LTRMP FY09 Scope of Work

Minimum Sustainable Program

Additional Program Elements

Long Term Resource Monitoring Program
Minimum Sustainable Program

Aquatic Vegetation Component

The objective of the Long Term Resource Monitoring Program (LTRMP) Aquatic Vegetation Component is to collect quantitative data on the distribution and abundance of aquatic vegetation in the UMRS for the purpose of understanding its status, trends, ecological functions, and responses to natural disturbances and anthropogenic activities. Data are collected within three LTRMP study reaches in the UMRS (Pools 4, 8, and 13 on the Upper Mississippi River). Data entry, quality assurance, data summaries, standard analyses, data serving, and report preparation occur under standardized protocols.

Methods

Aquatic vegetation sampling will be conducted following the LTRMP aquatic vegetation standard sampling protocol (Yin et al. 2000). One thousand three hundred and fifty sites will be surveyed in FY09, including 450 in Pool 4, 450 in Pool 8, and 450 in Pool 13 (Table 1). The presence/absence and abundance of aquatic plant species at each site will be measured and recorded. Pool-wide estimates of abundance and percent frequency of occurrence will be derived by pooling data over all strata.

Products and Milestones

Tracking number	Products	Staff	Milestones
2009A1	Complete data entry and QA/QC of 2008 data; 1250 observations.		
	a. Data entry completed and submission of data to USGS	Popp, Dukerschein, Bierman	30 November 2008
	b. Data loaded on level 2 browsers	Schlifer	15 December 2008
	c. QA/QC scripts run and data corrections sent to Field Stations	Sauer	28 December 2008
	d. Field Station QA/QC with corrections to USGS	Popp, Dukerschein, Bierman	15 January 2009
	e. Corrections made and data moved to public Web Browser	Sauer, Schlifer, Caucutt	30 January 2009
2009A2	WEB-based annual Aquatic Vegetation Component Update with 2008 data on Public Web Server.		
	a. Develop first draft	Sauer	28 February 2009
	b. Reviews completed	Popp, Dukerschein, Bierman, Sauer, Yin	28 March 2009
	c. Submit final update	Sauer	18 April 2009
	d. Placement on Web with PDF	Sauer, Caucutt	31 July 2009
2009A3	Complete aquatic vegetation sampling for Pools 4, 8, and 13 (Table 1)	Popp, Dukerschein, Bierman	31 August 2009
2009A4	Web-based: Creating surface distribution maps for aquatic plant species in Pools 4, 8, and 13; 2008 data	Yin	31 July 2009
Delayed Products			
2008A8	Final draft OFR: LTRMP Aquatic Vegetation Program Review (2007A9)	Heglund	30 September 2009
2007APE12	Draft LTRMP Report: Ecological Assessment of High Quality UMRS Floodplain Forests (Delayed)	Chick	30 April 2009
Intended for distribution			
Manuscript: Importance of the Upper Mississippi River Forest Corridor to Neotropical Migratory Birds (Kirsch, 2007APE1)			
Manuscript: Status and trends of floodplain forests on the Upper Mississippi River (Yao, 2007APE5)			
LTRMP Report: Status and Trends Report			

Literature Cited

Hirst, S. M. 1983. Ecological and institutional bases for long-term monitoring of fish and wildlife populations. Pages 175–178 in John F. Bell and Toby Atterbury, editors. Renewable Resource Inventories for Monitoring Changes and Trends. Proceedings of an International Conference, August 15–19, 1983, Corvallis, Oregon. College of Forestry, Oregon State University. 737 pp.

Ickes, B. S., and R. W. Burkhardt. 2002. Evaluation and proposed refinement of the sampling design for the Long Term Resource Monitoring Program's fish component. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, October 2002. LTRMP 2002-T001. 17 pp. + Appendixes A–E. CD-ROM included. (NTIS PB2003-500042)

McDonald L., T. McDonald, and D. Robertson. 1998. Review of the Denali National Park and Preserve (DENA) Long-Term Ecological Monitoring Program (LTEM). Report to the Alaska Biological Science Center Biological Resources Division, USGS. WEST Technical Report 98–7. 19 pp.

Strayer, D., Glitzenstein, J. S., Jones, C. G., Kolasoi, J., Likens, G. E., McDonnell, M. J., Parker, G. G. and Pickett, S. T. A. 1986. Longterm ecological studies: an illustrated account of their design, operation, and importance to ecology. Occasional Publication of the Institute of Ecosystem Studies, No.2. Millbrook, New York.

Yin, Y., J. S. Winkelman, and H. A. Langrehr. 2000. Long Term Resource Monitoring Program procedures: Aquatic vegetation monitoring. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. April 2000. LTRMP 95-P002-7. 8 pp. + Appendixes A–C.

Personnel

Dr. Yao Yin will be the principal investigator.

Fisheries Component

The objective of the LTRMP Fisheries Component is to collect quantitative data on the distribution and abundance of fish species and communities in the UMRS for the purpose of understanding resource status and trends, ecological functions, and response to natural disturbances and anthropogenic activities. Data are collected within six LTRMP study reaches in the UMRS (Pools 4, 8, 13, and 26 and Open River Reach on the Upper Mississippi River and La Grange Pool on the Illinois River). Data entry, quality assurance, data summaries, standard analyses, data serving, and report preparation occur under standardized protocols (Gutreuter et al. 1995; Ickes and Burkhardt 2002).

Methods

Fish sampling will be conducted following the LTRMP study plan and standard protocols (Gutreuter et al. 1995), as modified in 2002 (Ickes and Burkhardt 2002). Species abundance, size structure, and community composition and structure will be measured over time. Between 160 and 270 samples will be collected in each study area (Table 1). Sample allocation will be based on a stratified random design, where strata include contiguous backwaters, main channel borders, main channel wingdams, impounded areas, and secondary channel borders. Tailwaters in the impounded reaches and tributary mouths in the Open River will be sampled under a fixed site design. Sampling effort will be allocated independently and equally across 2 sampling periods (August 1–September 15; September 16–October 31) to minimize risks of annual data loss during flood periods and to characterize seasonal patterns in abundance and habitat use. Pool-wide estimates of abundance will be derived by pooling data over all strata.

New Product Descriptions

Work will begin to update the LTRMP fish protocols given changes since the last publication, and that will be forthcoming in FY10.

Products and Milestones

Tracking number[1]	Products	Staff	Milestones
2009B1	Complete data entry, QA/QC of 2008 fish data; ~1,590 observations		
	a. Data entry completed and submission of data to USGS	Popp, Dukerschein, Bierman, Chick, Sass, Hrabik	31 January 2009
	b. Data loaded on level 2 browsers; QA/QC scripts run and data corrections sent to Field Stations	Schlifer	15 February 2009
	c. Field Station QA/QC with corrections to USGS	Popp, Dukerschein, Bierman, Chick, Sass, Hrabik	15 March 2009
	d. Corrections made and data moved to public Web Browser	Sauer and Schlifer	30 March 2009
2009B2	Update Graphical Browser with 2008 data on Public Web Server.	Sauer, Popp, Dukerschein, Bierman, Chick, O'Hara, Hrabik	31 May 2009
2009B3	Complete fisheries sampling for Pools 4, 8, 13, 26, the Open River, and La Grange Pool (Table 1)	Popp, Dukerschein, Bierman, Chick, O'Hara, Hrabik	31 October 2009
2009B5	Final Draft LTRMP report: Relationship of juvenile abundance of select fish species to aquatic vegetation in Navigation Pools 4, 8, and 13 of the Upper Mississippi River, 1998-2007 (2007B5)	Popp, Delain	30 June 2009
2009B6	Model development (2008APE1b)	Ickes	30 September 2009

Delayed Products			
2008B9	Draft manuscript: Standardized CPUE data from multiple gears for community level analysis (re-worked 2006B5)	Chick	30 March 2009
2006B6	Draft manuscript: Spatial structure and temporal variation of fish communities in the Upper Mississippi River. (Dependent on 2008B9 acceptance into journal)	Chick	30 March 2009
2007B4	Draft manuscript: Proportional biomass contributions of Non-native fish to UMRS fish communities	Ickes	30 July 2009
2007B8	Draft manuscript: Proportional Size Density and Frequency of Occurrence of Flathead Catfish (*Pylodictis olivaris*), Channel Catfish (*Ictalurus punctatus*), and Blue Catfish (*I. furcatus*) in an impounded and unimpounded reach of the Upper Mississippi River. (Expanded work on 2006B12; returned to author for revision; 12/23/2009)	Hrabik, McCain, Herzog	30 September 2009
2007APE3	Draft LTRMP report: Testing the Fundamental Assumption underlying the use of LTRMP fish data: Does variation in LTRMP catch-per-unit-effort data reflect variation in the abundance of fishes?	Chick	30 April 2009
2007APE8	Final draft: A Proposal to restore Specific Monitoring Elements to the LTRMP	Team Leaders	30 March 2009

Intended for distribution
Completion report: Exploratory Analysis of Index of Biotic Integrity Scores Calculated from Datasets Obtained from Three Different Day Electrofishing Protocols (2006B9; Bartels)
Manuscript: Evaluation of a Catch and Release Regulation for Largemouth Bass in Brown's Lake, Pool 13, Upper Mississippi River (2007B7; Bowler)
Completion report: LTRMP Fisheries Component collection of six darter species from 1989–2004. (2006B13; Ridings)
USGS Series: Non-native fishes in the Upper Mississippi River System: A Synthesis of Information from the Long Term Resource Monitoring Program (2008B4; Irons)
Manuscript: O'Connell, M.T. with A.M. Uzee-O'Connell and Valerie A. Barko. (in press) Occurrence and predicted dispersal of bighead carp (*Hypophthalmichthys nobilis*) in the Mississippi River System: Development of a Heuristic Tool in D. Chapman and M. Hoff (editors). Asian Carp Symposium Proceedings, American Fisheries Society Symposium. (2005APE13; Barko)
LTRMP Report: An Evaluation Of Macroinvertebrate Sampling Methods For Use In The Open River Reach of The Upper Mississippi River; Kathryn N. S. McCain, Robert A. Hrabik, Valerie A. Barko, Brian R. Gray, and Joseph R. Bidwell (2005C2)
Manuscript: Fishes of the Mississippi River System: a 40 year synthesis of research on one of the world's great rivers. (2008B8, Ickes)
Manuscript: River engineering and flooding: Systemwide empirical modeling of the Mississippi and Lower Missouri Rivers (2008B6; Ickes)
Manuscript: Effects of river engineering on flow conveyance and flood stages: Reach-scale empirical modeling of the Mississippi and Lower Missouri Rivers (2008B7; Ickes)

[1]Tracking number sequence: Year, last letter of USGS BASIS task code "BNBLB", ID number

Literature Cited

Gutreuter, S., R. Burkhardt, and K. Lubinski. 1995. Long Term Resource Monitoring Program procedures: Fish monitoring. National Biological Service, Environmental Management Technical Center, Onalaska, Wisconsin, July 1995. LTRMP 95-P002-1. 42 pp. + Appendixes A–J

Ickes, B. S. and R. W. Burkhardt. 2002. Evaluation and proposed refinement of the sampling design for the Long Term Resource Monitoring Program's fish component. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, October 2002. LTRMP 2002-T001. 17 pp. + Appendixes A–E. CD-ROM included. (NTIS #PB2003-500042)

Personnel

Mr. Brian Ickes will be the principal investigator.

Water Quality Component

The objective of the LTRMP water quality component is to obtain basic limnological information required to (1) increase understanding of the ecological structure and functioning of the UMRS, (2) document the status and trends of ecological conditions in the UMRS, and (3) contribute to the evaluation of management alternatives and actions in the UMRS.

Data are collected within six LTRMP study reaches in the UMRS (Pools 4, 8, 13, 26, and Open River Reach on the Upper Mississippi River and La Grange Pool on the Illinois River). Data entry, quality assurance, data summaries, standard analyses, data serving, and report preparation occur under standardized protocols (Soballe and Fischer 2004).

Methods

Limnological variables (physicochemical characteristics, suspended solids, chlorophyll *a*, phytoplankton [archived], and major plant nutrients) will be monitored at both stratified-random sites (SRS) and at fixed sampling sites (FSS) according to LTRMP protocols.

Fixed site sampling

Fixed site sampling will be conducted as in FY2006 (Table 1).

Stratified random sampling

Stratified random sampling will be conducted at full effort levels (same as FY2006) for fall, winter, spring, and summer episodes (Table 1).

In situ data collection

For both FSS and SRS *in situ* data will be collected on physicochemical characteristics per the standard protocols (Soballe and Fischer 2004).

Laboratory analyses

Samples for chemical analysis (nitrogen (total N, nitrate/nitrite N, ammonia N), phosphorus (Total P, SRP), and silica) will be collected at all fixed sites and at approximately 35% of all stratified random sampling locations as specified in the sampling design. Samples for chlorophyll and suspended solids (total and volatile) will be collected at all SRS and Fixed sites. We will not collect data on major cations and anions in water samples in FY2008. Sampling and laboratory analyses will be performed following LTRMP protocols (Soballe and Fischer 2004) and Standard Methods (American Public Health Association 1992).

New Product Descriptions

2009D6: Comparison of zooplankton in the UMR between channel and backwater strata, and between Geomorphic Reach

The effects of Asian carp on the zooplankton community in the UMRS may be substantial and monitoring these impacts will be important to understanding community changes in plankton and ultimately the impacts on native fish species. This study will provide insight into distribution, densities, and composition of zooplankton in select habitats of the river. The sampling design allows comparison between main channel and backwater strata as well as a comparison of the plankton community in a turbid water quality environment with minimal SAV (i.e. Geomorphic Reach 1) and a higher transparency water quality environment with substantial SAV (i.e. Geomorphic Reach 3). The zooplankton have been identified and counted by the DNR Biology Lab. Rob has just begun analysis and hopes to publish the findings in a peer reviewed journal. We propose to use MSP time and funding to do the analysis and writing.

