Introduction: Science to Support Adaptive Habitat Management, Overton Bottoms North Unit, Big Muddy National Fish and Wildlife Refuge, Missouri

By Robert B. Jacobson

Chapter 1 of
Science to Support Adaptive Habitat Management: Overton Bottoms North Unit, Big Muddy National Fish and Wildlife Refuge, Missouri

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Chapter 1
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Abstract

Extensive efforts are underway along the Lower Missouri River to rehabilitate ecosystem functions in the channel and flood plain. Considerable uncertainty inevitably accompanies ecosystem restoration efforts, indicating the benefits of an adaptive management approach in which management actions are treated as experiments, and results provide information to feed back into the management process. The Overton Bottoms North Unit of the Big Muddy National Fish and Wildlife Refuge is a part of the Missouri River Fish and Wildlife Habitat Mitigation Project. The dominant management action at the Overton Bottoms North Unit has been excavation of a side-channel chute to increase hydrologic connectivity and to enhance shallow, slow current-velocity habitat. The side-channel chute also promises to increase hydrologic gradients, and may serve to alter patterns of wetland inundation and vegetation community growth in undesired ways. The U.S. Geological Survey's Central Region Integrated Studies Program (CRISP) undertook interdisciplinary research at the Overton Bottoms North Unit in 2003 to address key areas of scientific uncertainty that were highly relevant to ongoing adaptive management of the site, and to the design of similar rehabilitation projects on the Lower Missouri River. This volume presents chapters documenting the surficial geologic, topographic, surface-water, and ground-water framework of the Overton Bottoms North Unit. Retrospective analysis of vegetation community trends over the last 10 years is used to evaluate vegetation responses to reconnection of the Overton Bottoms North Unit to the river channel. Quasi-experimental analysis of cottonwood growth rate variation along hydrologic gradients is used to evaluate sensitivity of terrestrial vegetation to development of aquatic habitats. The integrated, landscape-specific understanding derived from these studies illustrates the value of scientific information in design and management of rehabilitation projects.

Background and Introduction

The channel form and flow regime of the Lower Missouri River have been substantially altered to promote economic development, but at the expense of fish and wildlife habitat (National Research Council, 2002). The Lower Missouri River (generally defined as the Missouri River downstream of Gavins Point Dam at Yankton, South Dakota, fig. 1) drains 1,300,000 km^2 (square kilometers) at its mouth (U.S. Army Corps of Engineers, 1998). The river has been regulated since 1954 by the Missouri River Reservoir system, the nation's largest reservoir system with nearly 93 km^3 (cubic kilometers) of storage. Engineering of the Lower Missouri River began in the 1830's with clearing, snagging, and bank stabilization to improve conditions for steamboat navigation. Most of the river's engineering structures date from the Missouri River Bank Stabilization and Navigation Project, first authorized in the Rivers and Harbors Act of 1912 and followed by an additional six acts of Congress in 1917, 1925, 1927, 1930, 1935, and 1945 (Ferrell, 1995). Wing dikes and revetments stabilized the riverbanks, and narrowed and focused the thalweg to maintain a self-dredging navigation channel from Sioux City, Iowa, 1,200 km downstream to St. Louis, Missouri. These engineering structures created a narrow, swift, and deep channel from what was historically a shallow, shifting, braided river, resulting in the loss of as much as 400 km^2 of river-corridor habitats (Funk and Robinson, 1974; Hesse and Sheets, 1993; NRC, 2002; Galat and others, 2005).

Recognition of the scope of habitat loss has increased interest on rehabilitating parts of the Missouri River to help recover native biota (Latka and others, 1993). The U.S. Army Corps of Engineers (USACE) began implementing the Missouri River Fish and Wildlife Mitigation Project (Mitigation Project) in 1986. Initial authorization for mitigation along the Lower Missouri River was for 48,100 acres; an additional 118,650 acres were authorized in 1999 (USACE, 2004c). In

