

**Strategic Plan for the
Long Term Resource Monitoring Program
on the Upper Mississippi River System,
FY 2010-2014**

Endorsed by the Environmental Management Program
Coordinating Committee

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Strategic Plan for the Long Term Resource Monitoring Program on the Upper Mississippi River System, 2010 – 2014

Executive Summary

“The mission of the Long Term Resource Monitoring Program is to support decision makers with the information and understanding needed to maintain the Upper Mississippi River System as a viable multiple-use large river ecosystem.”

The Long Term Resource Monitoring Program (LTRMP) was created over 20 years ago as part of the Environmental Management Program (EMP). The LTRMP consists of a comprehensive program of monitoring, research, and data management that provides critical information about the status and trends of key resources. LTRMP information is used extensively by resource managers, planners, administrators, scientists, academics, legislators, and the general public for improved understanding, problem solving, and informed decision-making about issues important to the UMRS.

This strategic plan identifies a set of broad priorities for 2010-2014 selected from a broader universe of possibilities. It defines a larger program than the current LTRMP, but out of necessity does not identify all potential partnership information needs. In addition to the core elements of monitoring, research, and data management, this plan addresses important new information needs resulting from data gaps that have been identified as our understanding of the ecosystem improves. Implementation of this strategic plan will be accomplished through the development of a companion effort known as an operational plan, which will provide the implementation details.

The actions presented in this plan are essential to addressing those information needs, understanding the river ecosystem, and helping decision makers make informed choices. Many elements of the plan build upon other elements and should be sequenced (e.g., research is needed to define mussel sampling methods before a monitoring procedure can be established) to help inform future budget decisions. In addition, maintaining professional staff, facilities, and equipment is essential to continuing LTRMP's reputation for state of the art science and data delivery.

This plan also provides a link to the newly authorized Navigation and Ecosystem Sustainability Program (NESP), which integrates ecosystem restoration and navigation efficiency on the UMRS. Restoration goals have been established jointly under EMP and NESP and focus on ecosystem process, function, structure, and composition. The LTRMP is ideally suited to aid in the development and tracking of key indicators that will document progress towards those goals. This will ultimately lead to a better understanding of the ecosystem services provided by the UMRS. In addition, LTRMP data can aid in planning and evaluating habitat restoration projects following an adaptive management framework proposed by NESP.

Outcome 1: Enhanced knowledge about system status and trends

Output 1.1: Status and trends information based on long-term data sets for aquatic vegetation, water quality, fish, and land use/land cover.

Output 1.2: Indicators of success at system, floodplain reach, and geomorphic reach-scales based on system goals and objectives.

Output 1.3: Additional information for status and trends knowledge regarding mussels, bathymetry and floodplain elevation, floodplain forest, and invertebrates.

Output 1.4: Data collected at spatial scales that are appropriate to monitor progress toward meeting system and reach goals and objectives.

Outcome 2: Enhanced knowledge about system process, function, structure, and composition

Output 2.1: Insights about river process, function, structure, and composition based on long-term data sets.

Output 2.2: Information generated from focused research agenda on setting management objectives and defining indicators, aquatic vegetation, mussels, floodplain connectivity, and landscape patterns.

Output 2.3: Decision support tools (e.g., models of system structure and function) to facilitate improved scientific understanding and restoration management.

Output 2.4: Operational framework for adaptive management that clarifies relationships at multiple scales among past, present, and future adaptive management projects.

Outcome 3: Enhanced use of scientific knowledge for implementation of ecosystem restoration programs and projects

Output 3.1: Use LTRMP infrastructure, data sets, and expertise to help formulate, design, and evaluate ecological restoration projects.

Outcome 4: Enhanced ecological understanding to inform decisions

Output 4.1: Key decisions are informed by LTRMP data, research, and decision support tools.

Output 4.2: Key decision makers are satisfied with LTRMP information and decision support system.

Strategic Management of LTRMP Organizational Resources

Strategy 1: Effectively manage LTRMP data and information by maintaining information technology systems, enhancing water quality software, providing user-friendly interface for web based library and query tools, expanding data clearinghouse functions, and extending data catalogue functions.

