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January 1979

Floral and Faunal Changes in Lowland Hardwood Forests in Missouri Resulting from Channelization, Drainage, and Impoundment



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>
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>
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FLORAL AND FAUNAL CHANGES IN LOWLAND HARDWOOD FORESTS IN MISSOURI RESULTING FROM CHANNELIZATION, DRAINAGE, AND IMPOUNDMENT[1]

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Office of Biological Services
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EXECUTIVE SUMMARY

Fauna and flora were monitored for one year in lowland hardwood forests on three sites near the St. Francis River, Missouri. Sites were either channelized, drained, or impounded as greentree reservoirs. Line transects, point-center quarter method, increment cores, and canopy photos were used to monitor vegetative conditions. Mist-netting, belt transects, aerial inventories, and snap-trapping were techniques used to monitor animal presence and abundance. Records on surface water, ground water, surface soil moisture, precipitation, and St. Francis River stages and discharges were maintained.

Channelization of the St. Francis River effectively reduced the depth of flooding and the frequency of inundation regardless of the river stage. As drainage improved, a greater forest area was cleared by landowners for row crops than was lost during channel construction. Forests are continually being cleared in southeastern Missouri, but forest area declined by 78 percent near channelized sites whereas forest area along unchannelized sections declined by only 7 percent during the same interval. Stream length was reduced by 56 percent on channelized areas and the stream sinuosity index dropped from 2.5 to 1.08. Backwater cutoffs continued to provide good wildlife habitat immediately after channelization. As time from the date of channelization increased, habitat along cutoffs gradually deteriorated because adjacent cover was cleared or because the old channel was silt filled or deliberately filled and farmed. Where channelization is completed

habitat must be protected by fee title acquisition or by a program that restricts forest clearing.

Levees provide good alternatives to channelization. Floods were contained by levees and little riparian habitat was lost, but plant species composition consists of more water tolerant forms than on non-leveed areas. Habitat is less valuable for many ground dwelling mammals because annual inundation may be extensive between the levees for long periods and to depths that restrict the development of ground cover. Battured lands should be in public ownership.

The composition of vegetation on spoil banks with low fertility and high sand content was not typical of early successional sites in the St. Francis Basin, and re-establishment of typical forest cover on these spoils may never occur. Sandy soil from spoil banks erodes readily and spreads onto adjacent farmlands and reduces fertility.

Differences in depth of flooding, frequency of flooding, duration of inundation, soil moisture conditions, soil type, and soil fertility influenced vegetative composition. The variety of surface water and soil moisture conditions that occurred on the study sites were reflected in the distribution and abundance of seedlings. Few herbaceous plants occurred on flooded sites. Seedlings and shrubs were more abundant than herbaceous forms on flooded sites, but not as abundant as on dryer sites. Pin oak and overcup oak had better growth and were dominant on wet sites, but willow oak and sweetgum were more likely to occur on dryer sites.

When the natural pulsations in water are changed by channelization or drainage, the plant community slowly changes to one characteristic of dryer sites. When natural pulsations in water are changed by greentree reservoirs, the plant community slowly changes to one characteristic of a wetter site.

Greentree reservoir managers must be cognizant of these changes and attempt to duplicate the natural pulsations.

Wood ducks did not use the channelized river, but use of backwater cutoffs was similar to the unchannelized stream. The diversity and abundance of forest birds was less on channelized sites than on unchannelized areas. Herons and waterfowl were absent from drained areas or sites lacking surface water. The highest trapping success for small mammals occurred on the dryest sites where food and cover was abundant and the poorest success occurred on sites with extensive flooding where vegetation was sparse or nonexistent.

Techniques for good environmental assessment include aerial photos to monitor gross forest changes, point-center quarter method for woody composition, increment cores for growth, and line transects for herbaceous growth. The abundance and distribution of animal populations are difficult to assess without a large investment in field time over a long period. Belt transects were effective to monitor bird presence and abundance. Concurrently, information must be available on frequency, depth and duration of flooding, water table, surface soil moisture, and fertility.

This report was submitted in fulfillment of Contract Number 14-16-0008-1195 by the University of Missouri-Columbia under the sponsorship of the Office of Biological Services, U.S. Fish and Wildlife Service. Work was completed as of January 19, 1979.

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INTRODUCTION

Forest area within the lowland hardwood ecosystem of the Lower Mississippi Valley has declined rapidly because forest lands have been cleared and replaced with rowcrops. Other factors that affect the loss of lowland forests are discussed by Holder (1970), Hedlund (1971), and Korte and Fredrickson (1977). The most detailed estimates of forest losses are available for Arkansas and Missouri. Only 728,340 ha (18 percent) of the original 4,012,928 ha of forest in Arkansas remained in 1970 (Holder 1970). By 1975 Missouri had lost nearly 96 percent of its original 1 million ha of lowland forest (Korte and Fredrickson 1977). Other hardwood forest areas remaining included 604,899 ha in Mississippi (1967) and 1,518,826 ha in Louisiana (1974), but figures are not available for Tennessee, Kentucky, and Illinois (Sternitzke and Christopher 1976). The largest remnant of the Missouri forest lies within Mingo Swamp near the upper reaches of the lowland portion of the St. Francis River.

Most of the swamplands in southeastern Missouri were originally drained before 1920 by a network of ditches. Drainage was facilitated by levees that were constructed along the west side of the St. Francis River between the Ozark Uplift and Arkansas. These levees prevented water interchange between the St. Francis and Black Rivers. Levees constructed on both sides of the St. Francis River along the border between Missouri and Arkansas contained the flow of water from upstream areas. Although drainage was improved, it was inadequate to allow for successful production of rowcrops within Mingo Swamp.

Between 1945 and 1955, much of Mingo Swamp was purchased by the federal and state governments. Since then the forests on public lands have regenerated, but forests on private lands have been subjected to increased exploitation. Some sites within Mingo Swamp are well drained, but others resemble historic conditions in that flooding occurs over long periods. Impoundment for water storage and greentree reservoir management are practices commonly used on public lands. The manipulations have impacted the forest system and represent typical management practices throughout the Mississippi Delta. The diverse history of land use and management within Mingo Swamp and along the St. Francis River provided several treatments that were useful in assessing habitat changes within the same geographical and ecological area.

Few in-depth studies have been conducted on this ecosystem especially those that monitor the effects of the annual pulsations in water on plant and animal communities. This effort was an attempt to expand our understanding of the impacts of water resource developments and wetland wildlife management on lowland hardwood forests and to examine techniques for effective habitat assessment. The need for this baseline information has become increasingly important as the forest area declines and as an understanding of the importance of wintering habitat for waterfowl and other birds becomes apparent. The objectives were:

1.) To identify the effects of channelization, drainage, and impoundments on the species composition, density, re-establishment, and growth of plants in lowland hardwood communities.

2.) To identify and monitor the effects of channelization, drainage, and impoundments on animals selected as indicator species at several trophic levels in lowland hardwood communities.

3.) To identify and develop reliable techniques to monitor and predict changes in fauna and flora as the result of channelization, drainage, and impoundment.

STUDY AREAS

Field investigations were conducted within the upper reaches of the St. Francis River Basin. The basin encompasses about 1.5 million ha of lowlands within southeastern Missouri and eastern Arkansas. The area is a relict valley of the Mississippi River and is characterized by warm wet springs, hot humid summers, and mild winters. Average annual rainfall for a 30 year period (1940-69) was 111.84 cm at Wappapello, Missouri (U. S. Weather Bureau 1940-69). Soil is weathered alluvium with firm, acidic gray silt loam topsoil and gray clay subsoil.

As drainage improved, the forest was cleared and most lands are now in rowcrops (Korte and Fredrickson 1977). The remnant forest in southeastern Missouri is located primarily along streams and as public lands on the Duck Creek Wildlife Management Area and on Mingo National Wildlife Refuge. Forests are dominated by lowland species such as overcup oak (Quercus lyrata), pin oak (Q. palustris), bald cypress (Taxodium distichum), water tupelo (Nyssa aquatica), and water locust (Gleditsia aquatica).

Four soil types occur within the study sites that were selected along the St. Francis River and within Mingo Swamp. From Lake Wappapello to Crowley's Ridge soils are predominantly Calhoun series with Dubbs series occurring on some higher elevations. Falaya-Fountain association soils predominate for about 15 km north of Crowley's Ridge and continue for about 44 km south of

Crowley's Ridge. The Sharkey association predominates south of the Falaya-Fountain association. The silty alluvium of Dubbs, Calhoun and Falaya-Fountain soils are characteristic of natural levees along streams on the study area. The clay soils of the Sharkey association are characteristic of backwater areas and are affected by both soil moisture extremes. Dubbs and Calhoun soils are acid to strongly acid, but Falaya-Fountain and Sharkey soils are neutral to alkaline. Both Falaya-Fountain and Sharkey soils are poorly drained.

