Upper Mississippi River Restoration Program

Science in Support of Restoration and Management
FY16 SOW

Enhancing Restoration and Advancing Knowledge of the Upper Mississippi River

Addressing the FY2015–2025 UMRR Strategic Plan
23 February 2016

With Addendum
19 April 2016

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One of the criteria for evaluating success in achieving FY2015–2025 UMRR Strategic Plan is a highly integrated program in which research and monitoring inform restoration and management efforts. The knowledge, information, and data from the UMRR's Long Term Resource Monitoring Element provides the foundation needed to evaluate progress in advancing ecosystem and management objectives, identify future restoration needs, and determine the Upper Mississippi River's health and resilience.

Developing and Applying Indicators of Ecosystem Resilience to the UMRS

Ecological resilience can be defined as the ability of an ecosystem to absorb disturbance and still maintain its fundamental ecological processes, relationships, and structure. The concept of ecological resilience is based on the understanding that most ecosystems can exist in multiple alternative states rather than exhibiting a single equilibrium state to which it is always capable of returning. For example, shallow lakes have been shown to exist in either a clear-water heavily vegetated condition, or a turbid condition with little or no vegetation. The magnitude of disturbance (e.g., change in nutrients or turbidity) a lake in either state could sustain and remain in that state is the ecological resilience of that system.

Most management agencies are interested in quantifying the resilience of ecosystems because it can help them identify locations, scales, and degrees of management intervention needed to maintain healthy, productive ecosystems, or to shift ecosystems to more desirable states. In some cases, managers might be interested in reducing the resilience of an undesirable state (e.g., the turbid, unvegetated state above), whereas in other cases, managers might be interested in maintaining or increasing the resilience of a desirable state (e.g., the clear-water, vegetation state above).

Although there exists a substantial theoretical and conceptual literature on ecological resilience and how it could inform ecosystem management, applied examples are less common. Very little work has been done to develop indicators of ecosystem resilience for large rivers. Nevertheless, many of these concepts are clearly relevant to the Upper Mississippi River System (UMRS) and the U.S. Army Corps of Engineers' Upper Mississippi River Restoration (UMRR) Program. For example, the UMRS has experienced changes that have been associated with reduced resilience and shifts to undesirable states in other ecosystems. Examples of such changes include accumulation of nutrients and sediments, redirection of water flows, altered flow regimes and water elevations, changes in flood frequency and floodplain connectivity, and proliferation of non-native species. How have these changes influenced the health and resilience of the UMRS?

The UMRS also exhibits characteristics that likely contribute to its resilience and which may be augmented by various management actions. The longitudinal orientation of the river provides a diversity of climatic and environmental conditions, which might maintain the resilience of, for example, fish communities in the face of interannual variability and long term changes in climate and other ecological drivers. Some portions of the UMRS maintain extensive lateral connections and hydrogeomorphic diversity across the floodplain, which allow fish species to persist through substantial seasonal and interannual fluctuations by seeking suitable habitat in various locations. How do these hydrogeomorphic characteristics and the diversity of fish, vegetation, invertebrates, and other biota they contribute to the health and resilience of the UMRS?

It is likely that management actions could alter some of the features typically attributed to resilience. For example, if connections among contrasting aquatic areas substantially contribute to the resilience of the UMRS, then how and where could managers modify hydrological connectivity (e.g., dredging, altering channel-backwater connections, island construction) to improve the resilience of desired states or reduce the resilience of undesired states?

OBJECTIVES

This project will be the primary responsibility of a post-doctoral scientist collaborating with scientists at the U.S. Geological Survey, Upper Midwest Environmental Sciences Center (UMESC) and scientists and managers throughout the UMRR partnership. The objectives are:

1) Establish a resilience working group to capitalize on the diversity of expertise and perspectives that comprise the UMRR partnership. The intention is that this group will include representatives from at least one UMRR field station (Casper), the US Fish and Wildlife Service (Winters), the US Army Corps of engineers (Hubbell, Hendrickson, Richards) and the USGS Upper Midwest Environmental Sciences Center (Jeff Houser, who will serve as the project lead; Nate De Jager; and the post-doctoral scientist). This working group will be substantially involved in the formulation and conduct of this project.
2) Develop a clear conceptual understanding and definition of ecological resilience as applied to the UMRS.
    a) Small working group will develop a draft ("strawman") conceptual model of ecological resilience in the UMRS.
    b) Convene workshop to discuss and refine this model. Participants will be determined by resilience working group.
    c) Small working group will refine conceptual model based on input from workshop
3) Use the conceptual model to guide:
    a) Development of indices of resilience for the UMRS using data from the UMRR-LTRM.
    b) Description of the current resilience of multiple reaches of the UMRS.
    c) Evaluation of the factors contributing to the resilience of the UMRS
        i) Where the UMRS is in a desirable state, what contributes to the resilience of that state and what management actions might maintain or increase that resilience?
        ii) Where the UMRS is in a less desirable state (e.g., lack of vegetation in the lower impounded reach), what contributes to the resilience of that state and how might management actions overcome that resilience?
4) Evaluate the potential effects of HREPs on resilience of the UMRS
    a) Conceptually: Expand conceptual model to specifically consider what aspects of resilience may be affected by HREPS.
    b) Empirically: Use LTRM data and additional data collected at selected HREPS to evaluate actual effects observed in the field.
5) Consider how understanding derived from addressing the above objectives could inform and improve management of the UMRS.
    a) How do current management actions affect the resilience of the UMRS?
    b) Is there potential to improve current management actions, or develop new management actions, as a result of considering the river's resilience?
6) Suggest ways in which ecological experiments or natural variation can be used to test our understanding of resilience within the UMRS, and consider the potential for managing resilience through HREPs.

WORKPLAN AND DELIVERABLES

We will begin by identifying the factors that most likely affect the resilience of the UMRS, and actions that might contribute to increasing resilience. This will be done via a review of existing literature and discussions with scientists and managers across the UMRR partnership. We will then work to quantify various aspects of the resilience of the UMRS to the extent possible with existing UMRR-LTRMP data. Finally, we will begin to examine theoretical and empirical descriptions of the effects management actions on the resilience of the UMRS.

Results of these efforts will be communicated to the partnership via a seminar or workshop and presentations at various UMRS meetings. We will communicate results to a national and international audience via presentations at scientific conferences and in peer-reviewed publications.

Expected Time Line:

Activity	Fiscal year
Hire Post-doctoral (P.D.) researcher	FY 15
P.D. & UMESC staff discuss resilience relative to UMRS	FY15
P.D. discusses resilience concepts with river managers at workshop, and ongoing UMRS meetings,	FY15-16
Develop ideas for defining and measuring resilience	FY15-16
Apply measures of resilience to UMRS using LTRMP data, and evaluate factors affecting resilience within UMRS	FY16
Consider how resilience concepts can inform and improve management of the UMRS, and ways to test resulting predictions.	FY16-17
Communicate results to partnership, and write report and manuscript	FY17

Tracking number	Products	Staff	Milestones
2016R1	Updates provided at each quarterly UMRR CC meeting and A team meeting	Bouska, Houser	Various
2016R2	Initial meeting of full Resilience Working Group	Bouska, Houser	October 2015
2016R3	Draft conceptual model	Bouska, Houser	30 May 2016

Landscape Pattern Research and Application

The goal of landscape pattern research on the Upper Mississippi River System is to develop concepts, maps and indicators that provide both regional-level decision makers and local-level resource managers with information needed to effectively manage the UMRS.

As described in the UMRR Landscape Pattern Research Framework (De Jager 2011), landscape pattern research on the UMRS focuses on linking decisions made at regional scales with restoration actions carried out at local scales. While regional program managers and decision makers are concerned with improving the overall ecological condition of the entire UMRS, local resource managers work to address site specific habitat and resource limitations. Landscape ecology, which focuses on the linkages between patterns visible at broad scales and ecological patterns and processes that occur at local scales, can help to integrate these two scale-dependent management activities. (Strategic Plan Outcome 2, Output 2.2, Outcome 4)
Objectives

1) To develop broad-scale indicators of habitat amount, connectivity and diversity for the purposes of a) identifying areas for ecosystem restoration across the entire system and b) to track status and trends in habitat area, diversity and connectivity.

2) To connect broad-scale landscape pattern indicators with local-scale ecological patterns and processes critical to restoration project development.

Product Descriptions

2016L1: Draft Manuscript: Changes in land cover and land use 2000-2010. Nathan De Jager (UMESC), Jason Rohweder (UMESC)

UMR system-wide 2010 Land cover data is scheduled for completion by the end of FY2015. We intend to examine the changes that have occurred over the past 10 years as the data become available (In FY 15 but extending into FY16). We will extend the temporal extent of previous land cover land use change analyses (De Jager et al. 2013a). We will focus on the 15-class data set because it allows for assessment of changes in vegetation classes important to resource managers. One question we are particularly interested in is how far south recent increases in SAV have extended? Other questions have to do with invasion by reed canarygrass, which is mapped as the 'wet meadow' class. In 2016 a draft manuscript will be completed, which reports our findings. This research addresses objective 1.2 of the landscape patterns research framework (patterns of land cover composition).