Products and Milestones

Tracking number	Products	Staff	Milestones
2009D1	Complete calendar year 2008 fixed-site water quality sampling	Houser, Popp, Dukerschein, Bierman, Chick, Sass, Hrabik	31 December 2008
2009D2	Complete laboratory analysis of 2008 fixed site and SRS data; Data loaded to Oracle data base.	Yuan	30 March 2009
2009D3	Complete data entry, QA/QC of calendar year 2008 fixed-site and SRS data.	Rogala. Popp, Dukerschein, Bierman, Chick, Sass, Hrabik	30 May 2009
2009D4	Complete FY 09 fixed site and SRS sampling for Pools 4, 8, 13, 26, Open River, and La Grange Pool (Table 1)	Popp, Dukerschein, Bierman, Chick, Sass, Hrabik	30 September 2009
2009D5	WEB-based annual Water Quality Component Update with 2008 data on Public Web Server.	Rogala	30 June 2009
2009D6	Draft completion report: comparison of zooplankton in the UMR between channel and backwater strata, and between Geomorphic Reach	Popp, Burdis	1 August 2009
Delayed Products			
2008D8	Final draft manuscript: Primary production, and dissolved oxygen dynamics in UMRS backwater lakes and main channel. (2007D8)	Houser	30 July 2009
2005D7	Final draft LTRMP report: Main channel/side channel report for the Open River Reach.	Hrabik	1 June 2009
2005APE26	Final draft LTRMP report: retrospective, cross-component analysis for Pool 26	Chick	15 March 2009

Intended for distribution
LTRMP report: Pool 5 water quality, pre- and post-drawdown (2008D7; Popp & Burdis)
LTRMP report: Sampling of light regime in support of aquatic vegetation modeling (2008D6; Dukerschein, Giblin, Hoff)
Completion report: Examining nitrogen and phosphorus ratios N:P in the unimpounded portion of the Upper Mississippi River (2006D9; Hrabik & Crites)
Manuscript describing results of analyses of spatial and temporal patterns in UMRS WQ. (2006D5; Houser)
Completion report: Lake Pepin zooplankton and water quality data (2006D7; Popp & Burdis)

Literature Cited

American Public Health Association, American Water Works Association, and Water Environment Federation. 1992. Standard methods for the examination of water and wastewater. 18th edition, American Public Health Association, Washington, D.C. 981 pp. + 6 color plates

Soballe, D. M., and J. R. Fischer. 2004. Long Term Resource Monitoring Program Procedures: Water quality monitoring. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, March 2004. LTRMP 2004-T002-1 (Ref. 95-P002-5). 73 pp. + Appendixes A-J.

Personnel

Dr. Jeff Houser will be the principal investigator.

Statistical Evaluation

Statistical support for the LTRMP 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 LTRMP documents that contain statistical content. The 'Guidance for statistical analyses' purpose is designed to save money for the LTRMP, at both UMESC and the field stations, by helping LTRMP staff use data and analytical time more efficiently. The statistician is also responsible for ensuring that newly developed statistical methods are evaluated for use by LTRMP. This guidance would include assistance for LTRMP additional program element projects requiring a minor amount of the statistician's time, but projects needing more assistance would build statistical support into that specific scope of work.

Guidance for management includes assistance with modifications to program design, with standardizing general operating procedures, and with estimating power to detect changes and trends. For example, LTRMP's focus on long term rather than on annual changes has important implications for program design. This is because the number of years of sampling is typically more important than the number of samples per year in increasing power to detect long-term trends (given some minimal number of samples per year).

The statistical component will help ensure that potentially useful analyses of data from within and across components are identified, that methods for analysis are appropriate and consistent, and that, when possible, multiple analyses work together to achieve larger program objectives regardless of which group (UMESC, field stations, COE, etc.) conducts analyses. The statistician is also responsible for reviewing LTRMP documents containing statistical components for accuracy and for ensuring that quality of analyses is consistent among products. A primary goal of statistical analyses is to avoid drawing inappropriate conclusions leading to ineffective or even harmful management actions. Within the UMR, there are a variety of confounding factors and conditions that could produce spurious correlations or lead to inappropriate conclusions regarding cause and effect. Appropriate statistical analysis and interpretation is critical to understanding the limitations of LTRMP data. This, in turn, is critical in efforts to distinguish 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 Descriptions

2009E1: Provide statistical code on the web that can be used to calculate means and trends, with standard errors and confidence intervals, from LTRMP fish, vegetation and water data. The rationale for this product are that the estimation of means and trends from LTRMP data may be both challenging and require specialized software. UMESC currently provides stratum means with SEs (all components), and poolwide means with SEs (fish and vegetation only). But, we don't provide mean estimates for portions of strata, and for combinations of strata less than the whole pool (e.g., the mean for the backwater contiguous and side channel strata). Nor do we currently provide trend estimates. This product will allow the calculation of these statistics. Because the code will be provided on the web, this product will be useful to both LTRMP and non-LTRMP investigators. Code will primarily be in SAS but, given sufficient interest, could be supplied in other languages (e.g., R, Stata) in a subsequent year.

Products and Milestones

Tracking number	Products	Lead	Milestones
2009E1	Update LTRMP Statistical Web Pages (Draft)	Gray	30 September 2009
Intended for distribution			
Completion report: "An introduction to the analysis of LTRMP's vegetation rake data" (2007E1; Gray)			
Completion report: "Estimating temporal trends in data derived using LTRMP's submersed aquatic vegetation rake sampling design" (2007E2; Gray)			
Completion report describing methods of estimating variance components from LTRMP water quality data (2008E1)			
Completion report: "Cumulative HREP effects on ecological characteristics of impounded regions of the UMR" (2007APE10)			

Personnel

Dr. Brian Gray will be the principal investigator.

Data Management

The objective of data management of the LTRMP is to provide for data collection, correction, archive, and distribution of a 90 million dollar database that consists of over 2.2 million records located in 195 tables. The 2.2 million data points currently in the system require regular maintenance and upgrading as technologies change. Also, having a publicly accessible database requires a significant level of security. This is accomplished by having the systems Certified and Accredited by a rigorous, formal process by the USGS Security team.

Methods

Data management tasks include, but are not limited to:

- Review daily logs to ensure data and system integrity and apply application updates.
- Develop and maintain field notebook applications to electronically capture data and begin the initial phase of Quality Control/Quality Assurance (QA/QC).
- Administer and maintain the Oracle LTRMP database.
- Administer and maintain LTRMP hardware, software, and supplies to support LTRMP program needs.
- Administer, maintain, and update the LTRMP public and intranet data browsers to insure access to all LTRMP data within USGS security policy.

Products and Milestones

Tracking number	Products	Staff	Milestones
2009M1	Update vegetation, fisheries, and water quality component field data entry and correction applications.	Schlifer	30 May 2009
2009M2	Load 2008 component sampling data into Oracle tables and make data available on Level 2 browsers for field stations to QA/QC.	Schlifer	30 June 2009
Intended for distribution			
Online viewer (ArcServer) of historical data (2007VTj, Fox)			

Personnel

Mr. Ben Schlifer will be the principal investigator.

Land Cover/Land Use with GIS Support

Although the Long Term Resource Monitoring Program (LTRMP) will not collect data under the minimal sustainable program, the Program will maintain program expertise, manage existing data, and provide limited on-demand Geographic Information System (GIS) technical assistance.

Provide on-demand GIS technical assistance, expertise, and data production to the Environmental Management Program partnership including, but not limited to:

- Aerial photo interpretation
- Interpretation automation into a digital coverage
- Flight planning and acquisition of aerial photography
- Change detection and habitat modeling
- Georeferenced aerial photo mosaics (pool-wide, Habitat Rehabilitation and Enhancement Projects (HREPs), land acquisition areas)
- Georeferenced archival map/plat mosaics (Brown Survey, Mississippi River Commission data, Government Land Office data)
- Produce graphics and summary tables for partnership publications, posters, and presentations
- Conversion of ASCII coordinate data from a GPS to a spatial dataset
- Conversion of all georeferenced data to a common projection and datum for ease of use in a GIS
- Maintain, update, and oversee the aerial photo library of over 50,000 print and digital images.
- Maintain, update, and enhance over 20 million acres of land cover/land use and aquatic areas data spanning the late-1800s through the year 2000. This includes improving existing or developing new crosswalks for comparison of existing datasets, cropping datasets to common extents, and ensuring that all datasets are in a common coordinate system.
- Assist in the maintenance and updating of the USGS-Upper Midwest Environmental Sciences Center's (UMESC) web-based geospatial data repository.

Product Descriptions

Although the primary focus of this component is to provide technical assistance and maintain existing databases, as time allows the following LTRMP projects can be initiated and progress made on:

1. Generate GIS-ready (.xml format) metadata for spatial data being served over the internet. The data being served have metadata included but is in either text format (.txt) or web format (.html). Converting these metadata files to .xml will provide access from within the GIS.

2. Reformat and serve the lower Pool 4 and Pool 5 Light Detection and Ranging (LIDAR) data. These data are currently being served, without restriction, by the Corps of Engineers (http://www.mvp.usace.army.mil/gis/default3.asp?theme_id=18) St Paul in ARC Grid format. However, reformatting will allow serving in same format along side newly acquired data which will add to systemic coverage. We propose to develop and serve this data in various georeferenced GIS formats such as digital elevation models (DEMs) in TIFF or GRID format, hillshade images, and other useful products that can help resource managers assess LIDAR's usefulness to their management efforts.

3. Continue to update the detailed spreadsheet of all LTRMP aerial photography currently housed at UMESC, including date, pool location, format (color infrared, natural color, black-and-white), scan status (yes/no, dots per inch), interpreted status, photo scale, and

extent of coverage (partial or complete). This document will be updated as necessary and served via the internet.

Products and Milestones

Products
Intended for distribution
Assessment of high-resolution digital imagery for UMRS vegetation mapping and software-based vegetation classification (2007APE13; Robinson)

Personnel

Mr. Larry Robinson will be the principal investigator.

Bathymetry Component

The overall goal of the LTRMP Bathymetry Component is to complete a system-wide GIS coverage of UMRS bathymetry used to quantitatively and qualitatively assess the suitability of essential aquatic habitats. Presently, eight pools (Pools 4, 7, 8, 9, 13, 21, 26, and La Grange Pool) are complete, six pools (Pools 5, 10, 18, 24, Alton Pool, and the Middle Mississippi reach) are over 80% complete, six pools (Pools 17, 20, 22, 25, and Peoria and Marseilles Pools) are between 60 and 80% complete, and the remaining twelve pools are less than 60% complete. Although LTRMP will not collect data under the minimal sustainable program, the Program will maintain some level of expertise to provide basic assistance with using the existing LTRMP data.

Provide on-demand technical assistance related to the bathymetric database to the EMP partnership including, but not limited to:

- Deliver data in non-standard formats, such as raw point data in GIS or text files.
- Adjust bathymetry data to selected water surface conditions (presently only available at “flat-pool” conditions)
- Calculate summary statistics (e.g., hypsographic curves and volume) for geographical subsets of the data
- Advise partner agencies on data collection methods and locations that meet LTRMP needs
- Assist in spatial modeling using the bathymetric data

Work on this component in FY09 will focus on completion of a working multi-year bathymetric data acquisition plan outlining a process and financial needs to complete the system-wide bathymetry dataset. The comprehensive plan, developed jointly by the USACOE and USGS, is considered a working document that will be updated as progress on the plan is made. This plan will be distributed to the partnership in FY09 for review and approval and will be implemented in FY10 contingent upon available funding and the 2010-2014 Operating Plan.

The bathymetric data acquisition plan will cover several topics including: the current status of UMRS bathymetric data coverage with data gap maps, identifying priority areas for data collection, data standards, data collection through contracting, short-term and long-term acquisition plans and funding requirements.

UMESC POC: Jim Rogala

USACE POC: Karen Hagerty

Products and Milestones

Products
Intended for distribution
UMRS Bathymetric Data Acquisition Plan (2008T2; Hagerty&Rogala)

Personnel

Mr. Jim Rogala will be the principal investigator.

Table 1. LTRMP sample collection for FY09.

	Study Area					
Component	**4**	**8**	**13**	**26**	**La Grange**	**Open River**
Vegetation	450 stratified random sample sites over growing season.	450 stratified random sample sites over growing season.	450 stratified random sample sites over growing season.	—	—	—
Fisheries	~160 samples; 2 periods: Aug. 1–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sample sites.	~180 samples; 2 periods: Aug. 1–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sample sites.	~200 samples; 2 periods: Aug. 1–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sample sites.	~180 samples; 2 periods: Aug. 1–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sample sites.	~270 samples; 2 periods: Aug. 1–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sample sites.	~165 samples; 2 periods: Aug. 1–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sample sites.
Water Quality	135 stratified random sites done in each episode (winter, spring, summer, and fall); 14 fixed sites	150 stratified random sites done in each episode (winter, spring, summer, and fall); 13 fixed sites	150 stratified random sites done in each episode (winter, spring, summer, and fall); 12 fixed sites	121 stratified random sites done in each episode (winter, spring, summer, and fall); 9 fixed sites	135 stratified random sites done in each episode (winter, spring, summer, and fall); 11 fixed sites	150 stratified random sites done in each episode (winter, spring, summer, and fall); 9 fixed sites

2008 Additional Program Elements

Tracking number	Milestone	Target Date	Lead
2008APE1a	Draft completion report: Developing an empirical framework for reconstructing and modeling UMRS floodplain disturbance histories: Year 1, historic data extraction and summaries.	30-Mar-09	Ickes
2008APE2	Draft LTRMP technical report; Setting quantitative fish management targets for LTRMP monitoring	30-Mar-09	Sass
2008APE3	Draft completion report: Evaluation of two double sampling designs for sampling mussel beds in the UMRS	30-Mar-09	Rogala
2008APE4a	Draft completion report: FY05-07 data--Analysis and support of aquatic vegetation sampling data in Pools 6, 9, 18, and 19	30-Mar-09	Yin
2008APE4b	Data entry and data quality checking of the 2008 data--Analysis and support of aquatic vegetation sampling data in Pools 6, 9, 18, and 19	30-Dec-08	Yin
2008APE5	Draft LTRMP Technical Report; Experimental and Comparative Approaches to Determine Factors Supporting or Limiting Submersed Aquatic Vegetation in the Illinois River and its Backwaters	30-Mar-09	Sass
2008APE6	Data set for 2008 field season: Hydrologic connectivity between off channel areas and the main channel: an empirical test of an important driver of potential HREP effects on biological production and organism health	30-Mar-09	Richardson
2008APE7	Draft Completion Report: A Proposal to Restore Specific Monitoring Elements to the LTRMP	30-Mar-09	Team Leaders

FY09 Research Additional Program Elements

Have the recent increases in aquatic vegetation in Pools 5 and 8 been the result of water level management drawdowns, HREPs, or natural fluctuations?