Mingo Swamp soils are Calhoun series light gray silt loam or silty clay loams. Surface soils are dominantly gray to dark gray silt loam with a weak granular structure that grade into a lighter gray and at about 50.8 cm change to a gray silty clay. On some low sites, shallow muck soils occur over gray plastic clays.

Study areas were categorized on the basis of how man altered the water regimes in the forest system: impounded, drained, channelized, or leveed. Five wooded sites along the St. Francis River within Stoddard, Butler, and Dunklin Counties, Missouri were selected as control and treatment areas to investigate the effects of levees and channelization (Figure 1). An unchannelized section of river in Butler and Stoddard Counties with forest in early successional stages served as the control for a section of river that was channelized less than one year before the study in Butler and Stoddard Counties and a section that was leveed in Dunklin County prior to 1929. A second unchannelized section with forest in an advance stage of succession served as a control for a section of the St. Francis River that was channelized prior to 1968 and had forest in a similar stage of succession.

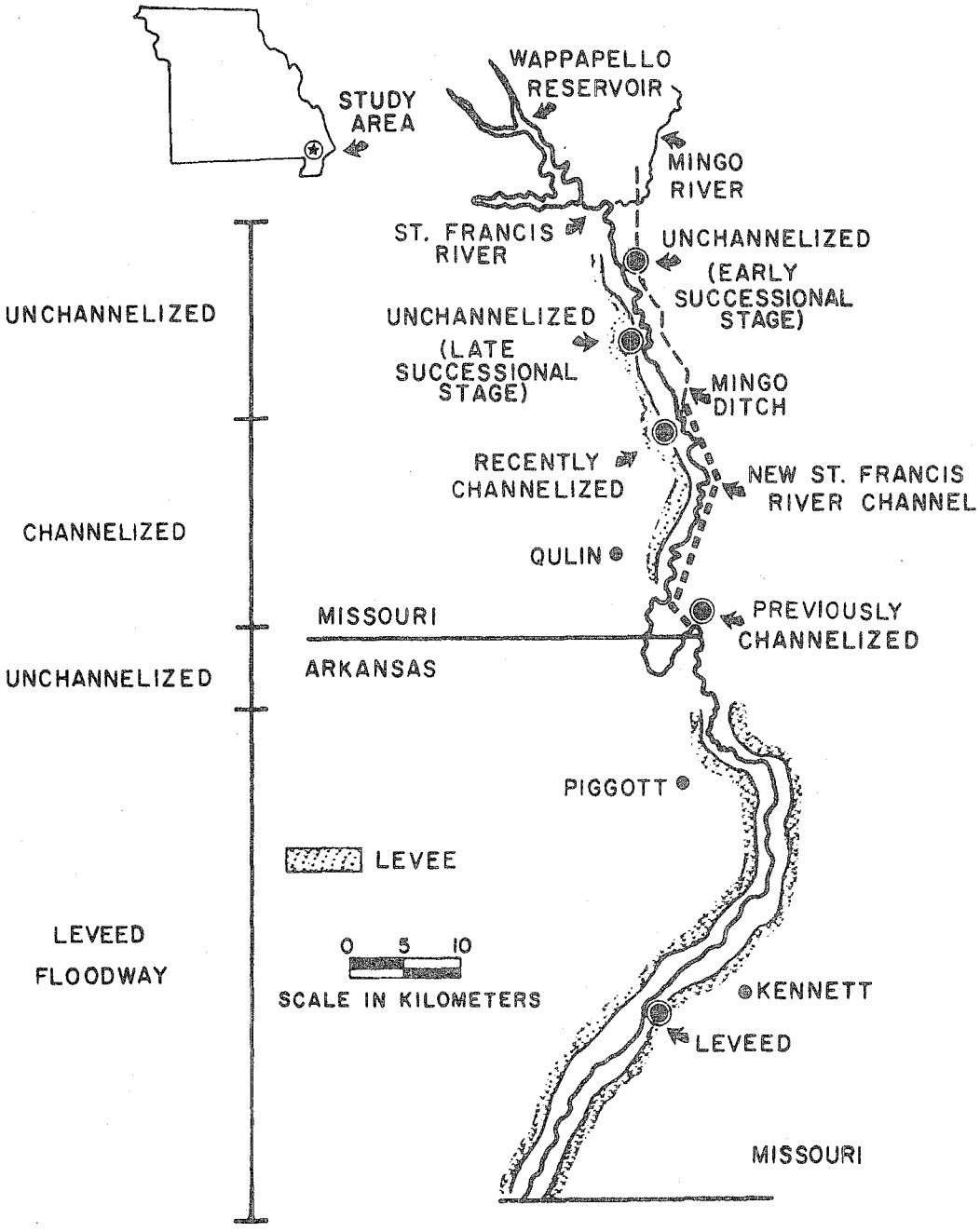


Figure 1. Location of five study sites along the St. Francis River in southeastern Missouri.

Areas within Mingo Swamp were used to assess the impacts of drainage and periodic impoundment on the fauna and flora of lowland forests (Figure 2). A control area that has poor drainage and has a water regime similar to natural fluctuations was selected along Mingo River within Mingo National Wildlife Refuge.

Both drained and impounded treatment areas were on the Duck Creek Wildlife Area. Pool 3, a 259 ha compartment that is managed as a greentree reservoir, was selected as the periodically impounded area. The pool is flooded immediately preceding and drained immediately after the waterfowl hunting season each year. Heavy rainfall floods the area periodically.

A drained treatment area was selected near the upper reaches and adjacent to a sizeable drainage ditch. The area is inundated less frequently because of the high elevation and proximity to the drainage ditch. The site is characteristic of forestlands that are some distance from a natural or modified river channel.

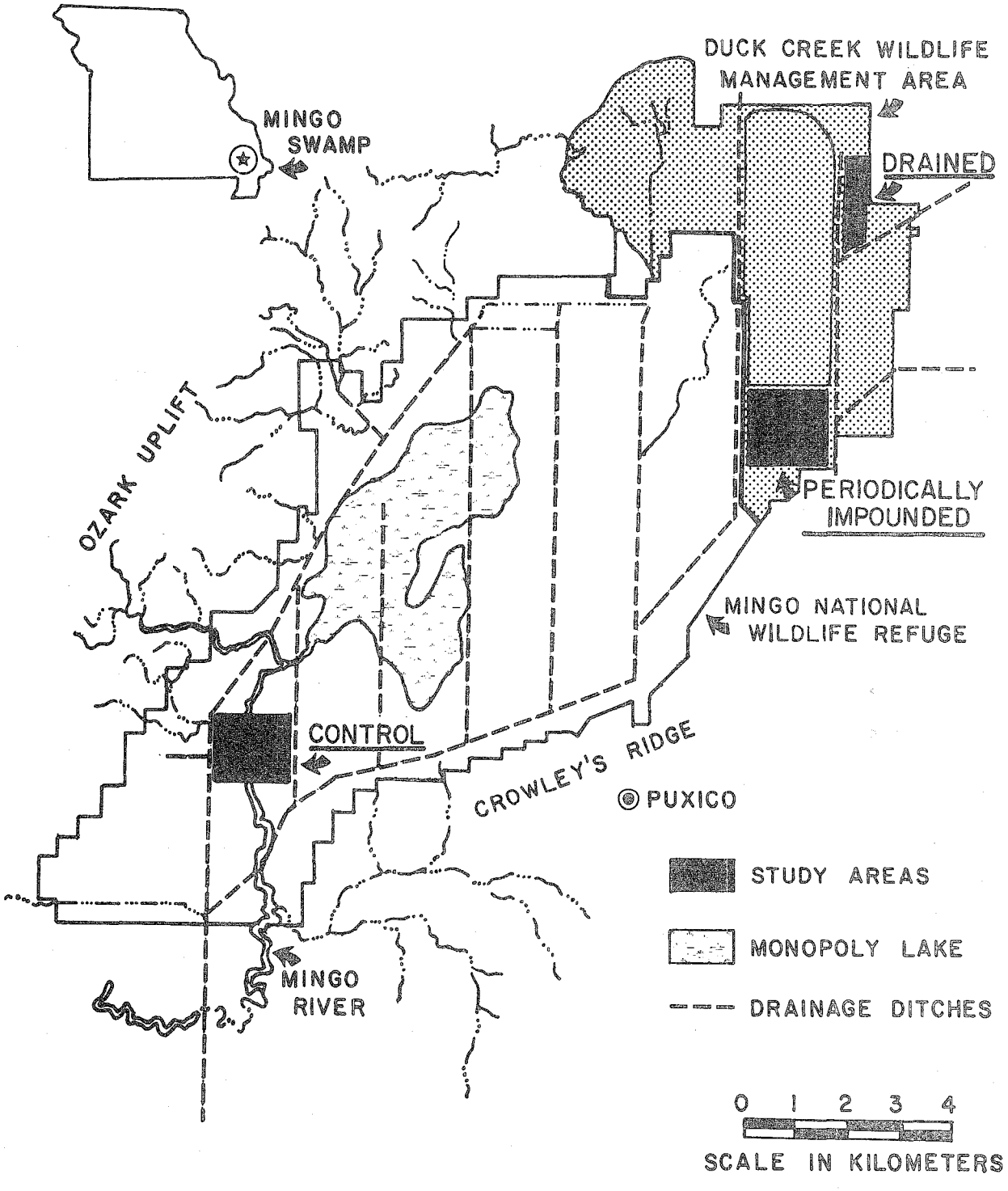


Figure 2. Location of three study sites in Mingo Swamp.

