NESP ENV Report 4

UPPER MISSISSIPPI RIVER SYSTEM

NAVIGATION AND ECOSYSTEM SUSTAINABILITY PROGRAM

Environmental Science Panel Report
Ecosystem Services: FY 2006 Workshop Summary and Initial Strategy Development

US Army Corps of Engineers®
Rock Island District
St. Louis District
St. Paul District

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Upper Mississippi River System
Navigation and Ecosystem Sustainability Program

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Environmental Science Panel Report: Ecosystem Services: FY 2006 Workshop Summary And Initial Strategy Development

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Executive Summary

In early planning and guidance documents, the Navigation and Ecosystem Sustainability Program (NESP) Science Panel strongly encouraged the exploration of ecosystem services as important expressions of the value of the Upper Mississippi River System (UMRS) to humans, and as measures by which the consequences of ecosystem restoration alternatives could be more comprehensively evaluated. Ecosystem services have received little previous attention on the UMR. The Science Panel recognized that in order to begin developing a strategy for understanding and using information related to ecosystem services under NESP, external expertise must be sought. This workshop served as the initial dialog between selected experts, several members of the Science Panel, and interested parties within and outside of the Corps of Engineers. The broad objectives of the workshop were to present important program background information to the invited experts, and to make strategic recommendations about how ecosystem services should be analyzed, quantified, and applied under NESP.

This report includes a record of the presentations and the discussions that took place at the workshop, four "outcomes" - written products that workshop discussions revealed were necessary to establish a long-term strategy, and a section on next steps. The outcomes include: a framework for identifying, measuring and valuing UMRS ecosystem services; descriptions of ecosystem services currently considered to be important on the UMRS and therefore warranting NESP evaluation; a description of tools already available for evaluating ecosystem services; and suggestions developing the NESP ecosystem services strategy. These outcomes are intended to provide initial stepping stones for advancing a NESP ecosystem services strategy. Given that many NESP partners are relatively new to the concepts of ecosystem services, and that strong consensus on definitions, measures, and valuation methods of ecosystem services will be required to use this information in management assessments, the Science Panel will encourage open communication with and among NESP partners to continue to clarify and refine the concepts contained in this report.

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Citation

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1 Introduction

A. Workshop Background

The role of the Science Panel is to provide guidance to the Corps and NESP partners on issues associated with future integrated and adaptive implementation of the program. Panel teams were established in 2005 to focus attention on specific elements of the adaptive management process: habitat project evaluation and sequencing; monitoring; report card; ecosystem services; model integration; and ecosystem goals and objectives. Ecosystem service recommendations included in a Science Panel report in early 2006 included support for full and open stakeholder discussion to reveal which services can and should be used to evaluate: "balance" among economic, ecosystem and social sectors; the allocation of ecosystem restoration funds; and the measurement of progress toward ecosystem objectives. The Science Panel strongly supported the need to solicit expertise from outside the UMR.

B. Workshop Objectives

1. To present, to external experts on ecosystem services, the intent of N.E.S.P., and describe the beliefs and questions that the Corps and other river stakeholders have expressed about the future value and use of ecosystem services information,

2. To evaluate and refine a 15-year goal statement for exploring UMR ecosystem services and incorporating results into river management decisions, and

3. To discuss and develop an initial coarse outline of a strategy for achieving the 15-year goal.

The first objective was completed. We quickly realized that the second and third objectives were beyond the scope of this initial dialog. However, we were able to focus much of the discussion on the information and steps necessary to develop a NESP ecosystem services strategy. This information is contained in the workshop outcomes described below. The workshop outcomes include: a conceptual framework for understanding and quantifying ecosystem services; descriptions of important ecosystem services provided by the UMR; brief descriptions of measurement and analysis tools; and suggestions regarding the content and sequencing of future work tasks.

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2 Participants

The workshop was convened on May 24-26, 2006, St. Louis, Missouri by the Ecosystem Services Team of the NESP Science Panel. Members of the team are: Ken Lubinski (USGS & TNC); Mike Davis (MN DNR); and Bob Clevenstine (USFWS). The workshop was facilitated by Brian Stenquist (MN DNR). Invited experts were previously selected to cover a broad range of experience and knowledge related to different kinds and applications of ecosystem services.

Science Panel

John Barko (Co-Chair) – US Army Corps of Engineers (USACE), Engineer Research & Development Center (ERDC), Waterways Experiment Station, Vicksburg, Mississippi

Barry Johnson (Co-Chair) – US Geological Survey (USGS), Upper Midwest Environmental Science Center, La Crosse, Wisconsin

Steve Bartell – E2 Consulting, Maryville, Tennessee

Charlie Berger – USACE, ERDC, Waterways Experiment Station, Vicksburg, Mississippi

Robert Clevenstine – US Fish and Wildlife Service (USFWS), Rock Island Field Office, Rock Island, Illinois

Michael Davis – Minnesota Department of Natural Resources, Lake City, Minnesota

David Galat – USGS Cooperative Research Unit, University of Missouri, Columbia, Missouri

Kenneth Lubinski – USGS, Upper Midwest Environmental Sciences Center and The Nature Conservancy, La Crosse, Wisconsin

John Nestler – USACE, ERDC, Waterways Experiment Station, Vicksburg, Mississippi

Larry Weber – Iowa Institute of Hydraulic Research, University of Iowa, Iowa City, Iowa

Regional Support Team

Claude Strausser – USACE, St Louis District, St Louis, Missouri
Jon Hendrickson – USACE, St Paul District, St Paul, Minnesota
Kenneth Cook – USACE, St Louis District, St Louis, Missouri
Kevin Landwehr – USACE, Rock Island District, Rock Island, Illinois
Charles Theiling – USACE, Rock Island District, Rock Island, Illinois
Daniel Wilcox – USACE, St Paul District, St Paul, Minnesota

Program Support Team

Kenneth Barr – USACE, Rock Island District, Rock Island, Illinois
Sandra Brewer – USACE, Rock Island District, Rock Island, Illinois

Invited Experts

Larry Bray	Tennessee Valley Authority
James Caudill	US Fish and Wildlife Service
Susan Durden	US Army Corps of Engineers, Institute of Water Resources
Robert Davis	University of Colorado
LeRoy Poff	Colorado State University

Agency/Organization Representatives

Todd Strole	The Nature Conservancy
Dan Fetes	US Army Corps of Engineers, Rock Island District
Steve Ashby	US Army Corps of Engineers, Engineer Research Development Center
Dick Steinbach	US Fish and Wildlife Service

3 Workshop Discussions

A. Day 1

1. Session I : An Overview of NESP and the UMR

The first session of the workshop provided background on NESP to the experts, as well as a sense of how the Science Panel views ecosystem services and their value under NESP. The session stimulated many questions from the experts and agency representatives, and set a positive exploratory tone for the rest of the workshop, described by one guest as surprisingly "lively and good-natured".

Notable Discussion Points

Following a presentation on NESP by Ken Barr

1. Adaptive management of the economic component of NESP
2. Fish passage economics:
   - will results be worth the costs?
   - how will they me measured and compared?
   - the need to address benefits at the systemic scale.
3. Nutrient recycling benefits associated with draw-downs
4. The programmatic limits of NESP (and which ecosystem services within those limits?)
5. Potential conflicts between recreation and ecosystem condition
6. The existence of market and non-market (i.e. biodiversity) services

Following a presentation on River Ecosystem Services by Paul West

1. Measuring the losses and gains of services with and without different management actions
2. The appropriate time scales for selected services
3. Audiences and messages
4. Assumptions related to biodiversity and sustainability

Following a presentation on Conceptual Modeling of Ecosystem Services by Lubinski

1. The need to encourage and the public inform scientists and managers about what it values
2. The need to value social rate of return
3. The critical need to specify the management goal (i.e. ecosystem health, sustainability, stability, the virtual reference condition)
4. The realities of achieving both ecosystem and economic health

2. Session II: What Can and Should NESP Try to Achieve in 15 Years?

This session began the discussion of the ecosystem service strategies and tasks that should be implemented under the NESP during its early years. Previously, workshop organizers had agreed to start this discussion with the following strawman goal (with explanatory bullets) that the invited experts could consider and react to:

By 2021, fully and routinely incorporate UMRS ecosystem service measures and valuations into Corps (NESP) decisions related to floodplain restoration decisions, and broader stakeholders considerations of whole system (ecosystem, economic, cultural) balance and sustainability.

- *Make trade-offs among system components explicit.*
- *Identify minimal necessary ecosystem service standards at appropriate spatial scales.*
- *Clarify important uncertainties to stakeholders to develop continuing learning objectives.*
- *Forecast future ecosystem service conditions under real and practical management decisions. Use forecasts to establish adaptive strategies.*

Notable Discussion Points:

Following the presentation on the Strawman Goal by Ken Lubinski

1. NESP ecosystem services efforts should:
    - define and quantify service outcomes under different management alternatives
    - clearly state the problems being addressed
    - measure services at pool reach scales
    - focus on manipulating functions – responses to adaptive management
    - incorporate ecosystem services into the Corps' decision making policy
    - identify the key services accounting for value.
    - "incrementally incorporate…"
    - address interacting time and space scales
    - developing ecosystem service indicators of ecosystem health – that can be measured annually or every 2 years
    - account for natural variation.
    - identify the range of management actions that can/will attain success/failure of specific goals.
    - identify benchmarks on achieving a 15-year goal and assign shorter timeframes to them
    - address benchmarks of ecosystem services
    - associate sets of services that are rendered by goals and objectives (that can be rolled up into system goals).

2. Regarding the listing of UMR ecosystem services:

   - Work of other groups (Smithsonian, Oakridge) is valuable
   - Need to start with a full list, then prioritize
   - Full list and prioritization process should be linked to goals and objectives

3. Regarding criteria for listing and prioritizing services, criteria should include:

   - scarcity and availability of substitutes
   - risk status
   - value to stakeholders
   - value to decision makers (in terms of clarifying trade-offs or reflecting other services that aren't measured)
   - application to objectives

   - criteria should be similar to if not identical to those used in establishing report card indicators.

4. Table 1 identifies ecosystem services listed as important by workshop participants.

Table 1. Important UMR Ecosystem Functions, Structures and Services identified at the workshop. Selections were based on Farber et al. (2006). Two other lists are provided for comparison.

Category Service	Farber et al. (2006)	Navigation Feasibility Report (2004)	Millenium Assessment (2005)	NESP Ecosystem Workshop (May, 2006)
Supportive Functions and Structures				
Nutrient Cycling	X	X	X	X
Net Primary Production	X		X	X
Photosynthesis			X	
Pollination/Seed Dispersal	X		X (considered regulation)	
Habitat	X	X		X
Hydrological Cycle	X		X	X
Biodiversity		X		X
Regulating Services				
Gas Regulation	X	X		-
Climate Regulation	X	X (river valley)	X	-
Disturbance Regulation	X		X (hazard regulation)	X
Flood control		X		
Biological Regulation	X		X (pest regulation)	X
Water Regulation	X		X	-
Soil Retention	X		X	X
Floodplain soils		X		
Soils for floodplain agriculture		X		
Soil formation		X (consider supportive)		
Waste Regulation	X	X (assimilation)	X	X
Nutrient Regulation	X			X
Air Quality Regulation			X	-
Provisioning Services				
Water Supply	X		X (Fresh water)	X
Municipal		X		
Residential (groundwater)		X		
Industrial Process Water		X		
Industrial Cooling Water		X		
Residential/Commercial Cooling Water		X		
Irrigation Water - Agricultural		X		
Irrigation Water - Urban landscapes		X		
Livestock Watering		X		
Transportation				X
Hydroelectric Power		X		
Food	X	X	X	X
Raw Materials	X	X	X	X
Genetic Resources	X	X	X	X
Medicinal Resources	X	X	X	-
Ornamental Resources	X			-
Cultural Services				
Recreation	X			X
Boating		X		
Opportunities		X		
Ecotourism			X	
Aesthetic	X	X	X	X
Science and Education	X			X
Spiritual and Historic	X	X	X	X

B. Day 2

The depth of the Day 1 discussions required an unexpected amount of time and therefore at an *ad hoc* meeting of Science Panel members to start Day 2, we decided to abandon the original Day 2 agenda in favor of giving the experts and agency representatives adequate time to share their knowledge and experiences, and to use the afternoon of Day 2 to run through an exercise of identifying ecosystem services that would likely be associated with a planned Corps multiple-project effort on Pool 18. The resulting discussions revealed that several ecosystem measurement tools already in use may be appropriate for future work under NESP.