Introduction/Background

Habitat Rehabilitation and Enhancement Projects (HREP) and water level management drawdowns (drawdowns) are two restoration methods employed on the Upper Mississippi River System (UMRS) to improve the river system's ecological health. HREPs use a variety of techniques including island building, dredging, and flow manipulation that can alter current velocities and reduce wind and wave induced re-suspension of sediments, which, in turn, can enhance aquatic vegetation. Drawdowns are intended to mimic the natural hydrograph by lowering surface water-levels during the summer growing season to promote the germination and growth of aquatic vegetation on newly exposed areas. The effectiveness of each method in restoring aquatic vegetation has been demonstrated and reported in open literature (Langrehr et al, 2007; Kenow & Lyon, 2008) and agency reports (River Resources Forum, 2008). Recent restoration efforts in Pools 5 and 8 of the UMRS have nearly simultaneously employed both methods and consequently confounded our understanding of the resulting restoration impacts in these Pools. Furthermore, increases in aquatic vegetation have been observed elsewhere in the UMRS where the two restoration methods were not a factor, leading managers and researchers to question how much relative impact the management actions had compared to natural fluctuations in aquatic vegetation. To date, a quantitative and comparative analysis of natural fluctuations in aquatic vegetation and the impacts of the two restoration methods, in terms of targeted species responses, longevity of effects, and costs and benefits remains absent. Such information will help managers prescribe the most effective restoration method in regard to aquatic vegetation on the UMRS.

Relevance of research to UMRS/LTRMP

This project examines how management actions versus natural fluctuations affect aquatic vegetation communities over time. The objective of this study is to determine if increases in aquatic vegetation in recent years, especially submersed aquatic vegetation (SAV), in Pools 5 and 8 can be attributed to drawdowns, HREPs, natural fluctuations, or some combination of these factors.

This project analyzes if and how various management actions affect aquatic vegetation communities in the Upper Impounded Floodplain Reach (Pools 1–13) of the Upper Mississippi River (UMR). The Upper Impounded Reach has had an increase in aquatic vegetation over the last few years, possibly due to lower discharge and increased water transparency. In Pool 8, 1.5 ft summer drawdowns were conducted for two years (2001 and 2002) following the completion in 1998 of the Stoddard Islands HREP. That HREP had begun to promote the growth of aquatic vegetation in the project area and possibly triggered a similar response in the vicinity of the impounded area. In Pool 5, a 1.5 ft drawdown was carried out in 2005, a year prior to two years of lower than average discharge. At the same time the Spring Lake Islands HREP was being constructed in one of the backwaters of the pool. As adaptive management becomes more of a requirement for restoration projects on the river, managers need a comprehensive analysis to address questions such as how much of the SAV response was due to drawdowns, how much to HREPs, and how much too non-anthropogenic fluctuations. Managers also need to have more information on the persistence of the vegetation responses so that the frequency of drawdowns can be prescribed in management plans.

A second objective is to assess the longevity of a pool-wide summer drawdown on emergent and other forms of aquatic vegetation. True color aerial photographs of Pool 5 were taken in 2005, 2006, and again in 2007 during peak biomass. Funding for the film, photography and orthorectification was provided by a USGS State Partnership Grant in 2005 and by the LTRMP in 2006 and 2007. Interpretation of the 2005 photos and analysis of change in the area covered by key vegetation communities from pre- to post-drawdown were funded by the USGS State Partnership Grant, and interpretation of the 2006 photos was funded by the Minnesota DNR. However, funding is needed to complete interpretation and analysis of the aerial photos that were taken during the summer of 2007. Without this analysis the persistence of initial increases in emergent vegetation, and whether the annuals that germinated after the first year of the drawdown were replaced by perennials in the following years, will remain a question. This analysis would provide managers with information about three consecutive years of potential vegetation changes and help them make decisions in the future about frequency and cost effectiveness of drawdowns as a viable technique to increase and sustain fish and wildlife habitat on the UMR.

This proposed project addresses the question "What factors control the abundance, diversity, and distribution of aquatic vegetation in the UMRS?" by attempting to link the response of key aquatic vegetation communities in selected pools to various management actions or to natural fluctuations caused by changes in key hydrological and water quality variables. Managers and researchers can learn a great deal by following changes in aquatic vegetation communities over time subsequent to a drawdown. The number of years of consecutive drawdowns (2 yrs. in Pool 8 and 1 yr. in Pool 5) and between drawdowns can affect whether most of the germinating vegetation are annuals or perennials, and the length of time that the various communities persist.

Methods: (Detailed enough so reviewers can understand specifically what you will do. i.e., study design, field methods, and statistical analysis. You may cite an accepted protocol, if appropriate):

We'll compile and analyze aquatic vegetation data collected in Pools 4, 5, 8 and 13 by the LTRMP and other federal and state agencies. Because more hydrologic and vegetative data exist for Pool 8, it will be used as the primary study site and data from the other three pools will be used as supporting evidence or as pseudo controls. Vegetation changes from 1998 to 2008 will be tracked on an annual basis. The pool will be divided into sections that represent the longitudinal and lateral hydrological gradients within the pool, influence of HREP (Figure 1), and degree of drawdown exposure (Figures 2-4). Using a water elevation model of Pool 8, we can predict water level based on discharge. According to our model, the predicted and actual daily water level at Lock and Dam 8 matched very well during the three years prior to the 2001 summer drawdown (Fig. 2). Such model credibility allowed us to estimate what the water level would have been if the drawdown had not been conducted in 2001 and 2002. This same model will be used to calculate how many days a site of known elevation was dewatered by the drawdown.

By analyzing the variance in the occurrence of aquatic vegetation as a response to the factors listed above, quantitative estimations of the effects of HREPs, drawdowns, and flow regime will be produced. We'll repeat the analyses by dividing the vegetation into groups of interest.

In addition, aerial photos will be used to assess emergent vegetation changes over time resulting from the drawdowns of Pool 5 (2005) and Pool 8 (2001-2002). True color aerial photography collected in September 2007 at 8"/pixel will be interpreted to the genus level where possible for Pool 5 and lower Pool 8. The interpreted photo overlays will be scanned, orthorectified, and converted to digital datasets for use in a GIS (shapefile format). Recent pre- and post-drawdown aerial photography for Pool 5 has been interpreted for the years 2000 (31-Class), 2004, and 2006. Pre- and post-drawdown aerial photography for Pool 8 has also been interpreted for the years 1998, 2000, and 2003.

We conducted a few exploratory analyses using the approach described above based on data collected between 1998 and 2005 and produced some initial estimates (Table 1). For example, using 2000 as the reference year, we estimated that by 2005 the Pool 8 drawdowns in 2001 and

2002 could be responsible for 1200 and 2400 acres of increase of emergent and submersed aquatic vegetation, respectively; and 300 acres of reduction of rooted-floating leaf vegetation. These preliminary estimates were produced based on a few assumptions and parameterizations that need to be critically tested, which is a major part of the proposed project.

Products and Milestones

Tracking number	Products	Milestones
2009APE1a	Draft manuscript for USGS internal review	1 September 2009
2009APE1b	Submittal of manuscript to journal	1 March 2010

Response to partner comments regarding separating causal mechanisms:

This project attempts to quantitatively separate the causal mechanisms to the recent positive vegetation response. We recognize that it is a challenging task but respectfully point out in this field of science we have to accept and work with imperfection of assumptions and parameterizations. We have provided a lot more details of our methods and some outcomes of our preliminary analyses. We'll demonstrate that our approach will be reasonable and the estimates will be accurate at a scale that is biologically meaningful.

Response to partner comments regarding different scales of photo interpretation

All UMRS photo interpretation since 1998 has been performed using a hierarchical classification system that collapses 150+ genus classes into 31 generalized classes. This methodology allows for direct comparison of datasets produced at different scales since the finer classes fold directly into coarser ones. For example, a polygon mapped as Sagittaria/Sparganium at the genus level would always be mapped as Deep Marsh Perennial at the general classification level. Analysis of different datasets would then take place at the level of commonality. Older datasets that were mapped prior to the development of this classification in 1998 have been "crosswalked" to the class that best fits. The "Leersia/Sagittaria" polygon mapped in 1989, crosswalks to "Wet Meadow" using the current classification based on the presence of Leersia which typically grows in drier conditions than Sagittaria.

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Principal Investigator**:** Yao Yin

Collaborators: Larry Robinson, Walt Popp, Megan Moore

Figure 1. Delineation of HREP influenced areas in Pool 8

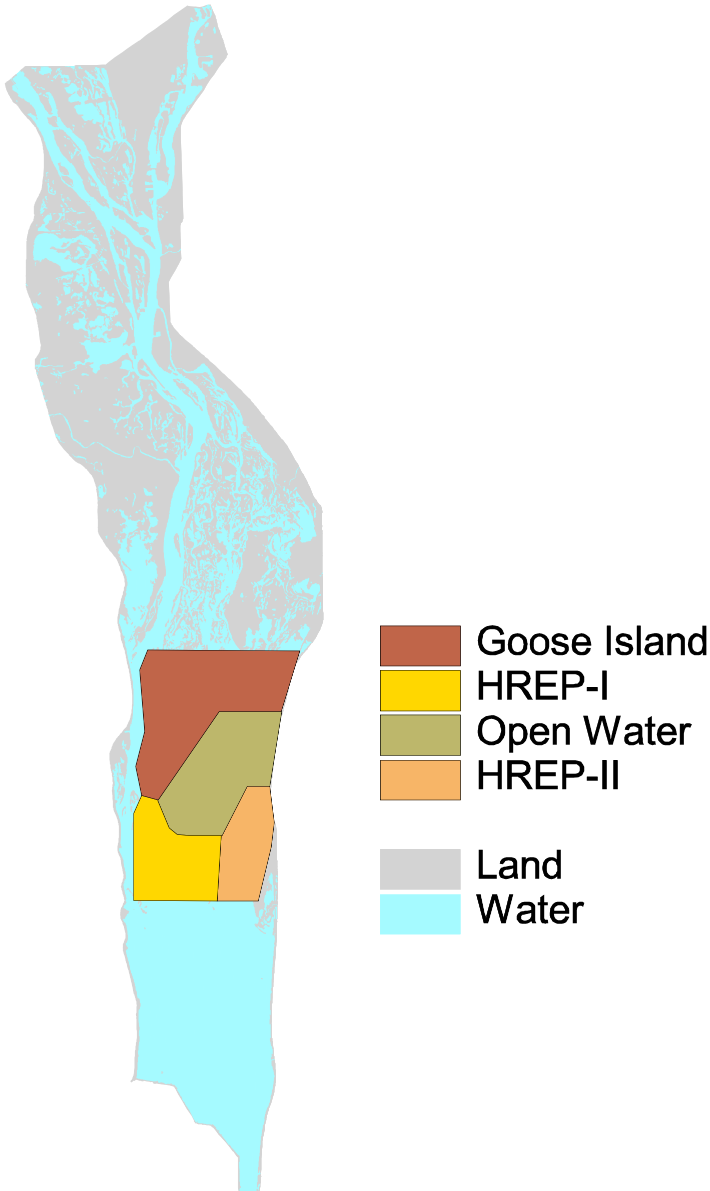

Figure 2. We have built a model to predict the surface water level in Pool 8 based on discharge. The predicted (blue line) and actual (black line) daily levels at Pool 8 Dam gauge matched very well during the three years prior to the 2001 summer drawdown, which allows us to reliably estimate what the surface water level would have been if the drawdowns were not conducted in 2001 and 2002. This same model will be used to calculate how many days a site of known elevation was dewatered by the drawdowns.

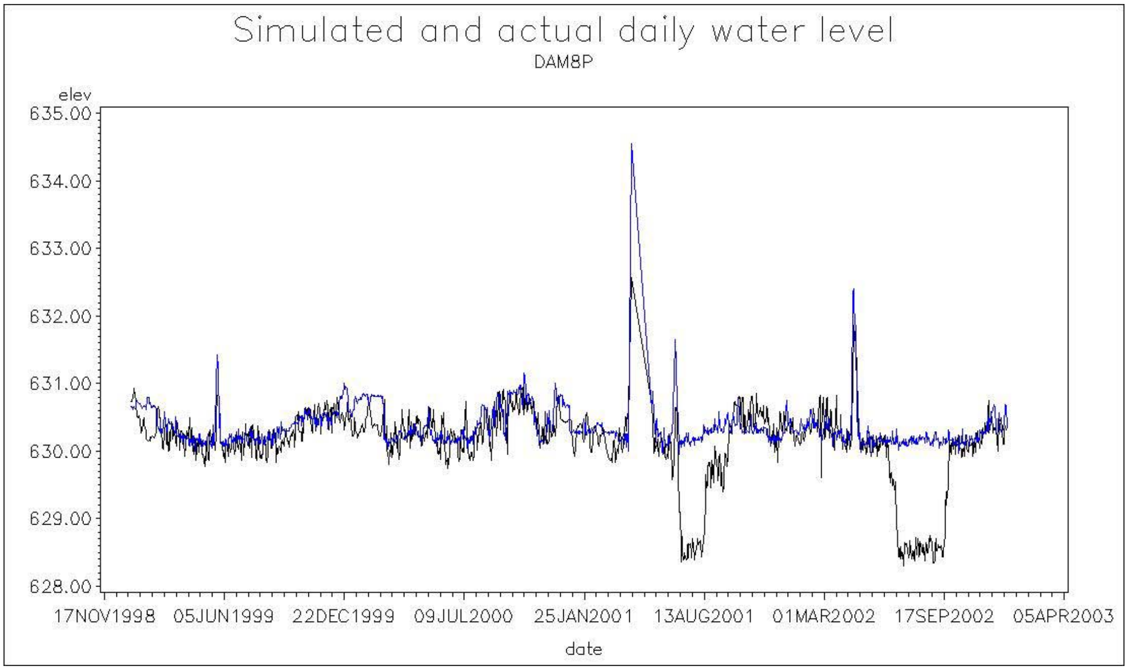

Figure 3. Sample map of dewatered areas in Pool 8 predicted by the surface water level model,

High=site dewatered due to low discharge, Exposed=site dewatered due to drawdown, Deep= continuously submerged site.

