Prepared in cooperation with the U.S. Army Corps of Engineers' Upper Mississippi River Restoration Program and the National Great Rivers Research and Education Center

Proceedings of the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois

Open-File Report 2026–1001

U.S. Department of the Interior
U.S. Geological Survey

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Preface

In anticipation for increased funding made possible by the Water Resources Development Act of 2020, the Upper Mississippi River Restoration (UMRR) Program identified a need to conduct river-wide assessments of floodplain vegetation. In January 2025, we assembled a group of subject matter experts to perform the following tasks:

1. Review Upper Mississippi River Restoration's current floodplain vegetation research portfolio,

2. Identify important features and goals for long-term floodplain vegetation monitoring,

3. Evaluate the suitability of existing datasets for system-wide vegetation assessments, and

4. Discuss emerging opportunities to learn about floodplain vegetation dynamics from local-scale restoration and management projects.

This document is a summarization of what occurred at the meeting and provides suggested next steps toward developing the capacity to conduct routine long-term monitoring and assessment of floodplain vegetation as part of the Upper Mississippi River Restoration Program.

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Figures

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Abbreviations

FIA	Forest Inventory and Analysis
FMG	Forest Management Geodatabase
HGU	hydrogeomorphic unit
HREP	Habitat Rehabilitation and Enhancement Project
LCLU	land cover land use
LTRM	Long Term Resource Monitoring
MDC	Missouri Department of Conservation
sUAS	small uncrewed aerial systems
UMRR	Upper Mississippi River Restoration
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

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By Shelby A. Weiss,[1] Matthew L. Trumper,[2] Nathan R. De Jager,[2] Lyle J. Guyon,[1] and Molly Van Appledorn[2]

Workshop Introduction

The Upper Mississippi River Restoration (UMRR) Program's Long Term Resource Monitoring (LTRM) element provides information about the status and trends of key river resources and their underlying processes through monitoring, research, and data management. The LTRM serves a wide range of stakeholders, including resource managers, planners, administrators, scientists, academics, legislators, and the public. After the Water Resources Development Act of 2020 (Public Law 116–260, Division AA, 134 Stat. 2615, enacted December 27, 2020) the UMRR–LTRM partnership began to prepare for a potential funding increase. Through a series of workshops, the program identified a number of information needs, including the need for increased capacity for floodplain vegetation research and monitoring. Specifically, the UMRR workshops identified a need to routinely assess floodplain vegetation dynamics across the river system. In January of 2025, we hosted a workshop that brought together subject matter experts (table 1) to focus attention on the information needed to better understand and assess floodplain vegetation dynamics. This document summarizes activities that occurred at the workshop (figs. 1 and 2). Specific presentations, breakout sessions, and workshop activities are presented in chronological order, with presenters and leaders identified. For more information, readers are encouraged to contact the listed presenters or leaders. On the first day, we explored LTRM's current floodplain ecology research portfolio to help workshop participants identify potentially important features of a long-term floodplain vegetation monitoring component. We concluded the first day with a presentation on LTRM's submersed aquatic vegetation monitoring component, to provide an example of the features of what many recognize as a successful vegetation monitoring component. We also closed out on day 1 with a presentation outlining a funded scope of work describing the steps that we intend to take following the workshop to develop a plan for floodplain vegetation monitoring. On the second day, we evaluated the suitability of existing datasets for system-wide vegetation assessments, explored the history of floodplain vegetation management within UMRR, and discussed emerging opportunities to learn about floodplain vegetation dynamics from local-scale restoration efforts. We concluded the workshop with small group activities focused on helping us identify the characteristics of successful floodplain vegetation sampling designs, considering existing datasets and the needs of management agencies. The purpose of this document is to share with the UMRR partnership and other interested organizations, a summary of what occurred at the workshop. We hope to raise awareness of these efforts, provide opportunities for different stakeholders to participate in the planning process, and use the information presented here to help establish a plan to build capacity within the UMRR program to conduct routine vegetation assessments.

[1]National Great Rivers Research and Education Center.

[2]U.S. Geological Survey.

Table 1. In-person and online attendees to the Upper Mississippi River Restoration Long Term Resource Monitoring Floodplain Vegetation Workshop in January 2025.

[IDNR, Iowa Department of Natural Resources; INHS, Illinois Natural History Survey; MDC, Missouri Department of Conservation; MN DNR, Minnesota Department of Natural Resources; NGRREC, National Great Rivers Research and Education Center; USACE, U.S. Army Corps of Engineers; USFWS, U.S. Fish and Wildlife Service; USGS, U.S. Geological Survey; WI DNR, Wisconsin Department of Natural Resources]

Attendee	Agency or organization	In person versus online
Dave Bierman	IDNR	In person
Seth Fopma	IDNR	In person
Jim Lamer	INHS	In person
Dave Herzog	MDC	Online
Molly Sobotka	MDC	Online
Grant Sprague	MDC	Online
Tony Long	MN DNR	In person
Stephanie Szura	MN DNR	In person
Dale Gentry	National Audubon Society	In person
Tara Hohman	National Audubon Society	In person
Lyle Guyon	NGRREC	In person
Shelby Weiss	NGRREC	In person
Kyle Bales	USACE	Online
Mike Dougherty	USACE	In person
Christopher Hawes	USACE	Online
Andy Meier	USACE	In person
Davi Michl	USACE	In person
Marshall Plumley	USACE	Online
Lane Richter	USACE	Online
Carli Schlabowske	USACE	Online
Ben Vandermyde	USACE	In person
Lauren Larson	USFWS	In person
Matt Mangan	USFWS	Online
Stephen Winter	USFWS	In person
Kristen Bouska	USGS	In person
Nathan De Jager	USGS	In person
John Delaney	USGS	In person
Jim Fischer	USGS	Online
Matthew Trumper	USGS	In Person
Molly Van Appledorn	USGS	In person
Alicia Carhart	WI DNR	In person
Patrick Kelly	WI DNR	In person

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Read-Aheads

1. Document: 1.1_Floodplain_Veg_Info_Need (Scope of Work)
2. Systemic Forest Stewardship Plan (Guyon and others, 2012)
3. Land Cover Mapping (Dieck and others, 2004)

Session 1 (12:30 p.m. to 5 p.m., Tuesday, January 7): Long Term Resource Monitoring's Floodplain Research Portfolio

12:30 p.m.	Welcome, background information, workshop goals, and agenda (De Jager)
1:00 p.m.	Upper Mississippi River Restoration Program (UMRR) projects and funding lines • Spatial Data Component and Landscape Patterns Research (De Jager) • Ecohydrology Research (Van Appledorn) • Future Landscapes (Delaney) • Long Term Resource Monitoring (LTRM) Science Meeting Projects ▫ Overview of the Focal Area (Van Appledorn) ▫ Dendrochronology Projects (Van Appledorn) ▫ Hydrogeomorphology and Groundwater Dynamics (Van Appledorn) ▫ Forest Canopy Gap Dynamics (Guyon) ▫ Invasives and Reforestation (Guyon) ▫ Using Uncrewed Aerial Systems to Monitor Postflood Mortality Response (Guyon) ▫ Bird-Habitat Associations (Hohman) ▫ 1993 and 2019 Flood Studies (Weiss)
2:15 p.m.	Break
2:45 p.m.	Small group activities: What parts of the portfolio are most useful for what?
4:00 p.m.	Characteristics of a Successful Monitoring Component: LTRM's Aquatic Vegetation (Larson)
4:15 p.m.	Scope of Work for Information Need 1.1 Floodplain Vegetation Change Across the System (Weiss)

Figure 1. Agenda showing day 1 of the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois.

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Session 2 (8 a.m. to 4 p.m., Wednesday, January 8): Characteristics of a Successful Floodplain Vegetation Monitoring Component, Data Review, and Data Sharing

8:00 a.m. Land cover land use data: What can and what can we not monitor with it? (De Jager)

- Forest communities
- Herbaceous communities

9:00 a.m. Break

9:15 a.m. Upper Mississippi River system systemic Forest Data Sets (Weiss and Trumper)

- LTRM Data: 1993 and 2019 Flood Data (Weiss)
- U.S. Army Corps of Engineers (USACE) Forest Management Geodatabase (Weiss)
- USACE Permanent Plots (Trumper)
- U.S. Forest Service Forest Inventory and Analysis Data (Trumper)
- Compare and contrast
- Large group poll everywhere questions
- Small group discussion
- Reports to full group—Synthesis discussion

11:15 a.m. Break

11:30 a.m. Working lunch

- What does a successful floodplain vegetation monitoring component look like?
  Poll Everywhere questions (large group)
  - What are your greatest barriers to monitoring floodplain vegetation?
  - Which of the following tools would you find valuable? (rank?)
- Data Management Issues: Storing, sharing, and agreements—Large group discussion?

Session 3 (1 p.m. to 3 p.m., Wednesday, January 8): Forest Management and Related Data Collection Opportunities

1:00 p.m. Brief History of Floodplain Vegetation management in the Upper Mississippi River Restoration Program, the Navigation and Ecosystem Sustainability Program, and the U.S. Army Corps of Engineers

1:15 p.m. Information Need 4.2 Learning from Restoration (Bouska)

1:30–2:30 p.m. Poll Everywhere discussion on learning from Habitat Rehabilitation and Enhancement Projects

Figure 2. Agenda showing day 2 of the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois.

