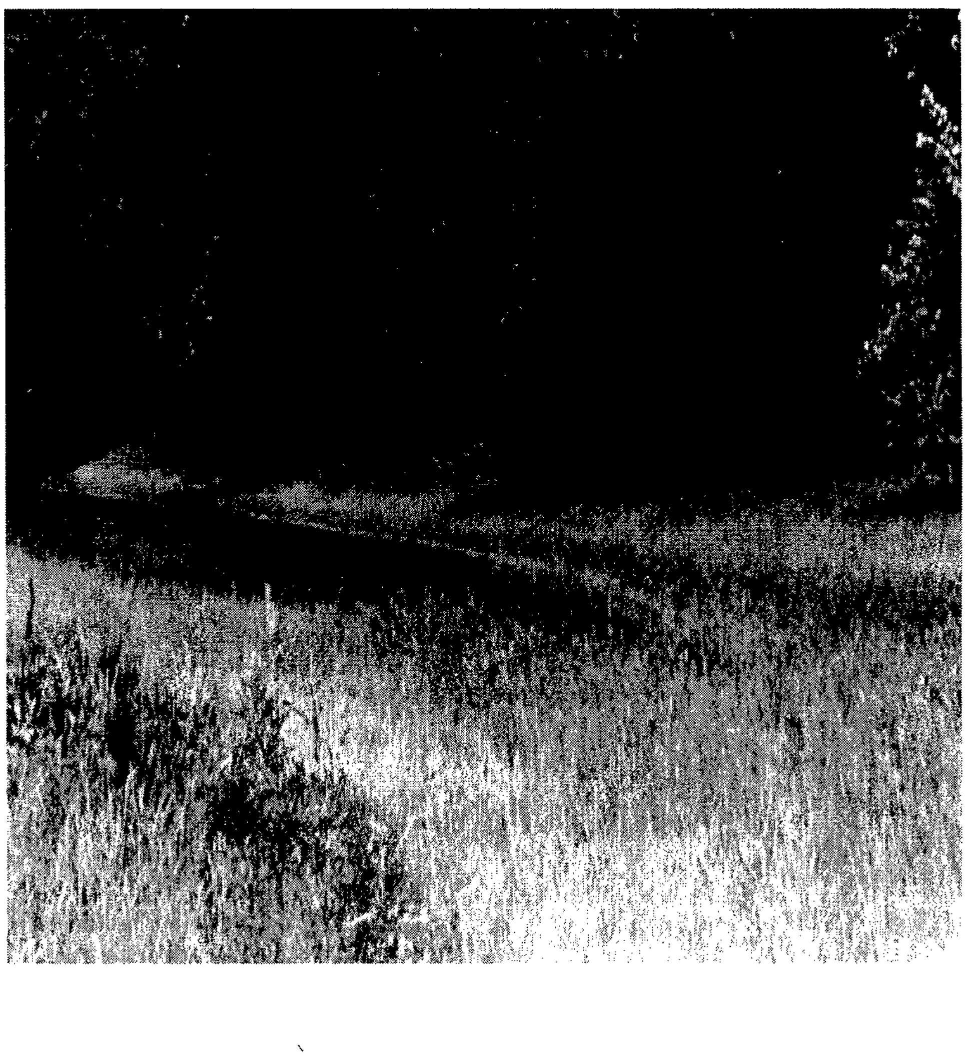
Long Term Resource Monitoring Program

Technical Report
2000-T001

Response of Vegetation and Fish During an Experimental Drawdown In Three Pools, Upper Mississippi River



August 2000

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by

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August 2000

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Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' (Corps) Environmental Management Program. The LTRMP is being implemented by the U.S. Geological Survey's Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

This report was prepared under Strategy 1.2.3, *Determine Effects of Water Levels and Discharges on the Upper Mississippi River Ecosystem,* and Goal 3, *Develop Alternatives to Better Manage the Upper Mississippi River System*, as specified in the Operating Plan of the LTRMP for the Upper Mississippi River System (U.S. Fish and Wildlife Service 1993). The purpose of this work was to monitor the response of vegetation from an experimental drawdown during 1995 and 1996 in Pools 24 and 25 and Melvin Price Pool on the Upper Mississippi River and to refine a previously developed geographic information system model to predict areas that would be dewatered because of alternative water-level management plans.

Response of Vegetation and Fish During an Experimental Drawdown In Three Pools, Upper Mississippi River

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Abstract. An experiment to improve ecological conditions while maintaining a 9-foot (2.74-m) navigation channel was continued in 1995 and 1996 on the three pools of the Upper Mississippi River managed by the St. Louis District, U.S. Army Corps of Engineers. Water levels were held from 1 to 3 feet (0.3 to 0.9 m) lower than maximum regulated elevations at the dam from about mid-June through July in Pools 24 and 25 and Melvin Price Pool. Water levels were then gradually raised as discharge allowed. Vegetation was surveyed along an elevational gradient in eight areas in 1995 and six areas in 1996. Seven plant genera were identified in 1995 and five genera in 1996. *Amaranthus* spp. (pigweed), *Cyperus* spp. (chufa), *Echinochloa* spp. (wild millet), and *Polygonum* spp. (smartweed) were found in 30–90% of the sites. Plants grew 7–10 inches (17.8–25.4 cm) in about 30 days and then grew more quickly as water levels were slowly raised. On July 27, 1995, aerial infrared photographs (1:15,000) were taken of the lower stretches of the three pools. Photographs also were taken of Pool 22, where no drawdown occurred. These photographs were interpreted, specifically searching areas near the waterline with signatures representing the above plants. In Pools 24 and 25 and Melvin Price Pool, between 255 and 880 acres (103 and 356 ha) of plants were measured near the waterline, compared to just 51 acres (20.6 ha) in Pool 22 where water levels near the dam were held at the project pool elevation. A geographic information system model was also used to predict areas that would be dewatered under various water-level management options. Minnow seining data collected on the three pools from 1986 to 1996 were also analyzed. The total numbers of fish per haul and Simpson's Diversity Index showed no significant detrimental effects during years when water levels were held on the low side of the operating band. We believe that this management experiment was successful and that continuation, as conditions allow, would be beneficial.

Keywords: Drawdown, fish, Mississippi, river, upper, vegetation, water-level management, water levels

Introduction

An experiment to improve ecological conditions while maintaining a 9-foot (2.74-m) navigation channel was initiated in 1994 on Pools 24 and 25 and Melvin Price Pool (Figure 1) on the Upper Mississippi River. Instead of holding water levels on the high side of the operating band as usual, water levels were held on the low side of the operating band with the goal of increasing plant production. The experiment was performed in cooperation with the Pool 25 Natural Resources Management Committee (Committee), an interagency group whose goal is to improve habitat in the Upper Mississippi River floodplain. Committee members are listed in Appendix A.

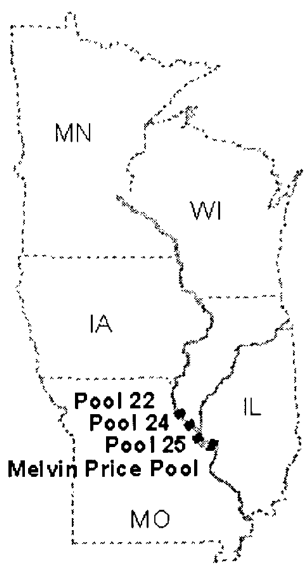

Figure 1. Location of Pools 22, 24, and 25 and the Melvin Price Pool on the Upper Mississippi River.

The 1994 experiment was considered successful by the Committee. *Amaranthus* spp. (pigweed), *Cyperus* spp. (chufa or flatsedge), *Echinochloa* spp. (wild millet or cockspur), *Leptochloa* spp. (sprangle top), and *Polygonum* spp. (smartweed or knotweed) colonized the dewatered area. The plant community in the dewatered zone grew 2–3 feet (0.6–0.9 m) by early August. Seed production seemed to be excellent and substantial numbers of waterfowl used the area during fall migration. Additional information concerning the 1994 experiment is in Busse et al. (1995).

Here we report on the continuation of the water-level experiment in 1995 and 1996. Two additional goals were quantifying plant response and refining a previously developed geographic information system (GIS) model to predict areas that would be dewatered when using alternative water-level management plans. Plant response would be estimated from ground surveys and aerial photography. We also analyzed minnow seining data collected on all three pools between 1986 and 1996.

This report extends involvement by the U.S. Geological Survey Upper Midwest Environmental Sciences Center concerning water-level management in the St. Louis District. Previous studies summarized historical discharges and water-level management practices in Pool 25 (Wlosinski 1996), the effects of water-level management alternatives on habitats (Wlosinski and Rogala 1996), and estimating land ownership requirements in moving the control point in Pool 25 (Wlosinski and Rogala 1997).

Some of the terminology used in this report may not be common but is used routinely for water-level management or analysis with GIS. Definitions for these terms are included in Appendix B.

Methods

Water Levels

The Committee recognized the fact that the Mississippi River is put to multiple uses, including navigation and biological habitat. It also recognized that water levels and pool slope are highly dependent on discharge. With those facts in mind, the Committee made two suggestions in spring 1995 for water-level management: provide a safe and dependable navigation channel and provide better opportunities of reproductive success of fish, vegetation, invertebrates, and associated organisms.