2016L2: Draft Manuscript: Effects of flooding, invasion by reed canarygrass, and increased nitrogen deposition on decomposition and nitrogen cycling along the UMR Floodplain. Swanson, Strauss, Thomsen (UW-L) & De Jager (UMESC)

Since 2010, N. De Jager has been providing assistance and information to local US Army Corps of Engineers foresters (Randal Urich et al.) to guide forest restoration at a site just south of La Crosse, Wisconsin. In cooperation with personnel at the University of Wisconsin-La Crosse, studies were conducted from winter 2010 to summer 2011 on the role(s) herbivory by white-tailed deer and flooding play in forest recruitment and invasion by exotic reed canarygrass (De Jager et al. 2013b, Cogger et al. 2014). In 2012, a collaborative experiment involving Whitney Swanson (student) of the University of Wisconsin-La Crosse was initiated to examine rates of nitrification across the elevation gradient of the floodplain and in response to management actions that created different plant community types (De Jager et al. 2014L1). In 2013, W. Swanson initiated a new study for her Masters research that focuses on the effects of flooding, invasion, and increased nitrogen deposition on rates and patterns of organic matter decomposition and nitrogen cycling. She collected final soil samples in 2014 and conducted data analysis in 2015 (2015L4). These studies are helping us better understand how management decisions that relate to river-floodplain connectivity, and establishment of different plant community types might alter important aspects of ecosystem function, including nutrient and elemental cycling. This research partially addresses objective 2.2 (floodplain soil nutrient dynamics) of the Landscape Patterns Research Framework.

2016L3: Draft Manuscript: Review of Landscape Ecology on the UMR. N.R. De Jager (UMESC).

The objective of the research proposed here is to synthesize the findings of studies conducted under the umbrella of the landscape patterns research framework in the context of alternative management and climate change scenarios. This effort is focused on linking broad-scale management decisions about the restoration of floodplain and aquatic habitats with the objectives of local-scale restoration projects under current environmental conditions and those possible under future climate change scenarios. This research addresses objectives put forth in a recent SOW that funds N.R. De Jager to synthesize results of previous landscape ecological studies on the UMR.

2016L4: Draft Manuscript: Reed canarygrass abundance and distribution in the UMR. Miller, A. (UWL), Thomsen, M.T. (UWL), De Jager, N.R. (UMESC), Yin, Y. (UMESC), Erin Hoy (UMESC).

Reed canarygrass (RCG) is a problematic invader of UMR floodplain forests. Over the past few years, we have been examining the role different management actions play in limiting the spread and potentially eliminating RCG at forest restoration sites near La Crosse, WI. During 2015 Amber Miller (UW-L) and Erin Hoy (UMESC) began examining the distribution, abundance and spread of RCG as a wet meadow (using LCLU data) as well as in the understory of floodplain forests (using COE forest inventory data). Patches of reed canarygrass were identified from 15-class land cover maps and aerial photography for pools 5, 6, 7, and 9. Changes in the abundance and distribution will be estimated from these maps from 2000 to 2010. The proportion of forest area inventoried by the U.S. Army Corps of Engineers and Fish and Wildlife Service that has been invaded by reed canarygrass will be estimated. Relationships between reed canarygrass cover and spread will be examined against hydrology data sets. The data constitute the first large-scale assessment of RCG in the UMR floodplain, despite widespread concern over its invasion. This research is aimed at addressing objective 2 of the landscape patterns research framework: To connect broad-scale landscape pattern indicators with local-scale ecological patterns and processes critical to restoration project development. This particular project addresses objective 2.1 of the landscape patterns research framework, floodplain community composition and succession.

2016L5: Draft Manuscript: Linking flood inundation, ecosystem functions, and ecosystem services: the state of the art. De Jager, N.R. (UMESC), Morlock, S. (USGS), Johnson, K. (TNC)

Flooding is a primary driver of riverine ecosystem functions, including plant succession and diversity; nutrient availability, cycling, and flux; and aquatic and terrestrial animal habitat quantity and quality. These ecosystem functions directly impact the ecosystem services that floodplains provide to society, such as: clean water, recreational opportunities, and flood protection. The flood-ecosystem connection is becoming a major focus of UMRR landscape ecology research and partner efforts to valuate, understand, and manage this ecosystem. Water scientists from the USGS and Army Corps of Engineers are currently developing geospatial tools to simulate water velocities, flood extents and depths on floodplains. Meanwhile, USGS ecosystem scientists are conducting river and floodplain ecosystem studies. And finally, partner agencies (e.g., The Nature Conservancy) are conducting river and floodplain ecosystem services assessments. However, the inputs and outputs of these efforts rarely align, making it difficult for any of these studies to make use of the other ongoing efforts. This disconnection is currently a major barrier to restoration and management efforts, as well as efforts to plan for alternative restoration or climate change scenarios along rivers and floodplains. The objective of this project is to identify the linkages among hydrodynamic and flood inundation modeling efforts, ecosystem studies, and ecosystem services assessments. This research addresses objective 1.1 of the landscape patterns research framework (patterns of flood inundation).

2016L6: Data Analysis and Presentation: Spatial patterns of the invasive faucet snail *Bithynia tentaculata* in Pool 8 of the UMR.

Bithynia tentaculata (faucet snail) is an invasive gastropod that was first reported in Lake Michigan in 1871 and has since rapidly spread through the Nation's waters. This invasion has been extremely problematic in the Upper Mississippi River (UMR), specifically Pools 7 and 8 as these areas lie along the continental avian flyway. As an intermediate host for several exotic trematode parasites, *B. tentaculata* is linked to regular regional waterfowl mortality events and negative impacts on native waterfowl populations. This study is designed to better predict the distribution of *B. tentaculata* relative to submersed aquatic vegetation and other habitat features, to examine spatial and temporal changes in the abundance and distribution of *B. tentaculata* from 2007-2015, and gain some insights into how restoration actions might influence the distribution of this species and its effects on native species. This research addresses objective 2.3 of the landscape patterns research framework (Aquatic community composition).

Tracking number	Products	Staff	Milestones
2016L1	Draft Manuscript: Changes in land cover and land use 2000-2010.	De Jager & Rohweder (UMESC)	30 September 2016
2016L2	Draft Manuscript: Effects of flooding, invasion by reed canarygrass, and increased nitrogen deposition on decomposition and nitrogen cycling along the UMR Floodplain	Swanson, Strauss, Thomsen (UW-L) & De Jager (UMESC)	30 September 2016
2016L3	Draft Manuscript: Review of Landscape Ecology on the UMR	De Jager (UMESC)	30 September 2016
2016L4	Draft Manuscript: Reed canarygrass abundance and distribution in the UMR.	Miller & Thomson (UW-L), De Jager and Yin (UMESC)	30 September 2016
2016L5	Draft Manuscript: Linking flood inundation, ecosystem functions, and ecosystem services: the state of the art.	De Jager (UMESC), Morlock (USGS), Johnson (TNC)	30 September 2016
2016L6	Data Analysis and Presentation: Spatial patterns of the invasive faucet snail *Bithynia tentaculata* in Pool 8 of the UMR	Weeks & Haro (UW-L), De Jager (UMESC)	30 September 2016
2015L6	Presentation: Developing methods to map floodplain functions and ecosystem services	Morlock (USGS), Johnson, De Jager	30 July 2016
2015L6a	Draft Manuscript: Developing methods to map floodplain functions and ecosystem services	Morlock (USGS), Johnson, De Jager	30 Sept 2016

Intended for distribution
Manuscript: De Jager, N.R., Swanson, W., Strauss, E.A., Thomsen, M., Yin, Y. Accepted. Flood pulse effects on nitrification in a floodplain forest impacted by herbivory, invasion, and restoration. Wetlands Ecology and Management. (2014L1).
Manuscript: De Jager, N.R., Houser, J.N., Ickes, B.S. Submitted. Patchiness in a large floodplain river: associations among hydrology, nutrients, and fish communities. River Research and Applications. (2014L3)
Fact Sheet: De Jager, N.R. 2014. Landscape Ecology on the Upper Mississippi River: lessons learned, challenges, opportunities (2013L3).
Manuscript: De Jager, N.R., Rohweder, J., Yin, Y., Hoy, E. 2015. The Upper Mississippi River floodscape: spatial patterns of flood inundation and associated plant community distributions. Applied Vegetation Science (2015L2).
Manuscript: Kreiling, R.M., De Jager, N.R., Swanson, W., Strauss, E.A., Thomsen, M. 2015. Effects of flooding on ion exchange rates in an Upper Mississippi River floodplain forest impacted by herbivory, invasion, and restoration. Wetlands (2015L3).
Manuscript: Scown, M., Thoms, M. and De Jager, N. R. In Press. 'Measuring spatial pattern in floodplains: A step towards understanding the complexity of floodplain ecosystems'. In: *River Science: Research and Applications for the 21st Century*. D. J. Gilvear, M. Greenwood, M. Thoms and P. Wood (eds). John Wiley and Sons, UK, pp. (2015L7)
Manuscript: Scown, M. W., Thoms, M. C. and De Jager, N. R. In Review. The effects of survey technique and vegetation type on measuring floodplain topography from DEMs. Earth Surface Processes and Landforms. (2015L8)
Manuscript: Scown, M. W., Thoms, M. C. and De Jager, N. R. In Review. An index of floodplain surface complexity. Hydrology and Earth Systems Science. (2015L11).

