program, Iowa Soybean Association and others

Complete scoping exercise as FY09 deliverable

Plan values hierarchy workshops; leverage for maximum partner involvement

1.8 Appendices

Appendix A: FML Hierarchy of Values and Ecosystem Services

Appendix B: FML Conceptual Model: Example depicting comparison of two 2022 futures: Biofuel Targets (BT) as compared to No Biofuel Policies (NP)

Appendix C: Experts' Contributions to FML Study

Appendix D: List of Future Products of FML Study

Appendix E: FML Study linkages to ESRP Nitrogen and Wetlands themes, and how global climate change (GCC) relates to FML

Appendix A: FML Hierarchy of Values and Ecosystem Services

For any given cell, the question *Why is this important?* is answered moving to the left, whereas the question *"What is meant by this?* is answered moving to the right. Rightmost entries fundamentally contribute to quality of life; bolded, leftmost entries are treated as basic ecosystem services. Bolded entries will be comparatively valued by managers and scientists in planned, values elicitation workshops. Indented cell entries should be read as continuations of the above entry. Extends over five pages.

Improve Health	Min Illness	Min water-related illness	Purify (make potable) Water	***Water quality***
and Safety			Ensure water availability	***Groundwater storage***
				Surface water storage
			Min Pests (Pest Damage)	***Biodiversity***
		Min air-related illness	Max/Ensure Air Quality	***Air Quality***
	Min Deaths	Max flood safety (=Min flooding)	***Flood moderation***	
	Min injuries	Max flood safety (=Min flooding)	***Flood moderation***	
Increase Economic	Min reduced potential	Max Avail. of Nat'l Capital	Min Pests (Pest Damage)	***Biodiversity***
Benefits	for agric production	(Nat. "resources")	Max/Ensure Air Quality	***Air Quality***
			Ensure Water Availability	***Water quality***
				Groundwater storage
				Surface water storage
			Minimize erosion	***Flood moderation***
				Natural cover
			maintain soil productivity	***Soil Quality***

		Ensure pollination potential	***Biodiversity***
			Natural cover
	Avail. of agricultural technology	Maintain genetic stocks for breeding	***Biodiversity***
			Natural cover
Min reduced potential for	Min Pests (Pest Damage)	***Biodiversity***	
forestry production	Ensure Air Quality	***Air Quality***	
	maintain soil productivity	***Soil Quality***	
Min reduced pot. for indus prod'n	Ensure Water Availability	***Groundwater storage***	
		Surface water storage	
	Min loss to infrastructure & property	***Flood moderation***	
	Ensure Water Quality	***Water quality***	
	maintain soil productivity	***Soil Quality***	
	Min Pests (Pest Damage)	***Biodiversity***	
Min loss of potential fishery	Lost Benefits derived from Midwest	***Water quality***	
benefits		***wildlife (target fish)***	
	Lost Benefits Outside (e.g., GOM)	***Water quality***	
		wildlife (target fish)	
Min potential property/capital	Minimize loss from pests	***Biodiversity***	
loss	Minimize flood hazard	***Flood moderation***	
Min Lost Outdoor Recreation	min lost Hunting opportunities	***wildlife (target species)***	
potential	min lost Fishing opportunities	***wildlife (target fish)***	
		Water quality	

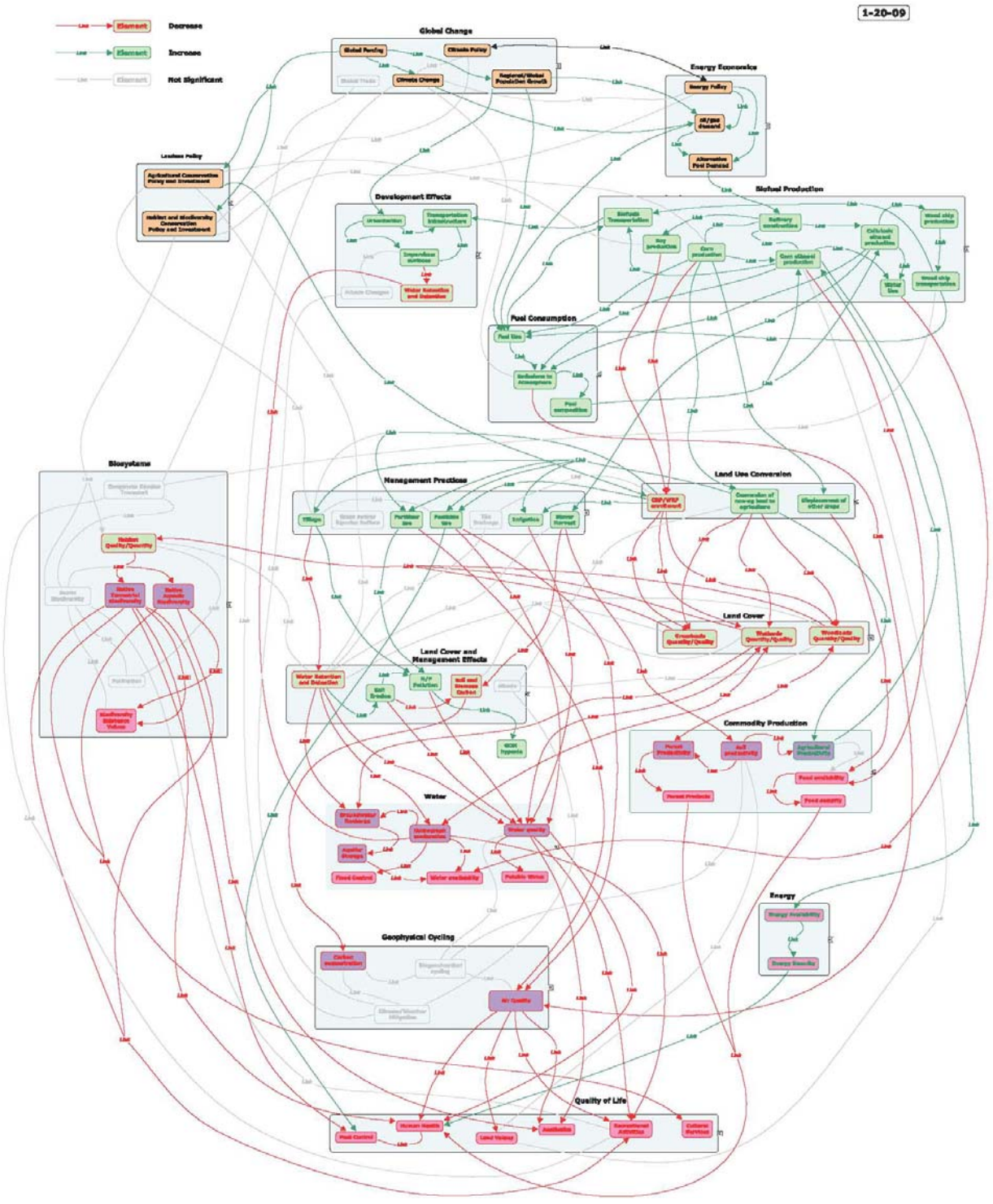
		min lost Hiking opportunities	***open space (forests, meadows,…)***
		Min lost Boating oppor	***Natural cover***
			Lanscape mix
			Water quality
		min lost wildlife watching opportunties	***Biodiversity***
Improve Sociocultural Sustainability	Min loss of the rural aesthetic (a.k.a. rural landscape)	Landscape Mix	***Lanscape mix***
		visibility	***Air quality***
	Min Impacts on Subsistence activities	Impacts on hunting opportunities	***wildlife (target species)***
		Impacts on fishing opportunities	***wildlife (target fish)***
		Impacts on native species	***Biodiversity***
	Min Lost Outdoor Recreation potential	min lost Hunting opportunities	***wildlife (target species)***
		min lost Fishing opportunities	***wildlife (target fish)***
			Water quality
		min lost Hiking opportunities	***open space (forests, meadows,…)***
		Min lost Boating oppor	***Natural cover***
			Lanscape mix
			Water quality
	Min Adverse Impacts on Trad'l Rural Livelihoods	Impacts on Ag Production Jobs	***Soil Quality***
			Water quality
			Surface water storage
			Groundwater storage

			Biodiversity
			Natural cover
			Flood moderation
		Impacts on Processing Jobs	***Same as ES for Ag Production Jobs***
		Impacts on Forest indus jobs	***Same as ES for Ag Production Jobs***
		Impacts on recreation jobs	***Same as ES for Ag Production Jobs***
Min Ecological Impacts ("Existence Values")	Maximize viability of migratory bird species	In Midwest Study Area	***Wildlife (target species)***
			Biodiversity
			Water quality
			Natural cover
		Outside of Midwest Study area	***Wildlife (target species)***
			Biodiversity
			Water quality
			Natural cover
	Maximize viability of aquatic species	In Midwest Study Area	***wildlife (target fish)***
			Water quality
			Natural cover
		In marine systems in GOM	***wildlife (target fish)***
			Water quality
			Natural cover
Be Precautionary	Minimize Climate Change	Min Net CO2 Additions	***Carbon storage***

w.r.t. Large-Scale Risks		Min Net CH4 Additions	***Carbon storage***
("Risk Aversion")	Minimize Risk of Biodiversity	minimize loss of migratory species	***Wildlife (target species)***
	Collapse		***wildlife (target fish)***
			Biodiversity
			Water quality
			Natural cover
			Air Quality
		maintain populations of native species	***Wildlife (target species)***
			wildlife (target fish)
			Biodiversity
			Water quality
			Natural cover
			Air Quality
		minimize invasive species	***Wildlife (target species)***
			wildlife (target fish)
			Water quality
			Natural cover

Appendix B: FML Conceptual Model: Example depicting comparison of two 2022 futures: Biofuel Targets (BT) as compared to No Biofuel Policies (NP)

Drivers are orange, services are pink. Green arrows indicate relationships that increase in this scenario comparison, red arrows are decreases. Grayed arrows are not important or not changed in this comparison



Appendix C: Experts' Contributions to FML Study

Expert (expertise)	FY2009 hours	Areas of critical contribution
Lisa Wainger (landscape ecology and economics)	700	Hours apply to tasks in support of ESRP Valuation Theme as well as FML Study <u>Support of FML</u> Definition of ecosystem services, development of ecological production functions, development of decision support system <u>Support of ESRP Valuation</u> Convener for ESRP Economics Network Developing ecosystem service classification approach
Peter Woodbury (ecology and risk assessment of bioenergy systems)	200	Development of scoping analysis (conceptual models and hypotheses) for FML
Liem Tran (decision science, statistics, modeling)	400	Development of analytical hierarchy of values for FML Study Comparative analysis of environmental models for use in FML Development of landscape optimization procedure for development of MS landscape Preparation of a new GIS backend for the EDT (and integrating with existing SPlus version)

Appendix D: List of Future Products of FML Study

The list below describes the five earliest FML products.

Product	**Completion date**	**Description**
FML Scoping analysis	Sept 2009	Assessment hypothesizing the directions and orders of magnitude of potential changes in land use patterns, environmental stressors and ecosystems services for two alternative future scenarios in the Midwest
Maps for FML BY & BT landscapes	Sept 2010	Methods & maps for current (BY) and future Biofuel Targets (BT) landscape coverages, including N fertilizer loadings & wetlands
Online EDT with landscape coverages and statistics for BY and BT landscapes	Sept 2010	EDT users will be able to use EDT to compute descriptive metrics based on landscape coverage data for Baseyear (BY and Biofuel Targets (BT) landscapes
Map for MS landscape	Dec. 2010	Methods & maps for Multiple Service (MS) landscape coverages, including N fertilizer loadings & wetlands
Ecosystem service analysis for BY landscape	Sept 2011	Ecol. production functions, service indices & coverages for Baseyear (BY) landscape

Appendix E: FML Study linkages to ESRP Nitrogen and Wetlands themes, and how global climate change (GCC) relates to FML

Nitrogen: We will estimate and map current and alternative-future atmospheric exchange and fertilizer loadings and stream loadings (at 8-digit HUC scale) of Nr for our study area. In that we also will be estimating services over this area, it may be possible to derive statistical relationships between these loadings and services.

Wetlands: The FML study is using existing wetland coverages from the 2001 National Land Cover Dataset, augmented by vegetative-type descriptions from the LANDFIRE data base. In the future we may be able to update this information through landscape modeling of wetland classes anticipated to be developed by ESRP Wetlands. The timing of this development will determine whether it will be possible to incorporate improved classification information in FML modeling of ecosystem services.

GCC: Midwestern landscapes change rapidly with agricultural market conditions, because they are agriculturally dominated. Since we are generating relatively near-term (2022) future scenarios, our analyses cover a timespan in which climate change signatures will not be distinguishable from interannual variability. Therefore, GCC per se not be reflected. However, agricultural practices are expected to respond in the near-term to carbon-market opportunities, and we will calculate carbon sequestration-related services for our landscapes.

Ecosystem Services Research Program
Tampa Bay Ecosystem Services Demonstration Project
Marc Russell, Gulf Ecology Division, NHEERL
Status Report and Future Directions: June 22, 2009

1.1 Project or Theme Goal

The Tampa Bay Ecosystem Services Demonstration project will illustrate how regional and local managers can proactively use alternative future scenarios to conserve and enhance the integrity and productivity of ecosystems , and the goods and services they produce to benefit human well-being.

1.2 Conceptual Model and Description

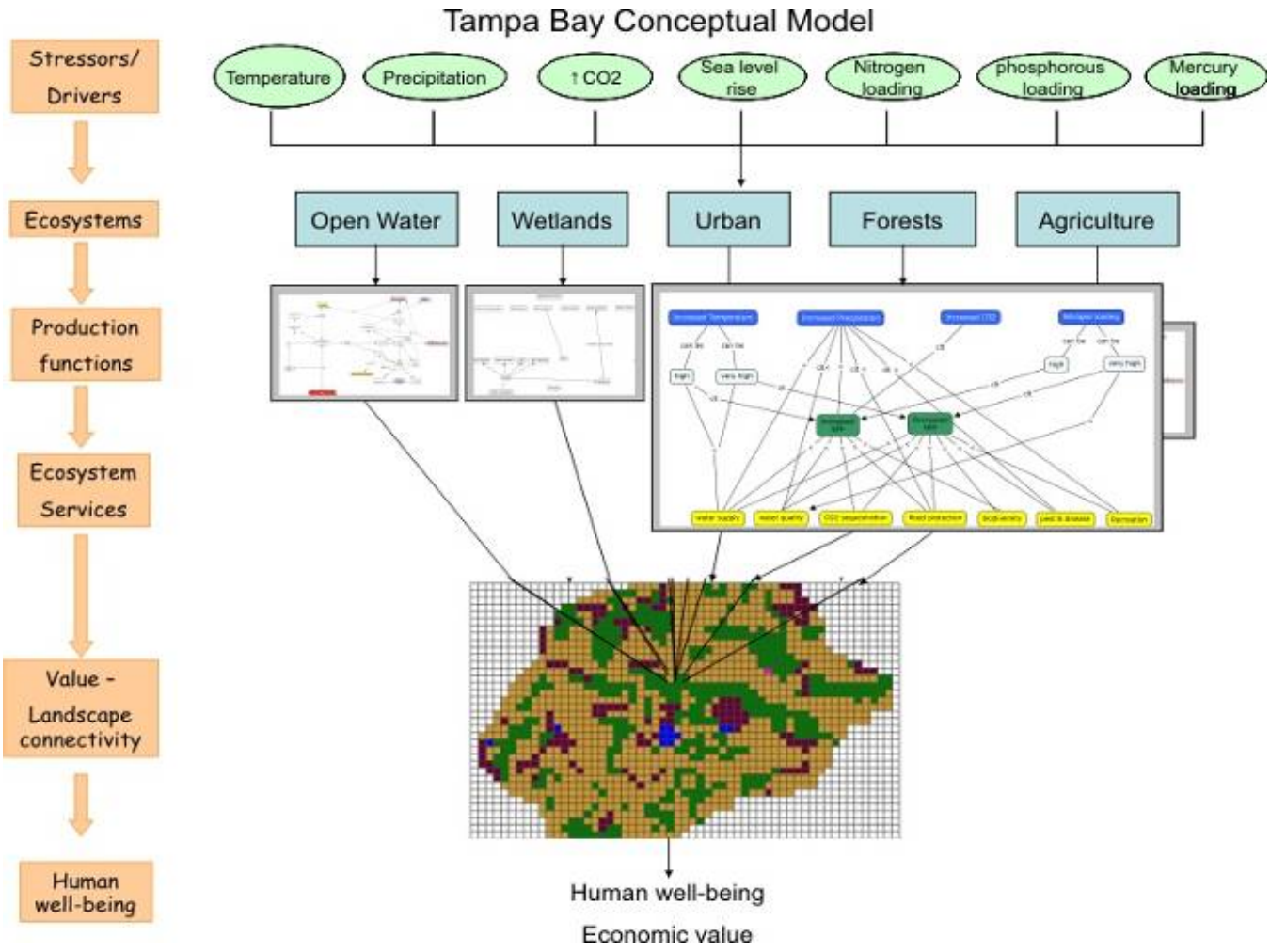


Figure 1. We are linking stressors and drivers to production functions in various ecosystems. These functions are then translated into services with value to humans in a spatially explicit manner. Stressors and drivers will then be defined by multiple future scenarios so that the production of services can be compared.

1.3 Expected Impact/Rationale

The Tampa Bay region is faced with some tough decisions on how to manage their natural systems as population continues to grow and the watershed becomes more urbanized. We are linking stressors and drivers to important production functions in various ecosystems. These functions are then translated into services that humans value. The effects of defined stresses, such as climate change or urbanization will be modeled in alternative future scenarios so that the production of valued services can be coupled to decisions about competing uses of the landscape. Ultimately we want ecosystem services to be considered in land use, zoning, and other planning decisions. To facilitate this outcome we are working towards getting key groups in the Tampa Bay region to understand the concepts of ecosystem services and to then promote and champion the consideration of impacts on ecosystem services by decision making officials

1.4 Current Status

1.4.1 Research Underway in FY 2009

The iterative and adaptive approach to Tampa Bay started by combining input of local information from a technical advisory group in Tampa with initial literature searches and development of a conceptual map. We assessed the state of knowledge, importance, and relative value of ecosystem services to inform our draft implementation plan in 2008. Reviewer comments on the implementation plan were then addressed at a January 2009 workshop that gathered Tampa Bay science experts and managers. At that workshop we refined our conceptual models, validated our state of knowledge, and identified priority questions to address.