Day 1: Long Term Resource Monitoring's Floodplain Ecology Research Portfolio and Identification of Important Features of Long-Term Floodplain Vegetation Monitoring

A Brief History of Floodplain Vegetation Studies within Long Term Resource Monitoring

Nathan R. De Jager

Abstract

The Comprehensive Master Plan for the upper Mississippi River system was developed in 1982 (Upper Mississippi River Basin Commission, 1982) and identified a need for long-term monitoring of a wide range of components of the river system, including floodplain vegetation. The Water Resources Development Act of 1986 (33 U.S.C § 652, Public Law 99–662, 100 Stat. 4082, enacted November 17, 1986) authorized funding to begin what would become the Long Term Resource Monitoring (LTRM) element of UMRR. Later, in 1988 and again in 1992, operating plans were developed for LTRM and identified plans for monitoring specific river system components, several of which were specific to floodplain ecology (Rasmussen and Wlosinski, 1988; USFWS, 1992). In this presentation, we briefly reviewed efforts focused on developing and using data on five floodplain-relevant components of the 1992 operating plan: (1) river discharge, (2) floodplain elevation, (3) terrestrial vegetation, (4) floodplain habitat, and (5) wildlife. Throughout the years, LTRM has done extensive work developing river discharge data and floodplain elevation data for the upper Mississippi River system and used these datasets to further develop floodplain inundation models (De Jager and others, 2016, 2018; Van Appledorn and others, 2021, 2024a). Terrestrial vegetation has primarily been assessed using decadal land cover data (refer to summary from day 2 detailing LTRM's land cover land use [LCLU] data, in section "Day 2: Evaluating the Suitability of Existing Datasets for System-Wide Vegetation Assessments and Discussing Emerging Opportunities to Learn about Floodplain Vegetation Dynamics from Local-Scale Restoration and Management Projects"). After large floods in 1993 and again in 2019, however, UMRR–LTRM collected data to examine rates of tree mortality and compositional shifts in relation to flooding (Yin, 1998; Yin and others, 2009; Weiss and others, 2025). Examining floodplain habitat and wildlife use of the floodplain has been done less frequently and typically through collaborations with other agencies (for example, U.S. Fish and Wildlife Service [USFWS] and the National Audubon Society). Currently, the LTRM conducts floodplain research and monitoring activities through four main thematic areas: (1) landscape patterns research and application, (2) ecohydrological research, (3) future landscape adaptation informed by historical landscape patterns and climate scenarios, and (4) a number of short-term focused research studies developed through UMRR's science planning meetings. Each of these areas is expanded upon in the following presentations.

Long Term Resource Monitoring Spatial Data Component and Landscape Patterns Research

Nathan R. De Jager

Abstract

The LTRM Spatial Data Component works in collaboration with other agencies, technical specialists, and scientists to: (1) develop and maintain decadal LCLU maps; (2) develop system-wide digital elevation models; (3) develop maps, models, and tools using LCLU and digital elevation models data; and (4) conduct system-wide assessments by applying maps, models, and tools to the upper Mississippi River system. LCLU data exist for the years 1890, 1989, 2000, 2010, and 2020 for the entire upper Mississippi River system. These maps delineate vegetation communities using aerial photography. A system-wide topobathy dataset was developed for the year 2015 by merging terrestrial lidar data with bathymetric surveys to create seamless elevation models for each reach of the upper Mississippi River system. Activities related to developing a second, newer topobathy dataset for the upper Mississippi River system are ongoing. Together, the LCLU and topobathy data form the foundation for several additional mapping and modelling efforts including forest area-density mapping (De Jager and Rohweder, 2011, 2022), aquatic areas mapping (De Jager and others, 2018; Wilcox, 1993), geomorphic analyses and classifications (Scown and others, 2015a, 2015b, 2016a, 2016b; Vaughan and others, 2025), flood inundation modelling (De Jager and others, 2016, 2018; Van Appledorn and others, 2021, 2024a), submerged aquatic vegetation modelling (Carhart and others, 2021; Delaney and Larson, 2024; Carhart and others, 2024), and sediment resuspension modelling (Rohweder and others, 2008). Many of these maps and models formed the basis for the most recent system-wide assessment of Habitat Needs Assessment II for the upper Mississippi River system (De Jager and others, 2018; McCain and others, 2018).

The Landscape Patterns Research Framework was developed in 2011 (De Jager, 2011), outlining research activities that complement the Spatial Data Component. This framework has made it possible to fund additional geospatial analyses and modelling work. One of the main objectives of the research framework was to guide efforts focused on developing measures of landscape structure. Since 2011, research into quantifying patterns of floodplain inundation

(De Jager and others, 2016, 2018; Van Appledorn and others, 2021, 2024a), patterns of floodplain land cover (De Jager and others, 2013; De Jager and Rohweder, 2017), and patterns of forest area density (De Jager and Rohweder, 2011) have been the primary areas of work relevant to the floodplain. The other main objective was to link measures of landscape structure to local-scale ecological patterns and processes. Research has generally focused on aspects of floodplain forest community composition and structure (De Jager and others, 2012, 2016; De Jager, 2012) as well as floodplain soil characteristics and how they relate to patterns of floodplain inundation (De Jager and others, 2015, 2019a; Kreiling and others, 2015; Swanson and others, 2017). Finally, the long-term vision for the Landscape Patterns Research Framework has been to develop a more quantitative understanding of landscape dynamics so that future modelling efforts could apply such knowledge to forecasting future landscape changes under alternative management and environmental conditions. The best example of this work is a coupled flood inundation-forest succession model that allows researchers and managers to explore actions such as timber harvest, invasive species management, and elevation modifications in concert with changes in river flows (De Jager and others, 2019b, 2024; Trumper and others, 2025).

Long Term Resource Monitoring Ecohydrology Research

Molly Van Appledorn

Abstract

The Ecohydrology component comprises interdisciplinary research in support of scientific and management applications in the upper Mississippi River system that spans five integrated main domains: social systems and river management, biogeochemical processes, hydrology, vegetation, and geomorphology. Of these five domains, particular research projects under the latter three topics were discussed in more detail for their relevance to understanding floodplain vegetation in the upper Mississippi River system. Hydrology of the upper Mississippi River system is foundational to its form and function, and several recent efforts have advanced our understanding in this domain. First, Van Appledorn (2022) analyzed discharge records from four U.S. Geological Survey (USGS) streamgages along the mainstems of the Mississippi and Illinois Rivers from 1940 to 2019 revealing increasingly wetter conditions over time. Patterns included increases in measures of annual discharge (maximum, mean, minimum), increases in the number of days in high-flow condition, and shifts in seasonal discharge dynamics. A database of historical and recent daily water surface elevations for the U.S. Army Corps of Engineers (USACE) gaging stations along the mainstems of the Mississippi and Illinois Rivers is currently in review with plans for query tool development. UMRR Science in Support of Restoration project’s goal is to have a thoroughly documented, query-able hydrologic database that is updated with contemporary hydrologic records in a semi-automated way, facilitating easier scientific and management applications. As a complement to the historical and contemporary hydrologic database, a series of three virtual workshops were held for the UMRR partnership between September 2021 and January 2022 to identify roles, expertise, priorities, and needs for a dataset of projected hydrologic conditions, define an ideal hydrologic dataset, and develop an evaluation framework and proposal for acquiring and testing the suitability of such a dataset. Outcomes from this productive workshop series are documented in Van Appledorn and Sawyer (2023). The LOCA-VIC-mizuRoute hydrologic data products were identified during the workshop series and were evaluated for use in UMRR applications. The products poorly represented historical conditions observed for gages throughout the upper Mississippi River system basin at temporal scales important for certain UMRR applications (Van Appledorn and others, 2025). A final project related to the hydrology domain is the systemic upper Mississippi River system Floodplain Inundation Model, which was first summarized in the indicators report associated with the second upper Mississippi River system Habitat Needs Assessment (De Jager and others, 2018), fully described by Van Appledorn and others (2021, 2024a), and published as raster datasets by Van Appledorn and others (2018). Since its inception, the model has been used to also explore temporal trends in inundation patterns (Van Appledorn and others, 2026) and integrated into other floodplain research projects (for example, De Jager and others, 2019b; Delaney and others, 2024). The model is also currently being used to characterize potential future shifts in inundation. Other approaches to inundation modelling have been undertaken to address specific research and management questions in nonsystemic settings, for example, Reno Bottoms Habitat Rehabilitation and Enhancement Project (HREP; De Jager and others, 2024; Trumper and others, 2025). Under the vegetation domain, an effort is underway to classify floodplain forest assemblages based on their species composition and size structure. The USACE forest inventory dataset is the basis for the work, and USACE staff are partnering in this effort. Another area of active work is to understand patterns and processes surrounding dead trees as they transition to aquatic habitats. Van Appledorn and others (2024b) documented large wood occurrences in the six LTRM key pools and tested hypotheses about hydrogeomorphic drivers of their distribution patterns. In addition, pilot studies using machine learning and (or) artificial intelligence are underway to map large wood pieces systemically in the upper Mississippi River system and investigate transport dynamics using camera traps. Finally, under the geomorphology domain, planform changes and backwater sedimentation rates were documented by pool by Van Appledorn and Rogala (2022). These are relevant within the context of the floodplain vegetation workshop because

new land surfaces can be inferred from planform change, and rates of elevation change in near-shore and shoreline areas can be inferred from backwater sedimentation rates. Lastly, Fitzpatrick and others (2024) described a conceptual model of hydrogeomorphic change in the upper Mississippi River system, which is currently being operationalized by Vaughan and others (2025) in the form of mapping hydrogeomorphic units (HGU). These units are defined through geospatial analyses of surficial geometries revealed in the topobathy dataset and have been successful in identifying floodplain features such as scroll swales, flood chutes, scroll bars, natural levees, flats, and backwater bars (Vaughan and others, 2025). HGU maps of select pools are currently being incorporated into new research projects with efforts underway to expand mapping to additional pools.

Long Term Resource Monitoring Future Landscapes Research

John Delaney

Abstract

Research in this area focuses on learning from historical landscape patterns to inform future landscape adaptation. This research builds upon foundational work on floodplain vegetation ecosystem states (Bouska and others, 2020), the floodplain inundation regime (Van Appledorn and others, 2021, 2024a), the vegetation community (De Jager and others, 2016, 2019b, 2024), and climate change adaptation planning (Delaney and others, 2022; Bouska and others, 2025; Van Appledorn and Sawyer, 2023). Our two initial projects were focused on gaining a better understanding of the habitat suitability (Delaney and others, 2024) and ecological niche of *Phalaris arundinacea* L. (reed canarygrass; Delaney and others, 2025) in forested areas of the upper Mississippi floodplain. We are also working to better understand reed canarygrass in nonforested portions of the floodplain. First, we will analyze changes in reed canarygrass dominance in wet meadows between the decades of 2010 and 2020 and quantify the interim inundation regime to understand how long-term inundation may influence reed canarygrass dominance. We will then use the field observations of reed canarygrass dominance to assess reed canarygrass dominance in wet meadows from satellite imagery. With annual estimates of reed canarygrass dominance, we will be able to study how growing season inundation influences annual changes in distribution. The information learned from this work on reed canarygrass in forest understories and wet meadows will be combined with information on other land cover types, and their interactions with inundation, to parameterize a spatial state and transition model for reed canarygrass and other important floodplain plant community types across the upper Mississippi River floodplain. The spatial state and transition model will be driven by inundation with the potential to apply different hydrologic scenarios to better understand how changes in inundation may drive land cover change into the future.

