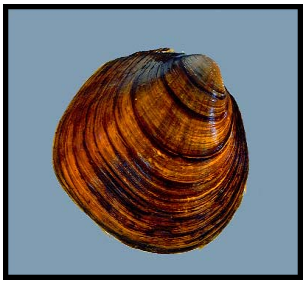
Examining Biological Indicators for the Upper Mississippi River:
Applications in Clean Water Act & Ecosystem Restoration Programs







Final Report
May 5-7, 2009 Workshop

Upper Mississippi River Basin Association

with support from

The United States Army Corps of Engineers and
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Top right: Weaver Bottoms, Pool 5, Minnesota Department of Natural Resources

Bottom right: Round pigtoe, U.S. Fish and Wildlife Service

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I. Executive Summary

Background and Workshop Purpose

The Upper Mississippi River Basin Association (UMRBA), with support from the United States Army Corps of Engineers (USACE) and the United States Environmental Protection Agency (US EPA), hosted a workshop May 5-7, 2009 to examine potential applications of biological indicators in Clean Water Act (CWA) and ecosystem restoration programs on the Upper Mississippi River (UMR). This workshop was an outgrowth of UMRBA's 2008 Ecosystem Restoration-CWA workshops, and was designed to meet the following goals:

1. Frame the issue – needs for, and potential uses of, indicators in ecosystem restoration and CWA programs on the UMR.
2. Review current research and development efforts on the UMR.
3. Learn from the experiences with indicator development and use in other large aquatic ecosystems.
4. Identify key issues/objectives/obstacles that need to be addressed, evaluate opportunities for cross-program coordination, and identify next steps in the development and application of biological indicators on the UMR.

Workshop Structure and Discussion Themes

The workshop included presentations from national and regional experts addressing a number of topics related to biological indicators, including programmatic perspectives, scientific context, key concepts, current research on the UMR, and case studies from other large aquatic ecosystems. The workshop also incorporated several discussion sessions, which allowed participants to further examine the ideas presented and identify areas for potential collaboration related to the application of biological indicators on the UMR. The following themes emerged from these workshop discussions, and are described further in the main body of this report:

- Protection and Restoration Goals
- Leadership and Collaboration
- Motivation and Driver for Action
- Regulatory and Programmatic Requirements, Constraints, and Opportunities
- River System Complexity and Geographic Scale
- Standardization of Sampling Methods
- Data Sharing, Analysis, Compilation, and Comparability
- Biological Tools, Indicators, and Indices
- Long Term Resource Monitoring Program as a Base for Expanded/Enhanced Monitoring and Assessment
- Stakeholder Engagement and Input

Possible Next Steps

Contained within the themes of the workshop discussions were a number of potential areas for further action. UMRBA, USACE, and US EPA staff involved in implementing the workshop have identified the areas below as among the most promising for future effort. This was done to further discussion among the partner agencies, and it should be emphasized that these potential next steps do not presently represent formal recommendations from UMRBA, USACE or US EPA.

- Establishing an *Ad Hoc* Ecosystem Restoration-CWA Interagency Committee
- Engagement of CWA Staff in Ecosystem Objective-Setting for UMR Reaches
- Holding a Biological Condition Gradient Workshop
- Engagement of CWA Staff in LTRMP Analysis Team Refinement of Indicators
- UMRBA WQTF Development of Biological Assessment Guidance for the UMR
- Inventory and Comparison of Sampling Methods and Data Sets
- Examining the Use of LTRMP Infrastructure to Support Enhanced Monitoring
- Monitoring Progress of the Lake Pepin TMDL and Mississippi Makeover Effort
- Enhancing Outreach and Communication

Further information about these potential next steps is provided within the main body of the report.

Moving Forward

The workshop was designed to facilitate dialog and generate ideas. With completion of this report, the project has reached its conclusion. However, these efforts were just an initial step in exploring the potential for cross-programmatic applications of biological indicators on the Upper Mississippi River. UMRBA will work with the workshop funding agencies, as well as other potential lead agencies, to examine possible next steps and will assist, as appropriate, in helping agencies move forward where they see opportunities for action. In the near term, this report is being provided to workshop participants, program managers, key work groups, and decision makers with the goal of helping to inform a collaborative discussion about potential next steps at UMRBA's August 4, 2009 quarterly meeting.

II. Introduction

As river management programs have grown and matured on the Upper Mississippi River (UMR), interest has increased regarding the application of biological indicators in both Clean Water Act (CWA) and ecosystem restoration program contexts. Among the questions that have been raised concerning the use of biological indicators on the UMR are:

- What are the potential benefits of incorporating biological indicators into CWA and ecosystem restoration programs on the UMR? What are the potential obstacles to their use?
- How might approaches applied elsewhere inform the application of biological indicators on the UMR?
- What are the potential connections between CWA and ecosystem restoration programs in applying biological indicators on the UMR? Are there approaches to indicators for the UMR that can apply effectively in *both* CWA and ecosystem restoration contexts?
- How should each program area proceed in applying biological indicators on the UMR? How should ongoing collaboration regarding indicators be sustained?

In recognition of this interest, and in response to suggestions at its 2008 Ecosystem Restoration-CWA Workshops, the Upper Mississippi River Basin Association (UMRBA) hosted a biological indicators workshop on May 5-7, 2009 in Dubuque, Iowa. The workshop, entitled "Examining Biological Indicators for the Upper Mississippi River: Applications in Clean Water Act and Ecosystem Restoration Programs," brought together key UMR program staff, as well as leading national and regional experts in the use of biological indicators, for a series of focused presentations and discussion sessions.

The United States Army Corps of Engineers (USACE) and the United States Environmental Protection Agency (US EPA) co-funded the workshop, and an *ad hoc* interagency work group helped shape its content and structure.

This workshop report includes a brief background regarding biological indicators and their current use on the UMR, provides an overview of the workshop, describes the themes arising from workshop discussions, and suggests possible next steps in moving forward with biological indicators for the UMR.

III. Background: Biological Indicators and Their Current Application on the UMR

Advantages of Biological Indicators

Proponents of biological indicators have identified several potential advantages to their use in management and regulatory programs. The use of biological indicators to assess the health of ecological systems, as opposed to relying only on physical and/or chemical parameters, has been described as having the advantages of: 1) allowing the biology to integrate and reflect the impact of multiple stressors; 2) potentially being more cost-effective than constituent-specific monitoring programs; and 3) producing measures that can be communicated more broadly and effectively to the public, for whom the status of biological organisms is generally more accessible than metrics for chemical or physical constituents. These potential advantages have spurred interest in the application of biological indicators both nationwide and on the UMR.

Potential Applications within Clean Water Act and Ecosystem Restoration Programs

Both CWA and ecosystem restoration programs need effective methods to assess aquatic ecosystems. As such, opportunities to incorporate biological indicators exist in both program areas.

In a CWA context, the states can use biological indicators in their Section 305(b) waterbody assessments. In turn, these assessments inform the determination of which waters are considered to be impaired under Section 303(d) of the Act. Both the text of the CWA (Sections 303 and 304) and US EPA policy encourage the use of biological indicators and biological assessments in the states' programs. Many states have moved forward in adopting biological approaches for wadeable streams in their CWA programs and are now examining the application of these techniques to larger rivers.

From an ecosystem restoration perspective, biological indicators can aid in the design and assessment of restoration projects, both individually and at pool, reach, and system levels. For example, monitoring population assemblages that reflect ecosystem structure, composition, and function could be used to characterize habitat quality along the UMR, including an indication of rates and scales of ecosystem processes. The results could be used to formulate and justify management goals and priorities, guide adaptive management, and document the impacts of restoration projects.

Development and Application of Biological Indicators Nationally

Other programs have successfully used biological indicators and biological assessments on wadeable streams, and the use of these techniques on "great" rivers has been rapidly evolving in recent years. Research regarding biological indicators for great rivers and the actual application of those indicators now appears ripe for consideration by practitioners on the UMR. For example, the US EPA's Environmental Monitoring and Assessment Program – Great River Ecosystems (EMAP-GRE) has begun to release the results of its monitoring for great rivers[1]

[1] EMAP-GRE defines a "great river" as one with a discharge of over 3,000 m^3/s at its mouth, or having a basin area greater than 1,000,000 km^2.

and is developing biological indices specific to the UMR. Also, the Ohio River Valley Sanitation Commission (ORSANCO) has implemented biological assessment tools on the Ohio River that may offer valuable lessons for potential application on the UMR.

Development and Application of Biological Indicators on the UMR

In addition to national level developments, there are a number of programs and venues on the UMR in which biological indicators are being discussed, developed, or applied. However, it should be noted that there are not yet widely accepted biological indices for CWA or ecosystem restoration programs on the UMR.

Described below are some of the venues in which UMR work on biological indicators is taking place, or where the application of biological indicators would hold value:

Long Term Resource Monitoring Program (LTRMP) – The LTRMP has conducted ongoing monitoring in six study pools on the UMR system (including the Illinois River) since 1987. In its recently completed report *Status and Trends of Selected Resources of the Upper Mississippi River System*, the LTRMP used its data to examine 24 identified potential indicators of ecosystem health, 14 of which are biological indicators. The LTRMP's Analysis Team (A-Team) has also initiated a review of indicators to inform development of the next Status and Trends Report. Additionally, numerous research projects affiliated with the LTRMP are relevant for work on UMR biological indicators.