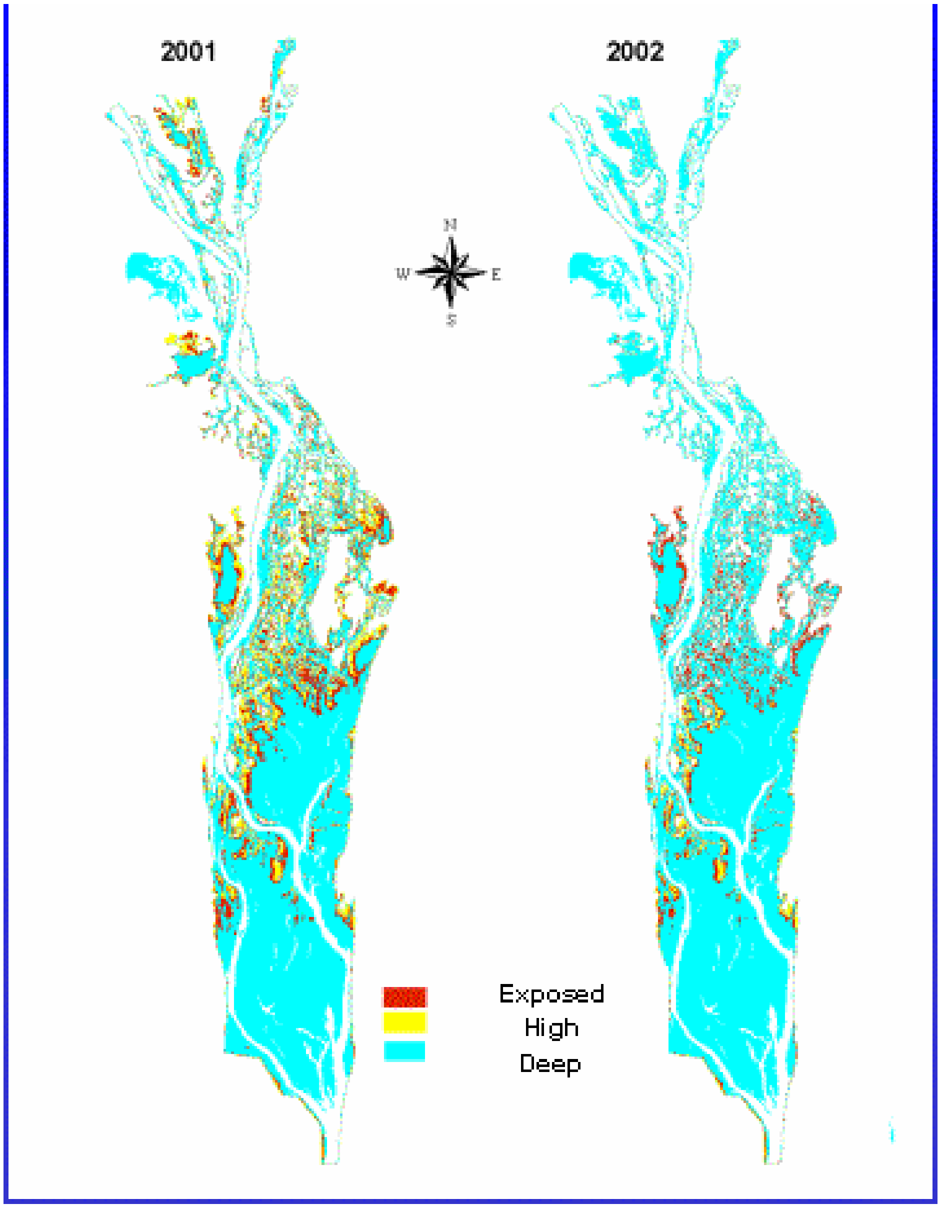

Figure 4. Estimated daily acreage dewatered during the 2001 summer water level drawdown in Pool 8.

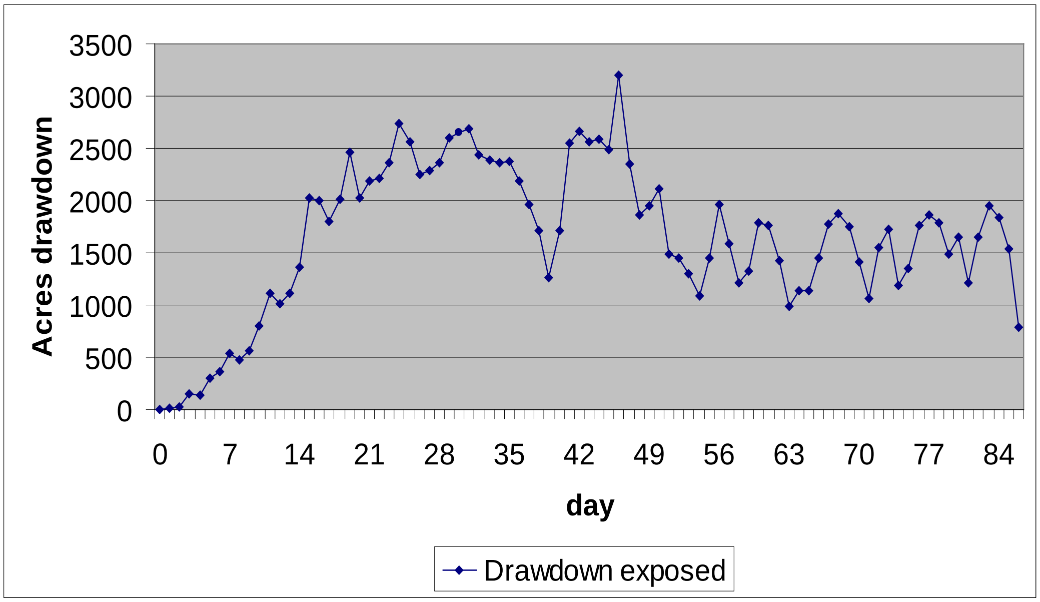

Table 1: Outcome of one of many preliminary analyses that estimate the vegetation acreage changes from 2000 to 2005 that are attributable to the summer water level drawdowns in 2001 and 2002 in Pool 8 as compared to the habitat rehabilitation enhancement projects (HREP) in Stoddard Bay. (The accuracy of estimates has not been verified and the methods used have not been critically review by peers)

	Drawdown	HREP
Emergent	+1200(acre)	+30
Rooted floating	-300	+380
Submersed	+2400	+640

Movement of unionids during a planned water level drawdown in Pool 6 of the Upper Mississippi River

Introduction/Background

Resource managers are currently using water level drawdowns to rehabilitate habitats for vegetation and other desirable species in the Upper Mississippi River (UMR). Drawdowns may have unintended effects on native mussel populations. Over the past few summers, scientists from UMESC and river resource agencies have conducted systematic pool-wide surveys of mussels in three navigation pools (Pools 5, 6, and 18) to determine pool-wide population estimates (Rogala et al. 2007, Rogala and Newton 2008a). Collectively, these surveys suggest that there is a considerable mussel population in these pools, but that a small, but significant fraction resides in shallow water—the area presumed to be most affected by a drawdown (Rogala and Newton 2008b). We estimated mortality of mussels associated with the drawdown, but in the absence of more definitive data, we assumed that mortality in the drawdown zone was 100%. However, it is likely that some fraction of these mussels are able to migrate out of the drawdown zone and reach deeper water—especially in sloped areas. Some mussels may also survive by burrowing into the substrate to estivate. The proposed research aims to estimate the fraction of mussels that are able to move, either vertically or horizontally, to avoid short-term mortality during a water level drawdown.

Movement behavior is an important adaptation of unionids to flow conditions in rivers and enables them to respond to regular disturbances that occur as a result of changing flow conditions and water levels. Unionids move for several reasons. First, mussels may move (vertically and horizontally) seasonally into aggregations to enhance reproduction (Amyot and Downing 1998, Watters et al. 2001). Second, vertical movement may help mussels to escape predation as buried mussels are less prone to predation. Third, vertical burial in sediments may help unionids to control zebra mussel infestation (Schwalb and Pusch 2007). Natural rates of mussel movement in rivers are largely unknown. Three mussel species in the River Spree in Germany moved an average of 11 ± 15 cm/wk (range, 0-226) in the horizontal plane from May to October and roughly 70% of the mussels were found completely buried in sediment (Schwalb and Pusch 2007).

The Schwalb and Pusch (2007) study was limited in spatial scale—movement of mussels was restricted within corrals. Recent technological advances may allow us to follow movement of mussels over larger spatial scales. Kurth et al. (2007) evaluated the effectiveness of passively integrated transponder tags (PIT tags) in mussels. They successfully recaptured 78% of tagged mussels and found that 93% of the recaptured mussels retained their PIT tags after 21 months. Mortality of tagged mussels was 1.3%. In particular, the recapture rate of mussels in the Sebasticock River, Maine, with PIT tags and visual confirmation were 2-fold greater than those of visual searches alone. Thus, PIT tags permit repeated, non-destructive sampling of individuals with little disturbance, last indefinitely, and appear to have negligible effects on short-term survival of mussels.

Movement of mussels may be influenced by differences in shell geometry among species because shell form has been shown to be closely related to locomotor function (Watters 1994). Unionids have been categorized into subfamilies that differ greatly in behavior and life history. Thus, we may expect species-specific differences in movement behavior associated with water level drawdowns. Amblemine mussels close their valves tightly and are probably better at conserving water than Lampsiline mussels. Prior research suggests that Lampsilines are more active than Amblemines (Haag et al. 1993, Waller et al. 1999). Thus, we hypothesize that Lampsilines are more likely to move horizontally across the sediment surface to reach deep water, whereas Amblemines are more likely to burrow vertically into sediments and "wait" for the water to return. In a study of mortality of unionids associated with water level drawdown in Pool 5 of the UMR, Amblemine mussels had higher survival rates than Lampsiline mussels (WDNR et al. 2006).

Movement of mussels may also be influenced by physicochemical variables. Movement of mussels in the River Spree was influenced by discharge, water temperature, day length, and water level (Schwalb and Pusch 2007). It has been hypothesized that the lower limit of a mussel's vertical distribution may be limited by low dissolved oxygen concentrations in deeper sediment (Schwalb and Pusch 2007) and perhaps by sediment temperatures. Slope may also be important in predicting survival of mussels as water levels recede during a drawdown. Research by the WI DNR during the Pool 5 drawdown suggested that survival of mussels on sloped sites was potentially greater than on un-sloped sites (WDNR et al. 2006). Highly sloped surfaces might cue directional movement and provide easier access to deeper water than unsloped surfaces.

Relevance of research to UMRS/LTRMP

In the past few years, we have developed a scientifically rigorous sampling design to obtain pool-wide population estimates of unionid mussels. Although the systematic pool-wide mussel abundance data have assisted resource managers in understanding where mussels are located, and in what abundances, within specific UMRS pools, concern about the potential for deleterious effects on native mussels continues to jeopardize HREP activities such as water level drawdown. Lacking definitive data, we have assumed a 100% mortality of mussels in the drawdown zone. The proposed research aims to evaluate the movement of mussels out of the drawdown zone and survival of mussels that estivate in river sediments during the drawdown period. Thus, the proposed research is relevant to the UMRS and the LTRMP because it addresses the unintended consequences of a key resource management tool on populations of an important faunal group in the UMRS.

Methods

The proposed work will contribute to the overall collaborative effort of understanding the unintended consequences of water level drawdowns on native mussel populations in the UMRS. Our objective is to characterize and compare the movement of two common mussel species across low and high slope areas in Pool 6 during the summer of 2009. We will use data from a shallow water survey in Pool 6 (Rogala and Newton 2008) to choose 3 high slope and 3 low slope areas in shallow water sandy areas off the main navigation channel (the current plan calls to draw down the pool by 0.5 foot). We will also have 6 control areas—3 with low slope and 3 with high slope—in a portion of Pool 6 that is not overtly influenced by the drawdown. The corners of each of the 12 areas will be marked with stakes. Each area will be roughly 2 meters in width and length.

We will randomly place about 5-15 Amblemine mussels (e.g., Amblema plicata, Quadrula pustulosa, or Fusconaia flava) and 5-15 Lampsiline mussels (e.g., Lampsilis cardium, Lampsilis siliquoidea, or Obliquaria reflexa) in the 0-1 ft contour within each area before the drawdown begins. This way, most mussels have a relatively high probability of being exposed during the drawdown without all individual being placed near the shoreline. We will attempt to collect mussels from the general vicinity of each area to reduce the placement of mussels into different habitats. All mussels will be marked using an identification mark (number etched into shell and/or bee tag) and a fraction of mussels will be marked using PIT tags and I-buttons to record sediment temperature. In addition, we will affix a known length of buoyant fishing line to each shell to estimate the vertical position of each mussel in the substrate at each time period. We will try and locate mussels at least twice a month from June through October—a time period that encompasses the drawdown. We anticipate the field effort will take about 3 days per week from June to October. For each mussel we recover, we will record (1) its horizontal position by triangulation with the stakes demarking the area, (2) its vertical position with the fishing line, (3) a crude estimate of the slope of the sediment surface in the immediate vicinity of the mussel, (4) water temperature at the sediment-water interface, and (5) water depth.