Mussel Research Framework

(June addendum to the FY2015 SOW):
2015MRF1–2: Spatial patterns of native mussels in the UMRS

North America contains an impressive diversity of native freshwater mussels (Unionoida)—more species of mussels occupy the Mississippi river basin than the entire continent of Europe. However, the density and diversity of freshwater mussel assemblages have substantially declined in many river systems, presumably due to exploitation, urbanization, habitat degradation and fragmentation, and pollution. Over the past 50 years, about 20 species have been extirpated or greatly diminished from the Upper Mississippi River System (UMRS). Conservation and restoration efforts towards mussels are hampered by a lack of knowledge on how mussels are distributed across the UMRS landscape. Mussels occur in aggregations termed mussel 'beds', however little is known about the structure of these beds or at what scale they occur. Recently, UMESC scientists have been exploring spatial patterns of native mussels in the UMRS using data from pool-wide mussel surveys in Pools 3, 5, 6 and 18. These data suggest that spatial patterns are present at large scales (i.e., 300 m), but the patterns vary among pools and between adult and juvenile mussels. The next logical step is to zoom in and assess the spatial patterns at a smaller spatial scale, such as the scale of the mussel bed. Data on how mussels are distributed across the landscape will help managers design effective surveys for mussels, aid in selecting sites for restoration projects, and may provide insights into the role of spatial heterogeneity in the functioning of river ecosystems (i.e., identify hotspots for diversity). The objective of this study is to quantify the degree and spatial scales of patchiness in the distribution of juvenile and adult mussels at small spatial scales.

Preliminary results of spatial patterns at the large scale (pool wide, >300 m scale) suggest that no single mechanism appears to structure freshwater mussels. If the primary variable(s) structuring mussel assemblages across the four sampled pools is related to hydrology and hydraulic patterns (which is reasonable given the recent work of the UMESC native mussel team), then these features can be manipulated by resource managers to benefit native mussel assemblages. Successful restoration efforts for native mussels will depend on knowledge of where these aggregations occur, where the highest density areas occur, and how they are spatially structured. Quantifying the spatial patterns of mussels will help us answer these questions and will lead to more informed habitat rehabilitation and enhancement projects (HREPs) to benefit mussels. The proposed research supports question 1a (What are the spatial and temporal patterns in mussel assemblages in the UMRS?) of the "Scientific Framework for Research on Unionid Mussels in the UMRS" as well as question 2.3 (What are the ecological consequences of landscape patterns on aquatic community composition?) of the "Scientific Framework for Landscape Pattern Research on the Upper Mississippi and Illinois River Floodplains".

Methods:
We will identify existing datasets that have quantitative data on mussel assemblages at smaller spatial scales (i.e., within a mussel bed). For example, we are aware of datasets in Pool 5 (2013) and Pool 8 (2001) that could be used to assess small scale spatial patterns. We will also coordinate identification of datasets with Heidi Dunn (Ecological Specialists, Inc.) and the Mussel Coordination Team. We will establish criteria for the types of data we need to ultimately perform spatial statistics. Once we receive the data, we will re-format the datasets into a common format suitable for obtaining spatial statistics. Although the current budget is only sufficient to compile and summarize key datasets, we intend this work as a first step toward a detailed analysis of spatial patterns of mussels at smaller scales relevant to many HREPs and will seek additional funds to complete this project.

*Products and Milestones**

Tracking number	Products	Staff	Milestones
2015MRF1	Spatial patterns of native mussels in the UMRS: Establish selection criteria, identify existing data sets, and re-format to a common data suitable for spatial analysis	Ries, Newton, De Jager, Zigler	1 April 2016
2015MRF2	Spatial patterns of native mussels in the UMRS: brief summary letter, including complied dataset, GIS layers, map	Ries, Newton, De Jager, Zigler	1 June 2016
Intended for distribution			
Manuscript: Reis, P., De Jager, N.R., Newton, T., Ziegler, S. In Review. Spatial patterns of native freshwater mussels in the UMR. Freshwater Science.			

*See Addendum for additional work products

Pool 12 Overwintering HREP Adaptive Management Fisheries Response Monitoring

This is a continuous project that builds on several years of pre-project fisheries monitoring for the Pool 12 Overwintering HREP. We have been performing pool-wide electrofishing in Pool 12 since 2006. We have also been performing fyke netting in backwater lakes that will be rehabilitated, as well as other backwaters in Pool 12 that will not be rehabilitated (as a control). We also perform otolith extraction from bluegills from the lakes we net in to obtain aging, sexing, and mortality information.

Introduction/Background: The Iowa DNR has been studying centrarchid overwintering habits and habitat requirements in the Upper Mississippi River for over 30 years. This work has identified the physical conditions necessary for overwintering and ecological responses to fisheries habitat restoration in HREPs such as Brown's Lake (Pool 13) and Mud and Sunfish Lakes (Pool 11). All of these projects considered fish movement into individual backwaters and habitat suitability in response to restoration. Centrarchid overwintering issues have long been important to river managers because much backwater habitat has been greatly altered or reduced by sedimentation since the 1930s. Centrarchids are also a key component of the sport fishery in the Upper Mississippi River, and public interest in the population dynamics of these species is high.

Questions still exist as to the longitudinal spacing of fisheries overwintering HREP projects. The Pool 12 Overwintering HREP is unique because four backwater lakes (Sunfish, Stone, Tippy, and Kehough - in order of construction) are being rehabilitated in the same navigation pool (all within roughly eight river miles of each other), in the same window of time, and as part of the same HREP.

Relevance of research to UMRR: The Pool 12 Overwintering HREP is being designed and implemented using active adaptive management principles to assess fisheries benefits beyond individual backwaters, whereas prior HREP monitoring considered centrarchid condition and behavior within specific backwaters. This work ultimately aims to answer long-standing questions related to the spacing of fish overwintering HREP projects, and this is an ideal case to attempt this assessment for the reasons mentioned in the Introduction.

The Iowa DNR has been collecting pre-project data in these backwater lakes since 2006. We will have several years of pre-HREP project and post-HREP project fisheries data that will inform the adaptive management process that many UMRR partners are interested in as the UMRR evolves. The pre- and post-dredging fisheries monitoring of this HREP will inform other river managers who are working on topics such as standardized HREP monitoring protocols (USACE and USGS), bluegill overwintering models (USACE), and research frameworks associated with aquatic overwintering issues in the Upper Mississippi River Basin (USGS). This work falls within the USACE's priority research areas for FY15.

Methods: Pre-project (pre-dredging) data has been collected in Pool 12 since 2006. This proposal will provide another annual increment of pre-project fisheries sampling (pool-wide electrofishing and backwater lake-specific fyke netting). We will continue with these sampling efforts in the rehabilitated and control lakes throughout the construction period. We will attempt to collect as many years of post-project data as we have of pre-project data from each backwater lake so we can compare "before and after" centrarchid condition, population dynamics, and mortality to assess if there is a positive response in the fishery in the rehabilitated backwaters.

Continued post-project fisheries monitoring will also show if centrarchid populations will be enhanced throughout the entirety of Pool 12, or just in the rehabilitated lakes. We also have pool-wide and backwater fisheries monitoring conducted annually in neighboring Pool 13 as part of standard UMRR

LTRM fisheries component monitoring. Thus, Pool 13 will also serve as a control to determine if the fisheries response is specific to the rehabilitated areas in Pool 12, or if centrarchid population dynamics remain similar to those we observe in Pool 13 during the same period of time.

“Treatment” (rehabilitated) Lakes	“Control” Lakes
Sunfish (RM 564)	Wise (RM 561.5)
Kehough (RM 567.5)	Fishtrap (RM 566)
Tippy (RM 571.5)	Green’s (RM 572.5)
Stone (RM 572)	Frentress (RM 576)

Products and Milestones*

Tracking number	Products	Staff	Milestones
2016P13a	Collect annual increment of pool-wide electrofishing data	Bierman and Bowler	1 November 2015
2016P13b	Collect annual increment of fyke netting data from backwater lakes	Bierman and Bowler	15 November 2015
2016P13c	Perform otolith extraction from bluegills for aging	Bierman and Bowler	1 December 2015
2016P13d	Age determination of bluegills collected in Fall 2014	Bierman and Bowler	1 February 2016
2016P13e	In-house project databases updated	Bierman and Bowler	31 March 2016
2016P13f	Summary report compiled and made available to program partners	Bierman and Bowler	30 September 2016

*See Addendum for additional work products

Statistical Evaluation

Statistical support for the UMRR LTRM provides guidance for statistical analyses conducted within and among components, for contributions to management decisions, for identifying analyses needed by the Program, for developing Program-wide statistical projects, and for reviewing LTRM documents that contain statistical content. The statistician is also responsible for ensuring that newly developed statistical methods are evaluated for use by LTRM. Guidance for management includes assistance with modifications to program design and with standardizing general operating procedures.

The statistical component will help identify useful analyses of data within and across components, ensure analytical methods are appropriate and consistent, and, when possible, coordinate multiple analyses to achieve larger program objectives regardless of which group (UMESC, field stations, USACE, etc.) conducts analyses. The statistician is also responsible for reviewing LTRM documents that contain substantial statistical components for accuracy, and for ensuring that quality of analyses is consistent among products. A primary goal of statistical analyses is to draw appropriate conclusions to inform effective management actions. Appropriate statistical analysis and interpretation is critical to making proper inferences from LTRM data. This, in turn, is critical for distinguishing between natural variation and human effects and in evaluating the long-term effects of management actions, such as HREPs, water level manipulations, or increases in navigation.

Product Description

2016E1: Trends in summer water temperatures in the LTRM UMR study reaches**.**

This product represents an elaboration of 2012E2 (a completion report titled "Summer water temperature in the Upper Mississippi River"). This 2016 product will elaborate both the analyses and the discussion associated with 2012E2 to form a draft manuscript for submission to a peer reviewed journal.