1. Session III. Expert Presentations and Associated Discussions

Note: The following material has been reduced and edited from notes taken during the session. For clarity and flow, the presentations and discussions are presented in first person format. However, these should not be considered direct quotations.

a. Bob Davis

We first have to educate ourselves about the matrix between ecology and economics (figure 1). Human actions act upon ecosystem structure and functions, but this is not the only parameter, there are biophysical parameters as well. Scientists have been preoccupied with these biophysical parameters. The beginning of the progress toward quantifying Ecological Production Functions is in the Wilcox spreadsheet shown by Ken Barr yesterday (Objectives vs. Services).

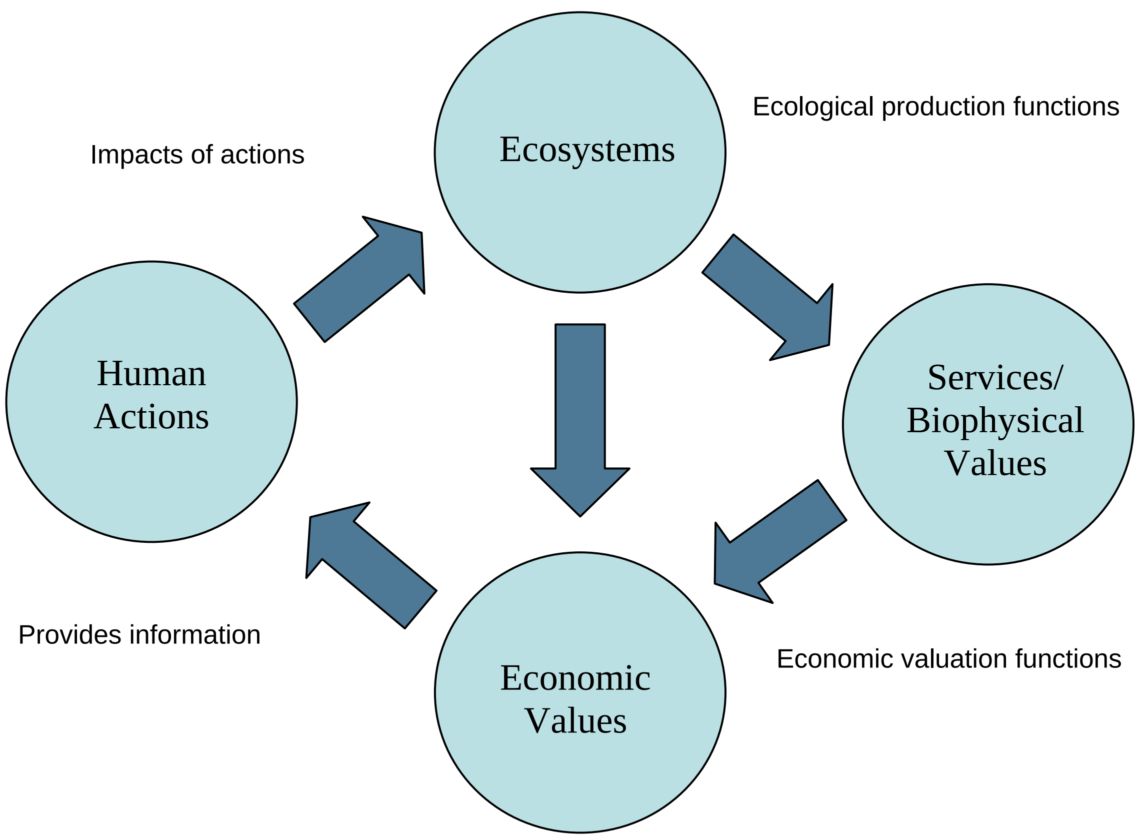

Figure 1. Conceptual framework adapted from the National Research Council (2004)

This is where the problem begins – what are your objectives, inputs? What do decision makers want? What are the consequences of different actions? We could help decision makers if we could think clearly of inputs and outputs. Why do you have the objectives in the 2003 Science Panel report? What do we get when we increase topographic diversity? We should go through the matrix and look at what makes sense to do next – rank actions in order of things to do – benefits, timing, etc. We're not there in terms of being able to quantify services. We should put early effort into Ecological Production Functions. The Science Panel has put a lot of effort into this, but it is not organized in terms of outputs. It seems as though you are approaching this in terms of landscape architects. Consider the example of the barge pilot who wants the cleanest engine room. Why? Just to have a clean engine room? No, his purpose is to have the best functioning engine to drive the ship. Objectives need to be written so they are getting at outputs.

What is the source of economic values? It is the willingness to pay.

If you are going to make progress in the next step toward values (economic values…willingness to pay) you also need to work on the value function. The production function and the value function make the ecological model. It is a major step for economists, scientists and engineers to make a collaborative leap to these functions.

Product tradeoffs need to be recognized. If Y1 and Y2 are products, there are times when they compliment each other, and when they are in equilibrium. But at some point they may conflict with each other (figure 2).

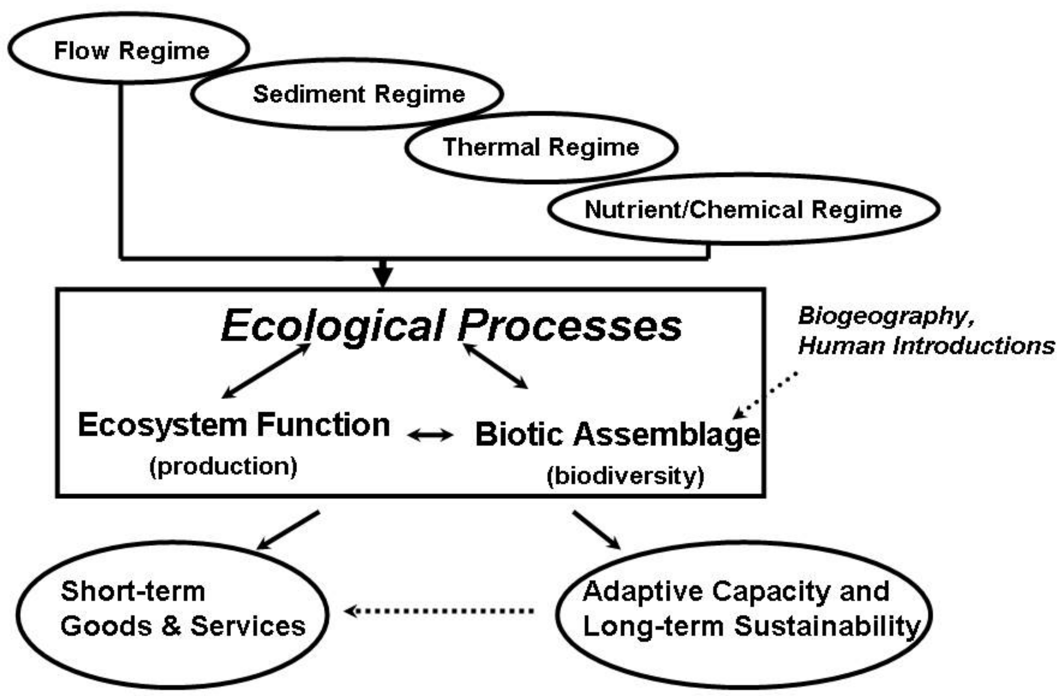

Figure 2. Links between river ecological drivers, processes and services.

Regional economic benefits need to be assessed as well as local benefits.

It would be wise to have a full statement of ecosystem services that we propose to produce and willingness to pay values that we expect to receive from those services by the time of the 15-year re-authorization. There is no regional impact/expenditure impact for genetic resources and other similar services. Market/non-Market and user specific/user non-specific dichotomies need to be addressed. Everyone benefits if there is some carbon sequestration associated with some of these services. But the standard benefits (i.e. hunting, fishing, aesthetic, commercial materials) are readily evaluated at the regional and national level.

Some inputs can be called outputs and vice versa. Net Primary Production can be both an input and an output. But it is best to be very clear in this by identifying the constituency that you are addressing.

Discussion

Nestler – Who should develop the production function - stakeholders or scientists?
Davis Response **-** It should be the scientists and engineers that develop the primary ecological production functions. Stakeholders includes the states, and they have a good sense of the input/output relationships in their reach of the river. Count on those people to develop and quantify those relationships. Stakeholders in the non-scientific sense could give feedback in the economic valuation methods. One way to do this is through a survey method or to develop a panel. Ecological Engineering is a key term here.

Nestler – When trying to attach a monetary value to some of these functions some people use the opposite – the penalty function, to evaluate value. Do you have any thoughts on this? Is this an option for decision support for the UMR?
Davis Response **-** A lesser penalty is more desirable. It sounds like Nestler has inputs from a systems model. The penalty system is of value.

Wilcox - As a society we put a monetary value on particular items yet there are other items that we don't put a monetary value. There is a whole array of ecological values to the UMRS, but we only put a monetary value on a few of those services. If we only focus on a few of those services and don't pay attention to the entire array then I think we are deluding ourselves in decision making activities.
Davis Response **-** You need to focus on the major services first. Take recreation for example. Duck hunting and bird watching can be economically equal. You can value both by willingness to pay. You can shortcut this by simply saying that this species has a right to live, but that is more difficult than simply using the production function.
More often than not it takes the valuation of the most important functions (goods and services) to carry the day that the benefits of a project exceed the costs. You can always include a narrative of the items that you left out.

Galat - Should we go through our objectives with that thought and prioritize them based on this.
Davis Response **-** Yes, your objectives become you inputs. They are really intermediate inputs/objectives. The value of the final output is what you are moving toward. You can use the idea of value added (wheat…to milled grain…to bread…to market).

b. Larry Bray

TVA does some different things to put dollar values on actions. The Chickamongue Lock is an example. They've looked at situations where the traffic went to the roads instead of the waterway, and the consequent effects (.i.e. more air pollution, repaved roads, more accidents, etc). How many trucks would be on the roads if these locks closed became a take home message.

I left the meeting yesterday not knowing who the stakeholders were. Come up a list of services that seems appropriate. You have a national audience to keep the funding coming, which is tied to the local audience. You have some strong stakeholder groups – levee districts, navigation, farmers. You have to find these indicators, put monetary values on them, and communicate this to the stakeholders.

Discussion

Barr - How did TVA develop the Regional Economic Development figures for the NESP?
Bray Response – Does everyone here have the Principles and Guidelines? The rules are somewhat lax in RED – you can count construction. The model operates annually, and operates 35 years into the future. This is used for load system planning. What value does the ecosystem bring to society – how do you measure this? He said they did a literature review on social rates of return – there is a lot of literature on this. There is some thought that the social rate of return on ecosystem restoration is 3 percent, though the evidence is scant. There is some (also scant) evidence that in the Rock Island District the social rate of return on EMP is 1 percent. A paper can be made available. If I could get a complete set of data on ecosystem restoration moneys spent nationally I would be willing to sit down with his statistician and get a better dollar.

Davis, R. **-** Another method could be used.

Clevenstine – Do the 1 percent and 3 percent rates of return accrue back to a geographic area?
***Bray Response* -** I assume it will accrue back to the region. The author is Treyz. There have been papers written on this and one published. This is basically a migration function –as money is invested in the region it makes it more attractive for people to visit and then live there.

Theiling - Galat's student has a lot of data on WRP, would that be useful to Larry's effort?

Lubinski - Is construction cost data the only kind that is needed?
Bray Response – This is not the only input that can be used, but that is what was used for this.

Wilcox - Using the cost of ecosystem restoration efforts for regional economic benefits is a huge leap of faith. Not all ecosystem restoration efforts are successful – some aren't successful and don't have benefits. The monies spent on restoration through the NESP will be "small potatoes" compared to all of the ecosystem restoration being funded nationally.

Galat - We estimate about $1 billion/year in ecosystem restoration.
Bray Response – With better data we would be willing to refine the models we have.

c. LeRoy Poff - There are some measurable ecosystem characteristics that can be indicators of sustainability – there are biological drivers that drive the ecological processes that produce these ecosystem characteristics. It is our challenge to define the natural range of variation at appropriate scales of space and time.

There is a point I want to articulate, since I am not seeing it in our current discussion. It is about drivers, processes, and characteristics leading to and being expressed as ecosystem services (see Figure 2). How do we select these services? What are our selection criteria?

Some selection criteria were listed yesterday. But selection criteria can be goal-driven to achieve “Whole system balance and sustainability”. It is important to communicate the interaction from management action to biological process to ecosystem service. We seem to be missing a clear conceptual model that can be communicated to the Corps and the stakeholders.

Discussion

Nestler – Regarding whole system/trade-off analysis, one of the ways to do this is to think of trade-offs in time and space – one pool one year, one pool another year. If you look at “whole systems” then you could miss some of the other temporal/spatial trade-offs.
Poff Response – I agree. It would be difficult to deal with all of these tradeoffs. This may be better addressed later today, but it is a strategy that needs to be discussed.