The Committee's recommendation for water-level management for fish reproduction was to maintain steady to slightly rising water conditions for at least a 30-day period in the spring. Pool surface elevation was not considered as important as keeping fluctuations to less than 0.5 foot (15 cm) in any 10-day period. Steady pool levels were requested between May 1 and June 30, with the period between May 15 and June 15 being the most critical. The Committee also thought it beneficial for the pool selected to have residual vegetation from a previous year to increase spawning and nursery habitat.

The request for water-level management for plant reproduction included a drawdown of 0.5–2.0 feet

(0.15–0.6 m) for at least 30 days, starting when the normal high spring flows recede. This plan would better mimic a more natural hydrograph. The pool would then be raised after the drawdown at a rate not greater than 0.2 feet (6 cm) per day.

The St. Louis District would continue to manage water levels within the guidelines established in the Master Water Control Manual and appendixes (U.S. Army Corps of Engineers 1980a–d) to assure that a 9-foot (2.74-m) navigation channel is maintained. The guidelines require that water levels be managed as a function of discharge and allow some flexibility within certain discharge ranges. Maximum drawdown below the project pool elevation at the three dams is between 3.5 and 6.5 feet (1.1 and 2.0 m). A sample plan for water-level management is presented for Pool 25 (Figure 2). Flexibility is measured as the vertical difference between the low and high side of the operating band. There is little to no water-level flexibility at either low or high discharges.

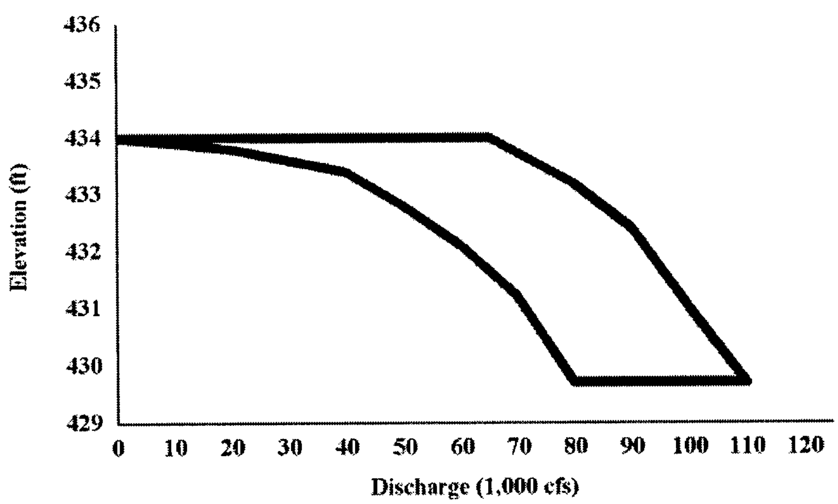

Figure 2. Water elevation relative to discharge according to the water-level management plan for Pool 25. Wlosinski (1996) includes information on how discharges were estimated.

Water levels were measured immediately upriver of the dams at gages previously established by the St. Louis District. Drawdown values were calculated as the difference between project pool elevations and the water surface measured immediately upriver of each dam. Project pool elevations are 449.0, 434.0, and 419.0 feet (136.86, 132.28, and 127.71 m) for Pools 24 and 25 and Melvin Price Pool, respectively. Water levels at the three St.Louis District dams were compared to water levels in Pool 22 which is managed by the Rock Island District. The project pool elevation for Pool 22 is 459.5 feet. Pool 22 was managed according to the plan outlined in Appendix 22 of the Master Reservoir Regulation Manual (U.S. Army Corps of Engineers 1980e). That plan calls for water levels between 459.1 and 459.6 feet (139.93 and 140.08 m) at the dam when discharges are below 163,000 cfs (4,613 cm).

Ground Surveys

Eight sampling locations in 1995 and six in 1996 were selected for monitoring among the three pools (Table 1). The locations were semi-randomly selected and had to be easily accessible areas with a gentle slope. In 1995, two or three sites at each location were established along a transect, each approximately 0.5 feet (15 cm) apart in elevation. In 1996, two sites were established at each location with the first site being 0.8 feet (24 cm) lower in elevation than the present woody tree line and the second 0.8 feet (24 cm) lower than the first. We measured species presence, plant height, and the number of stems in a 1.6 feet (49 cm) square area at each site. Each site was measured at about 1-week intervals in 1995 and 2-week intervals in 1996. Sampling commenced on June 22, 1995, and June 26, 1996. The last sampling period was August 9 in 1995 and September 4 in 1996. Photographs were also taken at each site during most sampling visits. No ground surveys were performed in Pool 22 during either year.

Vegetation Mapping

Color infrared, 1:15,000 scale, vertical, stereo, 9- x 9-inch (23- x 23-cm) aerial photographs of

Table 1. Location of vegetation surveys in the three pools affected by a drawdown.

	1995	1996	River mile	Miles from dam
Pool 24				
Crider Island	X		279.5	6.0
Pharrs Island	X	X	276.5	3.0
Clarksville Refuge	X	X	275.5	2.0
Pool 25				
Stag Island	X	X	248.5	7.0
Jim Crow Island	X	X	246.0	4.5
Turner Island	X		245.0	3.5
Batchtown	X		243.0	1.5
Melvin Price				
Dresser Island	X	X	205.5	2.5
West Alton		X	204.0	1.0

Pools 22, 24, and 25 and Melvin Price Pool were taken on July 7, 1995. The photographs covered about 8 miles (12.9 km) of each pool, immediately upriver of their respective dams. Standard Long Term Resource Monitoring Program photointerpretation, cartographic, and automation methods were used to map and automate the data (Arndt and Olsen 1995; Owens and Hop 1995; Owens and Robinson 1996; Owens et al. 1997). Photographs were interpreted with the standard Long Term Resource Monitoring Program land cover/land use classification system and a mirror stereoscope on a light table. The photointerpreter identified vegetated areas near the waterline. The interpretation was performed on clear plastic overlays registered to the photograph with a 0.18-mm drafting pen. The photointerpretation was checked by a senior photointerpreter and by the field biologist for accuracy and completeness. The interpreted data were then transferred to 1:24,000 USGS quadrangle topographic maps with a manual zoom transfer scope. The transferred data were checked by a senior cartographer for accuracy and completeness. The transferred data were automated with a digitizing table and placed into a spatial database in vector format.

Fish

Fish monitoring was not performed specifically to evaluate the drawdown experiment on pools within the St. Louis District. However, fisheries data have been routinely collected in a similar manner since 1986 by the Illinois Department of Natural Resources (DNR). We used that data to test for pool-wide differences between years (1986–93) when pools were held on the high side of the operating band and (1994–96) when pools were held on the low side of the operating band during early to mid-summer.

Between 1986 and 1990, sampling was conducted with a 4- x 20-foot (1.2- x 6.1-m) minnow seine with 0.635-cm ace mesh. After 1990, sampling was done with a bag seine of the same dimensions, but with a 4- x 4-foot (1.22- x 1.22-m) bag. Seines used in the study have been treated with black net coat. Most seine hauls were made in a downstream direction (the direction of water flow). Periodically, when catch rates were low or sampling area was limited, seine hauls were made in both upstream and downstream directions. Length of seine hauls varied with sampling location and substrate type. When boat ramps were sampled, seine hauls were limited to the width of the ramp. Seine hauls made on natural sand beaches were all about 50 feet (15 m) long. All seine hauls are considered to be comparable with respect to catch rate.

Sampling locations, habitat and substrate type, and the number of hauls are shown in Table 2. Habitats sampled during the study include 7 tailwater sites, 27 main-channel border sites, 3 side channel sites, and 11 backwater sites. Among these habitat types, four substrate types sampled include concrete, cobble, gravel, and sand. Thirty-one of the sampling sites were concrete boat ramps, 12 were gravel boat ramps, 6 were natural sand beaches, and 2 were cobble. Boat ramps were the preferred sampling locations because of their accessibility and consistency of sampling conditions over time. Also, when biologists with the Illinois DNR's Reservoirs Program compared seining data obtained from natural habitats with that from boat ramps, the results from

Table 2. Fish sampling locations, habitat and substrate types, and the number of seine hauls per pool and year.