Water quality regulating ecosystem functions, such as those responsible for controlling nitrogen processing rates in wetlands, were identified as a priority research area. We are currently developing a research task focusing on this priority.. Another critical question identified is how to connect upstream ecosystem types to those downstream using an accounting unit that is scaled appropriately for use by local decision makers. This is critical to the identification of the beneficiaries from biological functions producing ecosystem services as well as spatially locating stressor response relationships in the landscape.

The “open water group” - focused on seagrass based ecosystems - identified the intermediate services of water quality regulation as important. The group also suggested that influential stressors, such as human usage, should be linked to the intermediate service of habitat support for biodiversity and the resulting final service of food and fiber generation. (Deficiencies in the knowledge base for ground water’s influence on water quality and human use effects on habitat structure and function were identified as potential places for research to focus on if resources become available.

The project is currently developing a linked model to assess the influence of nutrient loading on water quality and its subsequent effect on light attenuation and sea-grass growth. These models will then be tied to a fishery production model with results being translated into human benefits and value of this final ecosystem service for the recreational fishery in Tampa Bay.

The above mentioned projects and modeling efforts rely heavily on well reviewed literature searches. We have already completed an extensive literature search for seagrass ecosystems and are currently reviewing that literature for ecological production functions. The Tampa Bay wetlands group is partnering with the larger ESRP wetlands group and supplementing their literature searches and reviews by including local reports and ongoing projects. The current Tampa Bay team has little expertise in agriculture and forest issues so we are pursuing outside collaborative help to provide us with existing information.

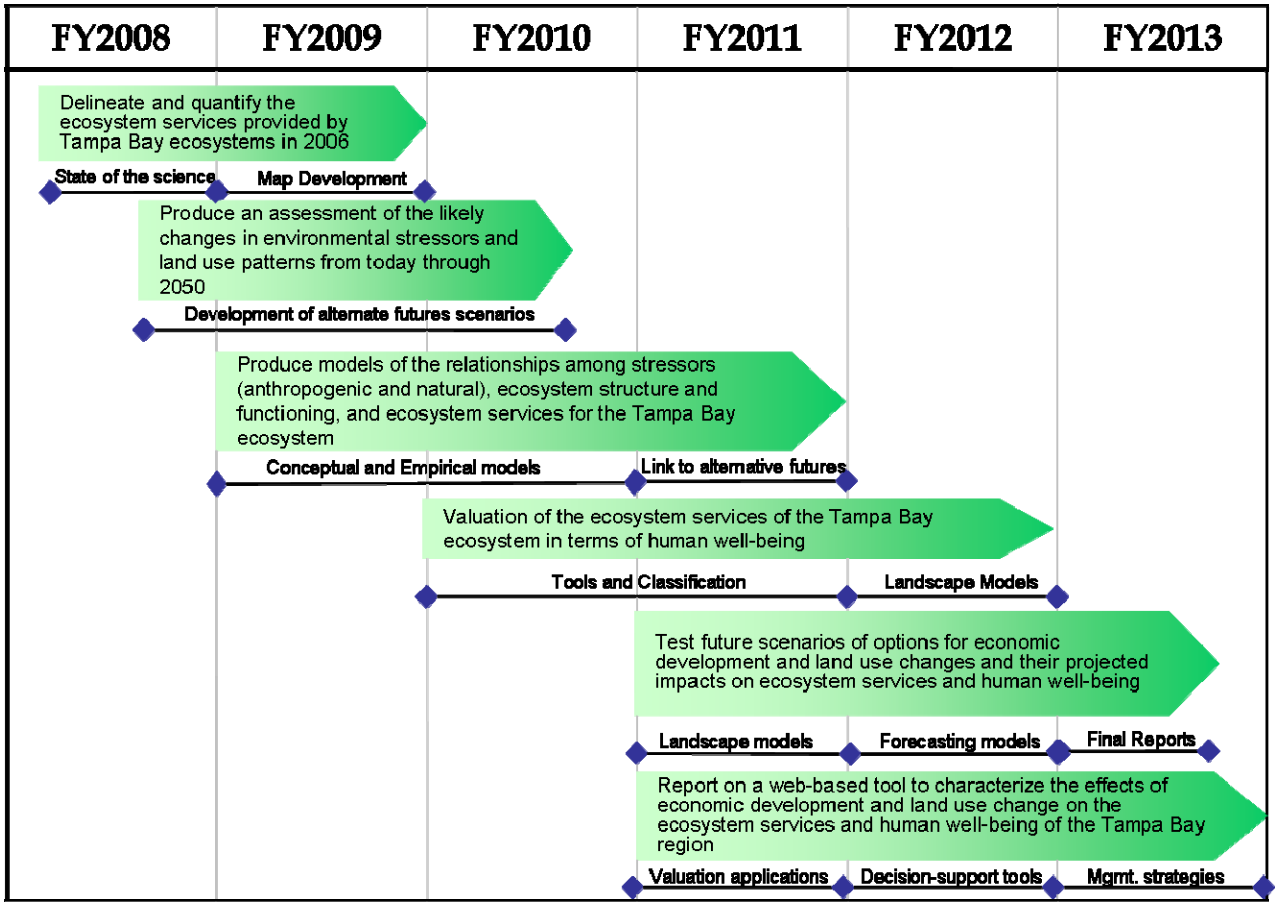


Figure 2. General trajectory of Tampa Bay research as planned for the next 5 years

To identify knowledge gaps for making the critical project steps we have developed concept maps for each ecosystem type (See Appendix B). These have been revised during a workshop and have been standardized to show both the importance of services and the amount of information available for translating drivers to functions and then to services.

The Tampa Bay Ecosystem Services Demonstration Project implementation plan was sent out for external peer review in July 2008 after completion of internal peer reviews. Reviews were competed and a reconciliation memo addressing our response to the reviewer's comments was sent to the reviewers in November 2008. The Tampa Bay team, which includes researchers in 9 scientific disciplines, is currently working with the other ESRP teams, our many outside agency

partners (see Figure 3), and our hired experts (David Yoskowitz - Ecological Economist, George Henderson – Fish and Wildlife) to edit the implementation plan to reflect the many refinements we are making in response to peer reviewer comments. We are also scaling back the plan to be more practical given staff, resource, and time limitations while also adding detail to those tasks that are critical to the success of the project.

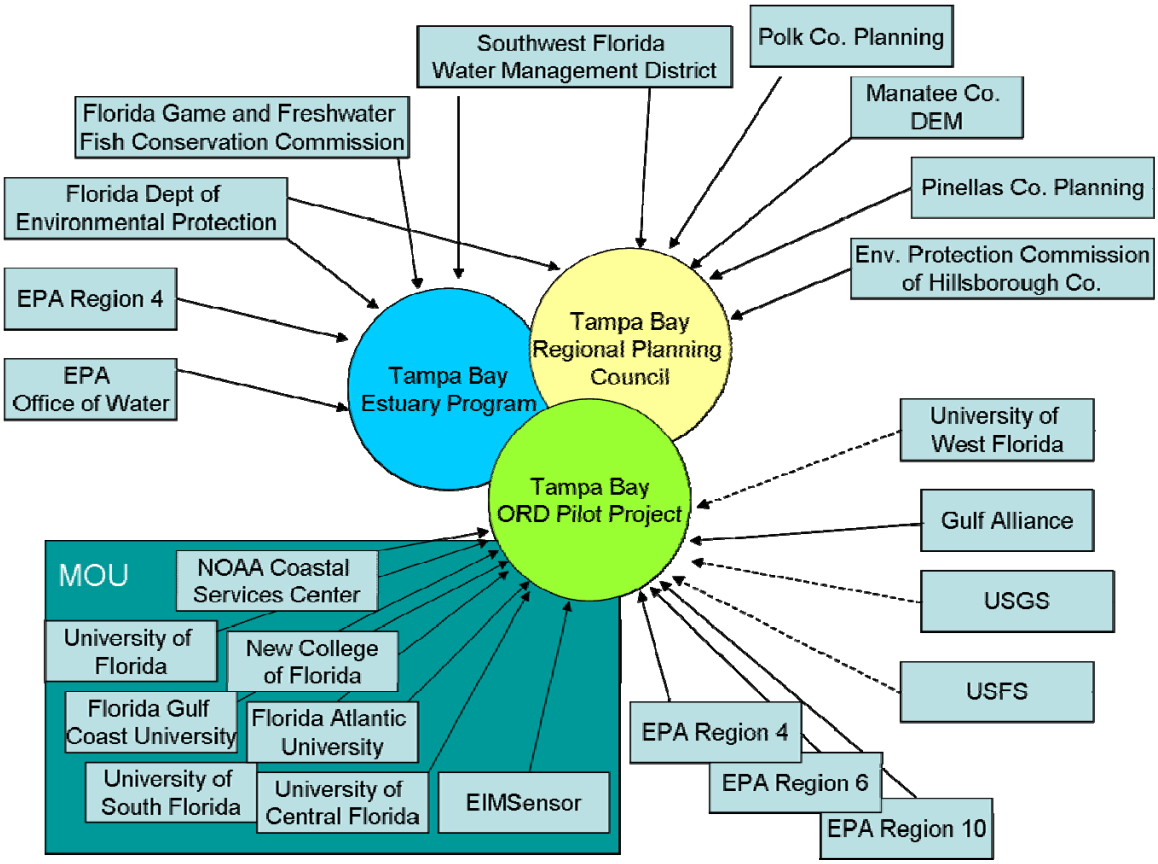


Figure 3. Relationships between the ESRP Tampa Bay team and outside partners.

1.4.2 Current Impacts, Critical Accomplishments and Innovations

Technical advisory group has been created to provide advice and feedback on conceptual models, issues of interest, and early products at local, county, and regional scales.

A total of 7 MOUs with academic institutions and one MOU with a private company are complete. These arrangements have allowed us to work with outside experts on our research planning and have fostered collaborative research efforts.

Conceptual maps linking predicted stressors, through ecological functions and processes, to ecosystem service production endpoints have been developed, refined during a workshop, and standardized for research prioritization.

Extensive but focused literature searches are either complete or are ongoing. Reviews of this literature will provide values for mapping ecological process rates, be linked to our conceptual maps to produce a decision support tool, and will help identify specific research needs.

Local liaison individual has been identified and is being pursued as an ESRP expert hire.

An initial valuation of different ecosystem services was produced through the development of a local relative valuation index that we piloted in Tampa in December 2008 with a small set of local resource managers and scientists generally knowledgeable about ecosystem services. We infer from the results of this valuation pilot that the ecosystem services of water quality regulation, habitat functions, and freshwater supply may be of higher value than others including recreation, aesthetics, flood control, and climate regulation.

We are collaboratively producing a brochure with key Tampa groups to help them promote the concepts of ecosystem services.

1.4.3 Publications and Papers Presented in 08/09 and forthcoming

Presentations –

- "Ecological Services – Research Approach, Tampa Bay" – ACES conference December 10th, 2008. Naples FL.

- "Tampa Bay Ecological Services Demonstration Project" - ESRP program update February 26th, 2009. Webinar

- "Mapping Ecosystem Services in Tampa Bay, FL" – US-IALE conference April 15th , 2009. Snowbird UT.

Forthcoming:
Presentations –

- "Mapping Ecosystem Services in Tampa Bay, FL" – CERF conference November 2009. Portland OR.

- "Synthesis of existing development and climate change scenarios with links to ecosystem services." – CERF conference November 2009. Portland OR.

Manuscripts –

- "Ecosystem Services Research Prioritization Approach – Tampa Bay"

- "Hurricane Impacts on Ecological Services and Economic Values of Urban Forest"

- "Mapping ecosystem service generating landscapes – Spatial accounting units"

- "Using high-resolution land cover data to generate a relative index of stormwater mitigation ecoservices"

- "Accounting for natural resources and environmental sustainability: Linking ecosystem services to human well-being"

1.4.4 Resources

Approximately 4-5 FTE are actively working on this project. We are currently submitting multiple proposals with outside collaborators to leverage outside EPA funding sources as well as tapping into the ESRP programmatic funding for nitrogen. If successful we will need travel and supply support for our current staff to complete these funded projects.

We have approximately 1 FTE of effort coming from our outside partners/clients.

1.5 Response to SAB Comments

The SAB expressed concern that program funding and resource availability might be insufficient to meet the ambitious program goals. The Tampa Bay project has responded to our resource limitations by involving potential end users of our products in planning and prioritizing what research would generate the most improvement in our ability to quantify, map, and predict the production and delivery of ecosystem services both today and in the future. Research efforts have been prioritized using a cost- benefit type analysis factoring in importance to stakeholders, economic impact, and research achievability given current funding and time constraints. A significant effort has been made to identify those knowledge gaps that are most important to fill. Critical gaps in expertise have been somewhat alleviated by use of the ESRP expert hire program to hire an ecological economist and a fish and wildlife expert.

We are also aware that project success requires that the tools generated must be used by the range of local to regional decision makers. To that end we have initiated an iterative development process with early products being evaluated by stakeholders for both content and format. To facilitate this iterative approach we have taken steps to identify, meet, and update a range of regional to local decision makers representing the majority of interests in the Tampa Bay region. We have also begun the process of informing and gathering feedback from both our regional office partners and the national offices.

The SAB recommended that we clearly describe existing and planed interactions among proposed research program components, with other Agency Programs, and with other federal agencies involved in assessment of ecosystem services. The focus of the Tampa Bay project has subsequently shifted to become more aligned with the other ESRP efforts, especially the national focus on nitrogen and wetlands. This alignment serves to integrate our work with others in the agency, thus better leveraging our existing capabilities, but is, fortunately, well aligned with feedback on priorities from our regional and local stakeholders. We are currently planning a cross place based assessment of the production of two specific final ecosystem services that are both influenced by the intermediate service of nitrogen regulation and that provide real benefits in the Tampa Bay and other regions. We are also heavily focused on completing studies of nitrogen regulating processes and associated service production in representative wetland types in the southeastern U. S. which includes both the Tampa Bay region but also the Coastal Carolina's placed based study but also holds the majority of U. S. wetlands. To better facilitate a scientific community level effort to assess the status and trends of ecosystem services in the U.S. we have set in motion several collaborative efforts which include research with NOAA, USGS,

and USFS. We have also completed MOU's with a suite of academic institutions with scientific expertise relevant for this place based project and a private company with expertise in web-based decision support development. Through the many partnerships we have initiated we are addressing the SAB concerns that we had not clearly defined how EPA would provide the expertise to accomplish valuation, decision support, and outreach and education that ultimately will allow us to link our ecological production functions to economic and human well-being endpoints.

Our research goals have been vetted through an external peer review of our implementation plan. Our overall project conceptual model and goals have not changed but heavy revisions of specific research efforts are underway to address the reviewer comments. Many details are being added so that individual research components can be assessed for their degree of potential for success, uncertainty, as well as their usefulness to the overall project. Our iterative tool development approach will continue to allow us to reform and redirect our research driven tools to better meet the design requirements of end-users, while maintaining sufficient separation from the research process for results to be scientifically credible and unbiased.

1.6 Challenges

While our core group at GED and outside agency partners continue to identify research priorities, expertise to address many priorities exists in other divisions and organizations .It remains difficult to get the right people and groups together without sufficient information on available funding.

The hiring of experts, post docs, and student contractors is a long process and is becoming increasingly difficult to coordinate with our dwindling administrative support. We have insufficient funds to enable our ecological economist (expert hire) to conduct needed valuation studies in the Tampa Bay region forcing him to use his existing database information and benefit transfer methods to estimate Tampa specific values.

We have had to re-focus proposed research projects on what can be done with existing personnel and budget. While this does make the research more practical and accomplishable, gaps in knowledge in areas of de-emphasis may adversely affect model certainty during future scenario ecosystem services production predictions.

1.7 Future Directions

While we focus on defining the relationships between stressors, functions, and services and mapping them we are also assessing existing scenarios for comparison with our baseline 2006 landscape . Several alternative scenarios have been developed for the Tampa Bay region. Modeled landscapes show predicted land use for 2010 (SWFWMD 2002), predicted development intensities for 2025 (Xian and Crane 2005), and we can also draw upon two alternative scenarios of urban development out to 2060 (Barnett and Dobshinsky 2007). The Tampa Bay Reality Check exercise (http://www.realitychecktampabay.com/) has also generated landscape maps for the location of the 2050 predicted population through an interactive process with Tampa Bay citizens in an attempt to promote regional scale management of what could be a potentially large and damaging influx of people to the area.

The Tampa Bay Ecosystem Services Demonstration Project must feed organized information and research findings into a decision support tool so we can reach our project outcome of getting ecosystem services considered in Tampa land use, zoning, and planning decisions. This tool must be able to map ecosystem service production, identify beneficiaries of those services and allow managers to assess alternative scenarios using a common currency. We are collaborating with EIM sensor (www.eimsensor.com), a company specializing in real time monitoring and visualization of environmental data. EIM sensor is also working with the ESRP decision support framework group. EIM sensor has developed a dashboard interface that allows for spatial selection of areas of interest, visualization of simulations of alternative scenario inputs, and provides a reporting out function that is both visually pleasing and informative for decision makers and their staff. This integrative tool could be used to present information on current and predicted functional rates and values of resulting ecosystem services from a user defined area. Ultimately we hope that the tools can help local managers deal with tough decisions by providing them with information on the ramifications of their decisions to the services the Tampa Bay regional population relies on for their continued health and well-being.

Literature Cited

Barnett, Johnathan and Andrew Dobshinsky. 2007. An Alternative Future: Florida in the 21st Century 2020, 2040, 2060. Prepared for the Metropolitan Center for regional Studies at the University of Central Florida by the City Planning 702 Urban Design Studio at the University of Pennsylvania. Available at http://www.1000friendsofflorida.org/planning/2060.asp

SWFWMD (Southwest Florida Water Management District). 2002. Future Land Use GIS Shapefiles for the Southwest Water Management District, FL. Available from http://www.tampabay.wateratlas.usf.edu/Default.aspx

SWFWMD (Southwest Florida Water Management District). 2004. Current land Use GIS Shapefiles for the Southwest Water management District, FL. Available from http://www.tampabay.wateratlas.usf.edu/Default.aspx

Xian, George and Mike Crane. 2005. Assessments of urban growth in the Tampa Bay watershed using remote sensing data. Remote Sensing of Environment 97:203-215.

