Columbia Environmental Research Center

Ecological Dynamics of Wetlands at Lisbon Bottom, Big Muddy National Fish and Wildlife Refuge, Missouri

Final Report to
U.S. Fish and Wildlife Service
Big Muddy National Fish and Wildlife Refuge

December 2002
Revised December 2003

Open-File Report 2004-1036

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

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Columbia, MO

Contents

Conversion Factors and Vertical Datum

Multiply	By	To obtain
	Length	
foot (ft)	3.048×10^{-1}	meters
mile (mi)	1.609×10^{0}	kilometers
	Area	
acre (ac)	4.047×10^{3}	square meters
	4.047×10^{-3}	square kilometers
	4.047×10^{-1}	hectares
square mile (mi^2)	2.59×10^{0}	square kilometers
	Flow	
cubic feet per second (cfs, ft^3/s)	2.832×10^{-2}	cubic meters per second

Sea level: In this report “sea level ” refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment for the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

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Executive Summary

Intensive physical modification of the Missouri River for navigation, flood control, and power generation has dramatically changed the river corridor. Dams, revetments, channelization, and levee construction activities have constrained the river into a single fast, deep channel and disconnected the river from the flood plain. These dramatic hydrological alterations have reduced the available habitat for numerous bird, fish, invertebrate, and plant species. Several native species have declined, leading to their federal listing under the Endangered Species Act. It is widely recognized that recovery of endangered species is primarily dependent on physical habitat rehabilitation. Land acquisition for ecological rehabilitation in the Lower Missouri River has historically been impeded due to the lack of land available from willing sellers and lack of funds and authority. However, this situation changed in 1993 following a severe flood. Flooding broke many levees and scoured numerous deep holes in the flood plain; in addition, thick layers of sand were deposited on numerous crop fields. Subsequently, much flood-altered farmland was willingly offered for sale by private landowners. Much of this land was then purchased by governmental agencies for environmental rehabilitation. Lisbon Bottom is one of several parcels of flood-damaged land that was purchased from willing sellers by the U.S. Fish and Wildlife Service as part of the Big Muddy National Fish and Wildlife Refuge. Lisbon Bottom is a loop bend in the river near Glasgow, Missouri. Flooding at Lisbon Bottom in 1993 and 1995 breeched local levees and created a diverse wetland complex. Lisbon Bottom is managed in a passive manner. The levees have not been rebuilt, and floods and vegetative succession continue to alter the landscape. A side-channel chute was formed by further flooding in 1996 and 1997. The diversity of wetland types and the continued connection to the river make Lisbon Bottom an excellent natural laboratory for the study of flood-plain wetland processes and the use of flood-plain wetlands by biota.

This study had 3 objectives: 1) quantify spatial and temporal distribution of biota in aquatic habitats of Lisbon Bottom in relation to changes in hydrological variables that are associated with the spring flooding regime, 2) document biological responses as they are related to habitat dynamics, and 3) analyze and interpret these results to provide managers with information necessary to develop management strategies for Lisbon

Bottom and other tracts of the Big Muddy National Fish and Wildlife Refuge. To accomplish these objectives we conducted a study of the hydrology, limnology, and biological dynamics of zooplankton, macroinvertebrate, fish, and waterbird communities during Spring 1999.

The hydrology of Lisbon Bottom was influenced by overbank flooding from the river and chute, groundwater, rainfall, and valley-wall tributaries. Lisbon wetland types include deep scours (formed during the 1993 and 1995 floods), shallow temporary wetlands with minimal direct surface drainage area, and shallow temporary wetlands with direct surface-water connections to valley-wall tributaries.

Wetlands along the valley wall, far from the main channel, are recharged by main-channel flow only when flow is well over bank. These wetlands are recharged more frequently by local rainfall and by flow from valley-wall tributaries. Hydrologic variation in wetlands that are recharged by local rainfall is of greater magnitude and much more frequent than variation in deep scours. Deep scours, in contrast, had more stable water levels.

The deep scours at the top and bottom margins of Lisbon Bottom are similar in some respects, but differ in others. These wetlands are thermally stratified during the summer and have anoxic hypolimnia. They are devoid of aquatic macrophytes and are strongly influenced by river flooding. Differences are due to the periodicity and energy of flood events. Because the down-valley gradient of Lisbon Bottom is greater than the channel slope, backflooding from the river connects the river to downstream scours more often and for longer duration than the upstream scours. Topflooding events, while less frequent, occur with more energy, and temporarily destratify the upstream scours.

Nutrient availability was greater in river-influenced wetlands than in the valley-wall wetlands due to nutrient-rich conditions of the river. Overbank floods provide pulses of nutrient inputs to the wetlands, which are followed by increases in algal production and subsequently by increases in zooplankton production. In contrast, the valley-wall tributaries deliver lower levels of nutrients and suspended sediment to flood-plain wetlands which promotes clear, shallow conditions that favor growth of emergent and submergent aquatic macrophytes. Lower nutrient inputs and removal of nutrients by macrophytes in valley-wall wetlands result in lower phytoplankton and zooplankton density. Macroinvertebrate density, on the other hand, is strongly correlated to the presence of inundated vegetation, and thus the stream-influenced valley-wall wetlands are highest in macroinvertebrate density and biomass.

Twenty-seven species of crustacean zooplankton, mostly cladocerans and herbivorous copepods, were captured in Lisbon Bottom wetlands. Predacious copepods were not common in the wetlands. Zooplankton density and diversity were related to flood events and nutrient pulses resulting from flood events. Topflooding wetlands had higher densities and diversities of zooplankton than backflooding wetlands, due to greater phytoplankton availability and possibly due to greater predation by fishes in the backflooding wetlands. Crustacean zooplankton density was much lower in stream-influenced wetlands than in the river-influenced wetlands, probably owing to lower nutrient availability and thus lower phytoplankton production in those wetlands.