Strole - The only thing that slide 5 has a question mark on was selection criteria. Is that where we should focus?
Poff Response **-** We obviously want to get to these services, so maybe the selection criteria are what we need to look at.

Consider the spatially specific parts of the system – 37 pools. Will only 4 of these be under a management regime? If you recognize that the river is connected by hydraulics – you need to look at the spatial distribution of its parts (floodplain, locks, etc). There is compensation between patches. If one patch has severe disturbance there may be some compensation – migration, repopulation. The system should be viewed as a landscape with specific patches on the landscape.

Barko - Aside from considering services and selection, something else that we haven’t come to terms with is the definition of sustainability. What measures do you use to evaluate sustainability?. Maybe we need to back off of objectives, instead work on the service and use those from the top-down.

Galat – I agree with John in that when working from the top-down we are a really looking at systemic functions. He likes the idea of looking at the services separately from the objectives. If we go from our objectives to the services it will bias us a bit. If we build our services and then review them with the objectives it will help us clarify our thoughts.

B. Davis – Let’s also review the conflict between user-driven services and science-driven services. The science-driven approach is focused on inputs, while the user-driver approach is usually driven by outputs.

Galat - If we go the service route we will see where that tension lies. Once that is identified we will have to decide if we will be driven by the science or the users.

B. Davis - It would be good to review the links between the objectives and the services.

Wilcox - If we don’t have good recognition of current UMRS ecological state and understand what its output could be, then we may set our objectives at the wrong level. People are used to what is currently here. When we go out to the public and describe a restored ecosystem the public says they like what they have – they are used to a degraded ecosystem and do not understand how productive the ecosystem can be.

Durden - Particularly in the Corps, our view of education it convincing people that we are right. We don't recognize the public's ownership of the resource – we focus on what we think is right, rather what they value and what they need.

Wilcox - I would prefer not to go out and lecture people about the values of ecosystem restoration, but would rather have successful restoration that would be self-educating. When you can restore that phenomenal abundance of life to an area people will react to it.

Durden - In a public meeting that I attended they had artists at the meeting who would draw pictures of what people wanted of the ecosystem.

d. Jim Caudill

Consider economic value as a constant. If you are looking at these biological services I am assuming that you are going to have annual or seasonal measurements. However, you may only have economic valuations calculated every few years (assuming that we won't have the resources to do annual surveys). The economic value becomes a constant – this is an economic index (there can be annual adjustments for inflation). This may not be a problem. In the FWS we have discussed this. In some cases we are looking at data that are 15 years old. This can create problems for some managers.

Discussion

Galat - Is there is some understanding of what other factors can influence this economic value?
***Caudill Response* -** Economic conditions, housing values, recreation, economic stability in the region can all effect value.

Durden – I think that a well thought out benefits transfer approach may be more accurate – these are more peer reviewed and have the better expert backing.
***Caudill Response* -** It is important to take manager's expectations into account. How will they perceive this information and what will their expectations be?

Wilcox – I've seen many good studies on economic valuations and understand the complexities of the willingness to pay methods. I'm concerned about getting the higher levels of the Corps to accept these methods – we have to certify the models that we use. If we use models that are already peer reviewed, and don't try to reinvent the wheel we have a good chance of selling this.

B. Davis – The Corps' Principles and Guidelines discuss how to use non-market values for non-market goods. Look at that and use those methods.

Barr – Does the FWS have models on willingness to pay for improvements to the refuges?
***Caudill Response* -** They don't have the resources to do these surveys, but it could be done.

M. Davis - How do you get to the economic value of mussel beds – the general public may not have a good idea on this? How do you handle services that have ecological value but that society may not recognize?

B. Davis - If you put a panel together you may be surprised with the willingness to support this – but you have to present the facts. You cannot go out and just ask what their willingness to pay without informing them first.

Lubinski - How do you measure items that don't have a recognizable service for right now? In the framework diagram, is this the purpose of the route that bypasses the Economic Production Functions and the Economic Value Functions?

B. Davis - Not necessarily. You can go through the process.

Clevenstine - A group in FWS used a mussel replacement exercise.

Durden - An NGO in Tennessee working on educating the public did some surveys of how effective that this was. She thought that none of these services are new – none of them would not have literature.

Nestler - Catching regional fish is not important to me, but protecting a national resource is. I suspect that others would feel the same way.

Wilcox - This is a bequest value – knowing that they are there for your grandchildren. There are lots of other values. I think you need to use them all.

B. Davis - The NRC said this is the Total Value.

e. Susan Durden

We need to make sure that we are tying our services to actions. W also need to look at this incrementally, and we also need to think about monitoring (social science modeling, NOAA report). The team has done the right things by realizing that you need these services and by getting people to the table.

Main points to the Corps and Science Panel:

- Language – it is important to communicate the definitions
  Ecosystem Characteristics vs. Benefits vs. Services

- Linkages – this is very important – objectives to actions to services and back to objectives. There may be some bad assumptions there – it is an iterative process and by going through it you get the linkages correct. The linkages between economists, ecologists and social scientists also need to be maintained.

- Listing of Services – use an established list. In terms of resource use, identifying the perfect list is not critical. The list will evolve eventually, so just pick one. The Millennium List is probably the most current.

- Valuing – start with the benefits transfer approach. The model is available on the website. It is used by the Corps, is user friendly, and has support. In response to a comment from **Barr** that these surveys were done in the 1970s, Durden's response was that the expenditure values have been updated, so the surveys are not as important.

- Existing Resources – EPA has formed a science advisory board on this very topic. They have written a report based on various EPA programs and identified how they fill in the gaps in their evaluation. Seventy five to eighty percent of the issues were common to the different agencies. Only 20-25% percent were unique to an agency or program. She recommended the Corps use the work of these others groups – their report is on the web. Nicole Owens (EPA) would be very good contact. The work that BoozAllen has demonstrated has very innovative techniques and they were extremely honest in what they did. Next February Resources for the Future is putting on a conference on Ecosystem Services. The conference is free.

Suggestions:

- Pick 3 services in terms of priority
- In 2-years have a framework
- In another year complete the valuing of those 3 services
- 2-more years to develop into a generic framework.
- This program would be a good demo for the work that the Corps is doing with the collaborative planning EC – Randy Allen. Doing this well can serve the bigger picture that people in Washington are concerned with.
- Specifically focus on communication (local decision makers). We need to show what is happening and answer the "so what" questions.

Discussion

Lubinski – What is the Benefits Transfer Approach?
Durden Response **-** This is a way to get values for services. You look at other people's work and use what applies to your needs. You may choose to do original research in one area and then apply it to others.

Barr – Is it like a real-estate appraisal?
Durden Response **-** This is a good analogy.

Barko - What is a generic framework?
Durden Response **-** It is a generalized approach that you can apply to all the services that you are considering evaluating.

Clevenstine - From the Household Surveys the FWS already have the top 3 services – water quality, biodiversity, recreation – agriculture and transportation are lower on the list.
Durden Response **-** Those 3 services would be very good for an initial demonstration. In terms of decision support systems, I recommend two different models: MCDM (Multi Criteria Decisions Methodology) or CARS (Computer Aided Reasoning System). Both of these models work with situations of deep uncertainty. This can give you a structured way of looking at decision making – your focus isn't on a line, but rather on quadrants. It won't necessarily give you the best answer, but helps you to identify you critical decisions. These models are very transparent.

2. Session IV: Learning from Walking Through the Pool 18 Example

The afternoon session was devoted to stepping through two of the questions the Corps will likely face as it seeks to engage ecosystem service information to manage multiple projects adaptively.

> **Actions - What actions can we take to improve aquatic plants in this pool?** The action that the team is thinking about is a 2-foot drawdown. This entails advanced dredging. There will also be impacts to recreation. Marinas will have to be dredged out and boat ramps extended. Where will the Corps put all the dredge material? Fish spawning may be impacted too. Plants will emerge, ducks will probably use this. What and where are the alternative measures? There will be a need to compare these alternative plans to see what their outputs are. Also, we'll have to do incremental analysis of each management action. It is within this Corps planning process that we need to use this goods and services model. Currently we are using Habitat Areas, but they are not easily comparable between different geographic areas.
>
> **Inputs and Output**s **- What ecosystem services will change?** Fish passage improvements and floodplain restoration were discussed. There was some discussion about objectives seeming to be inputs. But others saw management actions as being the inputs.
>
> We are going to do A, which is going to produce B which will result in C. For today we need to work this in two directions from A to C and from C to A. There was some discussion on taking the 3 services identified by FWS and then going back to the objectives.

The Science Panel described how the Corps intends to use three reaches of the UMR as experimental areas for evaluating how different management actions could be used achieve pool-scale ecosystem objectives. We then discussed how several ecosystem services provided by Pool 18 could be defined, measured, and used to most effectively achieve ecosystem objectives in this area.

Examples:

Action: Increase Aquatic Plants
Impacted Ecosystem Service: Recreation

We discussed of the movement of waterfowl and hunters. Would there be more birds and hunters, or would they just be migrating from one locality to another? Several hypotheses exist: A) the birds will stay on Pool 18 longer; B) the birds will be in better shape so there may be increased number of duck days in the system. One expert suggested that an additional day of bird watching or an additional day of hunter/days is what matters. By increasing the number of aquatic plants, we may affect recreation services (recreation use days, recreation use quality).

Action: Increase Aquatic Plants
Impacted Ecosystem Service: Water Quality

We need to be careful of this and avoid double counting. Water quality improvements can help aquatic plants which can improve hunting – if so, those benefits should be counted in recreation. However, water clarity also improves aesthetics.

Wilcox - The planning of ecosystem services should be centered around our ecosystem objectives.

B. Davis – I would like to see people focus on the ecosystem services – what do you want to see?

Clevenstine - We need to focus on the poolwide/systemwide objectives. Not just the objectives of a particular management action. We need to realize that it is water quality for humans that is being measured.

Action: Increase Aquatic Plants
Impacted Ecosystem Service: Biodiversity

Humans value biodiversity as is evidenced by their willingness to pay for ecosystem restoration.

Durden – Office of Management and Budget does not make sense out of biocentric plans, so therefore we need to focus on more common sense.

Lubinski – What about using TNC as an example **-** donors have donated over $1billion in order to preserve biodiversity. This term is not usually included in services because it really is an umbrella for many different services. It provides for all these other services on the list.

Poff – Think in terms of adaptability and ability to exist in varying habitat conditions—the ability to survive.

Nestler - Resilience to change tends to improve if you have biodiversity. Have there been studies where biodiversity has been assigned a monetary value?

Wilcox – I'm not sure if we will be able to handle this in any other way than narrative?

Nestler - Biodiversity may not have to be dealt with individually, it may be able to be folded in; recreation is an indicator of this.

Poff - This could be done the other way. Biodiversity could be an ecosystem function rather than a service.

B. Davis – Following through on most of this conversation would result in double counting. It (biodiversity) hasn't been added to the list of things that can be valued. The only other thing that could be added would be aesthetics.

West - Biodiversity will be measured on the report card.

Galat - When we use the approach that everything has to be a production function we are missing much of the complexity and interaction of the system.

3. Session V: Closure

Positive expressions about the value of the workshop discussions were voiced by all of the participants. It was clear that cross-dialogues need to be maintained between ecologists, economists, and social scientists as well as between the different river interest groups.

The Corps and the Science Panel sincerely thanked the invited experts for their time and insured them that measures will be taken in the future to continue the discussion started at this workshop.

4 Workshop Outcomes

A. Ecosystem Services Conceptual Framework

Based on discussions presented at the workshop, and especially the presentations by Robert Davis and LeRoy Poff, the Ecosystem Services Team suggests that a conceptual framework based on one developed by National Research Council (2004) be accepted as a valuable tool for organizing future NESP ecosystem services work. The framework (Figure 1) depicts the flow of ecosystem services from ecosystems, and identifies two sets of functions (ecological production functions and economic valuation functions) that must evaluated and understood in support of UMR restoration decisions.

People utilize goods and services produced by ecosystems. The biophysical quantity of the service (such as water quality) is quantified by defining the *ecological production function*. This production function can be difficult to define and it is important to document assumptions made. Approaches for developing the production function include defining the relationship between area and services produced (such as x acres equals y ducks or hunters), or by defining more complex relationships between the biota and processes that produce the service (such as how velocity, volume, and wetland location/size all effect water quality). Ideally, the biophysical quantities are in units that have existing markets. For example, if the quantity is in number of ducks or hunters, the biophysical value can be more easily translated into dollar value based on how much money a typical hunter spends in a season.