MATERIALS AND METHODS

HABITAT CHANGES

Changes in channel length and riparian forest area for unchannelized, channelized, and leveed sections of the St. Francis River were determined from 1966 series (pre-channelization) and 1973-74 series (post-channelization) aerial photographs.

To record present habitat conditions as a reference for future changes, nine permanent photo stations (three on leveed sites, four on channelized sites, and two on unchannelized sites) were established along the St. Francis River. In January, in June and in October 1976, four black and white and four color photographs (two each facing downstream and two each facing upstream) were taken at each photo station with a 35 mm SLR camera fitted with 35 mm lens.

PLANT COMMUNITIES

Species composition and density of plant communities were sampled along line transects. Transects were selected randomly in a predetermined direction in Mingo Swamp and perpendicular to the stream channel in forested sites along the St. Francis River. The transects intersected representative elevations and vegetation on each site. Samples were taken at fifty randomly selected points on each 1200 m of transect in Mingo Swamp and along the St. Francis River at the unchannelized early successional forest and at recently channelized sites. Thirty randomly selected points were sampled on the St. Francis River

in unchannelized late successional forest, previously channelized and leveed sites. Elevation (above mean sea level) at each sample point was determined with a transit.

Trees and Saplings

In July and August 1976, trees and saplings were sampled on all study areas by point-centered quarter method (Cottam and Curtis 1956). Species, distance-from-point (dfp), and diameter-at-breast height (dbh) were recorded for the nearest tree (dbh $\geq$ 10.5 cm) in each quarter. Species and dfp were recorded for the nearest sapling (dbh < 10.5 cm and height > 1 m) in each quarter. Heights of trees and larger saplings (height > 5 m) were determined with a Haga altimeter and for smaller saplings by ocular estimate.

Basal Area Growth Rates

Basal area growth was determined for representative tree species on each of the Mingo Swamp areas. Two increment cores were extracted from each of two trees (one with crown suppressed and one with crown not suppressed) of selected species. Growth rates were determined by the Tree-Ring Laboratory, U. S. Geological Survey, Reston, Virginia.

Canopy Cover

In August 1976, canopy cover was recorded on Kodak Tri-X-Pan Professional film with a fish-eye lens, pinhole aperture canopy camera. Seven to eleven exposures were taken at randomly selected points along line transects in woodlands on each study area and along spoil bank line transects on the recently channelized and previously channelized areas. Percent open canopy was determined from contact prints with a 5 mm grid formed by punching 0.5 mm diameter holes in an acetate overlay.

Forest Floor Vegetation

Forest floor vegetation (seedlings, shrubs and herbs) were sampled on all study areas in May and July 1976, and on the impounded and drained areas in Mingo Swamp in September 1976. Species and stem counts were recorded for seedlings (dbh < 10.5 cm and height < 1 m), shrubs, and herbs in a 0.5 m x 1.0 m quadrat placed at each sample point on the line transects. Quadrats were marked for relocation with surveyor's flags.

Spoil Bank Vegetation

In May and August 1976, spoil bank vegetation was sampled at 0.5 m intervals on recently channelized and previously channelized areas along eight 300 m line transects. Plant species were recorded if the plant touched the mark on the transect tape or if a part of the plant was directly over or under the mark. Three transects were on or adjacent to spoil banks of riverine origin or on those spoil banks formed recently by dredging material from the natural river channel. Two transects were on or adjacent to spoil banks of non-riverine origin or on spoil banks that were formed recently by dredging a new channel across a meander of the natural stream. Three transects were on or adjacent to spoil banks (non-riverine origin) that were at least 8 years old.

ANIMAL COMMUNITIES

Avian Use

Forest birds. Forest bird surveys were conducted on all study areas in October and December 1975 and in February, April, June and August 1976. Each two-hour survey was initiated within 30 minutes of local sunrise on days with clear or partly cloudy skies, and consisted of a single observer that identified species by sight or by vocalizations along transects. Although vocalizations

were used to identify species, the numbers of birds were determined only by sightings. On the St. Francis River areas, avian use was determined within 30 m of the stream channel for two 30 minute periods (one before and one after the one-hour survey of avian use in the woods away from the channel).

In May 1976, mist-netting was conducted in forested habitat along one unchannelized and one channelized segment of the St. Francis River for 20 hours and 9 hours respectively. Netted birds were removed from the net immediately, identified, sexed and released.

Breeding waterfowl, raptors, and semi-aquatic birds. Monthly waterfowl counts were made on six 11 km segments (3 unchannelized, 2 channelized and 1 leveed) of the St. Francis River during March, April and June 1976. When water levels were high enough to permit passage of a flat-bottomed boat, counts of waterfowl, semi-aquatic birds, and raptors were made on meander cutoffs along channelized stream segments. Each count was initiated within 30 minutes following local sunrise on days with clear or partly cloudy skies and consisted of traversing the 11 km segment of river channel as quickly as possible. Counts were terminated when other watercraft activity was encountered on the river.

Wintering waterfowl. During November and December 1975, and January and February 1976, aerial census of waterfowl were conducted along four 8 km segments (1 unchannelized, 2 channelized and 1 leveed) of the St. Francis River. All waterfowl observed within one kilometer of the river channel were recorded.

Mammalian Use

Small mammals. Small mammals were snap-trapped on all study areas in October and December 1975, and in February, April, June and August 1976. Two 300 m traplines, each consisting of 20 stations at 15 m intervals, were established on each study area. At each station, three commercial grade

snap-traps baited with peanut butter, were set within a 1.5 m radius for 72 hour trap periods. Traps were checked daily, animals were removed and traps were rebaited when necessary. Control areas and respective treatment areas were trapped simultaneously. When surface water inundated some of the stations, the trapline was moved to a higher site.

On the St. Francis River sites, one trapline was set within 30 m of and parallel to the river channel and one trapline was set in the woods away from the channel. On recently channelized and previously channelized areas, ten stations of the trapline near the channel were set between the channel and the spoil bank and ten stations were set on the spoil bank.

Other mammals. A list of mammals was compiled for each study area from snap-trap results, actual sightings, tracks, scats and other signs encountered while working on the area.

WATER REGIMES

Surface Water

Surface water levels were monitored within Mingo Swamp by periodically checking water gauges installed at the lowest sample point on each area. Readings were taken at least bi-weekly, but readings were made more frequently during periods of precipitation.

Ground Water

Water table depth was determined for two sites on each of the Mingo Swamp study areas in August. Water levels were measured immediately after the 7.5 cm holes were prepared with a soil sampling auger. Because water levels rose as much as half the distance between the surface and the level of the first reading after 24 hours, only the initial readings are reported. Data on ground water was available from five wells that are monitored by the Missouri Geological Survey within Mingo Swamp.

Surface Soil Moisture

Surface soil moisture was monitored on Mingo Swamp areas from mid-April 1976 to November 1976. On each area, ten gypsum soil moisture blocks were installed 8 cm below the soil surface at sample points with land surface elevations representative of the elevation range for the study area.

Precipitation, River Stages, and Discharges

Precipitation data were available from two sites: Wappapello, Missouri Weather Station and Duck Creek Wildlife Area Headquarters. The Wappapello Station is about 6.5 km from the Mingo Swamp control. The Duck Creek Headquarters is about 3.0 km from the periodically impounded and drained areas.

Pre-channelization and post-channelization river stage and discharge records for unchannelized, channelized and leveed sections of the St. Francis River were obtained from the U. S. Army Corps of Engineers, Memphis District Office, Memphis, Tennessee.

RESULTS

PRECIPITATION

Ten years (1963-72) of precipitation data from Wappapello and Duck Creek were used for comparison. Between 1 October, 1975 and 30 September, 1976, precipitation was 109.46 cm at Wappapello and 113.96 cm at Duck Creek. Although the annual rainfall for the study year was near the ten year average, monthly precipitation varied considerably.

