Compilation of Upper Mississippi River System Science Questions developed by the Long Term Resource Monitoring Program

Includes:

1. **Questions from the Science Planning Effort in 2003**
2. **FY07 Additional Program Element Focus Areas**
3. **FY08-FY09 Additional Program Element Focus Areas**

A Hierarchical List of Science Questions Related to the Environmental Management Program on the Upper Mississippi River System (UMRS)

NOTE: This file contains the full list of questions developed through the Science Planning Work Group on 9 January 2003 and from subsequent comments and feedback. This full list shows the wide variety of input received and the full range of detail (up to 7 levels deep) in the questions developed.

PRIMARY MANAGEMENT QUESTION: How can we manage the UMRS to provide for commercial navigation and still maintain the ecological benefits that the river provides?

PRIMARY SCIENCE QUESTION: What controls the abundance, diversity, and distribution of biota in the UMRS?

I. HABITAT IN GENERAL: Does habitat availability, diversity, or context control biotic abundance or diversity?

A. Is habitat diversity directly related to biotic diversity?

1. Are main channel habitats critical for maintaining biotic production and diversity within a river reach?

B. Is habitat limiting for specific types of biota?

1. Are differences in abundance of biota related to habitat differences?

a. Can we predict the abundance of biota based on habitat features?

(1) Are there specific habitat features or conditions that limit the abundance of particular biotic communities or assemblages?

(2) Do the relations of biota to habitat features vary longitudinally?

(a) Can we predict the abundance of submersed vegetation throughout the UMRS based on light regime, depth, and current velocity? How important is sediment type or consolidation? ...short-term (daily or weekly) variation in water levels?

i) Do vegetation beds modify local conditions in a way that provides better habitat for plants (positive feedback)?

2. Are HREP's effective at increasing abundance or diversity of biota?

a. Do HREP's increase species abundance at the pool (or larger) scale or simply concentrate existing production (Local vs Reach effects)?

(1) Do HREP's concentrate fishes and increase exploitation rates?

(a) Can increased exploitation be compensated by more habitat?

(2) Do HREP's have be of a specific size or spatial extent to produce a regional or systemic response?

(3) Is there a most effective spacing for HREP's based on the availability of other habitats within the affected reach?

(4) How much of specific habitat types are needed (minimal or optimal) and at what scale and configuration?

(a) How do we determine when/if a HREP is no longer effective?

C. Does size, distribution, or configuration of habitat patches affect biotic abundance?

1. Are larger patches of intact habitat needed or do more, smaller patches provide the same benefit?

a. How much connection among patches (or distance between patches) is required to provide quality habitat?

(1) How much of specific habitat types are needed for particular species or communities?

D. Does increased connection of the river with its floodplain increase biotic abundance or diversity?

1. In leveed reaches of the river is biotic abundance or diversity reduced on the channel side of the levees? ... behind the levees?

a. What is the abundance and diversity of biota in leveed areas?

b. Can water bodies behind levees be managed to increase production of fishes in mainstem waters? ... waterfowl at a reach scale?

(1) What is the optimal approach for managing the connection of water bodies behind levees?

2. Does increasing the connection of off-channel water bodies to the main channel during low flows increase biotic abundance or diversity?

a. In leveed areas, can semi-connected side channels near the main channel be managed to provide benefits similar to historical off-channel habitats?

E. Do tributaries exert a local influence on biotic abundance or diversity within the river corridor?

1. Is that effect dependent upon the quality of inputs and habitats associated with the tributary?

II. NAVIGATION - Does navigation and its infrastructure affect biotic abundance and diversity?

A. Is abundance or diversity of biota reduced in navigated channels compared to unnavigated channels?

1. Is the abundance and diversity of biota related to the proportion of total habitat represented by main channel? ....by unnavigated side channel?

2. Is fish abundance lower in the main channel than in unnavigated side channels?

a. Are any differences due to differences in levels of boat traffic (commercial or recreational)?

(1) Avoidance of moving barges

(a) Is fish abundance in navigated channels negatively correlated with number of barge passages?

(b) Does avoidance of barges increase energetic costs for fishes?

(2) Effects of turbidity

(3) From mortality due to boat passage

(4) Effects of wakes

b. Are differences due to habitat differences (wing dikes, revetments, etc.)?

(1) Do hydraulic conditions in navigated channels reduce habitat quality? during summer? during winter?

(2) Do wing dikes increase biotic abundance within main channels?

(3) Does armoring shorelines with riprap increase abundance of invertebrates?