The biophysical values are converted to economic values by defining an *economic production function*. In many cases, expressing the value of and ecosystem service in dollar values is advantageous because it more readily enables tradeoffs among services to be evaluated. However, there are not currently markets for most ecosystem services. Where markets do not exist, several non-market valuation approaches can be applied, such as willingness to pay, hedonic pricing, substitution costs, etc. In some cases, it may be more effective to present the value using other metrics. For example, values can be represented in terms of number of species, percentage of people that cultural or spiritual connection to the resource, etc.

These biophysical and economic values provide information to decision-makers for assessing the tradeoffs among different policy or management alternatives. Action taken will have an impact on the ecosystem that provides the service. Ideally, there will be similar metrics developed for the report card on ecosystem health and the evaluation of ecosystem services. In some cases, there will be some processes that are critical to maintaining ecosystem health, but are not directly translatable into production of ecosystem services. As the framework is implemented, it will be important to include several ecosystem services so that tradeoffs can be assessed. This reduces the chances that the system will be managed for one service at the expense of others.

B. Integrating Ecosystem Services and Ecosystem Health

LeRoy Poff presented a framework for selecting which ecosystem services to focus our efforts on. Similar to recommendations of the science panel's Report Card team, Poff advocated for taking a multi-scale (time and space) approach for assessing ecosystem health that uses indicators of the drivers (e.g., flow regime), processes (e.g., spatial distribution of habitat), and biota. Where possible, these indicators, or ecosystem characteristics, should be expressed in units consistent with valuation of ecosystem services. Poff advocated that the selection criteria for the priority ecosystem services recognize three main factors: *constraints* (institutional, social, scientific), *audience* (valuable to stakeholders, decision-makers), and *goals* (ecology and economics, balance and sustainability).

C. Important Ecosystem Services of the UMRS

Workshop participants were asked to review a recent scientific synthesis of ecosystem services (Farber et al. 2006) and to identify services that are important enough on the Upper Mississippi River System to warrant evaluation under the NESP. Participant selections are listed in figure 3.

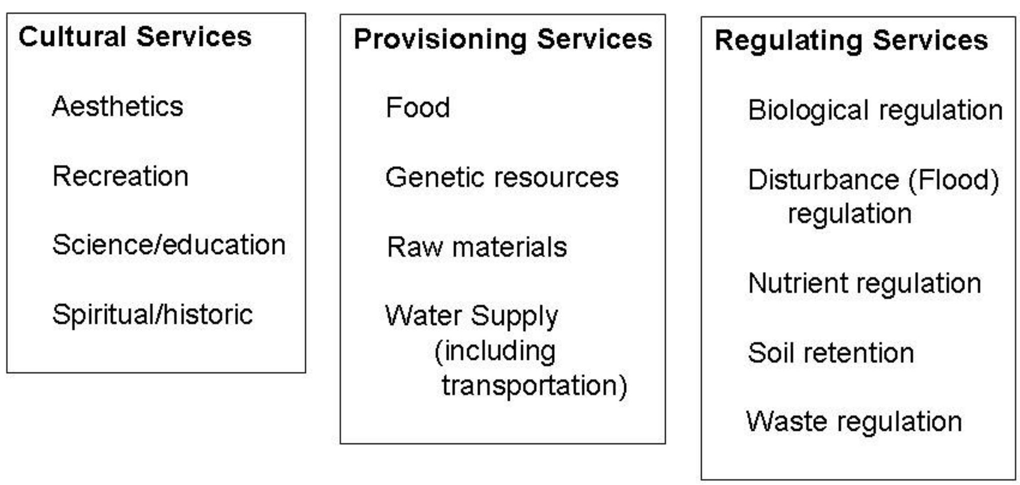

Figure 3. UMR Ecological Services highlighted at the workshop.

The exercise revealed that since every ecosystem service can be seen from a variety of perspectives, a working set of definitions will be necessary to guide future assessments of individual services and trade offs associated with management actions. A second observation was that it is common to confuse some ecosystem services with each other and with the supporting ecosystem functions (i.e. biodiversity) that generate them. This confusion is in part due to the existence of multiple definitions developed for different kinds of ecosystems. The Ecosystem Services Team therefore offer the following material as an initial step in the development of a consistent and clear set of descriptions for use on the UMRS.

To provide the appropriate context for the ecosystems services, this material also includes descriptions of ecosystem support functions and structures. In order to present a consistent scientific foundation for the whole NESP adaptive management process, the Science Panel needs to integrate what we are calling ecosystem support functions and structures with the essential ecosystem characteristics that have already been identified (Lubinski and Barko, 2003).

The descriptions of the ecosystem services include brief comments about the service itself, the human groups that benefit from the service, and any apparent issues that related to spatial scales and program authority. Several of the ecosystem services, such as nutrient regulation and soil retention, will eventually require assessments that distinguish the contributions of the UMRS floodplain corridors from the contributions from the tributary stream network. The following descriptions, given the programmatic limitations of NESP, tends to be corridor oriented, but we've also attempted to recognize when it is difficult to make a corridor/tributary distinction.

There are many connections between the services that make it difficult to address them independently. As a result, during the early years of NESP we expect that these descriptions will be refined and elaborated by managers, stakeholders and scientists as ecological production and economic value functions for each service are developed.

D. Ecosystem Support Functions and Structures

Ecosystem support functions and structures are considered necessary for the production of all ecosystem services. As a consequence, changes, either negative (as a result of any damaging human activity) or positive (as a result of pollution control or restoration for example) in the river's support functions and structures can impact multiple ecosystem services in complex ways.

Generally, humans do not use ecosystem support functions or structures directly. Their values are rarely measured or quantified, especially at scales relevant to the UMRS. However, in order to quantify many UMR ecosystem services, some measures, or at least estimates, of each of these support functions and structures will probably be required.

1. Biodiversity

Biodiversity was not identified as an ecosystem support function by Farber et al (2006), but its importance in the UMRS was discussed in the Navigation Feasibility Report (U. S. Corps of Engineers, 2004), and at the Ecosystem Services Workshop. Its relationship to ecosystem productivity, stability and sustainability was reviewed by Tilman (1997). The Millennium Assessment (2005) included the following definition:

> *Biodiversity is the variability among living organisms. It includes diversity within and among species and diversity within and among ecosystems. Biodiversity is the source of many ecosystem goods, such as food and genetic resources, and changes in biodiversity can influence the supply of ecosystem services."*

Biodiversity is closely associated with the essential ecosystem characteristic “Biota” that was described in the Navigation Feasibility Study conceptual model (Lubinski and Barko, 2003). Further, the desire to include biodiversity as a management target under NESP is embodied in one of the existing Tier-Two ecosystem goals: “To maintain viable populations of UMR native species” (Lubinski and Barko, 2003). The focus on native species highlights and distinguishes desirable actions from the need to reduce or control invasive species. The recent emphasis on biodiversity as a target of many natural resource programs is in part due to the recognition of past limitations of managing for single species.

As an ecosystem support function, biodiversity affects almost all ecosystem services, but especially disturbance regulation, raw materials, food, genetic resources, recreation, and aesthetics.

2. Habitat. Habitat refers to the environment in which an individual organism or species lives. In addition to terrestrial and aquatic habitats, the UMR includes transitional habitats that are especially characteristic of floodplain river ecosystems. During their life spans, mobile species occupy many places, requiring different resources from their surroundings. The UMR, functioning as an upper unit of the north-south Mississippi River corridor, supports a variety of long-distance migratory fish and birds in addition to an abundance of resident species. This support structure is equivalent to the essential ecosystem characteristic of the same name in the NESP conceptual model.

Habitat structural variability in the UMR exists over several different scales: system; river; reach; pool; and within and among recognized habitat categories. The difficulty of measuring, analyzing, and managing variability across these scales presents one of the most difficult challenges to biologists and managers.

Variability characterized the undisturbed UMR before human alterations began.
UMR habitats have gone through a variety of changes, many leading to loss of habitat diversity. Because of the unique hydraulic and geomorphic conditions within each river reach, defining “reference conditions” based on a “least disturbed site” approach has been problematic.

3. Hydrological Cycle. Farber et al (2006) described the hydrological cycle as an ecosystem support function that includes all of the movements and storage of water throughout the biosphere. It embraces processes like global precipitation and evaporation that extend far beyond the limits of NESP. Within the boundaries of NESP, the hydrological cycle is controlled by precipitation and evaporation within the basin, and human activities that utilize river water. These factors control the river’s hydraulic regime, and strongly influence ecosystem services that are dependent on discharge or water levels.

The part of the global hydrologic cycle that drives surface water into and through the UMRS is affected by local, regional and global climate patterns, making it susceptible to climate change. Relative to many other large river basins, the humid climate of the UMRS basin, and the limited amount of human-engineered off channel water allocations, have together contributed to the system’s values as a long-term source of aquatic biodiversity, and a predictable means of commercial transportation.

The hydrologic cycle is the primary driver of two of the systems EEC’s, water quantity and water quality. The low gradients of most of the UMRS reaches, and even many of its tributaries limit the hydropower value of the system.

Variable national weather patterns make it difficult to quantitatively distinguish the part of the global hydrologic cycle that affects the UMRS during any one window of time. Although the weather of the UMRS generally comes from the west, the jet stream and currents of air from the Gulf of Mexico can dramatically alter this pattern. During the summer, fronts of thunderstorms frequently pass over the UMRS at 3-5 day intervals. Spatial variability in the precipitation associated with these storms can result in heavy flows in some tributaries, while little or no flow increases occur in others.

For NESP to function effectively over a 50-year period, it will be necessary to remain aware of and responsive to global warming and precipitation forecasts, and also any national and global climate change policies that might affect flow regimes of the UMRS.

4. Primary Production. Primary production involves the conversion of sunlight into biomass by plants. Net Primary Production (NPP) is a conventional measurement of the amount of organic material generated by plants within a defined area and over a defined period of time minus the material that is decomposed or consumed. Relative to other ecosystems, floodplain river ecosystems under natural conditions are highly productive. Floodplain ecosystems of the UMRS acquire energy from two sources: NPP within the system boundaries: and from the transport organic material into the UMR from its basin and tributary network. Net primary production in terrestrial habitats is largely controlled by vegetation cover, sunlight, rainfall, temperature, and nutrients. In aquatic and transitional habitats, water depth, period of inundation, and water turbidity are additional controlling factors. Net Primary Production in the UMRS includes the production of agricultural crops in the floodplain.

Primary Production directly supports many UMRS ecosystem services, including disturbance regulation, biological regulation, waste regulation, nutrient regulation, food, raw materials, recreation, aesthetics, and spiritual and historic services.

5. Nutrient Cycling. Farber et al (2006) described nutrient cycling as including all of the mechanisms by which nutrients are stored, processed, and acquired within the biosphere. Examples include the nitrogen and phosphorus cycles. In the context of the UMRS, we’re concerned primarily with excess loadings of nutrients from waste treatment plants and agricultural operations, and the reduced ability of the rivers to process nutrients, included below under the ecosystem service Nutrient Regulation.

Enriched nutrient concentrations have been widely observed in UMRS waters since fertilizers became widely accessible after the second World War. Although eutrophic conditions have been associated with algal blooms and fish kills in waters of the UMRS, the most dramatic effects of enriched nutrients within the systems have been observed through the growth of the Hypoxic Zone in the Gulf of Mexico over the last two decades.

E. Ecosystem Services

Ecosystem services are the benefits that humans derive from ecosystems. Over the last several decades, scientists have started to consistently group ecosystem services into one of three categories: regulating services, provisioning services, and cultural services. The following sections discuss each of the ecosystem services considered at the workshop

1. Regulating Services. Undisturbed ecosystems tend to be self-maintaining as a result of long-term predictability of their primary abiotic drivers (including natural disturbances), and biotic processes that favor resident species. Regulating ecosystem services are the benefits that humans derive from the ability of ecosystems to regulate themselves and conditions around them. The regulating ecosystem services considered important by the workshop participants were: a. biological regulation; b. disturbance regulation (flood control); c. nutrient regulation; d. soil retention; and e. waste regulation.

a. Biological Regulation. Farber et al (2006) described this ecosystem service as focusing on the control of pests and diseases. It results from species interactions, such as grazing, predation, and competition.

There was little discussion of this service at the workshop, possibly because of the limited number of relevant examples that seem to exist on the UMRS. It is possible to conceptually link this service to biodiversity, using the conventional wisdom that in systems that are species rich, many of the functional ecosystem niches available to potential invasive species are full, and thus the system's risk of being invaded by pests is relatively low. However, at this time it is difficult to envision a specific group of humans that benefits from this service, and how that benefit might be of value on the UMRS.

Issues Related to Upper Mississippi River Spatial Scales: Unknown until more specific mechanisms are identified.

Potential NESP Authority Issues: Unknown until more specific mechanisms are identified.

b. Disturbance (Flood) Control. The primary disturbance regulation service provided by UMRS results from the capacity of it's floodplains to mediate flood peaks. When floods spread out across open, un-leveed floodplains, the vertical rise of the water surface is reduced in proportion to the lateral space provided by the floodplain.