1.7 Appendices

Appendix A: Hierarchy of services being addressed in research described

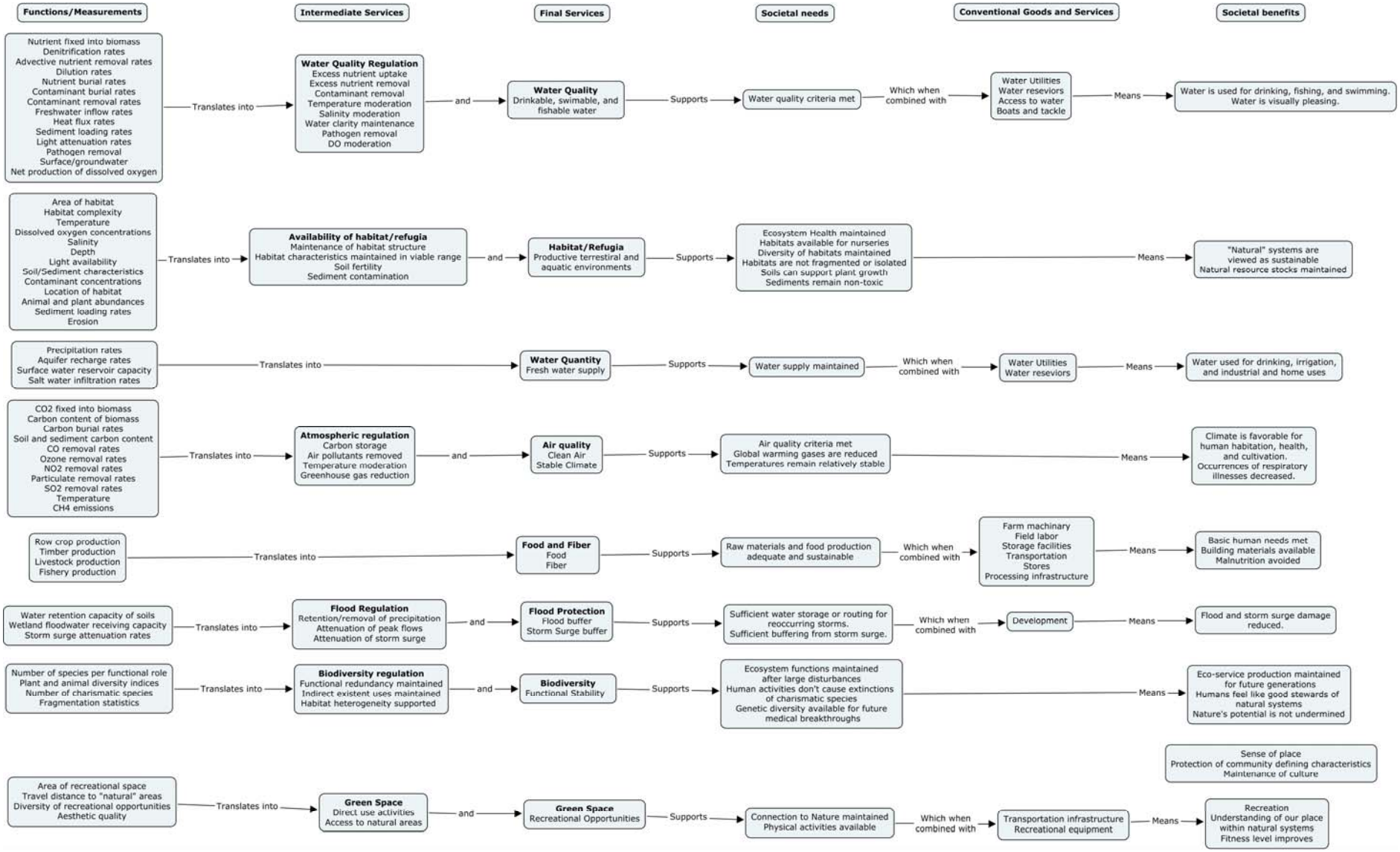


Figure A1. Many ecological functions and physical processes produce final ecosystem services which either directly or in combination with conventional goods and services provide benefits to humans.

Figure A1 provides an illustration of the linkages between those intermediate and final services of interest in this Tampa Bay demonstration pilot project. Through literature reviews we are finding values for some of the functions/variables that produce services. These values are generally not Tampa specific and should be used with caution. Some values just don't exist. These are and will be identified as knowledge gaps by our work and may serve as justification for further research after this pilot. The priority service of Water Quality is missing some critical literature values. Pilot research efforts will address those functions associated with nitrogen processing in wetlands and their effect on water quality as a final service. We will also focus on nitrogen and other contaminants movement through upland/wetland/open water systems in an effort to quantify water quality as an intermediate service that affects habitat and refugia and their production of the final service of shell and finfish stocks. Exact units for each measure leading to services are still to be determined from our literature reviews.

Appendix B Conceptual model and most significant scientific uncertainties (critical path)

The project conceptual model (figure 1 above) shows the general linkages between stressors and drivers to production functions in various ecosystems. These functions must then be translated into services with value to humans in a spatially explicit manner. Stressors and drivers will then be defined by multiple future scenarios so that the production of services can be compared.

To identify knowledge gaps for making the critical project steps we have developed concept maps for each ecosystem type in Fig. 1. These have been revised during a workshop and have been standardized to show both the importance of services and the amount of information available for translating drivers to functions and then to services.

Agriculture and forest concept maps identified water quality as the primary service of concern with several secondarily important services. In this context water quality mainly relates to constituent loading to downstream ecosystems and thus acts more as a stressor on wetland and open water systems than a service provided by agricultural or forested land which are designed mainly for production of food and fiber. A lot of information already exists on the production of food and fiber and the water quality outputs from these landuse activities, but as noted by workshop participants there is still a basic need to identify where on the landscape specific agricultural and forested land are located.

The emphasis on water quality as both a stressor and a service continues through wetlands and into our open water concept maps. Nutrient loading and its effects on water quality as an intermediate and final service in wetlands and open water systems was identified as a priority pathway were more research is needed. Denitrification research was specifically called for to fill in a critical knowledge gap for Tampa Bay wetlands

which also included research into movement of nitrogen from upland landscapes, through wetlands, and into open water systems. Tracking the movement and processing of nitrogen through the landscape will require EPA scientists to focus on process based research using targeted sampling efforts. Human use and nutrient loading were identified as high priority stressors to quantify effects from in open water systems.

One other critical step in our conceptual map is the translation of services into values that can be used to quantify benefits to humans. It has become clear during our literature searches that new valuation studies will be required to place satisfactory values on many of our service endpoints.

Appendix C Expert's Contributions
Current expert

Yoskowitz –

- Completed an initial valuation of Tampa Bay ecosystems using the combination of FLUCCS land use data and Costanza's valuation studies; this information is being used to prioritize research efforts for the Tampa Bay Ecosystem Study.
- Developed, with Sharon Hayes, a valuation index needed to obtain relative value data from Tampa, FL representatives.
- Developed an expert ACES Conference session that focuses expert discussions on defining Gulf of Mexico Ecosystem Services.

Experts being pursued
Henderson – Fish and wildlife expert and project liaison
Northrop – Urban forest expert

Appendix D List of Future Products

Concept maps – Concept maps for each general ecosystem type in the landscape will be completed with attached literature citation lists and functional rates.

Maps – Functional rates for various landscape types will me mapped at the landscape scale and then will be cumulated into ecosystem service accounting units.

Valuation index – Relative valuation index illustrating how ecosystem services values can be generated from local feedback even with a lack of economic valuation studies.

Initial decision support tool – Map linked information tool allowing users to search literature citation database associated with concept maps for each ecosystem type in the landscape.

Models – Dynamic models relating stressor gradients to select ecosystem service production and to valuation production functions

Appendix E Cross-cutting issues

Mapping - Explore connectivity issues using nitrogen fluxes across landscape

Wetlands and Nitrogen - Tampa watershed wetlands mapped, and ecological services values defined (nitrogen removal and storm surge protection)

Global Climate Change and Energy - CO2 removal and sequestration maps from "UFORE" and City-Green for Urban Forests and pasturelands in Tampa Watershed under various future energy production scenarios.

Ecosystem Services Research Program
Willamette Ecosystem Services Project (WESP)
R. David Hammer, Western Ecology Division
Status Report and Future Directions, June 22, 2009

1.1 Project or Theme Goal

Develop methodologies to characterize and assess critical ecosystem services necessary for a sustainable quality of life in the Willamette River Basin (WRB). Working with key partners in state, federal and private sectors, we will identify stakeholder needs and use the best available science and knowledge to build a risk assessment-based evaluation of changes in essential ecosystem services. We will evaluate services of concern to decision-makers in making sustainable management and land use decisions in the face of growing populations. Future scenarios will include climate change impacts on ecosystem services.

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1.2 Conceptual Model and Description

WESP Conceptual Framework

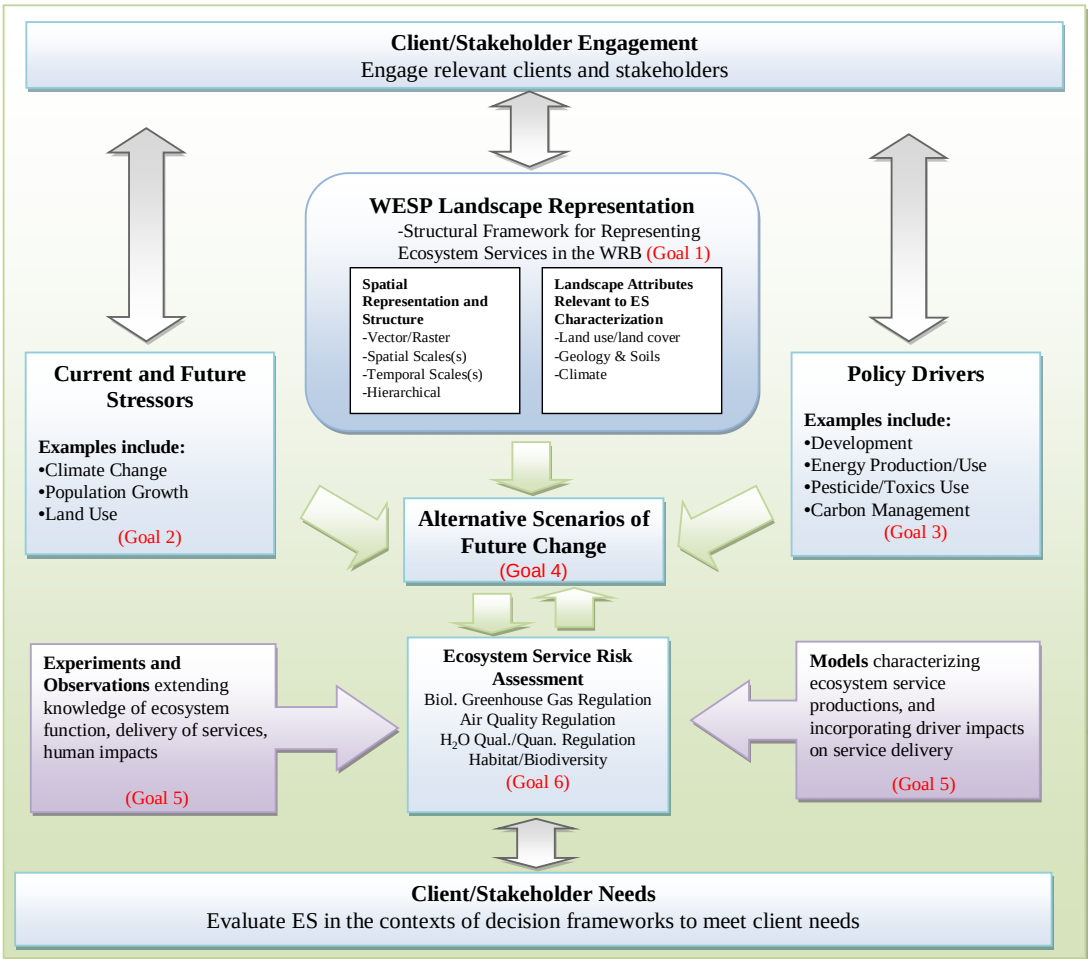

Figure 1. WESP conceptual framework. Specific project goals are identified, along with key examples.

1.3 Expected Impact/Rationale

The immediate impact of EPA efforts in WESP will be to broker and catalyze cooperative efforts among the many state, federal and NGO groups involved in ecosystem services-related activities in the WRB. The WRB is a place where quality of life and environmentally "friendly" lifestyles are important and the public is heavily engaged in active debate about environmental resource management. More than half of the land is publicly owned, but the natural resource base has been heavily exploited over a relatively short period of time. Key environmental issues include degradation of native fish habitat, water quality and quantity, population growth and the impacts of climate change on native species and water. Issues are compounded by complicated water rights and jurisdictional authorities, and a population that is economically and politically divided between urban and rural perspectives. The initial efforts of our assessment efforts indicate that an important EPA role can be to serve as a "synergizer" of related but disconnected activities already underway.

EPA research on ecosystem services in WRB will: 1) "plug gaps" to enhance and complete current efforts among collaborators; 2) synthesize, through use of models and with data analyses, previous and existing research in ways that provide regulatory and monitoring standards; 3) lead long-range planning for development of an Oregon water use plan (Oregon is the only state in the Pacific Northwest (PNW) without a long range water plan); and 4) develop monitoring strategies so that local, state and regional planners can monitor and assess ecosystem restoration and management strategies. Most of our efforts will center on water use issues, including restoration of salmon habitat in the Willamette River and its major tributaries, with a focus on the effects of climate change on surface and groundwater dynamics. Water quality efforts will focus on water temperature, which is a primary concern for 23 native fish species, and TMDL's, for which the implementation and monitoring are important in both the Puget Sound Basin and the WRB. Other key contributions regionally and nationally will be in developing precise, quantitative assessments of soil carbon sequestration and methods to scale environmental data from transects and plots to watersheds and regions. Key collaborations among others in ESRP research will be in water quality and quantity regulation, native fish habitat restoration and monitoring, carbon sequestration and climate change impacts on ecosystem services. We will use an EPA-developed habitat model (HexSim) to assist development of terrestrial habit standards.

1.4 Current Status

We are in various stages of the assessment phase, with plans near completion for implementation of ecosystem services research to address: 1) carbon sequestration and offset forestry (both urban and in state, federal and private forests); 2) terrestrial habitat; 3) Willamette River restoration and native fish habitat; and 4) effects of climate change on regional surface water flow. In the fall of 2009 we will complete the external review and evaluation of GTMel, an EPA-developed model that may have important implications for prediction anthropogenic and climate change stressors on biogeochemistry processes. If the model proves useful, it will have important applications regionally and nationally. We are

working with the Willamette Partnership to determine how best to inform and monitor ecosystem services to serve both regulated and entrepreneurial ecosystem services markets, and we are actively engaged with the Institute of Natural Resources (INR) at Oregon State University (OSU) to develop landowner and public needs assessment tools.

1.4.1 Research Underway in FY 2009

Research on the effects of hyporheic flow on Willamette River temperature and native fish habitat has begun at Green Island, near Eugene, Oregon. This work is being expanded to Confluence Island, where the City of Eugene will acquire rights to discharge tertiary effluent into gravel bars rather than construct cooling towers. These efforts are laying groundwork for a systematic restoration of riparian vegetation and historic stream channels between Eugene and Albany, Oregon. The river restoration effort will include nearly 30 state, federal and private organizations and will include assessments of water quality and quantity, aquatic and terrestrial habitat, carbon sequestration, and recreation and aesthetic values. We are planning user needs surveys and prioritizing the steps in river restoration. Two major private funding sources are involved. We hope to have the long range restoration plan in place within 18 months and to have begun the systematic restoration, including monitoring and field research, within 24 months. A key component of this effort will be assessing terrestrial and aquatic vadose zone and groundwater dynamics, and EPA will lead this portion of the research. Carbon sequestration and offset forestry evaluation in the Panther Creek watershed (Coast Range) will begin in August, 2009, with more than a dozen cooperators. Urban forestry work has begun in Corvallis and Portland.

The Implementation Plan (IP) was recently revised and has had internal EPA review. The WESP IP is a conceptual plan that requires that specific research projects each be accompanied by peer-reviewed plans. The Green Island work has been reviewed. Research plans for the activities described above are nearly completed.

The Panther Creek project uses new technology (LiDAR) to precisely quantify the landscape and build a systematic, landscape-attribute based sampling approach that will quantify SOC systematically, while collecting ancillary soil, hydrologic, biological and chemical data to investigate a full suite of related ecosystem effects and processes. The data will be analyzed through a spatially-explicit decision support tree approach that will identify correlations among ecological attributes and allow scaling beyond the site. This approach will be tested at different locations in the WRB.

The Willamette River restoration effort will be based upon detailed landowner surveys and open forum discussions. The restoration will be hydrological, biological and physical, and will involve municipal, state, federal and private groups. It will include futures scenarios based upon population growth, land use change and climate change. A variety of creative restoration philosophies will be used, along with monitoring efforts at several scales using new technologies.

1.4.2 Current Impacts, Critical Accomplishments and Innovations

The primary response to new plans to date from collaborators is renewed enthusiasm because EPA will participate as a collaborator within the WRB. Key activities to date include:

- Using HexSim with The Nature Conservancy (TNC) to identify the necessary amount and distributions of terrestrial habitat for native species indigenous to WRB prairie and savannah ecosystems. Results will be used by TNC, US Fish and Wildlife and Oregon Department Wildlife to prioritize land retention and acquisition and development of long-term management plans.