Rainfall during the study was below normal in October, January, April, and September, but greater than normal in June and July (Table 1). Total rainfall in June was 24 cm on the control and 25.34 cm on the impounded and drained area or about 300 percent more than the 10-year mean. Rainfall in July was about 150 percent more than the 10-year mean. In southeastern Missouri, heavy rainfall (12 to 25 cm within a 24 hour period) is not unusual and may occur at any season, but these heavy rainfalls more typically occur during winter or spring months.

WATER REGIMES

Surface Water

Beavers (Castor canadensis) have built levees and dams that affect drainage in Mingo Swamp. Hence, depths of surface water at each sample point could not be determined from land surface elevations and gauge readings at the lowest sites.

Table 1. Monthly precipitation from October 1975 through September 1976 and mean monthly precipitation for the ten-year period 1963 to 1972. Precipitation was measured at Wappapello, Missouri Station (for control area) and at Duck Creek Wildlife Area headquarters (for periodically impounded and drained areas)

	Monthly precipitation (cm)			
	Control		Periodically impounded and drained	
	Monthly	10-year mean	Monthly	10-year mean
Oct.	3.98	6.65	2.59	6.17
Nov.	11.93	9.32	9.75	9.67
Dec.	11.98	10.16	12.40	11.12
Jan.	4.29	8.22	4.54	7.46
Feb.	5.48	7.01	6.72	7.36
Mar.	10.43	11.53	11.68	11.43
Apr.	4.74	11.81	6.98	12.62
May	9.19	11.25	12.54	12.87
Jun.	24.00	7.49	25.34	8.91
Jul.	14.96	9.93	16.10	9.24
Aug.	5.61	7.89	3.12	9.98
Sep.	2.87	12.70	2.22	12.14
Total	109.46	113.96	113.98	118.97

Major differences in surface water conditions between the control, impounded, and drained sites were the maximum and minimum depth of flooding, the duration of flooding, and the extent of flooding at maximum depth (Table 2). Drainage was effective on the drained site because both minimum and maximum water depths were the same (0-5 cm) and water never accumulated during the growing season. Water regimes were similar on the control and impounded area in minimum and maximum depths during both dormant and growing seasons. Although flooding occurred over a longer period on the drained site (Table 2), maximum water depths inundated only 20 percent of the drained sample points whereas 80 percent of control and 100 percent of periodically impounded sample points were flooded.

Heavy precipitation had an obvious effect on surface water on both the periodically impounded and drained areas (Figure 3). Flooding the periodically impounded area by release of water from a reservoir caused an earlier and more pronounced rise in water during the wet winter season than occurred on the control and drained areas. Heavy rains in late June and early July caused rapid increases in water levels on control and periodically impounded areas, but no surface water accumulated on the drained area. Because the periodically impounded area has better drainage than the control, surface water levels decreased rapidly in January when rainfall was low.

Ground Water

Based on 18 years of data (1957-74) from a Missouri Geological Survey well at the Duck Creek Wildlife Area, the local water table fluctuates annually with higher levels from March to June and lower levels from July to November (Figure 4). During this study, the same pattern was apparent from the five wells within Mingo Swamp. The water table along transects was lower in August in Mingo Swamp than in January and April (Table 3).

Table 2. Maximum and minimum surface water depths and duration of flooding on control, periodically impounded and drained areas in Mingo Swamp during dormant (October through March) and growing (April through September) seasons

Characteristic	Control		Periodically impounded		Drained	
	Dormant	Growing	Dormant	Growing	Dormant	Growing
Minimum depth (cm)	10-15	0	10-15	0	0-5	0
No. days flooded	19	40	20	52	99	147
% season flooded	10	22	11	28	54	80
Maximum depth (cm)	>35	>35	>35	>35	0-5	0-5
No. days flooded	36	21	84	20	84	36
% season flooded	20	11	46	11	46	20
Mean depth (cm)	27	16	33	12	<1	<1

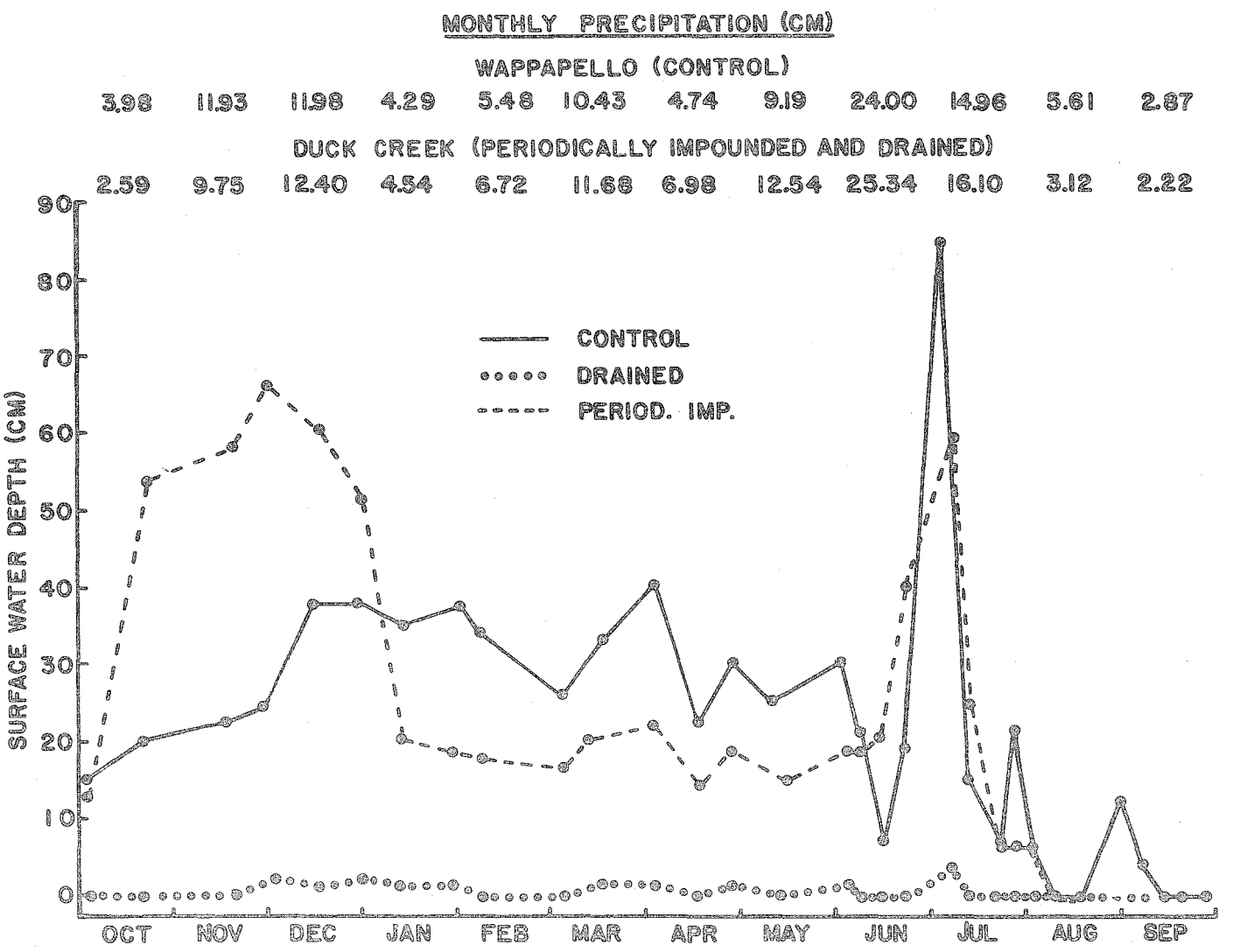


Figure 3. Monthly precipitation at Wappapello, Missouri and surface water depths in Mingo Swamp 1975-76.