Station	River mile	Habitat[a]	Substrate	State	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Pool 24															
Lock and Dam 22 Tailwater	300.9	tw	concrete	MO	3	5	5	5	2	3	5	4	3	6	3
Cincinnati Landing	296.2	mcb	concrete	IL	4	7			3	5	3	5	3	5	2
Dupont Access	294.0	mcb	concrete	MO			1	4	1	5	6	2	3	4	4
Willow North Access	288.2	bw	gravel	IL										3	3
Pike Station Access	284.3	mcb	concrete	IL	4	8	6	3	4				8	6	5
Two Rivers Marina	283.2	bw	concrete	IL						4	3	3	6	4	3
Delair Public Access	280.8	sc	gravel	IL				1	1	5	5	4	6	6	4
Little Calumet Creek	277.2	trb	gravel	MO	2	6	5	2	2	5	5	3	6	3	4
Silo Park Access	276.1	mcb	gravel	MO										3	6
Pleasant Hill Access	273.7	mcb	gravel	IL	–	2	–	–	–	–	–	1	–	3	4
Pool 24 Totals					13	28	17	15	13	27	27	22	35	43	38
Pool 25															
Clarksville Access	273.2	tw	concrete	MO	3	6	4	3	2	5	5	3	4	4	2
Rip Rap Landing Access	265.3	mcb	concrete	IL	2	7	6	4	1	2	5		6	5	2
Hamburg Ferry Access	258.5	mcb	concrete	MO			5	3	1	6	4		4	5	3
Prairie Slough	257.5	bw	gravel	MO					2	4	5	2	4	3	4
Red's Landing Access	254.0	mcb	concrete	IL	5	11	4	5	3	5	5	2	9	5	4
Upper Gilead Slough	253.6	bw	concrete	IL			2	1	3	3	4		5	4	5
Norton Woods Access	252.0	sc	gravel	MO					2						
Lower Gilead Slough	250.5	bw	gravel	IL										1	4
Turner Landing Access	246.3	mcb	gravel	IL	3	6	6	3	4	5	5		3	5	4
Foley Public Access	245.0	sc	gravel	MO	2	7	4	3	2	2	4		4	4	3
Cockerell Hollow Access	243.4	bw	concrete	IL	–	–	–	–	–	4	2	1	4	2	2
Pool 25 Totals					15	37	31	22	20	36	39	8	43	38	33

Table 2. Continued

Station	River mile	Habitat[a]	Substrate	State	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Pool 26															
Winfield Ferry West	241.0	tw	concrete	MO				1							
Winfield Ferry	240.8	tw	concrete	IL	3	6	6	4	1	6	7	1	6	5	4
Cedar Hills Resort Access	239.7	mcb	concrete	IL					2	7	6	2	4	4	3
Martin's Landing	234.0	mcb	cobble	IL	5	9	11	5	1	8	5		7	6	5
Golden Eagle Ferry	228.5	mcb	sand	IL	2										
Royal Landing	223.0	mcb	concrete	IL	3	11	7	4	4	10	10		11	4	4
Royal Lake Access	222.6	bw	gravel	IL						3	3		3	2	1
Pohlman Slough Access	222.5	bw	concrete	IL	3	2	2		2	3	3	1	4	3	6
Grafton Public Access	218.2	mcb	concrete	IL	4	14	6	4	2	6	6	2	6	4	2
Piasa Harbor Access	209.5	trb	concrete	IL	5	8	5	5	5	6	3	4	6	5	4
West Alton Access	202.9	bw	concrete	MO	4	4	5	4	1				2	2	6
Alton Public Access	202.7	bw	concrete	IL					2	8	9	7	4	6	7
Ellis Bay Public Access	202.0	bw	concrete	MO	-	-	-	-	-	5	6	-	-	-	-
Pool 26 Totals					29	54	42	27	20	62	58	17	53	41	42

[a]bw = backwater, mcb = main channel border, sc = side channel, trb = tributary, tw = tailwater

boat ramps were equal to or better than those from natural habitats (Cruse 1989). The number of seine hauls per pool ranged from 8 to 62 over the 11-year period.

Two to four sampling trips were made each year between May and September. The count of fish collected from all hauls at a site were combined, and the total number of hauls was also recorded. Easily identified fish were recorded and fish were returned to the river. All other fish caught were preserved in 10% buffered formalin until they were identified.

We performed two types of analysis with the minnow seining data; total numbers of fish per haul and Simpson's Diversity Index (McGarigal and Marks 1994). The total numbers of fish per haul was calculated pool wide and on the lower versus upper halves of each pool. The comparison for different parts of the pool was made because the drawdowns have a greater effect near the downstream dam. Both analyses were performed for every year within each pool. Data from all stations were used except for stations between river miles 201 and 203. This area was originally in the tailwater of Lock and Dam 26 before Melvin Price Locks and Dam was constructed.

Simpson's Diversity Index was calculated as follows:

$$SDI = 1 - \sum_{i=1}^{m} P_i^2$$

where:

SDI = Simpson's Diversity Index, m = number of individual species, and P = the number of individuals of species i divided by the total number of individuals in the sample.

The index ranges from 0 (when only one species is present in a sample) to less than 1. However, we arbitrarily assigned an SDI of -0.1 for those instances where no individuals were found in a sample. Because the number of species can be a function of the number of hauls, we subsampled 8 hauls from all hauls in a pool, for each year, 10 different times, calculating an SDI for each time. The 10 different SDIs were then averaged. Fish groups that could not be identified to species, such as shiners and buffalo, were treated as species, as were species crosses.

Spatial Model

We integrated a hydrologic and spatial model for Pool 25 to predict areas that would be dewatered. The model used was described in Wlosinski and Rogala (1996). Water surface profiles were predicted with HEC-2 under steady-state conditions of 19,000 cfs (538 cm) and 56,000 cfs (1,585 cm). The 19,000 cfs figure was selected because it predicts water surfaces near the flat pool elevation and it was the discharge that occurred when the original aerial photographs were taken in 1989. The 56,000 cfs figure was an arbitrary selection because discharge varied throughout the drawdown period. It does, however, result in a drawdown of approximately 1.6 feet (49 cm) at Lock and Dam 25, which was within the recommendations of the Committee. We created GIS coverages of water surface elevations with the HEC-2 generated profiles. A GIS overlay of the water surface elevation and data representing bottom geometry was performed to generate land-water data for the two discharge conditions. The difference between the two land-water coverages was our predicted area that would be dewatered because of the drawdown. Models were not developed for other pools because of a lack of spatial data.

Results and Discussion

Water Levels

Water levels during summers 1995 and 1996 are presented for Pools 24 and 25 and Melvin Price Pool in Figures 3, 4, and 5, respectively.

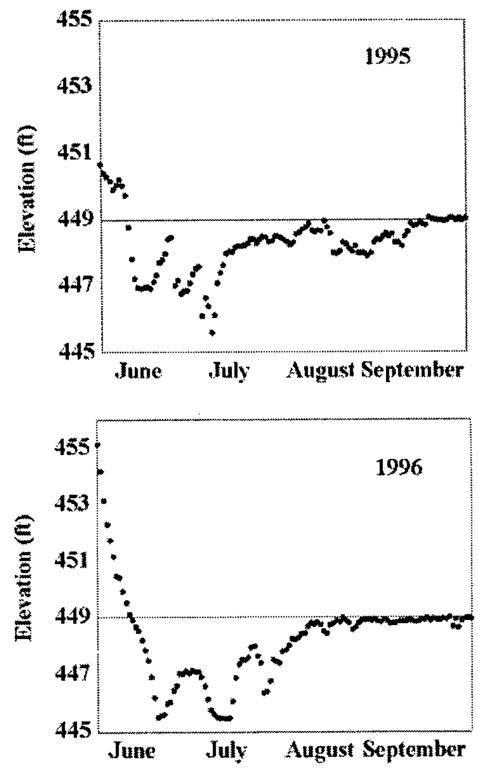

Figure 3. Measured water-level elevations (feet above sea level) immediately upriver of Lock and Dam 24 in 1995 and 1996.

Figure 6 contains water levels in Pool 22 during 1995 for comparative purposes. The horizontal line in the figures represent the project pool elevation for the respective pools. Open river conditions existed in all four pools at the beginning of June, for both years, with the drawdown being initiated as soon as conditions allowed except for Pool 22. Drawdown amounts vary within and among pools as a function

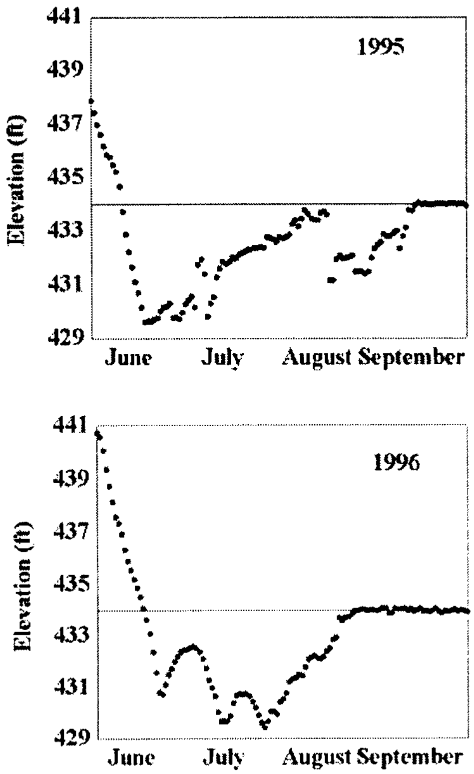

Figure 4. Measured water-level elevations (feet above sea level) immediately upriver of Lock and Dam 25 in 1995 and 1996.