- Precise quantification of soil organic carbon (SOC) sequestration in forest, agricultural and prairie habitats. EPA has leveraged $150,000 in contributions for acquisition of LiDAR data to access to the total LiDAR data base (more than $10 million). We have leveraged $80,000 of field sampling to more than $110,000 of forest inventory work by BLM and $250,000 soil laboratory analyses by the Natural Resources Conservation Service. Results will be used to develop a soil-landform based template of SOC that will be applied to the rest of the WLB. This template should have national importance. This effort will allow the opportunity to consider the "bundling" concept in both qualitative and quantitative ways. SOC has important direct and indirect effects on many ecological processes related to ecosystem services (soil fertility, speed of biological "turnover" of organic matter, soil aggregation that influences water infiltration and percolation, soil microbial function and diversity, hill slope stability when vegetation is thinned or removed, etc.). By using a stratified, hierarchical terrain-attribute based approach, we can build a database that allows rigorous analyses of co-variances of chemical, physical and biological attributes. This should aid our efforts to "scale out" or "scale beyond" specific research sites.

- Working with 27 collaborators on first steps of Willamette River restoration. EPA will conduct economic assessment of ecosystem services resulting from restoration, will participate in river sampling for temperature monitoring and impacts of point bar formation on hyporheic flow, will conduct isotopic analyses of water samples to determine how Willamette River flow is proportioned among surface, groundwater and vadose zone sources, and will collaborate on assessment of floodplain carbon sequestration and terrestrial habitat improvement. EPA investment for critical research will be about $250,000 in the first two years, but will result in full partnership in a restoration effort that will involve more than 25 cooperators and nearly $10 million in other funding sources. EPA's role in this effort will expand as newly hired EPA scientists become engaged in the project. This effort will consider possible ecosystem services "trade-offs" as well as actual and potential outcomes.

1.4.3 Publications and Papers Presented in 08/09 and forthcoming

It is estimated that 2-8 publications are currently drafted, with at least six forthcoming in the next six months and more than a dozen within the next two years.

1.4.4 Resources

Eleven members of the WED Ecological Effects Branch (EEB) and two members of the Freshwater Ecology Branch are investing time in ESRP. Four of these are full-time, and the remainder are 1/3 to ½ time, with those contributions scheduled to increase and the project matures and other activities are concluded. Active participants from other EPA groups include parts of two FTE's from the Ada, OK laboratory and parts of two others from the Las Vegas laboratory. EEB branch members currently involved in SP2 research are actively investigating ways in which to engage in ESRP work through biofuels and climate change-related work. It is anticipated that 15 of the branch members will be engaged in ESRP by the beginning of FY 09-10.

Our abilities to conduct key relevant research are fund-limited at present. An increase in research support funds would greatly expand our abilities to engage collaborators.

It is estimated that EPA is currently cooperating with 25 individuals outside EPA, and that number will grow to more than 80 within the next 12 months.

1.5 Response to Comments

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1.5.1 Response to Program Office Comments

Dr. John Bolte has been engaged to lead a workshop/discussion in July to focus on the appropriate "end points" for the WESP project. Dr. David Hulse, senior author of the Willamette Futures document, and David Promozich, Co-Director of the Willamette Partnership, have been invited to participate. The discussion will focus on the appropriate metrics and "deliverables" suitable for Dr. Bolte's decision support model (ENVISION) and upon the kinds of metrics that would be most useful to inform ecosystem service markets.

Another workshop will be held later in the summer to focus upon sampling strategies necessary to optimize opportunities to bundle ecosystem services and to enhance scaling efforts. Dr. E. Henry Lee, the EEB statistician will have a leadership role in these discussions.

1.5.2 Response to SAB Comments

SAB comments noted that: ecological condition endpoints were the focus, rather than ecological services; the focus was on effects easiest to value using previously accepts methods and readily available data, rather than addressing the full range of relevant ecological values; and there was a lack of systematic valuations where they could have been useful for site-specific or regional decisions

The SAB recommended that WESP include: early identification of effects that are socially important ;.prediction of ecological responses in value-relevant terms; and consideration of the possible use of a wider range of valuation methods.

The WESP IP was revised in late 2008 and early 2009 in order to enhance responsiveness to stakeholder needs in the WRB. . The goal was to develop a research/outreach/collaboration

perspective that would also meet EPA program needs as best we could. The decision to use the Risk Assessment paradigm was because ultimately, EPA is a regulatory agency, and that the results of the ESRP work would inform rules, regulations and decision support tools that would be based upon probabilities and uncertainties

Another component is reviewing available data, but expanding upon those data and existing methods to become relevant to identifying and addressing ecological values. The two previously cited projects are examples.

1.6 Challenges

The most significant organizational, administrative, and scientific challenges WESP faces include:

- Convincing scientists accustomed to working on empirical research to "go forth" from their offices and computers to meet, engage with, and attempt to understand the client/stakeholder community. This requires skills, attitudes and motivations not previously required of Ph.D. research scientists. Embracing the Integrated Multidisciplinary Research (IMD) model will be important for WESP to have maximum impact and to develop the metrics most suitable for WRB stakeholders.

- Limitations in financial resources to meet the wide array of needs.

- Lack of the broad range of technical skills needed to support this kind of effort, including: data base managers, statisticians, and GIS technicians and non-PhD. personnel skilled at client/stakeholder interface relationships at the field level.

- At the highest levels of federal government there is a need for agreement upon the kinds of collaborations that should exist to meet the common good. Agency jurisdictional authorities, both real and imagined, make it difficult for "the field" to respond rapidly and effectively to opportunities. Extraordinary collaboration often occurs at the state level, but this could be enhanced with clear signals from higher authorities. For example, the NRCS, by virtue of the district conservation offices in each county, has a national network through which stakeholder needs can be addressed. This network should be expanded to include needs beyond USDA, and should be revised to better serve the suburban-rural interface, which is the most significant social, political, economic and ecological ecotone in the United States.

1.8 Appendices

Appendix A: Hierarchy of Services

Carbon sequestration, both biological and mineral across a variety of land uses (forest management, stand age, urban, agricultural, prairie, savannah, and wetland)

- Quantities (mass/unit area)

- Sequestration rates

- Recalcitrant vs. biologically active fractions

- Correlations among other ecological units (nutrient-supplying capacity, soil infiltration, plant growth, etc.)

Water quality regulation.

- Quantify the interacting effects of climate and land use on ecosystem processes controlling pollutant movement from upland ecosystems into water bodies.
- Determine the effects of potential mitigation and adaptation options (e.g., biological carbon sequestration, alternative energy production, and water resource development) on pollutant, temperature and sediment loading to aquatic ecosystems.
- Identify the impacts of global change on water quality and ecosystem management programs, and how can the capacity of programs and managers for responding to global change be enhanced.
- Evaluate the benefits and trade-offs of land management activities to mitigate green house gases on water resources in the WB.
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Habitat/biodiversity

- Explore how landscape change, life history, and disturbance together influence biodiversity.
- Evaluate the consequences of alternative future scenarios for selected wildlife populations in response to a common set of stressors and policy drivers.
- Search for valuation metrics that facilitate comparison with other ecological services
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Greenhouse gas regulation:

- Determine theoretical maximum values of greenhouse gas regulation for the basin.
- Model the reduction of those maxima by stressors and policy drivers singly and in combination.
- Quantify the relations between greenhouse gas regulation and other ecosystem services.
- Assess the impacts of greenhouse gas mitigation strategies on ecosystem services.

Air quality regulation:

- Assess the potential for air quality regulation in different ecosystems in the WRB under current conditions.
- Assess the spatial extent of potential stressors on air quality regulation within the WRB.
- Assess the risk to air quality regulation in response to a common set of stressors in the WRB using alternative future scenarios.

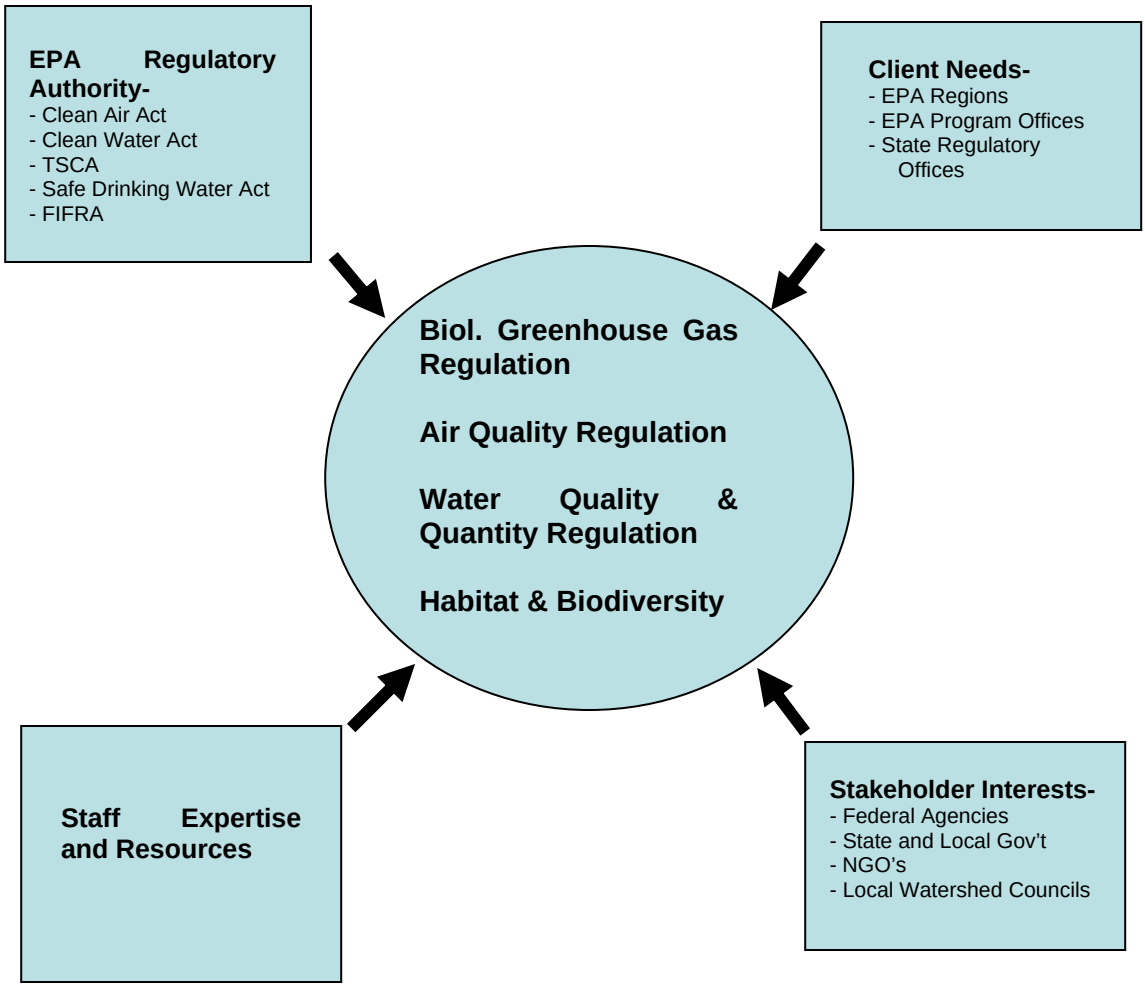
Scaling of ecosystem services:

- Assess existing data, identify knowledge gaps and collect data to fill them.
- Examine and correlate interactions among ecosystem processes at a variety of scales along soil-water continua.
- Use hydropedological units (the combinations of geomorphology, surficial shape, and internal soil properties that control water infiltration and percolation) to "scale out" from sample points, plots and transects to watersheds and regions across a variety of land uses.
- Test the hydropedological unit concept with sample plots and transects within hierarchical, nested watersheds.

Decision support framework:

- Understand relevant client decision processes for which the decision framework could provide significant added value.
- Identify, utilize, and adapt an existing decision framework supporting the capabilities described above to the representation, integration and analysis of key ecosystem services across alternative future trajectories of change.
- Develop decision-oriented models of key ecosystem services suitable for use in decision framework and incorporate these models into the framework.
- Demonstrate, at multiple scales in the WRB, a prototype decision support tool utilizing this framework.
- Document the utility of this tool in addressing client decision support needs.

Appendix B: Conceptual Model



Appendix C: Experts' Contribution

Two experts are associated with WESP. Dr. John Bolte (OSU) has been a very valuable contributor. He participated in the revision of the WESP IP and is the task lead for the Decision Support task. He has a perspective that is not otherwise represented on the project, and has been instrumental in educating EPA research staff about the role of decision support tools and how we should conduct our research and assessment in ways that lead logically to efficient application of our findings to a decision support system.

The second expert, Dr. Steve Polasky, has only recently been officially employed. We will benefit from his perspectives and experience with the Natural Capital Project and his experience applying regional work to a national scale.

Appendix D: List of Future Products

1. Assessment standards for soil carbon sequestration on a variety of land uses.

2. Assessment of greenhouse gas emission rates as a function of changing land use.

3. Terrestrial habitat assessment model, refined for ecosystem services applications.

4. Surface water aquatic habitat assessment tool based upon river geomorphology and flow regimes.

5. Willamette River Basin hydrologic model – temporal and spatial distributions of water in surface, vadose zone and groundwater compartments as a function of land use, anthropogenic stressors and climate change.

Appendix E: Linkages to nitrogen and wetlands plans and how climate change relates to WESP

1. Climate change is a critical and integral component of all of the work that will be done in WESP. We are discussing ways to use climate change as the template through which we can integrate EPA's "headwaters" work into WESP. We will rely heavily upon data analyses from the "Coast to Cascades" weather station transect for which we have 12 years of site-specific weather, soil water, and tree growth data. The transect extends from the Oregon Coast to the east side of the Cascades.

2. Wetlands trading is an active and important component of the Willamette Partnership group. The wetlands expertise in the Western Ecology Division lies within the FEB, and their efforts have been focused on the ESRP national wetlands inventory and assessment efforts. The project leader is in active discussions with the directors of the Willamette Partnership to determine how WESP might participate in their assessment/monitoring needs. Wetlands, particularly floodplain wetlands, will be an important component of the Willamette River restoration/monitoring effort.

3. The Oregon Department of Environmental Quality (DEQ) has advised us that nitrate in groundwater is their primary N concern in the WRB. We have initiated discussion with the US Geological Survey (USGS) to determine how we can collaborate to investigate/evaluate that concern. The Green Island component of WESP includes sampling/observation/analyses to assess the effects of riparian forests on nitrogen dynamics between adjacent agricultural field and the Willamette River. At this juncture, N in surface waters appears to be a relatively unimportant concern among stakeholders in the WRB. The primary water quality metric for aquatic habitat is water temperature, which will be addressed specifically and in detail in the Willamette River restoration research. How is WESP collaborating with ESRP N (Jana)?

Ecosystem Services Research Program
Coastal Carolinas Project
Deborah Mangis Ph.D/Dorsey Worthy
Status Report and Future Directions. June 24, 2009

1.1 Project or Theme Goal

The goal of the Coastal Carolinas Project is to determine how ecosystem services in the coastal Carolinas are affected by changes in regional stressors - reactive nitrogen, climate change, development, and others. In addition, we are evaluating how changes occurring upstream of the Coastal Carolinas (e.g., development) are affecting ecosystem services in the Coastal Carolinas.

1.2 Conceptual Model and Description

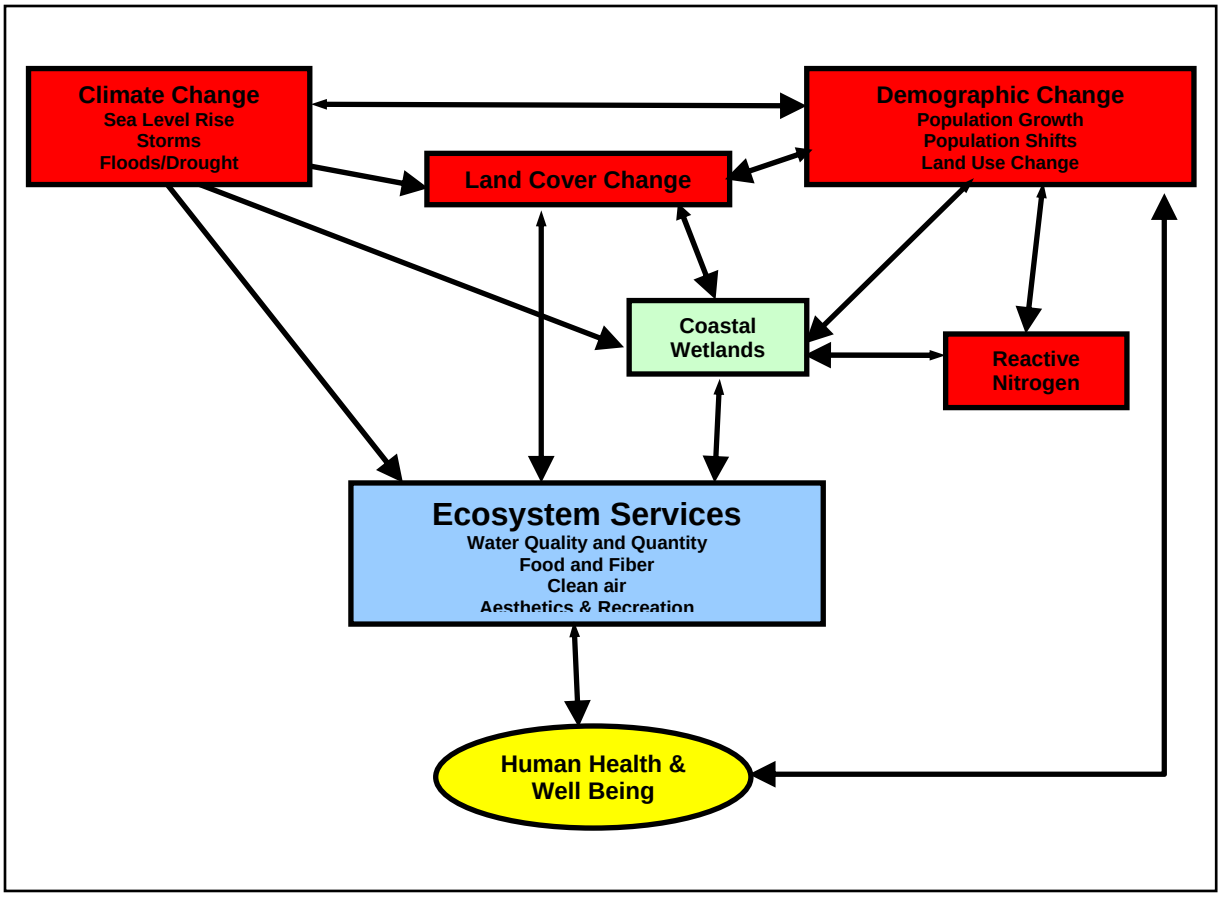


Figure 1: This general conceptual model shows the major changes we will be evaluating.