Initially, we had intended to develop qualitative future climate scenarios to apply to the spatial state and transition model with the hope that the scenarios could also serve other research and adaptation purposes across the program. Although qualitatively based, these initial scenarios would have been developed through literature review and consultation with regional climate experts. In 2023, we had the opportunity to propose the development of models that could provide quantitative projections of discharge, water surface elevation, and water temperature across the upper Mississippi River system. The 3-year project is underway with promising initial model performance. During the study, we will continue to refine the models, test their performance under novel conditions (for example, greater air temperatures and heavier precipitation), and apply them to a downscaled Coupled Model Intercomparison Project Phase 6 model ensemble. These comprehensive quantitative projections will allow us to build scenarios with the help of managers, researchers, and climate experts to evaluate vegetation changes and reed canarygrass invasion in response to changing hydrologic conditions.

Long Term Resource Monitoring Science Meeting Floodplain Focal Area Projects (5-Minute Presentations)

Nathan R. De Jager, Molly Van Appledorn, Lyle J. Guyon, Tara Hohman, and Shelby A. Weiss

Overview of the Focal Area (Nathan R. De Jager)

Abstract

Every 2 years the UMRR Program hosts a science meeting to bring together practitioners with the goal of developing collaborative research projects across a broad range of thematic areas. Floodplain ecology has consistently been a focal area for the science meeting since 2018. The main emphasis of the floodplain focal area has been to develop projects that lead to a greater understanding of relations among floodplain hydrogeomorphic patterns, vegetation and soil processes, wildlife habitat, and nutrient export. Ongoing floodplain ecology projects developed at the UMRR science meeting are described below, including projects focused on quantifying forest growth dynamics, hydrogeomorphic dynamics, forest gap dynamics, invasive species, forest mortality, bird-habitat associations, and forest community response to large magnitude floods.

Dendrochronology Projects (Molly Van Appledorn)

Abstract

Two dendrochronology projects have been funded by the UMRR Science in Support of Restoration Program. First, a project was funded in the fiscal year 2018 cycle with the goals of (1) understanding forest growth trends, (2) understanding associations between forest recruitment and growth and environmental characteristics, (3) determining appropriate stocking densities, and (4) identifying where the current upper Mississippi River system floodplain can support hard mast forest communities and resilient stand dynamics for other forest communities. Work for this project occurred in the Rock Island USACE district. King and others (2021) describe forest structure and environmental correlates with a focus on 15 *Carya illinoinensis* (Wangenh.) K. Koch (pecan) stands. A second manuscript broadens the sampling area to other stands and also examines growth related to canopy health (Férriz and others, 2026). The second dendrochronology project, funded during the fiscal year 2022 cycle, had goals of (1) understanding current age structure of floodplain forest sites and its spatial variability, (2) understanding disturbance history in the context of environmental variability, and (3) identifying effective management actions and indicators for intervention. This project analyzed an existing dataset of >1,100 increment cores from *Acer saccharinum* L. (silver maple)-dominated stands in the USACE St. Paul district. Multiple publications are in preparation including ones that document wood anatomy and chronology development (M.L. Trumper, U.S. Geological Survey, written commun., 2025) and age structure, age-size relations and spatial patterns (L. Voth Rurup, University of Minnesota, written commun., 2025), with plans for additional products exploring environmental relations in more detail. Next steps for this project include a stakeholder workshop (March 3–4, 2025) and multivariate and tree-mapping analyses and manuscripts.

Hydrogeomorphology and Groundwater Dynamics (Molly Van Appledorn)

Abstract

A project to understand the role of surface-subsurface hydrology and soil characteristics on floodplain vegetation in the upper Mississippi River system through space and time was funded during the fiscal year 2024 cycle. The main goals of the project are to (1) define linkages among surface-subsurface hydrology, soils, and vegetation across hydrogeomorphic features in the upper Mississippi River system and (2) assess the ability of the upper Mississippi River system floodplain inundation model to estimate groundwater dynamics. The project will combine empirical studies with modelling efforts using a spatially nested design. Field sites will be in each of the three USACE districts and comprise HGU map products of (Vaughan and others, 2025). Field sites will be instrumented with shallow groundwater wells to monitor hydrology, survey soil and vegetation, and simulate local hydrologic dynamics during a 10-year period using a numerical hydraulic model calibrated by empirical measures. Water availability by landform (empirical and 10-year simulation) will be calculated, and multivariate statistics will be used to relate vegetation to environmental conditions. The upper Mississippi River system floodplain inundation model will be evaluated against empirical hydrologic measurements and the more complex hydraulic model. Site selection (Reno Bottoms) and installation of wells is complete for the St. Paul district with data collection commencing in spring 2025. Site selection is in progress for Rock Island and St. Louis districts with well installation and data collection expected to commence fall 2025 or early 2026. Because this is a new project, no related products are currently available.

Forest Canopy Gap Dynamics (Lyle Guyon)

Abstract

A floodplain forest canopy gap dynamics project was funded in the fiscal year 2018 cycle to assess the current abundance and distribution of forest canopy gaps in the upper Mississippi River system, and to determine what proportion of these gaps have been recolonized by forest tree species relative to herbaceous plants and (or) invasive species. In most forest systems, the dynamics of forest canopy gap development play an important role in the transition from relatively short-lived, early successional tree species to longer-lived, late successional tree species. In resilient forest systems, tree seedlings establish within newly created canopy gaps and grow to close the gap within one or two decades of disturbance; however, evidence in portions of the upper Mississippi River system indicates that floodplain forests do not appear to be following these same trajectories, with canopy gaps instead seeming to fail to recruit new tree seedlings and reverting to nonforested cover types. Because of the heavy dominance of short-lived tree species in current upper Mississippi River system forests, there is concern that continued failure of canopy gaps to recruit back to forest could be an early indicator of long-term, widespread forest loss as gaps become larger and begin to coalesce into large, nonforested areas. Little research to date has documented either the density and distribution of forest canopy gaps across the upper Mississippi River system or the vegetative conditions within those gaps to provide an initial assessment of forest dynamics in those areas. This study used remotely sensed data and field sampling to assess the conditions of forest canopy gaps within six navigation pools on the upper Mississippi River and one pool on the Illinois River. In

general, canopy gap distributions and characteristics were similar across the study area, with most pools having gaps in the forest canopy ranging from 3 to 5 percent of the total forest area. Gap sizes were also relatively uniform, with most pools averaging 0.09 to 0.14 hectare per gap. The highest proportion of forest cover in canopy gaps at the pool level was driven by the total number of gaps and not gap size, indicating that canopy gap formation in this system was commonly due to individual tree or small cluster mortality. Undesirable, competing vegetation was dominant in most canopy gaps, with *Phalaris arundinacea* L. (reed canarygrass) and native forbs being most prevalent in upper pools and vines most problematic in the lower pools. In the upper pools, very little viable forest regeneration is occurring within canopy gaps. The viability of forest regeneration increases in middle and lower pools, though competing vegetation continues to be a problem. Overall, canopy gaps appeared most likely to transition back to forest in lower pools, and chronic forest loss facilitated by regeneration failures seemed most likely in upper pools; however, competing vegetation in lower pools may still interact with woody regeneration to limit effective reestablishment of forest canopy. Geospatial and field data are available online as a U.S. Geological Survey data release (https://doi.org/10.5066/P9BLTSTZ, Sattler, 2026), and the final completion report for this project is available at: https://umesc.usgs.gov/data_library/ltrmp_other/other_page.html.

Invasives and Reforestation (Lyle Guyon)

Abstract

A project to assess reforestation methods in floodplain areas heavily colonized by invasive plant species was funded during the fiscal year 2019 cycle. The invasive plant species *Humulus japonicus*, Sieb. & Zucc. (Japanese hops L. [reed canarygrass]) affect native vegetation. This study evaluated novel reforestation methods to rapidly close canopy openings colonized by invasives and reduce their cover at four study sites ranging from southern Wisconsin to southwestern Illinois. Each site contained three replicates of four 20 x 20 m plots comprising four tree planting treatments. These included two using large diameter *Salix* L. (willow) cuttings planted at different densities, one using container stock of *Platanus occidentalis* L. (American sycamore) and *Populus deltoides* W. Bartram ex Marshall (eastern cottonwood), and a control plot with no planted trees. Half of each planting treatment also received maintenance treatments for invasives control. Results indicated that planting, maintenance, and site had statistically significant effects on tree survival, invasives cover, and overall plant community diversity. Specifically, trees that received maintenance had higher survival than those that did not; willow cuttings had higher survival than container stock, whereas site results were mixed. Annual and cumulative tree height growth was statistically significantly greater in willow cuttings planted at the highest density. Invasive species cover was statistically significantly lower in maintenance treatments and willow plantings, with site results again mixed. Plant community diversity was highest in maintenance treatments and in willow plantings but was still extremely low at the northernmost site. Vegetation patterns were strongly influenced by invasives and reinforced the general inverse relation between plant community diversity and invasives cover. Overall, results indicated that tree plantings using large willow cuttings can be an effective method to quickly reforest areas along the upper Mississippi River that have been colonized by invasive plant species, and that incorporating tree planting maintenance activities in early years can lead to better survival. A manuscript produced from this project is published at Invasive Plant Science and Management (Guyon and others, 2026).

Using Uncrewed Aerial Systems to Monitor Postflood Mortality Response (Lyle Guyon)

Abstract

A project looking to use small uncrewed aerial systems (sUAS) to monitor and survey regeneration and recruitment in areas of forest canopy loss was selected for funding during the fiscal year 2024 cycle. Thousands of hectares of floodplain forest canopy have been lost in the upper Mississippi River system after prolonged flooding in 2018–2019. Questions remain as to whether this loss is temporary or permanent, why some areas may be resilient and others are not, how the forest is regenerating, and what this can tell us about where these landscapes are headed. We know floodplain forests in the upper Mississippi River system are affected by invasive species, changes in inundation patterns and a changing climate, and that regeneration patterns and regeneration success vary across the system. Forests commonly regenerate after disturbances, and upper Mississippi River system forests that recently experienced heavy mortality may just be starting over, but are they? There is a time-sensitive natural experiment underway, the outcome of which will dictate the successional pathways of vast areas of the upper Mississippi River system floodplain landscape for generations. Results from this project will provide critical information about the pathways these areas are following, where they may lead, and what factors may influence their direction. To address the need to capture these ephemeral conditions over large areas at a high resolution quickly, we plan to deploy sUAS and field crews concurrently to address three questions critical to upper Mississippi River system partners, scientists, and landscape managers: (1) Are upper Mississippi River system floodplain forests that recently experienced heavy canopy mortality regenerating?, (2) What successional pathways are regenerating forests following?, and (3) Can sUAS supplement

or supplant on-the-ground vegetation data collection? Fieldwork in support of this project is scheduled to begin during the summer 2025 field season.