2016E2: How well do trends in LTRM percent frequency of occurrence SAV statistics track trends in true occurrence?

The LTRM assumes that our estimates of percent frequency of occurrence ('occurrence') of submersed aquatic vegetation (SAV) accurately track actual occurrence. However, this assumption has not been carefully evaluated. This work will be important to managers and ecologists who are interested in trends in SAV levels, especially where such trends begin or end with low occurrence (SAV occurrence levels at sites selected for HREPs will typically below). This work will directly address the primary LTRM goal of estimating temporal trends in ecological indicators. In addition, the work will help managers better evaluate the effectiveness of efforts to alter SAV levels, including through HREPs.

Products and Milestones

Tracking number	Product	Staff	Milestone
2016E1	Draft manuscript: Trends in summer water temperatures in the LTRM study reaches	Gray	30 Sept. 2016
2016E2	How well do trends in LTRM percent frequency of occurrence SAV statistics track trends in true occurrence?	Gray, Erickson	30 Sept. 2016

Intended for distribution
Completion report that describes methods of estimating variance components from LTRMP water quality data (2008E1; Gray)
Manuscript: Inferring decreases in among- backwater heterogeneity in large rivers using among-backwater variation in limnological variables (2010E1, Rogala, Gray, Houser)
Completion Report: Summer water temperature in the Upper Mississippi River (2012E2). Gray, Robertson, Houser, Rogala.
Completion report: An assessment of trends in water temperature in La Grange Pool (2012E3; Gray, Robertson, Rogala, Houser)

Aquatic Vegetation, Fisheries, and Water Quality Research

New Product Descriptions

2016A6: Aquatic Plant Response to Large-Scale Island Construction in the Upper Mississippi River

Short-term vegetation response to island construction has been previously documented (Langrehr et al. 2007); however island projects are designed with an intended 50-year life span and should be evaluated periodically for longer-term responses. Preliminary analyses comparing pre- and post-construction species richness for the Pool 8 Islands complex have been completed, and additional evaluations will be conducted; possible comparisons include:

- “Before” (1998-2007) vs “after” (2008-2014) data in the area of influence.
- Area of influence sites vs. vegetated reference sites of comparable depth and distance from land.
- Area of influence sites vs. reference sites in open water (after Langrehr et al. 2007) outside the area of influence – these are in the impounded area of the pool and tend to be deep and unvegetated.

Several potential questions and approaches are being considered. For example, have individual project phases performed differently? Do species colonize project areas in a particular order? Is there a “successional” process involved? What role do invasive species play in vegetation response?

Island construction is a frequently used tool in UMRR restoration projects, and is intended (in part) to reduce fetch and created sheltered areas for aquatic plant growth. This work will provide additional insights on longer-term SAV response to island construction and provide valuable insights to managers for design of future projects.

This project meets the Guiding Principles of the UMRR 2015-25 Strategic Plan and supports its implementation by using UMRR Long Term vegetation data to (1) evaluating ecological response to project features (Obj. 1.2, Strategies 2 and 4) (2) gain knowledge about status and trends (Obj. 2.1, Strategy 2), and (3) to provide insights and understanding about key ecological questions in order to inform and improve management **(**Obj. 2.2, Strategies 1 and 5).

2016A7: How many years did the effects of the 2001-2002 Pool 8 drawdown on arrowheads (*Sagittaria latifolia* and *S. rigida*) last?

The water level drawdown in Pool 8 was lowered during the summers of 2001 and 2002 to promote establishment of emergent vegetation on shallow water fringes. LTRM monitoring data indicated a spread of emergent vegetation, including *Sagittaria latifolia* and *S. rigida*, in the ensuing years. An exploratory analyses conducted in 2008 detected more arrowhead in dewatered areas after drawdown compared to before drawdown years. The follow up analysis will repeat the analysis, to reveal how long the arrowheads persisted on drawdown dewatered sites.

2016B12: Draft Manuscript: Benefits of Collaboration among Long Term Fish Monitoring Programs in Large Rivers (Fisheries Journal)

This paper will explore the benefits of long term monitoring and benefit of collaboration to allow learning across typical river scales. The basic question is: can we compare long term monitoring programs to assess potential for collaboration & coordination at national scale? This paper will contrast and compare 5-6 different long term fisheries monitoring programs. Biologists and resource managers designing and conducting monitoring programs for fish in large river systems tend to focus on single river basins or segments of large rivers, missing opportunities to learn from those conducting fish monitoring in other rivers. We suggest that deliberate comparisons of fish monitoring programs across basins could greatly improve the design and implementation of fish monitoring programs in large river systems including the UMRS.

2016B13: Draft Manuscript: An Assessment of Long Term Changes in Fish Communities within Large Rivers of the United States (Environmental Monitoring journal)

This paper explores multiple objectives using data from 5-6 different large river fisheries monitoring programs including:

- Can we demonstrate ability to compare some findings across basins
- Can we assess and make inferences about trends in fish (assemblages?), invasives, other metrics?
- Are we getting the same type of signals in different programs?
- What commonalities are we seeing at largest scale, regional scales?

Understanding trends in biological, chemical, economic, and physical parameters will be important to resource managers and will inform management decisions and strategies to mitigate the effects of landscape scale stressors such as climate change and invasive species introductions. Our goal is to use data collected from large river fish monitoring programs with disparate goals to better understand spatial and temporal trends of fish communities in large rivers as a first step towards better understanding the factors affecting these resources.

2016B15: Technical Support to River Managers Investigating UMR Walleye Dynamics

River managers have been responding to increased public interest and reports of a decreased recreational walleye catch. Walleye populations are of great interest to the anglers of Wisconsin, as evidenced by the popular "Wisconsin walleye initiative" and annual concerns over bag limits in the ceded territory. WDNR fish managers, in cooperation with Minnesota and Iowa DNR's, have begun using UMRR-LTRM walleye data in conjunction with their own surveys to evaluate Walleye population dynamics. In FY 16, they will explore LTRMP data to improve their understanding of Walleye population dynamics and how certain attributes (structure and function) of the UMR ecosystem relates to those dynamics. Of particular interest to managers is (1) understanding population trends, (2) recruitment, (3) river processes affecting recruitment and survival to recreationally desirable size classes and (4) effects of possible management practices and populations.

River managers requested ongoing technical assistance with this project from La Crosse Field Station staff and the UMRR LTRM Fish PI throughout FY 16. The results of this work will help to inform managers and the public about Walleye status and trends, factors affecting population dynamics, and associated implications for making management decisions to improve the overall fishery health.

UMRR long-term data for Pool 8 indicate that Walleye CPUE has remained stable and low for the past dozen years. Walleye PSD values depict a stable pattern over time, with scores ranging from about 40 to 80. The 2013 value of 78 was at the higher end of the spectrum, suggesting primarily larger adults in the population. High CPUE occurred in 1994, 1997 and 1998, and again in 2007. Catch rates in 2011 and 2012 were rebounding from the all-time low in 2010, but declined again in 2013 (Figure 1 [source: UMRR La Crosse Field 2013 Station Annual Summary]).

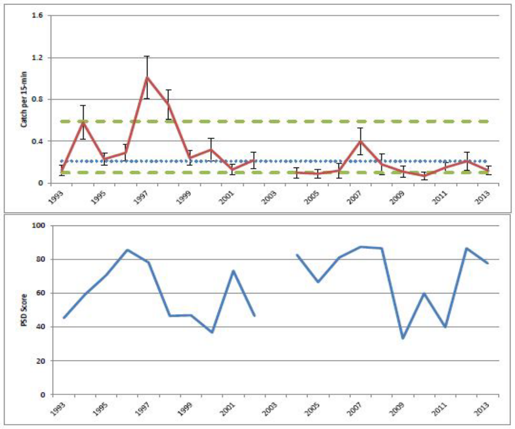


Figure 1. UMRR-LTRM Pool 8 Walleye CPUE & PSD Scores, 1993-2013

Targeted sampling efforts for Walleye and Sauger conducted by state managers since 1992 show a similarly declining trend (Figure 2)

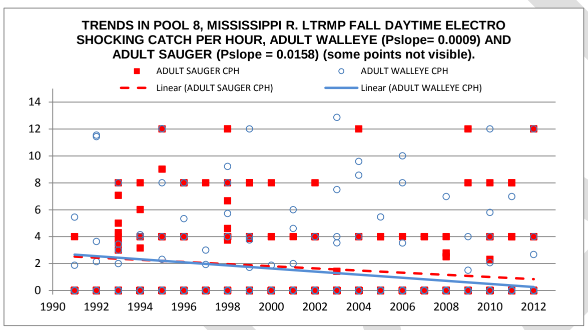


Figure 2. Wisconsin DNR Fall Walleye and Sauger Targeted Sampling 1991-2012

In order to respond to angler interest, and prior to formulating management strategies, managers need relevant knowledge about the UMR populations and factors contributing to UMR population dynamics. UMRR Fisheries Specialists and technicians understand the intricacies of the sampling design, inherent data strengths and limitations, and appropriate use of statistics necessary to fully utilize the UMRR long-term dataset (e.g., http://www.umesc.usgs.gov/ltrmp/stats/statistics.html). Additionally, they bring first-hand ecological knowledge gained from over 20 years of fisheries experience.

This project supports implementation of the UMRR 2015-25 Strategic Plan by using UMRR Long Term fisheries data in combination with other data sources to (1) gain knowledge about status and trends (Obj. 2.1, Strategy 2), and (2) to provide insights and understanding about key ecological questions to inform and improve management (Obj. 2.2, Strategies 1 and 3).