Environmental Monitoring and Assessment Program – Great River Ecosystems (EMAP-GRE) – As mentioned earlier, work under this US EPA probabilistic monitoring program has included sampling of the UMR, as well as other great rivers. Results of this monitoring are now being made available and will soon be compiled into an assessment document. EMAP-GRE is currently developing biological indices for the UMR, including fish and macroinvertebrate indices of biotic integrity (IBIs).

State-Led Efforts – Numerous state-led efforts are underway to investigate and/or incorporate biological indicators, including:

- *Wisconsin DNR Large River Fish IBI* – Wisconsin DNR has developed a large river fish IBI that may be applicable to the UMR.
- *Lake Pepin TMDL* – The Lake Pepin Total Maximum Daily Load (TDML) development effort, and the associated "Mississippi Makeover" project (a visioning and planning effort for the UMR's Pool 3 and Minnesota's Lower Vermillion River), are identifying indicators to serve as endpoints for assessing restoration and remediation success. These efforts are being led by the state of Minnesota with contributions from the state of Wisconsin, along with federal and local-level participants.
- *Submersed Aquatic Vegetation Index* – Minnesota DNR and Wisconsin DNR, with support from the LTRMP, have been working jointly to develop an index that uses submersed vegetation as an indicator of ecosystem health on the UMR.

UMRBA Water Quality Task Force (WQTF) – The WQTF, which includes members of state and federal CWA-implementing agencies, has expressed a strong interest in developing biological tools for the states' use in assessing the UMR under the CWA.

Reach Objective Setting – USACE, in collaboration with ecosystem restoration program staff from various federal and state agencies, is developing ecosystem restoration objectives for the four UMR system floodplain reaches[2]. CWA program staff have also begun to engage in these efforts at various levels for the different reaches. Biological indicators or indices may be helpful performance metrics for determining if these objectives are being met.

2008 Ecosystem Restoration-CWA Workshops – At the 2008 workshops to explore potential connections between the CWA and ecosystem restoration programs on the UMR, participants identified work on biological indicators as one of the most promising opportunities for cross-program collaboration. In fact, the May 5-7, 2009 Biological Indicators Workshop was a direct outgrowth of the 2008 workshops (see Appendix A for a list of collaboration opportunities identified at these workshops).

Opportunities for Moving Forward and Role of Workshop

In summary, there appears to be an important opportunity at present to make progress in developing and applying biological indicators for the UMR. Contributing to this opportunity are: 1) advancements in research about, and application of, biological indicators on great rivers; and 2) recent interest and activity across agencies and programs on the UMR regarding biological indicators. In light of these recent developments, this workshop sought to capitalize on both technical advancements and cross-program interest by bringing together researchers and practitioners to examine opportunities, as well as obstacles, for biological indicators on the UMR.

[2] The four floodplain reaches of the UMR system are: Upper Impounded Reach (St. Anthony Falls through Pool 13), Lower Impounded Reach (Pools 14-26), Unimpounded Reach (Lock & Dam 26 to Ohio River confluence), and the Illinois River.

IV. Workshop Overview

Participants

A total of 71 individuals participated in the workshop, including 19 invited guest speakers. Representation from CWA and ecosystem restoration programs was roughly equal, and included state and federal program staff, as well as non-governmental organizations (NGOs). See Appendix B for a list of workshop participants.

Goals

With input from the *ad hoc* interagency work group described earlier, the workshop was designed to meet the following goals:

1. Frame the issue — needs for, and potential uses of, indicators in ecosystem restoration and Clean Water Act programs on the UMR.
2. Review current research and development efforts on the UMR.
3. Learn from the experiences with indicator development and use in other large aquatic ecosystems.
4. Identify key issues/objectives/obstacles that need to be addressed, evaluate opportunities for cross-program coordination, and identify next steps in the development and application of biological indicators on the UMR.

Structure and Process

The workshop was conducted over the course of three days, and was structured to provide information via a series of presentations and to allow for considerable discussion among participants and presenters. A copy of the workshop agenda is included in Appendix C.

Presentations

The presentations were organized in three segments as follows:

Introductions, Program Goals and Scientific Context – This segment included presentations from CWA and ecosystem restoration program representatives describing: 1) how their programs currently perform key functions and whether they use biological indicators; 2) the potential applications and expected value of biological indicators within these program functions; 3) requirements, directives, or policies that influence their use of biological indicators; 4) practical and science-based challenges and constraints to the use of indicators within their programs; and 5) ongoing efforts to incorporate biological indicators within their respective programs.

Also included in this segment were "key concepts" presentations addressing: 1) benefits and limitations of biological indicators; 2) biological indicators in relationship to other indicators and data; 3) single-species indicators vs. multimetric indices; 4) reference condition, the

concept of the biological condition gradient[3] (BCG); 5) indices of biotic integrity[4] (IBIs), and different types of these indices, such as fish and macroinvertebrate; and 6) practical considerations, including costs and timelines to implement.

Current Research on the Upper Mississippi River – These presentations provided information to participants regarding current biological indicator-related efforts on the UMR, most of which are at the research and development level. Each speaker described their work by addressing the following: 1) genesis and intent of the research, 2) data used in the research, 3) geographic scope, 4) status of work and primary findings, and 5) potential for application in ecosystem restoration and CWA programs.

Case Studies from Other Large Rivers/Ecosystems – These case studies highlighted other regions' experiences in developing and implementing biological indicators. This included discussions of single indicator and multimetric indicator approaches; public involvement; practical considerations; and specific CWA, ecosystem restoration, and cross-program applications.

Note: Key points from the presentations are provided in the next section of this report.

Discussions

Program-specific discussion groups on the first and second days allowed participants to react to the presentations, ask questions of speakers, consider the use of biological indicators in their program areas, and identify potential areas of cross-programmatic collaboration. On the final day, cross-programmatic groups were formed to help identify most promising opportunities for collaboration and possible next steps.

[3] The biological condition gradient (BCG) is a conceptual model for interpreting detrimental change in aquatic ecosystems, and provides a framework for characterizing the impact of human disturbance on the condition of a waterbody.

[4] Indices of biotic integrity are multimetric indices that combine several attributes of a community (such as fish or macroinvertebrates) into a single "score" reflective of a waterbody's biological condition.

V. Key Points from Workshop Presentations

The workshop presentations gave participants a great deal of valuable information regarding biological indicators, the scope of which is well beyond what can be fully captured in this report. However, in an effort to convey some of this important information within the context of this report, presenters were invited to identify key points from their remarks. These key points are provided below.

Note: The workshop presentations are available electronically upon request from UMRBA. Please contact UMRBA at 651-224-2880 or mdaniels@umrba.org to obtain the presentation(s) of interest. Additionally, references cited by presenters are listed in Appendix D of this report.

Status, Goals, and Potential Applications of Biological Indicators in a Clean Water Act Context (Gregg Good, *Illinois EPA*)

- Within their Clean Water Act regulatory program, each UMR state has the following:
  - An aquatic life use designation for the UMR;
  - Chemical numeric water quality criteria;
  - Narrative water quality criteria;
  - Access to state, LTRMP, NASQAN, and other datasets;
  - Common assessment reaches for the UMR; and
  - The ability to make a CWA 305(b)/303(d) mainstem assessment for "their" portion of the UMR.
- However, the UMR states do not have cross-border Clean Water Act assessment results consistency because of:
  - Different use designations and numeric/narrative water quality criteria;
  - Different assessment methodologies; and
  - Different amounts of data, and differing utilization of other programs' data.
- Asking the questions "across the bridge." Can I eat the fish or not? Can I swim or not? One says "yes" and on says "no!" This is the problem.
- Biological approaches may help in both improving consistency and in collaborating with ecosystem restoration programs. However, questions regarding biological approaches and cross-program collaboration include:
  - Can we use biology (i.e., fish, bugs, plants) to make better, more consistent cross-border assessments of the UMR?
  - Is biology potentially the unifying assessment tool among the five states' CWA programs on the UMR, and between ecosystem restoration and CWA programs?
  - Is "health" of the UMR "good" from both CWA and ecosystem restoration program perspectives?
- The opportunity to move forward collaboratively is now! Ongoing and emerging efforts that make now a unique time include:
  - Advancements in science to develop IBIs;

- Cross-program interest expressed at the two CWA/Ecosystem Restoration Workshops in 2008;
- Synergy with the WQTF's broad examination of UMR designated uses; and
- Five-state 604(b) proposal includes addressing the use of biology in the states' CWA assessments for the UMR.

Setting Biological Goals in a Clean Water Act Context (Roy Smogor, *Illinois EPA*)

- For Clean Water Act responsibilities, each state must define aquatic-life uses in the context of the CWA's ultimate aquatic-life goal (i.e., biological integrity) and the CWA's interim aquatic-life goal (i.e., sufficiently balanced populations/assemblages of aquatic life).
- Defining, designating, and assessing attainment of aquatic-life uses is best accomplished by using biological indicators. Valid use of such indicators requires a clear understanding of the benchmark (reference) biological conditions on which the biological indicators are based. For Midwest U.S. streams, the benchmark biological condition does not necessarily represent highly natural conditions; therefore, the highest scores for a biological indicator do not necessarily represent a highly natural condition.
- To validly interpret biological indicators based on benchmark (reference) conditions, one must determine the level of naturalness (or lack thereof) represented by the benchmark conditions used to develop the indicator. By using the concepts of the Biological Condition Gradient, one can anchor the benchmark biological condition along an absolute scale of condition that ranges from highly natural to highly impacted (by human technologically-based actions).