Bird-Habitat Associations (Tara Hohman)

Abstract

This project investigates the response of bottomland forest bird species along the upper Mississippi River to management, and possible bird habitat preferences. Based in Pools 3 (Gores Wildlife Management Area), 7 (Black River Bottoms Management Area), 8 (WKTY Radio Station Management Area), 12 (Pool 12 Forestry HREP), 14 (Beaver Island and Steamboat Island), and 25 (Ted Shanks Conservation Area, Red's Landing and Batchtown Management Units), we focused on areas that either have not had management done to forest stands, or areas where management occurred at least 2–5 years ago. We established 100 points in each Corps district and its designated pools to conduct bird point count surveys. All points overlap with USACE, USFWS and National Great Rivers Research and Education Center collected forest inventory data. For this 3-year project, we have completed year 1 data collection and summaries, including running bird density estimates for each species with adequate detections (approximately 30 plus species). For year 2, we plan to repeat this process and survey the points we have not visited and complete additional data summaries. For the final year of the project, we will start looking at bird density response to management actions, and where possible, preferences to habitat features we can identify on the landscape. Results from this project will be incorporated into bottomland forests for birds reports that can be used to help inform and influence management actions.

Flood Studies: 1993 and 2019 (Shelby A. Weiss)

Abstract

This study investigated forest successional patterns and tree survivorship after the 1993 and 2019 flood events across eight reaches of the upper Mississippi River system (Pools 4, 8, 13, 17, 22, 26 of the Mississippi River, Open River on the Mississippi River, and La Grange reach of the Illinois River). Field data were collected from a minimum of 45 plots per pool in 1995 after the 1993 flood, and 39–45 plots per pool were revisited and sampled in 2021, after the 2019 flood. We compared mortality rates and inundation attributes at plot locations between the two flood events, and we employed a multivariate ecological trajectories approach to analyze changes in species composition through time (Weiss and others, 2025). The project also included the development of an interactive Shiny app for data visualization, which is currently in progress. We concluded that postflood mortality for each event varied spatially and generally reflected patterns in inundation duration. Most trajectories of forest plots were dominated by *Acer saccharinum* L. (silver maple) and changed relatively little in species composition and structure through time. In plots dominated by either *Quercus* L (oak) species or *Populus deltoides* W. Bartram ex Marshall (cottonwood), species importance shifted toward more shade- and flood-tolerant species after the 1995 surveys.

Workshop Participant Organizations and Experience

Workshop participants were polled to summarize the range of agencies or organizations, years of experience, roles, and region present for the workshop. Among those who attended the workshop either in person or online, more than half of participants responding to this question (18 out of 32) were from Federal agencies, which included USACE, USGS, and USFWS (fig. 3). State agencies represented the next highest category with 28 percent. Nongovernment agencies and organizations associated with universities represented the remainder of participants (fig. 3).

Participants were also asked to report their years of professional experience at their agency, and responses ranged from 1 to 27 years, with nearly half of responding participants (46 percent) having less than 6 years of professional experience, but 18 percent having more than 15 years of professional experience (fig. 4). Most roles in attendance were relatively evenly represented, and of those who responded, 30 percent were program managers, 33 percent were research scientists, and 26 percent were field biologists. The least represented were resource managers, which represented 11 percent of responding participants. Finally, whereas representation existed across different reaches of the upper Mississippi River system, the upper impounded reach (Pools 3–13) made up a strong majority (70 percent) of attendees who responded when asked where they were based. Least represented was the Illinois River reach, where only one participant was based (table 2).

It should be noted that in combination, some roles within reaches were not represented at the workshop. Specifically, resource managers based outside of the upper impounded reach were not in attendance, nor were program managers in the lower impounded reach. In addition, research scientists from the Illinois River reach, and field biologists from Open River reach or Illinois River reach were not in attendance.

Workshop Participant Perspectives on the Importance of Monitoring

Participants were asked why they considered monitoring the upper Mississippi River system floodplain vegetation to be valuable, and 18 unique reasons were provided. Participants

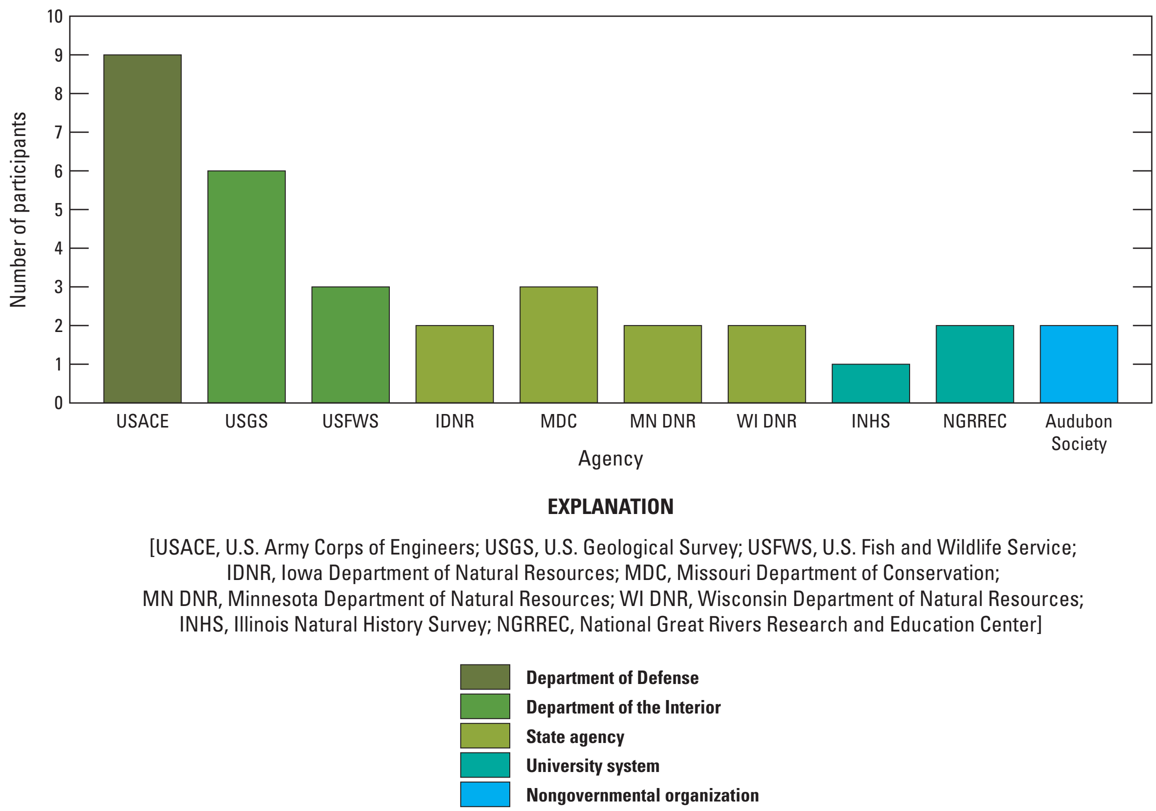

Figure 3. Vertical bar graph showing the number of responding participants by agency or organization attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois.

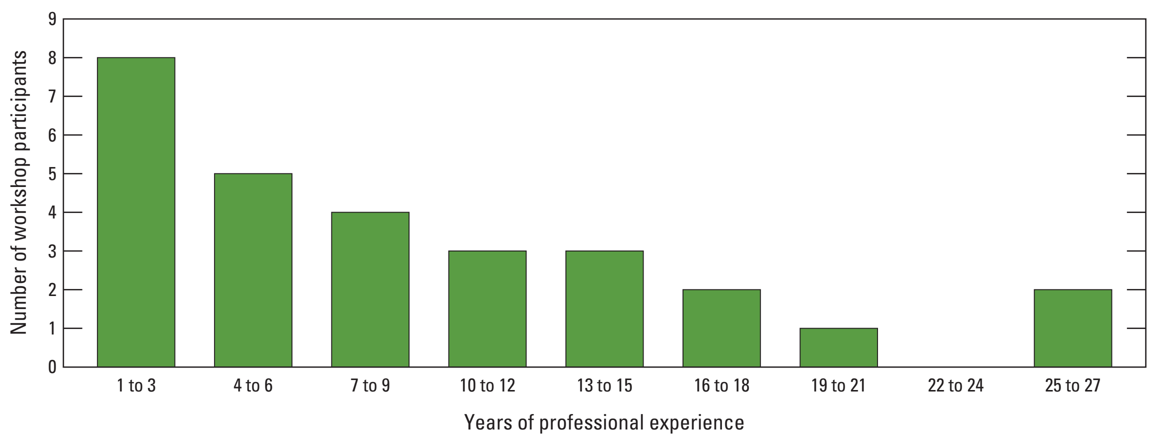

Figure 4. Vertical bar graph showing self-reported years of professional experience of workshop participants attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois.

Table 2. Upper Mississippi River system reaches where workshop participants attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois, reported they were based. The upper impounded reach extends from Minneapolis Minnesota to lock and dam 13 near Clinton, Iowa. The lower impounded reach extends from lock and dam 13 to lock and dam 26 near St. Louis, Missouri. The open river reach extends from lock and dam 26 to the confluence with the Ohio River near Cairo, Illinois. The Illinois River reach is the entirety of the Illinois river from Chicago, Illinois, to the confluence with the Mississippi River near St. Louis, Missouri.

Reach	Percentage (number) of participants
Upper impounded reach	70 (19)
Lower impounded reach	15 (4)
Open River reach	11 (3)
Illinois River reach	4 (1)

Table 3. Response themes and corresponding votes by participants attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois, for the question, "Why is monitoring the upper Mississippi River system floodplain vegetation valuable?"