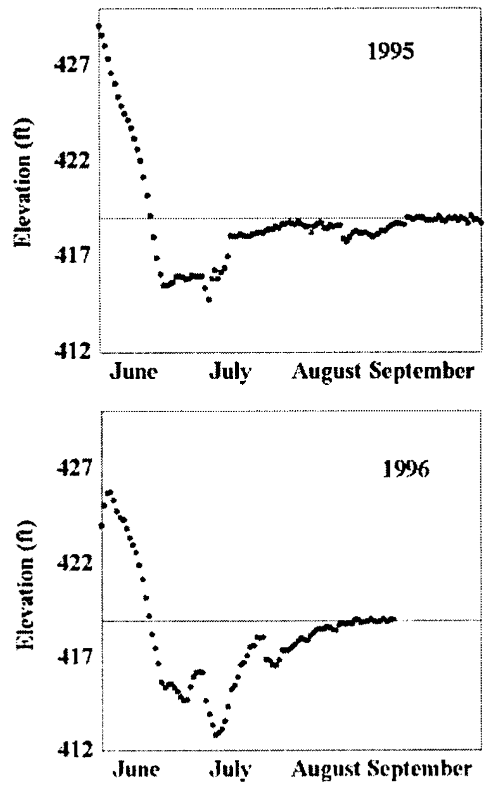

Figure 5. Measured water-level elevations (feet above sea level) immediately upriver of Melvin Price Locks and Dam in 1995 and 1996.

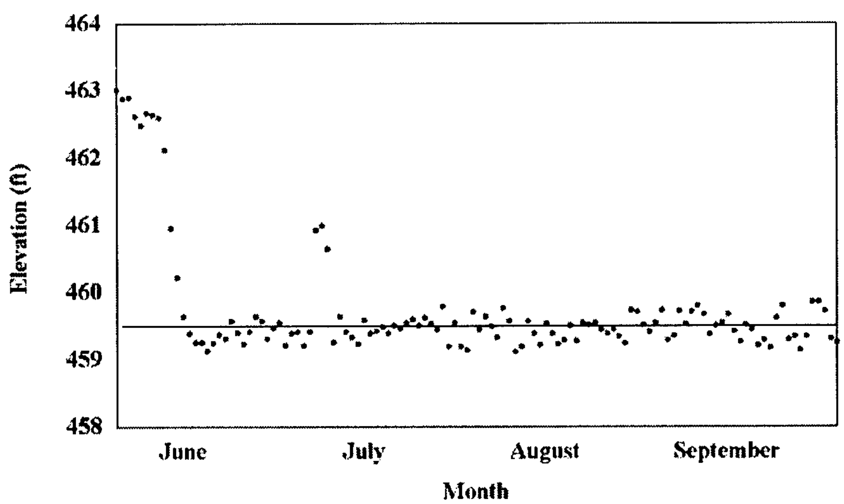

Figure 6. Measured water-level elevations (feet above sea level) immediately upriver of Lock and Dam 22 in 1995.

of discharge, location in the pool, and water levels at the dam. Drawdown amounts at the dam for all three pools for both years are shown in Table 3. Pool 24 had a 1.2–2.0 foot (37–61 cm) drawdown for about 30 days in both years. Drawdowns of about 3 feet (0.91 m) occurred in Pool 25 and Melvin Price Pool in both years. A part of the drawdown amount is due to lowering water levels at particular discharge levels, and part due to holding water levels on the low side of the operating band.

All three pools were managed intensively to assure a 9-foot (2.7-m) channel was maintained throughout the experiment. No barges were reported to have run aground as a result of the experiment. High discharges during the spring of both years were considered adequate for fish reproductive success, and the flow rate remained in a range during the summer that allowed management for increased vegetative growth.

Table 3. Amount of drawdown at Pools 24 and 25 and Melvin Price Pool in 1995 and 1996.

	1995			1996		
Pool	Amount, feet (m)	Duration (days)	Date	Amount, feet (m)	Duration (days)	Date
24	1.2 (0.37)	31	5/30–6/29	2.0 (0.61)	30	6/6–7/5
25	2.9 (0.88)	28	6/3–6/30	1.5 (0.46) 2.7 (0.82)	58 30	6/8–8/5 6/27–7/26
Melvin Price	3.0 (0.91)	21	6/9–6/29	2.8 (0.85)	29	6/6–7/4

Discharge is also being presented for the same periods for Keokuk, Iowa (Figure 7), and Grafton, Illinois (Figure 8), for comparative purposes. These are the two closest gages where discharge is estimated by the U.S. Geological Survey. The gage at Keokuk is about 63 miles (101 km) upriver of Dam 22, and the gage at Grafton is in Melvin Price Pool about 17 (27 km) miles upriver of the dam.

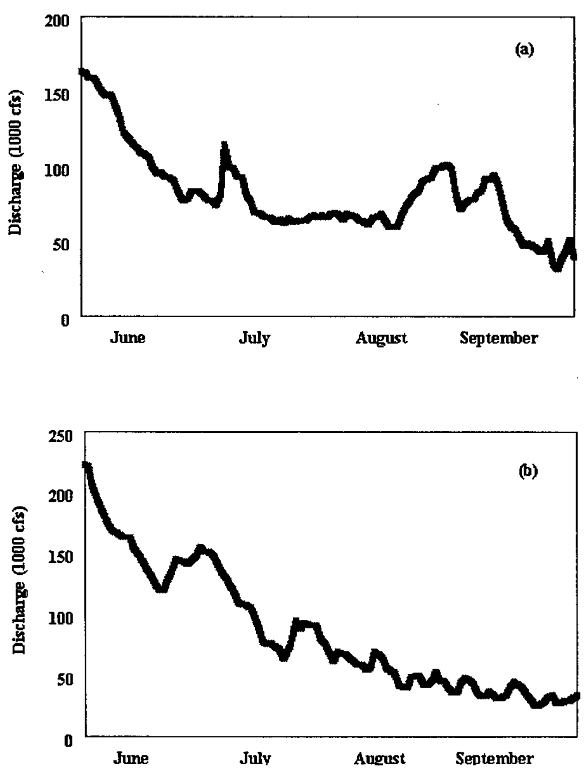

Figure 7. Estimated discharges at Keokuk, Iowa, in 1995 (*a*) and 1996 (*b*).

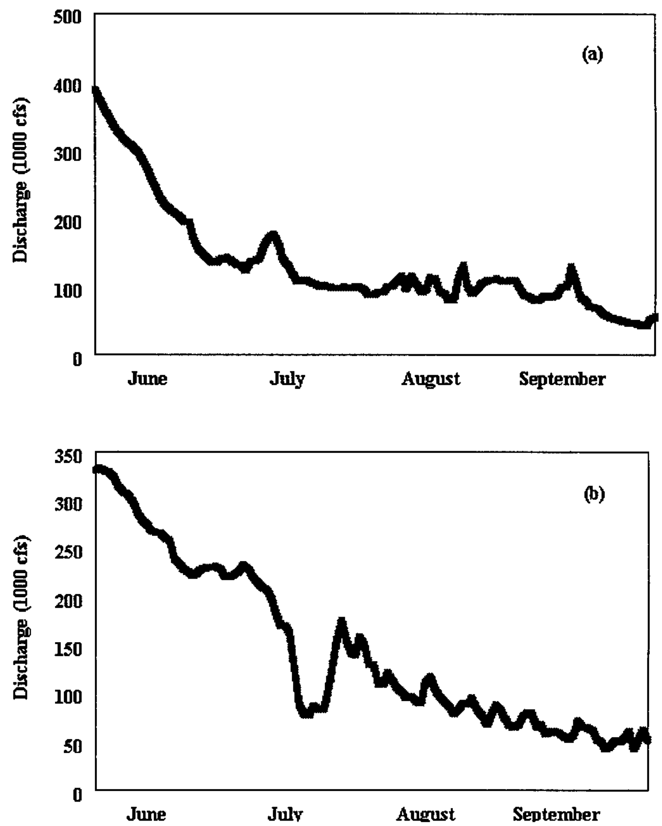

Figure 8. Estimated discharges at Grafton, Illinois, in 1995 (*a*) and 1996 (*b*).

Ground Surveys

Seven plant genera were identified in the 20 survey sites in 1995 (Figure 9): *Polygonum* spp., *Cyperus* spp., *Echinochloa* spp., *Amaranthus* spp., *Setaria* spp. (yellow foxtail or bristlegrass), *Panicum* spp., (panicum), and *Leersia* (rice cutgrass). The above species were also present during the 1996 survey except for *Setaria* and *Panicum*, with the dominant plants being found at a greater percentage

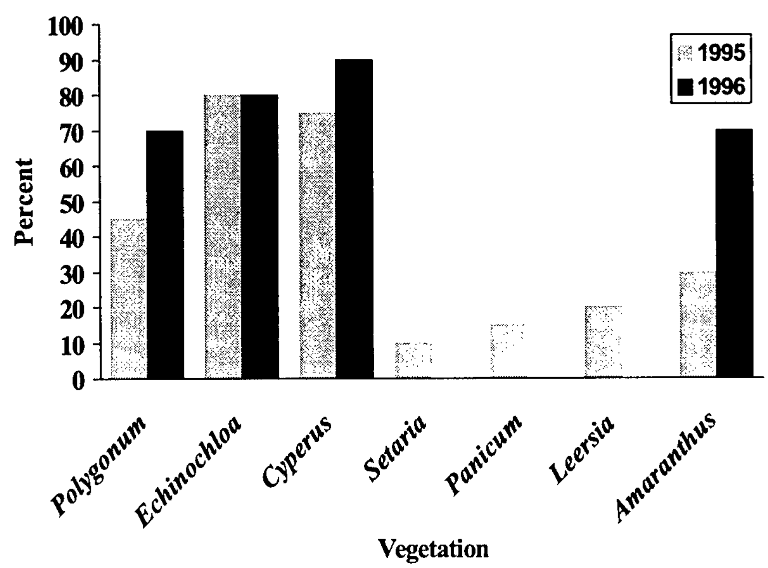

Figure 9. Frequency of occurrence of vegetation at all sampling sites in 1995.