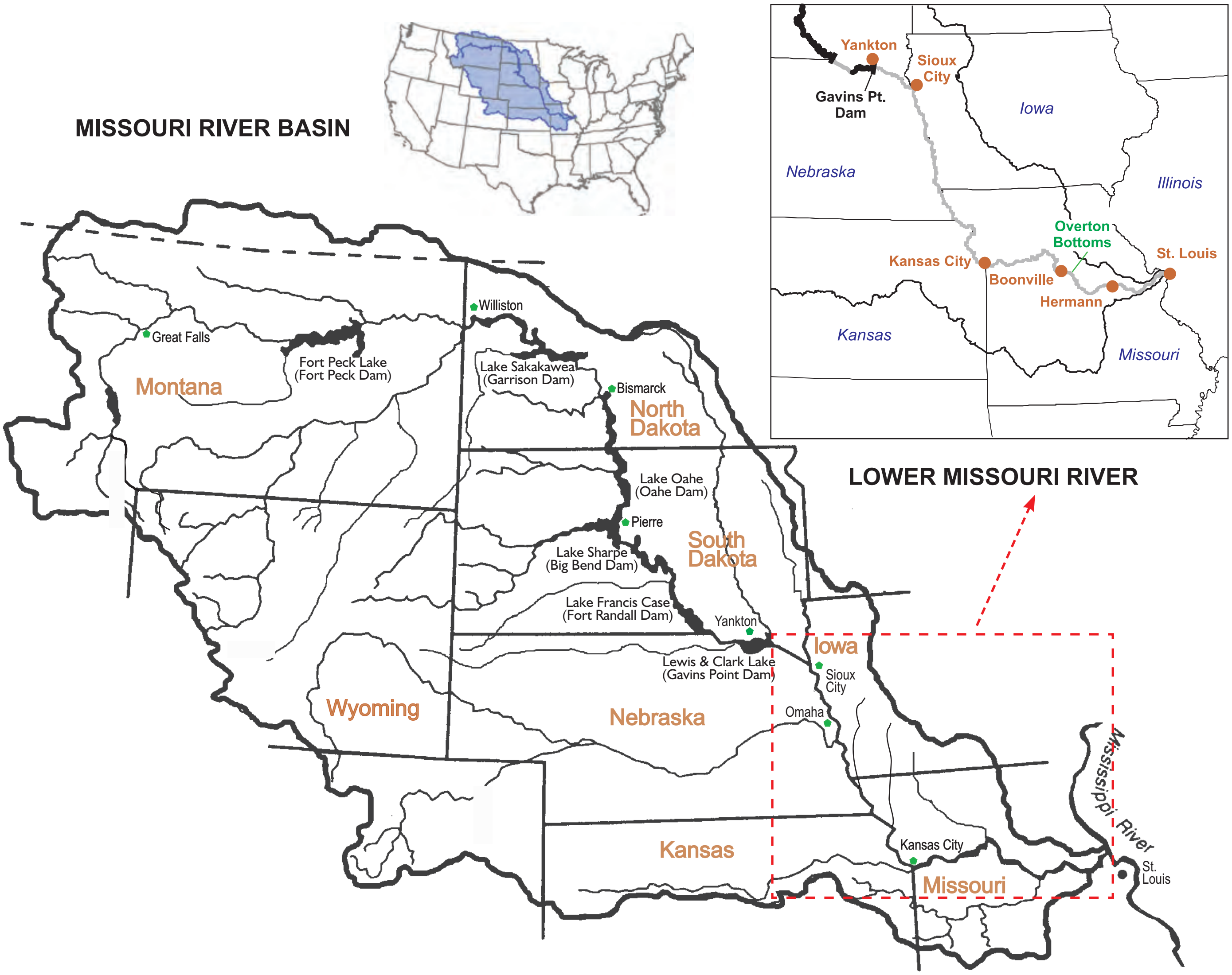
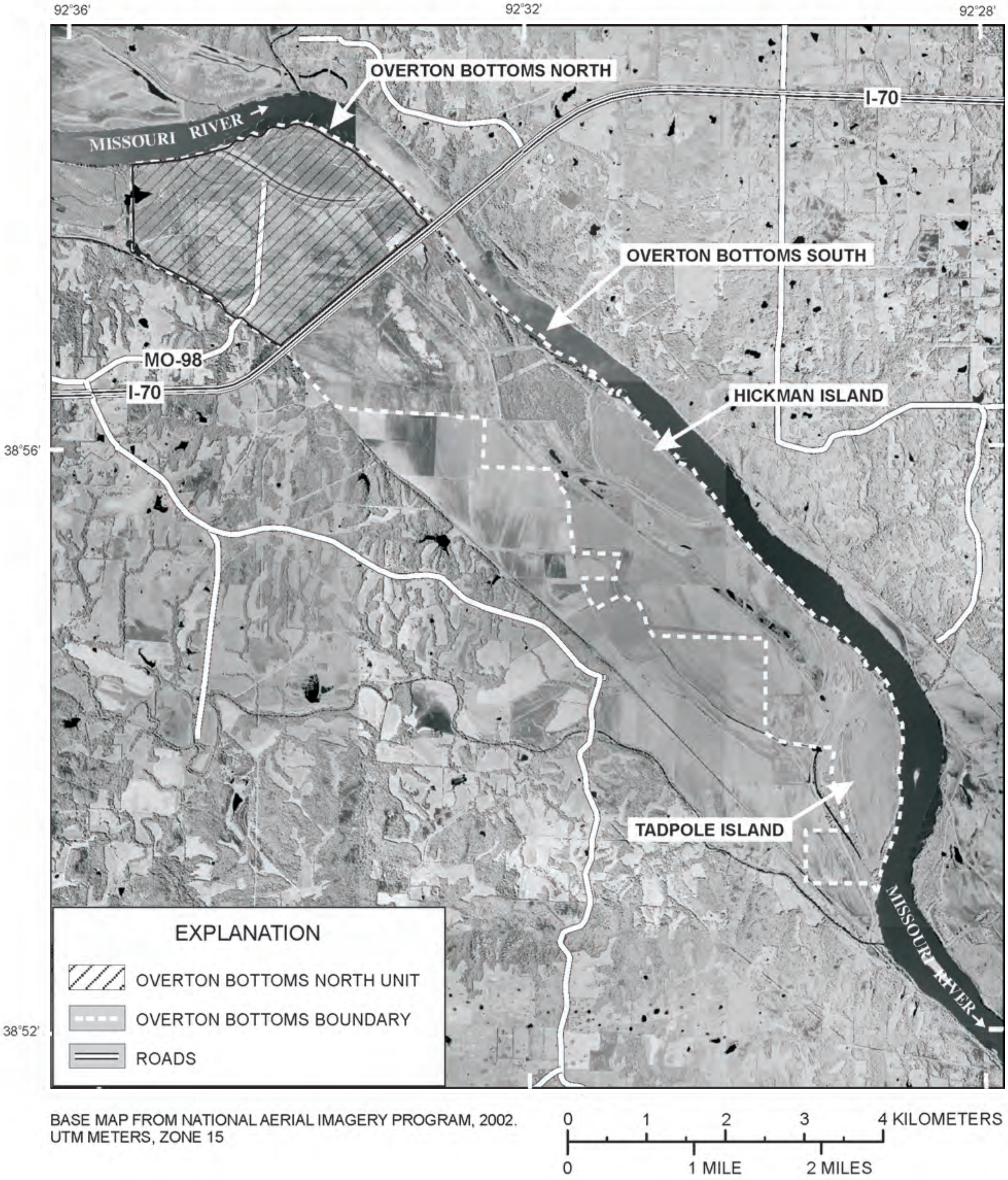


Figure 1. Lower Missouri River. The Lower Missouri River is defined as the 1,340 km of river from Yankton, South Dakota to St. Louis, Missouri. It starts downstream from the lower-most mainstem dam and ends at the confluence with the Mississippi River. The downstream 1,175 km is heavily engineered with wing dikes and revetments to form a stable, self-maintaining navigation channel from Sioux City, Iowa to St. Louis.

1994, the U.S. Fish and Wildlife Service (USFWS) created the Big Muddy National Fish and Wildlife Refuge (Refuge) to acquire 60,000 acres of Missouri River bottomland between St. Louis and Kansas City, Missouri for habitat rehabilitation. Following the “Great Flood” of 1993, numerous landowners sold their flood-damaged lands to the USFWS, USACE, and other government agencies.