We will be evaluating the impacts of climate change, land cover change, reactive nitrogen, and demographic change on ecosystem services in the Coastal Carolinas, with emphasis on wetland ecosystems.

While we are bounding our analysis of ecosystem services to the counties that border the coast, we are also evaluating how activities upstream of the coast (e.g. development in Raleigh, NC) impact coastal services, and how many of the ecosystem services produced in the coastal zone are exported to other areas (e.g., fisheries). This program provides great opportunities for collaboration with academia, other federal agencies, and state and local decisions makers. For example. several NOAA labs are looking at how ocean resources are affected by changes in coastal ecosystem services; we are pursuing collaborations with those labs, since we have little salt water expertise. Working with state researchers, we hope to standardize our climate change scenarios to fit in with state research and state projects on climate change at the coast. We need help with monetization, ocean hydrology, ocean impacts, and estuarine hydrology, since our greatest uncertainty is getting from the ecosystem endpoints that EPA is accustomed to measuring to the monetization of these services, and since EPA does not focus on salt water environments.

1.3 Expected Impact/Rationale

The long term impact of the Coastal Carolinas Ecosystem Services Project will be to reverse the loss and degradation of the services provided by coastal wetlands and other ecosystems, and to provide coastal communities the information and tools to help sustain these services in the face of population shifts, rising sea levels, and changing climate.

Many coastal communities are growing rapidly, straining both the public infrastructure and the natural environment that support them. Meanwhile, sea level rise and increased storm intensity and frequency caused by climate change are expected to present increasing hazards to the same infrastructure and environment that is being stressed by growth. Individually and collectively, these changes are likely to result in disruptions that will diminish both the well-being of coastal dwellers and visitors and the ability and capacity of the natural systems to deliver those ecosystem services valued by coastal dwellers and visitors. The combined effects of growth and climate change will vary from instance to instance, but it is most likely that they will be cumulative or synergistic.

Coastal ecosystems that provide many ecosystem services for coastal communities are expected to experience increasingly rapid declines as a result of growth. The effects of climate change are less clear. For example, wetlands are expected to migrate, but whether they will be able to deliver the same quality and quantity of services remains unknown. Simultaneously, the growth and climate change scenarios will interact to alter development patterns as land use regulations change and the market responds via changing prices, rising insurance costs, and the availability of substitute locations for residents and visitors. As the quality and quantity of ecosystem services are jointly determined by ecological production and direct or indirect human consumption or enjoyment, a coupled economic-ecological model is required for evaluating ecosystem service stocks and flows.

Under a range of plausible alternative futures, the Coastal Carolinas project will characterize and quantify the changes in the spatial and temporal distribution of coastal ecosystem service production and determine how those changes translate into changes in human well-being (health and welfare). Improved understanding of feedbacks between development and the changing coast will improve the understanding of environmental and economic risks and planning and management opportunities in space and time. This improved understanding is likely to lead to better science input to decision making at multiple scales. The information generated by this project will serve as a meaningful input into emergent climate-smart growth, adaptation planning, and climate-related conservation planning

1.4 Current Status

1.4.1 Research Underway in FY 2009

The Coastal Carolinas Ecosystem Services Project conducted a series of meetings and constituents workshops from 2008 through early 2009 to gauge the awareness of coastal communities and decision-makers of the value of coastal ecosystem services, and to gain an understanding of the issues and processes through which local land used decisions are made, and research that is currently being conducted. The meetings included academics, governmental scientists, state and local decisions makers, and the public. . This information is being used to develop an implementation plan which will be completed in 2009. The essential elements of this plan will be to:

1. Identify the services provided by coastal ecosystems in the Carolinas, with emphasis on coastal wetlands - What are the services, what are the units, what are the values and linkages?

2. Locate these ecosystems and related services in the landscape.

3. Determine the effects on these ecosystems and their related services with changes in coastal populations, nitrogen levels, sea level, and climate.

Currently, NERL is conducting a prototype study (APES) to link water quality models to habitat models to fisheries models in sub-basins in the Albemarle-Pamlico Watershed. These models have been linked together using the FRAMES modeling system. This will help us link water quality changes upstream to effects on ecosystem services in the coastal areas of the Carolinas.

Work is also under way at NERL to extend a new change detection methodology from the Albemarle-Pamlico watershed to all Coastal Carolinas watersheds. This approach uses the NASA MODIS satellite sensor to characterize the seasonal changes within each pixel, and to detect shifts away from this established temporal signature. This technique provides an accurate and rapid detection of land cover change, and may also provide an early indication of climate change with earlier green-up of the landscape.

Another project is underway at NERL to develop aircraft or field deployable sensors which can detect and characterize reactive and non-reactive nitrogen concentrations over relative broad area of wetlands. This approach will provide a means for determining wetlands denitrification rates under a variety of tidal, climate, and nutrient loading conditions.

Mapping of the coastal wetlands has begun, along with evaluation of the best models to use to predict sea level rise and its impacts on the wetlands.

The landscape types for the Coastal Carolinas have been mapped.

Status of your implementation plan (IP). The Coastal Carolinas implementation plan is currently in its first draft. The plan will be completed and reviewed by September 30, 2009. The number and type of scientific disciplines working on the team include: economist (1), decision support developer (1), mapping (2), atmospheric deposition (1), human health and well being (2), remote sensing (2), GIS (3), geology (1), water modelers (2), wetland ecologists (2), estuarine ecologists (2), external hire conceptual mapping (1), and external partners (NOAA) (1). The draft will go through at least three internal reviews and edits before being reviewed by an external review panel that is currently being identified.

1.4.2 Current Impacts, Critical Accomplishments and Innovations

Through our series of meetings and workshops, we have increased the awareness of the ESRP Coastal Carolinas project and also created expectations among state and local managers for information and research products. We are being asked to participate in state and federal meetings in the coastal Carolinas related to climate change (e.g. On the technical board of the Albemarle/Pamlico estuary– chosen as a climate ready estuary under the EPA program). We have also improved collaboration with our federal partners – e.g. NOAA, USFS, and USFWS. We are all looking forward to the collaboration and outcomes of our research.

We are meeting with North and South Carolina groups who have been recently given money to evaluate sea level change in the Carolinas, so that we do not duplicate efforts, and can use our resources more effectively.

1.4.3 Publications and Papers Presented in 08/09 and forthcoming

Various presentations on the Coastal Carolinas have been given to the ESRP, ORD Divisions, and other federal and state partners. Alex Macpherson gave a presentation entitled "Ecological Production Functions: theoretical and Practical Exploration" at the U.S Society for Ecological Economics in Washington, D.C. May 31-June 3, 2009.

1.4.4 Resources

We currently have 11 FTE resources committed to the Coastal Carolinas at this date.

Approximately $300k above FTE levels is currently budgeted for the Coastal Carolinas through NERL-ESD Category-C resources.

We have occasional assistance from expert Allyson Beale, and anticipate additional assistance from experts Lisa Wainger and Liem Tran

1.5 Response to Comments

1.5.1 Response to Program Office Comments

The Coastal Carolinas offers us the opportunity to support the Office of Water (OW) "Healthy Watersheds programs" by linking water quality and fish habitat models in watersheds, and by evaluating impacts of development and climate change (at times upstream of coastal areas) on coastal ecosystem services – including water quality and water provisioning. Coastal wetland mapping, impacts of sea level rise on wetlands and areas to preserve for future wetlands will support OW in the wetlands protection program.

1.5.2 Response to SAB Comments

The Coastal Carolinas project is evaluating the impacts of ongoing change processes such as global climate change and development. We are also looking at these impacts on a variety of scales from a small watershed to large watersheds; on tidal estuaries, and on estuaries that have their headwaters outside the coastal plain. In addition we are including various human responses to global climate change from business as usual, hardening in place, and fleeing, and responses in between. We are developing the decision support tool to be able to nest different size watersheds for use by decision makers at scales from local to regional. For developing water

provisioning and water quality we are linking water quality and hydrology models, and landscape change models.

SAB specific Coastal Carolina comments in italics and ESRP responses are below:

SAB report p 105: ". The problems being faced by coastal Carolinas are no different than are being faced by Georgia. Why was this project cut off at the Carolinas? In many respects state protections on coastal development are much stricter in the Carolinas than in Georgia, which provides considerable opportunities for useful comparisons." While we agree that Georgia is facing the same problems as the Coastal Carolinas, we chose to limit our work in the Coastal Carolinas due to proximity to RTP for travel, and due to limited FTE and resources to work on the project. To expand the program to include Georgia would tax our ability to complete the project in a timely fashion. If we can come up with good ecosystem service production functions and impacts of climate change and growth, the results will be applicable to other coastal areas

P 21: Long-term Goal 5 - Place Based Demonstration Projects "We therefore recommend that: The Plan should contain a transparent explanation of the process used to select sites for place-based demonstration projects. To this end, we recommend that EPA consider using the following organizing principles (along with others as appropriate, so long as they are transparent) for selecting and justifying different areas for place based demonstration projects. Whether more or less than four such areas will be chosen will be governed by these principles":

- *The areas must be widely representative of the major ecological areas in the U.S. where humans live or on which they rely*. Much of the US lives within 50 miles of the coast. Impacts in coastal areas will affect a majority of the US population whether it be where they live, or play. The techniques developed in the Coastal Carolinas can be used to evaluate impacts of development and climate change in other coastal areas.

- *Historic, current and projected future changes to ecosystem services in these areas must be documented/predicted (in this regard we support use of the concept of "ecosystem services districts and operational management options" discussed on page 5 of the Plan).* In the last 10 years, growth in some of the Coastal Carolinas has more than doubled. Growth in these areas will continue, and the Coastal Carolinas will be impacted by climate change in the form of sea level rise and increased frequency and duration of storms. It therefore allows a good evaluation of the impact of population growth and climate change on ecosystem services.

- *It must be possible to generalize/transfer the findings of place-based investigations to other geographic areas/systems in the U.S. (and also, where appropriate, outside of the U.S.).* The results of the Coastal Carolinas will definitely be transferable to other parts of the SE U.S, and some NE and pacific coastal areas.

- *The selected areas as a set should provide opportunities for systematic comparisons and contrasts in important ecosystem services, structures and functions, as well as opportunities for collaborative studies in concert with the wetland (and coral reef or alternative ecosystem) and the nitrogen study components of the Ecological Research Program.* The Coastal Carolinas give a wonderful opportunity for collaborative studies with the wetland theme, since the major ecosystem in the Coastal Carolinas is wetlands – fresh and estuarine. Nitrogen is an important contributor in the study area to water quality and its associated ecosystem services. Sources of nitrogen include hog farms and other agricultural

- *For each selected area, appropriate data must be available on the local ecology, ecosystem services, and changes in those services. Adequate local resources (EPA or other [partner] staff and facilities) must be available*. In the Coastal Carolinas we have a major EPA facility located in Research Triangle Park, NC; we have academic marine study areas in the Coastal Carolinas; NOAA maintains labs in North and South Carolina who are interested in working with us; and the Albemarle/Pamlico estuary has been named a participant in the EPA climate ready estuary program.

- *Although not an organizing principle, it is also highly recommended that local decision makers be supportive of these efforts in their area.* After holding meetings with local and state decision makers, they are very interested in the results of the Coastal Carolina Project, and some of them are interested in participating in the project.

1.6 Challenges

The most significant organizational challenges are getting scientists from different EPA organizations to commit to work in the Coastal Carolinas – especially if field work requires substantial travel from their home location. Also, determining all of the work that is being accomplished outside of the ESRP by states, other Federal Agencies, academics and others is progressing, but will take some time to work out the appropriate interactions. We will be looking to find help from some of the local universities working with the Sea Grant Program for help in this area. We lack a hydrologist who can bridge the gap from freshwater to salt water. The members of the ESRP are not used to valuing ecosystem services, and valuing the services in the Coastal Carolinas will be a challenge. While some of the services such as recreational fisheries are easier to value, many remain that need research applied to develop the valuation models.

1.8 Appendices

Appendix A: Hierarchy of services being addressed in research described , including units of measure

Final list and units of measure are now being developed but currently includes:

Supporting: ecosystem production, biogeochemical cycling and biodiversity

Provisioning: food, timber and fiber production,

Regulating/Provisioning: water quality, air quality, climate regulation (greenhouse gases),

Cultural: recreation and aesthetics/sense of place

Appendix B: Conceptual Model and most significant scientific uncertainties, currently—critical path

While we are developing the Coastal Carolinas implementation plan, we are evaluating several conceptual models, from the overall program conceptual models, to models for specific areas of research in the program.

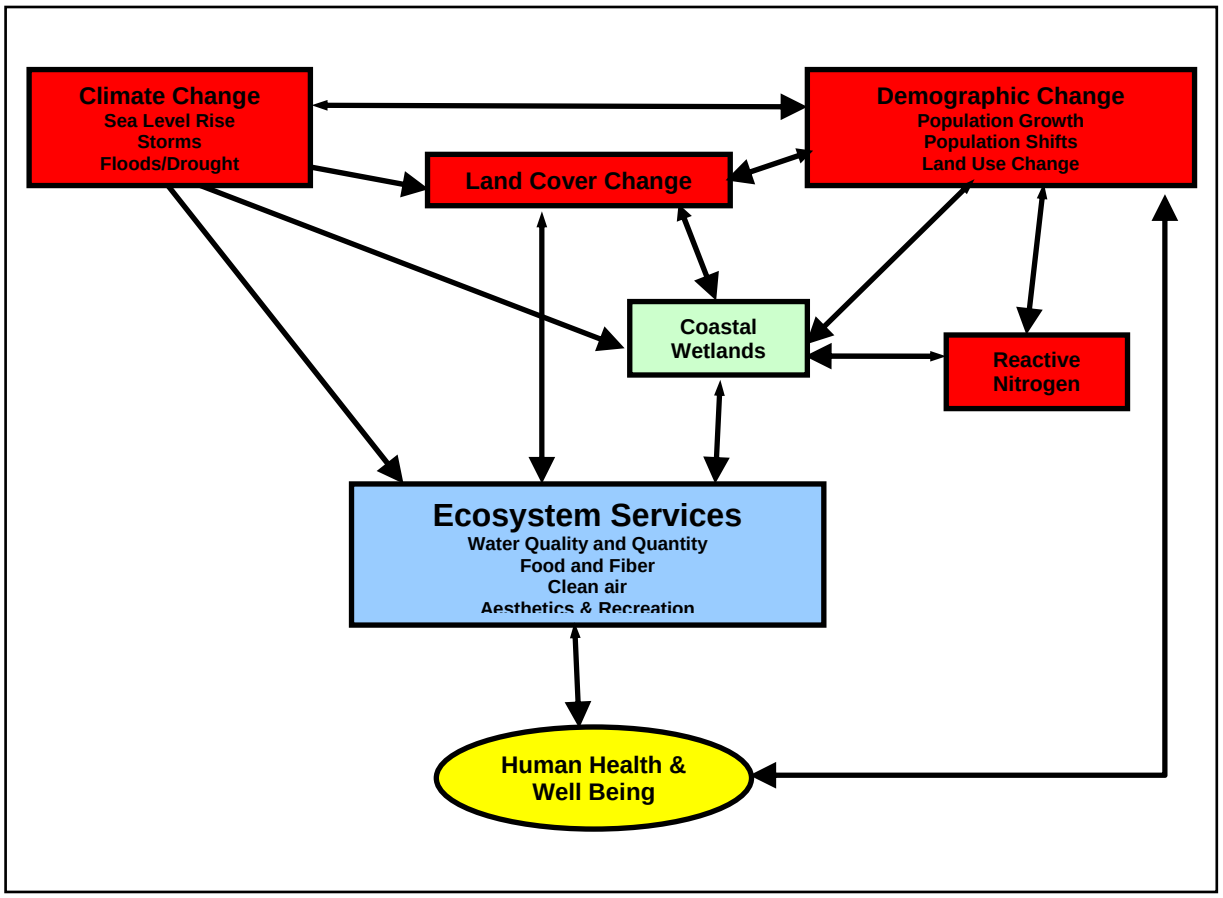
Figure 1: ESRP Coastal Carolina conceptual model for impacts of the stressors of climate change, demographic change, reactive nitrogen, and land use change on ecosystem services

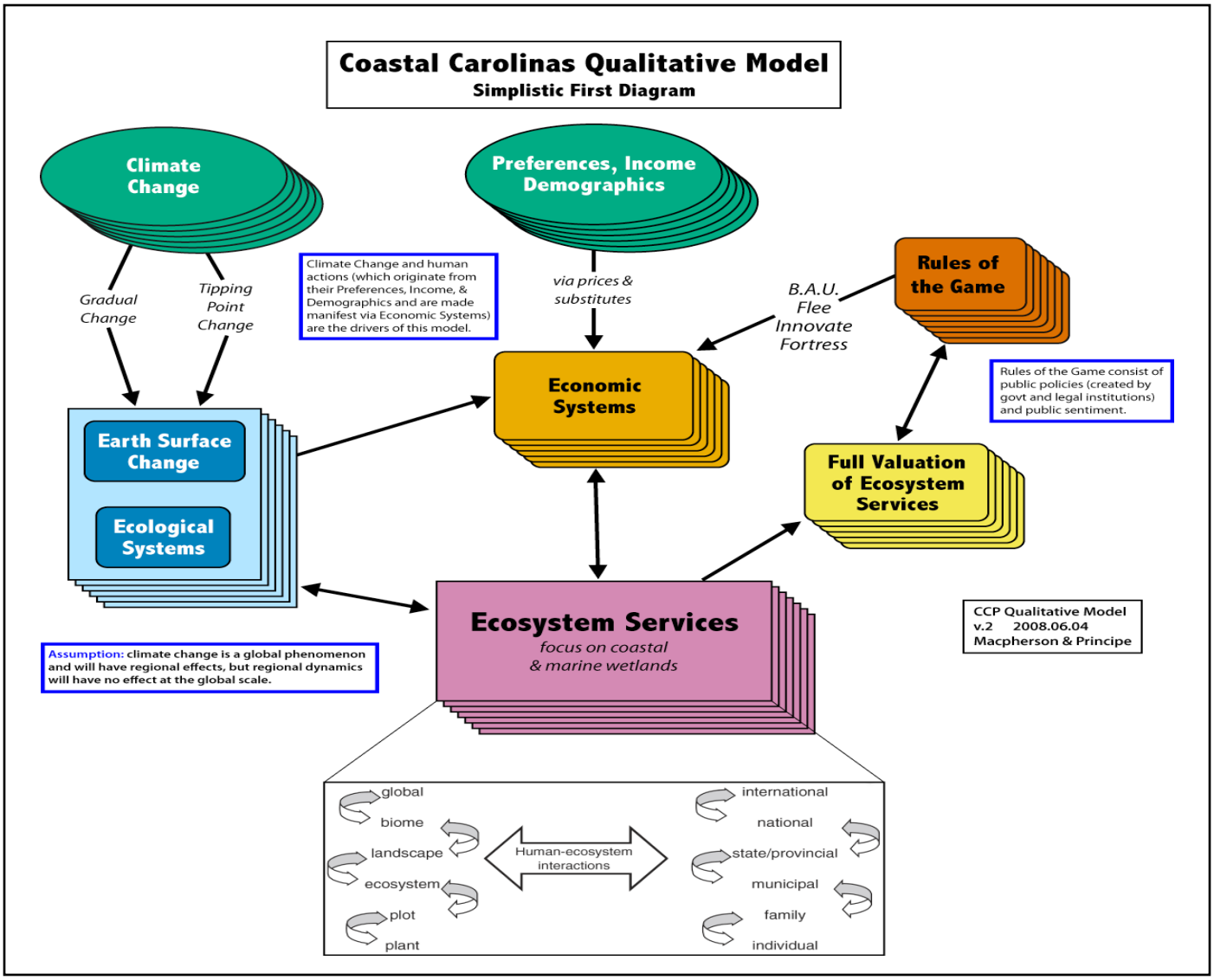
Figure 2: ESRP Coastal Carolinas conceptual model including valuation of ecosystem services