Between 255 and 881 acres (91 and 357 ha) of plants were measured near the water line in Pools 24 and 25 and Melvin Price Pool, compared to just 51 acres (20.6 ha) in Pool 22. Less than 60 acres (24 ha) of plants were found in all four pools in 1989 when water levels were held on the high side of the operating band. However, we cannot be sure that the difference in 1995, between Pool 22 and the other pools, is attributable solely to water levels in Pool 22 not being dropped as in the three other pools. Other factors, such as bottom geometry and sediment types, may have also played a role in the acreage figures among pools. In addition, estimates of vegetated areas may be low because narrow bands of vegetation can be missed by the photointerpreters. The pens used to transfer information from photointerpretation represent a swath on level ground about 15 feet (4.6 m) wide. This swath, even if recognized by the photointerpreter, may be represented as a linear feature that is not reflected in acreage estimates. In addition, trees may have obscured some vegetation, and field biologists noted that large vegetated areas were under water at the time photographs were taken.

of sites in 1996. In 1995, stem densities exceeding 100 individuals per plot were measured soon after germination. Stem densities dropped to, and remained, around 10 to 40 individuals per plot after about 30 days. Although not measured, seed production appeared to be quite high during the late summers of both 1995 and 1996.

The growth rate of the three dominant species—*Echinochloa*, *Cyperus*, and *Polygonum*—are presented in Figures 10, 11, and 12, respectively. *Polygonum* and *Echinochloa* exhibited two different germination periods in 1996, probably due to the timing of drawdowns in different pools. About 30 days were required for plants to grow to a height of about 10 inches (25 cm) during both summers. Plants then grew more quickly as water levels were slowly raised. Of the three dominant plants, *Cyperus* reached a height of about 40 inches (101 cm), *Echinochloa* 50 inches (127 cm), and *Polygonum* over 50 inches (127 cm).

Vegetation Mapping

The estimate of plant coverage from photointerpretation, for 8-mile (12.8 km) stretches just upriver of the dams, is shown in Figure 13.

Maps depicting the vegetation beds that we believe are attributable to water levels in Pools 22, 24, and 25 and Melvin Price Pool are presented in Figure 14. Over 90% of the beds in all four pools were classified as a mix of forbs and grasses (Table 4).

Fish

The number of fish per haul is shown in Figures 15 through 17 for Pools 24 through 26, respectively. The average number of fish per haul between 1986 and 1993 was 27.6 in all three pools combined, as compared with an average of 29.2 fish between 1994 and 1996. The total number of fish collected per haul for the upriver and downriver

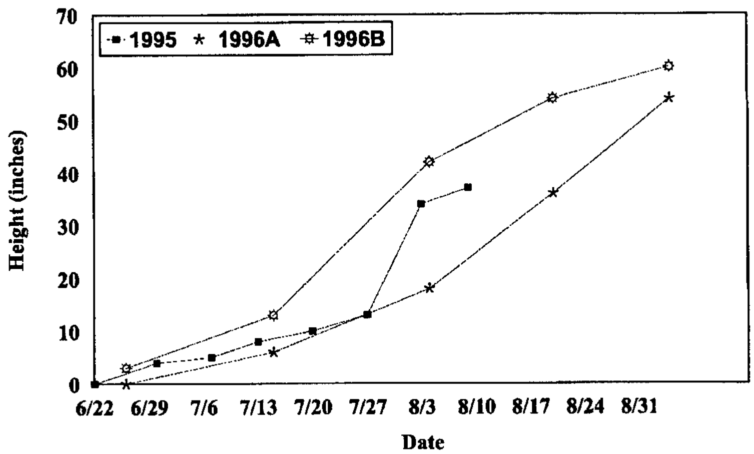

Figure 10. Average height of *Echinochloa* spp. (millet) at all sampling sites. Heights were measured for plants that germinated at two different times (1996A and 1996B).

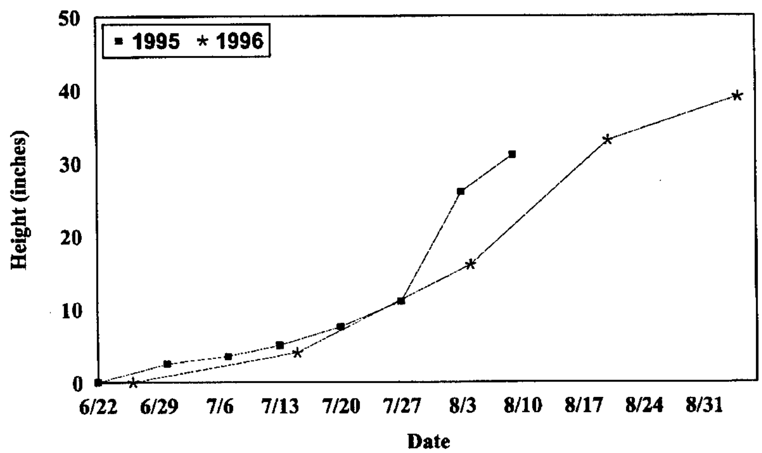

Figure 11. Average height of *Cyprus* spp. (chufa) at all sampling sites.

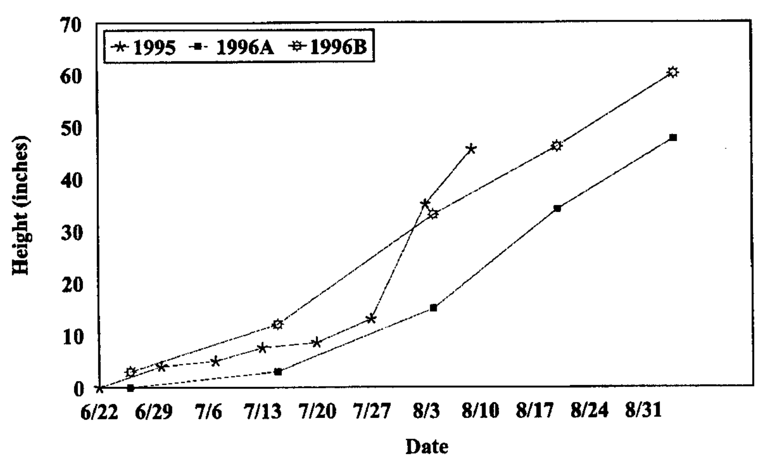

Figure 12. Average height of *Polygonum* spp. (smartweed) at all sampling sites. Heights were measured for plants that germinated at two different times (1996A and 1996B).

portions of the pools is shown in Figure 18. In the downriver portion of the three pools, the average number of fish per haul between 1986 and 1993 was 32.9, as compared with an average of 40.0 fish between 1994 and 1996. The averages in the upriver portion of the pools were nearly equal between the two periods; 22.6 between 1986 and 1993 versus 21.0 between 1994 and 1996.

Similar results were found for Simpson's Diversity Index. The average index was 0.57 for all three pools when water levels were held on the high side of the operating band, compared with an index of 0.58 between 1994 and 1996. The index for Pools 24 through 26 are shown in Figures 19 through 21, respectively.

Our analyses were performed on all fish species combined. Undoubtably, analysis on individual species would probably show that populations for some species were higher and others lower, when comparing results of the two water-level management conditions. Considering the variability in fish data collected between 1986 and 1993, we believe the lower water levels at the three dams in the St. Louis District had no significant detrimental effect on the fish community.

Spatial Model

The spatial model predicted that 1,046 acres (423 ha) in the lower 8 miles (12.8 km) of Pool 25 would be dewatered at 56,000 cfs (1,585 cm) as compared to 19,000 cfs (538 cm). This can be compared to the 881 acres (357 ha) of vegetation mapped from photointerpretation. The dewatering may seem contrary to normal river hydrodynamics, but it should be

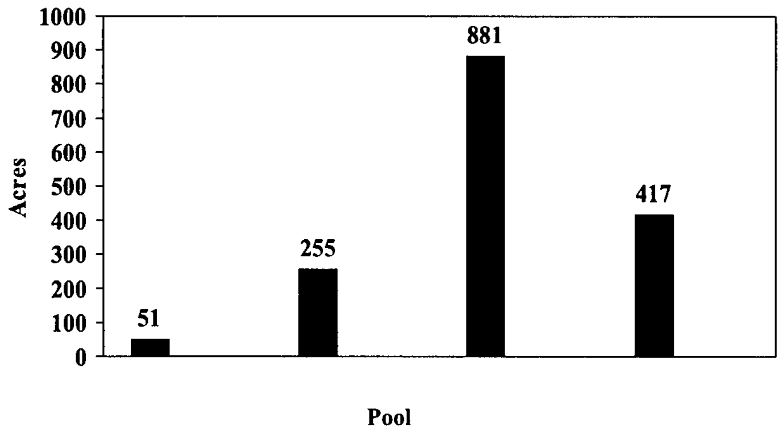

Figure 13. Acres of vegetation near the waterline in 1995 estimated from aerial photography.

remembered that water levels at the dam are lowered as discharge increases to moderate levels in pools where water levels are managed with a mid-pool control point. This type of plan was originally devised because less land had to be acquired by the Corps of Engineers for construction of the 9-foot (2.7-m) channel project.