The Overton Bottoms North Unit of the Refuge (fig. 2) was originally acquired by the USACE as part of the Mitigation Project. Subsequently, the Refuge also purchased some adjacent land that was incorporated into the Overton Bottoms North Unit. Following the Mitigation Project model, the USACE-owned area was developed by the USACE and turned over to the USFWS for management.

Like many ecological restoration efforts, the Overton Bottoms North Unit Rehabilitation Project involves considerable uncertainty (USACE, 1999; Wissmar and Bisson, 2003). Because levee breaks have opened the area to flow from the Missouri River, ecological responses are affected strongly by stochastic hydrologic events. Poorly predictable hydrologic events are further modulated by complex interactions between surface water and ground water. Ground-water hydraulics are also strongly controlled by poorly understood stratigraphy and sedimentology of surficial materials. Many have argued that management of natural resources in the context of uncertainty requires an adaptive management approach in which management actions are treated as experiments, and results are incorporated back into management strategies (Federal Interagency Stream Restoration Working Group, 1998; Downs and others, 2002; Palmer and others, 2005).



BASE MAP FROM NATIONAL AERIAL IMAGERY PROGRAM, 2002.
UTM METERS, ZONE 15

Figure 2. Location of the Overton Bottoms North Unit, Big Muddy National Fish and Wildlife Refuge, Missouri. The Overton Bottoms North and South Units are part of the U. S. Army Corps of Engineers Missouri River Fish and Wildlife Mitigation Project. The North Unit is managed by the U.S. Fish and Wildlife Service; the South Unit is managed by the Missouri Department of Conservation.

Purpose and Scope

This report presents a case history of application of scientific investigations to adaptive management of a rehabilitation project along the Lower Missouri River. In the case of the Overton Bottoms North Unit, a key management question is how vegetation communities will respond to hydrologic alterations imposed by reconnection of the flood plain with the channel and side-channel chute construction. The trade-offs between aquatic habitat enhancement in the side-channel chute and potential degradation of flood-plain and wetland communities are of concern to Refuge managers (M. Gallagher, oral commun., 2002). The underlying scientific questions involve interaction of surface water and ground water, modulation of ground-water hydraulics by complex surficial geology, and the extent to which the target vegetation communities are sensitive to the altered hydrologic gradients. We chose vegetation as the biologic response variable because it is an element of habitat for many other biologic assemblages, it is directly manageable, and it is relatively easy to measure its distribution and processes.

This report is partitioned into six chapters that include:

1. This introduction.
2. Geologic and topographic context of the Overton Bottoms North Unit.
3. Ground water and surface water hydrology of the Overton Bottoms North Unit.
4. Broad-scale vegetation community responses to altered hydrology.
5. Fine-scale cottonwood growth-rate responses to altered hydrology.
6. Implications of scientific investigations for the adaptive management of the Overton Bottoms North Unit.

Recent History of the Overton Bottoms North Unit

Before the summer of 1993, the Overton Bottoms North Unit area was mostly farmland used for production of corn and soybeans. The peak daily mean flow during the 1993 flood was 20,400 cms (cubic meters per second) measured 16 km upstream at Boonville, Missouri. This discharge nearly matched the estimated 0.002 chance flood (that is, 500-year recurrence interval) for the Boonville gaging station (USACE, 2004a). The flood waters overtopped and breached levees at Overton Bottoms, flooded the valley from bluff to bluff, eroded a deep scour hole under the Interstate 70 bridge approach, and deposited extensive sand splays on the flood plain in the Overton Bottoms South area (fig. 2).

The 1993 flood was followed by six years of relatively high flows during which Overton Bottoms flooded multiple times (fig. 3). Six floods during this period were near or exceeded the estimated 0.2 chance flood (5-year recurrence interval) and 11 floods were near or exceeded the 0.5 chance flood (2-year recurrence interval). Long duration of the 1993 flood, recurring flooding, and un-repaired levees made the area nearly impossible to farm. During 1994–1997, the USACE and USFWS completed purchase of most of the Overton Bottoms North Unit, which eventually totaled 800 ha (hectares) (USACE, 1999).

The main habitat rehabilitation effort for the Overton Bottoms North Unit was construction of a flow-through side-channel chute to provide aquatic habitat (USACE, 1999). Roads and parking lots were designed to afford access to the public. Management of the remaining 683 ha was originally intended to be low maintenance with managers relying on natural processes to recover flood-plain habitats to pre-agricultural conditions (USACE, 2002). However, some active planting of mast-bearing trees and invasive plant control efforts have been undertaken.

Previous Scientific Investigations

The 1993 flood also resulted in a new emphasis on ecological research on the Lower Missouri River. Numerous studies were undertaken to improve understanding of the role of flooding in sustaining populations and ecosystem processes (see for example, Galat and others, 1998). These studies illuminate the complex interactions between the water and land and the subsequent response of biota. Studies included:

- Integrative studies of flood-plain ecosystem processes including relations among hydrology, limnology, fish, shorebirds, and invertebrates (Chapman and others, 2004; Havel and others, 2000).
- Wetlands and waterfowl abundances (Ehrhardt, 1996; Humburg and others, 1996; McColpin, 2002).
- Vegetation community establishment and growth (Mazourek, 1998).
- Nutrient processing and limnology of the Missouri River and flood-plain wetlands (Knowlton and Jones, 1997, 2000, 2003; Blevins, 2004).
- Alluvial aquifer ground-water flow and relations between surface-water discharges and ground water (Kelly, 2000, 2001; Jacobson and Kelly, 2004a).
- Fish communities in scours and shallow-water habitats marginal to the main channel (Galat and others, 1997; Grady and others, 1999; Sargent and Galat, 2002).