Upper Mississippi River System Sustainability (Ken Barr, *USACE*)

- Ecosystem restoration is one of four mission areas of the Corps of Engineers. To support this mission, the Corps has traditionally used a number of tools to: 1) formulate project alternatives; 2) evaluate the alternatives; 3) recommend, design, and construct the project; and 4) monitor and evaluate project performance. Most traditional tools are habitat-based and infer a biological response.
- The Navigation and Ecosystem Sustainability Program (NESP) provides for the dual purpose operation and maintenance of the navigation system using adaptive management. The focus is on management actions (defined as projects by the Corps of Engineers).
- To be used effectively for adaptive management, indicators need to be responsive to management actions. Therefore, indicator choice and sampling designs must be carefully considered.
- Issues of scales are also important. To account for longitudinal (upstream-downstream) differences on the system, geomorphic reaches may be useful. The UMR-IWW Navigation Study has defined 12 geomorphic reaches for the system (West Consultants 2000).
- The large river system also has a complex cross section (latitudinal variation) consisting of main channels, channel borders, secondary channels, tertiary channels, connected backwaters, and isolated backwaters. The floodplains also contain a complex array of

geomorphic features. Indicator choice and sampling design must consider this complexity as well.

- Historic references are informative. However, they are seldom useful as absolute references for the establishment of quantitative, obtainable ecosystem objectives. In establishing objectives, multiple references should be considered, including historic, virtual, internal (condition gradient), and external (Paraná) references.
- Transparency and collaboration are essential to the success of any method used for the establishment and monitoring of ecosystem objectives. Black boxes must be transparent and understandable by the stakeholders. Inputs and outputs need to be meaningful.

<u>Ecosystem Restoration Perspective</u> (Marvin Hubbell, *USACE* and Barry Johnson, *USGS*)

- Potential applications of biological indicators, in an ecosystem restoration perspective, include:
  - Biological indicators should be directly linked to ecosystem restoration goals and objectives at the system, reach, and/or project scale.
  - Development and adoption of goals and objectives will guide development of indicators and needed monitoring protocols and procedures.
  - Used to evaluate progress in meeting ecosystem restoration goals and objectives.
  - Two major types of biological indicators:
    - Indicators of ecological health.
    - Indicators to track progress in meeting social/management goals and objectives.
  - Both types of indicators are essential for use in ecosystem restoration.
    - Ecological health indicators are needed to help identify the condition of the ecosystem; and
    - Social/management indicators are needed to track progress to meeting identified goals and objectives.
  - Provide an assessment of key characteristics that define the condition of the ecosystem.
    - Challenge is to define "condition."
      - What is the reference condition?
      - What aspect of the "condition" will be addressed?
  - Aid in the identification, selection, and prioritization of restoration efforts.
    - Appropriate restoration techniques are dependent upon drivers.
  - Provide information to define needed research relative to indicator dynamics.
  - Help evaluate the outcomes of ecosystem restoration efforts at different scales.
    - Is the indicator useful at only one scale or additive over multiple scales?
    - Are different indicators needed for each scale?
    - Are the same or different data collection efforts needed at each scale?
  - Serve as a communication tool.
    - Need to identify and define critical communication needs.
    - Define what is to be measured and how to report on change/no change.

- Practical and scientific-based challenges include:
  - Should capture the complexity of the ecosystem but still be easily monitored and understood.
  - Should be responsive to changes induced by important system drivers and stressors, and management efforts.
  - Should be responsive to real or underlying change but not highly variable.
  - Consider both leading and lagging indicators.
    - Leading or real time indicators are preferable.
  - Cost effective.

Key Concepts in the Development and Use of Biological Indicators (Chris Yoder, *Midwest Biodiversity Institute*)

- We need "better" biological indicators and bioassessment — critical questions cannot be answered unless bioassessment data and indicators are sufficiently detailed and adequate. Extracting the rich information contained in the assemblages is dependent on operating a robust biological assessment program.
- Resource management programs should be judged by the biological outcomes that are produced. As such, biological assessment generates the essential feedback about whether management practices have been effective. Management practices that are validated by desired biological outcomes can be applied with a greater degree of confidence. Those that are not can either be modified in accordance with that feedback or discarded.
- Monitoring and assessment is an integral part of an overall water resource management program — this applies equally to CWA and non-CWA programs. It functions best when it functions as an integral part of these programs as opposed to a piecemeal "add-on" after the fact or otherwise. Adequate monitoring and assessment assures that chemical, physical, and biological indicators will be used in their most appropriate roles as indicators of stress, exposure, and response.
- The rigor of each monitoring and assessment program needs to be understood and quantified. Key concepts include accuracy, comparability, comprehensiveness, and cost-effectiveness. The critical technical elements methodology provides a way to determine the rigor and comparability of different programs in a multi-jurisdictional setting.
- The Biological Condition Gradient (BCG) should be a unifying theme and concept for assuring that the different approaches to biological assessment that exist on the UMR are producing comparable assessments. The best results would be obtained by conducting a comprehensive workshop and producing a detailed BCG model for the Upper Mississippi River mainstem.
- A BCG model would be the basis for exploring and developing tiered aquatic life uses and biocriteria applicable to the UMR mainstem. This would ensure consistency in management actions and their outcomes along the entire mainstem and would have equal applicability to both CWA and non-CWA programs.

Restoration Perspectives on Biological Indicators (Kristen Blann, *The Nature Conservancy*)

- Important to distinguish between "status" indicators — i.e., indicators that tell you how the system/biodiversity is faring overall — and "effectiveness" indicators, which should provide feedback on how well your projects/actions/programs are performing in moving towards the goal. Both are usually needed, and are often not the same.
- Some indicators should be designed to inform action or at least communication; at least some indicators should be diagnostic (e.g., show where action is needed).
- Diagnostic indicators are often those that look at the underlying driving processes and/or key ecological attributes (e.g., hydrology, habitat) that are critical components needed to achieve the water quality/biodiversity goal.
- Indicators must take into account differences in reference system types (~ baseline potential) across the appropriate geographic scale, but there is also a need for indicators that are comparable (apples & apples) across state and legislative boundaries.
- Diagramming conceptual models and results chains can be useful tools in identifying uncertainties, disagreements, and research needs; in communicating amongst diverse interdisciplinary groups; in keeping the goal in mind; and in keeping the logic explicit.
- Always keep the goal(s) of monitoring in mind.

Upper Mississippi River Monitoring Overview (John Sullivan, *Wisconsin DNR*)

- Lack of interstate coordination of water quality monitoring makes systemic assessments difficult.
- State and Federal agencies have cooperated on monitoring activities but more needs to be done, especially as it relates to the use and development of biological monitoring for Clean Water Act and ecosystem evaluations.
- A strategy for biological indices use should be developed that considers successful efforts like LTRMP, EMAP, and other large river bioassessment programs.
- Consider all sources of information when selecting useful indices.

Great River Bioassessment: Development of a Multimetric Index for Macroinvertebrates (Ted Angradi, *US EPA*)

- We have developed an approach to defining UMR reference conditions based on a multimetric stressor gradient.
- Reference condition in this approach is least disturbed condition.
- An index of biotic integrity for the littoral benthos (macroinvertebrates) is available and is in press at the Journal of the North American Benthological Society.
- More information is available from EPA (email: angradi.theodore@epa.gov).

An Index of Ecological Condition Based on Great River Fish Assemblages (Mark Pearson, US EPA)

- EMAP-GRE Goals:
  - Develop, demonstrate, and transfer methods to make consistent, unbiased, cost-effective condition assessments for the Ohio, Missouri, and Upper Mississippi Rivers.
- Fish metrics in GRFIn represent relevant ecological attributes of Great River fish assemblages, including:
  - Life history, trophic guilds, health (DELTs), important guilds such as minnows, great river specialists.
- GRFIn contributes to great river assessment by:
  - Yielding statements of condition ("This is what we found") as well as assessments of condition ("What we found was (or was not) disturbed relative to conditions in the reach") at scales of river, river reaches, and states.
  - Establishing biological indicators based on fish assemblages that can be used in Clean Water Act reports.
  - Creating a reference condition database for WQ standards and biocriteria development.

Fish Assemblages in Off-Channel Areas for the UMR (Brent Knights, *US Geological Survey*)

- Key Findings
  - Fish assemblages in off-channel areas (OCAs) of the Upper Mississippi River (UMR) varied with environmental conditions…that is, they were deterministic/indicative.
  - Tolerant assemblages occurred in OCAs with high total suspended solids (TSS) and nitrogen concentrations.
  - Centrarchids (bluegill, black crappie, and largemouth bass) and other like-habitat species occurred in greater abundances in OCAs with low hydrologic connectivity and aquatic vegetation (like those in upper Pool 8 UMR) characterized by:
    - Low total suspended solids and nitrogen
    - Moderate amounts of moderately deep water
    - High variability of dissolved oxygen concentration
- Management Implications
  - If TSS is a primary influence, and it is driven by watershed factors, then achieving assemblages like those in upper Pool 8 may be difficult in some regions (e.g, upper Pool 4 UMR and La Grange Pool, Illinois River) without both in-floodplain and watershed management. In those areas, applying in-floodplain measures only would be somewhat analogous to treating the symptoms but not the cause.
  - In other regions less affected by high TSS, current enhancement efforts to improve OCAs for centrarchids and other like-habitat species are congruent with our findings…that is, manage for optimal connectivity, depth, and vegetation.
- Implications for Indicators (least disturbed condition approach)
  - If we know what we want in OCAs, and it still exists somewhere in the UMRS, we can:
    - Try to manage for like environmental conditions, and

- Monitor assemblages to see if they move in the "direction" we expect…that is, lower relative abundances of "tolerant" species and greater relative abundances of limnophilic centrarchids (including large fish) and other like-habitat species. Long term monitoring is essential because of the inherent variability in fishery data in large complex ecosystems.