The area predicted to be dewatered, by river mile, followed the same trend as the acreage of plant growth

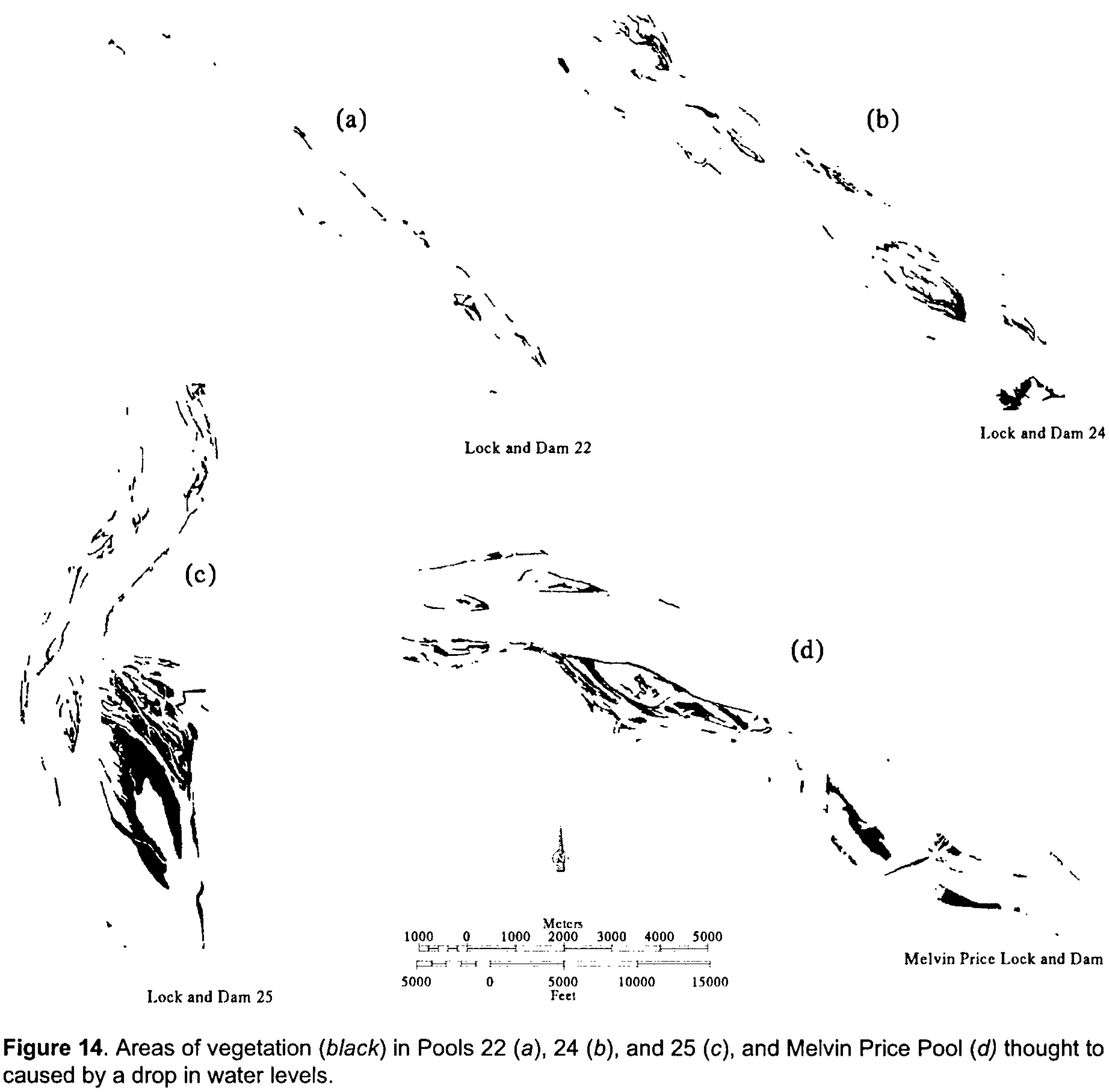

Figure 14. Areas of vegetation (*black*) in Pools 22 (*a*), 24 (*b*), and 25 (*c*), and Melvin Price Pool (*d*) thought to be caused by a drop in water levels.

Table 4. Amounts of vegetation estimated from aerial photographs taken on July 27, 1995.

Pool	Vegetation class	Area, acres (ha)	Area (%)
22	Leersia/Sagittaria	2.1 (0.85)	4.1
	Leersia	0.4 (0.16)	0.8
	Forb/grass mix	48.2 (19.5)	95.1
24	Scirpus/grass/forb	22.9 (9.3)	9.0
	Forb/grass mix	232.1 (94.0)	91.0
25	Scirpus/grass/forb	26.6 (10.8)	3.0
	Carex/grasses/forb	10.0 (4.1)	1.1
	Forb/grass mix	843.6 (341.5)	95.9
Melvin Price	Scirpus/grass/forb	46.7 (18.9)	11.2
	Forb/grass mix	369.8 (149.7)	88.8

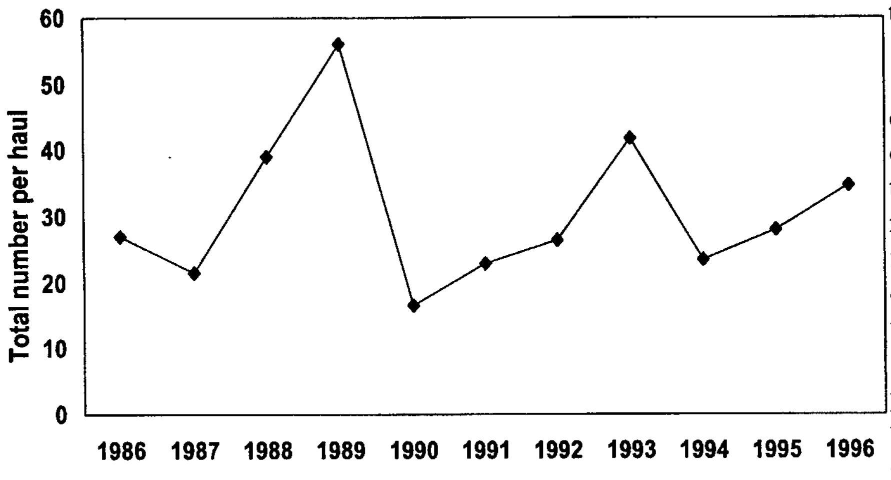

Figure 15. Mean total numbers of fish (all species) per seine haul in Pool 24.

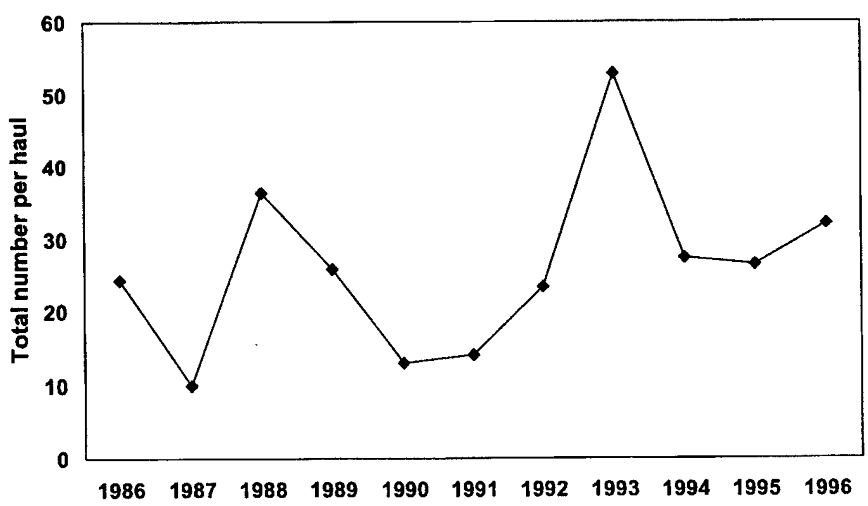

Figure 16. Mean total numbers of fish (all species) per seine haul in Pool 25.

estimated from photointerpretation (Figure 22). The greatest effect was near Batchtown at river miles (km) 243 (391.0) through 245 (394.2). However, although predicted and observed areas were usually in the same general areas, they were not necessarily the same exact areas (Figure 23). About 492 acres (199 ha) predicted to be dewatered had vegetation. Another 555 acres (225 ha) predicted to be dewatered did not have vegetation, according to the photointerpreter. In addition, 387 acres (157 ha) had vegetation observed in areas not predicted to be dewatered by the model.