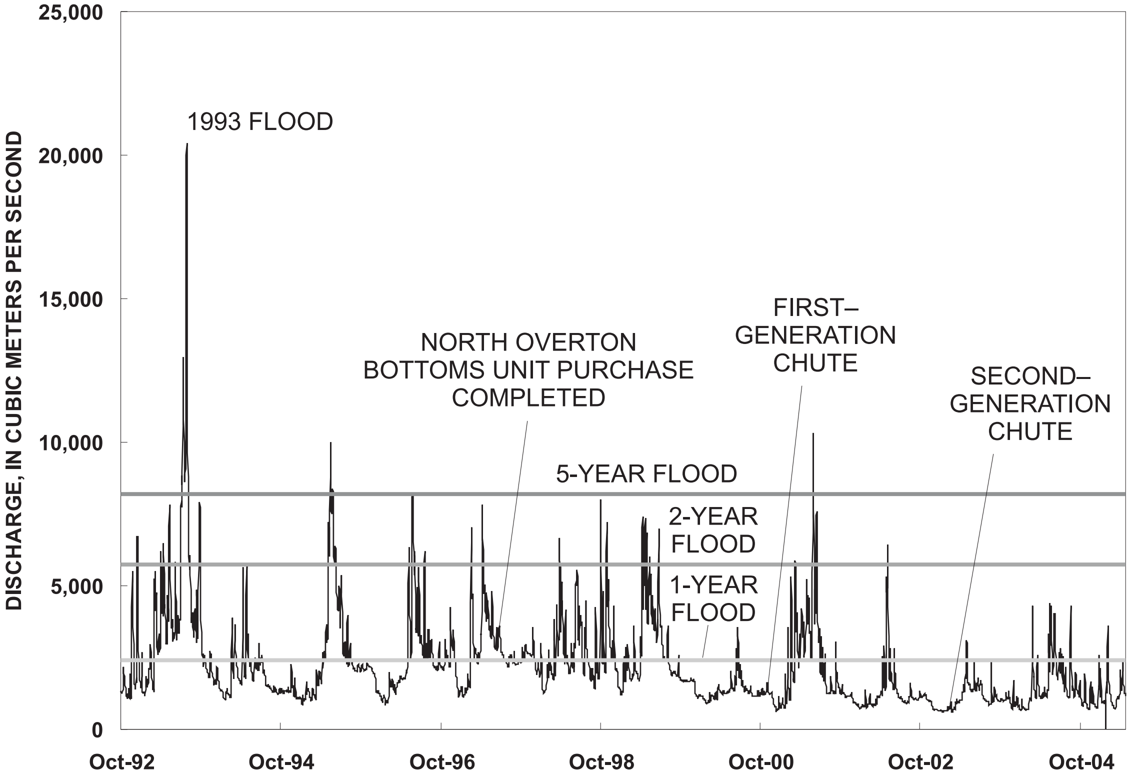


Figure 3. Missouri River at Boonville, Missouri, 1992–2005. Discharge recurrence intervals and events in the construction of the Overton Bottoms North Unit are noted. Recurrence intervals were calculated from the U.S. Army Corps of Engineers (2003).

- Life histories and habitat use of flood-plain dwelling turtles and mammals (Bodie and others, 2000; Bodie and Semlitsch, 2000a,b; Williams and others, 2001).
- Hydrology and geomorphology of the Lower Missouri River, including hydrology and geomorphic evolution of side-channel chutes (Jacobson and others, 1999; Galat and Lipkin, 2000; Jacobson and others, 2001; Jacobson and Heuser, 2002; Jacobson and others, 2004a, b).

Resource Management Issues

Rehabilitation strategies on the Missouri River fall into several distinct categories, covering a range of passive to intensive approaches (table 1).

The intent of all these rehabilitation strategies is to naturalize the river corridor (see Rhoads and others, 1999) by increasing the diversity and dynamic range of habitats. However, the scientific basis for design of such projects is poor. Most designs are based on the premise that any change that increases topographic and hydrologic variability will be an improvement. This approach assumes that once the new physical system is in place, there will be desirable biological results. Experience in monitoring physical aspects of several existing rehabilitation projects has demonstrated that stochastic hydrology and poorly understood sediment and woody-debris transport systems combine to produce substantial uncertainty in how the physical template will evolve (Jacobson and others, 2001; 2004b; Chapman and others, 2004). Moreover, general understanding of the inherent complexity of riverine ecosystems indicates that biotic responses are likely to be complex and unpredictable (Hilderbrand and others, 2005; Wissmar and Bisson, 2003).

The large uncertainties associated with performance of rehabilitation projects dictates an adaptive management approach in which performance monitoring and analysis are used to adjust project design, enhance maintenance, and/or realign project objectives (Downs and others, 2002). Within the adaptive management framework, rehabilitation projects become large-scale field experiments that have great potential for exploration of complex ecosystem responses to imposed manipulations (NRC, 1999, 2002; Allen and others, 2001).

Table 1. Types of rehabilitation activities in the Lower Missouri River corridor

Type	Objectives	Approach
Intensively managed wetlands	Provide specific wetland habitats and associated food sources at specific times of the year to support, mostly, waterfowl production.	Construct leveed wetland compartments; manipulate interior drainage; pump or drain as needed to optimize water levels; plant food crops for water fowl
Passive wetlands	Provide general wetland habitats at least cost.	Remove levees to increase frequency of flooding
Side-channel chutes	Provide off-channel aquatic habitats; increase hydrologic connection of valley bottom to main channel.	Construct off-channel chute; inlets and outlets variably designed to achieve hydroperiod and sediment transport objectives
Shallow-water within channel	Provide shallow, slow current-velocity habitat along margins of main channel.	Increase top width; remove revetment and allow lateral erosion; manipulate wing dikes to achieve diversity of habitat.