Strategy 2: Effectively manage LTRMP personnel and facilities by creating a workforce plan that provides direction for staffing roles and responsibilities and professional development, maintains facilities, and utilizes the equipment refreshment plan to maintain equipment.

Strategic Plan for the Long Term Resource Monitoring Program on the Upper Mississippi River System, 2010-2014

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The actions presented in this plan are essential to addressing those information needs, understanding the river ecosystem, and helping decision makers make informed choices. Many elements of the plan build upon other elements and should be sequenced (e.g., research is needed to define mussel sampling methods before a monitoring procedure can be established) to help inform future budget decisions. In addition, maintaining professional staff, facilities, and equipment is essential to continuing LTRMP's reputation for state of the art science and data delivery.

This plan also provides a link to the newly authorized Navigation and Ecosystem Sustainability Program (NESP), which integrates ecosystem restoration and navigation efficiency on the UMRS. Restoration goals have been established jointly under EMP and NESP and focus on ecosystem process, function, structure, and composition. The LTRMP is ideally suited to aid in the development and tracking of key indicators that will document progress towards those goals. This will ultimately lead to a better understanding of the ecosystem services provided by the UMRS. In addition, LTRMP data can aid in planning and evaluating habitat restoration projects following an adaptive management framework proposed by NESP.

Outcome 1: Enhanced knowledge about system status and trends

Six study reaches are monitored annually by LTRMP (Figure 1). Standardized monitoring in these six reaches provides valuable information over the wide range of environmental and human-use gradients that exist in the UMRS. The multi-component and multi-habitat sampling design provides data on a broad range of environmental conditions and on biota at both community and species levels. Current monitoring protocols for water quality, aquatic vegetation, fish, and land cover continue to build upon a historic database that now spans more than 20 years. Program partners have identified monitoring resource status

and trends as the highest priority of LTRMP because of our need to understand recent and long-term trends in indicators of management success (see Output 1.2), cyclical changes in important ecological components, and the status of indicators used for analyzing relationships among components. Maintaining the continuity and integrity of the data set for the active components is crucial to these analyses. For large rivers that are highly variable over space and time, long-term data are essential to understanding system dynamics. The LTRMP will continue to build upon over 20 years of data and experience in delivering high quality scientific information to decision makers. The knowledge derived from consistent monitoring will continue to be directly incorporated into management actions and question-driven scientific investigations, thereby enhancing existing knowledge about ecosystem process, function, structure, and composition (Output 2.1) and building upon our ability to evaluate management actions (Output 3.1).

Output 1.1: Status and trends information based on long-term data sets for aquatic vegetation, water quality, fish, and land use/land cover.

By maintaining sampling designs and procedures, the relevance of a monitoring program increases over time. Longer data strings mean that changes in status and trends can be more reliably detected against the background of long-term cycles and wide variation. Desired levels of statistical confidence for assessing trends in indicators of success will be determined under Output 1.2. The generalized sampling design used by LTRMP allows a wide variety of questions to be addressed through data analyses. Some questions require different statistical designs and can be best answered through focused study (see Outcome 2). The long-term data will, however, continue to be an important source for investigating system process, function, structure, composition, and status and trends. The sampling effort required to produce data sets that are useful for analyses of both trends and status and other elements of this Strategic Plan will be addressed in the next phase of planning with development of an Operational Plan for FY 2010-2014. LTRMP will continue to evaluate the effectiveness of the data and the efficiency with which it is collected.

Activities

- a) Activities associated with current standardized data collection are shown in Table 1.

Output 1.2: Indicators of success at system, floodplain reach, and geomorphic reach-scales based on system goals and objectives.

The UMRS Partnership recently developed ecosystem restoration goals for the UMRS. Development of geomorphic reach objectives has been initiated and is expected to be completed within the next 18 to 24 months. The development of indicators based upon these goals and objectives will be an important activity under EMP and the newly authorized Navigation and Ecosystem Sustainability Program. LTRMP will continue to use its rich historical database to refine the list of indicators in the 2008 Status and Trends Report and to develop new key system and reach scale indicators. The monitoring program will be used to track the status and trends of those indicators over time to measure progress towards meeting system and reach goals and objectives

Activities

- a) Aid in the development of key indicators by providing LTRMP data and information.
- b) Track the status and trends of key indicators using LTRMP data and information.