B. Do dams or dam operations reduce biotic abundance and diversity?

1. Does the habitat mosaic in pools resulting from impoundment (the 1I3'rds mosaic) increase biotic abundance and diversity?

a. Is biotic diversity or abundance different among the thirds?

2. Do current water level management policies affect biological abundance or diversity? (the Natural Flow Regime hypothesis)

a. How do present patterns of flows and water levels differ from historical patterns? Are any differences consistent throughout the system or do they vary among locations?

(1) What is the natural range of variability of flood/drought disturbances over time and space in the UMRS?

b. Do summer drawdowns increase biotic production?

c. Is it possible to use water level management to periodically regenerate the increase in production derived from "new reservoir syndrome?"

d. Does maintaining high water levels at low flows contribute to change in floodplain forest communities?

(1) Does increasing dominance of floodplain forest communities by silver maple reduce total or relative abundance of forest fauna?

(2) Has the reduction in mast trees in floodplain forests changed the abundance or diversity of floodplain fauna?

e. Does high variability in water elevation reduce biotic production?

(1) Does water level management using a mid-pool control point reduce habitat quality and biotic production in the lower portion of pools?

3. Are the pools within the UMRS at an ecological equilibrium with the effects of dams and water management?

a. If not, what short term and long term change can we expect as the river continues to adjust?

b. Have the dams created changes in sediment transport that affect habitat dynamics?

(1) Have the dams altered the hydraulics of flows, especially flood flows, to the extent that island formation and scouring of off-channel habitats no longer occurs?

(2) Is it possible to divert enough flow into backwater areas to create beneficial sediment scouring?

4. Do dams reduce the ability of fishes to access critical habitats and reduce reproduction and adult abundance?

a. Do dams restrict the distribution or expansion of invasive species?

C. Does repetitive dredging reduce the abundance of biota in the main channel?

1. Is the abundance of benthic organisms (or benthic drift) lower in dredged channels compared to channels that are not dredged?

a. What is the abundance of benthic organisms in the main channel?

2. Are there specific species and life stages of fishes that are affected by dredging?

III. TROPHIC RELATIONSHIPS: What energy sources support secondary production in the UMRS?

A. Which, if any, of the primary river conceptual models (River Continuum, Flood Pulse, Riverine Productivity) is most appropriate for the UMR? Does the appropriate model change seasonally, longitudinally, or with changes in geomorphology, hydrology, or level of human modification to the system?

B. What energy source supports production of fishes?

1. Is the source different for different fish communities, e.g., backwater communities versus channel-dwelling fishes?

2. Does food (energy) availability limit fish production?

c. Why is growth of many fishes better in the La Grange pool than in many other pools?

IV. PHYSICAL VERSUS BIOLOGICAL CONTROL: What role do biotic interactions (including human demands) play in determining biotic abundance and diversity?

A. Does overharvest limit the abundance of specific fishes or of native mussels?

1. Can overharvest be compensated by increased habitat, food resources, or stocking? 2. Are exclusion or refuge zones a potential solution?

B. To what degree does predation limit the abundance of invertebrates (including zebra mussels) or fishes?

C. To what degree is fish reproductive success driven by environmental factors or by density dependent factors?

D. Are invading species changing the abundance and diversity of biotic communities, especially native species?

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V. ECOLOGICAL STRUCTURE AND FUNCTION: What is the underlying structure and function of the UMRS and does that structure or function limit our ability to manage effectively?

A. What level of abundance (or production) is expected in the UMR or in specific habitats within the UMR?

B. Does abundance of biota or community composition differ longitudinally within the UMRS?
1. Are differences related more to large scale systemic factors (e.g., climate, geomorphology) or to local differences (e.g., habitats, exploitation)?
2. Are ecological processes consistent longitudinally? If so, then differences in biota among locations should be due to differences in habitats and drivers rather than differences in function.

C. Is abundance of biota related to levels of variation or disturbance in specific drivers, such as water levels, habitat diversity, etc? (the Intermediate Disturbance Hypothesis)
1. Is biological abundance and diversity affected more by "extreme events" than by the normal range of conditions?
2. Does water level variation affect abundance or ecological succession of floodplain or aquatic vegetation?
3. Can we manage water levels in off-channel and leveed areas to promote desirable plant and animal communities?
4. Can fire be used to promote or maintain native vegetation on the floodplain?

D. What constitutes a complete, sustainable system for the UMR?
1. Is there a point in time that defines that complete system?
   a. Is the pre-European system an appropriate standard.
      (1) Is information available to define the pre-European system?
2. What are the key components needed to sustain a viable ecosystem for the UMR?