Products and Milestones

Tracking number	Products	Staff	Milestones
Aquatic Vegetation			
2015A7	Data compilation and analysis: Aquatic macrophyte communities and their potential lag time in response to changes in physical and chemical variables	Moore	30 June 2016

2015A8	Draft completion report or manuscript: Aquatic macrophyte communities and their potential lag time response to changes in physical and chemical variables in the LTRM vegetation pools	Moore	30 June 2017
2016A6	Analysis: Aquatic Plant Response to Large-Scale Island Construction in the Upper Mississippi River.	Drake and Gray	30 May 2016
2016A6a	Draft manuscript: Aquatic Plant Response to Large-Scale Island Construction in the Upper Mississippi River.	Drake and Gray	30 Sept 2016
2016A7	Draft completion report: How many years did the effects of the 2001-2002 Pool 8 drawdown on arrowheads (*Sagittaria latifolia* and *S. rigida*) last?	Yin	30 May 2016
Fisheries			
2015B5	Letter summary: Exploring years with low total catch of fishes in Pool 26	Gittinger, Ratcliff, Lubinski, Chick	15 Nov 2015
2015B17	Draft Manuscript: Fish Trajectory Analysis	Ickes, Minchin	30 September 2016
2014B10	Presentations, draft completion report: Paddlefish population characteristics in the Mississippi River Basin	Hupfeld, Phelps	1 Dec 2015
2006B6	Draft manuscript: Spatial structure and temporal variation of fish communities in the Upper Mississippi River. (Dependent on 2008B9 acceptance into journal)	Chick	30 Sept 2016
2008B9	Draft manuscript: Standardized CPUE data from multiple gears for community level analysis (a previous manuscript was submitted and not accepted by the journal, 2006B5; 2008B9 is a revised manuscript) (Chick)	Chick	15 Dec 2015
2016B12	Draft Manuscript: Benefits of Collaboration among Long Term Fish Monitoring Programs in Large Rivers (Fisheries Journal)	Counihan, Ickes, Casper, Sauer	31 Dec. 2015
2016B13	Draft Manuscript: An Assessment of Long Term Changes in Fish Communities within Large Rivers of the United States (Environmental Monitoring journal)	Counihan, Ickes, Casper, Sauer	31 Dec. 2015
2016B14	Draft completion report: Exploring Years with Low Total Catch of Fishes in Pool 26	Gittinger, Ratcliff, Lubinski, Chick	30 Sept 2016
2016B15	Summary letter: Technical Support to River Managers Investigating UMR Walleye Dynamics	Andy Bartels, Kraig Hoff, Fish Managers from WI, MN, and IA	30 Sept 2016
Water Quality			
2015D13	Initial analysis and draft manuscript: Coherence in temporal variation of select water quality parameters across strata and study reaches	Houser	1 Sept 2016
2015D14	Draft manuscript: Coherence in temporal variation of select water quality parameters across strata and study reaches	Houser	1 Sept 2017
2015D15	Analysis of Lake Pepin rotifers; data from 2012-2014	Burdis	30 March 2016
2015D16	Draft manuscript: Trends in water quality and biota in segments of Pool 4, above and below Lake Pepin	Burdis	31 Dec 2015
2014D13	Presentations, draft completion report: A Comparison of Side and Main Channel Fish Community and Water Quality Characteristics	Sobotka, West, Phelps	1 Dec 2015
2016D17	Draft manuscript: Relationship between the temporal and spatial distribution, abundance, and composition of zooplankton taxa and hydrological and limnological variables in Lake Pepin (Reformatting for submission to River Research and Applications)	Burdis	30 Sept. 2016

USACE UMRR LTRM Technical Support

This paper describes the roles of the U.S. Army Corps of Engineers district UMRR LTRM Technical Representatives, which are supported with LTRM funds to help facilitate the two directional communications between each home district and the Regional Program. These individuals shall serve as a point of contact with each district for LTRM data and information, and the use of LTRM data in the identification, formulation, and evaluation of HREPs.

This SOW captures an anticipated level of effort to accomplish the tasks herein, which is reflected in the funding allocated. This SOW represents approximately 190 hours for each representative (n=3) in fiscal year 2016; no change from FY2015.

[NOTE: In years when the annual appropriation is less than the amount needed to fully fund Base Monitoring (such as FY13 and FY16), the amount available for the Corps' LTRM Technical Representatives could be reduced proportionately and the SOW could be adjusted accordingly. This option may be exercised for FY16]

MAJOR DUTIES

1. Technical Support to Regional LTRM Manager

Estimated Level of Effort (~40 hours)
For all Document Review – Each document review should be coordinated throughout home district as appropriate, all comments received should be consolidated, and transmitted to the LTRM Project Manager (copy furnish the other 2 district LTRM Representatives). A minimum of 2 weeks of review and comment preparation time should be provided, if possible.

a. Annual SOW (translation of the 2015-2025 UMRR Strategic & Operational Plan annually for Base Monitoring and Science in Support of Restoration & Management SOWs) – participate in conf calls as needed (1-2/yr)
b. Other reports - varies, as needed, and could include research frameworks, research proposals, Resilience indicator project
c. Regular monthly conference calls with the UMRR Regional Program Manager, LTRM Project Manager, 3 HREP coordinators, 3 LTRM Technical Representatives, and others as needed (~12/yr)

2. Represent UMRR LTRM and home district at all regular A-Team Meetings

Estimated Level of Effort (~40 hours)
Work under this heading includes two directional communications – regional coordination, bringing information back to the districts, and bringing local knowledge, issues, or questions to the A-Team. The level of effort hours will vary with length of meeting, meeting location, and level of prep/follow up.

a. Conference calls – 2/year
b. Meetings – ~2/year
c. Support A-Team activities as appropriate

3. Serve as UMRR LTRM data and resource contact for district PDTs (HREP-LTRM Integration)

Estimated Level of Effort (~80 hours)
Generally, each district's LTRM Technical Representative serves as a proactive resource, promoting the use and/or application of LTRM data (including research, models, etc) in their home district, primarily for

project planning and monitoring. Knowledge of the available datasets (online and others), models, graphical browsers, etc, and personnel at UMESC and the field station(s) is critical for this task.

4. Other Meeting Attendance (if funding and time allow)

Supported Level of Effort (~30 hours)
Work under this heading includes dissemination of information, etc, from meeting/conference attendance to district personnel, PDT's, as appropriate. Discretion in choosing meetings is strongly recommended since the **funding level does not support attendance at all of these listed below**.

a. MRRC–Held in conjunction with April A-Team meeting
b. UMRCC –annual and/or technical session meetings
c. FWWG, FWIC or RRAT (tech) for meetings in home district

COMMUNICATION
Each UMRR LTRM Technical Representative will participated in regular UMRR Program conference calls and provide updates of their significant UMRR and UMRR-related activities to the UMRR LTRM Management Team. If any significant activities are reported to their Commander, the UMRR management will be made aware.

POC for the UMRR LTRM Technical Representatives is the UMRR LTRM Project Manager, Karen Hagerty.

Products and Milestones

Tracking number	Products	Staff	Milestones
2016COE1	Quarterly update submitted to the LTRM Management Team	McCain, Theiling, Potter	31 Dec. 2015
2016COE2	Quarterly update submitted to the LTRM Management Team	McCain, Theiling, Potter	30 March 2016
2016COE3	Quarterly update submitted to the LTRM Management Team	McCain, Theiling, Potter	30 June 2016
2016COE4	Quarterly update submitted to the LTRM Management Team	McCain, Theiling, Potter	30 September 2016

Science Coordination Meeting

UMESC will host the UMRR Science Coordination Meeting as called for in FY16. The purpose is to review and exchange information on research conducted during the past year. This would include work on analyses of LTRM data, focused research projects, modeling, new data collection, HREP evaluations, literature reviews, tool development, etc. Persons invited to participate in the 2-day meeting will be LTRM funded researchers (UMESC, Field Stations, graduate students/faculty, partners, contractors, etc.), the A-Team, the LTRM management team, and interested managers and partners.

Tracking number	Product	Staff	Milestone
2016N1	Science Planning Meeting	Houser, Sauer, Lowenberg, Hubbell, and Hagerty	Winter-Spring 2015-2016

A-Team and UMRR-CC Participation

USGS-UMESC and Field Station staff are often called upon to participate at quarterly A-Team (http://www.umesc.usgs.gov/ltrmp/ateam.html) and UMRR-CC (www.mvr.usace.army.mil/Missions/EnvironmentalProtectionandRestoration/UpperMississippiRiverRestoration/Partnership/CoordinatingCommittee.aspx) meetings. The field station team leaders, component specialists, and UMESC LTRM management staff are expected to participate in the A-Team meetings, if possible. Additional staff may participate as appropriate. Participation at UMRR CC meetings will be by request only. This participation could include sharing of scientific knowledge and/or presentations on current projects. Any participation by LTRM staff at A-Team and/or UMRR CC meetings will be listed in the quarterly activity products. .

Literature Cited

Cogger, B.J. De Jager, N.R. Thomsen, M. 2014. Winter browse selection by white-tailed deer in bottomland forest restorations of the Upper Mississippi River Valley, USA. Natural Areas Journal 34: 144-153.