Statistical analyses will include comparisons of survival, and horizontal and vertical migration rates of mussels between high slope and low slope areas and between species. Directionality and dispersion of movement will be assessed by Monte Carlo tests on random walks (Hooge et al.

2001). The experimental design includes the main effects of treatment (low slope, high slope), species (Amblemine, Lampsiline) and time. Co-variates include sediment temperature, water temperature, water depth, and discharge.

In the event that the drawdown is cancelled, we would continue with the proposed research because it provides baseline information and methodologies to estimate the natural movement of mussels in shallow water zones of the UMR.

NOTE: In addition, we received about $11K from the U.S. Fish and Wildlife Service (Winona, MN) that will cover the costs of the PIT tags and receiver, one part-time field technician, and a small portion of Newton and Zigler's time. Also, the proposed research will complement a U.S. Army Corps of Engineers (St. Paul, MN) study to examine mortality of unionids in the shallow water zone during the drawdown.

Products and Milestones

Tracking number	Products	Milestones
2009APE2a	Draft completion report including sample design, methods, and results	30 January 2010

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Principal Investigator: Teresa J Newton

Collaborators: Steve Zigler, Mike Davis, and Gary Wege

The effects of river nutrient concentrations on metaphyton, submersed aquatic vegetation and dissolved oxygen across a connectivity gradient.

Introduction/Background

Nutrients in the Upper Mississippi River (UMR) have been studied extensively, but this work has focused on factors determining nutrient load and the impacts of nutrient export by the river to the Gulf of Mexico (*e.g.*, Rabalais et al. 1996, Dagg and Breed 2003). UMR nutrient concentrations are generally high (UMR Status and Trends Report, forthcoming) and relatively little is known about the effects of elevated nutrient concentrations (eutrophication) on river ecosystems (Hilton et al. 2006).

One potential impact of increased water column nutrient concentration is increased epiphyton and metaphyton growth (*e.g.*, filamentous algae and duckweed; Phillips 1978). There is evidence from other freshwater systems that excessive epi- and metaphyton growth is detrimental to submersed aquatic vegetation (SAV) abundance, primarily through reducing the light available to SAV (Phillips et al. 1978, Jones et al. 2002, Hilton et al. 2006, and Morris et al. 2003). In the UMR, there is evidence that abundant metaphyton is associated with high nitrogen and phosphorus concentrations, and preliminary evidence that metaphyton is more often limited by nitrogen than phosphorus in the backwaters of the UMR (Sullivan, *in prep*; Giblin 2008).

Previous investigation found nutrient concentrations to be positively correlated with metaphyton abundance (Sullivan, *in prep.*). Most off channel areas have two major sources of potential nutrient input: hydrologic nutrient transport from the main channel and sediment nutrient release. Though nutrient concentrations are often high in the UMR, there is considerable spatial and temporal variability (Houser 2005). Connectivity to the main channel has been shown to be an important determinant of nitrogen concentrations in the UMR (Richardson et al. 2004) and sediment release can be an important source of phosphorus (James et al. 1995). We will investigate both sources of nutrient input by selecting backwater study areas with different levels of connectivity to the main channel and measuring rates of sediment nutrient release.

A thick canopy of metaphyton severely limits light penetration into the water column (Pokorny and Rejmankova 1983, McDougal et al. 1997, Dodds et al. 1999, Brush and Nixon 2002). Low light availability may reduce growth rates, abundance, diversity, and community composition of SAV (*e.g.*, Phillips et al. 1978, Jones et al. 2002). Reduced SAV photosynthesis may also lead to low dissolved oxygen (DO) concentrations in the water column, and there is evidence that thick metaphyton mats are associated with low DO concentrations in the UMR (Sullivan, *in prep.*). These low DO areas are poor habitat for many organisms, and there is evidence that hypoxic conditions can have negative effects on wild celery (Morris et al. 2003). Furthermore, low dissolved oxygen concentrations may facilitate sediment phosphorus release (*e.g.*, James et. al. 1995) creating a positive feedback that further promotes metaphyton growth.

Aquatic plant tissue analysis provides a functional indicator of nutrient enrichment in aquatic systems (USEPA 2002). Because metaphyton obtain their nutrients from the water column, metaphyton tissue analysis provides an indication of water column nutrient availability. Changes in the ratio of C:N or C:P in plant tissues can provide a measure of N or P limitation in aquatic systems. Thus, tissue analysis of metaphyton may provide a means for evaluation nutrient limitation and the response to nutrient enrichment in the UMR. Nutrient enrichment can be the result of nonpoint or point source inputs or the introduction of nutrient-laden waters into backwater areas through proposed habitat restoration projects featuring improved hydraulic connectivity. Nutrient analysis of metaphyton tissue can improve our understanding of how backwaters sequester nutrients and how nutrient enrichment may negatively affect water quality or aquatic habitat availability.

Relevance of research to UMRS/LTRMP

SAV plays a central role in the UMR (Korshgen 1988 and Janecek 1988). If high nutrient concentrations contribute to levels of metaphyton that are detrimental to SAV, understanding the links among connectivity, nutrient availability, metaphyton abundance and SAV health will be important for river management. These links are currently poorly understood. The main objective of this proposal is to improve our understanding of the relationships among sediment nutrient concentrations, water column nutrient concentrations, metaphyton abundance, SAV abundance and diversity, and dissolved oxygen concentrations in the UMR.

The results of this research will address two of the APE 09 focus areas: aquatic vegetation and connectivity. The proposed work will provide important information on the links among sediment nutrient concentrations, water column nutrient concentrations and metaphyton levels, and will improve our understanding of the impacts of metaphyton abundance on more desirable forms of aquatic vegetation. It will also help quantify the impacts of river eutrophication on SAV, and the extent to which those effects depend on connectivity to the main channel.

<u>Objectives and approach</u>
Specifically, we propose to examine associations among connectivity to the main channel, nutrient concentrations and metaphyton levels, and the impacts of metaphyton levels on dissolved oxygen concentrations and SAV abundance and diversity. We will use three distinct but complementary approaches: a comparative field survey of selected backwater areas of Pool 8 of the UMR, analysis of existing LTRMP water quality component data, and analysis of existing LTRMP vegetation component data. We will use these approaches to address the following questions:
1) Is there evidence that metaphyton abundance has negative effects on SAV abundance or diversity during the current or subsequent growing seasons?
2) How is metaphyton abundance related to sediment or water column nutrient (N and P) concentrations and dissolved oxygen concentration?
3) How are sediment and water column nutrient (N and P) concentrations related to each other and to rates of nutrient release from the sediments? How strong is the relationship between connectivity with the main channel and nutrient concentrations in backwater lakes?
4) How is connectivity related to vegetation abundance and diversity, and nutrient composition (N, P & C) of metaphyton plant tissue? Which nutrient(s) (N, P, and or C) does metaphyton tissue nutrient composition indicate is limiting for metaphyton growth?

<u>Expected results</u>

Comparative field survey

The proposed field work builds on initial work in the UMR which found evidence that abundant metaphyton occurred in areas of high nutrient concentrations and low DO concentrations (Sullivan, *in prep.*). The proposed comparative field survey will take a broader perspective, include substantially more sites, and include measurements that will provide insight into the mechanisms promoting high metaphyton abundance. We will explicitly examine the role of connectivity and sediment release in determining nutrient concentrations, the link between the resulting nutrient concentrations and metaphyton abundance, and the effects of metaphyton abundance on DO and on SAV abundance and diversity.

We will also examine N:P:C ratios in metaphyton tissue samples to investigate nutrient limitation of metaphyton in the UMR (Hall and Cox 1995, USEPA 2002). It is hypothesized that the nutritional status of metaphyton will change as a function of connectivity with flowing channels, internal loading, or point source inputs. More isolated (less connected) areas are known to have low inorganic N (Richardson et al. 2004) and this should be reflected in low N:C ratios. In addition, high dissolved P flux from sediments in backwater areas with low DO should result in a surplus of

P relative to N. It is hypothesized that metaphyton nutrient composition may provide an index for evaluating connectivity due to a gradient in inorganic N availability. Understanding factors influencing the growth and development of metaphyton and water quality will be important for the evaluation of nutrient impairment problems on the river and may provide a useful biological indicator for evaluating the response of flow introduction or flow removal (isolation) associated with natural and human-induced flow modifications (habitat restoration) in the river's floodplain. For example, flow introduction of nitrogen-laden river water into a nitrogen-limited backwater may have unintended negative consequences on water quality and contribute to eutrophication impacts.

Analysis of LTRMP WQ data

Existing LTRMP WQ data includes nutrient concentrations, DO concentrations, and visual estimates of metaphyton (in 2005 – 2008; see Methods) and vegetation. Thus, we will be able to use this data set to look at broad patterns in nutrients, DO, and metaphyton across the years in which LTRMP has collected data. Furthermore, connectivity to the main channel for all backwater sample sites can be quantified. Thus, we can use this data to address our proposed questions concerning the relationships among connectivity to the main channel, water column nutrients, metaphyton abundance and dissolved oxygen.

Analysis of LTRMP vegetation data

Existing LTRMP vegetation monitoring data will be analyzed to address how metaphyton is associated with SAV at three spatial scales (rake, site and backwater lake) and whether those scale-dependent associations have been relatively stable over the ten-year sampling period. We will also address whether metaphyton levels at smaller scales are influenced by SAV levels at larger scales (e.g., whether metaphyton levels at sites are more strongly associated with SAV levels at the site or at the larger lake scale). These results will help managers determine what fractions of variation in metaphyton levels are associated with the larger spatial scales at which remediation is easier. The results will help scientists because understanding the scales at which metaphyton varies most will improve our understanding of metaphyton and SAV dynamics.

We will then elaborate the above analyses to include lake connectivity and discharge. Adding these potential predictors will allow us to address whether we can treat metaphyton growth as amenable to flow manipulation. Failure to find associations with connectivity will imply that metaphyton levels are determined by and must be managed based on lake-specific issues (such as release of nutrients by benthic sediments). The analyses of LTRMP vegetation data will also help us determine whether the backwater areas selected for the companion field study (see above) were typical of other potential study areas in Pool 8.

Summary

The proposed research will synthesize results from a diverse and complementary set of approaches designed to answer important questions concerning the relationships among connectivity, nutrients, metaphyton and SAV. We will take advantage of the existing LTRMP vegetation and water quality data and field station infrastructure and expertise. The proposed work will benefit from, and integrate, metaphyton data analysis to be conduct by the Wisconsin Field Station (Shawn Giblin) as part of the LTRMP MSP. We have also added the intensive analysis of LTRMP vegetation data proposed by Brian Gray (UMESC) in order to broaden the spatial and temporal extent of our investigation of the relationships among connectivity, metaphyton and SAV. The inclusion of William James (Eau Galle ERCD laboratory) provides us with sediment analysis capabilities central to improving our understanding of nutrient cycling in the backwaters of the UMR. The participation and resource contributions of John Sullivan (WDNR) indicate the relevance of this work to management concerns on the UMR.

Methods

<u>Comparative field survey</u>

Data will be collected in 10 backwater areas selected along a gradient of connectivity (connectivity will be defined as proportion of backwater perimeter connected to channel because water residence time data do not exist). In each backwater area, we will follow standard LTRMP water quality and vegetation sampling procedures (Soballe and Fischer 2004, Yin et al. 2000). In addition, we will measure sediment chemistry, metaphyton tissue composition, and metaphyton presence/absence, biomass and coverage (Table 1). The number of sampling sites within each backwater area will vary among measurements (Table 1), but all sampling sites will be derived from the grid used in selecting LTRMP vegetation sampling sites (Yin et al. 2000).

All sampling sites in each backwater area will be sampled for all parameters once in mid- to late-July, the time of maximum metaphyton biomass. Additional water quality samples will be collected in early summer (mid- to late June), to identify initial conditions in each backwater area. A second vegetation sampling will be conducted at the 100 vegetation sites near the end of August to assess the effect of metaphyton on submersed vegetation within a single growing season. Water samples will be analyzed at the UMESC Water Quality Laboratory using the standard LTRMP protocols and the standard LTRMP in situ measurements will be made at each site (Soballe and Fischer 2004). Vegetation sampling will follow standard LTRMP methods (Yin et al. 2000).

Metaphyton abundance at each site will be determined by visual estimates of percent cover and quantitative measures. Specifically, metaphyton biomass measurements will be made at 20 randomly selected sites within each of the 10 backwater areas (following the site selection protocol of Yin et al. 2000). A qualitative rating of the relative abundance and cover of metaphyton type (algae vs. duckweed) will be made at each site within a 25- m ring around an anchored boat. A 20 cm diameter soil screen (0.5 mm mesh) will be used to collect a composite sample at three assigned locations around the boat (front, center-starboard, center-port) at each sampling site. The metaphyton dry weight will be determined for each composited sample. At a subset of the metaphyton sites, metaphyton tissue will be analyzed for C, N and P by the University of Wisconsin Soil and Plant Analysis Laboratory. Metaphyton samples dominated by filamentous algae will be preserved for identification. Supplemental measurements at metaphyton each site will include water depth, temperature, dissolved oxygen, pH, and turbidity. The results of the comparative field survey will address all four of the proposed questions.

<u>Sediment analysis</u>
Sediment cores will be collected from 3 sites from each of the selected backwater areas in Pool 8. Three sediment cores will be collected at each site. Two of the cores will be used for determination of N (as ammonia) and P (as dissolved P) release rates under oxic and anoxic conditions using established methods (James et al. 1995, James et al. 2008). The third core will be used for determination of sediment physical-chemical characteristics of the upper 10 cm sediment layer (Table 1). The P fractions selected for analysis represent exchangeable pools that can contribute soluble P to the overlying water column. A known volume of sediment will be dried at 105 ^{o}C for determination of moisture content and sediment density and ashed at 550 ^{o}C for determination of loss on ignition organic matter. Sediment total phosphorus, loosely-bound P, iron-bound P, alumninum-bound P, non-reactive P, and labile organic P will be determined using established methods (Plumb 1981, Hieltjes and Lijklema 1980, Psenner and Puckso 1988, Nürnberg 1988). Each of these fractions differs in their biological availability and distinguishing among them will substantially improve our understanding of P cycling in backwaters of the UMR. All sediment analysis will be performed by Bill James at the ERDC Eau Galle Aquatic Ecology Laboratory. The results of the sediment analysis will address Question 2 and Question 3.