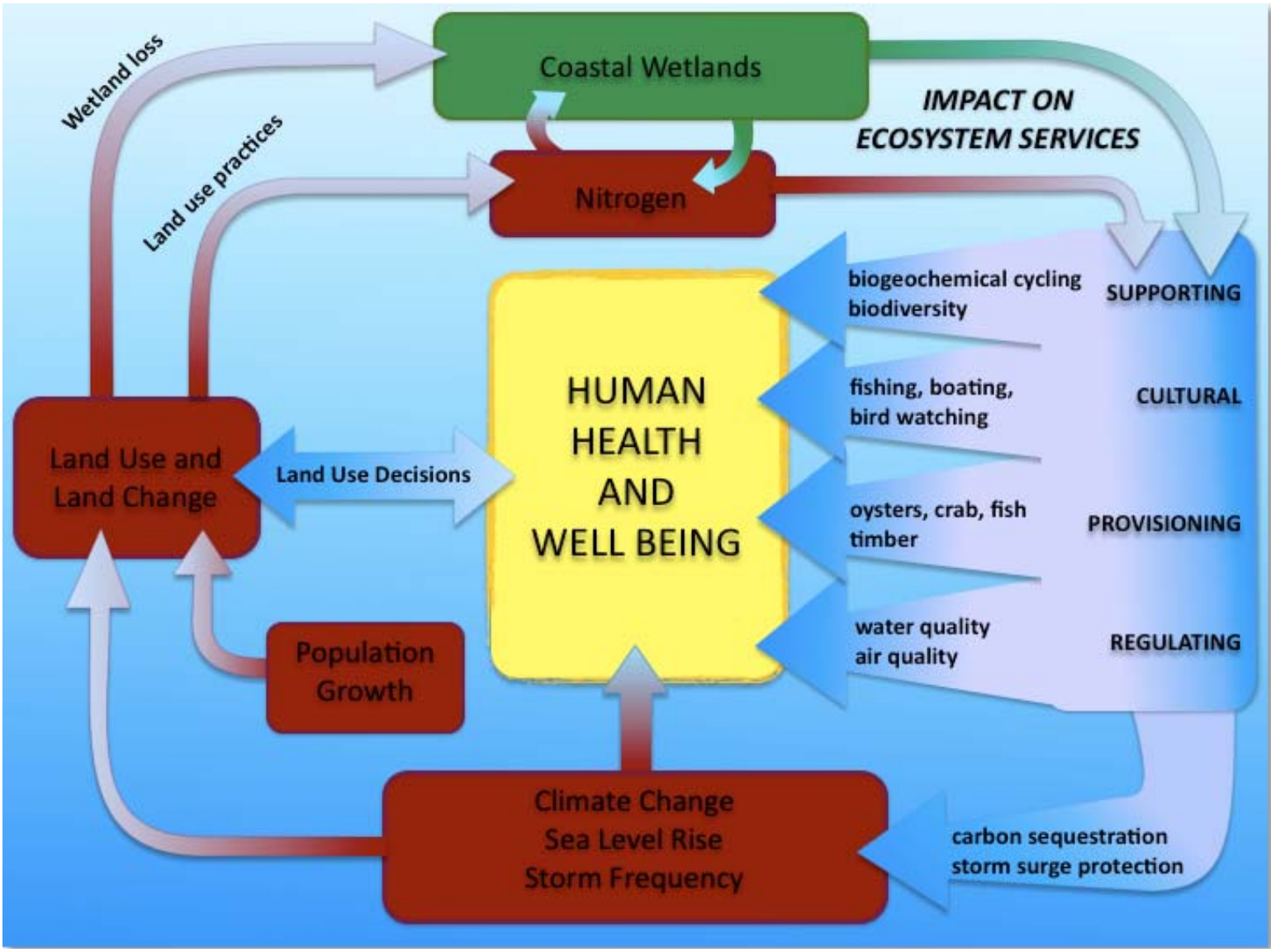
Figure 3: ESRP alternative Coastal Carolinas conceptual model

Figure 4: Conceptual model of potential changes in ecosystem services with sea level rise.

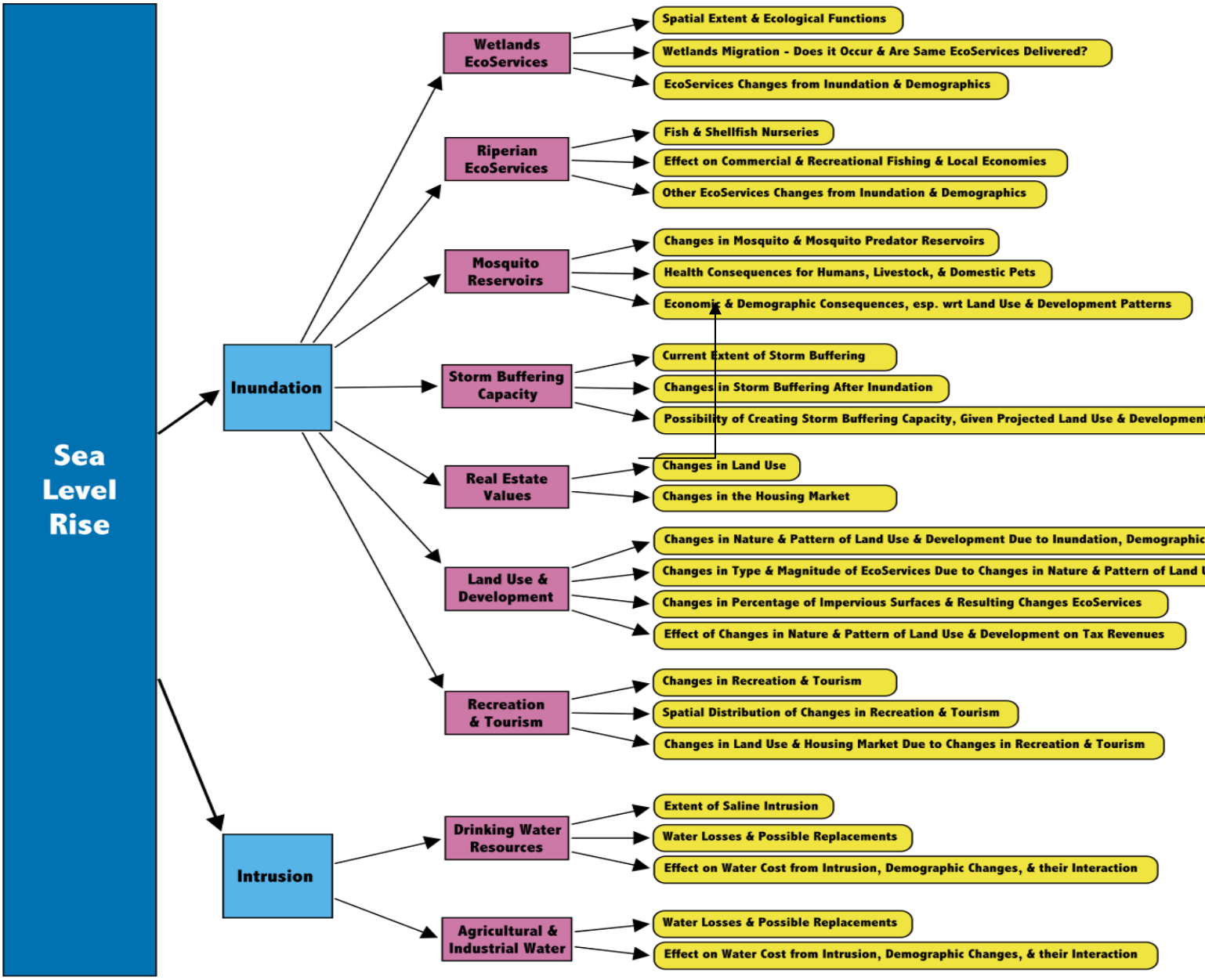
Figure 5: Conceptual model of integrating necessary air and water quality models in the Cape Fear Watershed to address impacts on ecosystem services

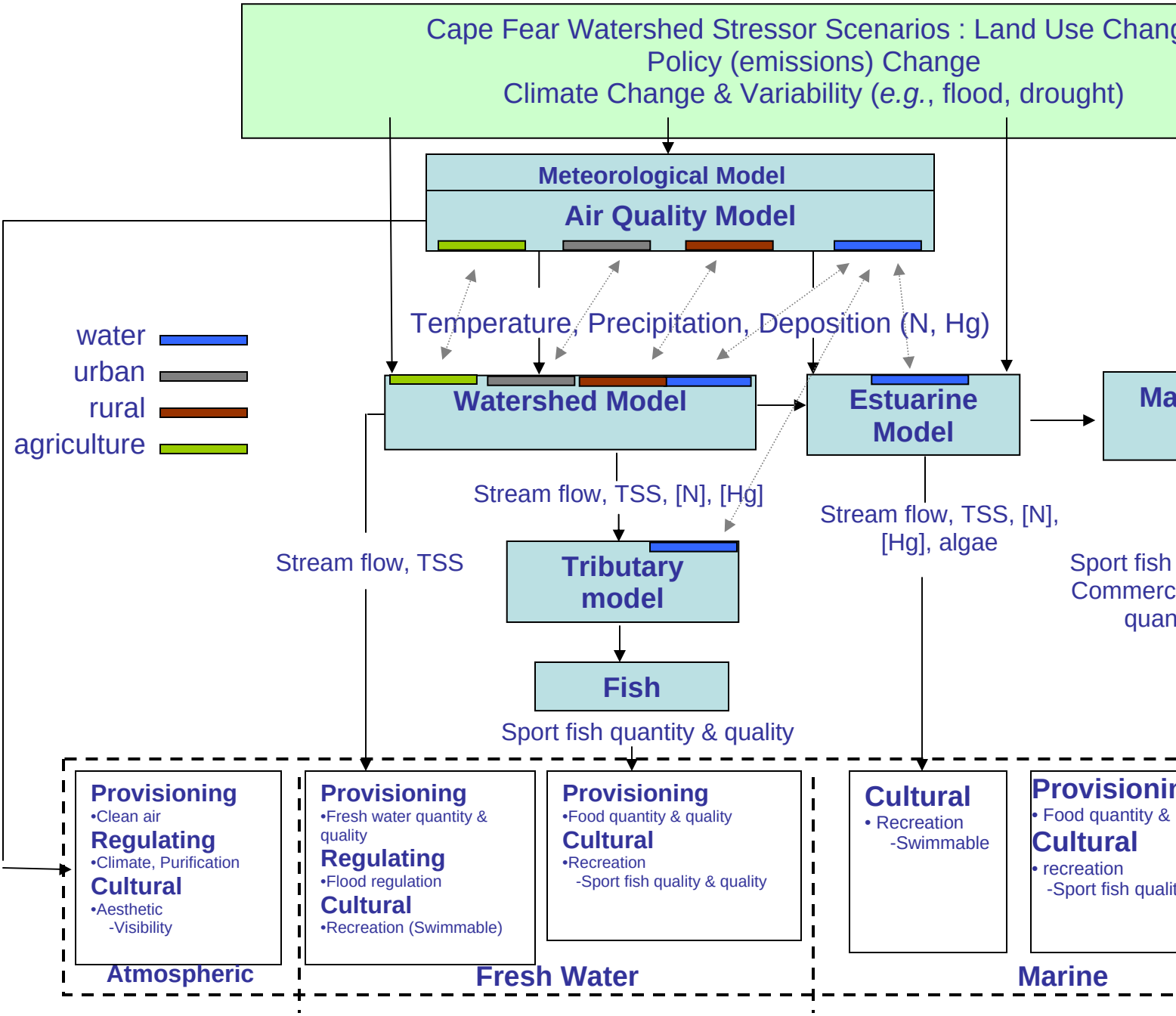



Coastal Carolinas Qualitative Model
Simplistic First Diagram
Climate Change
Preferences, Income Demographics
Gradual Change
Tipping Point Change
Climate Change and human actions (which originate from their Preferences, Income, & Demographics and are made manifest via Economic Systems) are the drivers of this model.
via prices & substitutes
B.A.U.
Flee
Innovate
Fortress
Rules of the Game
Rules of the Game consist of public policies (created by govt and legal institutions) and public sentiment.
Economic Systems
Earth Surface Change
Ecological Systems
Full Valuation of Ecosystem Services
Ecosystem Services
focus on coastal & marine wetlands
Assumption: climate change is a global phenomenon and will have regional effects, but regional dynamics will have no effect at the global scale.
CCP Qualitative Model
v.2 2008.06.04
Macpherson & Principe
global
biome
landscape
ecosystem
plot
plant
Human-ecosystem interactions
international
national
state/provincial
municipal
family
individual


Wetland loss
Coastal Wetlands
IMPACT ON
ECOSYSTEM SERVICES
Land use practices
Nitrogen
biogeochemical cycling
biodiversity
SUPPORTING
HUMAN
HEALTH
AND
WELL BEING
fishing, boating,
bird watching
CULTURAL
Land Use and
Land Change
Land Use Decisions
oysters, crab, fish
timber
PROVISIONING
water quality
air quality
REGULATING
Population
Growth
Climate Change
Sea Level Rise
Storm Frequency
carbon sequestration
storm surge protection

Examples of Possible Ecosystem Services-Related Research Questions – Climate Change Scenarios




Cape Fear Watershed Stressor Scenarios : Land Use Chang
Policy (emissions) Change
Climate Change & Variability (e.g., flood, drought)
Meteorological Model
Air Quality Model
water
urban
rural
agriculture
Temperature, Precipitation, Deposition (N, Hg)
Watershed Model
Estuarine Model
Ma
Stream flow, TSS, [N], [Hg]
Stream flow, TSS, [N], [Hg], algae
Stream flow, TSS
Tributary model
Sport fish
Commerc
quan
Fish
Sport fish quantity & quality
Provisioning
•Clean air
Regulating
•Climate, Purification
Cultural
•Aesthetic
-Visibility
Atmospheric
Provisioning
•Fresh water quantity & quality
Regulating
•Flood regulation
Cultural
•Recreation (Swimmable)
Provisioning
•Food quantity & quality
Cultural
•Recreation
-Sport fish quality & quality
Fresh Water
Cultural
• Recreation
-Swimmable
Provisionir
• Food quantity &
Cultural
• recreation
-Sport fish qualit
Marine

Appendix C: Experts' Contributions—demonstrate the value of the money being spent

Allyson Beale has provided significant assistance with planning and facilitating our Constituents Workshop and Public Meetings, and has developed a detailed conceptual model, which will allow dynamic links to real-world data, and provides a ready means for visualizing ecosystem services rate functions and variables.

Appendix D: List of Future Products

1. Spatially explicit land cover maps and Land cover change maps and forecasts, including ecosystems and bundled ecosystem services and values

2. Reactive nitrogen detection and quantification systems

3. Spatially explicit models to assess effects of climate change and sea level rise on coastal ecosystem services

4. Spatially explicit models to assess effects of nitrogen on coastal ecosystems

5. Decision support tools incorporating spatially explicit models to assess changes in ecosystem services in response to management or regulatory decisions

Appendix E: Cross Cuts

Global climate change will have a dramatic impact on Coastal Carolinas ecosystem services. The coastal areas of North and South Carolina are subject to potentially catastrophic tropical storms and hurricanes, which are expected to increase in frequency and intensity with the gradual warming of the Atlantic. In addition, many of the lower-lying areas will be the first to be impacted by rising sea levels with the continued warming of global oceans and melting of polar ice. Ironically, much of the newest construction is in lower lying coastal areas, much of the higher elevations having been previously developed. Climate change is a major stressor in the Coastal Carolinas.

Wetlands are the principal ecosystem in the Coastal Carolinas, and we will be working very closely with the Wetlands team and the wetlands mapping team in developing our implementation plan. Under LTG 2, Mapping, the methods are being developed to map national wetlands. An aspect of the mapping is coastal wetlands. Some of the coastal mapping methods will be developed by mapping the Coastal Carolina wetlands. The functional aspects of the coastal wetlands , e.g. .nitrogen removal are being coordinated with both the wetlands group and the nitrogen group.

Nitrogen is a significant stressor to many of the coastal waters of the Carolinas, but not all. We will be working to compare the southern bays and sounds which are less impacted by nitrogen loading, to those of the Albemarle-Pamlico Estuaries, which are showing significant impacts of both atmospheric and land-source nitrogen loadings. North Carolina is a major source of atmospheric and water nitrogen due to many hog farms (combined animal feeding operations – CAFOs) upstream of the coastal areas.