De Jager, N.R, Rohweder, J.J., and J.C. Nelson. 2013a. Past and predicted future changes in the land cover of the Upper Mississippi River floodplain, USA. River Research and Applications. 10.1002/rra.1615

De Jager, N.R., Cogger, B.J., and Thomsen, M.T. 2013b. Interactive effects of flooding and deer browsing on floodplain forest recruitment. Forest Ecology and Management 303:11-19.

Langrehr, H. A., Gray, B. R., and Janvrin, J. A., 2007, Evaluation of aquatic macrophyte community response to island construction in the Upper Mississippi River: Lakes and Reservoirs v. 23, no. 3, p. 313-320.

UMRR Science in Support of Restoration and Management – Remaining Tasks from FY2014 and FY2015

Tracking number	Milestone	Original Target Date	Modified Target Date	Date Completed	Comments	Lead
Development of Mussel Vital Rates						
2014MVR2	Brief summary report	30-Sep-16				Newton, Zigler, Davis
2014MVR3	Completion report on a vital rates of native mussels at West Newton Chute, UMRS	30-Sep-17				Newton, Zigler, Davis
Validation of Mussel Community Assessment Tool						
2014MCA2	Draft completion report on a validated mussel community assessment tool for use by river managers	1-Dec-15	1-Mar-16		state biologists are still ranking beds as part of validation	Newton, Zigler, Dunn, Duyvejonck
2014MCA3	Final completion report on a validated mussel community assessment tool for use by river managers	1-Mar-16	1-Jun-16			Newton, Zigler, Dunn, Duyvejonck
Effects of Nutrient Concentrations on Zoo- and Phytoplankton						
2014NC2	Database completed and analysis completed	13-Mar-16				Giblin, Campbell, Houser, Manier
2014NC3	Full manuscript completed	13-Mar-17				Giblin, Campbell, Houser, Manier
Ecological Shifts Turbid to Clear States						
2014ES2	Refined analyses and draft manuscrpt prepared	13-Mar-16			All analyses complete, manuscript in draft and co-author review 2 April 2015	Giblin, Ickes, Bartels
2014ES3	Manuscipt submitted for publication	13-Mar-17				Giblin, Ickes, Bartels
Asian Carps Recruitment Sources (#2)						
2014CRS2	Manuscript	31-Mar-16				Phelps, Mccain
Effects of Asian Carps on Native Piscivore Diets (#3)						
2014NPD2	Manuscript	31-Mar-16				Phelps, Mccain
Early Life History of Invasive Carps (#4)						
2014CLH2	Manuscript	31-Mar-16				Phelps, Mccain

Seamless Elevation Data						
2015LB5	Seamless Elevation for Pools 2, 5a, 6, 10-12, St Croix, and Pool 14	31-Dec-15	31-Jan-16		Slightly behind from issues that arose from Tier 2 processing	Dieck, Hanson
2015LB6	Seamless Elevation for Pools 15-19, 20, and 22-24	31-Mar-16				Dieck, Hanson
2015LB7	Seamless Elevation for Pools 25-OR & Kaskaskia	30-Jun-16				Dieck, Hanson
2015LB8	Seamless Elevation for the Illinois River	30-Sep-16				Dieck, Hanson
Fish Indicators of Ecosystem Health						
2015FI1	Preliminary set of species identified for the different assemblages by study reach submitted to A-Team as status update and for review	30-Aug-15	10-Feb-16		Post doc hiring delay resulted in project delayed	Anderson, Casper, McCain
2015FI2	Draft recommendation for the best attainable or target for each assemblage by study reach submitted to A-Team for Review	1-Oct-15	10-Feb-16		For presentation at 2016 UMRR Science Mtg in La Crosse briefing	Anderson, Casper, McCain
2015FI3	Initial draft Project Report submitted to A-Team for review	1-Dec-15	15-Mar-16		Incorporate feedback from 2016 UMRR Science Mtg presentation into La Crosse A-team briefing	Anderson, Casper, McCain
2015FI4	Final draft Project Report submitted to A-Team for review and endorsement at April meeting	1-Mar-16	1-Jun-16			Anderson, Casper, McCain
2015FI5	Final draft Project Report submitted to UMRR CC for endorsement at August meeting	15-Jul-16	15-Jul-16			Anderson, Casper, McCain
2015FI6	Final Report	1-Jun-16	30-Aug-16			Anderson, Casper, McCain
Plankton community dynamics in Lake Pepin						
2015LPP2	draft manuscript: Plankton community dynamics in Lake Pepin	30-Sep-16				Burdis

Estimating trends in UMRR fish and vegetation levels using state-space models						
2015SST2	Final completion report: Evaluation of trend estimation methods for LTRM fish and vegetation indices	31-Dec-15	15-Mar-16			Gray
2015SST3	Provide trend estimates for fish and vegetation web browser pages	30-Sep-16				Gray, Schlifer
Predictive Aquatic Cover Type Model - Phase 2						
2015AQ2	Apply model to Pool 4 and resolve discrepancies	31-Dec-15	31-Mar-16			Yin, Rogala
2015AQ3	Detailed summary of work for Phases I & II	31-Dec-15	31-Mar-16			Yin, Rogala, Ingvalson

Addendum

Spatial Patterns of native mussels in the UMRS

See original proposal in the FY16 UMRR Science in Support of Restoration and Management SOW, Completes work begun in FY15

Methods:

We will identify existing datasets that have quantitative data on mussel assemblages at smaller spatial scales (i.e., < 300 m). For example, we are aware of datasets in Pool 5 (2013) and Pool 8 (2001) that could be used for this analysis. Once additional datasets have been identified, we will run spatial statistics to identify spatial patterns occurring at these smaller scales. We will quantify the spatial patterns of both adult and juvenile (≤ 5 years old) mussels and for a cross-correlation between juveniles and adults. Data on juveniles and adults will indicate whether they are patchily distributed, whereas the cross-correlation analysis will indicate whether the density of juveniles is locally correlated with the density of adults. Separating adults and juveniles allows for a more comprehensive evaluation of mussel spatial patterns as they may tell different stories. For example, patches of largely adult mussels may indicate relic populations—habitats which allow for persistence of older individuals but may not favor juveniles, whereas patches of largely juveniles may indicate habitats conducive to juvenile settlement but may not necessarily lead to recruitment into the population. Patches with both adults and juveniles may represent areas of suitable habitat for both recruitment and persistence of mussels.

In all cases, we will quantify spatial patterns using Moran's I, which is a measure of spatial autocorrelation. By estimating Moran's I at increasingly longer distances among sample locations, we can generate correlograms which graphically display how correlated nearby samples are relative to distant samples. The resulting correlograms will estimate whether mussel distributions at these scales are random, gradient, or consist of randomly arranged patches (Fig. 1). Next, we will identify statistically significant spatial clusters (hot and cold spots) within the bed using the Getis-Ord Gi* statistic. These geostatistics will provide an understanding of the complexity of the spatial distribution of mussels at a given scale, while also providing opportunities for future research. For example, once hot and cold spots (with respect to mussel density) are identified, a suite of environmental variables could be measured and compared to determine possible mechanisms influencing mussel bed dynamics.

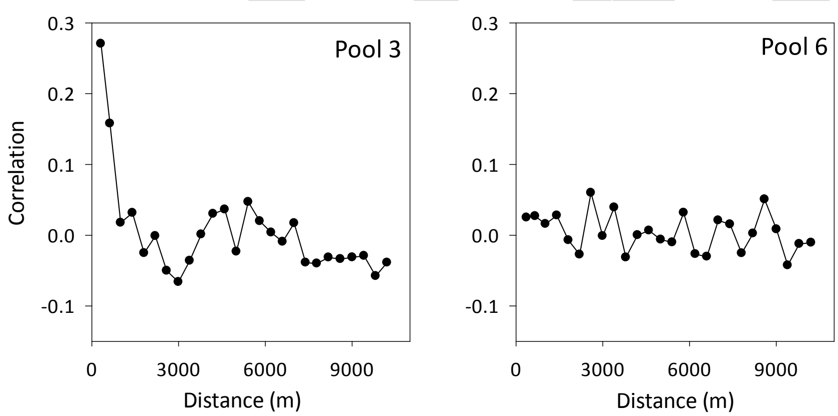


Figure 1. Example correlograms of juvenile mussels from Pools 3 and 6 of the Upper Mississippi River. Juveniles in Pool 3 display a positive correlation among nearby samples (i.e., < 1500 m), followed by a decrease in correlation with increasing distance, suggesting a patchy spatial pattern. In contrast, juveniles in Pool 6 have consistently low correlation among all sample locations, indicating a random spatial pattern.

Timeline:

- Identify existing data sets and re-format to a common database, beginning no later than 3 months after notification of funding.
- Data analysis of existing datasets will begin no later than 7 months after notification of funding.
- Completion report, submitted 20 months after notification of funding.

Products and Milestones

Tracking number	Products	Staff	Milestones
2016MRF1	Draft Completion report: Spatial patterns of native mussels in the UMRS	Ries, Newton, De Jager, Zigler	15 Sept 2017
2016MRF2	Final completions report: Spatial patterns of native mussels in the UMRS	Ries, Newton, De Jager, Zigler	15 Nov 2017

Pool 12 Overwintering HREP Adaptive Management Fisheries Response Monitoring – Pre-construction Biological Response Monitoring; Crappie Telemetry –Kehough Lake

Methods: This proposal will provide a year of pre-project centrarchid telemetry in Kehough Lake. Methods used in the FY2015 radio tracking study will be repeated; please note that these are covered in the Background discussion of this document.