Output 1.3: Additional information for status and trends knowledge regarding mussels, bathymetry and floodplain elevation, floodplain forest, and invertebrates.

The current monitoring effort provides critical data for the active components (e.g., water quality, aquatic vegetation, fish, and land cover). However, data from additional components are needed to broaden our understanding of the relationships among ecosystem components and processes and to track the status and trends of important species or guilds. Of the additional components considered, partners have identified mussels, bathymetry and floodplain elevation, floodplain forest, and macroinvertebrates as priority additional components over the next 5 years.

Activities

- a) Mussels—Freshwater mussels (Unionidae) are possibly the most threatened faunal group in the UMRS, yet we have very limited knowledge about the community ecology, distribution, and status of mussels within the system. The lack of information at the species, community, and population level complicates mussel resource management, impact assessment, and planning and construction of both habitat and navigation projects. Protocols for conducting mussel surveys and fundamental investigations of species distribution and ecology are needed to help design a long-term monitoring plan for mussels.
- b) Bathymetry & floodplain elevation—Floodplain topographic and bathymetric information is needed to create a seamless elevation data layer system wide. Such information is essential to habitat restoration planning, landscape modeling, and research about the ecology of floodplain communities.
- c) Floodplain Forest—Floodplain forest is one of the most important land cover types on the UMRS. Healthy and diverse forests are critical to the survival of many species, especially neo-tropical migrant birds. Since river impoundment in the 1930s, forests have undergone significant changes in species composition (e.g., declines in oak and hickory species and increases in silver maple) and distribution. Monitoring protocols should be developed to track changes in forest communities in addition to conducting focused research concerning the factors that affect forest composition and regeneration. This information is urgently needed to increase our understanding of restoration and management techniques and the ecological value of diverse floodplain forests.
- d) Macroinvertebrates – A healthy invertebrate community is essential to a productive and diverse river system. Aquatic insects, fingernail clams, and crustaceans provide essential food resources for migratory birds, fish, mammals, and other biota. They are also excellent indicators of water and sediment quality and may be indicators of system productivity. Current information about the status and trends of important macroinvertebrate communities is sparse. More broadly based, statistically valid monitoring protocols need to be evaluated to track changes in key macroinvertebrate communities. Focused research should be conducted to investigate factors that may limit macroinvertebrate distribution and abundance.

Output 1.4: Data collected at spatial scales that are appropriate to monitor progress toward meeting system and reach goals and objectives.

After river goals, objectives, and indicators are established at various geographic scales, additional status and trends information at corresponding spatial scales may be needed to enhance our ability to track success in meeting those goals within UMRS geomorphic and floodplain reaches, and the system. A variety of new or expanded monitoring designs may need to be developed depending on information needs. These could include additional sampling outside trend reaches at specific locations (e.g., tributaries) or a statistically based random sampling design at geomorphic and floodplain reaches, or

systemic scales. This information will provide decision makers with enhanced understanding of the dynamics of large floodplain rivers and facilitate successful multi-purpose resource management. Changes to the sampling designs and procedures will be considered only after careful evaluation of the existing protocols relative to the newly identified systemic, floodplain, and geomorphic reach objectives.

Activities

- a) After system and reach objectives and indicators are established (see Output 1.2), evaluate current sampling design for effectiveness at tracking indicators of success and, if needed explore new or reinstatement of original sampling designs.

Outcome 2: Enhanced knowledge about system process, function, structure, and composition

Effective management requires knowledge about factors controlling the dynamics and interactions of important system components. To gain this knowledge, the program should continue on a logical growth path by expanding from a primary focus on data collection to additional emphasis on analyses, research, and model building that stress work on Goals 1 (Understand the system) and 3 (Develop alternate management actions) in the 1993 Operational Plan. This will require development of a science-management process that provides for integration and coordination of research and monitoring activities. In addition, this will require using information and research capabilities to build on past efforts, particularly in producing models and decision support tools for managers.