Theme	Number of unique responses	Number of total votes
Tracks change throughout time	4	121
Informs management decisions	4	41
Helps to understand habitat	5	38
Acknowledges the intrinsic value of floodplain forests	2	14
Facilitates the understanding of processes	3	9

also had the opportunity to vote for other responses that they agreed with, which allowed for a rough ranking of these reasons. Of the responses given, we observed five broad themes regarding the value of monitoring floodplain vegetation, which ranked as follows according to tallies of votes: (1) tracking change throughout time, (2) informing management decisions, (3) helping to understand habitat, (4) acknowledging the intrinsic value of floodplain forests, and (5) facilitating the understanding of processes (table 3).

Small Group Discussion of Priorities and Gaps for Floodplain Vegetation Monitoring

To better understand what existing data or activities were valued by participants, and what might not currently be captured, we divided participants into four groups based on their professional role (scientist, station lead or administrator, manager, or field biologist) and asked them to discuss these existing valued products or gaps in the floodplain vegetation research portfolio and submit them to the online Poll Everywhere platform. Responses were summarized thematically to identify valued activities common across roles (tables 4 and 5). Importantly, these responses do not necessarily represent what these four roles exclusively view as valuable; rather, because the question was open response, these themes are better thought of as topics that were most readily recalled for each group.

Some existing activities were identified as being helpful to participants. Although no items were common to all four groups, several were submitted by three of the four groups, indicating some datasets or activities had broad value across multiple roles. These included local- and project-scale data, LCLU (U.S. Army Corps of Engineers, 2017), and the floodplain inundation model (Van Appledorn and others, 2024b; table 4). "Monitoring non-forest terrestrial vegetation" was the only research activity that does not currently exist that was identified as important by more than two groups (table 5). This was a research and monitoring gap discussed during several different parts of the agenda (figs. 1 and 2) and was explored in greater detail during the small group activities on day 2. The other activity gaps identified common to more than one group were: "Regeneration—landscape scale and spatial dynamics" and "influence of physical processes (for example, sediment deposition and erosion, and groundwater)," each submitted by scientists and managers.

Table 4. Categorized responses by those attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois. to the question "What projects and (or) activities discussed so far are most helpful or informative to your role?"

[Datasets reported as helpful or informative are indicated with a diamond. LCLU, land cover land use; --, no data; ♦, reported as helpful or informative by at least one participant]

Response theme	Submitted by scientists	Submitted by station leads and administrators	Submitted by managers	Submitted by field biologists
Local and project scale data	--	♦	♦	♦
LCLU data	♦	--	♦	♦
Topobathy data	--	--	--	♦
Invasives data	--	--	--	♦
Forest data – Regeneration	♦	--	--	--
Forest data – Structure	♦	--	--	--
Forest data – Current conditions and trends	--	--	♦	--
Forest data – "Fine scale" (frequency and (or) detail)	♦	♦	--	--
Dendrochronology	--	♦	♦	--
Floodplain inundation modelling	♦	--	♦	♦
Easy data access	♦	--	--	--
Interactive tools for data engagement	--	--	♦	--
Forum to share, organize, and develop new ideas	♦	--	--	--
Restoration work	--	♦	--	--

Characteristics of a Successful Monitoring Component: Long Term Resource Monitoring's Aquatic Vegetation

Alicia Carhart

Abstract

The LTRM vegetation component compiled a list of eight "guiding principles" for successful LTRM. These principles included the following: (1) strong programmatic partnership, (2) pioneering leadership, (3) flexibility, (4) firm protocols, (5) passionate and professional team, (6) component leader and specialists serving as both data collectors and data users, (7) promotion of LTRM and recruitment of new researchers and collaborators, and (8) connection between monitoring and research to support other stakeholders' needs. The vegetation component benefited greatly from a dedicated group of individuals that were involved in the initial protocol development. Flexibility was essential early on because the component determined monitoring objectives and appropriate sample sizes. Once established, it is important to have firm protocols with little subjectivity of sampling location and procedures. Any changes and (or) additions are considered carefully to ensure that historical data are not affected. The monitoring team is passionate about the resource and is involved in both collection and reporting of the data for river conservation. The component publishes several reports annually, which has helped promote LTRM and form new collaborations worldwide.

Scope of Work for Information Need 1.1: Floodplain Vegetation Change Across the System

Shelby A. Weiss

Abstract

"Information Need 1.1: Floodplain Vegetation Change Across the System" focuses on understanding and monitoring vegetation changes in the upper Mississippi River system. The project emerged from a May 2022 workshop that identified floodplain vegetation change as one of 29 information needs. Further evaluation of these information needs yielded 10 that were determined to be of high priority, including floodplain vegetation. This effort aims to use existing datasets and tools to understand and quantify long-term changes in floodplain plant communities through targeted research questions, with a focus on floodplain forests; however, considerations are also given to herbaceous communities, given concerns around invasion by non-native grasses and how they may emerge as an alternative stable vegetation type relative to floodplain forests. Initial activities of information need 1.1 include establishing a floodplain vegetation monitoring working group, evaluating data for trends in species composition and structure and the effects of different types of disturbance within the system, and finally, developing an interactive web viewer for stakeholders to easily access and engage with the data.

Table 5. Categorized responses by those attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois, to the question "What is happening to floodplain vegetation that is not captured in our current portfolio that would help you in your role? (This could be a subject, a time, a location, etc.)"

[Responses given by at least one participant from each role. --, no data; HREP, Habitat Rehabilitation and Enhancement Project; ♦, responses from at least one participant (from the column categories)]

Response Theme	Submitted by Scientists	Submitted by station leads, administrators	Submitted by managers	Submitted by field biologists
Quality versus quantity of vegetation data	--	--	♦	--
Site suitability for vegetation (current versus potential vegetation)	--	--	♦	--
HREP influence on succession	--	♦	--	--
Fine-scale species composition	--	--	♦	--
Herbaceous forest vegetation	--	--	♦	--
Nonforest terrestrial vegetation	♦	--	♦	♦
Regeneration failure	♦	--	--	--
Landscape-scale regeneration patterns, including spatial dynamics	♦	--	♦	--
Seed dispersal	♦	--	--	--
Genetic diversity	♦	--	--	--
Species watchlists and reporting (for invasives and rare species)	--	--	--	♦
Non-flood disturbances	♦	--	--	--
Island biogeography	--	♦	--	--
Ground truthing and validation of aerial data	--	--	--	♦
Aquatic to terrestrial habitat conversion	--	♦	--	--
Influence of physical processes (for example, sediment deposition, erosion, and groundwater)	♦	--	♦	--

Day 2: Evaluating the Suitability of Existing Datasets for System-Wide Vegetation Assessments and Discussing Emerging Opportunities to Learn about Floodplain Vegetation Dynamics from Local-Scale Restoration and Management Projects

Long Term Resource Monitoring Land Cover Land Use Data—What We Can and Cannot Monitor

Nathan R. De Jager

Abstract

The LTRM's decadal land cover data has been the most consistently funded and most well-used dataset concerning floodplain vegetation with 23 vegetation classes, and 31 total classes mapped using high resolution aerial imagery (Dieck and others 2015). This presentation reviewed the most abundant herbaceous communities mapped, including sedge and wet meadows, shallow marsh annual and perennials, and deep marsh annual and perennial communities. Some herbaceous communities (for example, wet meadows) are as abundant as some woody plant communities; however, the species composition within herbaceous communities can vary greatly within mapped polygons and is known to change over a time period of years to decades. Such information is not contained within the LCLU data. Woody plant communities were also reviewed, such as upland, lowland, floodplain, *Populus*, and *Salix* communities. Of these communities, floodplain forests are the most abundant. As for the limitations of herbaceous communities, mapped forest communities lack information regarding species composition and age structure. Without such information, it is difficult to quantify the value of floodplain communities as habitat for different species or predict their long-term dynamics.

Upper Mississippi River System Systemic Forest Datasets

Shelby A. Weiss and Matthew L. Trumper

Abstract

We evaluated four systematic forest datasets within the upper Mississippi River system: LTRM 1993 and 2019 flood studies data, USACE Forest Management Geodatabase (FMG) Forest Inventory Phase II data, USACE Permanent Plot data, and U.S. Forest Service (USFS) Forest Inventory and Analysis (FIA) data. We reviewed each one for spatial and temporal coverage, how representative they were in terms of relative percentage cover by forest type and inundation regime attributes and their respective strengths and limitations for continued long-term monitoring. To assess land cover, we used data from the 2010 LCLU dataset (U.S. Army Corps of Engineers, 2017) and extracted the most dominant land cover type for each plot. For assessing inundation regime attributes, we extracted the average growing season flood days from the upper Mississippi River system Floodplain Inundation Attribute Rasters dataset (1972–2011; Van Appledorn and others, 2018) for each plot location, averaging over plot area.

Characteristics of each dataset are outlined in table 6. Sampling intensity and coverage varies across these datasets. LTRM flood studies plots are in a select number of pools (eight) with moderate numbers of plots per pool, whereas USACE Permanent Plots and the USFS Forest Inventory and Analysis plots are present across many pools, but with relatively few plots per pool. USACE FMG plots are numerous, with a sampling density of one plot per 0.25 acre. Temporally, all plots except for the LTRM flood studies plots are sampled on a rotating basis system-wide, meaning that not every plot is sampled in every sampling year. LTRM flood studies plots were only sampled after large flood events, but all target plots for each year were sampled within the given year of interest. LTRM flood studies plots go back the farthest in time (to 1995). Although these datasets adequately represent most forest types, wet floodplain forest is often overrepresented and less abundant cover types, such as mesic bottomland hardwood forests, were poorly represented across datasets. In terms of inundation, the datasets generally capture intermediate floodplain functional classes well, but areas with very short or long flood durations are less consistently represented, although USACE FMG data captured the greatest range of average growing season flood days.

Each dataset has distinct strengths: LTRM flood studies excel at flood event evaluation, FMG provides high sampling density across 23 pools, USACE Permanent Plots offer detailed individual tree development data, and the Forest Inventory and Analysis program provides consistent 5-year resurveys, with relatively high levels of detail (table 7). The limitations of these datasets include incomplete or sparse coverage of the Illinois River and Open River reaches, limited understory or regeneration data, and rotational sampling designs that constrain the extent that a given dataset can provide a “snapshot” of vegetation conditions in a specific sampling year (table 7). Additionally, none of these datasets were designed to capture herbaceous vegetation communities within nonforest land cover types. These findings suggest opportunities for improving systematic forest monitoring in the upper Mississippi River system.