We know most about this service from studies that have documented what happens when the service is lost (e.g. as a result of agricultural levee construction. While the flood control service provided by floodplains is generally accepted among river scientists, the specific degree to which levees have exacerbated floods on the UMRS has been a matter of long and intense debate (Pinter and Heine 2002; Pinter 2005).

Before the levees were built, humans that occupied floodplains, especially at moderate and higher elevations, were the primary beneficiaries of this service. However, technological advances allowed some humans to start building levees to reduce even further the frequency and duration of floods in specific areas, thus removing the land behind the levees from contributing to active floodplain ecosystem functions except during extreme floods when the levees break or are overtopped.

Numerous physical, hydraulic, and biotic processes are affected when flood pulses are absorbed by the floodplain. Thus, all of the river's essential ecosystem characteristics are influenced by this interaction between the floodplain and the river's flow.

Potential Spatial Scales Issues. The effect and value of the floodplain in reducing flood peaks cannot be measured solely on a site-by-site basis. It is well known that levees influence flood water heights not only at the site of the levee, but upstream and downstream as well. In addition, multiple levees generate cumulative effects. These observations suggest that a well understood process for measuring this service at multiple scales will be vital under NESP.

Potential Authority Issues. Flooding within the UMRS generates a tremendous amount of damage, and thus any measurement, examination, or valuation of disturbance (flood) control under NESP is likely to be scrutinized by a wide number of state and federal agencies responsible for minimizing flood damages or dealing with the consequences of floods.

c. Nutrient Regulation. Farber et al (2006) described nutrient regulation as the maintenance of major nutrients with acceptable bounds. This is a major function of stream and river ecosystems, provided by the communities of plants and decomposers that contribute to nutrient cycling.

Humans currently benefit from this service in at least two major ways. Nutrient cycling within the UMRS system reduces eutrophication, a process that, when uncontrolled, produces blooms of blue-green algae, which can cause fish kills or at least reduce the aesthetic experience of human recreation on the river. Treatment plant operators also benefit when natural river nutrient cycling processes are functioning and maximum levels. Recent water regulations are establishing water quality standards for nutrients in rivers, and expensive treatment processes are being required to reduce nutrient loads from point sources. At least one major proposal is being developed within the UMRS to promote floodplain nutrient “farming” to reduce the future water treatment expenditures of a metropolitan treatment plant.

It has been hypothesized that increased nutrient cycling within the floodplains of both the upper and lower Mississippi River floodplains could help alleviate problems associated with hypoxia in the Gulf of Mexico. If so, this ecosystem service would likely be valued at a much higher level.

Issues Related to Upper Mississippi River Spatial Scales. In the UMRS basin, nutrient yields are greatest in streams draining agricultural areas (Stark et al 2001). Goolsby et al (1999) mapped average annual nitrogen yields from 1980-1996 in the Mississippi-Atchafalaya basin, and showed that the highest yields of nitrogen originated in Midwestern sub-basins.

It is unlikely that the nutrient regulation in the floodplain of the UMRS can be cost-effectively managed at small spatial scales. It is even somewhat questionable if the benefits of management actions at floodplain sites up to two or three thousand hectares can be measured effectively. Pilot projects should help determine this.

A spatial strategy for nutrient management in the UMRS will need to be based on the framework of the system’s tributary network and floodplain reaches.

Potential NESP Authority Issues. The legal responsibility for nutrient regulation in the waters of the UMRS rests with the State offices of the EPA. The NRSC is engaged in multiple programs designed to control soil and agricultural-related pollutants. There is a need for extensive coordination with these agencies to determine how NESP management actions can be effectively coupled with existing programs.

d. Soil Retention. Soil retention within the UMRS basin has been the subject of extensive conservation actions for decades. Farber et al (2006) primarily considered soil retention as a service provided by watersheds. The service improves the health of agriculture soils and their ability to produce crops, with farmers being the primary beneficiaries. The service also results in healthier rivers, with indirect benefits to downstream river users.

The floodplains of the UMRS naturally provided this service by trapping sediment whenever flood waters inundate terrestrial habitats. Terrestrial areas that are still within the Aquatic-Terrestrial Transition Zone (Junk et al 1989) continue to trap sediment. The capacity of aquatic habitats of the UMRS to trap sediments increased when the navigation dams were constructed. While the total sediment delivery of the UMRS to the lower Mississippi River has increased somewhat over the last century due to the conversion of uplands to agriculture, the total load of the sediment to the Gulf of Mexico from the entire river basin has decreased as a result of sediment trapping by large dams on the Missouri River.

Issues Related to Upper Mississippi River Spatial Scales. An objective assessment of this ecosystem service will require clear distinctions between upstream and downstream beneficiary groups.

Potential NESP Authority Issues. The NRSC is engaged in multiple programs designed to control soil and agricultural-related pollutants. There is a need for extensive coordination with this agency to determine how NESP management actions can be effectively coupled with its existing programs.

e. Waste Regulation. Farber et al (2006) described waste regulation as a human benefit derived from processes that break down non-nutrient compounds and materials. They listed pollution detoxification and the abatement of noise pollution as examples of this service. Costanza et al (1997) identified waste treatment and pollution control as examples of this service. From a riverine perspective, this service can be compared to the long held concept of the assimilative capacity of streams, a feature that has been observed below treatment plants for decades.

Humans whose waste ultimately winds up in streams are the beneficiaries of this ecological service. Before strict point source standards were established for the release of pollutants, treatment plant operators especially benefited from the service. Where pollution regulations now require treated effluent to be as clean or cleaner than the stream, people are no longer allowed to take advantage of this service.

Issues Related to Upper Mississippi River Spatial Scales. This service is strongly, but not completely, linked to municipal and industrial point sources of pollution. It also is valuable below feedlots. As a result, an effort to map this service across the UMRS would likely focus on these kinds of sites, and the mixing zones that occur below them. Cumulative impacts are likely to occur where such points are in close proximity. It is generally believed that increased connectivity of the floodplain to the river, which occurs during inundation, allows for increased waste regulation. Therefore the service is likely to be reduced where the floodplain has been constricted.

Potential NESP Authority Issues. Like nutrient regulation and soil retention, the management or regulation of waste regulation if of special concern to the EPA and NRCS. There is a need for extensive coordination with these agencies to determine how NESP management actions can be effectively coupled with its existing programs.

2. Provisioning Services. These ecosystem services generate products, often called ecosystem goods, that humans consume or use in other ways. Examples important to the URMS include food, raw materials, and water supply.

a. Food. Farber et al (2006) described this service as including the production of edible plants and animals for human consumption. They identified the hunting and gathering of fish, game, fruits, small-scale subsistence farming and aquaculture as examples of the service.

Within the UMRS, approximately 1.3 million acres of floodplain are used to produce crops. The system has historically supported a large commercial fishery. Approximately two-thirds of the basin (79 million acres) is used for agricultural production (corn, soy, dairy and meat products). In 60 corridor counties of the UMR, annual agricultural revenue was recently estimated at slightly over $5 billion (Industrial Economics, Inc. 1999).

Issues Related to Upper Mississippi River Spatial Scales: Non-compatible agricultural influences within the UMRS basin and its floodplains are more extensive than any other threat to the river's ecosystem quality. However, because many of the foods produced in the basin and floodplains are used for non-human consumption, and because many of the foods are shipped outside the basin, it is somewhat unclear how to categorize the specific human groups that benefit from this service.

One primary issue of spatial scale questions whether river ecosystem goals and objectives can be achieved only by taking action within the floodplains of the system. A critical variable is the amount of land in agricultural production. NESP restoration and conservation strategies that target river ecosystem structures and processes that are strongly dependent on upstream land use practices need to be designed to complement and work synergistically with watershed programs. Multi-scale agricultural practices that are more compatible with sustaining river ecosystem functions and services need to be actively promoted. However, promoting ecosystem-compatible food production in floodplain areas seems to be an especially feasible and valuable avenue for potential pursuit under NESP.

Potential NESP Authority Issues: Seeking ecosystem-compatible food production within the floodplains of the UMRS will require extensive coordination with individual farmers and Drainage and Levee Districts. Within the basin, similar coordination with watershed projects that are intended to address cumulative downstream benefits as well as site specific restoration goals is warranted.

Genetic Resources: Farber described genetic resources as genes used to improve crop resistance to pathogens and pests and other commercial applications. The gene pools represented by the native species of the UMRS are extensive and diverse. Further, several commercial operations in the Midwest are participating in programs designed to maintain genes of prairie plants. But we know of no programs that are currently designed to use or protect gene pools associated specifically with UMRS species.

b. Raw Materials._Farber et al (2006) described the provisioning service of raw materials as including building and manufacturing materials, fuel and energy, and soil and fertilizer. On the UMRS, notable examples include: lumber; plant fibers (of potential special attention today because of the trend toward greater use of biofuels); limestone, sand, and gravel; and energy. Mussels historically harvested for pearls, buttons, or the cultured pearl industry would be considered an ornamental raw material. Each of these raw materials benefits a specific group of humans.

In a 60-county corridor study of the UMR (Industrial Economics, Inc. 1999), annual revenues associated with mineral resources were estimated to be $1.2 billion. That same study estimated annual revenues associated with energy production to be $4.7 billion, although it should be noted that much of the coal required for fossil fuel power generation along the corridor was transported into the corridor as opposed to being produced within the system. The provision of energy from the river also requires water be drawn from the river for cooling purposes. The U. S. Geological Survey (1995) reported that power plants in the UMR corridor used 6.4 billion gallons of cooling water per day in 1995. Industrial Economics, Inc. (1999) reported that seven hydroelectric plants in the corridor generate approximately 125 megawatts of power annually.

While there are many spatial scale and authority issues associated with the provisional service of raw materials, these issues are believed to be mostly specific to the individual materials. Therefore they are beyond the scope of this broad assessment and will be described and evaluated in future reports of the Ecosystem Services Team.

c. Water Supply. Farber et al (2006) described the provision service of water supply as the filtering, retention, and storage of freshwater. From the perspective of the UMRS, this service includes the use of river water for drinking, irrigation, the support of commercial transportation, and several other purposes (table 1).

According to Industrial Economics, Inc. (1999), twenty two cities use water from the UMR, at an annual revenue of $130 million. Thirty million people benefit from drinking water provided by the UMR (UMRCC 2000).

Between 1993 and 2001, water levels in the UMRS supported annual barge traffic levels between 72.2 and 85.7 million tons on the Upper Mississippi River; between 41.8 and 50.9 on the Illinois River; and between 99.1 and 124.7 on the Middle Mississippi River (U. S. Army Corps of Engineers, 2004).

Issues Related to Upper Mississippi River Spatial Scales: Worthy of special attention is the need to adequately measure and evaluate this service as it relates to potential conflicts between supporting commercial traffic, providing adequate public and industrial water supplies, recreation, and enhancing ecosystem functions and structures. River drawdowns accomplished by modifying flows through navigation dams are a valuable restoration practice. The conditions necessary to achieve maximum ecosystem restoration benefits need to be modeled, ecosystem service outcomes need to be forecast, and optimal strategies for creating mutually acceptable results explored.

Potential NESP Authority Issues: Given the enormous learning and ecosystem restoration potential of navigation pool drawdowns suggested by recent pilot projects, NESP partners should consider active pursuit of authority changes necessary to maximize the opportunities presented by this management action. During the development of the Navigation Feasibility Study, some navigation industry representatives seemed to be open to discussing the establishment of windows in which barge traffic would be curtailed or barge drafts would be reduced (to 7 or 8 feet for example) to allow drawdowns of longer duration or magnitude. Such actions would require changes to Corps authorities for maintaining the 9-ft channel, and can only be achieved through a process that clearly lays out the desired outcomes for both river ecosystem functions and water supply services, as well as any uncertainties that could affect such drawdowns.

3. Cultural Services. Cultural ecosystem services include nonmaterial benefits people obtain from ecosystems. Examples important to the UMRS include: aesthetics; recreation; science and education; and spiritual and historic values.

a. Aesthetics. Farber et al (2006) described this cultural service as including the sensory enjoyment people feel as a result of being on or near a functioning ecosystem. On the UMRS, these benefits can be derived from driving, bicycling and walking along the rivers as well as by being on the water. As a result, there may be a somewhat fine distinction between this service and some forms of non-consumptive recreation (see below). Almost all people that recreate along the UMRS do so in part because of the system's aesthetic values.

Issues Related to Upper Mississippi River Spatial Scales: Conceptual spatial scale issues associated with this service do not seem to be particularly troublesome. However, it remains to be seen whether a well supported consensus about how this service can and should be measured exists. Ultimately, this service will have to be included in optimization analyses, and the spatial scales of all of the ecosystem functions and services included in any one exercise will have to be explicitly described.