In this study, 50 white and/or black crappie will be transmittered in one overwintering backwater in Pool 12: Kehough Lake. Kehough Lake will be rehabilitated in Phase III of the Pool 12 Overwintering HREP. Fifty fish will be transmittered in Kehough Lake after water temperatures have fallen below 10°C. Fish will be tracked intensively for a period of one year and every fish will be located once every two weeks. By stratifying the year into two-week segments and locating every fish within each two-week period, issues of autocorrelation of animal locations will be avoided (Otis and White 1999, Fieberg 2007). For each crappie location, position will be recorded with a GPS unit and dissolved oxygen, temperature, depth, secchi, and flow will be measured. This design will potentially yield 50 locations per two-week sample period (1,300 annually).

The 80% UD utilization contour for each backwater will again be quantified and graphed, using Kernel methods in the Home Range Extension (HRE) for ArcView. We will also again explore how landscape features such as the main channel, position in the pool or side channel complex, or proximity to other overwintering backwaters affects the UD.

Timeline: Late October 2015 through 30 September 2016, with transmitter activation in Nov 2015.

Milestones and products:

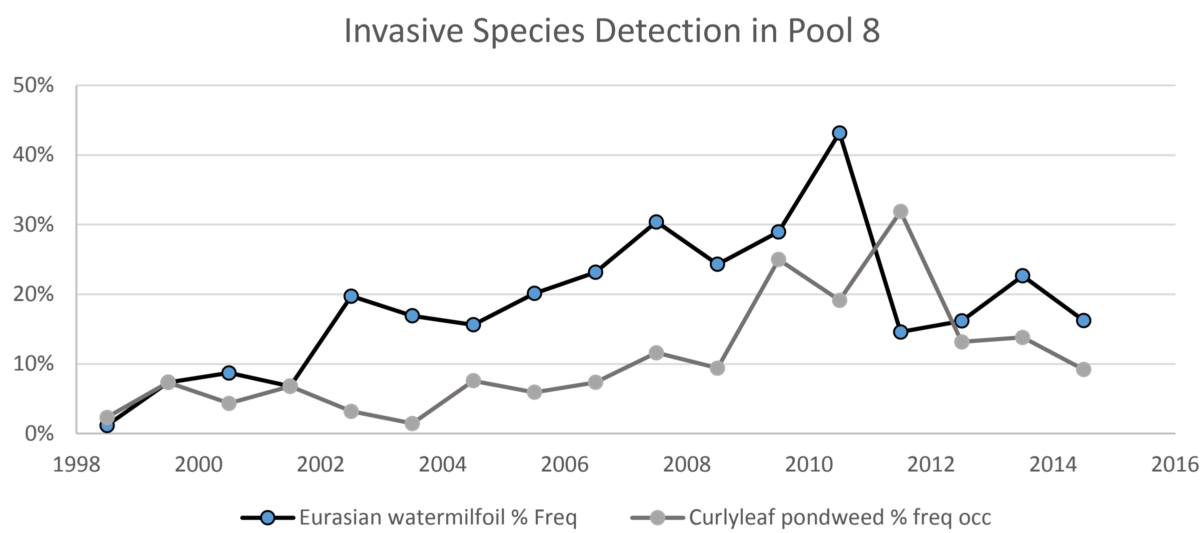
Tracking number	Products	Staff	Milestones
2016AM1	Capture fish and affix radio tags to white crappies in study lakes	Bierman, Hansen, Bowler, Theiling	November 2015
2016AM2	Location of tagged fish and update in-house project database	Bierman, Hansen, Bowler, Theiling	Ongoing through FY
2016AM3	Complete tracking portion of study	Bierman, Hansen, Bowler, Theiling	30 September 2016
2016AM4	Summary report: Analysis of tracking data and quantification of 80% UDs for Stone, Tippy, and Green lakes	Bierman, Hansen, Bowler, Theiling	30 September 2016
2016AM5	Summary report: Analysis of tracking data and quantification of 80% UDs for Kehough lake	Bierman, Hansen, Bowler, Theiling	30 September 2017

Understanding biological shifts in the UMR due to invasion by *Potamogeton crispus*

Description of Work
Invasive Potamogeton crispus (curlyleaf pondweed) has an unusual phenology with mid-summer senescence, fall germination, and possible winter photosynthesis. Here we examine its contribution to nutrient cycling and winter dissolved oxygen in Pool 8 of the UMR. We will quantify biomass, nutrient standing stocks growing season and senescence, and phytoplankton abundance associated with *P. crispus* beds. Seasonal logger data will be used to track winter dissolved oxygen concentrations associated with *P. crispus* beds and reference sites.

Aquatic invasive species (AIS) are a primary threat to aquatic ecosystem health. In addition to displacing native species, AIS can modify environments. In 17 years of annual vegetation monitoring, invasive *P. crispus* has been detected at 2-31% of sites in Pool 8 of the UMR (Figure 1) – its distribution is patchy with high densities noted in several backwater areas. The methods used by the LTRM, however, likely underestimate the prevalence of *P. crispus* due to its unusual phenology. Most growth and reproduction (formation of vegetative buds) occurs by mid-June, and senescence generally occurs by mid-July (Nichols and Shaw, 1986). LTRM surveys are conducted between mid-June and mid-August to target the predicted maximum biomass of aquatic vegetation generally, but miss the *P. crispus* maximum. The potentially large biomass of invasive *P. crispus* in combination with its temporally offset growth and senescence, plus its capacity for winter photosynthesis make it of particular interest in UMR ecosystem health. We propose to quantify the following biological shifts in the UMR ecosystem associated with *P. crispus*:

- **Earlier C, N and P fixation and release via decay** (mass balance calculations)
- **Increased primary production by phytoplankton** - a result of mid-summer senescence and nutrient release (reference site comparison)
- **Increased dissolved O_2 in winter - a** result of winter photosynthesis (reference site comparison)



We will determine whether senesce of *P. crispus* is linked to increased abundance of phytoplankton, which may also link to mid-summer metaphyton blooms (Sullivan and Giblin 2012). Similar nutrient-mediated links have been described in other systems – for example, an increase in phytoplankton biomass was seen in response to senescence and decay of invasive *Myriophyllum spicatum* in Lake Monroe, Indiana (most likely a result of P release; Landers, 1982).

Turions of *P. crispus* sprout in autumn and overwinter under the ice. Observations in Pool 8 and elsewhere (e.g. Nichols and Shaw 1986) suggests that *P. crispus* is photosynthetically active even under low light conditions created by thick ice and snow cover, and the species may contribute to winter periods of oxygen supersaturation and fish kills. This study includes a comparison of dissolved O2 dynamics in macrophyte beds dominated by *P. crispus* and native plants.
Understanding patterns in stream nutrient spiraling at a national scale, as developed by LINX 1 project (Peterson et al. 2001) was a major step forward in stream ecology. The role of periphyton and macrophytes in nutrient cycling of small, headwater streams was a component of this work. The timing

and relative amounts of nutrient sequestration by *P. crispus* (and of native plants) in a large river are of particular interest in this context.

Methods

Answering the questions posed here will require us to 1) produce estimates of *P. crispus* biomass and nutrient standing stocks during maximum and senescence phases, 2) quantify phytoplankton chlorophyll a concentrations in *P. crispus* beds and reference sites, and 3) track diurnal patterns of DO in *P. crispus* beds and reference sites during winter.

Site selection: Nine sites will be established: three within *P. crispus* beds in the Stoddard area, three within *P. crispus* beds in the Lake Onalaska area, and three reference sites matched for depth and other physical conditions, supporting mainly rooted native submersed vegetation.

i. Measure per-plant and per-quadrat biomass (including belowground) in May-June of 2016, and during the normal July-August LTRM survey period. Standard rake data will be collected at each site, and phytoplankton/chlorophyll samples will be collected.
ii. Develop a quantitative relationship between standard LTRM rake survey data and peak biomass of *P. crispus*, if possible, for application at the pool scale and over time.
iii. Measure plant C, N & P content in *P. crispus* for estimation of seasonal nutrient standing stocks in roots, stem, and reproductive structures (turions).
iv. Estimate nutrient contributions to the water column through senescence of *P. crispus*.
v. Deploy data loggers for temp/cond/DO measurements will be deployed:
   - June 2016 (maximum biomass)
   - August 2016 (senesced)
   - December 2016 (approximate time of 2014 fish kills)
   - March 2017 (winter conditions, increasing light)

Biomass surveys will be conducted over approximately ten days in late May 2016 and during the regular sampling season (mid-June to mid-August). Standard survey data will be collected following established protocols (Yin et al. 2000) in areas known to support *P. crispus*, with the addition of total plant biomass collection in quadrats where *P. crispus* is present (as determined by a diver). Whole plants, including roots, of all species will be collected by a diver from 9 sites (54 quadrats; each approximately 1.5 m x 0.35 m) per season. Biomass samples will be stored in ziplock bags, on ice, and in coolers and will be returned to the laboratory for processing within 24 hours. Wet and dry mass of each species and each tissue type (belowground, aboveground reproductive biomass, and aboveground vegetative biomass) will be determined. Samples will be composited by tissue type, homogenized by grinding, and ~10- mg subsamples will be submitted to UW Marshfield agricultural laboratory for CNP analyses. Dry samples of all species and tissue type will be stored in labeled vials for future analyses and comparison.

Time frame and logistic considerations for the work

FY 2016 Field collections, laboratory work and sample analyses. Data logger deployment and data collection.