Work under this outcome can be focused most effectively once management objectives and indicators of management success are developed by the partnership. System goals for ecosystem restoration efforts based on river process, function, structure, and composition have been developed by the broad river partnership. Geomorphic reach objectives are now being developed through similar regional efforts. The LTRMP should participate in and support those efforts where possible. The LTRMP data, combined with focused research, will continue to improve our understanding of how process, function, structure, and composition influence the physical, chemical, and biological components of the system, and ultimately the ecosystem services they provide.

The current Additional Program Element process for LTRMP focuses research on important management questions. These focused questions were developed and prioritized by the partnership and form the strategic research agenda of LTRMP. Current focal questions were developed for a two-year time frame and will be modified to direct focused research over the next five years. Implementation of this effort will be guided through the development of the focused research plan identified in Output 2.2. Many of the focal questions are related to process, function, structure, and composition. Addressing these questions will require a LTRMP staff committed to both research and monitoring.

In addition to focused research, adaptive management has been identified as one approach to enhance learning from management actions. A framework for adaptive management will likely be developed by the partnership, within the FY 2010-14 timeframe. Staff within the LTRMP can contribute to certain components of an adaptive management framework such as model development, restoration design intended to enhance learning, and development of monitoring plans to measure indicators of success at appropriate spatial and temporal scales

Output 2.1: Insights about river process, function, structure, and composition based on long-term data sets.

The LTRMP has created an unprecedented, multidisciplinary data set that provides a tremendous opportunity for developing new knowledge through data analyses. Analyses will concentrate on improving our knowledge of system structure and function as related to management needs. Such analyses will explore patterns in the data (among pools, strata, years, or seasons), relationships among variables (within and among components), evaluation of various metrics as potential indicators, or generating new variables from existing data (e.g., length frequencies, growth, year class strength, production). When appropriate, we will build on past analyses, contributing to the focused research agenda (Output 2.2), engaging others outside the partnership in conducting analyses, and using data sets outside of LTRMP as needed.

Activities

- a) Conduct analyses of LTRMP and other data sets.

Output 2.2: Information generated from focused research agenda on setting management objectives and defining indicators, aquatic vegetation, mussels, floodplain connectivity, and landscape patterns.

The activities listed below are in priority order, but we expect to address questions associated with all five research areas. The current annual time frame for Additional Program Element projects will be replaced with a 5-year focused research plan for each major question that can be implemented as funding and opportunities allow. The annual scope of work will follow the 5-year focused research plan with minor annual adjustments as we learn and get feedback from within and outside the program. Along with research efforts within the program, we will look for opportunities to leverage with other programs and funding sources, and to engage others outside the partnership (e.g., academics) in pursuing this agenda. In addition, we will look for opportunities for efforts under Output 2.1 to contribute to Output 2.2. New emerging issues may increase the importance of other questions and we should be flexible enough to be able to address those questions, if needed. However, our goal is to concentrate our science efforts and make substantial progress in addressing the priority areas as listed.

Activities

Develop and implement a 5-year focused research plan that will address the following five priority research areas. Additional areas may be added over time.

- a) Provide data and analysis to aid the partnership in setting (science and restoration) management objectives and defining indicators
- b) Aquatic vegetation
- c) Mussels
- d) Connectivity of the river to its floodplain
- e) Landscape patterns in the river corridor

Output 2.3: Decision support tools (e.g., models of system structure and function) to facilitate improved scientific understanding and restoration management.

Efforts under this output will be driven by the need to provide data and tools that help managers understand the system better and make more effective management decisions. These may include tools that organize existing data sources into portable data sets (e.g., the Spatial Query Tool) that managers can apply in their daily jobs and use to organize their own data. In addition, models are needed that combine existing data

and concepts into tools that document our current understanding of the system and can be used to explore outcomes of management alternatives. Modeling will be critical for developing effective adaptive management plans and for directing efforts in data analyses and focused research. A primary need is to develop a model that moves water and its associated constituents (chemicals, suspended materials, and biota) within channels and across the floodplain under varying discharge regimes. Once this modeling framework is built, a data layer depicting floodplain elevation (derived from combined bathymetry and LIDAR data; see Output 1.3) can provide a template for modeling management actions that modify flow distributions, water stage, or land elevation. Historical information on floodplain elevation and distribution of landforms can provide useful comparisons over time.