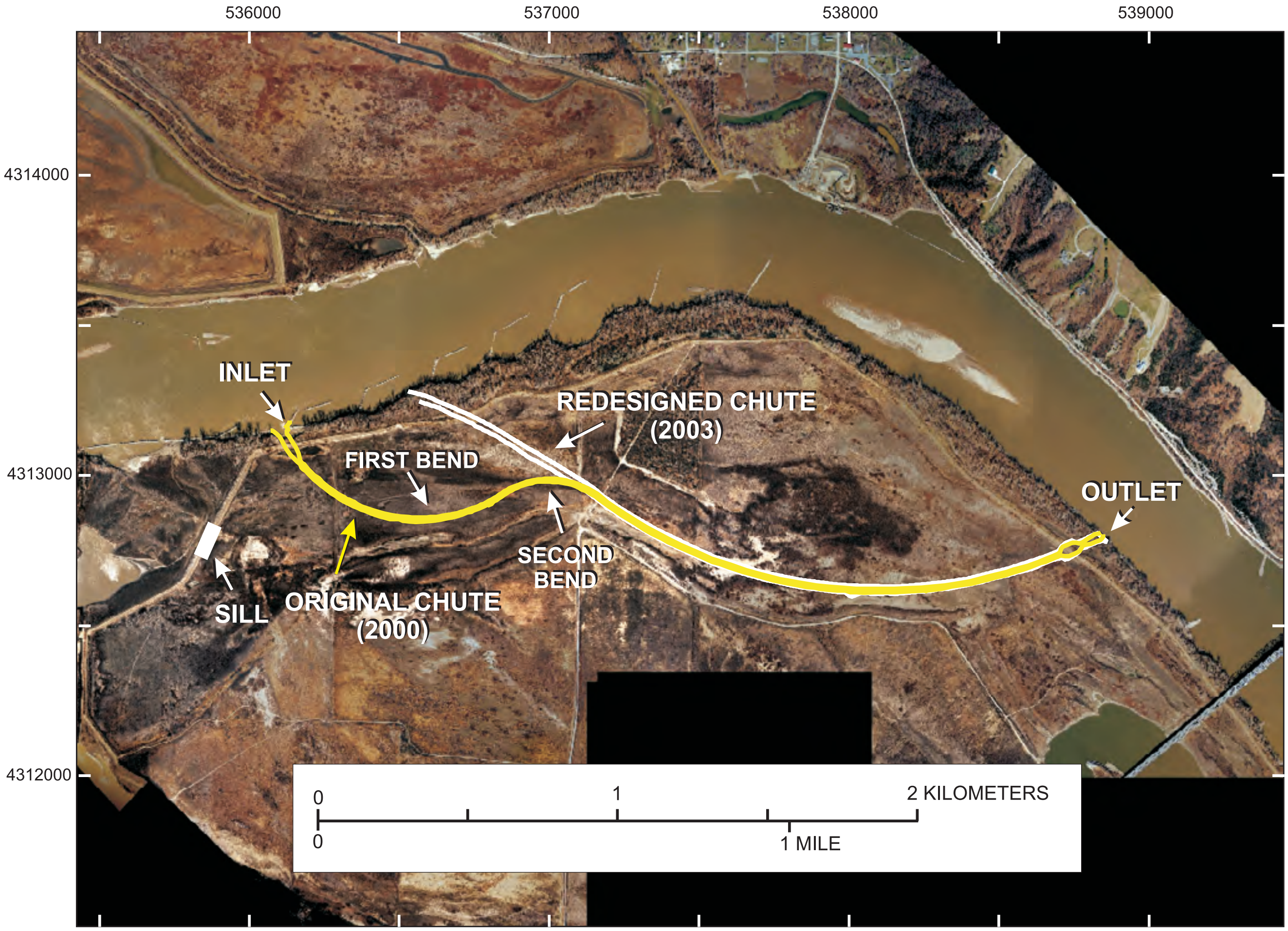
Overton Bottoms North Unit Case Study

Habitat rehabilitation at the Overton Bottoms North Unit provided an opportunity to use management actions as adaptive management experiments. The two major management activities at the Overton Bottoms North Unit were construction of the side-channel chute and relatively passive management of vegetation communities in the remaining area.

The long-term geomorphic evolution of the side-channel chute, the types of habitats it produces, and effects on adjacent flood-plain areas and the main channel of the Missouri River are primary management concerns at Overton Bottoms North (USACE, 1999). Jacobson and others (2004b) described hydrologic characteristics, hydraulics, habitats, and geomorphic evolution of four side-channel chutes on the Lower Missouri River, including the Overton Bottoms North Unit side-channel chute; the following description is from that report. The initial construction of the chute was in 2000 (fig. 4). Because of a very conservative design, the first generation of the side-channel chute was remarkably stable despite being designed as a pilot side-channel chute and being subjected to multiple floods with a 2–5 year recurrence intervals (fig. 3). After three years of existence, the Overton Bottoms North Unit side-channel chute had produced little natural aquatic habitat and was in danger of filling in with sediment in the downstream half. To correct this situation the side-channel chute was re-aligned and re-excavated during spring 2003. Excavation deepened, steepened, and enlarged the chute (figs. 4, 5). Placement of excavation spoil at the top of vertical banks was intended to promote bank instability and accelerate geomorphic adjustment. Compared to the first-generation design, re-engineering of the side-channel chute in 2003 reflected a much less risk-averse attempt to promoting dynamic habitats. The extreme change in side-channel chute form produced the opportunity to investigate the effect of hydrologic gradients on ecological processes as pursued in this report. Ongoing U.S. Geological Survey investigations are documenting geomorphic adjustment of the side-channel chute.

Vegetation community changes also are of particular interest to Refuge managers at the Overton Bottoms North Unit as they comprise fundamental habitat attributes for many other biotic components (Thomas Bell, oral commun., 2000). One frequently cited management goal for riverine areas is enhancement of hard mast-producing trees such as oaks and hickories to provide food sources for deer and turkeys (Grossman and others, 2003). An alternative management goal could be to restore the presettlement vegetation of the valley bottom. The early successional stages of cottonwood/willow communities that dominate much of the valley-bottom conservation lands affected by the 1993 flood were also dominant in pre-settlement time (Harlan and Denny, 2003) and have been shown to be important habitat for other bird species, including neotropical migrants (Swanson, 1999). The successional trajectory of flood-plain communities is therefore an important question for managers: should the communities be actively managed with planting, burning, or thinning, or can management values be achieved through low-maintenance, passive approaches?

A related vegetation issue is how to manage or control invasive species. Johnson grass *(Sorghum halepense)*, for example, is an aggressive non-native species that grows prolifically in open areas of the Overton Bottoms North Unit



DIGITAL BASE MAP DATA, UTM METERS, ZONE 15.
AERIAL PHOTOGRAPH, U.S. ARMY CORPS OF ENGINEERS, 2000, UNPUBLISHED DIGITAL DATA.

Figure 4. Locations of the side-channel chutes and features at Overton Bottoms North.