Potential NESP Authority Issues: No authority issues for this cultural service are anticipated at this time.

b. Recreation. Farber et al (2006) described this cultural service as providing the opportunity for a variety of activities, including rest, refreshment, ecotourism, bird-watching, and outdoor sports. Sightseeing, fishing, hunting and boating are broadly popular on the UMRS. The Upper Mississippi River Conservation Committee (2000) reported that $6.6 billion is annually generated from over 12 million visitor-days of people that hunt, fish, boat, and sightsee within the UMRS. This figure differs substantially from Industrial Economics, Inc. (1999), who reported annual revenues from recreation of $200 million from 60 UMR corridor counties.

Issues Related to Upper Mississippi River Spatial Scales: Of all the cultural ecosystem services, recreation is perhaps the service that has been most thoroughly studied, measured and valued. The discrepancies between the figures reported above however highlight the need, especially on a system as large and complex as the UMRS, to explicitly report all of the spatial variables upon which the service measurements and valuations are based.

Potential NESP Authority Issues: No authority issues for this cultural service are anticipated at this time.

c. Science and Education. Farber et al (2006) considered this cultural ecosystem service to include any benefits acquired by scientists or teachers from natural areas. The rivers of the UMRS have supported a tremendous number of studies leading to the advancement of knowledge on large rivers. The Long-term Resource Monitoring Program under EMP stands as one of the foremost river monitoring programs in the world. Many of these studies have focused on the use of the rivers for commercial navigation and agriculture, or simply the structure and function of large river ecology. Universities, non-profit organizations, and state and federal agencies have been participants. People of the region and nation benefit from these studies. The Great Rivers Partnership of The Nature Conservancy is designed to extend these benefits to people engaged in river science and education around the world.

Issues Related to Upper Mississippi River Spatial Scales: None

Potential NESP Authority Issues: None

d. Spiritual and Historic. _Farber et al (2006) the "use of nature as national symbols" and "natural landscapes with significant religious values" as examples of this cultural ecosystem service. The UMRS has a substantial value to many people because of its role in the development of the country. Communities along the river are increasingly trying to "reconnect" with the rivers, in part to keep the spirit of the river alive for new generations. The rivers play major roles in the art and literature of the region. They are focal points for ceremonies of several Native American tribes.

Issues Related to Upper Mississippi River Spatial Scales: None

Potential NESP Authority Issues: Methods developed to measure and value the historic value of the river should be coordinated with cities and villages along the rivers of the UMRS. Methods developed to measure and value the spiritual services of the river will need to be coordinated with Native American tribes.

F. Tools

Economic valuation of natural resources is focused on estimating the impact of changes on ecosystem services on the welfare of individuals (usually humans) and is based on utilitarianism. As such, economic valuation can not encompass *all* possible sources of value. Nonetheless, economic valuation is broader than the traditional concepts of commercial or financial value and economic valuation does include all values, tangible as well as intangible that contribute to human satisfaction or welfare. This broad definition is also known as "total economic value" and is briefly described because it provides the framework that underlies economic valuation methods.

The total economic value (TEV) framework is based on the presumption that individuals often view ecosystems as having multiple values. TEV provides a basis to ensure that all components of "value" are given recognition in empirical analyses and that "double counting" of values does not occur when multiple valuation methods are employed (Bishop et al. 1987; Randall 1991). The TEV framework does not imply or require that the "total value" (each component) of an ecosystem needs to be estimated in each case; the TEV simply framework simply implies that all values that an individual has should be counted.

In its simplest form, TEV distinguishes between *use* values and *nonuse* values. The former refers to those values associated with current or potential (in the future) use. Clearly *use* values are utilitarian whereas *nonuse* values represent non-consumptive uses (even sustainable levels of consumption) of the resource.

TEV allows both use and nonuse values to be considered. A classic example of this is a sewage spill on a river ecosystem. The spill results in foregone recreational trips to the river- a lost use value. The spill could also cause ecosystem injuries that would not affect recreation/commercial uses and that users would not observe. It might, for example, force aquatic-oriented species such as otters that are not seen by recreational users of the river, to another area. These users, as well as those that do not use the river, experience a loss because of this ecosystem injury. The loss by those who do not visit the river is a nonuse value, though there could also be a loss of nonuse values on the part of river users. The TEV framework does not necessitate estimating the total value of the river ecosystem, only the total loss in value associated with the spill – use and nonuse values of river users and nonuse values of people that do not visit the river.

The distinction between use and nonuse values is the fundamental theme in TEV analysis, in the majority of TEV frameworks that have proposed (Bishop et al. 1987; Freeman 1993; Randall 1991). Furthermore, when people hold use and nonuse values, the preferred approach is to estimate peoples' TEV rather than estimating the components and then adding the component estimates to compute a TEV. However, some methods are better able to measure selected components of TEV than others.

At this point, it is necessary to briefly discuss a common concept of measurement using a monetary metric. As mentioned earlier, the basic concept used by economists to measure welfare gains and losses as a result of ecosystem changes is based on the utilitarian notion that for any individual, the different sources of value that affect the individual's use can be potentially substituted; that is, an individual is willing and can trade a reduction in one value for an increase in another value such that his or her overall welfare is unchanged. In other words, the approach requires a determination of what people are willing to trade (to receive or give up) such that they are equally satisfied with or without the exchange. It is important to realize that such an approach does not rely on individual's actually paying for the change and studies have shown there can be a wide variation in what a person says he or she is willing to trade vs. what they will actually trade.

An illustrative example is a freshwater lake which could be restored resulting in enhanced sport fishing. An economic measure of this benefit is the maximum that anglers would be willing to pay (WTP) for enhanced fishing if they had to pay. For each angler, the maximum WTP represents how much money the angler is prepared to pay (give up) in exchange for increased fishing opportunities. WTP represents the reduction in total income that would be necessary to exactly offset the increase in angler use resulting from the restoration, thereby leaving anglers at the same use level as they were before, or without, the restoration. Maximum WTP can be aggregated for all anglers who benefit to determine the total benefits of the project.

The alternative to WTP is based on the amount, using the example above, that anglers are willing to accept to forgo improvement in fishing opportunities. The value of this loss or the forgone benefit from restoration can be measured by the minimum amount of income that anglers would be willing to accept as compensation for forgoing that benefit. This approach is known as willingness to accept (WTA) and the idea is the combined effect of not restoring the lake and compensation from not restoring the lake leave the utility unchanged (anglers are just as well off without the restoration as they would have been with it).

Both WTP and WTA examine potential trade-offs between money and the good or service being valued that leave the utility of the good or service unchanged from some base level. The difference between methods is in the base level of utility that is maintained when the trade-off is made. WTP considers trade-offs that leave utility at the level that existed prior to the improvement whereas WTA considers the utility level that would exist after improvement.

When valuing small price changes, WTP and WTA can be expected to produce similar results, difference mainly being the result of income limitation[1]. However, Hanemann (1991) points out that when valuing goods or services for which there is no close substitute (which is often the case for ecosystems) the two measures can give very different results. Typically, for environmental

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[1] Obviously, the amount that an individual is willing to pay for an environmental improvement depends on the amount that he or she is *able* to pay. Consequently, WTP is constrained by an individual's income as he or she could never be willing to pay more than the amount he or she has available. WTA, conversely, is not income constrained.

improvements, the amount an individual is willing to forgo is normally greater than the amount he or she is willing to pay to ensure the improvement.

Which method is preferred? It is more common to use WTP as an empirically reliable measure mainly because existing economic methods for estimating values capture WTP but not always WTA. Furthermore, in both theory and practice, WTA usually exceeds WTP (Hanemann 1991; Horowitz and McConnell 2002); WTP can be viewed as a lower-bound for WTA and can be considered a surrogate for the lower-bound value of the improvement.

1. Classification of Valuation Models. Measurement approaches are a common classification method to estimate use and nonuse values. This categorization is organized according to two criteria:

1. is the valuation method based on *observed* economic behavior from which individual preferences can be inferred or is the valuation method based on responses to survey questions that reveal *stated preferences* of individuals, and
2. are monetary estimates of values observed directly or inferred through some indirect method of data analysis

Indirect methods (table 2) are the most commonly used approaches to valuing aquatic ecosystem services in part because many services do not have market prices. Simulated market responses can be used to benchmark the validity of value estimates made from indirect methods but such simulations are rarely used to develop policy-relevant estimates of value. Consequently, the rest of this section focuses on household production function methods; production function methods, and stated preference methods.

Table 2. Classification of Valuation Approaches

	Revealed Preferences	**Stated Preferences**
Direct	Competitive market prices Simulated market prices	Contingent valuation, open-ended response format
Indirect	Household production function models Time allocation Random utility and travel cost	Contingent valuation, discrete-choice, and interval response formats
	Averting behavior	Contingent behavior
	Hedonics	Conjoint analysis (attribute based)
	Production function models	
	Referendum votes	

SOURCE: adapted from Freeman (1993)

2. Household Production Function Methods. Household production function (HPF) methods involve modeling consumer behavior, based on the assumption of a complementary relationship between an ecosystem service and one or more marketed commodities or that an ecosystem service. The linkage of an environmental service and marketed commodities results in the "production" of a utility-yielding good or service (Bockstael and McConnell 1983; Freeman 1993; Maler 1974; Smith 1991, 1997). Such methods provide a framework for examining interactions between purchases of marketed goods by the household and the availability of nonmarket environmental services, which are combined through a set of technical relationships to "produce" a utility-yielding final good or service. The classic example given in economic textbooks is the time and financial expense a family will invest to avoid contaminated drinking water from their faucets by purchasing a desired service – in this case potable water. The HPF approach allows economists to extract the value of environmental quality from information on the household's purchase of marketed goods. In the portable water example, the cost of the bottled water and time spent to acquire it would equal the value of clean water to the household. This example is also the quintessential example of averting behavior (Table A) as the household is attempting to avoid exposure to contaminated water.

Other examples of the HPF framework include traditional travel-cost and random utility models; averting behavior models; and hedonic methods. Traditional travel-cost attempt to infer nonmarket values of ecological services by using the travel and time costs that an individual incurs to visit a recreational site. The basic premise of this approach is that all other things being equal, people will choose the location with the lowest travel cost to obtain the desired good or service. When two sites have equal travel costs, people will choose the site with higher quality of goods or services. Traditional travel-cost models use the implicit price of travel (out-of-pocket travel costs and the travel time) and the number of times each individual visits a site to estimate the demand for that particular site. Drawbacks to this model are that the values of ecosystem services are fixed for the given site at the specific time of the analysis and can not be identified statistically.

Random utility models (RUM) however, are not site-specific; in fact they allow the user to compare a suite of sites that differ in ecological attributes and thus have different goods and services potential. The RUM approach looks at people's choices for use of goods or services (typically fishing opportunities) among the menu of available sites and determines the implied values people hold for the site attributes by making choices between sites that vary in terms of the cost of visiting the sites and their component attributes. The basic premise of this approach is that people compare the quality of the goods or services from a number of sites to select a site as opposed to ranking sites primarily on travel cost. This approach assumes people are willing to incur a higher implicit cost to improve the quality of their visit. Another important aspect of RUMs is that they can be designed to allow the number of participants to change as an ecosystem is altered. This is important because the average value per visit per person, the number of visits an individual makes, and the number of affected people determine aggregate, societal values. The key element for applying RUMs to aquatic systems is the existence of a good or service that affects the sites people use. RUMs have typically been applied to single-day recreation trips and have not examined multiple day trips. The justification for ignoring multiple-day trips is that such trips are often multiple-site, multiple-length, and multiple-purpose trips, which makes it extremely difficult to estimate values for ecosystem services as specific sites. This omission results in the underestimation of aggregate values that people place on ecosystem goods and services.

Averting behavior models have been increasingly used in quantifying the economic effects of pollution on ecosystems. These models are based on the presumption that people will change their behavior and invest money to avoid an undesirable health outcome. Thus averting behavior analyzes the rate of substitution between changes in behavior and expenditures on and changes in environmental quality in order to infer the value of certain nonmarketed environmental attributes. Although these types of studies provide a lower and upper boundary on the cost of degraded goods and services, they are not likely to be useful in measuring other economic values of ecosystem goods and services. Averting studies require that four conditions be met: 1. households must be aware of the degradation in goods or services they seek; 2. household must believe these degradations will adversely affect the health of at least on individual in the household; 3. there must be avoidance or exposure reduction activities the household can undertake; and 4. households must be able to make expenditures that result in optimal protection. This last condition is rarely met, resulting in total expenditures that underestimate value and marginal expenditures should be cautiously interpreted as a measure of marginal willingness to pay. At the same time, these models may overestimate economic values when joint production is present, an example of which is when drinking water is contaminated but also the natural taste of the water is undesirable. Averting behavior undertaken to reduce contaminant exposure could also improve the taste of the water. In this example, averting expenditures overstate what would be spent just to avoid the contamination.