A Fish-Based Index of Biotic Integrity for Wisconsin's Large Rivers, Including the UMR (John Lyons, *Wisconsin DNR*)

- Fish assemblages are useful for assessing the environmental quality of the UMR. But fish indices should be tailored to specific macrohabitats (i.e., channel borders, off channel/backwaters, impounded areas).
- In large rivers such as the UMR, it is impractical to get a complete and unbiased picture of the fish community during routine bioassessment sampling. But it is possible to get a fish sample that accurately indicates environmental condition.
- Determining the appropriate reference conditions (i.e., benchmarks for bioassessment) for the UMR is challenging, and data from other large Midwestern rivers that are less modified (e.g., St. Croix, Chippewa, Wisconsin) is highly relevant and useful in this regard.
- Standardizing sampling methods and calibrating metrics with fish data collected in a consistent manner are crucial to index development, but it has proven challenging to get a diverse group of river biologists to follow standardized protocols and not to "tweak" procedures in attempts to increase fish catch.
- Existing "generic" large river indices work reasonably well for the UMR, accurately reflecting known patterns and degrees of human impact.

Exploring UMR Fish Datasets and Indices (Andy Bartels, *Wisconsin DNR*)

- Our data suggested that sampling distance for electrofishing sites on the UMR should be about a kilometer long. Less than that yielded insufficient catches and more than a kilometer did not increase catches or IBI scores significantly.
- Despite higher catches, greater biomass, and more species detected in off-channel habitats than in main channel border sites, the Lyons and GRFIn IBIs were not significantly different. This suggests that these IBIs will not be effective in evaluating fish communities in off-channel UMR habitats. A different index will have to be developed.
- Our sampling methods comparison study indicated that both gear (dipnet mesh size) and operator (boat speed) considerations are important for standardization. Though it may be possible to compare datasets collected with different sampling methods, it would be best to standardize as much as possible.
- Cursory examination of the IBI data for spatial and temporal trends suggest that either index may show promise for use in ecosystem health assessments.

Developing Biocriteria Using Submersed Macrophytes for Assessing Ecosystem Health of the Upper Mississippi River (Heidi Langrehr, *Wisconsin DNR*)

- Advantages to using aquatic macrophytes as bioindicators include: they are rooted and cannot move to avoid unfavorable conditions; they respond to hydrologic, nutrient, and chemical events; they are relatively easy to identify and sample, and they need only be sampled once per year.
- We developed a submersed macrophyte IBI for main and side channels of the UMR using data collected from Pools 1 through 11.
- Chosen submersed macrophyte metrics included maximum depth of occurrence, percent frequency of occurrence, maximum number of species recorded per site, total rake score for wild celery, and Simpson's diversity index.
- Our submersed macrophyte index appeared to respond to high water levels in June 2008 in Pools 9, 10, and 11.

Floodplain Landscape Indicators for the Upper Mississippi River System (Nate De Jager, *US Geological Survey*)

- Landscape indicators can be used to assess the structure and function of the landscape; but as predicted by hierarchy theory, landscape patterns also regulate other measures of resource condition at finer spatial scales.
- Changes in human land and water use (impoundment, agriculture, development) have imposed longitudinal patterns on the UMRS; patterns that did not exist in the 1890s. These longitudinal patterns are imbedded in very similar patterns at the basin scale and relate strongly to water quality indicators.
- We detected strong longitudinal patterns in aquatic area diversity and structural complexity, and these measures relate to fish species richness across the UMRS.
- Forest and grassland habitat has been lost and fragmented into many more smaller patches. Strategic ecosystem restoration efforts could focus on highly fragmented areas and connect isolated patches, thereby reducing habitat fragmentation.

Determining Indicators for Florida Everglades Restoration (Kelly Keefe, *US Army Corps of Engineers*)

- The presentation summarized the multi-party process used to choose system-wide indicators to assess restoration efforts in the Florida Everglades.

Steele Bayou Environmental Restoration Project (David Johnson, *US Army Corps of Engineers*)

- Use environmental design concepts to modify traditional water resources projects. Adapt project plans to balance water resource needs and costs with restoration opportunities.
- In streams affected by agricultural non-point source pollution, the first step is to control sediment input into the stream.
- Channel cleanout may be necessary to restore the stream environment.
- Adequate pre- and post-project monitoring is needed to document stream improvements.

ORSANCO Biological Monitoring and Assessment Programs (Erich Emery, *ORSANCO*)

- The Ohio River Valley Water Sanitation Commission (ORSANCO) works with various state agencies to improve water quality in the Ohio River Basin. An interstate compact authorizes ORSANCO to adopt rules, regulations, and standards applicable to the Ohio River.
- The steps ORSANCO took to develop a biological assessment of the Ohio River were as follows: selected method; built database; defined reference condition; developed an index (includes testing and calibration, and setting expectations); defined assessment units (i.e., reach, pool, segment, local, area targeted for specific restoration activity); determined number of sites needed to make assessment; developed a strategy for determining when/where impairments exist; and defined corrective actions necessary to improve condition (CWA and restoration processes).
- All five habitat classes are now being assessed and scored as excellent, very good, good, fair, poor, or very poor. ORSANCO has established new IBIs for fish and macroinvertebrates (bugs), and is developing algae indicators. ORSANCO is also researching genetics, fish health, and emerging contaminants.

Lake Pepin TMDL Incorporation of Biological Indicators (Tim Schlagenhaft, *Minnesota DNR*)

- As a smaller part of the ongoing Mississippi River/Lake Pepin TMDL, the Mississippi Makeover project, in Pools 2 and 3, is exploring opportunities to incorporate biological indicators. The effort aims to bridge multiple projects and priorities of agencies that have responsibility to protect and improve water quality, wildlife habitat, and recreational opportunities in this area. Hopefully, this will result in congruent and complimentary project goals among local stakeholders and agencies.
- Various stakeholders are being involved throughout this effort, including local government officials, private citizens/landowners, industry/business interests, and nongovernmental organizations. Representatives from the USFWS, USACE, USGS, WI DNR, MN DNR, and MN PCA have been engaged on a more technical basis.
- For the Lake Pepin TMDL, and the Mississippi Makeover project, 15-year targets are being considered, with 8-year interim targets, for water clarity, aquatic vegetation, and sedimentation indicators. For the Mississippi Makeover project alone, 20-year targets are being considered for invertebrates (mussels), fish, and waterfowl indicators, as well as for an Aquatic Habitat Quality Index score.

VI. Themes Emerging from Workshop Discussions

The workshop included several opportunities for participants to share their thoughts and reactions, including break-out and plenary discussions. A number of themes emerged from these conversations, and these are summarized below. ***Note: These themes reflect a distillation and organization by UMRBA staff of the ideas expressed by workshop participants. The order of presentation of ideas is not intended to reflect relative priority, nor are the ideas of participants reported verbatim.***

General Observations on the Themes Discussed

In general, many of the themes discussed are broader in scope than the development and application of biological indicators *per se*, and reflect the participants' recognition of foundational concepts and key process issues associated with implementing biological indicators, particularly in a cross-programmatic context. While participants identified several foundational issues that will ultimately need to be addressed, they also voiced a pragmatic perspective, emphasizing that these larger scale issues need not block progress on more discrete efforts that may offer the most promise for near-term results.

Theme 1: Protection and Restoration Goals

Participants devoted significant time to exploring how goals for protection and restoration are established within each program area and whether these goals are sufficiently compatible to allow for the shared use of indicators. This question was not fully resolved during the course of the workshop, though participants concluded that it is a threshold issue for any future efforts to apply biological indicators broadly and cross-programmatically on the UMR.

Specific observations regarding *Restoration and Protection Goals*:

- While both ecosystem restoration and CWA programs generally share the goal of protecting and restoring the UMR, there is not currently a shared goal or vision for the desired state of the UMR across programs. Additionally, even within program areas, there may not be concurrence on the desired condition.
- Programs need to explicitly define both their ultimate and interim goals for the UMR, and communicate them across program areas and to the public.
- The choice of a reference condition establishes a baseline against which any ultimate and interim goals are established and measured. Programs need to be explicit about the reference conditions they use in assessing UMR conditions and measuring progress toward goals.
- Establishing a biological condition gradient (BCG) may help frame issues of reference condition, ultimate goals, and interim goals. A BCG workshop is a possible forum to explore these issues further.
- The ongoing USACE-led ecosystem objective-setting process provides an existing forum to address goals and objectives for the UMR. Additionally, the ecosystem restoration Science Panel, which helped frame the current objective-setting process, is a resource for further discussions of UMR goals.

- Using consistent terminology in articulating goals would aid in improving communication and understanding across programs.
- Lead agencies in the program areas could engage in structured discussions to further explore issues related to goal-setting and cross-program compatibility. Such discussions should seek to identify potential unifying themes across programs. A possible output of such discussions is a white paper on the topic.
- A crosswalk between geomorphic reaches and the CWA-assessment segments could serve as a basic tool to help programs better understand the geographic units at which objectives are being set and water quality standards are applied.