Activities

- a) Develop or improve models of sediment and flow dynamics
- b) Provide assistance to decision makers who ask for decision support tools

Output 2.4: Operational framework for adaptive management that clarifies relationships at multiple scales among past, present, and future adaptive management projects.

Ultimately, rehabilitation of the UMRS will be achieved by an accumulation of management actions that build on, and learn from, each other. Project implementation has been measured for past HREP projects and lessons learned have been incorporated into new projects and documented in the HREP manual. The learning opportunities provided by HREPs for both project implementation and ecological effects can be further enhanced through a more formalized and intentional process of adaptive management. Examples of additional learning opportunities include further evaluation of existing HREPs, and participation in design and evaluation of new HREPs (single and multiple projects) to increase their learning potential. These efforts will support development of a more formalized adaptive management framework as required under NESP. The LTRMP should participate when appropriate in ongoing activities to develop an adaptive management framework. That framework should build upon data, information, and planning available from LTRMP and other sources, and incorporate critical elements and issues embodied in the LTRMP strategic plan.

Activities

- a) Clarify relationships at multiple scales among past, present, and future restoration projects that provide significant learning opportunities
- b) Participate in and provide expertise as needed to refine ongoing adaptive management activities
- c) Participate in restoration planning efforts
- d) Develop an approach to documenting and delivering lessons learned

Outcome 3: Enhanced use of scientific knowledge for implementation of ecosystem restoration programs and projects

Effective ecosystem restoration involves using the best available information and decision support tools to formulate, design, and evaluate management actions that address system, reach and site-specific goals and objectives. This outcome envisions a greater linkage between river managers who design restoration projects and LTRMP staff who conduct monitoring and research so that restoration projects are developed with the best available scientific information.

The LTRMP capabilities should be used to inform the development of restoration goals and objectives, develop indicators, help design project evaluation studies, and track progress towards meeting those goals and objectives. In addition, there are opportunities to use LTRMP data, focused research, and modeling to aid in project evaluations and to better link site-specific projects to system and reach objectives.

The LTRMP staff and program managers should be proactive in recognizing opportunities to use multiple projects as replicates, alternate treatments, or large scale manipulations that provide improved learning potential. Establishing a communications and data link between LTRMP staff, Project Delivery Teams (PDTs), and the NESP Science Panel is an important component of this outcome.

Output 3.1: Use LTRMP infrastructure, data sets, and expertise to help formulate, design, and evaluate ecological restoration projects.

The purpose of this output is to ensure that the LTRMP information and staff are integrated into ecosystem restoration efforts at system, reach and site-specific levels, and that lessons learned are shared. Priority will be placed on ensuring existing knowledge and expertise are used to inform ecosystem project design and evaluation studies. LTRMP personnel and infrastructure will also continue to support completion of site-specific project evaluations.

Outcome 4: Enhanced ecological understanding to inform decisions

Critical to the success of EMP is providing decision makers with targeted, easily accessible, and usable information regarding the UMRS ecosystem. This will require both the development and delivery of important information that is responsive to identified needs.

Output 4.1: Key decisions are informed by LTRMP data, research, and decision support tools.

Activities

Identify decision makers, the information they need, and their preferred format for that information – including:

- a) Elected officials and the public – condensed information from various LTRMP sources
- b) Program managers – condensed technical information from program reports
- c) Project managers – technical reports from both cited and non-cited sources
- d) Scientists/technical professionals – scientific/technical information from peer reviewed journals

Output 4.2: Key decision makers are satisfied with LTRMP information and decision support system.

Activities

- a) Effectively and efficiently deliver LTRMP information and expertise to the key decision makers. This is a role for all EMP partners.
- b) Create a communications and outreach team/group with at least one new professional communicator at its core.
- c) Improve the delivery of LTRMP information based on decision maker feedback.