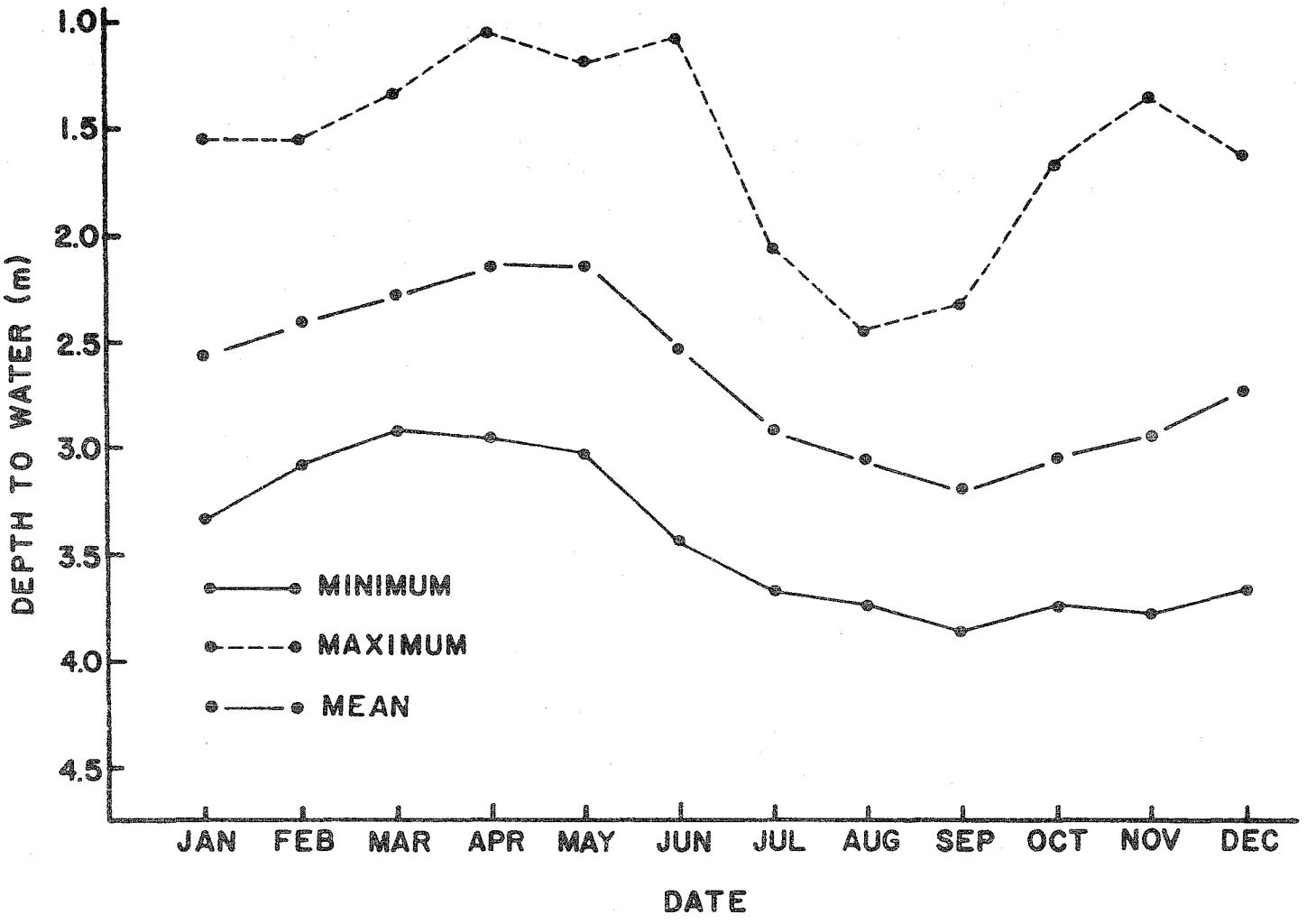


Figure 4. Maximum, minimum, and mean water table levels at the Duck Creek Wildlife Management Area headquarters, Bollinger County, Missouri.

Table 3. Depth to water table (meters below land surface) and elevation of sample point (meters above mean sea level) on control, periodically impounded, and drained areas and on five Missouri Geological Survey wells within Mingo Swamp

Well location	Date	Depth (m)	Elevation (msl)
Present study			
# 1 Control	08/1976	3.15	102.87
# 2 Control	08/1976	2.75	102.49
# 1 Periodically impounded	08/1976	2.49	103.74
# 2 Periodically impounded	08/1976	1.90	103.61
# 1 Drained	08/1976	3.15	104.60
# 2 Drained	08/1976	2.90	104.60
Missouri Geological Survey			
Duck Creek	11/19/75	1.52	104.85
	04/16/76	1.31	
Mingo Refuge # 1	01/20/76	1.07	103.63
	04/13/76	1.10	
Mingo Refuge # 2	01/20/76	1.89	104.85
	04/13/76	2.44	
Mingo Refuge # 3	01/20/76	0.76	104.85
	04/13/76	0.06	
Mingo Refuge # 4	01/20/76	1.74	103.02
	04/13/76	1.40	

River Stages and Discharges

To measure the impact of stream alteration on river stages, similar discharge rates from Wappapello Dam were selected for comparison that represented periods before and after channelization. The river stages were compared between sites (Table 4). Channelization of the St. Francis River caused significant decreases in river stages on channelized segments, but only minor changes on unchannelized and leveed segments. The changes in river stages on channelized sections were the most obvious during maximum discharge, but river stages during minimum discharges were reduced as well.

The decrease in river stages at maximum discharge was so great that both the frequency and depth of inundation of riparian lands was reduced on channelized sites. For example, mean monthly discharges at Wappapello Dam during March 1964 (pre-channelization) and December 1973 (post-channelization) were 166 and 199 cubic meters per second respectively. At St. Francis, Arkansas which is downstream from the channelized site, river flow was 229 cubic meters per second before channelization and 231 cubic meters per second after channelization. River stages at Dekyns Store, Missouri (channelized site) exceeded 6.0 meters above gauge zero for 21 consecutive days during March 1964 (pre-channelization), but did not exceed 4.2 meters during December 1973 (post-channelization). Riparian forests that were subject to inundation by a river stage of 6.0 meters were flooded for 21 days prior to channelization but were never inundated during a post-channelization period when the St. Francis River was moving nearly equal volumes of water past Dekyns Store. Disregarding differing discharge rates, daily river stages at Dekyns Store indicate that the riparian forest would have been inundated 7 times for a total of 84 days during

Table 4. St. Francis River stages at four sites before and after channelization. Comparisons are made between similar discharges from Wappapello Reservoir for maximum, minimum, and mean flows that occurred before (1966) or after (1971) channelization

	River stages							
	Maximum discharge			Minimum discharge		Mean discharge		
	Oct. 65 (101 m^3/s)	Apr. 76 (103 m^3/s)		Jun. 64 (1 m^3/s)	Jun. 72 (1 m^3/s)	Dec. 64 (19 m^3/s)	Jan. 72 (20 m^3/s)	
Unchannelized								
Wappapello, MO	3.7	3.4	(0.3)[a]	-1.7	-1.7 (0.0)	5.7	6.0	(0.3)
Fisk, MO	6.6	4.7	(1.9)	0.7	0.6 (0.1)	2.1	2.3	(0.2)
Channelized								
Dekyns Store, MO	6.2	2.2	(4.0)	0.6	0.0 (0.6)	2.2	0.4	(1.8)
Leveed site								
St. Francis, AK	5.6	4.9	(0.7)	0.8	0.6 (0.2)	2.4	2.2	(0.2)

[a]Difference between river stages before and after channelization.

the pre-channelization years 1964, 65, and 66, but would not have been inundated during the post-channelization years 1973, 74, 75, and 76.

SOILS

Physical Properties and Texture

Surface soils within Mingo Swamp were classified as clay loam on all control sites regardless of elevation (Appendix A-1). On the periodically impounded area, high sites were silt loam and low sites were clay loam. The drained area had clay on low sites and loam on high sites.

Recent soil surveys indicate that the unchannelized and the recently channelized study areas along the St. Francis River have Calhoun series soils but Falaya-Fountain soils occur on the previously channelized areas and Sharkey soils occur on the leveed areas.

Soils contained from 16 to 26 percent sand, from 48 to 58 percent silt and from 23 to 29 percent clay on higher elevations on unchannelized and channelized areas (Appendix A-1). Low sites contained from 15 to 42 percent sand, from 30 to 50 percent silt and from 26 to 37 percent clay. On the leveed area surface soils contained 69 percent sand, 18 percent silt and 12 percent clay on both high and low sites. The sandy surface soils on both the leveed area and low sites on the previously channelized area probably represent overburden deposited by floodwaters. Lower elevations on the previously channelized area contained more sand (42 percent) and less silt (30 percent) than soils in lower elevations on unchannelized or recently channelized areas.

Surface soils on and adjacent to spoil banks on channelized areas contained more sand and less clay than forest soils on channelized or unchannelized areas (Appendix A-1). Soil samples taken between the spoil bank and the remaining forested sites contained more sand and less clay than

undisturbed forest soils. Soils between the spoil bank and the river channel contained less sand and more silt and clay than soils on the spoil bank.

Fertility

Soils in Mingo Swamp were generally low in calcium, magnesium and potassium (Appendix A-2). Calcium, magnesium and potassium concentrations on control sites were greater on the higher elevations than for soils on lower elevations, but on periodically impounded and drained areas, calcium, magnesium and potassium were higher on low sites than for soils on high sites. Soils on high and low sites had pH's ranging from 4.3 to 5.0 throughout Mingo Swamp (Appendix A-2).