Theme 2: Leadership and Collaboration

Participants identified the need to establish leadership and/or collaborative structures to pursue cross-program work on biological indicators and related topics.

Specific observations regarding *Leadership and Collaboration*:

- Both CWA and ecosystem restoration programs can benefit from collaborating, and their ultimate success may depend on such collaboration. There is currently interest and opportunity in expanding collaboration in the context of biological indicators and related topics.
- Multiple UMR-related efforts are ongoing that involve the development and/or application of biological indicators. However, there is not a clear lead for coordination among these efforts. An organizing or unifying entity may be needed to coordinate, synthesize, and/or communicate information about these efforts. A cross-programmatic technical committee could be a possible solution.
- Previous interagency collaboration carried out in support of specific efforts, such as those related to pool draw-downs, may provide a model for successful collaboration on biological indicators.
- UMRBA may be uniquely positioned to facilitate collaboration, or even take a lead role in coordinating biological indicators and related efforts. UMRBA's role and relationship to the Comprehensive Master Plan for the Management of the Upper Mississippi River System should perhaps be reconsidered in light of the need to further define leadership and collaboration structures.
- The lead federal agencies for the program areas (USACE and US EPA, and perhaps also USGS and USFWS), along with UMRBA, should confer to discuss issues of leadership and collaboration, and identify mechanisms to address these issues.
- A more formal commitment between agencies may be needed to support ongoing cross-programmatic collaborative efforts.

Theme 3: Motivation and Driver for Action

While not an issue confined to development and application of biological indicators specifically, participants commented that motivation for action on the UMR, and affiliated funding support, is tempered by the lack of a "crisis" situation. Again, as with the two

previously described themes, this is a broader theme which may affect future efforts to develop and apply biological indicators on the UMR.

Specific observations regarding *Motivation and Driver for Action*:

- Relative to some other large aquatic ecosystems, the UMR may be viewed as being in fairly good condition. As such, there is not a perceived urgent problem or crisis driving further action. However, it continues to be important to protect and improve the condition of the UMR, and to support monitoring and other means of assessing the UMR's condition.
- While there may not be an immediate crisis, there is an opportunity to expand collaboration to benefit the UMR, both water quality and ecosystem efforts, and the public. Factors contributing to this opportunity include advances in research, expanding data sets, interest in collaboration, and ongoing efforts to identify objectives at the reach and system scale.
- There is a need to educate Congress and other decisionmakers regarding ecosystem restoration and water quality programs on the UMR, including the need for public investment in both program areas. As a specific example, it may be valuable to continue pursuing a possible US EPA designation of the UMR as a "large aquatic ecosystem," both to raise the UMR's profile within the agency and potentially to attract additional funding.

Theme 4: Regulatory and Programmatic Requirements, Constraints, and Opportunities

While placing value on continued collaboration, participants recognized that programs are constrained to a certain extent by their authorized missions and/or regulatory requirements. However, the participants also identified some opportunities that may be presented by regulatory or programmatic requirements. This is another broad theme, related to collaborative efforts beyond just the development of biological indicators per se.

Specific observations regarding *Regulatory and Programmatic Requirements, Constraints and Opportunities*:

- Although the UMR states and US EPA are seeking to minimize inconsistencies in state approaches to the CWA on the UMR, the current discrepancies between state CWA programs on the UMR present a challenge to cross-program collaboration in that there is not a unified CWA program for the UMR to interface with ecosystem restoration programs.
- US EPA's policy of focusing primarily on individual "pollutants" rather than a potentially broader definition of "pollution" under the CWA may not be optimal for addressing water quality stressors and potential remedies on the UMR.
- While programs are legitimately constrained by their authorizing legislation and governing regulations, this ought not prevent or discourage cross-program collaboration and coordination. In fact, collaboration may aid in meeting programmatic missions. Therefore, a "not in our mission" response to possible collaboration is not beneficial to program success.
- The pursuit of program-specific goals or requirements may actually aid progress in other program areas. Possible examples of this include: 1) implementation of total maximum daily loads (TMDLs) as a driver in identifying desired conditions (as is happening with the Lake Pepin TMDL and associated activities), 2) the potential contribution of ecosystem restoration projects to achieving aquatic life uses under the CWA, 3) the common ground

that the CWA's "fishable" goal may provide for working with resource-focused restoration programs, and 4) the potential for the CWA's antidegradation policies to prevent "backsliding" in setting goals for the condition of the UMR.

Theme 5: River System Complexity and Geographic Scale

Participants recognized that the complexity of the UMR and its large geographic scope present challenges in developing biological indicators, and in managing the river in general.

Specific observations regarding *River System Complexity and Geographic Scale*:

- Important longitudinal and lateral gradients of physical structure, habitat, water quality, and other features exist on the UMR. These gradients must be considered in developing biological indicators, as well as more generally in setting objectives, monitoring, and assessing the condition of the UMR.
- Because of the scale and diversity of the resource, it may be appropriate and necessary to set objectives at multiple scales, including systemic, floodplain reach, and geomorphic reach.
- The Open River Reach, from St. Louis to the confluence with Ohio River, is so different in character from the impounded system that approaches applied elsewhere on the UMR may not be appropriate or workable for the Open River.
- There is a need to consider the most appropriate scale for developing and applying biological indicators, as well as making other management decisions. Important lessons may be learned in this regard from several ongoing efforts, including reach objective-setting, the Mississippi Makeover effort, and the Middle Mississippi River Partnership.
- Ideally, it is desirable to have a data set that covers the entirety of the UMR, but the large physical scale of the system makes this essentially unattainable. Monitoring programs therefore have to make choices in how to best sample the system. For example, LTRMP has addressed this issue by sampling in six study pools representative of different areas of the system, and sampling across lateral strata within these pools. EMAP-GRE took a different approach, applying a probabilistic sampling method to the entire longitudinal extent of the UMR, but working almost exclusively in the main channel.
- While individual ecosystem restoration projects typically take place at a relatively small scale as compared to the entire system, there is a need to be able to better assess the cumulative effects of restoration at the reach and system levels.

Theme 6: Standardization of Sampling Methods

Participants recognized that standardizing sampling methods, for biological and other parameters, across programs and jurisdictions would be desirable, at least theoretically, for a number of reasons. But they also acknowledged the difficulty of standardization given different jurisdictional and programmatic needs and constraints.

Specific observations regarding *Standardization of Sampling Methods*:

- Standardization of sampling methods is a desirable goal in general. However, different approaches to sampling have evolved in different program contexts to meet different

missions, so standardization may not be easy to achieve or even desirable/necessary in some settings.

- Similarly, a monitoring strategy applicable for the entire geographic extent of the UMR and applicable across programs is a laudable goal. However, programs have taken different approaches to dealing with the geographic challenges presented by the UMR, as well as in meeting their program objectives, further contributing to dissimilarities in monitoring programs.
- Formal standardization may not always be needed if differing methods produce comparable results. Comparability analyses of methods and outcomes can help answer questions as to whether different approaches produce different results. Specifically, there may be value in further exploring LTRMP and EMAP methods and results to determine their comparability and compatibility.
- Even though the EMAP-GRE program itself may formally be at an end, its methods, approaches, and data are very relevant for consideration in refining monitoring approaches going forward.
- Even if standardization is pursued in general, it may be necessary to have different monitoring approaches for different spatial and/or temporal scales. For example, different approaches may be needed to assess conditions at the system or reach level, as compared to the project level or localized impairment monitoring.
- There may be a need to create a UMR "Water Monitoring Council" to address issues such as standardization of sampling methods.

Theme 7: Data Sharing, Analysis, Compilation, and Comparability

Data availability is undeniably a limiting factor. However, participants also recognized that a relative wealth of data is available for the UMR, including biological data. Thus, to some extent, the greatest challenge in applying biological indicators and other assessment tools may be in determining how best to apply data sets both within and across program areas.

Specific observations regarding *Data Sharing, Analysis, Compilation, and Comparability*:

- Sharing data across programs, where appropriate and applicable, is an important collaboration mechanism.
- There is a need to support and maintain a common database for all available UMR data sets.
- Existing data sets (LTRMP, EMAP, state, others) should be examined and gaps identified to help improve the ability of these monitoring programs to meet their own goals, as well as support other programs' needs.
- The compatibility between LTRMP data and US EPA's STORET database should be further examined.

Theme 8: Biological Tools, Indicators, and Indices

This theme captures the participants' perspectives on the "core" issue of the workshop — i.e., how to proceed in the application of biological indicators within and across UMR programs. It is presented here following the broader themes described above, as participants conveyed a

sense that some of the larger issues will need to be addressed if success is ultimately to be achieved on indicators. That said, participants also stressed that there are several specific, concrete steps that can be immediately pursued on indicators, contemporaneously with efforts to address the more global issues.