Strategic management of LTRMP organizational resources

Strategy 1. Effectively manage LTRMP data and information

Information generated under the LTRMP is only as useful as the quality of data management and delivery. Collecting, organizing, analyzing, storing, and reporting these data are fundamental program elements that cannot be compromised without jeopardizing the value of information and the historic database used by decision-makers and the scientific community.

Technology for data collection has advanced significantly and LTRMP has kept up with these advances, making the program a leader in the ability to manage and deliver data. Electronic data capture used by LTRMP has improved the efficiency, accuracy, and economy of data collection and entry. Geospatial data (land cover, bathymetry, aerial photography) are processed using advanced hardware and software and are used frequently by field managers and biologists to design and evaluate projects and investigate ecological relationships.

The relational database management system has been consistent over the life of the program and currently houses over 1.3 million records. Data from this system, as well as geospatial information and research results, are available in a variety of formats, including scientific manuscripts, program technical reports, completion reports, fact sheets, maps, and raw data. A comprehensive peer review process ensures scientific rigor and integrity. In addition, a web-based access system allows users to search and download information for specific uses.

Maintenance of existing data management tools, and investing in new technologies when appropriate, will improve efficiency and is critical to the continued integrity of this program. For example, new GIS technology allows for the creation of web enabled analytical tools that could previously function only on desktop computers. This allows users to view and access historical data over a much broader spatial scale than previously, which aids in measuring and tracking ecosystem indicators.

With adaptive management an important component of NESP, it is more important than ever to improve access to all forms of data and information pertinent to the Upper Mississippi River ecosystem. Some information collected by partners external to LTRMP can be accessed through the existing LTRMP database; however, expanding the data clearinghouse to provide “one-stop” access to non-LTRMP data would be a valuable step in implementing adaptive management.

Actions

- a) Maintain data management systems through an information technology refresher planning process
- b) Enhance the information management software used for data capture and management within the water quality component
- c) Develop a user-friendly interface with component data for web-based library and query tools
- d) Expand data clearinghouse functions
- e) Extend data catalogue functions

Strategy 2. Effectively manage LTRMP personnel and facilities

Meeting the outcomes in this strategic plan depends upon having appropriate staff and expertise within LTRMP. Staffing levels and expertise should be continuously evaluated to identify program needs, and training or additional staffing should be considered when necessary.

As with all effective organizations, maintaining productive and motivated staff is essential to program success. Within LTRMP there is a wide range of expertise from field station biologists and managers to USGS scientists and administrative personnel. It is important to provide the working environment and opportunities they need to develop professionally and ensure continuity in the program. For example, professional advancement for some positions within USGS is based on publication of peer-reviewed manuscripts. This process can take significant time; consequently some data useful to managers cannot be released prior to publication. Program administrators will develop effective ways to provide professional advancement opportunities for all LTRMP staff while meeting partners' data needs in a timely manner.

LTRMP facilities and equipment (boats, motors, sampling equipment, etc) need to be well maintained and replaced when necessary to maintain a safe and functional work environment.

Actions

- a) Create a workforce plan that provides direction for professional development and advancement for LTRMP staff, and includes or addresses:
 - Professional scientists and the support they need
 - Other professional and technical staff
 - Clarity about roles and responsibilities
 - Staffing necessary for the implementation of the strategic plan
 - Enhanced communication among staff in various LTRMP organizations
- b) Maintain the facilities
- c) Replace equipment as needed through the equipment refreshment plan

Figure 1. LTRMP Study Reaches (Pool 4, Pool 8, Pool 13, Pool 26, La Grange Pool, Open River Reach).