<u>Analysis of LTRMP WQ data and supplemental metaphyton data</u>
Supplemental metaphyton data was collected coincident with the standard LTRMP summer SRS WQ data in Pools 4 (2007-2008), 8 (2005-2008), and 13 (2007-2008). These supplemental data consisted of visual estimations of duckweed and filamentous algae cover and density. These data will be analyzed in conjunction with the standard LTRMP WQ data to partially address Question 2 and Question. The LTRMP WQ component collects visual estimates of aquatic plant coverage, vegetation density, and vegetation type (e.g., submersed, emergent, etc). This existing data will be

used to partially address Question 1. In addition, we will use the full LTRMP water quality dataset (1993 through present) to address whether nutrient levels are associated with channel nutrient sources by comparing nutrient levels with connectivity for sampled lakes. The analysis of the supplemental metaphyton data will be conducted by Shawn Giblin (WI-DNR) as part of a 2009 MSP project (entitled titled "Evaluation of Relationships Between Metaphyton and Water Quality Characteristics in the Upper Mississippi River") and the results will be integrated with those from the other aspects of this project to provide more comprehensive answers to the proposed questions.

Analysis of LTRMP vegetation data

In addition to the field survey, we will address how metaphyton and SAV levels are associated (Question 1) by analyzing eleven years of LTRMP vegetation data in the context of a largely overlooked source of variation in the LTRMP databases—that of backwater lakes (Gray et al. 2007). Analytical methods will follow those used by Gray et al. (2007) and Li et al. (*in press*). We will look at metaphyton associations with SAV at three spatial scales (rake, site and backwater lake) and at whether those scale-dependent associations are consistent across the eleven year sampling period. We will also investigate whether metaphyton levels have been associated historically with connectivity, a surrogate for channel sources of nutrients (Question 2). We will adjust for sampling date (metaphyton levels change during the sampling season), for whether SAV levels in a given lake are high or not (highly connected lakes with high levels of SAV may have nutrient levels closer to those of a poorly connected lake), and annual changes in discharge.

Products and Milestones

Tracking number	Products		Milestones
2009APE3a	Draft completion report based on analysis of LTRMP water quality and vegetation data entitled "Associations between selected WQ variables, metaphyton, SAV and connectivity in backwaters as inferred from LTRMP data."		30 January 2010

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Table 1. Details of sampling plan.

Measurement	Number of sample sites in each of 10 backwater study areas	Specific parameters measured
Water quality	3	TP, TN, NO3-N, NH4-N, SRP, Si, chlorophyll, turbidity, dissolved oxygen, temperature, pH (Soballe and Fischer 2004)
Vegetation	10 sites each sampled twice. Once mid/late June and once late August	Standard LTRMP vegetation component measures of SAV abundance and diversity (Yin et al. 2000).
Sediment nutrient release	3	Ammonia N and dissolved P
Sediment chemistry	3	Moisture content (%), sediment density (g/mL), loss on ignition (i.e., organic matter content, %), total N and P, exchangeable N, loosely-bound P, iron-bound P, and labile organic P (all expressed at mg/g).
Metaphyton biomass, presence/absence, abundance	20	Dry mass (g m^{-2})
Metaphyton tissue composition	5	TP, TN, TOC, minerals

Principal Investigator: Jeff Houser

***Collaborators*:** John Sullivan, Shawn Giblin, Heidi Langrehr, Brian Gray; Jim Rogala, Bill James, Terry Dukerschein

Quantifying changes in landscape patterns of the UMRS in space and time.

Introduction/Background

The Upper Mississippi River System (UMRS) is both heterogeneous and dynamic. The UMRS is heterogeneous because natural and anthropogenic disturbances shape the river landscape in different ways and at different scales (i.e. watershed, river reach, pool). The UMRS is also dynamic, continually changing from one year to the next as a result of the same natural and anthropogenic disturbances. The contemporary view of many ecologists is that the dynamics of landscape heterogeneity, whether man made or natural, are fundamental, causal agents that drive the dynamics of ecological systems (Levin 1992, Wu and Loucks 1995, Tilman and Kareiva 1997, Illius and O'Connor 2000), and the UMRS appears to be no exception.

Ecologists typically characterize the heterogeneity of landscapes by the complexity and/or variability of the properties that comprise the system in space and time (Li and Reynolds 1995). Heterogeneity is commonly characterized by measures of composition and configuration (Gustafson 1998; Turner et al. 2001). While composition can be assessed by the proportion of the landscape in different cover classes or cover class diversity, measures of configuration require attention to the spatial organization of different habitats across the landscape. Empirical analyses of system composition and configuration have led to numerous insights into the ecological causes and consequences of spatial heterogeneity (Turner and Chapin 2005). For example, changes in landscape patterns influence the flux of matter, energy, and species (Pickett and Cadenasso 1995, Vitousek et al. 1997) through changes in nutrient cycling (Dale 1997), hydrology (Girel 1994), energy partitioning (Wylie and Currie 1993), and the availability of habitat for species (Law and Dickman 1998, Morris 1992, White et al. 1997).

However, complex long-term and large-scale effects of management and/or environmental change cannot be assessed with empirical analyses of landscape pattern alone. Complimenting analyses of empirical data with mathematical models can lead to a better understanding of the consequences of changes in landscape composition and configuration (Bolliger et al. 2007). By quantifying changes in landscape patterns for the purpose of model simulations, evaluations of alternative scenarios is possible (Lischke et al. 2007). The purpose of the work proposed here is to quantify changes in landscape heterogeneity of the UMRS and use the results to evaluate future system conditions under alternative environmental or management change.

Relevance of research to UMRS/LTRMP

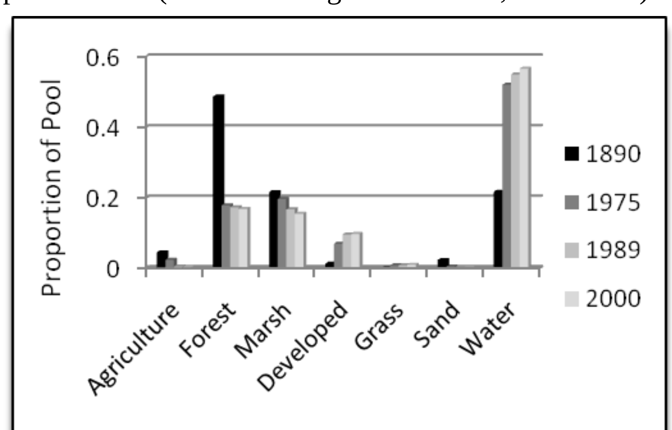
The Upper Mississippi River System (UMRS) has experienced a number of modifications since the 1800's (USGS 1999, WEST Consultants Inc. 2000, Theiling et al. 2000) but it is not our intent to summarize these modifications here. A substantial amount of work by personnel within the USGS and ACOE has revealed trends in the general ecological condition of the UMRS (USGS 1999), identified habitats in need of conservation and restoration (Theiling et al. 2000) and examined the cumulative effects of navigation projects (WEST Consultants Inc. 2000). From these studies it is clear that modifications to the UMRS have not occurred to the same degree across all portions of the river and that all portions of the river may not respond to disturbance in ecologically similar ways. However, no study has explicitly examined how the composition and configuration of the UMRS has changed over time and at different spatial scales in response to a century-long history of modification. In order to maintain the UMRS as a viable multiple-use large river ecosystem, LTRMP has identified a clear need for quantitative measures of landscape change; measures that can be used to evaluate the health of the UMRS, continue to monitor its condition, and forecast the effects of different management actions on future system conditions.

Methods

Landscape metrics
The most useful way to quantify spatial heterogeneity is based on data type (Allen and Hoekstra 1992, Dutilleul and Legendre 1993, Li and Reynolds 1995). The LTRMP has collected systemic land cover maps of the entire UMRS for the years 1890, 1975, 1989, and 2000. To quantify the relative heterogeneity of categorical maps, landscape ecologists typically use landscape metrics because of their ease to calculate with modern software (e.g. Fragstats 3.3) and because they are relatively easy to interpret (Bolliger et al. 2007). Landscape composition is typically assessed using metrics such as landscape diversity (Shannon's or Simpson's index) or the proportion of area occupied by different cover classes. Metrics of configuration include probabilities of patch adjacency, patch shape, or connectivity among patches and often reflect the degree of habitat fragmentation.

Using Fragstats 3.3 we calculated a few landscape-level composition metrics for Pool 8 of the UMRS from 1890-2000 (Fig. 1, Table 1). The results show a striking decline in the proportion of Pool 8 in forest and marsh habitat and a dramatic increase in developed area and open water (Fig. 1). These changes led to strong declines in both landscape diversity and evenness (Table 1). This indicates that Pool 8 in 2000 is heavily dominated by a single cover class, open water, as compared with data from previous years when the proportion of the landscape was much more evenly distributed across cover classes. Riverine landscape diversity has been suggested to influence a number of ecological and hydrological processes including: fluvial dynamics, disturbance regimes, and species diversity (Ward et al. 2002).

We also used Fragstats 3.3 to calculate a couple of class-level configuration metrics (Fig. 2). The results show an initial increase in patch density for forest and marsh habitat from 1890 to 1975 and 1989, followed by declines in patch density in 2000. In contrast patch density of developed land and open water declined over time (Fig. 2). These changes in patch density led to a larger degree of class aggregation in 1890 and 2000 for forest and marsh habitats as compared with 1975 and 1989 and monotonic increases in aggregation of developed land and open water. These results indicate an initial increase in fragmentation of forest and wetland habitat followed by a reversal of this trend in 2000 and continuous declines in the fragmentation of urban areas an open water. Fragmentation of natural habitats such as forests and wetlands reduces the dispersal success of organisms and patch colonization rates which may eventually lead to population declines and increased extinction probabilities (With and King 1999 a and b, With 1999).

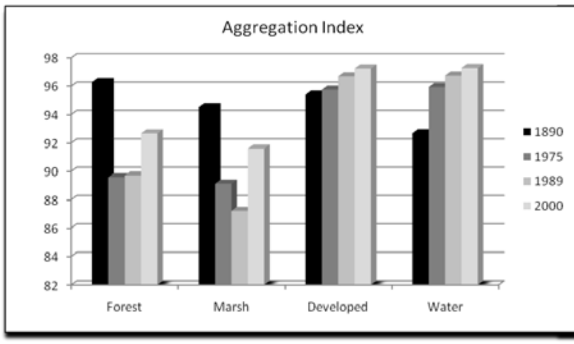


Landscape Composition Metrics

	Simpson's Diversity Index	Simpson's Eveness Index
1890	0.6671	0.8005
1975	0.6539	0.7629
1989	0.6313	0.7365
2000	0.6182	0.7212

Figure 1 and Table 1. Landscape-level composition metrics of Pool 8 UMRS, 1890-2000

With Fragstats 3.3, we have the capacity to calculate hundreds of composition and configuration metrics at the patch, class, and landscape-levels. However, our preliminary calculations have revealed that many metrics are correlated. In order to develop a few key landscape measures requires an analysis of the correlation among metrics and the removal of metrics that provide redundant information. We will use the methods outlined in Riitters et al. (1995) to develop measures of landscape change that are orthogonal to each other and hence provide very different information from each other. These metrics can then be used as quantitative measures of landscape change of the UMRS from 1890-2000.



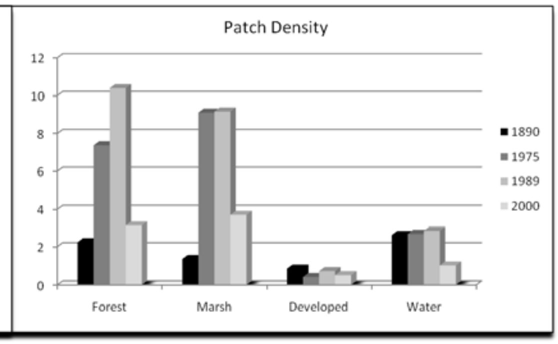


Figure 2 and 3. Class-level configuration metrics for Pool 8 UMRS, 1890-2000.

The degree of landscape change doesn't appear to be consistent across every pool of the UMRS, nor have changes been consistent across the major reaches of the UMRS. Therefore, we intend to calculate metrics for 1) the entire UMRS, 2) the four major floodplain reaches, 3) the 12 geomorphic reaches, and 4) each pool. This analysis will help us identify particular areas or scales that have changed more or less relative to other areas or scales. We are particularly interested in determining relevant scales where we can detect landscape changes due to habitat restoration projects and other management actions, both within pools and in other areas of the watershed.

Markov matrices of landscape change

Although much can be learned from the type of empirical analyses described above, such analyses do not allow for reliable forecasts of future landscape composition and configuration. Such forecasting is needed to evaluate different management actions and predict the effects of future environmental conditions on landscape structure and function. Markov transition matrices are commonly used to model and forecast changes in the composition of a series of GIS maps comprised of different cover classes (Pastor et al. 1993, Caswell 2001, Bolliger et al. 2007, Pastor 2008). For any two sets of maps separated by some time interval, the change of each pixel state can be summarized with a transition probability matrix. The underlying mathematical theory of Markov models can be found in Caswell (2000) and its application to population and ecosystem dynamics can be found in Pastor (2008). Our intent here is not to review these topics but instead to provide an example of how Markov matrices can be used to predict future changes in the UMRS. Our previous analysis of the changes in the proportion of Pool 8 in different cover classes revealed a loss of forests and marsh habitat and an increase in developed area and open water (Fig. 1) leading to overall declines in landscape diversity (Table 1). But using Markov matrices, we can further speculate as to what the stable distribution of land cover classes would be if future transition probabilities remained constant and equal to the transition probabilities between 1975-1989. As shown in Fig. 4, if transitions probabilities in the future are equal to 1975-1989, we will see a continual decline of forest and marsh habitat and a continual increase in developed area and open water. But what if future transition probabilities are constant and equal to those from 1989-2000? Now in Fig. 4, we find much less forest and marsh habitat loss, much less increase in developed land, and a greater increase in open water. The differences in the stable state distribution of classes from 1975-1989 to 1989-2000 reflect the sum of all management and physical and biological disturbances to Pool 8 across those time periods. The results suggest that major changes have taken place in the rate at which forest and wetland habitats have been lost in Pool 8. Perhaps even more changes have taken place since 2000 to conserve and restore these habitats?