Nitrogen removal by wetlands (fresh and estuarine), riparian buffers, and by shellfish in estuaries are aspects of the Coastal Carolinas research. In addition we will be researching how new methods of nitrogen detection (e.g. airborne sensors) can improve our understanding of nitrogen levels and their impacts on ecosystem services including water quality and water provisioning services and recreational services.

Coordination with Modeling.

We are working very closely with the NERL-ERD modeling team to extend the current MERT and APES models to incorporate linkages from upstream processes to downstream loadings and impacts. We will also be working with the NHEERL-AED to incorporate SPARROW and coastal and estuarine process models into the Coastal Carolinas FRAMES environment.

Ecosystem Services Research Program
Southwest Ecosystem Services Project (SwESP)
Lead – Nita Tallent-Halsell
Status Report and Future Directions. June 22, 2009

1.1 Project or Theme Goal

Quantify the impact of climate change and population growth on the bundle of major ecosystem services in the arid southwest (North America and Mexico).

1.2 Conceptual Model and Description

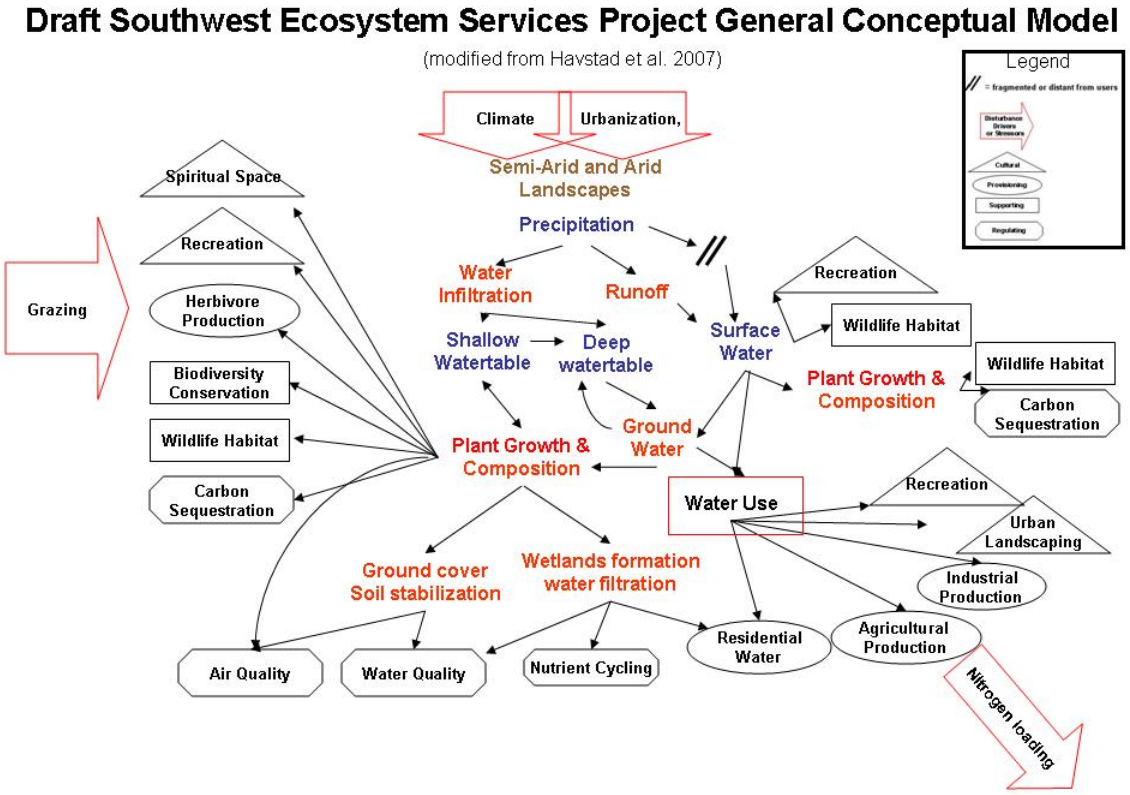


Figure 1 General conceptual model (draft) for the Southwest Ecosystem Services Project (SwESP). Block arrows represent disturbance drivers or stressors impacting ecosystem processes and shaped textboxes represent ecosystem services by type (see legend). The diagram traces from top to bottom the impact that climate change and/or urbanization may have on the amount and seasonality of precipitation which will directly (e.g., water infiltration and runoff) or indirectly (e.g., plant growth and composition, soil stabilization, wetland sustainability) impact other processes and/or services. Trade-offs resulting from livestock (grazing) and agriculture (nitrogen loading) production will need to be considered. This diagram has been modified from Havstad et al. 2007. (need the full citation at the end of the document)

1.3 Expected Impact/Rationale

Research areas include the impacts of climate change, urbanization, grazing and nitrogen loading, and measuring, modeling and mapping services. In order to address the ecosystem services derived from the desert, shrub- and grasslands, forest, agriculture, and urban ecosystems that comprise the arid southwest and the many stakeholders that value these landscapes, it will be necessary to implement several studies under the SwESP "umbrella" in the arid southwest. Research will be conducted through several, integrated, multi-disciplinary, multi-agency partnerships:

- The Assessment of Goods and Valuation of Ecosystem Services (AGAVES) will conduct an ecosystem services assessment of the San Pedro River Basin and adjacent watersheds in southeastern Arizona. The EPA ORD, Department of Interior USGS and BLM, USDA ARS, Upper San Pedro Partnership, University of Arizona, and others will partner and initially concentrate on clean water provisioning, carbon sequestration, recreation, and wildlife and livestock habitat and forage provisioning. This research builds upon previous efforts supported by the EPA Landscape Ecology Branch.
- The Santa Cruz Watershed Ecosystem Portfolio Model (SCWEPM) Project will develop a geographic information system based decision support tool that will integrate natural science, and economic and human health information in order to conduct a cost-benefit analysis of climate change and urban growth impacts on the U.S. and Mexico Border. EPA ORD, DOI USGS, the Sonoran Institute, and other partners will collaborate to address the impacts to ecosystems brought on by drought and urbanization. An example of a query that the decision support tool will address is how the development of drought sensitive landscapes (if the service of vegetative land cover is removed) may contribute to an increase in respiratory diseases. The goal of the SCWEPM is to develop a tool that will enable land managers in the US, Mexico, and the Tohono O'odham Nation to evaluate the impacts of land use decisions under different climate conditions and sizes of population. The LEB developed landscape assessment GIS tool, ATtiLA will be a component in the model platform.
- A study of the Public Values for the Santa Cruz River in Southern Arizona has been proposed by an EPA economist (post-doc) Matt Weber. This economic valuation research will proceed in two stages. The first stage is an extended focus group phase to provide a grounding for how area residents interact with and perceive the Santa Cruz river. The second phase will build on this information and construct a survey instrument to formally collect public values associated with realistic management changes. Valuation is anticipated to be a central part of survey analysis. However the opportunity to collect extensive qualitative statistics on human preferences for the riparian area will not be missed, and will complement valuation results.
- Designing and implementing a Native American Ecosystem Services Tribal Pilot Study with the Tohono O'odham San Xavier Reservation (located in the Santa Cruz watershed) is being considered to determine how an ecosystem services assessment can be linked with traditional knowledge to improve natural resource management and to identify decision support options. If implemented, this study

would compliment ecosystem service related studies that are being conducted with aboriginal peoples in Canada, New Zealand, and Australia.

- The Southwest Wetlands Ecosystem Services Study (SWESS), a component of the nationwide Wetland ESRP, will investigate the services of southwestern coastal and inland wetlands and compare them with wetlands in North America.
- The implementation of the UFORE Model in a southwestern city (Las Vegas, Nevada) is being investigated through an undergraduate student services contract (Angela Hammond). This effort began June 1, 2009.

1.4 Current Status

1.4.1 Research Underway in FY 2009

SwESP Timeline

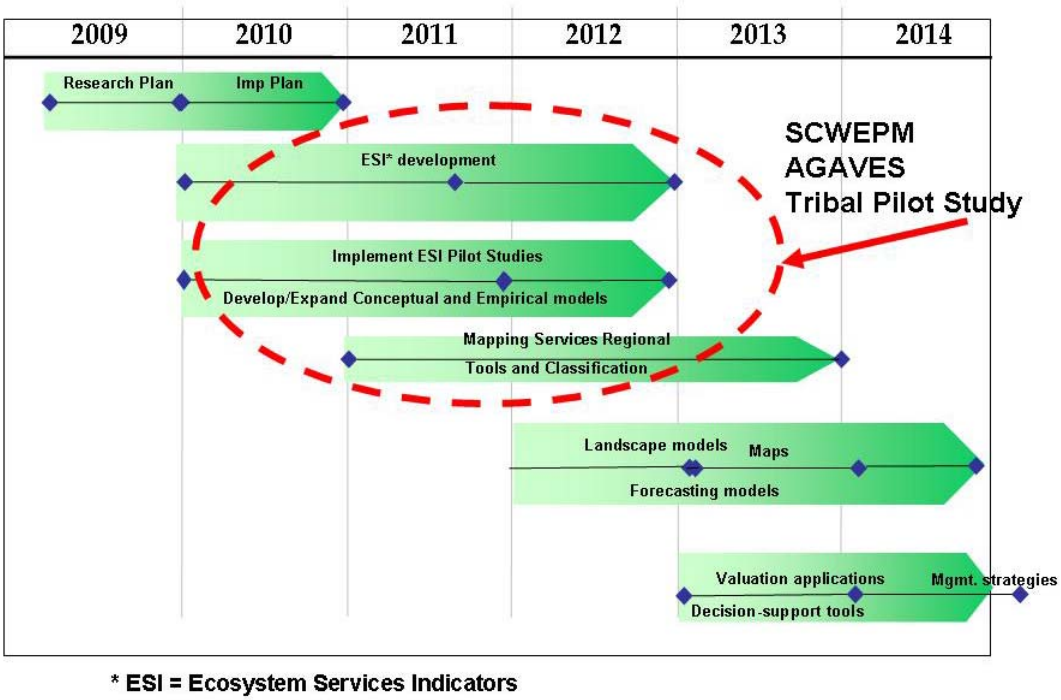


Figure 2 Timeline describing the general trajectory of SwESP research as planned for 2009 through 2014. SCWEPM = Santa Cruz Watershed Ecosystem Portfolio Model; AGAVES = Assessment of Goods and Valuation of Ecosystem Services Project in the San Pedro River Basin; and Tribal Pilot Study = Native American Tribal Ecosystem Services Study.

The SwESP was added to ESRP in July 2008 in response to SAB comments. A Research Strategy is being written and will be peer reviewed.. It will be cleared as a internal EPA document by September 30, 2009 and will serve as the bases for the SwESP Implementation Plan scheduled to be delivered no later than September 30, 2010.

1.4.2 Current Impacts, Critical Accomplishments, and Innovations

In less than a year, SwESP has created a framework on which research questions and interagency, multi-disciplinary studies can be implemented. Although the following research areas are in the early stages of planning, progress to date is noteworthy. [Please note that the proposed research has not been vetted through peer- or agency-review and therefore some studies, upon review of the SwESP Research Strategy, may be expanded while other areas might require that they be modified or dropped based on the availability of partners and resources and relevance to the Agency's mission.]

Considering that water availability drives ecological processes in drylands, modeling water availability and its use will dominate model and decision support development in the Southwest Ecosystem Services Project (SwESP). Ultimately, the long-term goal of SwESP is to be able to model the "water footprint" that humans have on specific ecosystems and thus, ecosystem services (analogous to the human carbon footprint). Specific research areas that were started in FY2009 that will contribute to our ultimate goal include:

An interagency agreement with the USGS is being developed in order to implement the Santa Cruz Watershed Ecosystem Portfolio Model (SCWEPM). Following several conference calls and webinars the inaugural meeting of the team is scheduled in Tucson, AZ on the 23 – 25 June 2009. Nita Tallent-Halsell, Caroline Erickson, and Matt Weber will be traveling to Tucson to attend, while Don Ebert and Michael Jackson will be participating via teleconference and USGS webex.

The SwESP Lead is one of three co-chairs of the Assessment of Goods and Valuation of Ecosystem Services (AGAVES) Project in San Pedro River basin. An AGAVES website and factsheet created by EPA (SwESP), USGS, ARC, and University of Arizona, to facilitate stakeholder outreach and education are scheduled for release in 2009. The AGAVES Science Plan is being drafted by EPA (Bill Kepner and Nita Tallent-Halsell), USGS (Darius Semmens, USGS Ecosystem Services Program Science/Research Lead) and ARS (Dave Goodrich) for further development by the research team in August 2009. Upon completion it will be submitted for peer- and agency-review. A MOU between EPA/ESRP and the Upper San Pedro Partnership (http://www.usppartnership.com/) is being reviewed by the USPP technical committee. SwESP is also vetting the feasibility and utility of the InVEST tool in the San Pedro Watershed.

In addition, meshing predictions of the impacts of changes in precipitation and temperature to existing hydrologic models of surface and ground water availability and human water use in the southwest is the focus of a Ph.D. student services contract with EPA, LEB. Recruitment by LEB hydrologist Yongpong Yuan has commenced, anticipating that the contract will be awarded in FY2009.

1.4.3 Publications and Papers Presented in 08/09 and forthcoming

Kepner, W.G., Semmens, D.J., Hernandez, M, and Goodrich D.G., 2009. Evaluating Hydrological Response to Forecasted Land-Use Change: Scenario Testing with the

Automated Geospatial Watershed Assessment (AGWA) Too l *in* Webb and Semmens, eds., Planning for an uncertain future—Monitoring, integration, and adaptation. Proceedings of the Third Interagency Conference on Research in the Watersheds: U.S. Geological Survey Scientific Investigations Report 2009-5049.
Allen, P., M. Nash, J. Christensen, A. Pitchford, R. Lopez, N. Tallent-Halsell, and L. Butler (in prep) Spatial Characterization and mapping of ecosystem services. To be submitted to Landscape Ecology.

Kepner, W. G., D. J. Semens, M. Hernandez, and D. C. Goodrich. 2008. Chapter 15: Evaluating hydrological response to forecasted land-use change. Pages 275-292 in J.C. Campbell, K.B. Jones, J.H. Smith, and M.T. Koeppe (eds). North American Land Cover Summit. Association of American Geographers, Washington, DC.

Levick, L., J. Fonseca, D. Goodrich, M. Hernandez, D. Semmens, J. Stromberg, R. Leidy, M. Scianni, D. P. Guertin, M. Tluczek, and W. Kepner. 2008. The Ecological and Hydrological Significance of Ephemeral and Intermittent Streams in the Arid and Semi-arid American Southwest.. U.S. Environmental Protection Agency and USDA/ARS Southwest Watershed Research Center, EPA/600/R-08/134, ARS/233046.

Presentations 2008 – May 2009:

Tallent-Halsell, N.G., C. Erickson, and W. Kepner. Modeling Ecosystem Serivces in an Arid Landscape using the InVEST Tool. Ecological Society of America 2009 Meeting, Albuquerque, NM. 1-7 August 2009.

Tallent-Halsell, Southwest Ecosystem Services Project. Ecological Society of America 2009 Meeting, Albuquerque, NM. 1-7 August 2009.

Weber, M. Ecosystem Services Valuation in the Southwest United States. Webinar with Landscape Ecology Branch and USGS. 30 April 2009.

Kepner, W. and G., K. Boykin. Modeling landscape-scale ecosystem services relative to biodiversity in the Upper San Pedro River Basin (US-Mexico). Association of American Geographers 2009 Meeting, US-Mexico Border Environmental Health, Association, Las Vegas, Nevada, 23 March 2009.

Tallent-Halsell, N.G. Southwest Ecosystem Services Project: Opportunities to Partner in the Great Basin. Webinar with the Great Basin Integrated Landscape Monitoring Pilot. 15 April 2009.

Tallent-Halsell, N.G. Southwest Ecosystem Services Project: Opportunities for Tribal Partnerships. Webinar with EPA National Tribal Caucus. 15 April 2009.

Tallent-Halsell, N.G. ESRP Southwest Ecosystem Services Project: An Update. ORD ESRP Webinar. 8 April 2009.

Tallent-Halsell, N.G., W. Kepner, and M. Weber. 2009. EPA's Southwest Ecosystem Services Project. School of Natural Resources and the Udall Center for Public Policy Studies, Tucson, Arizona. 26 January 2009
Allen, P., M. Nash, R. Lopez, J. Christensen, N. Tallent-Halsell, L. Butler, A. Pitchford, and A. C. Neale. Mapping Ecosystem Services: What is the State of the Science? A Conference on Ecosystem Services, Naples Florida 7 December 2008

Tallent-Halsell, N.G. The Shaping of the Southwest Ecosystem Services Program (SwESP). ESD / LEB Seminar. 25 November 2008

1.4.4 Resources

NERL 1.0 full-time science FTE, 2.5 part time science FTEs, 2 student support contracts and, unknown number of support scientists

NRMRL 0.4 of two post-docs

The SwESP needs additional funding for contract (student services, GIS, remote sensing), FTE, and/or partner support for development of ecosystem service indicators, decision support, and travel funds for federal staff.

1.5 Response to Comments

1.5.1 Response to Program Office Comments

None have been provided to date.

1.5.2 Response to SAB Comments

Adding a place based study in the southwest which will focus on water provisioning will address Ingrid Burke's initial response concerning the lack of representation "…six states [that] had population growth from 1990-2000 that was over 40%; none of them are included … In [the six states] among the most important ecosystem services are the provision of water (for metropolitan and agricultural use)."

The Southwest Ecosystem Services Project will enable the consideration of cross US and Mexico border (or transborder) changes to ecosystem services through the Santa Cruz Watershed Ecosystem Portfolio Model. This integrated modeling framework will be transferable to other arid regions located around the globe with similar concerns about continued provision of clean water for human use and sustainability of natural and constructed ecosystems.