Lastly, hedonic methods analyze how the different characteristics of a marketed good might affect the price people pay for the good or factor. The most common application of hedonic methods in environmental economics is real estate sales (Palmquist 1991, 2003; Taylor 2003). Hedonic analysis can be thought of as a statistical procedure for disentangling estimates of the premium people pay for ecological services. Using real estate as an example, lake front properties sell for more than identical properties without a lake front. Among lake-front properties, those located on eutrophic lakes sell for less than those with higher water quality. Hedonic analysis allows the user to tease out the influence of lake frontage and water quality from the cost of properties. This analysis is the first stage in the estimation of a hedonic model (Bartik 1987; Epple 1987) and results in implicit prices of property characteristics (presence of lake frontage and water quality in this example). The implicit price estimates provide the marginal prices that people would pay for a small change in each characteristic. For example, if the attribute of interest was feet of frontage that a property had, a first-stage analysis can provide the implicit price of a 1-ft increase in frontage but the analysis can not provide an estimate the question of how much value 100 ft of frontage would add to a property. In order to satisfactorily answer such questions, a large number of property sales where property characteristics vary must be analyzed with a second-stage model.

In order for hedonic models to work, it must be assumed that users (buyers and sellers in the real estate example of properties) have equal knowledge of the services. This is direct ramifications for managers of ecosystems because ecosystem quality indices developed by natural scientists may not provide relevant information to the users. The value of lake frontage properties on a eutrophied lake provide an illustrative example of this point. Potential buyers and sellers of such property can not directly observe elements of the water chemistry that is compromised but they certainly observe the physical manifestations of elevated nutrient levels. Thus a summary measure of eutrophication such as Secchi disk readings may be more aligned with buyer and seller perception than actual measures of water chemistry. This means that Secchi disk readings may do a better job of explaining changes in sale prices of properties than chemical measurements of water quality, which implies a more accurate estimate of the implicit price placed on eutrophication by homeowners.

For a hedonic study to be operational there are two important considerations: 1. the effects of ecosystems must be observable to users and 2. there should be minimal correlation between ecological services and other factors that affect sale prices. The collinearity of attributes is a serious issue because aquatic ecosystems have many attributes that are highly correlated. As long as services are correlated with other aspects of the ecosystem, hedonic studies are likely to overestimate prices and values.

3. Production Function Models. _Also known as “valuing the environment as input,” production function (PF) approaches assume that a good or service essentially serves as a factor input into the production of a marketed good that yields utility. Consequently, changes in the availability of ecosystem goods or services can affect the costs and supply of the marketed good, the returns to other factor inputs, or both. PF approaches therefore require modeling behavior of produces and their response to changes in environmental quality that influence production.

Production Function approaches generally use a two-step approach. In the first step, the physical effects of changes in an ecosystem good or service on an economic activity are determined. Second the impact of these environmental changes is valued in terms of the corresponding change in the marketed output of the relevant activity. In other words, the service or good is treated as an "input" into the economic activity, and like any other input, its value can be equated with its impact on the productivity of any marketed output. For those services that are difficult to measure, an estimate of ecosystem area may be included in the production function of marketed output as a proxy for he ecological service input. This approach is used often in assessing values of coastal wetlands. In models of habitat-fishery linkages, allowing wetland area to be a determinant of fish catch is thought to "capture" some element of the economic contribution of this important ecological support function (Barbier and Strand 1998; Barbier et al. 2002; Ellis and Fishcer 1987; Freeman 1991; Lynne et al. 1981). It is intuitive and therefore assumed that if the impacts of the change in wetland area input can be estimated; it may be possible to indicate how these impacts influence the marginal costs of production. Thus, an increase in wetland area increases the abundance of fish and thus lowers the cost of the catch. The value of the wetlands support for the fishery-which in this case is equivalent to the value of increments to wetland area-can then be derived from the resulting changes in consumer and producer value.

For the PF approach to be useful, it is critical that the underlying ecological and economic relationships are well understood. When production is measurable and either there is a market price for this output (for example commercial fisheries), determining the marginal value of the ecological service is straightforward. If the output can not be directly measured, either a marketed substitute has to be found or possible complementarily or substitutable ecological service and one or more of the other marketed inputs has to be explicitly specified.

The results of a PF are subject to fluctuations in market conditions and regulatory policies for the marketed output. For instance, a fishery may be subject to open-access conditions. Under these conditions, profits in the fishery would be dissipated and price would be equated to average and not marginal costs. As a consequence, producer values are zero and only consumer values determine the value of increased habitat area.

Most uses of PF to date have been concerned with valuing single ecosystem services; however this approach can be scaled-up to the ecosystem level through integrated economic-ecological modeling. The PF approach has the advantage of capturing more fully, the ecosystem functioning and dynamics underlying the provision of key services can be used to value multiple services arising from aquatic ecosystems.

4. Stated-Preference Models. Stated preference methods have been commonly used to value aquatic ecosystem services. There are two variants of stated-preference methods, contingent valuation (e.g. Bateman et al. 2002; Boyle 2003; Mitchell and Carson 1989) and conjoint analysis (e.g. Holmes and Adamowicz 2003; Louviere 1988; Louviere et al. 2000). Contingent valuation was developed by economists and is the commonly used approach, whereas conjoint analysis was developed in the marketing literature (Green and Srinivasan 1978). Contingent valuation attempts to measure the value people place on a particular environmental item taken as a specific bundle of attributes; conjoint analysis aims to develop valuation functions for the component attributes viewed both separately and in alternative potential combinations.

Contingent valuation is used to estimate values for applications, such as aquatic ecosystem services, where neither explicit nor implicit market prices exist. Conjoint analysis was developed to estimate prices for new products or modifications of existing products. It is conceptually similar to contingent valuation, and economists have come to recognize that it is another state-preference approach to estimating economic value when market prices are unavailable.

Both methods use survey questions to elicit statements of value from people with two key distinctions. First, contingent valuation studies generally pose written or verbal descriptions of the environmental change to be valued, while conjoint analysis poses the change in terms of changes in the attributes of the item to be valued. Consider a wetland restoration project as an example. A contingent valuation survey would contain a description of the wetland in its current condition and the wetland after restoration, whereas a conjoint survey would describe the wetland in terms of key attributes (e.g. number of breeding birds; plant diversity; acres). A contingent valuation study may contain this same information, but it would not be presented to estimate component values for each of these attributes. In terms of valuation, the contingent valuation study provides an estimate of the value of the marsh due to restoration, while the conjoint study provides a similar estimate and also estimates the amount of value contributed by each attribute. Thus, the attribute based approach of conjoint analysis provides implicit prices for key attributes of the aquatic ecosystem.

The second key difference between these stated-preference methods involves the response formats. Contingent valuation studies typically ask respondents to state their value directly or to indicate a range in which the value resides (Welsh and Poe 1998). In the latter case, econometric procedures are used to estimate the latent value based on the monetary intervals that respondents indicate. In conjoint analysis, survey respondents would be given alternatives to consider and asked to choose the preferred alternative or to rank the alternatives (Boyle et al. 2001). Again, econometric procedures are used to estimate values from the choices or ranks.

Many contingent valuation studies have investigated values for aquatic ecosystem services. So many, that several meta-analyses of these studies have been conducted (see Boyle et al 1994; Woodward and Wui 2001; Boyle et al. 1998a,b). In contrast, the use of conjoint analysis is relatively new for nonmarket valuation and few conjoint studies of aquatic ecosystem services have been undertaken. Nonetheless, the use of conjoint analysis is growing and may become more prominent in the valuation of aquatic ecosystem services because of its ability to estimate values for multiple services. Most aquatic systems provide multiple services and the ability to estimate marginal values for specific services is important for policy analyses.

Implementation of a stated-preference study requires that two key conditions be met:

1. the information must be available to describe the change in an aquatic ecosystem in terms of services that people care about, in order to place a value on those services; and
2. the change in the aquatic ecosystem must be explained in the survey instrument is such a way that people will understand and not reject the valuation scenario. In other words, survey questionnaires must be written in a way that is understandable to the target audience and the audience must be able to relate to the valuation scenario on some level that they care about the scenario.

Criticism of stated preference methods has arisen because they are not based on actual behavior (Diamond and Hausman, 1994; Hanemann 1994; Portney 1994). Debate has centered on the validity of employing contingent valuation techniques to estimate nonuse values (NOAA 1993). In contrast, the validity of conjoint estimates of value is a relatively unexplored area of research. However, there is a basic concern regarding the accuracy of stated-preference estimates of value. Studies conducted in controlled experimental settings suggest that both contingent valuation and conjoint methods may overestimate values (Boyle 2003; Cummings and Taylor 1998, 1999). The absolute magnitude of overestimation has not been established and consequently no definitive statements can be made regarding if the errors identified for stated-preference methods is greater than for any other method.

5. Benefit Transfers. The last type of valuation method are benefit transfers. As the name implies, a benefit transfer is the process of taking an existing value estimate and transferring it to a new application that is different from the original one (Boyle and Bergstrom 1992). There are two types of benefit transfer, value transfers and function transfers. Benefit transfers are commonly used in policy analyses because off-the-shelf value estimates are rarely a perfect fit for specific policy questions. The US EPA, recognizing the need to conduct benefit transfer, has developed the only peer-reviewed guidelines for conduct of these analyses (USEPA 2000). A value transfer takes a single point estimate or an average of point estimates from multiple studies, to transfer to a new policy application. A function transfers uses an estimated equation to predict a customized value for a new policy application.

However, the National Academy of Sciences does not advocate the use of benefit transfers for many types of aquatic ecosystem service valuation applications (hdkd). First, with the exception of few types of applications (e.g. travel-cost and contingent valuation estimates of sportfishing values) there are few studies that have investigated values of aquatic ecosystem services. Furthermore, most nonmarket valuation studies have been undertaken by economists in the abstract from specific information that links the resulting estimates of values to specific changes in aquatic ecosystem services and functions. Finally, studies that have investigated the validity of benefit transfers in valuing ecosystem services have demonstrated this approach is not highly accurate (Desvouges et al. 1998; Kirchhoff et al 1997; Vandenberg et al 2001). Because benefit transfers involve reusing existing data, a benefit transfer does not provide an error bound for the value in the new application after the transfer. For these reasons, benefit transfer is generally considered a “second best” valuation method by economists.

Summary of Tools

This section has briefly discussed a variety of ecosystem valuation methods and provided a limited number of examples of their application to aquatic ecosystem services with an emphasis on non-market approaches (Table 3).

For revealed-preference methods, the key issue is whether ecosystem services affect people’s behavior. If a service does not affect behavior, there are three alternative means of addressing this in a valuation analysis:

1. The service that does not affect site choice by an individual may affect a service that does affect site choice. In this case, ecological modeling is needed to establish the link between services, which is the essence of the PF approach.
2. Another valuation approach may be needed. For example, if a wetland provides filtration to yield potable groundwater, then a RUM is not the approach to capture this value. The value of potable groundwater might be better estimated using a hedonic model or a stated-preference study.
3. If currently available methods of economic valuation or ecological knowledge are not capable of modeling the ecosystem service relationship of interest, then consideration of the service has to be acknowledged outside the empirical benefit analysis.

Table 3. Integrating Nonmarket Valuation Methods of Aquatic Ecosystem Applications

Valuation Methods	Types of Values Estimated	Common Types of Applications	Ecosystem Services
Travel Cost	Use	Recreational fishing	Site visitation; fish catch rates; fish consumption advisories
Averting Behavior	Use	Human health	Waterborne disease; toxic contamination
Hedonics	Use	Residential property	Proximity to aquatic ecosystems; water clarity; water quality; aquatic frontage
Production Function	Use	Fishing; Hydrological functions; residential property; ecological-economic modeling of the effects of invasive	Habitat-fishery linkages; water quality-fishery linkages; habitat restoration; groundwater recharge by wetlands; biological invasions; eutrophication; storm protection
Stated Preferences	Use and nonuse	Recreation; Human health; other activities (passive or active) that affects peoples' economic values	Groundwater protection; wetland uses; sportfishing; waterfowl hunting
Benefit Transfer	Use and nonuse	Recreation and passive use	Sportfishing

These conditions apply to all revealed preference methods, they are best illustrated in conjunction with the PF approach. The PF approach relies on actual market behavior or value estimates from revealed-preference or stated-preference studies. This approach is important because many changes in functions and services of aquatic ecosystems do not directly affect humans (e.g. water quality and habitat changes that influence fisheries; eutrophication, invasive species). The PF approach is therefore a means of identifying values for these indirect relationships. Currently, the application of PF approaches has been limited to a few types of aquatic ecosystem services (Table B). Recent progress in developing dynamic production function approaches to modeling ecosystem services, such as habitat-fishery linkages and integrated ecological-economic analysis to incorporate multiple services and environmental benefit trade-offs have illustrated that the production function approach may have wider application to valuing the services of aquatic ecosystems as our knowledge of the ecological, hydrological, and economic features of these systems improves.