Most of the differences can be explained by the lack of resolution of the data from the hydrologic model, relatively low resolution data for bottom geometry, and discharges that varied throughout the growing season. The hydrologic model predicts only one value for water surfaces from one side of the river to the next, although minor differences do occur on the river. The bottom geometry surface was estimated from points that were as much as 200 feet (61 m) apart. Even the bottom elevation at the points that were measured are probably not exact because the method used assumes that both the water surface at the point and the horizontal location of the point are known. However, water surfaces at a particular location are estimated from gages that are miles away, waves can affect measurements, and the

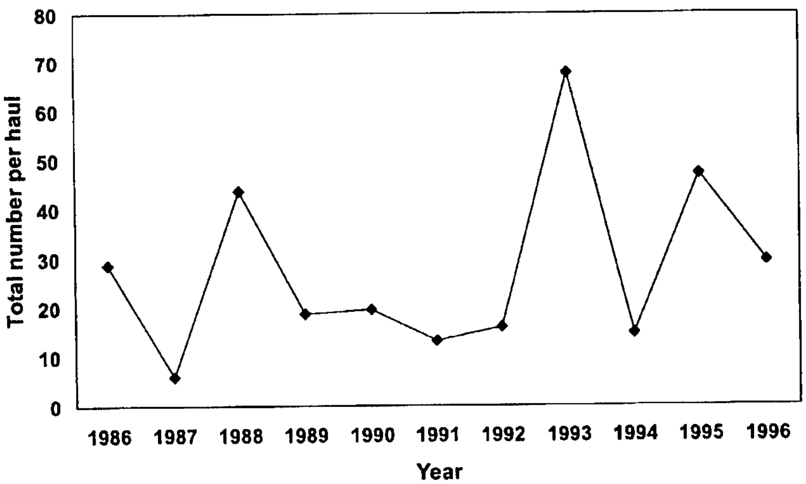

Figure 17. Mean total numbers of fish (all species) per seine haul in Pool 26.

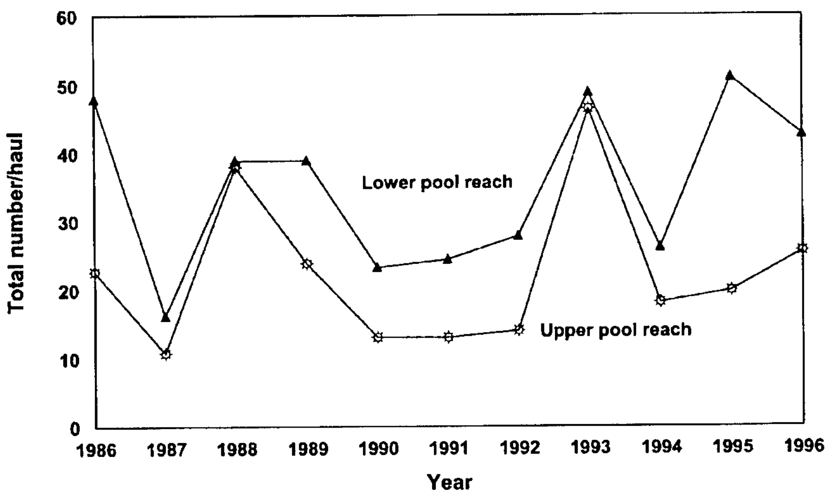

Figure 18. Mean total numbers of fish (all species) per seine haul in the upriver and down river portions of Pools 24, 25, and 26.

horizontal accuracy of establishing a point is about ± 15 feet (4.6 m). Changes in discharge and the resultant gate settings often produce water levels that change about 1 foot (30 cm) in a week at the dam (Figures 3–5), and possibly more as one moves upriver. In addition, plant growth is affected by many factors other than the presence or absence of water, such as substrate, current velocity, and light penetration. Therefore, we believe the model should only be used to obtain estimates of dewatered areas over relatively large areas (e.g., by river mile). Questions dealing with plant response in a particular area would need additional data.

Benefits of Vegetation

Aquatic macrophytes are essential to a healthy Upper Mississippi River ecosystem. Fassett (1985) included an appendix on the use of aquatic plants by birds and mammals that was obtained from 95 publications. Specific entries from Fassett include: the Cyperaceae, a favorite food of some wildfowl and eaten by muskrat, beaver, and deer; *Echinochloa* spp., eaten by wildfowl, upland game birds, song birds, and muskrats; *Leersia* spp., eaten by ducks and muskrats; and *Polygonum* spp., eaten by wildfowl, upland game birds, shore birds, song birds, deer, and muskrat. Martin et al. (1951) include the following information concerning the genera found in our study: Chufa is eaten by waterfowl, upland gamebirds, songbirds, and mammals; Rice cutgrass is eaten by waterfowl, marshbirds, shorebirds, and songbirds; *Echinochloa* is eaten by waterfowl, marshbirds, shorebirds, songbirds, upland gamebirds, muskrats, and rabbits; *Panicum* is eaten by waterfowl, marshbirds, shorebirds, songbirds, upland gamebirds, muskrats, rabbits, and white-tailed deer; *Amaranthus* is eaten by waterfowl, upland gamebirds, songbirds, rabbits, small mammals, and mule deer; and *Polygonum* is eaten by waterfowl, marshbirds, shorebirds, songbirds, upland gamebirds, muskrats, raccoon, squirrel, and chipmunk.

In a review of the literature on the interactions between fish and aquatic macrophytes, Janecek (1988) listed 84 Upper Mississippi River fish species reported to use macrophytes for some habitat

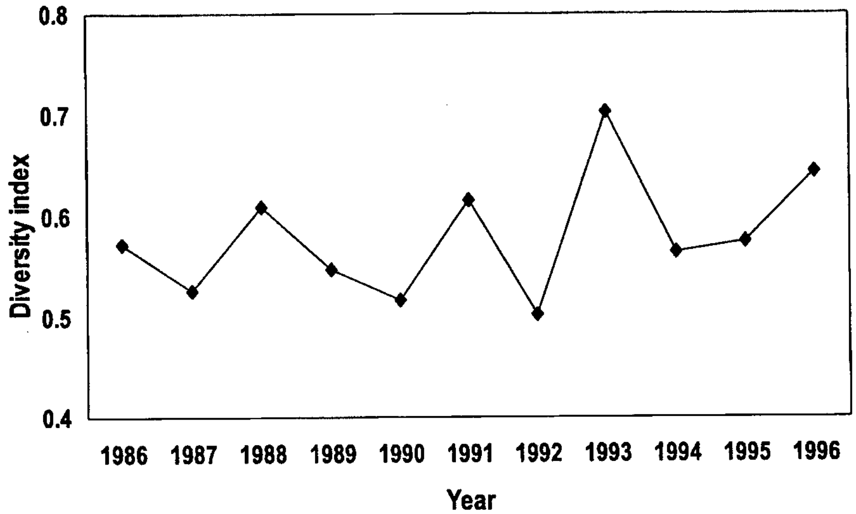

Figure 19. Simpson's Diversity Index for fishes sampled by seining in Pool 24.

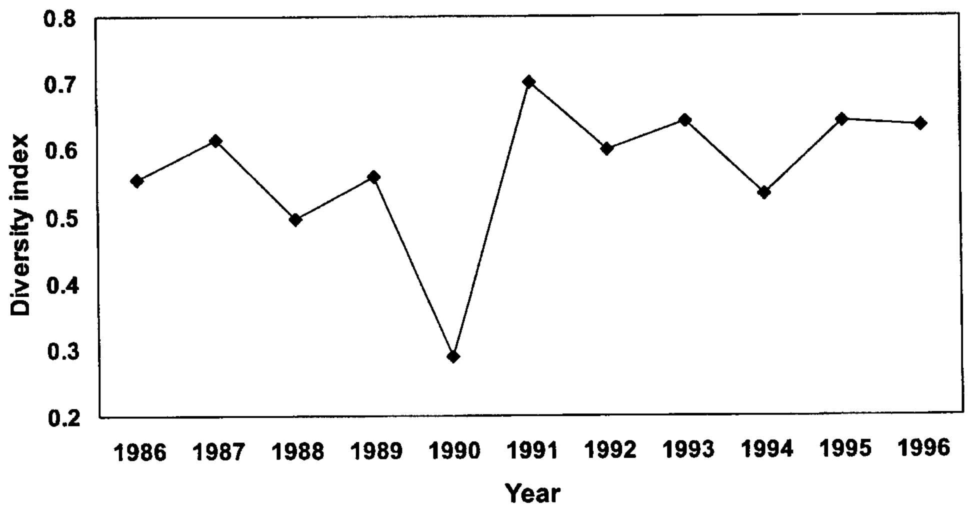

Figure 20. Simpson's Diversity Index for fishes sampled by seining in Pool 25.