Public Values for the Santa Cruz River in Southern Arizona: The tension between extraction and preservation is especially strong with water resource management in the Southwest. Water availability is a primary theme of the Southwestern Ecosystem

Services Program (SwESP). To complement efforts that focus on planning for human consumptive water needs, this study explores human values for non-consumptive uses of water. This research thus reflects a key point of the EPA Science Advisory Board Committee for Valuing the Protection of Ecological Systems and Services (CVPESS). In their draft report the CVPESS note that EPA value assessments have focused on relatively easily quantified benefits, rather than those that may be most important to society. This of course diminishes the relevance of the valuation study.
SAB also noted that ESRP did not include traditional ecological knowledge involving Native American tribes. The SwESP Tribal Pilot (assessment of services on tribal lands) will include such knowledge.

1.6 Challenges

SwESP will focus on complex systems in which our understanding of ecosystem services is quite limited in most cases. Just to identify, characterize, measure and map one service (water provisioning) is extremely time consuming. The prospect of evaluating bundles of up to ten ecosystem services can be daunting.

The SwESP needs additional funding for contract (student services, GIS, remote sensing), FTE, and/or partner support for development of ecosystem service indicators, decision support, and travel funds for federal staff.

SwESP goal is to assemble an interagency, multi-disciplinary team which requires sharing branch, division and laboratory resources (e.g., travel). However, our organizational structure does not readily support the sharing of funds for travel and other resources.

1.7 Future Directions

SwESP will continue to build relationships within EPA (other Branches, Divisions, Laboratories, and Regions) and with other organizations (DOI USGS, BLM, BOR; tribes; Mexican), in particular with those that are specifically mandated to concentrate on the ecological and sociological issues unique to the Southwest. SwESP will foster collaboration with existing projects/partnerships (Upper San Pedro Partnership, Great Basin Integrated Landscape Monitoring Pilot, Great Basin – Mojave Desert Climate Change Workshop development team, Border Environmental Health Initiative) as well as create an interdisciplinary, interagency, and international team focused on ecosystem services research.

The fact that the state of science (ecosystem services in urbanized arid regions) and SwESP are both in their infancy we have the opportunity to steer the development of innovative, and novel approaches to assessing ecosystem services.

1.8 Appendices

Appendix A: Draft Hierarchy of ecosystem services being addressed in the various sub-studies of the Southwest Ecosystem Services Project. AGAVES = Assessment of the Goods and Valuation of Ecosystem Services, California Coastal Wetlands = Coastal Wetlands and Estuaries in Southwest, Santa Cruz = The Santa Cruz Watershed Ecosystem Portfolio Model Study & Public Values of Santa Cruz River Study, Tribal Pilot = Assessment of Ecosystem Services in Tribal Lands

Service		Where/who in SwESP	Informing Indicators & Measures	Societal Benefit
Supporting Service	Biogeochemical Cycling			
	Carbon Cycling			
	Carbon pool storages	AGAVES	Standing biomass	Climate regulation
			Soil organic content	
	Carbon Sequestration	AGAVES	Net primary production	Climate regulation
	Nitrogen Cycling			
	N removal by denitrification (in riparia, rivers, lakes, reservoirs, wetlands)	California Coastal Wetlands	Microbial abundance; oxidation rate	Clean water
	Habitat / refugia			
	Terrestrial	Tribal Pilot, AGAVES, Santa Cruz	Nature, location, quantity & arrangement	Habitat Provisioning, Recreation, Cultural
	Aquatic			
	Wetlands/Riparia	AGAVES, Santa Cruz	Nature, location, quantity & arrangement	Habitat Provisioning, Recreation, Cultural
	Fresh water	AGAVES, Santa Cruz	Nature, location, quantity & arrangement	Habitat Provisioning, Recreation, Cultural
	Estuarine	California Coastal Wetlands	Nature, location, quantity & arrangement	Habitat Provisioning, Recreation, Cultural
	Near-coastal, marine	California	Nature, location, quantity &	Habitat Provisioning, Recreation, Cultural

		Coastal Wetlands	arrangement	
Regulating Service	Air quality regulation	TBD: Southern California?	Removal of pollutants	Clean Air, human health
	Disturbance & Natural Hazard Regulation			
	Erosion Control	AGAVES, Santa Cruz	kg/ha/year reduced	Air Quality, Water Quality, Human health (airborne particulates, aeroallergens)
	Flood Control	AGAVES, Santa Cruz	Change in flood peaks (2-yr., 10-yr., 50-yr. recurrence interval)	Water quality, climate regulation (retain vegetation – C sequestration), Habitat Provisioning,
	Fire Control	AGAVES, Santa Cruz	Fuel load	Air Quality, Water Quality, Human health (airborne particulates, aeroallergens)
	Disease Control	Santa Cruz	Host vector habitat	Support Human and ecosystem health
Provisioning Service	Food/Fiber Production			
	Animal protein			
	Terrestrial (livestock)	AGAVES, Santa Cruz	lbs/ha, animals/ha	Provisioning of food and nonconsumable products (leather, fertilize)
	Plant crops (grains, fruits, etc.)	AGAVES, Santa Cruz	Bushel /ha/year	Provisioning of food
	Grazing Forage Production	AGAVES	Livestock supported/ hay bale/ha	Provisioning of food for livestock
	Fuels	?	Net energy production	Provisioning of energy
	Water provisioning			
	Quality	California Coastal Wetlands		Clean water provisioning

	Quantity	AGAVES, Santa Cruz		water provisioning to support human consumption, industry, livestock, agriculture, habitat provisioning
	Surface water storages	AGAVES, Santa Cruz	Usable volume/capacity	water provisioning to support human consumption, industry, livestock, agriculture, habitat provisioning
	Groundwater	AGAVES, Santa Cruz	Maps of regional and alluvial aquifers Recharge rates per unit area Est'd. change in aquifer storage, or piezometric head., ft. above reference	water provisioning to support human consumption, industry, livestock, agriculture, habitat provisioning
	Timing: Maintenance of base flow	AGAVES, Santa Cruz	Statistical measures of baseflow characteristics, and change in same	
	Hydrologic regime	AGAVES, Santa Cruz	Statistical measures of flow regime, and change in same	energy production, water provisioning
Cultural Service	Recreational			
	Hunting & Fishing	AGAVES, Santa Cruz	Licenses/take	human well being, community revenue
	Ecotourism/nature Viewing/ trekking/ camping	AGAVES, Santa Cruz	Visits /year	human well being, community revenue
	Boating	AGAVES, Santa Cruz	Rentals/docking fees	human well being, community revenue
	Recreational Sports	AGAVES, Santa Cruz	Rentals	human well being, community revenue
	Sense Of Place	Tribal Pilot, AGAVES, Santa Cruz, Coastal California	TBD	human well being, community well being
	Spiritual value		TBD	human well being, community well being
	Existence value / bequest value		TBD	human well being, community well being

		wetlands		

Appendix C: Experts' Contributions—

Non-applicable at this time, however, we will be recruiting an expert in 2010.

Appendix D:

List of Proposed Future Products

Santa Cruz Watershed Ecosystem Portfolio Model (EPA & USGS collaboration)

AGAVES San Pedro Pilot Assessment (series of ecosystem services publications in collaboration with AGAVES partners)

Assessment of Ecosystem Services on Tribal Lands (Report; Peer Reviewed Publications

The impacts of rN on Ecosystem Services in arid and semi-arid regions.

Peer Reviewed publication: Public Values for the Santa Cruz River in Southern Arizona

Appendix E: Cross Cuts

Climate Change: Considering that life in the southwest is driven by the availability of water and that predicted changes to the region include drought everything that SwESP does will include consideration of changes in volume and seasonality of rain- and snow-fall. We will link or mesh predications (static or dynamic) from climate change models to water availability and use models We are also aware of the need to include water policy considering that western waters are more influenced by management than by nature. Our focus will be on the impacts of climate change on ecosystem services (i.e., decreased precipitation as rain and snow and shifts in the timing, intensity, and magnitude of precipitation events).

SwESP plans to co-host a climate change workshop in 2010 with the USGS. Leaders in understanding the ecological, economic, and sociological impacts of climate change (e.g., USGS National Climate Change Resource Center, Western Climate Initiative, Western Governors' Association) will be invited to participate. The objective will be for information exchange about ecosystem services, forecasts, climate models, interfacing models with other models, and consideration of interagency collaboration.

Wetlands:
The proposed SwESP research project is a component of the Nationwide Wetland ESRP Implementation Plan. The Southwest Wetlands Ecosystem Services Study, led by Ric Lopez, will develop approaches for assessing and designing robust strategies for quantifying and communicating the ecosystem services of estuaries and coastal wetlands, using ensemble modeling techniques that draw samples from a wide range of plausible computer-generated scenarios. The project will also focus on identifying policies and investments that perform well across a wide range of potential futures.

Reactive Nitrogen: The SwESP will propose research on the impacts of rN based on feedback from the Nitrogen-ESRP team, peer-reviewers, and Agency interest.
Air pollution-related atmospheric nitrogen inputs are a leading threat to western landscapes. The relationship between the level of N inputs into montane watersheds (primary sources of water in the southwestern US) and levels of nitrate in surface and subsurface drainage waters are well established. For example, nitrate concentrations in stream water in Southern California are the highest in North America for wildland watersheds. These high nitrate concentrations in runoff are a result of excessive ecosystem enrichment with N from atmospheric deposition leading to N saturated ecosystems (analogous to over-fertilized agricultural fields). This leads to a cascade of N-saturation of the vegetative community, generating excess N build up in litter and soil organic matter (which is than exacerbated by fire suppression efforts). We can surmise that chronic N deposition results in excess N in terrestrial, riparian and aquatic habitats in the west which in turn has lead to a change in the chemical environment of these ecosystems. Changes in chemistry have resulted in changes in the vegetative, microbial, and micro- and macro-flora and fauna (which sequentially can directly or indirectly impact ecosystem processes that contribute to services beneficial to humans, in particular water quality. The impacts of rN on the services provided by ecosystems in the southwest will be discussed in the Research Strategy.

Ecosystem Services Research Program
Cross Place Based Coordination
Coordinator: Hal Walker (401 782-3134) walker.henry@epa.gov_
Status Report and Future Directions. June 23, 2009

1.1 Project or Theme Goal

Cross Place-based (PB) research coordination is tackling the following issues:

(1) Cross organizational research. What should be common research activities among the place-based studies, and what, if anything, should not

(2) Develop common cross place research activities (e.g. mapping spatial extent of core ecosystem services using similar methods across the places). Are there opportunities we need to consider?

(3) Find other sites nationally, like LTER, other agencies' sites and explore potential synergies and cost-effective collaborations.

(4) Explore opportunities for ESRP to participate in the next Millennium Assessment (MA), by way of regional-scale analyses conducted here in the U.S. Much of the ESRP is based on the foundational work of the now completed MEA. The Millennium Assessment Follow Up (MAFU) studies have three goals: (A) advancing the knowledge base on ecosystem services and human well-being; (B) strengthening policy implementation at the country level based on the MA approach; and (C) outreach to disseminate the MA findings and framework to relevant stakeholders.

The Place Based research components of the ESRP are addressing MAFU goals (A) & (C), and will help strengthen policy implementation within the places. There are opportunities for cross place-based, and cross regional comparisons of ecosystem service production functions. This could involve testing ecological production functions develop for use within the place-based efforts, and the national mapping efforts. .Pursuing cross place based comparison opportunities could help strengthen national policy implementation (MAFU goal B), and simultaneously contribute to regional scale ecosystem service management. .

1.2 Conceptual Model and Description

Conceptual frameworks / models are being developed within each PB research effort, to help identify: a) principal drivers of change, b) possible disturbances to ecosystem structure and function, and c) ecosystem service response functions and ecological production functions that economists could use to assess ecosystem service benefits and benefits trade-offs. In parallel, the major ESRP themes are utilizing conceptual models to relate ecosystem structure and functions to a variety of ecosystem services endpoints (e.g. Provisioning, Regulating, Supporting, and Cultural). Ecological production functions are being developed and tested within the PB efforts, and some of these may be scalable for cross-regional comparisons and national assessments of ecosystem services. If this scaling works, economists and social scientists could use regionally validated ecological production functions, and alternative

benefit functions in analyses of benefits and benefits trade-offs. The approach is described in more detail in individual Place Based research descriptions.

1.3 Expected Impact/Rationale

Long Term (3 – 5 years): There is an opportunity to test ecological production functions developed within each Place Based effort, by developing cross place / cross regional comparisons. Cross regional comparisons could also utilize: 1) information from national scale monitoring programs designed to document regional variations in ecosystem condition among major ecoregions, and 2) regional scale models of factors affecting ecological production functions. (e.g. nutrient fluxes, or climate change) within major ecoregions. Comparisons of changes in ecosystem service production among regions could be used in conjunction with alternative benefit functions. The long term goal would be for ecosystem service production functions to be: developed, tested in cross-place / cross regional comparisons, and then used to assess benefit trade-offs for national policy development (as in MAFU Goal B) and regional scale management of ecosystem services.

Short Term (1 – 2 years): We can anticipate substantial progress in the individual Place Based research efforts, and increasing coordination between these efforts and the major ESRP thematic research. In particular, the location and spatial extent of ESRP Place Based studies enable us to compare how basic issues – such as mapping the spatial extent of ecosystem services for subsequent bundling – may need to be tailored to address differing biophysical characteristics of the site or varying spatial resolutions of ecosystem service estimates.

1.4 Current Status

From January thru June 2009, Place Based research leads initiated additional coordination between the Place Based work and the major ESRP themes. Monthly Coordination meetings in 2009 have focused on the following themes: February – Mapping; March- Nitrogen; April – Wetlands; May – Decision Support; June – revisiting Nitrogen, July – Monitoring. Resulting highlights to date include:

- Better coordination between ESRP Mapping Theme, and more localized PB efforts.

- Better coordination between ESRP Nitrogen Theme, and more localized PB efforts. PB research relating nitrogen attenuating features, ecosystem service production functions, and potential benefits trade-offs are now better represented in the final ESRP Nr Research Implementation Plan.

1.4.4 Resources

Cross place coordination is occurring, but the ESRP budget resources are managed within the major ESRP thematic, habitat specific, stressor specific, and place based work in the context of distinct research implementation plans that undergo separate peer review. Currently the ESRP budgets are linked to ESRP thematic research, habitat specific research, and place based research efforts. The opportunity to pursue cross place / cross regional comparisons

will require additional discussion and budget allocations that could be managed within PB studies or elsewhere in the regional to national scale ESRP thematic research.

1.5 Response to Comments

There were relatively few SAB comments directed at the Place Based components of the ESRP. One question related to the rationale for the initial selection of Place Based study areas. As discussed at the April 2008 review, the rationale combined scientific needs with operational feasibility, principally the proximity of ESRP staff and Laboratories and ESRP clients and stakeholders willing to participate in the studies over the long-term. . Since the initial selection of Place-Based study areas, the Cross-Place-based research theme has begun to formalize and capitalize upon the "experimental design" aspects offered by ESRP's suite of study sites, as requested by SAB comments. In addition, in response to SAB comments, ESRP has recently added a Southwest study location; the details of exact spatial extent are being refined in collaboration with ESRP clients and research partners.

1.6 Challenges

Significant scientific challenges: As noted by the recent SAB CVPESS report (June 2009) the science of ecosystem services requires more research to develop useful ecological production functions. Such methodologies are in their infancy. ESRP also needs to develop, test, and document ecological production functions, to determine how they can be used by economists to evaluate benefit trade-offs and alternative management decisions. Methods for developing ecological production functions depends, in turn, on iterating and synthesizing progress in their component parts; e.g., ecosystem service mapping, modeling, and monitoring, as well as how ecological production functions respond to changes in stressors or to management decisions. This is no small task, but we have begun to discuss how to proceed in a cohesive manner on this front.

We also see a need for ecosystem service research to become more transparent, both to facilitate more rapid scientific advancement, and to better inform national policy choices. Since much of this ecosystem service research involves computation, we especially need to have 1) reproducibility, and 2) Independent Verification and Validation (IV&V), two standard steps in software development. Reproducibility implies that when results are made available, others should be able to understand and reproduce the ecosystem service assessments, check calculations related to: a) ecological production functions, and b) alternative benefits functions. To be fully reproducible, there should be access to the underlying data / metadata and computational script

To move in this direction, we have an immediate need for better methods and protocols for Information Management / Data Management (IM/DM) to facilitate sharing of data, metadata, and computational script among researchers participating ESRP. In the former EMAP program, there were substantial resources committed to manage national EMAP databases. Something similar will be needed for the ESRP as this program matures.

Significant organizational challenges:

There are significant challenges to maintaining ongoing coordination among Cross Place Based research, including 1) having Place Based team members that are geographically scattered, and working in very different types of ecosystems, and 2) issues related to the coordination between the distinct Place-Based efforts, and larger regional / national scale thematic research.. Due to FTE and relatively tight budget allocations, there is limited capacity to conduct this coordination. The short-term organizational challenge is to simultaneously foster opportunities for cross-place research collaboration at the same time that individual Place Based teams compete for tight resources. The Place Based teams are primarily focused on individual Place Based study needs required to achieve their individually established goals. Place based research will likely continue to be inward looking in the short-term, with research primarily tuned to address the within-place ecosystem services and benefits tradeoffs. In the short-term the Place Based work can still be coordinated with the ESRP thematic research addressing National and regional scales.

There is an important longer-term opportunity for cross place based / cross regional comparisons of ecological production functions, and alternative benefit assessments. This implies the need for significant investment in IM/DM. The scientific foundations and for cross regional comparisons of ecosystem services can be supported in other components of the ESRP: mapping, monitoring, nitrogen, wetlands. However, Cross Regional comparisons of ecosystem services production functions and alternative benefits calculation that can be used for regional management of ecosystem services, will not be achievable without a significant increase in organizational resources and commitment to support ESRP IM/DM

1.7 Future Directions

These relate to the four issues identified in Section 1.1

Most important ongoing tasks:

In the short-term, the focus on improving coordination between the Place Based efforts that are operating on finer spatial scales, and the major ESRP thematic research operating at regional and national scales (e.g. mapping) will continue (Section 1.1, Issue (1).. This coordination will continue to facilitate both cross-place, and cross-theme discussions.

Next set of tasks:

- Developing cross place based research goals and hypotheses. (Section 1.1, Issue 2).

- Finding partners among other sites nationally (like LTER and sites from other Agency programs) that are willing and have resources to participate with ESRP. (Section 1.1, Issue 3)

- Continue exploring opportunities to have ESRP participate in the regional-scale assessment associated with the MAFU