In comparison to revealed-preference methods, stated-preference methods have the following advantages:

1. They are the only methods available for estimating nonuse values.
2. They are employed when environmental conditions have not or cannot be experienced so that revealed-preference data are not available.
3. They are used to estimate values for ecosystem services that do not affect people's behavior.

It is important to remember that all the methods discussed can result in over- or under- estimation of individual values for a specific application. Before any empirical study is used in a policy application it is important for the analyst to consider whether the point estimate(s) used underestimate or overestimate the "true" value. The final choice of method will depend largely on what ecosystem service is being evaluated as well as the policy or management issue that requires valuation.

G. Suggestions for a NESP Ecosystems Services Strategy

1. Task Sequencing. The May 2006 Workshop yielded a fairly extensive list of ecosystem services from which the Science Panel is tasked to develop a priority set for further investigation. Selected services will be analyzed to help guide decisions related to restoration priorities, and integrated into the overall set of indicators of river condition. A timeline or sequence of activities leading to selection of that set of priority services should draw from conceptual models of the Upper Mississippi River System and the feedback loop between ecological outcomes and evolving societal goals described the National Research Council's 2004 report (Figure 1).

Workshop experts suggested that the Science Panel and the Corps emphasize ecological production functions during the first two years of NESP. Methods for economic valuation functions can be evaluated during this period, but attempting to quantify economic valuation functions too soon may bias ecological production functions toward variables that are easy to measure but that do not capture the priority services.

Societal goals for condition of the UMRS are reflected in the services most valued by the public and stakeholders, and may be inferred by the results of previous surveys, workshops and other information-gathering efforts. But a survey of public needs and values specific to ecosystem services is also required.

Major steps in the sequence of selecting and integrating ecosystem services into the NESP planning process include:

1. developing a complete list of all known services provided by large floodplain rivers, specifically the UMRS. (Outcome B is an initial attempt at this list.)
2. developing a public survey design appropriate to the UMRS by:
    a. Engaging experts in field of resources valuation and survey design.
    b. Document assumptions for survey and its data model.
    c. Coordinate survey deployment schedule with other NESP elements.
    d. Complete survey design, cost estimate, and approval process.
3. executing the survey.
4. incorporating survey results with the indicator selection process, as first tier screen, followed by screening with indicator selection criteria.
5. using the survey results to develop example tradeoff analyses among services.

2. Communication. There are periodic needs for information distribution to stakeholders and the interested public, and periodic needs for information gathering from the same groups. To avoid redundancy with other NESP public involvement steps, the Ecosystem Services Team recommends that timing and or deployment of survey instruments, informational products, or meeting announcements and materials be coordinated through the NESP. It will also be critical for the NESP Public Involvement Team Leader to coordinate other program public involvement efforts with the ESFG to seek efficiencies in information transfer. During the course of the next calendar year, the Science Panel will present a paper at the 2007 National Conference on Ecosystem Restoration on our activities related to ecosystem services and their use in restoration planning.

3. Integration. The Ecosystem Services Team recommends that a member of the Economics Coordinating Committee participate on the Team and the Science Panel to better integrate our future steps of defining, assessing, and analyzing ecosystem services and associated tradeoffs. The Ecosystem Services Team also recommends that the Corps enlist a resource economist to assist the Science Panel and the team in framing the examination of ecosystem services and tradeoff analyses among selected services.

Ecosystem services, by definition, include only those services that benefit humans. The Ecosystem Services Team recognizes the potential risk associated with placing too much attention on such services at the expense of ecosystem support functions and structures (see Outcome B). This potential conflict is illustrated in Figure 4. To prevent such unwarranted attention, the Ecosystem Services Team recommends that the UMRS ecosystem goals and objectives now being developed primarily address ecosystem functions and processes and not ecosystem services. The development of modeling tools to understand how selected ecosystem services associated with one or a group of restoration projects could be optimized is necessary as a NESP strategy. However, services should not be considered collectively as being more important than the desired ecosystem functions or structures.

We believe that the selection of a suite of indicators for development of a restoration report card is linked to ecosystem functions, structures, and services that are most valued by society. To screen ecosystem services and integrate them into the report card indicator selection process, we suggest that the criteria identified for indicator/endpoint selection in Navigation Study Environmental Report 52 will again be valuable.

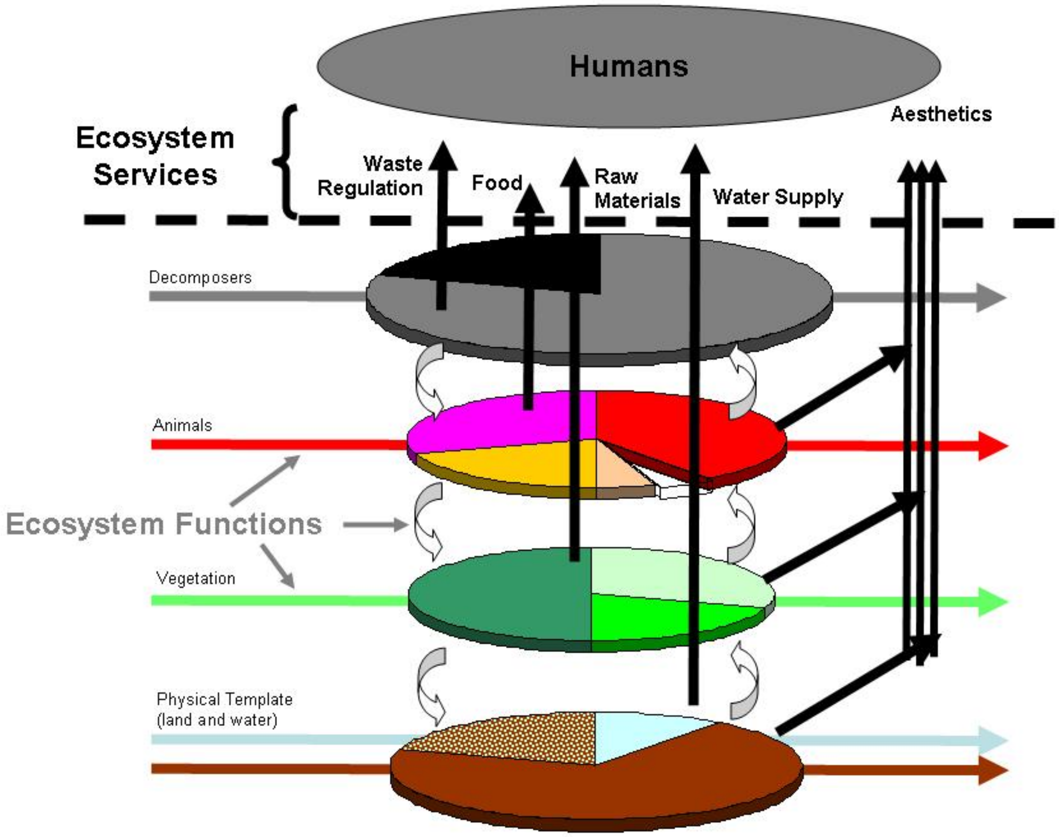

Figure 4. Focusing NESP ecosystem objectives only on ecosystem services could inappropriately direct attention away from support ecosystem services and structures.

Policy and management relevance is based upon the extent that a candidate endpoint addresses a societal issue or interest (e.g., recreation, biodiversity, water quality). A relevant endpoint should be clearly related to management actions and capabilities. Interested citizens and involved public groups with minimal technical expertise should be able to see how an endpoint relates to environmental quality. Ideally, environmental quality levels should be attributable to endpoint values.

Technical merit is concerned with the relationship between an endpoint and a structural and functional property of the ecosystem. Each endpoint must be based on scientific principles and scientific concepts. There should be confidence by analysts that the endpoint will yield reliable information and be indicative of the environmental changes of interest. Consideration needs to be given to how vulnerable an endpoint value is to confounding influences over time or space. We need to be confident that indicator values reflect the anticipated information of interest and not random or unrelated variations. Finally for technical merit, it is best if standard methods are available for measurements so data collection can be executed in a routine and confident manner.

Practicality relates to whether adequate data or feasible monitoring samples would be likely to yield accurate or reliable endpoint results. Are monitoring practitioners capable of routinely collecting the appropriate measurements in adequate amounts and quality? The costs and benefits of using the endpoint should be readily clear to program managers and the public and monitoring costs need to be reasonable over many years of use and fluctuations in agency budgets. Further, we considered whether quality control, timely reporting, and data storage and distribution could be easily managed. For practicality reasons, the endpoint should be closely related and compatible with established monitoring programs if possible.

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5 Next Steps

A. Report Review and NESP Partner Concurrence on Recommendations

This report, and especially its sections on workshop outcomes (Sections IV. A-D), includes specific descriptions and suggestions for future ecosystem services work under NESP. It should be reviewed by program partners and used to stimulate an extensive dialog between the appropriate committees and the Science Panel. Because the assumptions and methods associated with assessing ecosystem services are new and unfamiliar to many UMRS managers, we anticipate that the report will provoke substantial interest and many questions.

As soon as possible, the Corps should encourage NESP partners to accept the ecosystem services selected at the workshop, the descriptions of the services, and Science Panel suggestions related to developing a long-term ecosystem services strategy. Partner acceptance of the report and concurrence with our suggestions are desirable before additional work can be initiated.

B. Acquisition of Additional Economic Expertise

The Science Panel and the Corps should quickly review options for bringing additional economic expertise related to measuring and valuing ecosystem services to the Science Panel. Further, the Corps should evaluate options for assigning ecosystem service tasks to NESP staff. Options for acquiring more economic expertise should be clearly described and considered before an ecosystem services strategy is implemented.

The group of experts invited to the May, 2006 workshop should be reconvened as soon as the partner review described above (see Step A. to assist the Ecosystem Services Team in outlining the actual work of measuring and valuing services associated with pilot projects (see C below).

C. Initiation of Ecosystem Service Assessments

In-depth understanding of the value of ecosystem services in support of selected NESP decision making needs to be acquired through experience. The Science Panel and the Corps need to select one or more ecosystem restoration projects to serve as pilot efforts for measuring ecosystem production functions, economic valuation functions, and for assessing trade-offs associated with project alternatives. At this time, the “reach” projects seem best suited to serve in this capacity. The Louisa No. 8 conversion to Horseshoe Bend Unit of the Port Louisa NWR could serve as an alternative smaller scale pilot project. A non-NESP project, such as the MidAmerica Port proposal, may be worthy of consideration as a pilot project as well, as it would require attention to additional ecosystem services not normally affected by a project designed only to restore habitat .

D. Integration with Other NESP Adaptive Management Tasks and Potential Refinement of UMRS Essential Ecosystem Characteristics

The sources of river ecosystem services are the system's structures, functions and processes. The information we provide in this report additionally helps in refining the conceptual model and essential ecosystem services identified earlier by the Science Panel. A single operational framework of UMRS essential ecosystem characteristics that can be applied to all of the steps in the adaptive management process, and especially the development of NESP goals and objectives, will be highly valuable. The Science Panel needs to complete such a framework and begin using it consistently in future planning and presentations to NESP partners.

E. Public Involvement

Ecosystem service valuations are dependent on public desires. A process is required for polling the wants and needs of the various UMRS interest groups publics, especially in a way that provides information that can serve as valuable input into future ecosystem service assessments. An outline of this process needs to be developed in time to include public desires in the pilot project assessments (see C above). The process should include an outreach and education strategy to inform the publics about ecosystem services, the structures, functions and processes that support them, and the steps the Corps is taking to measure ecological production functions and quantify economic valuation functions. The Corps has experience in polling the public to document its desires for the future river and that experience should be used to the greatest extent possible.

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Appendix A
Initial Workshop Agenda

Day 1 - May 24, 2006

Introductions and Review of Workshop Objectives
Session I: An Overview of NESP and the UMR
Session II: What Can and Should NESP Try to Achieve in 15 years?

Day 2 - May 25, 2006
Session III: Expert Presentations and Associated Discussions
Session IV: Learning from Walking Through the Pool 18 Example
Session V: Closure

Day 3 - May 26, 2006: Ecosystem Services Team and Other Interested Parties

1. Workshop Outcomes - Reactions to the workshops
2. Next Steps - Action plan for the remainder of 2006