(Barbara Moran, oral commun., 2000). Managers would like to know whether Johnson grass invasion is a transient phenomenon that will eventually succumb to shading from tree communities, or whether Johnson grass will require a long-term management strategy. Understanding of the surficial geology and hydrology of the Overton Bottoms North Unit landscape may also demonstrate spatial controls on distributions of invasive species and therefore indicate ways to maximize management efforts.

In addition to terrestrial habitat management questions, there is considerable interest in aquatic habitats, especially as they promote recovery of threatened and endangered species. In 2003, the USACE began creating shallow, slow current-velocity habitat (SWH) intended to provide nursery and rearing habitat for young native fishes, and in particular to benefit the endangered pallid sturgeon *(Scaphirhynchus albus)* (USFWS, 2003; USACE, 2004b). SWH is defined as water 0 to 5 feet deep (0–1.5 m [meter]) and 0 to 2 feet per second (0–0.75 m/s [meter per second]) current velocity. The side-channel chute at the Overton Bottoms North Unit and additional areas adjacent to the Refuge on the margins of the main channel (fig. 2) have been considered part of the SWH enhancement effort. Development of aquatic habitat, however, necessarily involves a trade-off: the loss of some flood-plain or wetland habitat. For example, development of SWH in the main channel adjacent to the Refuge in 2004 resulted in the loss of approximately 8 ha (hectares) of woody riparian corridor. Mature cottonwood trees in the area may have provided roosting and nesting sites for bald eagles and other birds. A central question addressed by this volume is the extent to which development of the side-channel chute affects wetland hydrology, and consequently, flood-plain vegetation community patterns, growth rates, and associated habitats for other species.

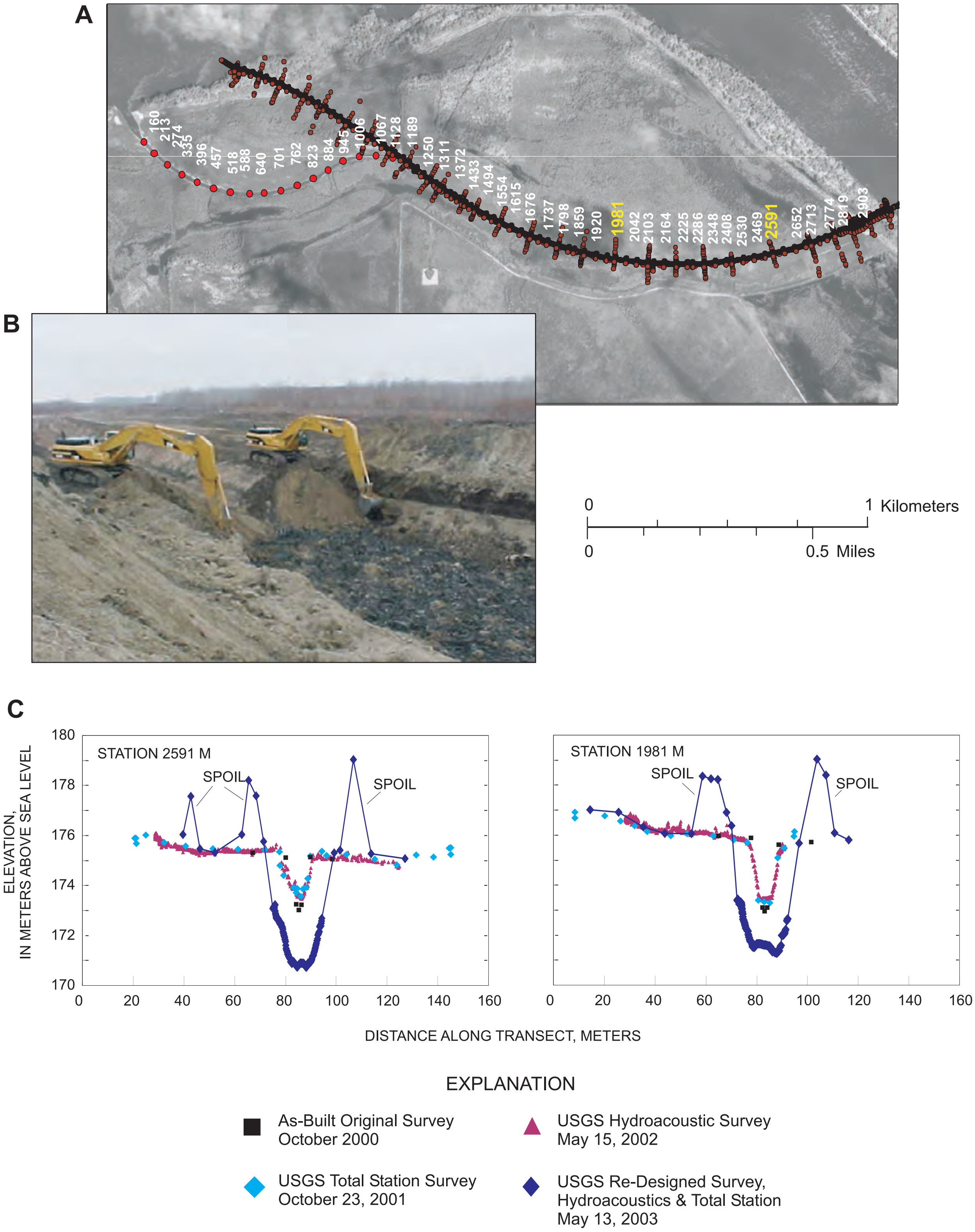


Figure 5. Adaptive re-excavation of Overton Bottoms North chute. A. Map of first-generation and second-generation chutes showing cross-section monitoring locations. B. Excavation of chute in spring 2003. C. Representative cross sections showing first generation of chute and the extent of deepening, steepening, and enlargement by re-excavation.

Science Questions

Although a great deal is understood in general about the value of connections between rivers and their flood plains (Junk and others, 1989; Bayley, 1995; Sparks and others, 1998), scientific understanding is insufficient to provide specific guidance for rehabilitation design and to evaluate resource trade-offs. This volume addresses some of the fundamental science questions underlying rehabilitation design in context of a specific landscape.