Dredging influenced macronutrient levels in surface soils but had little affect on soil pH. All surface soils on the St. Francis River areas were acid with pH values ranging from 4.7 to 5.5 on forested sites and from 4.9 to 5.5 on sites covered by dredge materials (Appendix A-2). Surface soil samples from forests on unchannelized, channelized and leveed sections of the St. Francis River contained from 1,904 to 3,024 kg/ha of calcium, from 627 to 941 kg/ha of magnesium and from 164 to 233 kg/ha of potassium (Appendix A-2). Surface soil samples on and adjacent to spoil banks contained from 1,120 to 2,128 kg/ha of calcium, from 437 to 762 kg/ha of magnesium and from 81 to 213 kg/ha of potassium. Undoubtedly, the generally lower macronutrient levels in soils adjacent to spoil banks are related to the erosion of nutrient poor dredge material from spoil banks onto adjacent soils. Farmers with land adjacent to spoils are cognizant of reduced fertility (Jolly, personal communication). Rowcrops do poorly after soils erode from the spoils and spread into adjacent farmland.

Surface Soil Moisture

The mean surface soil moisture (percent of field capacity at 8 cm during the growing season) was 77 percent on control, 75 percent on periodically impounded and 54 percent on drained areas and ranged from 0 to 100 percent on all areas (Table 5). Monthly maximum readings were high for all areas, but control and periodically impounded areas had a much higher percentage of readings above 90 percent of field capacity than did the drained area. Monthly minimum readings for all areas were relatively high from April to early July and much lower from mid-July to late October. However, the drained area had more readings below the wilting point (10 percent of field capacity) than did the control and periodically impounded areas (Table 5).

Surface water levels influenced surface soil moisture readings. Soils that appeared to be saturated, but were not inundated, consistently had 90 to 95 percent of field capacity. Field capacity of 100 percent occurred only when soils were inundated by surface water. Annual mean water depths were 16 cm on control, 12 cm on periodically impounded and less than 1 cm on drained areas (Table 2).

GENERAL HABITAT CHANGES

Changes in forest area and the length of active channel are provided in relation to both the linear distance in the St. Francis Valley and for the total length of the natural channel before channelization. The relationship between the linear distance of the valley and forest area provide a better assessment of total habitat losses in an area than do relationships between the natural channel length and forest area. Stream channelization in a 12 km segment of stream valley reduced active channel length from 30 to 13 km (57 percent) and reduced the stream sinuosity index from 2.5 to 1.08 between

Table 5. Maximum, minimum and mean surface soil moisture (percent of field capacity) by month for the 1976 growing season on control (C), periodically impounded (I) and drained (D) areas in Mingo Swamp

	Soil moisture											
	Maximum			Minimum			Mean			No. of readings		
	C	I	D	C	I	D	C	I	D	C	I	D
Apr.	99	100	99	82	87	84	95	96	87	18	20	20
	(88)[a]	(95)	(5)	(0)	(0)	(0)						
May	97	100	97	68	92	87	91	96	89	9	10	10
	(88)	(100)	(30)	(0)	(0)	(0)						
Jun.	98	100	100	88	88	65	96	97	88	35	40	38
	(97)	(97)	(50)	(0)	(0)	(0)						
Jul.	100	100	100	0	23	1	75	90	63	33	40	37
	(66)	(85)	(43)	(12)	(0)	(8)						
Aug.	98	100	99	0	0	0	70	69	41	39	50	48
	(51)	(44)	(6)	(28)	(20)	(52)						
Sep.	97	99	92	9	0	0	68	30	27	32	40	40
	(28)	(7)	(2)	(3)	(80)	(80)						

continued

Table 5. (Concluded)

	Soil moisture											
	Maximum			Minimum			Mean			No. of readings		
	C	I	D	C	I	D	C	I	D	C	I	D
Oct.	95	99	84	0	0	0	55	72	23	24	30	30
	(16)	(63)	(0)	(20)	(33)	(76)						
Season	100	100	100	0	0	0	77	75	54	190	230	223

[a]Percent of monthly maximum readings equal to or greater than 90 percent of field capacity and percent of monthly minimum readings equal to or less than 10 percent of field capacity.

1966 and 1973 (Table 6). During the same period no measurable stream length changes occurred in 23 km of unchannelized river valley or in 55 km of leveed river valley. Active channel length was 47 km on the unchannelized river and the sinuosity index was 2.04. On the leveed portion there were 70 km of active channel but the sinuosity index was only 1.27.

Numerous backwater cutoffs are formed when a new channel is dredged across a meander of a sinuous stream. Channelization on the 12 km segment of St. Francis River Valley created 20 km of backwater cutoffs or 0.43 km of man-made channel and 0.67 km of backwater areas for each km or riparian habitat that was lost when the new channel was dredged. Backwater cutoffs like those formed by the St. Francis project are closed at the upstream juncture with the new channel. Hence, the flow of water through the meander is no longer possible unless river stages are unusually high.

During the short duration of this study, accumulation of silt at the downstream openings of cutoffs was obvious. During low water, openings into the cutoffs were so shallow that passage by boat was impossible and walking was difficult because the silt was several feet deep. Within a few years, water flow into and out of these backwaters will be nil except at flood stage unless some modifications are made to direct stream flow through these meanders. Changes on other southeastern Missouri sites suggest that the forests along these meanders will gradually disappear and that eventually some of the cutoffs will be filled and farmed.

The riparian forests along the St. Francis River were reduced in two ways as a result of channelization. A 250 m wide strip of land was cleared along the route of the proposed channel to facilitate dredging operations. These preparations for channelization plus the subsequent clearing by landowners reduced riparian forests in the 12 km of channelized stream valley from 915 ha

Table 6. Changes in channel length, sinuosity and riparian forest area along unchannelized, channelized, and leveed sections of the St. Francis River Valley between 1966 and 1973

	23 km Unchannelized[a]		12 km Channelized[a]		55 km Leveed[a]	
	1966	1973	1966	1973	1966	1973
Stream characteristics						
Active channel (km)	47	47	30	13 (57)[b]	70	70
Backwater cutoffs (km)	0	0	0	20	0	0
Sinuosity index	2.04	2.04	2.50	1.08	1.27	1.27
Forest characteristics						
Total forest area (ha)	634	595 (6)[b]	915	199 (78)	3,417	3,386 (<1)
Forest ha/km active channel	13.5	12.7	30.5	15.3	48.8	48.4
Forest ha/km stream valley	27.6	25.9	76.3	16.6	62.1	61.6

[a]Length of stream valley.
[b]Percent loss.

to 199 ha or by 78 percent (Table 6). Forested area along channelized sections of the St. Francis River declined by 50 percent or from 30.5 ha to 15.3 ha per km of channel. On the basis of the length of the stream valley before channelization, forested area declined by 78 percent or from 76.3 ha to 16.6 ha per km of stream valley. In contrast, the riparian forest decreased by 6 percent from 634 to 595 ha in the 23 km of unchannelized stream valley and from 3,417 to 3,386 ha or less than 1 percent in the 55 km of leveed stream valley. In the unchannelized section, forest area declined by 27 percent or from 13.5 to 12.7 ha per km of channel, but forest area per km of stream valley declined by only 7 percent or from 27.6 ha to 25.9 ha/km.

VEGETATION

Composition and Diversity

Within Mingo Swamp, plant species diversity was the same on the control and periodically impounded areas (Table 7, Appendix B-1, B-2, B-3, B-4, B-5, B-6); each had 43 species. Diversity was higher on the drained area where 49 species of plants occurred. The more diverse flora on drained sites resulted from the occurrence of woody species. Trees accounted for 26 species on the drained area, but there were only 21 tree species on the control and 20 species on the periodically impounded area. The longer periods of inundation to depths of more than 5 cm on control and impounded sites undoubtedly are important in restricting establishment of woody species that are less resistant to flooding such as pawpaw (*Assimina triloba*), hackberry (*Celtis occidentalis*), red mulberry (*Morus rubra*), and winged elm (*Ulmus alata*).

Shrub diversity was greater on the drained (10 species) and impounded areas (11 species) than on the control (8 species) (Table 7). Diversity of herbs was similar on all three areas where 14 species occurred on the control, 12 on the periodically impounded, and 13 on the drained area.