Table 6. Key characteristics describing sampling intensity, frequency, and spatial and temporal coverage of available upper Mississippi River system systemic forest datasets. The total number of FIA plots within the upper Mississippi River system floodplain is an estimate based on publicly available plot locations.

[LTRM, Long Term Resource Monitoring; UIR, upper impounded reach; LIR, lower impounded reach; OR, open river reach; ILR, Illinois River reach; ~, approximately; USACE, U.S. Army Corps of Engineers; FMG, Forest Management Geodatabase; FIA, Forest Inventory and Analysis]

Dataset	Total number of plots (year)	Spatial coverage	Sampling density (mean plots per pool)	Time coverage	Survey frequency
LTRM flood studies	556 (1995) 347 (2021)	8 pools (UIR, LIR, OR, ILR)	70 (1995) 43 (2021)	1995, 2021	~25 years
USACE FMG (Phase II)	36,841	22 pools (UIR, LIR, OR, ILR)	1,535	2008–present (rotational)	Not applicable
USACE Permanent Plots	329	22 pools (UIR, LIR, ILR)	15	2003–present (rotational, single year per district)	~10 years
FIA	~146	31 pools (UIR, LIR, OR, ILR)	5	1998–present (rotational)	~5 years

Table 7. Identified strengths and limitations for each available upper Mississippi River system systemic forest dataset evaluated at the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois.

[LTRM, Long Term Resource Monitoring; USACE, U.S. Army Corps of Engineers; FMG, Forest Management Geodatabase; FIA; Forest Inventory and Analysis; UMRR, Upper Mississippi River Restoration]

LTRM flood studies	USACE FMG (Phase II)	USACE Permanent Plots	FIA
		Strengths	
Specifically designed to evaluate the effects of flood events System-wide, single-year surveys Detailed sampling across vegetation strata (including herbaceous and seedlings)	High sampling density across 23 pools Some areas have multiple phases of data (repeat sampling)	Good balance of spatial coverage, sampling density, and temporal resolution Detailed information about individual tree and stand development Rich ancillary data collected (for example, soils and sedimentation)	High temporal resolution, with consistent resurveys approximately every 5 years System-wide spatial coverage Detailed information about individual tree and stand development
		Limitations	
Sample size may be lacking for rarer species (depending on type of analysis) Few plots in less abundant forest types (for example, *Quercus*-dominant)	Understory and herbaceous layers limited to presence for species composition (and only three species) Only one Illinois River Pool (Alton) and limited coverage of the Open River reach	Rotating schedule means that we do not have a snapshot of UMRR forests at a given time Limited data for Illinois River and Open River reaches	Low sampling density Plot locations are confidential Rotating schedule means that we do not have a snapshot of UMRR forests at a given time

General Land Office Dataset

Andy Meier

Abstract

The species composition of floodplain forests in the upper Mississippi River Valley has changed substantially since European settlement, and particularly since the establishment of the 9-foot navigation channel project in the 1930s. It has been widely thought that a primary result of this change has been an increase in the prevalence and dominance of more flood-tolerant and light-seeded tree species, especially *Acer saccharinum* L. (silver maple), at the expense of less flood-tolerant and hard mast producing species, especially *Quercus* L. spp. (oaks). Many of these assumptions are built on datasets from the lower pools of the upper Mississippi River or datasets that overlap with adjacent bluff lands in the upper pools. Though a wider preliminary assessment of General Land Office surveys (circa 1840s) and Mississippi River Commission maps (circa 1890s) in Mississippi River Pools 3–10 does indicate an approximately 15 percent decline in hard mast species with concurrent increases in silver maple in the upper Mississippi River, the same datasets indicate that hard mast species were historically a minor component of the system, comprising only approximately 20 percent of total trees. Using upper Mississippi River land cover datasets for the area, many of the areas with the highest dominance of hard mast species in the early 1800s, particularly species in the marginally flood-tolerant *Quercus* section Lobatae (red oak group), were areas that were converted to agriculture or development well before establishment of the locks and dams, with remaining forest areas in more flood-prone zones. Silver maple has substantially increased in dominance in the upper Mississippi River, but this is primarily at the expense of other light-seeded species. Proportions of *Fraxinus* spp. L. (ash) and *Betula* L. (birch) have decreased by more than 10 percent, and *Ulmus* spp. L. (elm) and *Salix* spp. L. (willow) have also declined. Further, within the study area, natural regeneration of light-seeded species is far below the threshold required to maintain those species at their current levels. Concurrently, hard mast species make up a higher proportion of regeneration plots than they do in the forest canopy, indicating a potentially expanding distribution for those species. These data indicate that forest restoration in the upper pools of the upper Mississippi River should not discount the importance of light-seeded species in maintaining forest diversity from the perspective of historical vegetation and future forest resilience. Management actions should be undertaken that encourage the establishment of light-seeded species and hard mast.

Further, more detailed analyses of these pre-lock and dam datasets for the entire upper Mississippi River could provide valuable insights into historical terrestrial vegetation in the upper Mississippi River. Understanding that there have been fundamental changes in the upper Mississippi River since the 1800s, a basic understanding of conditions of the system at the time of European settlement and prior to establishment of the locks and dams would provide valuable insights into potential

community types, current species distributions relative to historical species distributions, or representative historical conditions.

Understanding Participant Monitoring Needs and Priorities

After providing background on the forest systemic datasets currently available for monitoring floodplain vegetation, we sought to better understand the types of information most important to participants and the desired spatial and temporal scale of that information. Broadly, participants were asked to rank drivers of change according to what they thought was most important to understand.

Across all responses from participants, “response to large-scale disturbances” ranked first, followed by “successional dynamics,” “climate change,” “management actions,” “invasive species,” and lastly, “insects and disease” (table 8). When asked about the spatial scale of desired information, from a list of multiple choices, 57 percent of participants selected “pool-level summaries of vegetation trends,” followed by 38 percent selecting “site-specific analyses of floodplain vegetation” (table 9). When asked about sampling frequency for forested areas, only one participant indicated that monitoring “just after significant events” as most helpful, whereas the other options, “5-year interval” or “10-year interval,” were more favored, with a 10-year sampling frequency selected by most participants (68 percent, table 10).

Table 8. Overall rankings from 22 responses by those attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois, to the question “What drivers of change are most important to you to understand about upper Mississippi River system floodplain forests?”

Response	Rank
Response to large-scale disturbance events (for example, flooding and drought)	1
Successional dynamics	2
Climate change	3
Management actions (for example, harvest and planting)	4
Invasive species	5
Insects and disease	6

Table 9. Percentage of participants attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois, who responded to the multiple-choice question regarding forest monitoring data needs: “What scale of information is most helpful to you?”

[HREP, Habitat Rehabilitation and Enhancement Project]

Response	Percentage (number) of participants
Systemic summaries of floodplain vegetation trends	5 (1)
Reach-level summaries of floodplain vegetation trends	0 (0)
Pool-level summaries of floodplain vegetation trends	57 (12)
Site-specific analyses of floodplain vegetation (for example, tied to an HREP or another specific project)	38 (8)

Table 10. Percentages of 22 responses by those attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois, to the question regarding forest monitoring data needs:“ What frequency of forest sampling is most helpful to you?”

Response	Percentage (number) of participants
Just after significant events	5 (1)
5-year interval	27 (6)
10-year interval	68 (15)

Participants were then provided the opportunity to list the vegetation monitoring metrics of most interest to them in an open response format. Table 11 lists these responses, whether the metric is summarized at the individual or community level, and which systemic datasets currently capture the metric. Participants were also able to vote for responses that they agreed with because they could view the other responses as soon as they were submitted in real time; however, it should be noted that responses submitted earlier provided more time for participants to notice them and decide to vote. For this reason, the submission order is also noted in table 11. Nineteen total metrics were submitted, with 8 representing vegetation structural metrics, 7 representing functional metrics, and 4 representing compositional metrics (table 11).

Finally, participants were asked to answer the free response question: “What are your greatest barriers to monitoring floodplain vegetation currently?” Their responses were then used to generate a word cloud to better visualize the dominant factors constraining monitoring activities across participants (fig. 5). Within the word cloud, multiple duplicate responses are represented with larger words. For example, time and staff limitations emerged as dominant concerns, indicated by their prominent size in the word cloud. “Staff,” which is the largest word in the word cloud, was indicated in 8 of the 25 (32 percent) responses, and 4 of the 25 (16 percent) responses noted “time” as a barrier. In a similar vein, “personnel” and “capacity” were also listed and further support the limitation of staff and resources to do monitoring. Funding also emerged as a common barrier among participants. Technical challenges were also noted, with participants submitting concerns about data management, recordkeeping, and a lack of consistency among protocols. Finally, the barrier of “expertise” was submitted by multiple participants, indicating there is not only a staffing constraint by some organizations, but also a limited number of staff present with the necessary expertise to perform monitoring-related activities.