We captured 167 species of macroinvertebrates in the Lisbon wetlands; 128 of these species are unique to the flood-plain wetlands and are not found in the mainstem. Thus, most of the invertebrates found in these wetlands are not likely to have been colonized from the river during flooding. Temporary wetlands that held water throughout the winter months due to the fall 1998 flood were likely in part responsible for the species assemblage found; the invertebrate community was dominated by overwintering species and groups of pioneer taxa that were available for dispersal to other basins after flooding occurred in mid-April, 1999. Macroinvertebrate species richness and density were highest in shallow, seasonal, vegetated wetlands and lowest in deep scour habitats. Although scours had lowest species richness throughout the early part of the study, they increased by late spring and summer periods. In all but the deep scours, the ratio of predator / herbivore-detritivores gradually declined during the study period, and the ratio of benthic / pelagic invertebrates peaked during the post-flood period. Both of these indicators appear to correspond with changes in the availability of organic matter over time due to flooding.

Forty species of fish were captured in Lisbon Bottom wetlands. Flood-plain spawning riverine fishes such as buffalo, gizzard shad, gar, and common carp used Lisbon Bottom for spawning during flood events; therefore fishes of the river clearly take advantage of this newly connected portion of the flood plain. Both topflooding and backflooding portions of the flood plain were used for spawning by riverine fishes, but topflooded areas were connected to the river less often. Temporary, topflooding, and stream-influenced wetlands of the Lisbon Bottom flood plain that held many young-of-the-year buffalo dried without being reconnected to the river; thus these fish became trapped and died. Backflooding areas were connected to the river more often and were not observed to trap large numbers of fish. Relative abundance and species composition of fishes using the flood plain were very different from the fish communities associated with the river and chute. Relative abundances of fishes also varied between wetlands, at least in part due to the wetland morphology, water source, and connectivity to the river. For example, deep scours were dominated by centrarchids, and backflooding wetlands had greater relative abundances of riverine fishes such as emerald shiner and shortnose gar. Young-of-the-year buffalo dominated the most ephemeral wetlands while red shiners and other small cyprinids and centrarchids were more common in deeper, less ephemeral temporary and seasonal wetlands. Crappie were common and large in the permanent scours. Crappie growth rates in the scours were high, despite narrow oxic epilimnia and temperatures that were higher than those known to provide good crappie survival and growth.

Thirty-one species of waterbirds were observed at Lisbon Bottom. Chronology of the presence of individual species was related to the spring migration periods of the species rather than the period of flooding, which occurred after the main migration of several species of waterbirds. Most waterbirds were observed on the river and chute prior to the flood, which occurred on April 16, 1999. After the flood, ducks, especially blue-winged teal, were mostly found on the vegetated, stream-influenced wetlands near the valley wall or on an intermittently connected exit scour. Total number of waterbirds, total numbers of ducks, and numbers of wood ducks were significantly greater in the valley-wall wetlands compared to other basin areas during the flood and post-flood period. Waterbirds that used the interior flood-plain wetlands tended to stay longer than those using the chute or river habitats. The river and chute habitats were used primarily for short migratory stopovers as opposed to longer, sustained use for feeding such as that observed for the valley-wall tributary wetlands.

Collectively, these results indicated that wetlands fed by valley-wall tributaries appeared to be different from scour and seasonal wetlands in other locations at Lisbon Bottom. Valley-wall wetlands were hydrologically fed by streams and thus had more sustained periods of inundation compared to interior wetlands that lack direct stream connections. These factors were important in providing the basis for emergent and submergent macrophyte growth, which was in turn important for invertebrate production and associated waterbird use. Thus, valley-wall wetlands might be important habitats sought by land managers in future land acquisition and management efforts. However, further studies may be necessary to fully understand these unique habitats. Fish communities that used the flood plain during flooding differed from communities documented in the chute and river habitats. Similarly, the invertebrate community of the flood plain contains a unique community composition compared to the river and chute habitats.

This study documented the interaction between hydrology and the biological dynamics within a single spring season at Lisbon Bottom. The wetlands of Lisbon Bottom are continuing to change due to ongoing scouring and sedimentation from floods. The vegetative community is beginning to mature and be dominated by woody species. It is anticipated that as the flood-plain forest matures it will alter hydraulic roughness and the subsequent distribution of flow velocities and sedimentation. Beavers both create wetlands by damming, and drain wetlands by constructing channels. The deep scours currently present are a result of a severe flood in which very high flows overtopped or broke agricultural levees; such wetlands would have been rare or nonexistent prior to channelization of the river. Without extremely high river flows and associated rescouring, sedimentation will continue in the deep scours and they will eventually cease to exist. Continued study of the hydrology, vegetation, and animal community dynamics of Lisbon Bottom could provide important information concerning the formation and ecological trajectory of newly created flood-plain habitats on the Lower Missouri River. Wetlands in the Lower Missouri River flood plain are highly dynamic and currently do not fit well within traditional wetland classification systems. Additional knowledge concerning wetland habitat classification approaches is needed for modified riverine systems. This information is important for development of an adaptive management framework for the Big Muddy National Fish and Wildlife Refuge.

Keywords: Lower Missouri River, hydrology, flood plain, fish, invertebrates, zooplankton, birds, spring rise, management, aquatic