Specific observations regarding *Biological Tools, Indicators, and Indices*:

- Tools can be refined following initial implementation, so programs do not necessarily need to wait until approaches are perfected or all underlying issues addressed. Programs can be pragmatic and opportunistic in moving forward in applying biological indicators.
- Target values for IBIs can be adjusted as management goals are refined, so these tools can be used flexibly to adapt to changing management strategies. Target values for IBIs can be re-adjusted and re-calibrated as management goals are refined This supports the notion of moving forward with some indicators/indices now, while questions of interim and ultimate management goals continue to be addressed.
- It is critical to have more than one biological index/indicator available in evaluating the UMR, and waterbodies generally. While individual indicators/indices can provide a lot of information on their own, they can not individually provide a complete assessment. Also, differences in results between indices/indicators may provide valuable information regarding the condition of the system and stressors on the system.
- The most promising categories for development and application of indices/indicators on the UMR appear to be fish, submersed aquatic vegetation, macroinvertebrates, mussels, algae, and landscape/floodplain. Of these, fish and vegetation indices appear to be the most ready for use in the near term. Additionally, total suspended solids (TSS) is a non-biological parameter that appears to be linked to the condition of several types of biota.
- Because expectations and goals may vary in different geographic areas, indices and indicators may need to be adjusted at the pool or geomorphic reach/assessment segment level. There can also be variation in desired condition between upper and lower portions of an individual pool. Examples of the need to adjust expectations to reflect such differences include: 1) the portion of the UMR to which a submersed aquatic vegetation (SAV) index can reasonably be applied and 2) the point(s), both laterally and longitudinally, where expectations for fish assemblages change.
- Indicators for off channel areas are needed to assess project success, as most of the restoration projects occur in off channel areas. CWA programs also need off channel indicators in order to make assessments of these areas. Currently, the CWA programs do not have adequate tools to assess off channel areas.
- Fish assemblages will be affected by exotic species. This may not alter the choice of an index or indicator selected, but may impact results and expectations. Also, a separate indicator or index may be needed to specifically measure impact of exotic species.
- Visual representation of assemblages, both existing and desired, can help in understanding and communicating the output of multimetric indices.
- Further clarity is needed regarding the costs of implementing indices generally, and macroinvertebrate indices specifically.

- While mussels are good integrators of watershed condition and therefore have potential as a broad-based indicator of system health, it may be difficult to identify the specific stressor affecting the mussels. Thus, specific problem identification and remediation would be challenging if mussels are used as the sole indicator.
- The program areas need to continue to explore tradeoffs between using individual indicators and multimetric indices, or both, in assessing the condition of the UMR.
- Different indicators may be needed for purposes of determining system status vs. assessing program effectiveness. Ideally, it is desirable to have indicators that are applicable in multiple contexts and in multiple programs, including social relevance. Also, indicators should be sensitive to management actions, with low variability in the absence of such interventions.
- Further development of conceptual models could enhance the understanding of how environmental conditions, and water quality specifically, affect biota. Suitable models do not currently exist to make these linkages throughout the system, though they are being developed as part of the reach objective-setting effort.
- Essential ecosystem characteristics (biota, geomorphology, habitats, hydrology & hydraulics, and water quality & biogeochemistry) can help guide the selection of appropriate indicators.
- Efforts to develop a decision support system (DSS) for the UMR should be continued and expanded to include water quality perspectives and needs.
- Existing and historical data can be used both in implementing proposed indices and in the development of new indices, as needed.
- ORSANCO has pioneered the integration of biological indices into CWA assessments for a large river, and its approach may be very instructive for efforts on the UMR.
- The recently completed LTRMP Status and Trends Report provides data for a number of UMR indicators, including biological indicators, and gives a promising starting point for further work on biological indicators. While the Status and Trends Report did not have a consensus set of objectives against which to evaluate its findings, it does compare its results to recommended values, where available. The LTRMP Analysis Team plans to develop refined indicators for use in the next Status and Trends Report. It may be helpful to explore which indicators may serve as an appropriate venue to engage water quality staff in the A-Team's effort.

Theme 9: LTRMP as a Base for Expanded/Enhanced Monitoring and Assessment

Using LTRMP to support expanded/enhanced monitoring and assessment of the UMR was a recurring theme in workshop discussions. Participants focused both on making better use of existing LTRMP data and on leveraging LTRMP infrastructure (physical and human) as a platform from which to expand monitoring and assessment efforts.

Specific observations regarding *LTRMP as* a *Base for Expanded/Enhanced Monitoring and Assessment*:

- Efforts should be renewed to familiarize CWA program staff with the LTRMP and its data sets, with the goal of expanding the use of LTRMP data in CWA assessments.

- CWA program staff should review LTRMP methods and data to identify constraints on the ability to meet CWA needs (e.g., limitations inherent in LTRMP's trend pool approach). CWA program staff should also review and provide feedback to LTRMP on the recent Status and Trends Report, the FY 10-14 LTRMP Strategic and Operational Plan, and the LTRMP monitoring protocols.
- The UMRBA Water Quality Task Force and LTRMP staff should further examine opportunities for collaboration between CWA programs and the LTRMP. These groups should jointly develop recommendations for using LTRMP infrastructure as a "base" for expanded monitoring. Also, they should consider funding mechanisms to build upon LTRMP infrastructure/program in support of additional monitoring.
- As appropriate, "outpool" LTRMP sampling should be pursued to aid CWA program needs.

Theme 10: Stakeholder Engagement and Input

Participants were mindful that, as further work on biological indicators proceeds, stakeholder engagement, input, and buy-in will ultimately be essential to success.

Specific observations regarding *Stakeholder Engagement and Input*:

- Stakeholder input in the development and application of biological indicators is important as the indicators must be meaningful not only to scientists and managers, but also to stakeholders and the public at large.
- UMR programs must be able to answer the public's straightforward question: "How's the river doing?" The Chesapeake Bay offers examples in how to communicate to the public in such a fashion.
- The use of common indicators across programs enhances the ability to communicate with the public. Sending a consistent message to the public also enhances the credibility of both agency and individual programs.
- Programs need to develop mechanisms for incorporating stakeholder input into the process of indicator selection and implementation. Establishing stakeholder working groups can be helpful in this regard. The Lake Pepin TMDL and Mississippi Makeover efforts include mechanisms for involving stakeholders that may be informative.

VII. Possible Next Steps

In their discussions and comments, workshop participants highlighted a number of possible next steps regarding the development and application of biological indicators on the UMR. Summarized below are what appear to be among the most promising areas for action. These next step options are not consensus recommendations from workshop participants, since developing such a consensus was not part of the workshop agenda. Rather, this section represents the efforts of UMRBA, USACE, and US EPA staff involved in implementing the workshop to reflect on the participants' discussions and identify the best opportunities for advancing biological indicators work on the UMR.

These potential next steps are primarily focused on cross-program collaboration opportunities, but also include specific actions that could be taken within either the CWA or ecosystem restoration program areas. As expressed by a project sponsor during closing remarks, these potential next steps do not prevent or preclude the immediate use of workshop information within and across programs as seen fit by program staff. Moreover, as noted previously in the report, work on the more discrete actions need not await progress on the broader issues.

Ad Hoc Ecosystem Restoration-CWA Interagency Committee

The need for continued conversations across program areas, particularly to address "big picture" issues of collaboration and leadership, as well as programmatic goal-setting and compatibility, was a recurring theme in the workshop. Many participants indicated that an effective forum would need to be smaller in scale than the workshop setting, and would include, at minimum, the lead federal agencies of USACE and US EPA, UMRBA, and representatives from other key agencies and organizations. Working as an *ad hoc* committee, participants could produce white papers to share progress, recommendations, upcoming activities, and other information with various audiences. The committee could determine how best to address the need for technical and stakeholder input, as well as consider whether a more formal commitment is needed between agencies to support ongoing collaboration. The committee could also work with both program areas to standardize terminology and definitions, where appropriate, in order to minimize confusion between the two program areas. Moreover, many of the other possible next steps described in the following paragraphs could be guided and informed by the *ad hoc* interagency committee.

Ecosystem Objective-Setting for UMR Reaches

Participants identified the ecosystem objective-setting process being led by USACE as an established forum to address issues of desired conditions for the UMR. Therefore, the continued and expanded engagement of CWA program staff in the objective-setting process, particularly over its next four-year cycle, appears to be a promising option for action. USACE and the UMRBA's Water Quality Executive Committee have already exchanged correspondence on this topic, and UMRBA Water Quality Task Force (WQTF) members have had initial engagement on some reaches. UMRBA can continue to work with USACE and CWA programs to define and formalize the role of CWA staff in this process. Additionally, part of this effort would include finalizing the reach "crosswalk" document that compares geomorphic reaches used for objective-setting with water quality assessment reaches.

Biological Condition Gradient Workshop

A biological condition gradient (BCG) workshop could be an important step in addressing issues of programmatic objectives. This type of workshop would frame and organize baseline understandings and expectations for the condition of the UMR along a human disturbance gradient. A BCG workshop could aid in objective setting and inform the development and application of biological indicators, including both status and effectiveness indicators for both ecosystem restoration and CWA programs. The question of spatial scope would need to be further explored to determine whether one workshop would be sufficient, or whether multiple workshops would be required to address the entirety of the UMR. The BCG would not necessarily be the exclusive approach applied in examining reference condition, as other approaches exist and need to be considered; but it could certainly be a valuable tool in framing discussions in a cross-programmatic context.

LTRMP Analysis Team Refinement of Indicators

CWA staff could lend valuable perspectives to the LTRMP Analysis Team's effort to re-examine indicators in advance of the next LTRMP Status and Trends Report. This engagement could lead to identifying indicators of use for both programs, and could aid the UMRBA WQTF's work on indicators and bioassessments (see below).