E. Are there multiple stable states of the UMR ecosystem?
1. What are the drivers that cause shifts between states?

F. What are the effects of land use in the uplands on delivery of water and other materials to the Mississippi? If upland use is changed, how long will it take to see changes in tributary inputs to the river?

G. Are habitats and ecological processes within the UMRS reaching a point where we may rapidly loose native species and critical ecological functions with little warning and little ability to recover (Catastrophe Theory)?

The Long Term Resource Monitoring Program
FY07 Additional Program Element Focus Areas

A. Fisheries Limiting Factors

This theme seeks an answer to the question: What limits fish production in the UMRS? This focuses on studies that provide insight into community structure, abundance, growth, habitat use, habitat availability, and dispersion of fishes in the Upper Mississippi River Basin. It also includes quantifying our ability to sample fish with specific gears or gear combinations to assess changes in abundance.

Examples of specific questions/topics include:

1. Overwintering Habitat: This topic uses the framework for research on overwintering habitat developed in 2005 to work toward resolving questions such as: (a) How much overwintering habitat is sufficient? (b) What is the quality of current habitat? and (c) How should overwintering habitat be spaced for maximum effectiveness?
2. Fish Migration / Movement: The dam system, dikes on floodplains, and changes in river flows has compromised fish migration and movement between pools, between channels and backwaters, and into tributaries. Understanding fish movements is vital to deciding the appropriate mix of habitat types required for successful management. This topic is intended to facilitate our understanding of fish migration patterns and fish dispersal at various scales.

B. Modeling land cover/land use changes in response to disturbance and management actions

Both natural disturbances and management actions can produce significant changes in land cover and morphology of floodplains. In addition, altered flow regimes and sediment-loading can affect sediment deposition and erosion patterns, and the size and distribution of islands, bars, and tributary deltas. Changes in the timing and duration of flow can result in major changes in plant communities. Management activities, such as draw-downs and island-building, can also change the physical conditions that determine plant community composition. This APE theme focuses on describing and modeling changes in land cover in response to changes in hydrologic regimes.

Examples of specific questions/topics include:

1. Predicting floodplain forest types and land cover based on land elevation and water level regimes.
2. Evaluate landscape ecology metrics for UMRS floodplain over multiple historic periods to determine changes in habitat types and their patterns including functional measures like patch size, fragmentation, connectivity, etc. (using Fragstats or similar software).
3. Using LIDAR to assess changes in floodplain elevation and predict future vegetative cover in response to water level management
4. Modeling the effects of changes in sediment-loading on the size and distribution of tributary deltas.

C. Floodplain forest

UMRS floodplain forests have changed and are continuing to change as a result of flow alterations caused by locks and dams, levees, other structures in the river, and flow management for commercial navigation. Dramatic large scale losses of forest habitat and changes in forest structure and species composition will occur unless active forest management is implemented. Such changes are likely to have undesirable impacts on wildlife, ecosystem functions, and aesthetics of the river. Today, forest loss continues as forested islands within pools (especially in the lower parts of pools) erode away because of increased wave action and sediment transport. Resource managers are very concerned that reed canary grass may invade these forest openings and further retard tree regeneration. Major questions still remain concerning the relation of floodplain forest to birds, reptiles and amphibians.

Examples of specific questions/topics include:

1. Define and describe functional relationships of forest establishment, maintenance, regeneration and modeling. (a) Hydrological modeling – hydrological features that affect forest sustainability, species diversity, restoration, and possible management techniques, and (b) Forest succession and effects on wildlife – a natural area to apply adaptive management.
2. Physical and Biological Assessment of Remaining High Quality Forest: Address management questions related to forest establishment, maintenance, and regeneration. Data needs to direct management to restore such areas to other places in the floodplain.
3. Identify the role of floodplain forests in ecosystem processes. Assess the role of floodplain forest in carbon cycling, nutrient cycling, flow and sediment dynamics on multiple scales. (Goal: To ask how much floodplain forest can be added or restored on different scales to confer benefits to aquatic conditions and overall river health.)
4. Assess the role of floodplain forest in maintaining wildlife populations, particularly birds and river dependent amphibians, reptiles, and mammals.

D. The abundance and production of biota and rates of biological processes in off channel areas

Connectivity and residence time can be managed through alteration of the many closing structures, operation of existing pumps, dredging, etc., which creates the potential for manipulative experiments. There are also natural contrasts among backwaters or backwater complexes that can be explored to provide insights into how these ecosystems function and how they could be optimally managed. This APE theme focuses on addressing these issues with existing LTRMP data through cross-component analyses or by collecting new data under experimental designs that complement existing information.