Surficial Geologic Framework

Surficial geology refers to the study of the rocks and mainly unconsolidated materials that lie at or near the land surface (Ruhe, 1975). Surficial geology encompasses the topography of the land surface and the stratigraphy, sedimentology, geochronology, and pedology of the underlying sediments (Jacobson and others, 2003). Only recently have substantive efforts been applied to describing and mapping the surficial geology of the Lower Missouri Valley (see publications cited in this volume, chapter 2).

Understanding of the surficial geologic record has two fundamental applications to adaptive management of bottomland resources. The sediments that comprise the alluvial valley fill, their properties and stratigraphic sequence, and their characteristic surface morphologies are strong controls on ground- and surface-water distributions. Surficial geologic maps and sub-surface data, therefore, are rich in information with a direct bearing on habitat capability of the landscape. In addition, the historical information that can be interpreted from understanding of surficial geology presents a unique perspective on long-term landscape behavior. The geologic record of how river deposition and erosion have responded to hydroclimatic and anthropogenic events can be important in understanding the range of disturbances a river is subject to under present-day conditions (Jacobson and others, 2003).

Scientific questions being addressed through surficial geologic investigations include:

- What are the effects of late Pleistocene and Holocene climatic events on hydrology, sediment supply, sediment transport, erosion, and deposition of the Lower Missouri River?
- What are the valley-scale controls on preservation, stratigraphy, and sedimentology of the alluvial valley fill?
- How do hydraulic properties, stratigraphy, and surface morphology correlate among mappable allostratigraphic units?

While the direct role of surficial geologic studies at the Overton Bottoms North Unit are in application to ground-water hydraulics and wetland distributions, the surface and subsurface data collected at Overton Bottoms North Unit for this project adds to a growing body of information on surficial geology of the Lower Missouri River.

Hydrology

Breaching of levees and construction of the side-channel chute at the Overton Bottoms North Unit increased the opportunity for hydrologic connection between the channel and the rest of the river corridor. Connectivity was increased for floods ranging from bankfull to those that would have overtopped the pre-existing levees with 1.5 to 10 year recurrence intervals. Flooding pathways provided by levee breaches and the chute, however, also may speed drainage from the flood plain after a flood, thereby decreasing length of inundation. In addition, the side-channel chute may allow for greater infiltration or drainage from the alluvial aquifer than would have existed without it. Because of complex interactions between surface and ground water, the net affect of rehabilitation activities involves considerable scientific uncertainty.

Science questions related to hydrology include:

- How do inundated area, residence times, depths, and current velocities vary with discharge?
- How are spatial patterns of inundation controlled by topography?
- How sensitive are surface-water flow patterns to hydraulic roughness induced by vegetation communities, and how do roughness effects change as communities undergo successional change?
- How do surface water and ground water interact to influence near-surface moisture distributions and water quality?
- To what extent do surficial geologic strata control permeabilities, transmissivities, and ground-water levels?
- How do topographic alterations associated with rehabilitation activities affect the overall hydrologic response of river bottoms?

The Overton Bottoms North Unit provides a field setting for exploration of these hydrologic questions and for evaluating how surface- and ground-water interactions may change over the long term as geomorphic and vegetation adjustments proceed. Although this report does not address all these questions exhaustively, it provides the framework for quantifying hydrologic alteration at the Overton Bottoms North Unit.

Selected Ecological Responses

Biotic changes associated with hydrologic alteration of the Overton Bottoms North Unit have the potential to be widespread as hydrology is a fundamental driver of river-corridor ecosystem processes. Responses may be direct responses to how much, how long, and how frequently a site is inundated, or responses may be complex and indirect in relation to vegetation and/or water-quality alterations. Moreover, biotic responses may be measurable at many different trophic levels, from primary productivity to population characteristics of vertebrate species.

Evaluations of ecological restoration projects must often confront which biotic indicators are most effective for performance assessment (Palmer and others, 2005). In some cases, performance may be best assessed in terms of physical/chemical parameters like residence time of water, carbon retention, or nitrogen processing. In many cases, however, there is a need to demonstrate performance in terms of biotic responses. Although vegetation communities are not a universal indicator of ecosystem performance, they are effective indicators because of the relative ease of sampling vegetation in the field and through remote sensing, and because vegetation often contributes substantially to habitat quality for other biota.

Dominant scientific questions related to vegetation communities are:

- What are the successional trajectories and time frame for flood-plain vegetation communities?
- Are trajectories toward steady state vegetation communities (measured in terms of species composition) different depending on the antecedent land cover?
- Are vegetation communities different depending on topographic and surficial geologic characteristics of the valley bottom?
- Are typical flood-plain vegetation communities sensitive to the scale of hydrologic alteration in flood-plain rehabilitation projects?

Because substantial areas at the Overton Bottoms North Unit have entirely new vegetation communities since the 1993 flood, the area serves as a long-term experiment for evaluating successional trajectories. In addition, active manipulation of the side-channel chute provides opportunities for experimental evaluation of sensitivity of tree communities to steepened hydrologic gradients.

The Role of Science in Adaptive Resource Management

The concept of adaptive management has been promoted as a way to deal with uncertainties in natural resource management. In its simplest form, adaptive management is a structured process of "learning by doing" (Walters, 1986, 1997), but it is also used to describe more formal processes of systems modeling and iterative hypothesis testing (Blumenthal and Jannink, 2000). Adaptive management is usually described as a formal, multi-step process (Walters, 1986):

1. Identification of management problems.
2. Setting of management objectives through the lens of the ecosystem/basin stakeholder vision and goals.
3. Integration of existing information on how the system operates into dynamic models to predict how alternative management decisions will alter the system.
4. Testing and selection of management experiments through the aforementioned models.
5. Design of actual field experiments.
6. Implementation of management experiments.
7. Monitoring and evaluation of experiments and their affects on system performance.
8. Feedback to update models, reassessment, update of management actions.
9. Repeat as necessary to achieve objectives, goals and vision.