UMRBA WQTF Development of Biological Assessment Guidance for the UMR

UMRBA is currently seeking funding to support development of a guidance document for integrating biological tools into the states' CWA assessments of the UMR. Working with UMRBA's WQEC and WQTF, this effort would address fish, vegetation, and macroinvertebrate indices in particular. While primarily intended for CWA program use, this project will require the input of researchers and practitioners from ecosystem restoration programs and could potentially produce indicators and methodologies of value to restoration programs. If funding is secured for this effort, it is anticipated to begin within the next year, at which point the WQTF would likely be in contact with ecosystem restoration program staff regarding participation in the project. A related step may be to identify more permanent representation from ecosystem restoration programs on the WQTF.

Inventory and Comparison of Sampling Methods and Data Sets

Workshop participants commented on the potential need to standardize sampling methods, and to further examine existing data sets to improve understanding and use of data across program areas. In order to achieve greater understanding of existing programs' methods and data, examine comparability, and look for gaps to be addressed, an inventory of sampling methods and data sets could be compiled. This would include LTRMP, EMAP, state monitoring programs, and other federal monitoring (from USGS, US EPA, etc.). A lead entity/agency would need to be identified for this effort. Possibilities include USGS, USEPA, the WQTF, or a yet-to-be formed UMR Water Monitoring Council. Such an effort would build on previous examinations of data and monitoring approaches, such as those done by the UMRCC and UMRBA.

Examine the Use of LTRMP Infrastructure to Support Enhanced Monitoring

A frequent theme in workshop discussions was the possibility of using LTRMP, and the LTRMP monitoring infrastructure in particular, to support enhanced monitoring for CWA programs. As discussed in the thematic summaries, this would likely include a review of LTRMP core documents and data by the WQTF/CWA program staff, followed by discussion with UMESC and field station staff regarding possibilities for expansion. Funding mechanisms would also have to be addressed. As appropriate, the WQTF and LTRMP could then make joint recommendations regarding the use of LTRMP to support enhanced monitoring.

Learn From the Lake Pepin TMDL and Mississippi Makeover Effort

The Lake Pepin TMDL process and the related Mississippi Makeover project are undertaking efforts both to develop endpoint indicators and to engage stakeholders in indicator development. Moreover, these efforts are taking place in a cross-program setting. As such, they may offer valuable insight on how to proceed both in indicator development/application and collaboration on the UMR. Updates to various standing forums (e.g., WQTF, A-Team, etc.) would be an effective way of communicating these lessons. In a similar fashion, the Middle Mississippi River Partnership may also offer helpful examples for collaboration on the UMR.

Outreach and Communication

Participants highlighted the need for ongoing outreach and communication to elected officials, agencies, stakeholders, and the public at large about both ecosystem restoration and CWA programs on the UMR. Raising the profile of the UMR within US EPA was specifically discussed, including the continued pursuit of inclusion in the agency's strategic plan and recognition of the UMR as a "large aquatic ecosystem." Efforts to raise the UMR's profile within US EPA have been led by the states' water quality agencies to date, and could potentially benefit from support by restoration programs and stakeholder groups. In addition, the importance of stakeholder involvement in indicator development was emphasized throughout the workshop. Therefore, any of the biological indicator efforts described above would be well served to consider how stakeholders are to be engaged in the process.

VIII. Closing Note

The workshop was designed to facilitate dialog and generate ideas. With completion of this report, the project has reached its conclusion. However, these efforts were just a first step in exploring the potential for cross-programmatic biological indicators on the UMR. UMRBA will work with the workshop funding agencies (US EPA and USACE), as well as other potential lead agencies, to examine these possibilities further and will assist, as appropriate, in helping agencies move forward where they see opportunities for action. In the near term, this report is being provided to workshop participants, program managers, key work groups, and decisionmakers with the goal of helping to inform a collaborative discussion about potential next steps at UMRBA's August 4, 2009 quarterly meeting.

Appendix A
Collaboration Opportunities Identified at 2008 Ecosystem Restoration-CWA Workshops

The excerpt below is taken from the UMRBA's "Final Project Report" on the workshops held in April and June 2008 to examine policy and practice interfaces between ecosystem restoration and Clean Water Act programs on the Upper Mississippi River. Identified collaboration opportunities specific to biological indicators have been highlighted in ***bold italics.***

Collaboration Opportunities Identified By Workshop Participants As Having the Greatest Promise

Ecosystem Restoration Objectives and Water Quality Standards

a. Include CWA program staff in ecosystem objective-setting process for geomorphic reaches.
b. Continue efforts to discuss, harmonize, and refine state CWA water quality standards applicable to the UMR (including designated uses and water quality criteria), with input from ecosystem restoration staff.
c. Include CWA program staff in work on the Upper Mississippi River Conservation Committee's Fisheries Plan.
d. Establish a standing UMR Ecosystem Restoration-CWA committee to continue discussions initiated at workshops.
e. Develop a UMR "Report Card" that is easily understood by the public and decision-makers, utilizing indicators from monitoring programs.

Biological Indicators

a. Development of biological indicators for the UMR that serve both CWA and ecosystem restoration programs. This involves a number of elements, including:
- ***i. An initial workshop on biological indicators/indices of biotic integrity, with additional workshops as needed.***
- ***ii. A review of existing approaches/ uses of biological indicators on the UMR, including data and indices from US EPA's Environmental Monitoring and Assessment Program.***
- ***iii. Identification of key target/indicator species.***
- ***iv. Public input on indicators.***
- ***v. Use of conceptual models to make biota-water quality linkages.***

Water Quality Monitoring

a. Examine quality assurance and analytical methods requirements for CWA and restoration program sampling, analysis, and data management to identify opportunities for enhanced data sharing.
b. Coordinate monitoring schedules across programs/agencies/states to maximize efficiency and minimize redundancies.
c. Summarize and share data from US EPA's Environmental Monitoring and Assessment Program across programs.
d. Use Long Term Resource Monitoring Program monitoring and data to assess biological response to nearby Habitat Rehabilitation and Enhancement Projects.
e. Form a UMR Water Quality Monitoring Council.

Watersheds, Tributaries, and TMDLs

a. Greater involvement of agriculture agencies in ongoing discussions regarding UMR ecosystem restoration and water quality protection.
b. Hold joint meetings between those working on tributary Total Maximum Daily Loads and UMR ecosystem restoration projects.

Water Quality Considerations in Ecosystem Restoration Projects

a. Include CWA program staff in ecosystem restoration project teams to engage in project planning and facilitate regulatory compliance.
b. Include CWA program staff in ecosystem restoration project prioritization.
c. Model and predict the cumulative water quality impacts of restoration projects.

Appendix B
Biological Indicators Workshop Participants
May 5-7, 2009

Illinois Department of Natural Resources
- Butch Atwood
- Ann Holtrop

Illinois Environmental Protection Agency
- Gregg Good
- Matt Short
- Roy Smogor

Iowa Department of Natural Resources
- Dave Bierman
- John Olson
- Adam Schnieders
- Bernie Schonhoff
- Tom Wilton

Minnesota Department of Natural Resources
- Megan Moore
- Walt Popp
- Tim Schlagenhaft

Minnesota Pollution Control Agency
- Mike Feist

Missouri Department of Conservation
- Kat McCain

Missouri Department of Natural Resources
- Mohsen Dkhili

Wisconsin Department of Natural Resources
- Todd Ambs
- Andy Bartels
- James Baumann
- Terry Dukerschein
- Shawn Giblin
- Jeff Janvrin
- Heidi Langrehr
- John Lyons
- John Sullivan

U.S. Army Corps of Engineers
- Ken Barr
- Kenneth Cook
- Karen Hagerty
- Charlie Hanneken
- Donovan Henry
- Marvin Hubbell
- Dave Johnson
- Kelly Keefe
- Chuck Spitzack
- Dan Wilcox

U.S. Environmental Protection Agency
- Ted Angradi
- David Bolgrien
- Bill Franz
- Ed Hammer
- Donna Keclik
- Mark Pearson
- Julianne Socha
- Chris Urban

U.S. Fish and Wildlife Service
- Nate Caswell
- Bob Clevenstine
- Mike Coffey
- Joyce Collins
- Jon Duyvejonck
- Rick Frietsche

U.S. Geological Survey
- Nate De Jager
- Suzanne Femmer
- Jeff Houser
- Barry Johnson
- Brent Knights
- Ken Lubinski
- Charles Peters
- Jana Stewart

Upper Mississippi River Conservation Committee
- Scott Yess

Izaak Walton League of America
Brad Walker

Midwest Biodiversity Institute
Chris Yoder

ORSANCO
Erich Emery

Prairie Rivers Network
Traci Barkley
Kim Erndt

The Nature Conservancy
Gretchen Benjamin
Kristen Blann
Todd Strole/U.S. Army Corps of Engineers

Upper Mississippi River Basin Association
Peg Donnelly/U.S. Environmental Protection Agency
Dave Hokanson
Kirsten Mickelsen

Appendix C
Workshop Agenda

EXAMINING BIOLOGICAL INDICATORS FOR THE UPPER MISSISSIPPI RIVER:
APPLICATIONS IN CLEAN WATER ACT & ECOSYSTEM RESTORATION PROGRAMS

May 5-7, 2009

Workshop Goals:

1. Frame the issue — needs for, and potential uses of, indicators in ecosystem restoration and Clean Water Act programs on the UMR.
2. Review current research and development efforts on the UMR.
3. Learn from the experiences with indicator development and use in other large aquatic ecosystems.
4. Identify key issues/objectives/obstacles that need to be addressed, evaluate opportunities for cross-program coordination, and identify next steps in the development and application of biological indicators on the UMR.