The advantage of Markov matrices is that their mathematics do not depend on the scale of the resolution of the data (Pastor et al. 1993). Therefore, Markov matrices provide a simple tool for assessing environmental or management actions across several different spatial scales and time periods. We therefore wish to examine differences in transition probabilities and resulting stable state land distributions between 1975-1989 and 1989-2000 and compare these trajectories to maps from 1890 for the same four spatial scales as the work described above. This will constitute the single most extensive review of land cover changes of the UMRS across several orders of magnitude differences in spatial scale. The results will provide managers with predicted future land cover distributions given scenarios of 1975-1989 and 1989-2000. We can ask a myriad different questions about the temporal and spatial scales at which we document the greatest change in land cover, or about the rate of change of land cover. We can also investigate the relationships among transition probabilities for different cover classes and specific landscape metrics. For example, does the degree of habitat fragmentation influence the probability of transition from one class to another class?

Spatio-Temporal Markov Chains

The advantage of Markov models is that they allow for evaluations of alternative scenarios for system conditions under past and future management change. But Markov models only represent spatially implicit temporal processes and summarize these processes as compositional metrics. To make a Markov model spatially explicit and model temporal changes in landscape configuration, a cellular automata (CA) (Balzter et al. 1998) is often combined with a Markov chain to create a Spatio-temporal Markov chain (STMC). A CA replicates a Markov transition matrix over a spatially explicit data set (such as the LTRMP GIS land cover maps). We wish to develop a STMC that can be used to evaluate the influence of different environmental and management changes on landscape configuration. We can then use the same methods described above (e.g. Fragstats 3.3) to quantify and compare future landscape composition and configuration with those of the past. We envision preparing this work as a web-based decision support system.

Broader Impacts

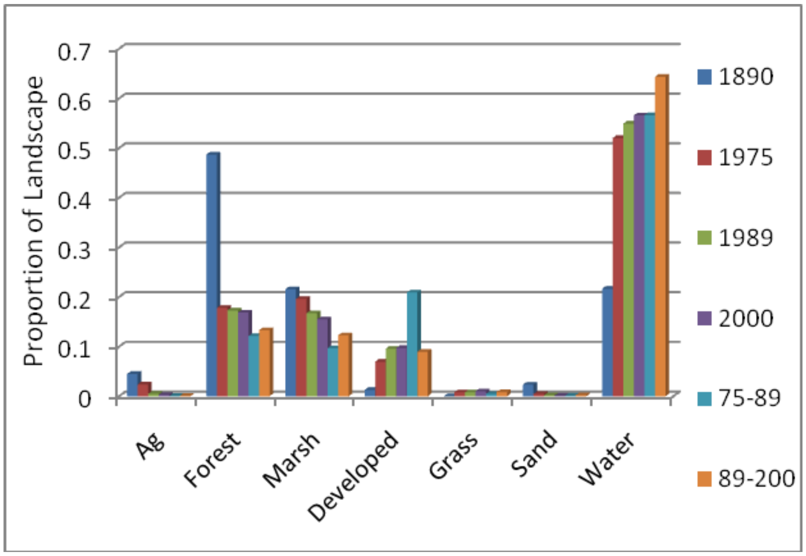


Figure 4. Past and future composition of Pool 8, UMRS, 1890-2000 and future scenarios based on changes from 1979-1989 and 1989-2000.

The focus of this proposal has been to describe the methods for quantifying landscape change of the UMRS and to use the results to forecast future changes and evaluate alternative management scenarios. This work will identify metrics that can be used as indicators of landscape change in response to management and restoration practices. Furthermore, any study of the causes and/or consequences of landscape patterns can only be conducted after temporal trends in landscape patterns have been quantified. Therefore, characterizing landscape patterns, as we have proposed here, is the starting point for additional cross-component pattern-process relationship studies.

Timeline/expected products

We anticipate preparing our work for publication in peer-reviewed journals such as *Ecological Indicators* and *Landscape Ecology*. The calculation of landscape metrics to derive measures of land change and the description of temporal changes in these measures will be prepared as a single manuscript to be completed by late summer 2009. The Markovian analysis of land change will also be prepared as a single manuscript by late summer 2009. Future work includes the construction of the STMC during late summer 2009 with expected completion as a web-based decision support system during winter 2010.

Products and Milestones

Tracking number	Products	Milestones
2009APE4a	Draft manuscript: The calculation of landscape metrics to derive measures of land change and the description of temporal changes in these measures	30 September 2009
2009APE4b	Draft manuscript: Markovian analysis of land change	30 September 2009

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Principal Investigators: Nathan DeJager

Restoration of Specific Monitoring Elements to the LTRMP

Submitted By:

LTRMP A-team

Committee:
John Chick – Illinois Natural History Survey
James Fischer – Wisconsin Department of Natural Resources
Robert Maher – Illinois Department of Natural Resources

We propose the following monitoring activities be restored for fiscal year 2009:

1. First time period of fish monitoring will be conducted at Pool 13, Pool 26, the La Grange Reach and the Open River Reach.

2. Fixed site water quality monitoring will be restored to Pool 4 and Pool 8 as outlined below.

Objectives

We believe that restoration of the monitoring activities described above will yield multiple benefits to the program, the most important of which likely will be realized in extensive analyses for monitoring program data from the early 1990's to 2009 (when MSP is set to expire). For the purposes of this proposal, however, we will focus on questions and products that can be realized on an annual time frame in accordance with the APE format. For fish monitoring, we will examine the dominant species, defined as the group of species that accounting for the majority (75%) of individuals captured across all four field stations, to address whether strong year-classes were produced. To assess the status of young-of-the-year production for each of the dominant species, a length interval corresponding to YOY will be defined based on comparisons of length data among time periods and mean CPUE and standard error intervals for this YOY length interval in period 1 will be compared to previous years (1994 to 2004) to assess the status of year classes strength (strong - higher mean, non-overlapping standard error; weak – lower mean, non-overlapping standard error, or average – overlapping standard error).

For the water quality component, we will focus on the UMRCC light criteria recommendation, and examine differences in the assessment of this criteria based on monthly versus biweekly monitoring. The effect of monthly versus biweekly monitoring on the outcome of the criteria is unknown and should be evaluated, along with the management recommendations that would arise from application of the UMRCC light criteria. Assessment of underwater light conditions will be made based on secchi disk depth, suspended solids, and turbidity at fixed stations for the growing season (May 15-Sept 15) based on (1) biweekly sampling data and (2) monthly data by dropping the extra sampling events from analyses. A historical analysis of underwater light conditions will be made for select sites to evaluate changes in light penetration through time.

The following fixed-sites are therefore proposed for restoration at two of the LTRMP field stations:

Field Station 1 (Lake City):
1. Restore bi-weekly, fixed-site water quality monitoring in Pool 4 during the summer period by adding 4 more days of sampling (two 2-day sampling episodes – one in July and one in August), resulting in bi-weekly coverage from April through August. 4/7/2008
2. Restore monitoring to 6 historical sites in Pool 5 from April through August. This would not result in any additional field days, as the sites would be sampled on the same trips as for the existing sites.

Field Station 2 (La Crosse):
1. Restore bi-weekly, fixed-site water quality monitoring in Pool 8 during the summer period by adding 4 more days of sampling (two 2-day sampling episodes – one in July and one in August), resulting in bi-weekly coverage from April through August.
2. Restore bi-weekly monitoring to 4 historical fixed-sites in Pools 8 and 9 from April through August. This would not result in any additional field days, as the sites would be sampled on the same trips as for the existing sites.

Site details, including rationale and some of the specific intended uses of the data are listed in Table 2.

Table 2. Specific locations and rationale for restored monitoring

Field Station	Pool	Location	Rationale and Specific uses of the data
Lake City	4	Existing sites	Bi-weekly sampling June-August to capture low-flow periods. Fish kills and nuisance algal blooms have occurred during a drought period.
La Crosse	8	Coon Creek	High sediment concentrations input to Pool 8 from a watershed with historic management efforts. Output above Pool 8 HREP phase III, stage 1.
La Crosse	9	Bad Axe River	Tributary to Pool 9 where several HREP projects are in planning stages. Pool 9 has also been selected by the Water Level Management Task Force for drawdown
La Crosse	9	Upper Iowa River	Tributary to Pool 9. The Upper Iowa River delta has been selected by the FWWG for an HREP project, and several others within Pool 9 are in planning stages. The Water Level Management Task Force has also selected Pool 9 for future drawdown
La Crosse	9	Reno Spillway	Output for Pool 8/Input to Pool 9. Embankment projects are in planning stages (NESP or other) that will affect Reno Bottoms in Pool 9. Water quality reflects the impounded portion of Pool 8 where the Pool 8 HREP Phase III islands will be built immediately upstream of this site, changing the sediment re-suspension dynamics. Site is also influenced by the sediment-rich Root River and HREP islands may change associated sediment movements

Products and Milestones

Tracking number	Products	Staff	Milestones
2009R1	Draft completion report, compilation of 3 years of sampling	Team Leaders	15 June 2010

Visualization Tools

Acquisition of 3-D Software

One of the new technologies being implemented in vegetation mapping is the interpretation of digital aerial photography using photogrammetric software and high-definition stereoscopic monitors. In order for the digital photography to be viewed in stereo and usable for mapping, a software package is needed to allow us to create digital stereo models of the aerial photography. The stereo models will allow the digital aerial photography to be viewed and photointerpreted on-screen in stereo or 3-D, in much the same manner as traditional stereoscopes have been used to interpret analog film. Since the digital aerial photography is already georeferenced to the earth within a couple of meters, all photointerpretation derived from these images is likewise georeferenced and just as accurate. This process eliminates several steps in the typical spatial data production workflow while maximizing efficiency and accuracy. Having this ability will be necessary for the interpretation of the 2010 systemic imagery so that tree heights can be accurately identified and labeled, and areas such as lowlands vs. uplands types can be correctly identified. Using the digital stereo models for on-screen photointerpretation minimizes the time and costs associated with preparing and editing GIS data while still maintaining the high accuracy of the data.

Creating Squarified Tree Mapping Tool to Determine if Quantitative Goals Are Being Met

Introduction/Background

The focus of this project is developing a web based graphing tool that can display squarified tree maps based of the Long Term Resource Monitoring Program's database. Tree maps area a great way for showing overall pictures while also providing ways to get very detailed information about specific areas of interest. The goal here would be to create a tool that would be flexible enough to display various data queries that would show if management goals are being met. Initially I'm leaning toward using the findings from the 2008 APE project "Setting quantitative fish management targets for LTRMP monitoring" by John Chick, Greg Sass and Brian Ickes projected to be completed in early 2009 and status and trend information from throughout the LTRMP programs history.

Relevance of research to UMRS/LTRMP

This tool although not a fix all for determining needs and problem areas of the Upper Mississippi River system would with the proper data indicators give an overall picture of positive and negative trends going on at the pool level. For example instead of looking at a hundred different graphs of fish species trends a tree map can display all of the species on one image indicating each individual trend with the ability to drill down to more specific data on individual species if needed. This should save time and be a more intuitive way of looking at reviewing status and trends data.

Methods

The first thing that will have to be done is the actual development of the web based tee mapping tool. This will be done with the web technology Java Applets which provides maximum flexibility for displaying graphics in a web browser. The best way to kind of visualize the tool I'm proposing is to look at an example of one in use today, like this one from Smart Money Corporation (http://www.smartmoney.com/map-of-the-market/ which displays changes in stock prices over a period of time; this one is set to daily. The nice thing about the tree map is that from one quick glance you can determine the overall trend of the entire target area while determining which areas are actually doing worse than others, in this example green is good and red is bad. Each individual square or rectangle is an individual stock and by clicking on the square you can then retrieve more detailed information or report on that individual stock.

The trick is to take this concept but plug in Long Term Resource Monitoring Data and how to format the chart to give the maximum benefit to managers. Once the tool is complete the next step would be to determine a couple of different data queries that can be fed into the tool initially. Like I mentioned above I would initially be looking at displaying status and trend data over the life of LTRMP and also possibly using the results of the John Chick 2008 mentioned in the introduction. The goal would be that the tool once completed will not have to change but overtime as better indicators for management becomes available or clearer, data sources feeding into the tool could be added or modified with little effort.