Examples of specific questions/topics include:

1. What is the role of backwater properties such as connectivity to the main channel, residence time, size of the backwater, or depth in determining rates of biological processes?
2. What is the role of off channel areas to the abundance and production of biota and habitat conditions?

E. What are the local ecosystem effects of elevated nutrient and suspended concentrations that are observed in the UMRS?

High concentrations of suspended solids and nutrients can be detrimental to desirable plant production, fish habitat, and river aesthetics. However, the mechanisms through which these detrimental effects occur and the range of concentrations (including the frequency and duration of high concentrations) at which negative effects become pronounced are poorly understood. A range of techniques could be used to address the topics below.

Nutrients

There is a range of potential impacts of high nutrient concentrations. High nutrient concentrations can promote the growth of undesirable algal (e.g., filamentous and blue-greens) and plant species (e.g., duckweed). High rates of production for these species can produce low dissolved oxygen levels due to large diel oxygen fluctuations or high B.O.D. loads when they die. Also, dense growth of duckweed can shade the entire water column reducing low oxygen levels and growth of submersed macrophytes.

Examples of specific questions/topics include:

1. Is there a consistent relationship between nutrients and duckweed and filamentous algae?
2. Are high nutrient concentrations associated with low dissolved oxygen?
3. How often, where, and under what conditions do blue-green algal blooms occur?
4. Are there other factors that interact with nutrients to produce these undesirable conditions?

Suspended sediments

Reduction in light penetration by suspended sediments may inhibit submerged vegetation, which is important as fish habitat and forage for waterfowl. Resuspension may be an important driver of suspended sediment concentrations in backwaters.

Examples of specific questions/topics include:

1. What are the primary mechanisms of sediment resuspension (e.g., wind mixing? boat/tow wakes? bioturbation by carp?) in backwaters and what are the consequences of that resuspension for biota and biological processes?
2. Are there management techniques that can be used in the lower river (below Pool 13) that will reduce suspended sediments and increase transparency locally, thus allowing aquatic vegetation beds to develop in specific areas?
3. How do vegetation and suspended solids interact? Is there evidence for alternate stable states (clear water + vegetation vs. cloudy water + algae) or are vegetation and suspended sediments both driven by discharge?

F. Impacts of invasive non-native species on water quality and the native biota

Invasive species can pose significant threats to large river ecosystems. Invasive plants, such as reed canary grass, purple loosestrife, and buckthorn, have often displaced native plants in floodplain communities, invasive Eurasian milfoil and curly-leafed pondweed can also form dense beds in backwaters making boating difficult. Invasive fauna, such as Asian carp and zebra mussels, may reduce plankton abundance and alter riverine food webs, with potential negative effects on native mussel and fish species.

Examples of specific questions/topics include:

1. What are the effects of high densities of zebra mussels on water quality (dissolved oxygen, suspended solids), plankton abundance, and native mussel populations? What causes the boom and bust cycles that zebra mussel populations seem to experience on the river?
2. What effect will bighead and silver carp have on the zooplankton community; what are the implications for native planktivores and for the larval and juvenile stages of all fish species?
3. Are there management strategies that can reduce the susceptibility of rivers to invasion or reduce the spread of invasives? Specifically, can restoration or mimicking of natural processes, by techniques such as summer drawdowns, help?

G. Using LTRMP data to help evaluate HREP projects

More than 40 UMRS HREP projects have been completed and more than 30 projects are in some stage of planning, design, or construction. Many of these HREPs are within LTRMP Trend Pools or pools sampled during out pool sampling. This Theme seeks proposals that have two primary functions: 1) use LTRMP and related data to help evaluate the biological, water quality, or ecological response of HREP projects, 2) help to provide sound ecological criteria to help guide development of HREPs.

Examples of specific questions/topics include:

1. Development of project specific sampling regimes that can use pool level data as a background condition to measure project response.
2. Identify data linkages among LTRMP components that would assist in the design or management of HREPs.
3. Conduct analyses of LTRMP data to identify factors or indicators that might be used in standardized monitoring plans to evaluate the ecological performance of different types of HREPs.

Long Term Resource Monitoring Program
Additional Program Element Proposal Process FY08
FY08 and FY09 Focus Areas

1) **Setting Management Objectives:** What are potential quantitative targets for management objectives and indicator levels for important resources within each of the four major floodplain reaches of the UMRS?

a) What are current levels (means, ranges, variability) of resource indicators, or indicator groups, among reaches and what were levels previously?