Tuesday, May 5

PART 1: INTRODUCTIONS, PROGRAM GOALS, AND SCIENTIFIC CONTEXT

Time	Attachment	Topic
11:45 a.m.		**Registration**
Noon		**Welcome** Chuck Spitzack, USACE Bill Franz, USEPA Todd Ambs, Wisconsin DNR/UMRBA Board
	A	**Workshop Purpose and Agenda** Dave Hokanson and Kirsten Mickelsen, UMRBA
	B	**Introductions**
12:30	**C**	**UMR Program Perspectives: Status, Goals and Potential Applications of Biological Indicators** *Speakers from each program area will describe:* ▪ *How their programs currently perform key functions (e.g. project planning and design, assessments, evaluations,etc.), and whether or not these functions incorporate biological indicators* ▪ *The potential applications and expected value of biological indicators within these program functions* ▪ *Requirements, directives, or policies that influence the use of biological indicators* ▪ *Practical and science-based challenges and constraints to the use of indicators within program areas* ▪ *Ongoing efforts to incorporate biological indicators into their programs* **a) Clean Water Act** Gregg Good and Roy Smogor, Illinois EPA **b) Ecosystem Restoration** Ken Barr and Marvin Hubbell, USACE and Barry Johnson, USGS, UMESC

1:50 p.m. **Comments/Discussion of Program Perspectives**

Facilitated plenary discussion intended to:

- *Synthesize the program perspectives*
- *Allow for Q&A to clarify program perspectives*

2:15 **Break**

2:30 **Key Concepts in the Development and Use of Biological Indicators**

Chris Yoder, Midwest Biodiversity Institute

An overview of theoretical and technical information regarding the development and application of biological indicators, to include:

- *Benefits and limitations of biological indicators*
- *Biological indicators in relationship to other indicators and data*
- *Single-species indicators vs. multimetric indices*
- *Reference condition*
- *Biological condition gradient*
- *Index of biotic integrity (and different types – fish, macroinvertebrate, etc.)*
- *Practical considerations: costs, timelines, etc.*

4:15 **Restoration Perspectives on Biological Indicators**

Kristen Blann, The Nature Conservancy

4:45 **Program Area Group Discussions (Speakers Available for Questions)**

Participants within the same program area participate in a discussion to:

- *Reflect on the presentations*
- *Discuss questions with speakers*
- *Refine and target ideas about where biological indicators fit into their program*
- *Think about what an ideal index or indicators might be for their program*
- *Begin to generate ideas about how biological indicators might apply across programs*

5:30 p.m. **Adjourn for the Day**

Wednesday, May 6

PART 2: CURRENT RESEARCH ON THE UPPER MISSISSIPPI RIVER

These presentations will provide information to participants regarding current biological indicator-related efforts on the UMR, primarily at the research/development level. Each speaker will describe their work by addressing the following:

- *Genesis and intent of the research*
- *Data used in the research*
- *Geographic scope*
- *Status of work and primary findings*
- *Potential for application in ecosystem restoration and Clean Water Act programs*

8:00 a.m. **Recap of Day 1 and Goals for Day 2**

Dave Hokanson and Kirsten Mickelsen, UMRBA

8:10 **UMR Monitoring Overview**

John Sullivan, Wisconsin DNR

8:20 **EMAP GRE Bioassessment: Development of a Multimetric Index for Macroinvertebrates**

Ted Angradi, US EPA, ORD

9:00 **EMAP GRE: An Index of Ecological Condition Based on Great River Fish Assemblages**
Mark Pearson, US EPA, ORD

9:20 **Fish Assemblages in Off-Channel Areas for the UMR**
Brent Knights, USGS, UMESC

9:40 **A Fish-Based Index of Biotic Integrity for Wisconsin's Large Rivers, Including the UMR**
John Lyons, Wisconsin DNR

10:00 **Break**

10:20 **Exploring UMR Fish Datasets and Indices**
Andy Bartels, Wisconsin DNR

10:40 **Developing Biocriteria Using Submersed Macrophytes for Assessing Ecosystem Health of the UMR**
Heidi Langrehr, USGS, UMESC

11:00 **Floodplain Landscape Indicators for the UMR**
Nate De Jager, USGS, UMESC

11:20 **Plenary Discussion/Questions and Answers for Speakers**
Full group given the opportunity to ask questions of the speakers. All speakers are available as "panel" in front of the group.

11:45 **Lunch**

PART 3: CASE STUDIES FROM OTHER LARGE RIVERS/ECOSYSTEMS
These case studies are intended to bring out issues, including single indicator and mulitmetric indicator approaches, public input on indicators, practical considerations, Clean Water Act applications, ecosystem restoration applications, and cross-program applications. Participants will have the opportunity to ask questions at the end of each presentation.

1:00 p.m. **Determining Indicators for Florida Everglades Restoration**
Kelly Keefe, USACE

1:45 **Upper Steele Bayou Environmental Restoration Project**
Dave Johnson, USACE

2:30 **Break**

2:45 **ORSANCO Biological Monitoring and Assessment Programs**
Erich Emery, ORSANCO

3:30 **Lake Pepin TMDL Incorporation of Biological Indicators**
Tim Schlagenhaft, Minnesota DNR

4:15 **Break**

4:30 **Program Area Group Discussions**

Program area groups will prepare for a report out at the beginning of the next day, which will provide their conclusions in regard to:

- *Usefulness and potential value in developing and applying biological indicators on the UMR within the program area (and how this has evolved from opening program description)*
- *Identification of challenges and limitations for the program area*
- *Formulating a vision for indicators in the program area: what would "ideal" indicators or an "ideal" index look like?*
- *Opportunities for cross-program collaboration*

5:15 **Comments and Observations from Day 2, Preview of Day 3**

5:30 p.m. **Adjourn for the Day**

Thursday, May 7

PART 4: MOVING FORWARD IN THE APPLICATION OF BIOLOGICAL INDICATORS ON THE UMR

8:00 a.m. **Recap of Day 2 and Goals for Day 3**

Dave Hokanson and Kirsten Mickelsen, UMRBA

8:15 **Program Area Report-Outs**

Program area groups report out their conclusions (as developed in the preceding afternoon's session).

9:00 **Cross-Program Groups**

With the ideas reported out above in hand, cross program groups now participate in a facilitated discussion to identify most promising areas for inter-program applications

10:00 **Cross-Program Groups Report Out**

Cross program groups report out on their most promising ideas

10:30 **Break**

10:45 **Formulating Next Steps (Large Group Facilitated Discussion)**

A concluding, large group discussion to do the following:

- *Assess the potential for collaboration between program areas in regard to indicators and indices*
- *Identify concrete next steps that could be pursued both within and across program areas*
- *Identify the following to aid in execution of concrete next steps: known information gaps, resources that might be required and might be available, potential lead agencies and individuals, possible timelines*

11:45 **Final Comments and Recap**

Noon **Adjourn**

Appendix D
Speakers' Reference List

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Upper Mississippi River System Sustainability
Ken Barr, US Army Corps of Engineers

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http://www2.mvr.usace.army.mil/UMRS/NESP/default.cfm

Ecosystem Restoration Perspective
Marvin Hubbell, US Army Corps of Engineers and Barry Johnson, US Geological Survey

Environmental Management Program Website:
http://www.mvr.usace.army.mil/EMP/default.htm

Long Term Resource Monitoring Program Website:
http://www.umesc.usgs.gov/ltrmp.html

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Floodplain Landscape Indicators for the Upper Mississippi River System
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Lake Pepin TMDL Incorporation of Biological Indicators
Tim Schlagenhaft, Minnesota DNR

Lake Pepin TMDL Project: http://www.pca.state.mn.us/water/tmdl/tmdl-lakepepin.html

Mississippi Makeover Project: http://www.dakotaswcd.org/wshd_missmak.html

Appendix E
List of Acronyms Used in this Report

BCG	Biological Condition Gradient
CWA	Clean Water Act
DELT	Disease, Eroded Fins, Lesions, and Tumors
DSS	Decision Support System
EMAP	Environmental Monitoring and Assessment Program
GRFIn	Great River Fish Index
IBI	Index of Biotic Integrity
LTRMP	Long Term Resource Monitoring Program
MN DNR	Minnesota Department of Natural Resources
MN PCA	Minnesota Pollution Control Agency
NASQAN	National Stream Quality Accounting Network
OCA	Off-Channel Area
ORSANCO	Ohio River Valley Sanitation Commission
SAV	Submersed Aquatic Vegetation
STORET	STOrage and RETrieval database
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UMR	Upper Mississippi River
UMRBA	Upper Mississippi River Basin Association
UMRCC	Upper Mississippi River Conservation Committee
UMR-IWW	Upper Mississippi River-Illinois Waterway
UMRS	Upper Mississippi River System
USACE	United States Army Corps of Engineers
US EPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WI DNR	Wisconsin Department of Natural Resources
WQEC	(Upper Mississippi River Basin Association) Water Quality Executive Committee
WQTF	(Upper Mississippi River Basin Association) Water Quality Task Force

Appendix F
Errata

P. 5 — State-Led Efforts — Submersed Aquatic Vegetation Index — US EPA's Environmental Monitoring and Assessment Program of Great River Ecosystems (EMAP-GRE) provided the majority of funding for this effort, with initial support from the Long Term Resource Monitoring Plan (LTRMP).