Brief History of Floodplain Vegetation Management in the Upper Mississippi River Restoration Program, the Navigation and Ecosystem Sustainability Program, and the U.S. Army Corps of Engineers

Ben Vandermyde

Abstract

Forest management in the Rock Island District for the Mississippi River Project includes implementing silvicultural prescriptions, planting efforts, and non-native invasive species treatments. The decision process to identify what forest management actions are implemented is a continuous flow from data collection, prescription development, coordination of potential effects, considerations to wildlife habitat use, and monitoring treatment response. Informed decision making for forest management includes leveraging nonforest data such as expected inundation during the growing season, geomorphology considerations, and area drainage post flood. Understanding the growth and development of forest post treatment loops back into the decision-making process for future treatment development. The intent is to meet forest diversity and health for maximizing wildlife habitat. Understanding the target forest conditions from the Systemic Forest Stewardship Plan with all the available forest data and nonforest data directs the best forest management action needed to reach specific forest conditions to achieve that mosaic of forest community types and structural development at the landscape level (Guyon and others, 2012). Silvicultural prescriptions, including thinning treatments and timber harvest, focus on establishing the correct sunlight availability and growing space to promote healthy growth of the residual trees post cut and for development of natural regeneration and planted trees. The commonly implemented thinning treatments include geometric, free, and crown thinning. Geometric thinning is a systematic removal of trees throughout a managed area to achieve a more uniform forest structure and evenly spaced canopy gaps. Free thinning targets specific trees of interest to have specific cutting conducted around the targeted tree regardless of canopy position of what is cut. Crown thinning is the targeted removal of trees in the canopy to favor the continual growth of other trees already in the canopy position. All three thinning prescriptions focus on only cutting back enough trees to provide the opportunity for that targeted growth response to reach the desired forest condition for that location. Timber harvests are only feasible when merchantable trees are within a managed area that needs a reduction in tree density to promote new tree growth. Often, there are not enough merchantable trees to merit the administrative costs of implementing a timber harvest, which frequently leads to implementation of a thinning treatment instead of a timber harvest. Currently, the focus is to use timber harvest prescriptions that retain as many canopy trees as possible and to not implement a clearcut. Tree planting is often paired with silvicultural treatments because post treatment creates opportunity with the change in sunlight availability and growing space to introduce species that are suited for the location and are without any parent tree seed source. Thus, tree species selected to plant in treatment areas are often diverse species such as *Quercus* L. spp. (oaks), *Carya* Nutt. spp. (hickories), and species that are less common than *Acer saccharinum* L. (silver maple), *Populus deltoides* W. Bartram ex Marshall (cottonwood), and *Salix* L. spp. (willow). Tree planting efforts that are in open areas or large canopy gaps are often targeted for planting early successional species that are common to establish tree cover fast. The focus of planting fast growing species in nontree cover locations is to achieve closed canopy conditions more quickly to prevent the invasion of unwanted and non-native vegetation, most of which are herbaceous unwanted species that are shade

Table 11. Summary of 22 responses grouped by metric attribute by those attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois, to the question “What monitoring metrics are of the most interest to you?” The number of participant votes, the level of ecological organization (individual or community) that the metric represents, and the order that responses were submitted to the Poll Everywhere platform is noted.

[LTRM, Long Term Resource Monitoring; USACE, U.S. Army Corps of Engineers; FMG, Forest Management Geodatabase; USFS, U.S. Forest Service; FIA, Forest Inventory and Analysis, USGS, U.S. Geological Survey; LCLU, land cover land use; HGU, hydrogeomorphic unit; --, no data; ♦, datasets that currently capture each metric; *, sampling targeted at forested sites; ※, captured only for species present as one of the top three dominant species in the understory]

Floodplain vegetation attributes	Unique responses	Monitoring metrics	Order of response submissions	Participant votes	Level of ecological organization represented by metric	Dataset capturing					
						LTRM flood study	USACE Permanent Plots	USACE FMG Phase II	USFS FIA	USGS LCLU for upper Mississippi River system	USGS HGU map for the upper Mississippi River system
Structure	8	Forest cover by community type	3	14	Community	--	--	--	--	♦	--
		Forest structure (overstory and understory)	1	13	Individual	♦	♦	♦	♦	--	--
		Forest community type correlation to geomorphology	4	12	Community	--	--	--	--	♦	♦
		Total forest cover	8	6	Community	--	--	--	--	♦	--
		Herbaceous vegetation cover	9	5	Community and Individual	♦*	♦*	--	--	♦	--
		Tree basal area	10	5	Individual	♦	♦	♦	♦	--	--
		Tree age	14	2	Individual	--	♦	♦	--	--	--
		Tree diameter	19	0	Individual	♦	♦	♦	♦	--	--
Composition	4	Species presence	5	10	Individual	♦	♦	♦	♦	--	--
		Species composition and structure (overstory and understory) and stem location	6	8	Individual	♦	♦	♦	♦	--	--
		Species-level basal area	13	4	Individual	♦	♦	♦	♦	--	--
		Herbaceous vegetation composition	16	4	Individual	♦*	♦*	※*	--	--	--

Table 11. Summary of 22 responses grouped by metric attribute by those attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois, to the question “What monitoring metrics are of the most interest to you?” The number of participant votes, the level of ecological organization (individual or community) that the metric represents, and the order that responses were submitted to the Poll Everywhere platform is noted.—Continued

[LTRM, Long Term Resource Monitoring; USACE, U.S. Army Corps of Engineers; FMG, Forest Management Geodatabase; USFS, U.S. Forest Service; FIA, Forest Inventory and Analysis, USGS, U.S. Geological Survey; LCLU, land cover land use; HGU, hydrogeomorphic unit; --, no data; ♦, datasets that currently capture each metric; *, sampling targeted at forested sites; ※, captured only for species present as one of the top three dominant species in the understory]

Floodplain vegetation attributes	Unique responses	Monitoring metrics	Order of response submissions	Participant votes	Level of ecological organization represented by metric	Dataset capturing					
						LTRM flood study	USACE Permanent Plots	USACE FMG Phase II	USFS FIA	USGS LCLU for upper Mississippi River system	USGS HGU map for the upper Mississippi River system
Function	7	(Woody) regeneration (listed twice)	2, 18	14	Individual	♦	♦	※	♦	--	--
		Forest health	12	6	Individual	♦	♦	♦	♦	--	--
		Establishment of new seedlings	7	6	Individual	♦	♦	※	♦	--	--
		Individual tree growth	11	3	Individual	--	♦	--	♦	--	--
		Mortality	15	3	Individual	♦	♦	♦	♦	--	--
		Stand level growth	17	3	Community	--	♦	--	♦	--	--

Figure 5. Figure showing word cloud generated from 25 open responses by those attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois, to the question "What are your greatest barriers to monitoring floodplain vegetation currently?"

intolerant. Forest management actions that include non-native invasive species treatments are focused on locations that have either had the investment in conducting a thinning treatment, tree planting, or will be a location for planting efforts.

Information Need 4.2: Learning from Restoration

Kristen Bouska

Abstract

Among the priority areas of growth identified as part of a planning process that the UMRR–LTRM partnership underwent in preparation for potential increased funding, was a need identified to build programmatic capacity to learn from habitat rehabilitation efforts in a strategic and coordinated manner. Key to building this capacity is to support additional personnel at the UMRR–LTRM field stations and a principal investigator at USGS Upper Midwest Environmental Sciences Center who would work at the interface of LTRM and HREPs. The roles of the principal investigator would be to lead and coordinate the component and to develop robust sampling approaches, designs, and analyses to answer research questions. The roles of the field station specialists would be to lead and coordinate data collection efforts within a reasonable distance from the field station and support design, data analysis, and interpretation of results. As a component, field station specialists and the principal investigator would additionally provide technical expertise to project delivery teams regarding LTRM data and resources; develop a firm understanding of HREP planning processes, tools, and resources; and promote knowledge exchange and collaboration between LTRM and HREP. Funding to support this information need was tentatively slated for fiscal year 2026. Initial steps to develop a research framework to identify priority research questions were guided by a partnership advisory group with brainstorming sessions at the 2024 UMRR Science Meeting and 2024 UMRR Workshop.

Participant Perspectives on Learning from Habitat Rehabilitation and Enhancement Projects

A selection of multiple-choice Poll Everywhere questions were included related to the learning from restoration information need to better understand how efforts between the floodplain vegetation change information need could work together with efforts to learn from restoration actions, such as those conducted through Habitat Rehabilitation and Enhancement Projects (HREPs). Participants were asked how they would prefer floodplain vegetation responses to HREPS be studied, whether it should be a new interdisciplinary component, within efforts of the existing vegetation research and monitoring group or studied by external partners or organizations. A relatively even numbers of participants (n=24) answered that they thought they should be studied as a new LTRM component (42 percent, 10) or within the existing research and monitoring group (38 percent, 9), and the remainder (21 percent, 5) responded that they preferred they be studied by external partners.

Participants were also asked about their organization's capacity for monitoring floodplain vegetation response to HREPs, with the majority (87 percent, 13) responding that they would potentially have capacity with additional staff (for example, hiring and conversions of new staff, term positions, and students). One responded that they had capacity with existing staff, and one indicated that they had no capacity at all.

Finally, participants were asked an open response question, "What specific research questions focused on floodplain vegetation responses to HREP features would benefit future project selection and (or) design?” and fourteen responses were submitted (table 12). Participants also had the opportunity to vote for responses they agreed with; however, it should be noted that those submitted earlier had greater opportunity to be voted on. Submitted first, and with the greatest number of votes was “long-term vegetation responses,” and second, “regeneration success” (table 12).

Small Group Sampling Design Activities

In two small group activities, participants split into three groups with each group being given a stack of prewritten sticky notes, from which they could select options from several dimensions of a sampling protocol design to create their own unique design, representing what they saw as an optimal approach to sampling vegetation. In the first session, groups did this for sampling terrestrial herbaceous vegetation cover types, and in the second session, groups selected options for floodplain forest sampling.

Sampling dimensions for herbaceous sampling designs included sampling extent, interval, and information level to collect. Options within each dimension are presented in figure 6; however, groups were encouraged to alter prewritten options if desired, or to create their own category within a given dimension. Groups generally agreed that a selection of pools could be used for sampling herbaceous communities, rather than trying to cover the extent for the upper Mississippi River system. Groups also selected relatively frequent intervals, either 1- or 5-year intervals. Groups tended to opt for a finer level of detail in information, recommending quantifying either percentage cover of all species present or for a select species of interest (for example, invasive species). Some groups acknowledged the tradeoff between acquiring much finer levels of information and sampling more frequently or over larger areas. One group proposed two possible approaches to balancing those tradeoffs (table 13, group 1), one where the entire upper Mississippi River system would be sampled but at a 5-year rather than 1-year interval and with less detail, or alternatively, select parts of pools but more frequently and in greater detail. Another group proposed adding in a separate sampling effort just geared toward assessing HREPs pretreatment and posttreatment (table 13). One online participant also noted that monitoring overall variability and “resetting” events was likely more relevant than monitoring annual variability, so recommended a slightly longer sampling interval of 3–5 years (table 13).

Sampling dimensions for forest sampling designs included sampling extent, interval, stratification, and information level to collect for the overstory and understory. Options within each dimension are presented in figure 7; however, groups were again encouraged to alter prewritten options if desired, or to create their own category within a given dimension. Groups generally agreed on several key aspects. For the sampling extent, all groups agreed on selecting reaches that are representative of the upper Mississippi River system, rather than limiting the focus to LTRM key pools, to ensure a more comprehensive representation of the forest communities.