Table 7. Species diversity of trees, shrubs, and herbs along the St. Francis River and within Mingo Swamp

	Trees	Shrubs	Herbs	Total
Mingo Swamp				
Control	21	8	14	43
Periodically impounded	20	11	12	43
Drained	26	10	13	49
St. Francis River				
Unchannelized				
Early successional forest	31	9	19	59
Late successional forest	30	10	12	52
Recently channelized	27	11	11	53
Previously channelized	27	8	8	43
Leveed	27	6	12	45

Along the St. Francis River plant diversity was greatest in early successional forest and least on previously channelized sites (Table 7, Appendix B-1, B-3, B-5, B-7, B-8, B-9, B-10). The diversity of trees and herbs accounted for the greater diversity on early successional sites. Fewer shrub species occurred on the leveed area and fewer herbs occurred on the previously channelized area than on any other St. Francis River location.

Trees and Saplings

In Mingo Swamp six species of trees, pin oak, overcup oak, shumard oak (Q. shumardii), red maple (Acer rubrum), cherrybark oak (Q. falcata), and shagbark hickory (Carya ovata) accounted for a least 10 percent of all trees encountered on at least one of the three study sites (Table 8). These species were ranked on the basis of relative density, relative dominance, relative frequency, and importance value (Krebs 1972:396).

Pin oak, overcup oak, shumard oak, and red maple had similar rankings in both relative dominance and importance values on the control and impounded areas. Pin oaks had an importance value of 116 on the impounded area and 102 on the control. Overcup oak was second in importance value on both impounded (72) and control (55). Shumard oak ranked third in importance value on both impounded (18) and control (34), and red maple ranked fourth on impounded (4) and control (33).

On the drained area, the relative importance rating was similar for pin oak (55) and southern red oak (54). Shumard oak (36) ranked third and shagbark hickory (29) ranked fourth. Overcup oak (9) ranked fifth and was ranked only slightly higher than red maple (7).

Twelve species of trees, box elder (Acer negundo), American hornbeam (Carpinus caroliniana), sweetgum (Liquidambar styraciflua), shellbark hickory

Table 8. Relative density, relative dominance, relative frequency and importance values for tree species accounting for at least 10 percent of all trees encountered on at least one of the Mingo Swamp study areas (control, periodically impounded or drained) and along the St. Francis River

	Characteristic				
	Relative density	Relative dominance	Relative frequency	Importance value	I.V. rank
Mingo					
Control					
Quercus palustris	26	52	24	102	1
Quercus shumardii	15	5	14	34	3
Quercus falcata	--	--	--	--	--
Quercus lyrata	18	17	20	55	2
Acer rubrum	15	7	11	33	4
Carya ovata	--	--	--	--	--
Periodically impounded					
Quercus palustris	37	49	30	116	1
Quercus shumardii	7	3	8	18	3
Quercus falcata	--	--	--	--	--
Quercus lyrata	22	30	20	72	2

continued

Table 8. (Continued)

	Characteristic				
	Relative density	Relative dominance	Relative frequency	Importance value	I.V. rank
Acer rubrum	2	< 1	2	4	4
Carya ovata	--	--	--	--	--
Drained					
Quercus palustris	16	27	12	55	1
Quercus shumardii	14	8	14	36	3
Quercus falcata	14	30	10	54	2
Quercus lyrata	4	1	4	9	5
Acer rubrum	3	1	3	7	6
Carya ovata	12	5	12	29	4
St. Francis					
Unchannelized early successional					
Acer negundo	17	9	17	43	1
Carpinus caroliniana	17	14	12	43	1
Carya laciniosa	7	12	8	27	2

continued

Table 8. (Continued)

	Characteristic				
	Relative density	Relative dominance	Relative frequency	Importance value	I.V. rank
Fraxinus pennsylvanica	1	1	1	3	4
Betula nigra	3	5	2	10	3
Acer saccharinum	1	1	1	3	4
Unchannelized late successional					
Carya laciniosa	10	8	8	26	2
Carya ovata	10	4	10	24	3
Fraxinus pennsylvanica	3	2	5	10	4
Acer rubrum	1	1	1	3	5
Liquidambar styraciflua	35	34	25	94	1
Recently channelized					
Acer negundo	13	17	12	32	2
Carpinus caroliniana	1	< 1	1	3	6
Carya laciniosa	1	< 1	1	3	6
Fraxinus pennsylvanica	13	8	14	35	1

continued

Table 8. (Continued)

	Characteristic				
	Relative density	Relative dominance	Relative frequency	Importance value	I.V. rank
Betula nigra	10	12	9	32	2
Acer saccharinum	6	2	3	11	4
Acer rubrum	3	1	4	8	5
Salix nigra	6	10	4	20	3
Liquidambar styraciflua	1	1	1	3	6
Quercus lyrata	12	9	11	32	2
Previously channelized					
Acer negundo	1	< 1	1	3	8
Carpinus caroliniana	16	10	11	37	2
Carya laciniosa	3	9	5	17	4
Fraxinus pennsylvanica	8	9	10	27	3
Betula nigra	3	8	5	16	5
Acer saccharinum	27	12	16	55	1
Acer rubrum	1	3	1	5	7
Quercus lyrata	3	5	3	11	6

continued

Table 8. (Concluded)

	Characteristic				
	Relative density	Relative dominance	Relative frequency	Importance value	I.V. rank
Leveed					
Acer negundo	6	1	4	11	5
Fraxinus pennsylvanica	13	10	12	35	3
Betula nigra	16	28	12	56	1
Acer rubrum	11	30	12	53	2
Fraxinus profunda	10	4	10	24	4
Salix nigra	10	5	9	24	4
Quercus lyrata	2	< 1	3	5	6

(Carya laciniosa), shagbark hickory, green ash (Fraxinus pennsylvanica), river birch (Betula nigra), overcup oak, silver maple (Acer saccharinum), red maple, pumpkin ash (Fraxinus profunda) and black willow (Salix nigra), accounted for at least 10 percent of all trees encountered on at least one of the five St. Francis study areas (Table 8). Box elder and American hornbeam were the most common trees in forests on the early successional sites on the unchannelized area. In the mature forests along the unchannelized area, sweetgum, shellbark hickory and shagbark hickory predominated. Green ash with an importance value of 35 and box elder, river birch and overcup oak all with importance values of 32 were common trees on the recently channelized area. On the previously channelized area, the most common trees were American hornbeam and silver maple. On the leveed area, river birch, red maple, green ash, pumpkin ash, and black willow were the most common trees.

Within Mingo Swamp the three most abundant saplings on the control were red maple, sweetgum, and slippery elm (Ulmus rubra) (Table 9). On the impounded area, four saplings were most common: persimmon (Diospyros virginiana), slippery elm, buttonbush (Cephalanthus occidentalis), and stiff dogwood (Cornus foemina). On the drained area, the most abundant saplings were red maple, American elm, slippery elm, and shagbark hickory.

Spicebush (Lindera benzoin), deciduous holly (Ilex decidua) and American hornbeam were most abundant on the early successional sites on the unchannelized area (Table 10). On late successional sites on the unchannelized area, buttonbush, slippery elm, green ash, stiff dogwood, American hornbeam and deciduous holly were abundant. Common saplings on the recently channelized area were buttonbush, winged elm, persimmon, slippery elm, and stiff dogwood. Deciduous holly, green ash, silver maple, and American hornbeam were most

Table 9. Density and mean height of saplings on control, periodically impounded, or drained areas in Mingo Swamp[a]

Species	Density (saplings/ha)			Mean height (m)		
	Control	Periodically impounded	Drained	Control	Periodically impounded	Drained
Acer rubrum	293	191	492	5	2[b]	2[b]
Diospyros virginiana	---	447	115	---	2	2
Ulmus americana	11	42	521	5	3	2
Ulmus rubra	164	255[c]	463[c]	3	5[b]	2[b]
Liquidambar styraciflua	188	21	115	5	2	6
Carya ovata	---	---	405	---	---	4
Cephalanthus occidentalis	---	234	---	---	2	---
Cornus stricta	58	234	144	2	2	2
All saplings	1,175	2,129[c]	2,899[c]	5	2[b]	2[b]

[a]Only those species that accounted for 10 percent or more of the sample are included.
[b]Mean heights different ($P \leq 0.05$) from mean height on control area.
[c]Mean sapling dfp greater ($\overline{P} \leq 0.05$) than mean sapling dfp for the control area.