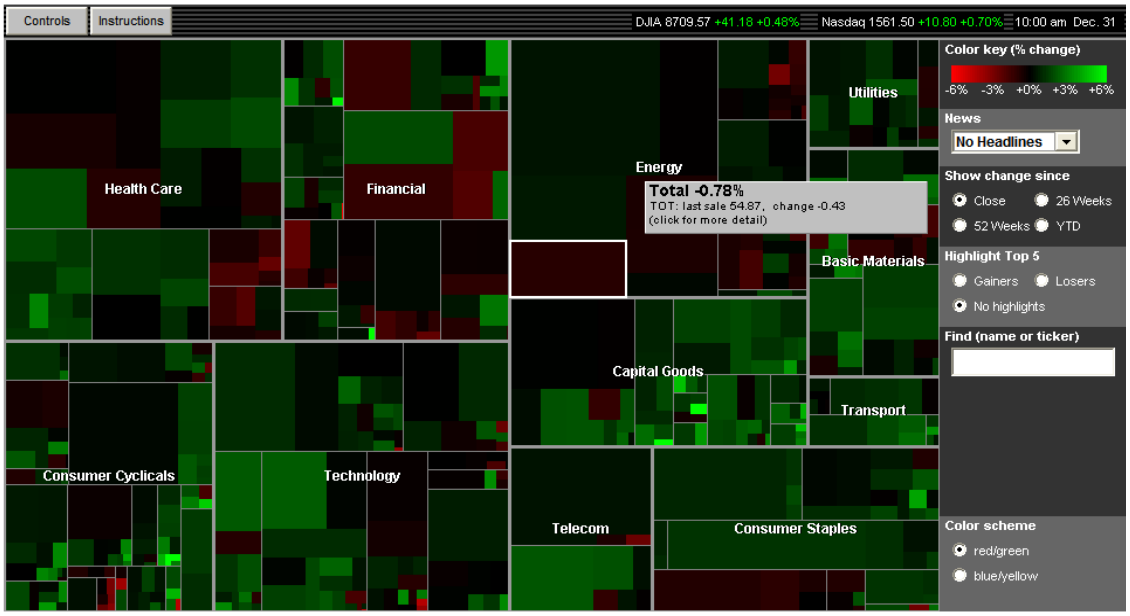

Image of Smart Money Web Application

Products and Milestones

Tracking number	Products	Milestones
2009APE6a	Active Web tool running with a couple of initial data queries	30 December 2009

Principal Investigator: Ben Schlifer

Redesign of Long Term Resource Monitoring Program Web pages to enhance communication of information on the Upper Mississippi River System

Critical to the success of Long Term Resource Monitoring Program (LTRMP) is providing targeted, easily accessible, and usable information to individuals regarding the Upper Mississippi River System. Communicating information from the LTRMP to a wide array of audiences, from LTRMP field technicians, Program advisors, scientists and river managers, politicians, and the general public is a very daunting task especially since these audiences have divergent information needs. In addition to numerous presentations given at regional and national scientific meetings, there are more than 300 scientific reports, graphical data browsers (summarizing multiple years of fish, water quality, and vegetation data), and the LTRMP land cover viewer (which allows users to quickly create maps of the Upper Mississippi River Land Cover data) available to all. Even with this vast amount of information, there is still a perception that the Long Term Resource Monitoring Program is “data rich, information poor”. One tool to help eliminate this perception is the use of the World Wide Web to communicate information.

Currently, the LTRMP Web pages hold a massive amount of data and information aimed at serving the variety of needs of all the aforementioned audiences. This often makes it difficult for users to easily find the information available to meet their needs. The objective of this project is to redesign the LTRMP Web pages to improve the delivery of LTRMP information and increase user-friendliness.

Products and Milestones

Tracking number	Products	Milestones
2009APE7a	Beta-version of redesigned LTRMP Web pages	30 December 2009

Principal Investigators: Jennifer Sauer and Jim Rogala

Field Equipment Refreshment

Investment in equipment refreshment over the past several years has been sporadic due to limited annual budgets. Equipment refreshment was identified by the partnership as a priority under the completed 5-year planning effort, with a minimum investment of $ 57,000 annually.

Field Station	Equipment
Lake City	18 ft Alum. Boat
Lake City	Boat Trailer
Lake City	WQ Multiprobe Logger
La Crosse	Ruggedized Field Laptop Computer
La Crosse	Outboard, 115 HP
La Crosse	Float Coat
La Crosse	Electric Winch for airboat
La Crosse	Iceman boots-3 pairs for winter wq
Bellevue	Airboat
Great Rivers	125 4Stroke motor (WQ boat)
Great Rivers	Water Velocity Meter (Fish)
Open River	Ruggedized Field Laptop Computer
Open River	GPS3+ (2)
Open River	Digital Camera
Open River	Survival suit
Open River	Garmin 168 Mapsounder (2)
Open River	Ohaus scale
La Grange	21' V Bottom Boat
La Grange	Boat Trailer for 21' Kann
La Grange	115 hp outboard
La Grange	Ruggedized Field Laptop Computer

Field Meeting

To foster communication between USGS UMESC and state field station staff, a joint meeting of all staff will be held in FY2009. Topics covered will include introduction of staff (new and old alike), highlight of work activities, review of sampling procedures, and collection of a suite of monitoring data.

LIDAR Acquisition and Processing

High resolution topographic data has regularly been identified as a high priority data need for improved ecosystem restoration and management. As mentioned in the 2000 UMRS Habitat Needs Assessment Report, this information is critical to improving our ability to forecast successional change of UMRS floodplain habitats. The elevation information will enhance restoration project planning and design by allowing the ability to more accurately model hydrologic regimes and system connectivity. Characteristics of inundation frequency, groundwater elevation and geomorphology can also be captured and modeled. Recent advances in remote sensing technology now allow for timely and affordable collection of high resolution topographic data. Light Detecting and Ranging (LIDAR) equipment uses aircraft mounted lasers too quickly and accurately measure ground elevation to within 6 inches which is considered its absolute accuracy

Product Description

The topographic information is served in several formats including raw x, y, z point ASCII text, one meter digital elevation models (DEMs), and two foot contour maps. When combined with existing bathymetric data, this information would generate a seamless topographic surface for the entire UMRS floodplain allowing researchers and planners to model and compare multiple water management scenarios.

Acquisition (contract award)

LIDAR data collected for this project will meet FEMA specifications. These specs, available on the FEMA web site (http://www.fema.gov/plan/prevent/fhm/lidar_4b.shtm), include 1.4 meter postings processed and filtered suitable for generation of 2-foot contours at a 95% confidence interval. Data will be flown in the fall of 2009 during leaf off and low water conditions to ensure collection of the most accurate and comprehensive data. The area to be flown will be from Lock & Dam 24 to River Mile 0 at Cairo, IL. Data acquisition will occur in FY10.

Processing & Serving

The data for the LTRMP area of interest (blufftop-to-blufftop for Navigation Pools 8–14 and 20–24) delivered in the standard LAS-format files (includes multiple-returns). These data will then be served by UMESC as zipped ASCII XYZ (easting, northing, and elevation), 1-meter and 5-meter DEMs in signed-TIFF format, and first-return and bare earth hillshades. Other products such as triangulated irregular networks (TINs) and contour lines can be generated and delivered upon request. Pools 15–19 will be flown in spring of 2009 with data delivery prior to end of FY 2009. Generation and serving of LIDAR-derived products from Pools 8–24* will be completed. This will be a collaborative effort among USGS, USACE, and the Iowa DNR.

Products and Milestones

Tracking number	Products	Staff	Milestones
2009LID1	LIDAR Data Acquisition Contract	Hagerty	30 September 2009
2009LID2	Servable LIDAR data of Pools 8–24*	Robinson	30 September 2009

Personnel

Karen Hagerty and Larry Robinson

*data delivery permitting; Pools 15–19

Operational Planning Ramp-Up

Areas of work:

1. Integration of bathymetry and LIDAR, Pools 8 and 13

   Methods will be assessed to develop a seamless elevation layer using LIDAR and bathymetry coverages. Data from Pools 8 and 13 will be used as test cases. If a functional process is developed, seamless elevation layers will be developed in early FY10.

Products and Milestones

Tracking number	Products	Staff	Milestones
2009OP1	White paper on methods assessment	Rogala	30 September 2009

2. The current annual time frame for Additional Program Element projects will be replaced with 5-year focused research plans for five priority research areas (see below) that can be implemented as funding and opportunities allow. In Fy09 work will begin in development of an overarching science management plan and mussel research plan.

Products and Milestones

Tracking number	Products	Staff	Milestones
2009OP2	Detailed outline for Science Management Plan	Johnson	30 September 2009
2009OP3	Detailed outline for Mussel Research Plan	Newton	30 September 2009

Assessment and Training for the 2010 Systemic Land Cover/Land Use Acquisition and Processing

With the advent of new technologies, the procedure for acquiring and processing the LTRMP 2010 LC/LU is changing. To ensure a high quality product and one comparable to earlier coverages, we will begin assessment and training on a number of fronts in 2009. Final training on procedures will occur in 2010.

Assess resolutions necessary for mapping a variety of land cover types.
Pools above Lock & Dam 13 contain numerous backwaters and emergent aquatic vegetation that makes up a large percentage of the overall land cover. A medium format digital camera does not natively collect imagery at a "scale", but at a resolution, typically between 1-inch per pixel and 24-inches per pixel. The higher the resolution, the lower the plane must fly, and the more flight lines will be needed to cover a given area. Based on scanned and orthorectified 9X9 analog film, we estimate that 6- to 8-inches per pixel should be sufficient to identify plant species and map complex aquatic vegetation to the 31-Class level. For Pools that are less complex and comprised largely of agriculture and urban environments, 12- to 15-inches per pixel should provide the level of detail needed to map to the 31-Class level.

To verify these projections, we propose to fly examples of each type at resolutions from 1-inch per pixel to 20-inches per pixel and determine which resolution is the best compromise between the detail required for vegetation classification and the amount of time and storage space required to collect the imagery. Flying the entire system at 3-inches per pixel would take many months and be overkill for what the systemic LCU data set intends to provide.

Assess multiple flying conditions.
Sun angle, wind conditions, haze, and clouds all contribute to how good or bad aerial photography is to work with and analyze. Since the sensors in digital cameras are capable of capturing more "bits" of information (8-bit for analog versus 12 or 14-bits for digital), they can collect useful imagery in a wider range of conditions. This testing will determine how early or late photography can be acquired and if a particular collection time offers better contrast between vegetation types or deeper water penetration for classifying submersed vegetation.

Assess accuracy of georeferenced aerial photography.
Software provided with the digital camera is capable of generating various levels of accuracy, depending on how the imagery is processed or post-processed. The imagery can be processed with standard GPS XYZ (easting, northing, and elevation), XY with background DEM, or differentially-corrected GPS and LIDAR-derived background DEM. Each process adds time to the final product, but makes a difference whether the imagery is accurate to within a couple of meters or within a couple of inches.

Assess the accuracy and resolution of floodplain LIDAR (If time allows)
Differentially-corrected GPS can improve the XY accuracy of digital photography to within inches. Test flights over various terrains can provide insight into the resolving power of LIDAR as well as its XY accuracy. If the imagery is of suitable resolution and is viewed in stereo, small swales and ridges will be apparent and their presence or absence on the LIDAR data can be noted. The LIDAR for Pools 8-24 contain first and last returns and may be used to determine the height and density of forest stands, and potentially species. A spring flight prior to leaf-out and another flight of the same area in the fall can help determine if there are landscape patterns that can predict certain species over others.

Products and Milestones

Tracking number	Products	Staff	Milestones
2009LCU1	Draft contract report: All photography and LIDAR testing will be documented and referenced for the 2010 systemic flight.	Dieck and Robinson	27 February 2010
2009LCU2	Presentation to the EMP Partnership on LC/LU procedures. To include time table on process, classification system, and field verification.	Robinson	21 May 2009

Appendix A: FY09 Budget Summary

FY 2009 BUDGET SUMMARY

		POC	FEDERAL	NON-FEDERAL	COE	TOTAL
MSP	Aquatic Vegetation Sampling	Yin	$ 275,671	$ 243,992	$ -	$ 519,663
	Fisheries Sampling	Ickes	$ 271,952	$ 939,609	$ -	$ 1,211,561
	Water Quality Sampling	Houser	$ 573,264	$ 862,820	$ -	$ 1,436,084
	Statistical Evaluation	Gray	$ 124,716	$ -	$ -	$ 124,716
	Data Management	Rood	$ 390,553	$ -	$ -	$ 390,553
	Science Management Support	Cntr Mgmt	$ 348,185	$ -	$ -	$ 348,185
	Bathymetric Component	Rogala	$ 20,725	$ -	$ -	$ 20,725
	Land Cover/Use	Robinson	$ 168,289	$ -	$ -	$ 168,289
				$ -	$ -	$ -
			$ 2,173,355	**$ 2,046,421**	**$ -**	**$ 4,219,776**
APE's	APE1 - Changes in landscape patterns	De Jager	$ 62,328			$ 62,328
	APE2 - River nutrient concentrations on metaphyton	Houser	$ 51,820	$ 16,433	$ 45,300	$ 113,553
	APE3 - Unionids movement	Newton	$ 55,804	$ 10,300		$ 66,104
	APE4 - Pools 5 & 8 water level menagement drawdowns	Yin	$ 94,349			$ 94,349
						$ -
						$ -
						$ -
						$ -
			$ 264,301	**$ 26,733**	**$ 45,300**	**$ 336,334**
LIDAR	LIDAR data acquisition				$ 400,000	**$ 400,000**
Travel	EMPCC travel		$ 4,422			**$ 4,422**
	Corps Technical Support				$ 50,000	**$ 50,000**
Travel	Field Meetings		$ 5,000	$ 9,740	$ -	**$ 14,740**
Field Equipment	Field equipment		$ 8,820	$ 68,897		**$ 77,717**
APE	APE management		$ 42,476			**$ 42,476**
Operational Planning	Meeting attendance		$ 19,163	$ 1,000		**$ 20,163**
Tools	Visualization tools	64,835	$ 64,835		$ -	**$ 64,835**
	3-d software	29,481				
	Sqarified tree maps	14,349				
	Redesign of LTRMP Web pages	21,005				
LIDAR	LIDAR processing and serving		$ 25,371		$ -	**$ 25,371**
Pubs	Pub hub		$ 5,159			**$ 5,159**
Restored monitoring	Restored monitoring		$ 12,692	$ 34,917		**$ 47,609**
sub-total	Technical APE and support total		$ 187,938	$ 114,554	$ 450,000	$ 752,492
Science Planning	Operational Plan		$ 91,398			$ 91,398
LC/LU training	GIS		$ 60,000			$ 60,000
FY09 LTRMP TOTAL			**$ 2,776,992**	**$ 2,187,708**	**$ 495,300**	**$ 5,460,000**
Other items:						
LTRMP/HREP integration			**$ 70,000**	$ -	**$ -**	**$ 70,000**
UMESC Tech spt for Report to Congress			**$ 20,000**	$ -	**$ -**	**$ 20,000**
GRAND TOTAL			**$ 2,866,992**	**$ 2,187,708**	**$ 495,300**	**$ 5,550,000**