Table 12. Responses in order of submission and corresponding participant votes by those attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois, to the question “What specific research questions focused on floodplain vegetation responses to Habitat Rehabilitation and Enhancement Project features would benefit future project selection and (or) design?”

Response	Order submitted	Votes
Long-term vegetation responses	1	13
Regeneration success	2	12
How do rates of establishment vary across topographic gradients, species, and years after various management actions and site conditions	3	8
Soil composition and vegetation response	4	7
Effectiveness of seed mixes	5	7
How does proximity or distance of newly created forest to existing forest influence wildlife benefits, particularly for land birds	6	5
Effectiveness of ridge and swale measures	7	5
Spatial scale of vegetation restoration efforts	8	5
Relations between design island elevations and vegetation success and how that varies in time and space	9	5
Island biogeography influence on habitat quality	10	4
Effectiveness monitoring, were objectives met	11	4
Importance of soil conditions relative to other factors	12	3
Timber stand improvement feature response in growth	13	2
Emiquon Key Ecological Attributes to evaluate that restoration may be worth exploring	14	1

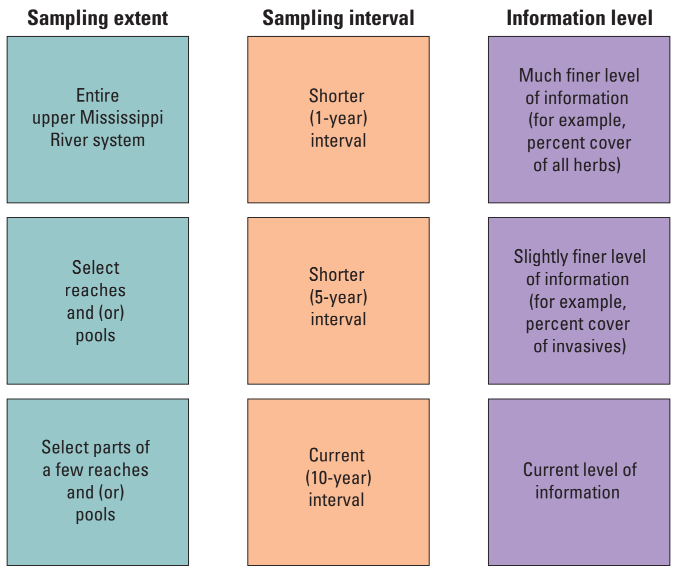

Figure 6. Figure showing three options within herbaceous vegetation sampling dimensions, which include sampling extent, sampling interval, and information level, provided to small groups attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the upper Mississippi River Restoration Program, January 7–8, 2025, in Moline, Illinois.

Table 13. Group selections from sampling options for designing an optimal herbaceous sampling protocol for the upper Mississippi River system by those attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois.

Group	Extent	Interval	Information level
1	Select parts of a few pools or Entire upper Mississippi River system	Shorter (1 year) or Shorter (5 years)	Much finer (percentage cover all herbs) or Slightly finer (percentage cover invasives)
2	Select reaches of the upper Mississippi River system	Shorter (1 year)	Much finer (percentage cover all herbs)
3	Select pools (two per reach)	Shorter (5 years) and Habitat Rehabilitation and Enhancement Project areas: prerestoration and postrestoration	Slightly finer (percentage cover invasives)
Comments from online participants	Select areas in reaches or pools (depending on input)	3–5 year sampling interval; Variability and “resets” might be more relevant than annual variation	More intensive sampling of a relatively small number of sites

Groups also generally accepted a 10-year interval as appropriate for the system, although a few caveats were made. One group noted adapting the sampling interval so that sampling would be triggered by a large-scale flood year but otherwise would follow a 10-year interval. This group also noted that for sampling of HREPs, specifically, a more frequent interval might be desired. Another group noted that shrinking the sampling interval to 5 years would provide more opportunity to observe variability through time.

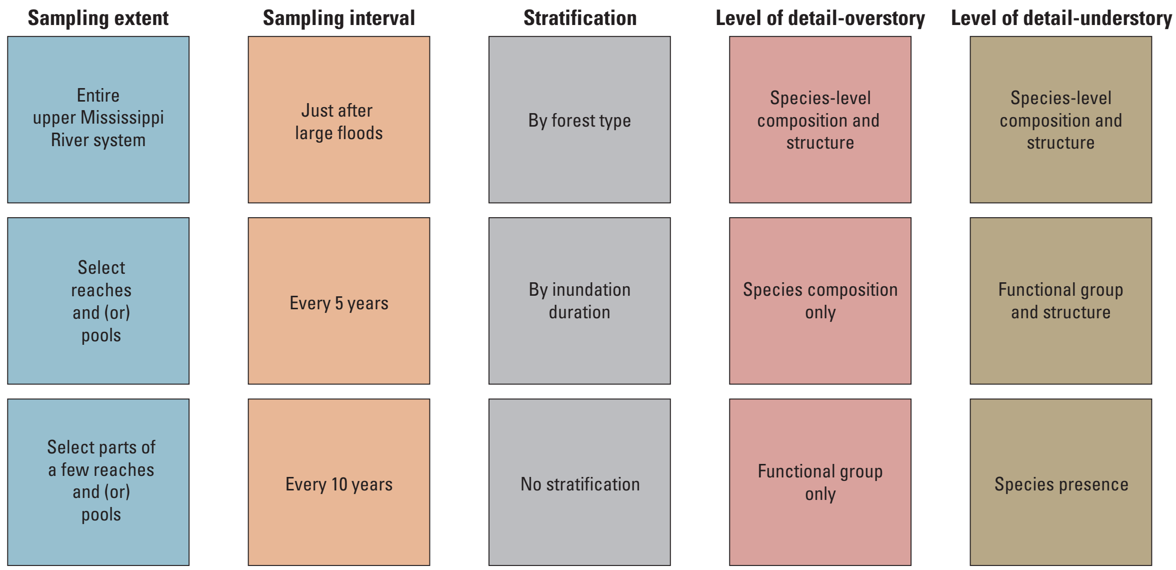

Figure 7. Figure showing 5 options within forest sampling dimensions, which include sampling extent, sampling interval, stratification, level of detail-overstory, and level of detail-understory, provided to small groups attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois.

Stratification methods chosen differed by group, but all tended to get at the idea of representing the range of forest types on the landscape and leaving opportunity for areas where forest types could potentially exist, even if they were not currently present (table 14). Group 2 chose forest type as their stratification method, whereas Group 1 created their own option, suggesting the use of HGU maps, because these would inherently include inundation information and more detail on geomorphic characteristics that could influence potential forest type. Group 3 opted for inundation duration as their stratification method, but when reporting to the larger group at the workshop, they noted that the HGU approach would also achieve what they were aiming to capture. For the overstory and understory level of detail dimensions, groups unanimously agreed that species composition and structure-level information should be collected. Given the effort required to reach the sampling locations, it was considered worthwhile collecting detailed information once on site.

Table 14. Group selections from sampling options for designing an optimal forest sampling protocol for the upper Mississippi River system by those attending the Floodplain Vegetation Monitoring Workshop for the Long Term Resource Monitoring Element of the Upper Mississippi River Restoration Program, January 7–8, 2025, Moline, Illinois.

[HREP, Habitat Rehabilitation and Enhancement Project; LTRM, Long Term Resource Monitoring; HGU, hydrogeomorphic unit]

Group	Extent	Interval	Stratification	Overstory
1	Select reaches (that represent the upper Mississippi River system)	Approximately every 10 years but flexible to allow for after major floods Higher temporal resolution for HREPs?	Geomorphic unit maps (which also include inundation information)	Species-level composition and structure
2	Select reaches	Every 10 years	Forest type	Species-level composition and structure
3	Select reaches (and not just LTRM pools)	5–10 years	Inundation duration to start with (but agree that HGUs would be desirable)	Species-level composition and structure

Synthesis and Next Steps

Throughout the workshop, several recurring topics emerged across polls and small group discussions, highlighting areas for special consideration in developing a long-term monitoring plan for floodplain vegetation in the upper Mississippi River system.

One gap in monitoring identified through our analysis of systemic datasets and from polling participants was a need for a system-wide effort to monitor and better understand nonforest vegetation communities in the floodplain. Increasingly, there is concern about invasion by non-native grasses (for example, *Phalaris arundinacea* L.) preventing the successful establishment of seedlings in a forest context. Further, there is a need to better understand the dynamics of herbaceous communities and the potential for them to represent an alternative stable vegetation type relative to floodplain forests, particularly after flood events that produce high forest mortality. Because field data do not represent these communities in great detail, incorporating their monitoring into future efforts would require an expansion of field sites and existing protocols.

Another gap that was highlighted by participants in this workshop is the need to better capture regeneration patterns across the upper Mississippi River system landscape. Currently, two systemic datasets capture regeneration explicitly: (1) the 1993 and 2019 Long Term Resource Monitoring flood studies and (2) the U.S. Army Corps of Engineers Permanent Plot dataset (table 11). The Long Term Resource Monitoring flood studies capture regeneration after specific large-scale events, and the U.S. Army Corps of Engineers Permanent Plots represent a long-term monitoring effort for capturing forest change through time. Using available data, the topic of regeneration should be considered for the focus of future targeted analysis efforts.

Finally, in discussions of desired future monitoring, participants noted a need to balance capturing information on floodplain vegetation dynamics at broad scales and for specific projects, such as HREPs. Although our current combination of available datasets captures many of the metrics and needs identified by participants (table 11), there is no current protocol for long-term monitoring of forest management actions. The addition of such a monitoring effort would require additional personnel and resources to implement, so future discussions on this topic are likely needed to determine the scale of such an effort and where it may best fit within the current Long Term Resource Monitoring portfolio.

The next steps after this workshop include: (1) forming a working group with representatives across organizations and reaches within the upper Mississippi River system to help shape plans for future monitoring efforts and provide feedback on upcoming analysis efforts, (2) outlining the utility of existing datasets in satisfying varied stakeholder information needs, (3) developing a framework for future monitoring work in the upper Mississippi River system, (4) performing targeted analyses of existing datasets to tackle priority research questions, and (5) streamlining access to existing datasets and information generated from them via interactive online tools. The working group will play an important role in shaping and providing feedback for these efforts.

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