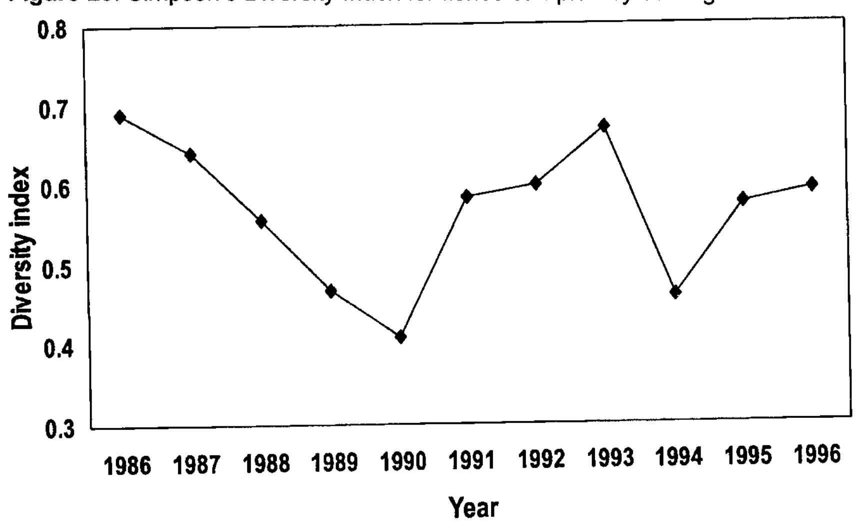

Figure 21. Simpson's Diversity Index for fishes sampled by seining in Pool 26.

function. He lists 44 species reported to spawn in, on, or near macrophytes. Unfortunately, Janecek also mentions that references to specific plants are scarce.

Opinions differ concerning drawdown effects on invertebrates. Factors found in a literature search (Wlosinski and Koljord 1996) affecting invertebrate populations during a drawdown include season, duration, vertical drop in water levels, species, vegetation, and sediment type. Becker et al. (1981) mentioned that invertebrate losses in shoreline zones because of drawdowns may be of little importance to overall ecosystem dynamics. Fredrickson and Reid (1988), in the U.S. Fish and Wildlife Services' Waterfowl Management Handbook, opined that management for specific plant communities may be the most practical way of increasing invertebrate production.

We did not examine the response of other populations such as waterfowl and shorebirds to the drawdown. However, observations in late summer and fall by the field biologists noted that, as water levels began to inundate vegetative growth, fish rapidly began to use the area. High invertebrate populations

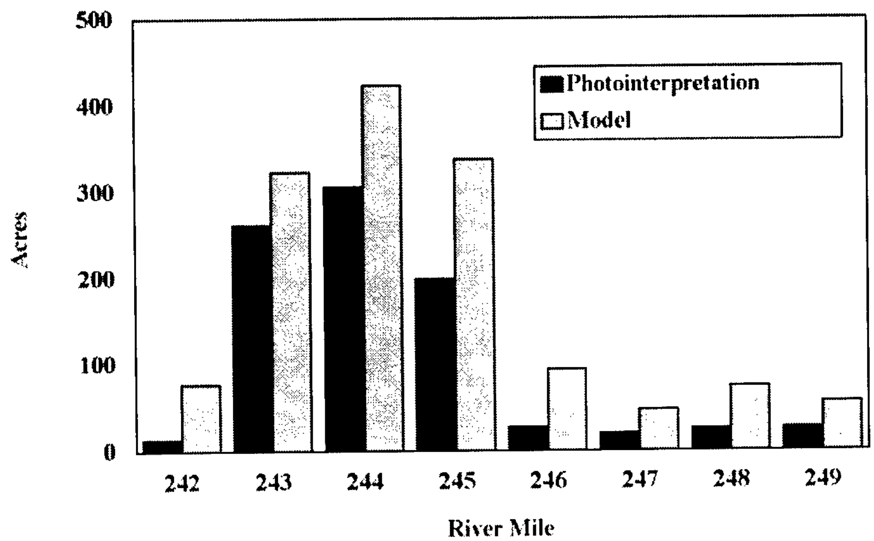

Figure 22. A comparison of acreage of dewatered areas predicted by the model to acreage of vegetation

Figure 23. A map of dewatered areas as predicted by the model in comparison with areas with vegetation estimated from photointerpretation in the lower stretch of Pool 25.

were also noted during casual observations made about 3 weeks after vegetation was inundated. The area was also heavily used by a variety of bird species during both the fall and spring migrations.

Conclusions and Recommendations

We found that (1) excellent plant growth occurred at all dewatered sampling sites during 1995 and 1996; (2) plants covered a much greater area in 1995 near the water line in Pools 24 and 25 and Melvin Price Pool, where a drawdown had occurred, than in Pool 22, where water levels were more constant; (3) the Pool 25 model reasonably estimated acreages and locations of plant growth prior to actual manipulation; (4) the fish community was not significantly affected during years when water levels were held on the low side of the operating band as compared to years when water levels were held on the high side of the operating band; and (5) navigation and recreation interests were not adversely affected by the drawdown and in many instances sandbars exposed during the drawdowns were used by numerous recreationalists. These conclusions lead us to believe that the water-level drawdown experiment has been successful during summers 1994, 1995, and 1996. However, results should be further assessed. Reid et al. (1989), in a review of moist-soil impoundments in the Upper Mississippi River, mentioned that *Echinochloa* spp. and *Cyperus* spp. are less likely to germinate or may produce fewer seeds during successive growing seasons. However, factors such as sediment deposition on the Mississippi River may lead to different results.

We believe that this experiment represents a step toward ecosystem management on the Upper Mississippi River System and recommend further consideration of drawdown as a management tool for riverine resources.

Acknowledgment

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Appendix B. Definitions of Terms Used in this Report

Term	Definition
Control point	A specific location in a pool where the Corps of Engineers maintains a target water level over a range of discharges
Coverage	A geographical data set containing attributes for discrete point, line, and/or polygon features in a vector data set or cell values for raster data sets
Drawdown	Water levels that are managed below the project pool elevation
Geographic Information System (GIS)	An organized collection of computer hardware, software, geographic data, and personnel adapted to efficiently capture, store, update, analyze, and display all forms of geographic information
Hydrologic model	A mathematical model that predicts water-level elevations from upriver to downriver, based on bottom geometry, gate elevation settings at the downstream dam, and discharge data
Maximum drawdown	The maximum drop in water levels at the headwater, below the project pool elevation, that would still allow a 9-foot (2.74-m) navigation channel
Open river	The condition when all of the movable gates at a dam are raised out of the water and the headwater and tailwater elevations are nearly equal
Operating band	The amount of vertical flexibility in holding water levels as a function of discharge
Overlay	A GIS process that operates on two or more data sets based on their geographic location. Types of operations include combining attributes of different coverages and performing mathematical functions based on attributes of multiple coverages
Pool	The body of water created upriver of a dam and extending to the next upriver dam
Project pool elevation	The water-level elevation needed to maintain a 9-foot (2.74-m) channel at zero discharge and the elevation for which each dam was designed
Vector	A GIS data structure that represents map features as a list of ordered *x,y* coordinates

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13. ABSTRACT (Maximum 200 words) An experiment to improve ecological conditions while maintaining a 9-foot (2.74-m) navigation channel was continued in 1995 and 1996 on the three pools of the Upper Mississippi River managed by the St. Louis District, U.S. Army Corps of Engineers. Water levels were held from 1 to 3 feet (0.3 to 0.9 m) lower than maximum regulated elevations at the dam from about mid-June through July in Pools 24 and 25 and Melvin Price Pool. Water levels were then gradually raised as discharge allowed. Vegetation was surveyed along an elevational gradient in eight areas in 1995 and six areas in 1996. Seven plant genera were identified in 1995 and five genera in 1996. *Amaranthus* spp. (pigweed), *Cyperus* spp. (chufa), *Echinochloa* spp. (wild millet), and *Polygonum* spp. (smartweed) were found in 30–90% of the sites. Plants grew 7–10 inches (17.8–25.4 cm) in about 30 days and then grew more quickly as water levels were slowly raised. On July 27, 1995, aerial infrared photographs (1:15,000) were taken of the lower stretches of the three pools. Photographs also were taken of Pool 22, where no drawdown occurred. These photographs were interpreted, specifically searching areas near the waterline with signatures representing the above plants. In Pools 24 and 25 and Melvin Price Pool, between 255 and 880 acres (103 and 356 ha) of plants were measured near the waterline, compared to just 51 acres (20.6 ha) in Pool 22 where water levels near the dam were held at the project pool elevation. A geographic information system model was also used to predict areas that would be dewatered under various water-level management options. Minnow seining data collected on the three pools from 1986 to 1996 were also analyzed. The total numbers of fish per haul and Simpson's Diversity Index showed no significant detrimental effects during years when water levels were held on the low side of the operating band. We believe that this management experiment was successful and that continuation, as conditions allow, would be beneficial.			
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The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System was authorized under the Water Resources Development Act of 1986 as an element of the Environmental Management Program. The mission of the LTRMP is to provide river managers with information for maintaining the Upper Mississippi River System as a sustainable large river ecosystem given its multiple-use character. The LTRMP is a cooperative effort by the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.