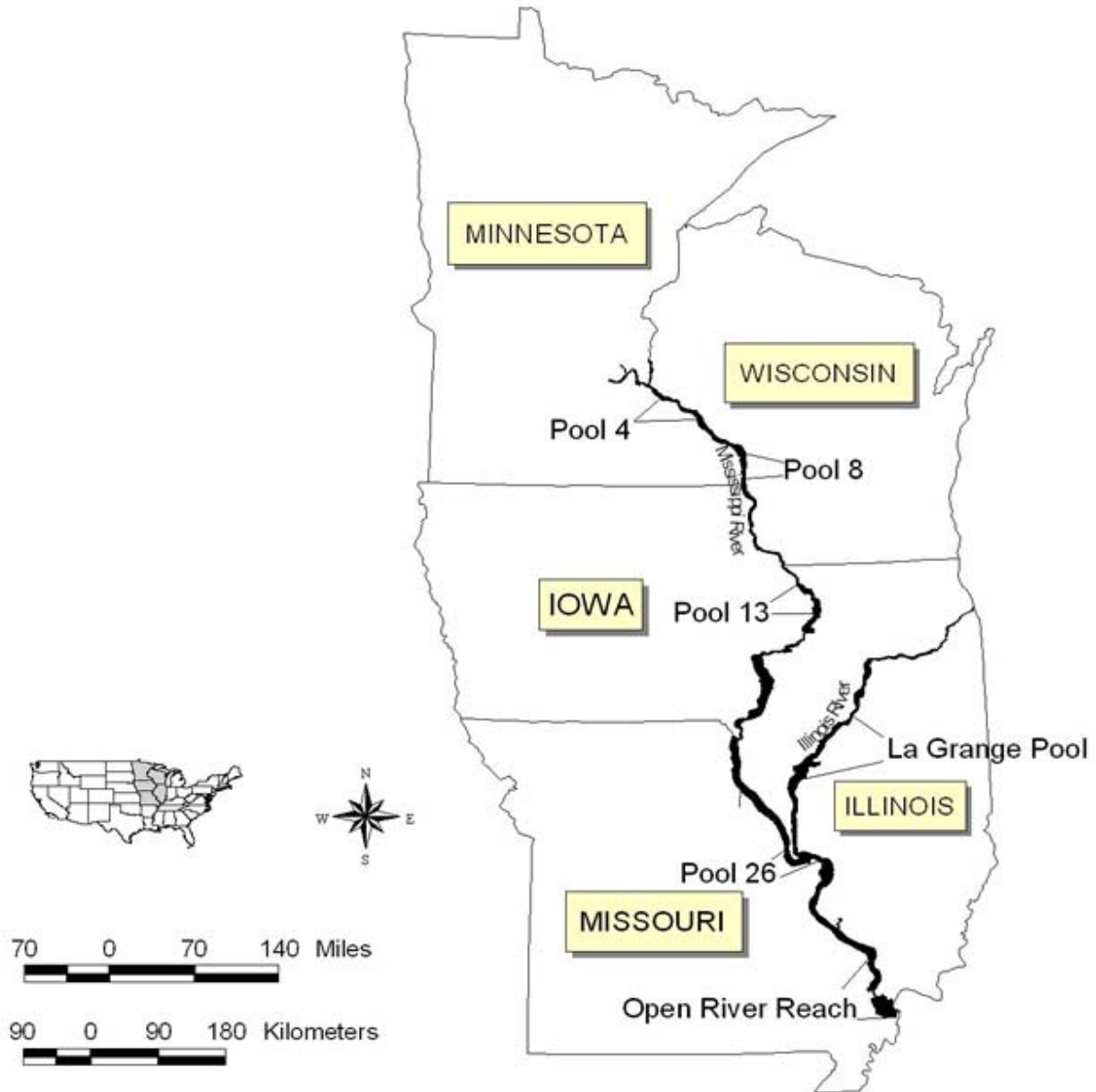


Table 1. LTRMP sampling effort, FY 2005-2009.

Component	Study Area					
	4	8	13	26	La Grange	Open River
Vegetation ¹	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 ²	~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 ³	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

Land Cover - Information on land cover is obtained from aerial photography collected approximately every 10 years to document change over time in response to both natural and anthropogenic disturbances. Systemic land cover of the Upper Mississippi River System has been mapped twice as part of the Long Term Resource Monitoring Program; 1989 and 2000.

¹ Principal aquatic vegetation data collected are species composition, relative and percent frequency, abundance (rake score), and distribution.

² Principal fish data collected are species composition, relative abundance (catch-per-unit-effort), and length distribution of catches. Subsamples from a few species are collected for age determination, growth analysis, and examination of food use.

³ Principal limnological data collected include physicochemical characteristics, suspended solids, chlorophyll a, phytoplankton [archived], and major plant nutrients.