POTENTIAL APPROACH: The Status and Trends Report is a first step. Determine levels of indicators using LTRMP data, state data, Navigation Study data, other current and historic databases, data from other river systems, professional judgment, and ecological theory. For example, estimate relative abundance, standing stock, or annual production of fishes using LTRMP fish data, state fisheries data, and information on fish larvae density from the Navigation Study.

i) Are indicator levels correlated with specific habitat types or features, or with areas considered "good" or "bad" (by professional judgment) for that indicator?

ii) Can indicators of relative abundance be related to actual abundances of various resources?

iii) How do indicator levels in the UMRS compare to other large rivers?

b) What are the possible future levels of various indicators among UMRS reaches given underlying ecosystem conditions and the potential for management?

2) **Connectivity:** Does increased connectivity of the river with its floodplain increase biotic abundance and/or diversity?

a) How do the features of connectivity (e.g., timing of flood, total area inundated, residence time, water depth, patch size, patch perimeter, connections among patches, and physical attributes of flooded habitats) change with different flood flows among pools and reaches of the UMRS?

POTENTIAL APPROACH: Use flow models and floodplain elevations to predict distribution and movement of floodwaters and predict these features of connectivity at different flows.

i) How have those measures changed from historical values?

ii) Do measures of connectivity correlate with levels of biotic indicators or production among different areas or reaches of the UMRS?

POTENTIAL APPROACH: Correlate levels of indicators [from question 1 above] with measures of connectivity.

b) Does reconnection of a leveed area with the channel increase biotic production, abundance or diversity at local or larger scales?

POTENTIAL APPROACH: Evaluate field experiments or rehabilitation projects that reconnect leveed areas to rest of the floodplain.

3) **Landscape Patterns:** How do landscape/habitat patterns within the UMRS floodplain relate to the abundance and diversity of biota?
a) What are key habitat types, variables, or functions to be included in this analysis?
b) What are the patterns and indicator metrics (e.g., total amount, patch size distribution, diversity, connectivity), for those key features at pool and reach scales within the UMRS over space and time?
POTENTIAL APPROACH: Using software that generates landscape metrics (e.g., FRAGSTATS) conduct quantitative analyses of UMRS land/riverscape patterns and develop a classification of aquatic and floodplain habitat areas (to include the effects of changing water levels). Develop summary statistics for the patterns of habitat areas by river reach, navigation pool, and sub-area.
i) How have these patterns or metrics changed over time?
c) Are there associations between levels of important indicators (biotic or abiotic) and simple (e.g., amount of habitat) or complex (e.g., patch size, connectivity) landscape metrics?
POTENTIAL APPROACH: Use LTRMP or other data sets to generate indicator levels at appropriate scales (patch, pool, or reach) then correlate with habitat measures and landscape metrics.

4) **Aquatic Vegetation:** What factors control the abundance, diversity, and distribution of aquatic vegetation in the UMRS?
i) How well do existing models predict vegetation distribution and abundance? POTENTIAL APPROACH: Apply existing models of vegetation growth and distribution [e.g., Y. Yin model, E. Best model, NAVSAV] to different areas of the UMRS to simulate past or present conditions, then check model predictions against observed levels of aquatic vegetation.
b) What is the potential standing stock and annual production of SAV in different parts the UMRS given existing abiotic conditions?
i) How do the conditions that allow for plant growth differ among different UMRS reaches and have they changed over time?
ii) What are the factors that seem to limit or preclude SAV below Pool 13?
iii) Under what conditions has SAV existed in Pool 19 historically?
c) How can we create conditions that will establish SAV below Pool 13?
POTENTIAL APPROACH: Design and evaluate mesocosm experiments or HREP's to address the critical factors for establishing SAV determined by modeling.

5) **<u>Mussels</u>**: How are mussels distributed, and in what abundances, within and among reaches of the UMRS? POTENTIAL APPROACH: Conduct field sampling at various scales, possibly stratified by potentially important habitat features.

a) Are mussels generally more abundant in some of the 4 major floodplain reaches?

i) Are distribution patterns at the pool-scale different among reaches?

b) How are mussels distributed relative to potentially important habitat features?

POTENTIAL APPROACH: Apply existing models to new pools/reaches that can be checked with appropriate large scale data, collected either pre- or post-modeling.

c) What constitutes a "good" or "healthy" mussel population/bed?

i) What are the population and recruitment dynamics of healthy mussel populations?

ii) How variable is year class strength and can it be related to hypothesized biotic or abiotic drivers?

POTENTIAL APPROACH: Age mussels from new or historic collections to determine and compare year class strengths.

d) Are there sampling designs or techniques that can provide quick and low cost assessment of mussel distribution and/or abundance (including tools like quadrate sampling, dredges, sleds, remote sensing)?

i) How do data from qualitative and semi-quantitative sampling methods relate to mussel abundance determined by quantitative sampling?