The rehabilitation project at Overton Bottoms North Unit did not follow this formal process. In particular, the design of management experiments around scientific models, steps 3–5, was omitted. Step 7 (including work described in this report and several other projects) was pursued opportunistically rather than being an integral part of the rehabilitation project. The assessment and modeling aspects of step 8 have not occurred. Re-excavation of the side-channel chute in 2003 could be interpreted as adaptive management, but it did not occur within the context of systematic evaluation of ecological performance of the system. Finally, whether adaptive management is institutionalized (step 9) in the future remains to be seen. Nevertheless, the Overton Bottoms North Unit Rehabilitation Project fulfills the fundamental descriptor of adaptive management as "learning by doing".

In retrospect, two simple conceptual models define the Overton Bottoms North Unit Rehabilitation Project experiment. The first conceptual model (or hypothesis) is that allowing hydrologic connection to the Overton Bottoms North Unit will create patches of vegetation communities that will evolve along successional trajectories defined by their position on the landscape and the underlying surficial geologic materials. Over a multi-decade time frame, these patches will provide spatially varied and dynamic habitats. The data and analyses presented in chapters 2–4 of this volume develop this model in greater detail.

The second conceptual model involves the detailed interaction between surface water and ground water adjacent to the side-channel chute. The model (or hypothesis) states that steep hydrologic gradients induced by the side-channel chute will affect hydroperiod in adjacent wetlands and growth rates of native tree species (fig. 6). Whether this conceptual model is valid or not depends, at least, on permeability of the alluvial materials and the sensitivity of tree species to the new hydrologic gradients. This model is explored in this volume, chapter 5.

Realistically, the rehabilitation project at the Overton Bottoms North Unit cannot be considered a formal experiment as it does not involve complete randomization of treatments and sampling; rather, the evaluation is a quasi-experiment similar to conventional before-after/control-impact designs (Block and others, 2001). Although quasi-experiments do not have the inferential power of completely randomized experiments, they are much more practical in typical field situations. In the case of the Overton Bottoms North Unit Rehabilitation Project, we consider retrospective analysis tracking vegetation community growth over time and evaluation of growth rates related to hydrologic gradients as exploratory quasi-experiments that can yield useful knowledge about process and broad constraints on possible effects. As such, they are especially useful in developing detailed hypotheses relevant to the existing landscape for subsequent testing under more rigorous conditions. While these experiments have not been designed to have the inferential power to reject hypotheses with any degree of statistical significance, they are intended to provide useful knowledge for management decisions.

Conclusion

The overall objective of the chapters in this volume is to provide scientific information that will be useful in adaptive management of Lower Missouri River rehabilitation projects. Adaptive management recognizes the important role of science in iteratively refining understanding and decreasing management uncertainties (for example, NRC, 2003). Science is most effective in resource management when it is demonstrably relevant, comes from authoritative sources, and comes from trusted institutions. These are the characteristics of salience, credibility, and legitimacy recognized in sustainable development theory (Cash and others, 2003).

Adaptive management projects also provide important opportunities for scientists to explore new ideas at landscape scales, to demonstrate the relevance of those ideas to management issues, and to communicate ideas to a broad audience. Under the best adaptive management scenario, substantial benefits will accrue to both scientists and managers. Hopefully, this report will achieve the goals of saliency, credibility, and legitimacy of science, and as such, it will contribute to the continued involvement of science in adaptive management of rehabilitation projects on the Lower Missouri River.

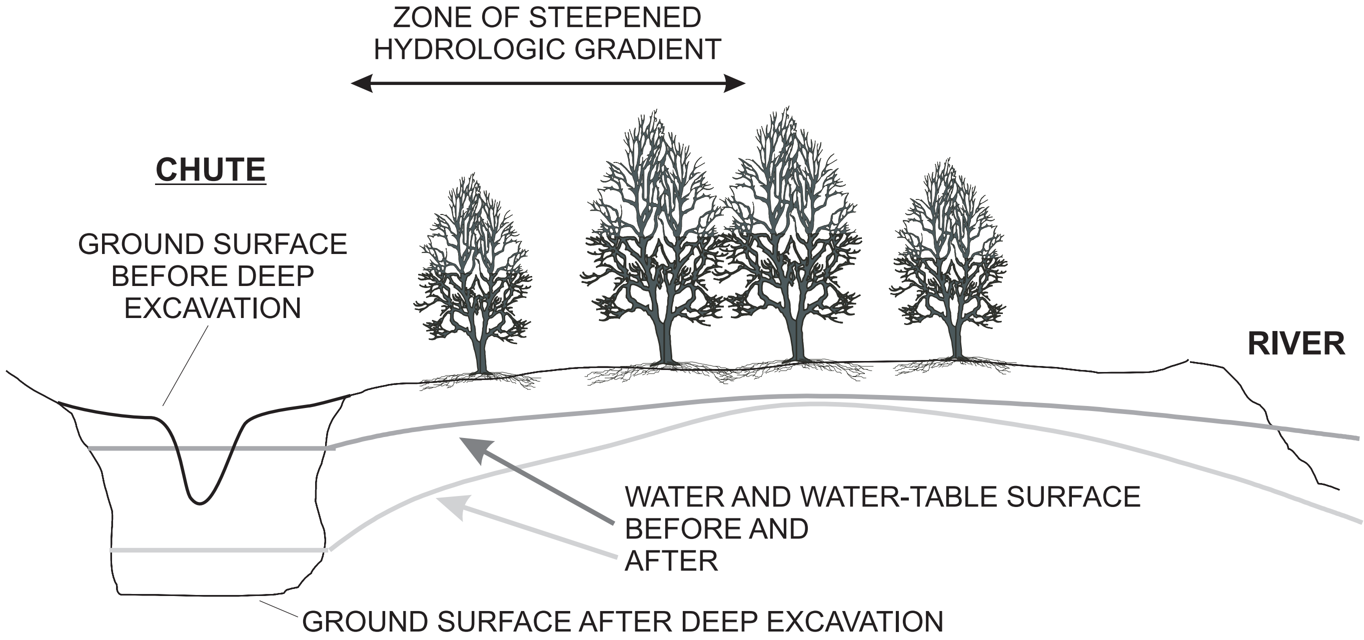


Figure 6. Conceptual model of how water levels, hydrologic gradients, and tree-growth rates might be expected to vary with deepening of the chute at Overton Bottoms North.

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