FY 2017 Data logger work completion. Report preparation. Quantitative analyses, and manuscript development for submission to peer reviewed journal. Identification of further work such as relation to O2 supersaturation/fish kills or N tracer studies comparing N dynamics in a native and invasive Potamogeton. Manuscript for peer review 1 June 2017.

Milestones and products:

Tracking number	Products	Staff	Milestones
2016PC1	Summary letter on FY16 work	Drake, Giblin, Nissen, Kalas	30 September 2016
2016PC2	Draft manuscript: Understanding biological shifts in the UMR due to invasion by *Potamogeton crispus*	Drake, Giblin, Nissen, Kalas	1 June 2017

Developing and applying trajectory analysis methods for UMRR Status and Trends indicators – Year 2

Introduction/Background:
In 2015, a proposal was funded titled **"Developing and applying trajectory analysis methods for UMRR Status and Trends indicators"** (Ickes and Minchin 2015). The project sought to determine whether functional fish assemblages (habitat, feeding, and reproductive guild assemblages) were on discernibly non-random trajectories over a 22-year period of time within and among each of the six UMRR LTRM study reaches. Results, presented in a summary letter in 2015, clearly demonstrated functional shifts in UMRS fish assemblages for all functional guild classes and UMRR LTRM study reaches with the sole exception of reproductive and habitat guilds in the Open River Reach of the Mississippi River.

Results from 2015 clearly demonstrated fundamental functional attributes of UMRS fish assemblages are changing over time in a directional way. Our initial null hypothesis was that trends over time in functionally-defined fish assemblages would be of a random nature. However, this hypothesis was rejected for the vast majority of functional groups and study reaches examined. The directionality of the shifts over time suggest some form of forcing mechanism, that itself is non-random, is likely driving these directional shifts. This forcing agent may be intrinsic to the fish communities themselves, or extrinsic factors that are directly affecting functional fish community responses throughout the UMRS. Intrinsic forces may include (a) effects of non-native fish species on native fishes; (b) changes in trophic and food web structure; and (c) changes in functional interactions within the fish community itself (i.e., predator-prey dynamics), perhaps mediated by changes in exploitation or disease. Extrinsic forces may include (a) effects of habitat rehabilitation; (b) habitat impairment; or (c) changes in river dynamics (i.e., flood and drought cycles; nutrient eutrophication; primary production pathways).

This work contributes to a body of knowledge that seeks to develop methods and indicators for Status and Trends Assessments within the UMRS basin. The method is capable of assessing whether communities are heading in an acceptable direction, even if they have not yet attained their desired composition. Our initial work has demonstrated that Trajectory Analysis as a method is sufficiently sensitive and adequate to detect trends in fish community functional responses across 1200 miles of river. Second, we seek to further study the proximate drivers of the observed trajectories to identify the intrinsic and extrinsic forces driving observed directional shifts in functional community attributes. Identifying the forces driving observed trajectories may suggest new management approaches that can influence fish communities throughout the UMRS. Finally, we seek to determine the fundamental nature of the trajectory responses themselves, indicative of possible regime shifts, with implication for ecological resilience assessments just beginning within the basin. Resilience theory provides three sets of mechanisms that give rise to regime shifts observable in ecological responses: (1) linear; (2) nonlinear; and (3) hysteretic responses. Further work is needed to identify which of the three mechanisms is driving observed trajectory shifts in fundamental functional attributes of UMRS fish assemblages.

Methods:
Fish community indicators will be developed and analyzed using Trajectory Analysis. Annual data for each multivariate fish indicator developed from each of six long term study reaches on the UMRS, will be analyzed for significant trends over time, and differences in the status and trends of each indicator will be evaluated among the six study reaches, representing 1200 river miles. For those functional groups and study reaches with demonstrably non-random trajectories over time, additional analysis and modeling will seek to infer (1) the mechanistic form of the trajectory response (linear, nonlinear, hysteresis); and (2) the environmental covariates seemingly driving these observed trajectory responses.

Products and Milestones

Tracking number	Products	Staff	Milestones
2016B14	Data assembly	Ickes, Minchin	30 May 2016
2016B15	Model functional trajectory	Ickes, Minchin	30 Sept 2016
2016B16	Summary letter	Ickes, Minchin	31 October 2016
2016B17	Draft Manuscript	Ickes, Minchin	31 October 2017

Addendum References

Pool 12

Fieberg, J. 2007. Kernel density estimators of home range: smoothing and the autocorrelation red herring. Ecology 88:1059-1066.

Otis, D. L., and G.C. White. 1999. Autocorrelation of location estimates and the analysis of radio tracking data. Journal of Wildlife Management 63:1039-1044.

Rogers, A.R., and A.P. Carr. 2002. HRE: The home range extension for ArcView user manual. Centre for Northern Forest Ecosystem Research, Ontario Ministry of Natural Resources. 27pp.

Steuck, M.J. 2006. An evaluation of winter habitats used by bluegill, black crappie, and white crappie in Pool 13 of the Upper Mississippi River. Iowa Department of Natural Resources, Federal aid to fish restoration annual performance report: Mississippi River investigations, Project F-160-R, Study 7021, Des Moines.

USACE 2013. System Benefits Monitoring Plan, Appendix K. Pages K1-K14 in Pool 12 Overwintering Habitat Rehabilitation and Enhancement Project Definite Project Report with Integrated Environmental Assessment (R-19F). Upper Mississippi River Restoration Program, U.S. Army Corps of Engineers, Rock Island District. 624 pp.

Potamogeton crispus

Binding, C.E., J.H. Jerome, R.P. Bukata, and W.G. Booty. 2007. Trends in Water Clarity of the Lower Great Lakes from Remotely Sensed Aquatic Color. Journal of Great Lakes Research 33(4):828-841

Clarke, S.J. 2002. Vegetation growth in rivers: influences upon sediment and nutrient dynamics. Progress in Physical Geography. 26: 159–172

Fischer, J.R., and T.O. Claflin. 1995. Declines in aquatic vegetation in navigation pool No. 8, Upper Mississippi River between 1975 and 1991. Rivers: Research & Management, 11:157-165

Sullivan, J.F. and S.M. Giblin. 2012. Growth, Tissue Composition and Stoichiometry of Duckweed Grown in Low Nutrient Backwaters of the Upper Mississippi River

Landers, D.H. 1982: Effects of naturally senescing aquatic macrophytes on nutrient chemistry and chlorophyll a of surrounding waters. Limnology and Oceanography 27(3), 428–39

Nichols, S.A. and B.H. Shaw. 1986. Ecological life histories of the three aquatic nuisance plants, *Myriophyllum spicatum*, *Potamogeton crispus*, and *Elodea canadensis*. Hydrobiologia 131: 3-21

Peterson, B.J., W.M. Wollheim, P.J. Mulholland, and 12 other authors. 2001. Control of Nitrogen Export from Watersheds by Headwater Streams. Science: 292 (5514), 86-90

Yin, Y., J.S. Winkelman, and H.A. Langrher. 2000. Long Term Resource Monitoring program procedure: aquatic vegetation monitoring. U.G. Geological Survey, LTRMP 95-P002-7, La Crosse, Wisconsin

Yin, Y. and R.M. Krieling. 2011. The evaluation of a rake method to quantify submersed vegetation in the Upper Mississippi River. 2011. Hydrobiologia 675: 187-195

Trajectory Analysis

Hagerty, K.H. and K. McCain. 2013. Indicators of ecosystem health for the Upper Mississippi River System. A report to the Analysis Team ad hoc indicators group, Upper Mississippi River Restoration – Environmental Management Program Long Term Resource Monitoring Program element, U.S. Army Corps of Engineers, Rock Island District, Rock Island, Illinois.

Ickes, B.S. and 8 others. 2010. Report on the advancement of indicators for Status and Trends assessments in the Upper Mississippi River System. Special committee on fish indicators for Status and Trends Assessments. Delivered to the Environmental Management Program

Coordinating Committee and the A-Team of the Environmental Management Program, U.S. Army Corps of Engineers, Rock Island District. Final report. July 30, 2010. 48pp.

Ickes, B.B. and P. Minchin. 2015. Developing and applying trajectory analysis methods for UMRS Status and Trends indicators. Summary Letter issued to the U.S. Army Corps of Engineers, Rock Island District and a product of the Upper Mississippi River Restoration program. 9 pp.

Johnson, B. L., and K. H. Hagerty, editors. 2008. Status and trends of selected resources of the Upper Mississippi River System. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, December 2008. Technical Report LTRMP 2008-T002. 102 pp + Appendixes A–B. Report available online at http://pubs.usgs.gov/mis/LTRMP2008-T002/

McCain, K., B.S. Ickes, A. Casper, and Q. Phelps. 2015. Fish Indicators of Ecosystem Health. A funded proposal submitted to the U.S. Army Corps of Engineers, Upper Mississippi River Restoration "Science in Support of HREPs" request for proposals, U.S. Army Corps of Engineers, Rock Island District, Rock Island, Illinois.

Sah, J.P., Ross, M.S., Saha, S, Minchin, P.R. & Sadle, J. (2013). Trajectories of vegetation response to water management in Taylor Slough, Everglades National Park, Florida. Wetlands, DOI 10.1007/s13157-013-0390-4.

U.S. Geological Survey. 1999. Ecological status and trends of the Upper Mississippi River System 1998: A report of the Long Term Resource Monitoring Program. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, April 1999. LTRMP 99-T001. 236 pp.