Table 10. Density and mean height of saplings along the St. Francis River

	Density (saplings/ha)	Mean height (m)
Unchannelized early successional forest		
Acer saccharinum	30	7
Carpinus caroliniana	154	5
Celtis occidentalis	30	2
Diospyros virginiana	30	5
Fraxinus pennsylvanica	61	2
Ilex decidua	340	2
Lindera benzoin	929	2
Ulmus alata	30	4
Ulmus rubra	61	4
All saplings	2,478	3
Unchannelized late successional forest		
Acer rubrum	77	2
Acer saccharinum	25	>1
Carpinus caroliniana	128	2
Celtis occidentalis	410	2
Cornus stricta	154	2
Diospyros virginiana	77	5
Fraxinus pennsylvanica	179	1
Ilex decidua	128	2

continued

Table 10. (Continued)

	Density (saplings/ha)	Mean height (m)
Lindera benzoin	51	> 1
Ulmus rubra	205	3
All saplings	2,054	2
Recently channelized		
Acer rubrum	148	2
Acer saccharinum	37	> 1
Celtis occidentalis	111	> 1
Cephalanthus occidentalis	407	2
Cornus stricta	259	2
Diospyros virginiana	333	2
Ilex decidua	148	2
Lindera benzoin	37	2
Ulmus alata	333	2
Ulmus rubra	259	3
All saplings	2,961	2
Previously channelized		
Acer rubrum	10	7
Acer saccharinum	52	8
Carpinus caroliniana	41	3
Celtis occidentalis	10	> 1
Cephalanthus occidentalis	5	> 1
Fraxinus pennsylvanica	78	3

continued

Table 10. (Concluded)

	Density (saplings/ha)	Mean height (m)
Ilex decidua	114	4
Ulmus rubra	10	3
All saplings	416	4
Leveed		
Acer rubrum	124	4
Celtis occidentalis	11	1
Cephalanthus occidentalis	22	1
Cornus stricta	146	2
Diospyros virginiana	33	4
Fraxinus pennsylvanica	45	3
Fraxinus profunda	124	3
Ilex decidua	90	2
All saplings	902	3

common on the previously channelized area. On the leveed areas, stiff dogwood, red maple, pumpkin ash, and deciduous holly were most common.

Tree densities were not different ($P > 0.05$) between the control and impounded areas (693 vs. 550 stems/ha) or between the impounded and drained (550 vs. 441 stems/ha) (Table 11). Density of trees was different ($P \leq 0.05$) between the drained and control areas (441 vs. 643 stems/ha). Basal area/ha and mean heights of trees on the control, periodically impounded, and drained areas were not different from one another ($P \geq 0.05$) (Table 12). Sapling density and height on the control (1,175 stems/ha; >5 m) were different ($P < 0.05$) from sapling density and height on both the drained (2,129 stems/ha; 2 m) and impounded (2,899 stems/ha; 2 m) areas (Table 11).

On unchannelized areas along the St. Francis River early successional sites had 450 trees/ha, but late successional sites had only 299 trees/ha (Table 11). Forests on recently channelized areas had 325 trees/ha as compared to 398 trees/ha on previously channelized and 504 trees/ha on leveed areas.

Heights of trees on the early successional sites were less ($P \leq 0.05$) than heights of trees on all river sites, and heights of trees on late successional sites were greater ($P \leq 0.05$) than heights on all other river sites (Table 11). Tree heights were similar on channelized and leveed sites ($P > 0.05$). Basal areas/ha were greater ($P \leq 0.05$) on leveed and late successional sites than on other river locations (Table 11).

Forest canopy. The percent of the forest canopy that was open was similar ($P > 0.05$) on all Mingo Swamp areas; control (16.2 percent open), periodically impounded (15.2 percent open), and drained (16.6 percent open) (Table 12).

Along the St. Francis River no canopy was present on recently channelized spoil banks, but some cover remained on spoil banks (99 percent open) that were

Table 11. Density and mean height of trees and saplings and mean basal area for trees in Mingo Swamp and along the St. Francis River

	Density (stems/ha)		Mean basal area (m^2/ha)	Mean height (m)	
	Trees	Saplings	Trees	Trees	Saplings
Mingo Swamp					
Control	693	1,175	37.1	20	5
Periodically impounded	550	2,129	35.8	20	2
Drained	441	2,899	34.4	19	2
St. Francis River					
Unchannelized					
Early successional	450	2,478	18.5	11	3
Late successional	299	2,054	33.5	23	2
Channelized					
Recently	325	2,961	21.8	15	2
Previously	398	416	27.8	17	4
Leveed	504	902	37.2	17	3

Table 12. Percent open canopy in Mingo Swamp and along the St. Francis River

	Minimum	Maximum	Mean
Mingo Swamp			
Control	12.0	21.5	16.2
Periodically impounded	10.3	18.9	15.2
Drained	12.0	19.8	16.6
St. Francis River			
Unchannelized	8.6	25.0	14.5
Channelized			
Recently	6.0	19.8	13.0
Top of spoil			
Spoil from riverine source	100.0	100.0	100.0
Spoil from non-riverine source	95.7	100.0	98.8
Spoil to woods	76.7	96.6	88.1
Previously	9.5	21.6	15.2
Top of spoil			
Spoil from non-riverine source	54.3	99.1	87.0
Spoil to woods	9.5	25.9	17.0
Leveed	6.0	23.3	14.7

formed by dredging across meanders (Table 12). Between the spoil bank and the remaining forested tracts, the percent of canopy that was open was 88 percent. The percent of canopy that was open was different ($P < 0.05$) on recently and previously channelized areas both on the top of spoil banks and between the spoil and the woods. Riparian forests that remained intact after the channelization retained their canopy characteristics. No differences ($P > 0.05$) occurred between the percent of canopy that was open on forest sites on recently and on previously channelized areas or between forests along unchannelized and leveed areas (Table 12).

Basal area growth rates. Average annual basal growths during 30 years (1947-76) (mm^2) for trees in Mingo Swamp were greatest for red maple (89.0) and less for shumard oak (62.5), pin oak (57.6), sweetgum (32.9), overcup oak (25.8), and willow oak (Quercus phellos) (21.7) (Table 13). Basal area growth of open grown red maple, sweetgum and shumard oak on the impounded area was slower than growth of overcup oak, pin oak and willow oak (Table 13). On the drained area, basal area growth of open grown red maple, pin oak, and shumard oak was slower than growth of sweetgum, overcup oak and willow oak. Within the same area, suppressed trees consistently had lower basal growth rates than open grown trees. Growth of suppressed trees on control and periodically impounded and drained areas was slower for sweetgum and pin oak than for red maple, overcup oak, shumard oak and willow oak.

Forest Floor Vegetation

Differences in vegetation are reported for species that were sufficiently abundant to appear in at least 10 percent of the quadrats on a site. Red maple and elm seedlings predominated on the control; southern red oak, red maple, elm, ash and buttonbush on the periodically impounded area; and elm, ash, and red maple on the drained area (Appendix B-2). Along unchannelized sections of

Table 13. Mean annual basal area growth of selected hardwoods in open and suppressed situations for the period 1947-76. Data for impounded and drained areas are expressed as a percent of control for open grown trees. Parenthetic data are for suppressed trees

	Annual basal area growth (mm^2)						
	Control		Periodically impounded		Drained		Mean
Red maple	100.0	(44.9)	94.5	(86.4)	27.4	(51.5)	89.0
Shumard oak	100.0	(37.8)	78.2	(49.0)	51.1	(42.5)	62.5
Pin oak	100.0	(52.0)	109.5	(45.5)	60.0	(49.5)	57.6
Sweetgum	100.0	(86.9)	57.5	(59.4)	101.1	(62.9)	32.9
Overcup oak	100.0	(67.6)	220.8	(128.5)	133.6	(68.8)	25.8
Willow oak	100.0	(76.8)	106.8	(227.0)	482.6	(238.1)	21.7

the St. Francis River in early successional stages, seedlings of boxelder, red maple, black willow, water tupelo, ash, deciduous holly and spicebush were most common but on the late successional unchannelized sections, boxelder and ash were most common (Appendix B-7). Both recently and previously channelized sites were heavily vegetated with maple and ash seedlings. Leveed areas had maple and ash but oaks and elms were abundant as well.

Fewer species of seedlings occurred in Mingo Swamp on the control (7) than on the periodically impounded (11) or drained (10) areas in May (Table 14). Not only did fewer species occur on the control, but seedlings were present in fewer of the 50 quadrats on the control (14 quadrats) than on either the periodically impounded (29 quadrats) and drained sites (33 quadrats). Both numbers and diversity of seedlings decreased in Mingo Swamp by July. Only 6 species of seedlings occurred on the control compared to 5 species on the periodically impounded and 9 species on the drained area (Table 14).

Early successional sites had 12 species of seedlings in May, but late successional sites only had 8 species (Table 14). Recently channelized areas had 13 species of seedlings, whereas 7 species occurred on previously channelized areas and 6 species occurred on leveed areas. More species of herbs occurred on early successional sites along the unchannelized river than on any other St. Francis site.

More quadrats had shrubs on the drained area (37) than on the periodically impounded (14) and control areas (20) (Table 14, Appendix B-4). The most obvious difference in shrub distribution on St. Francis River areas was that only 2 shrub species occurred on the leveed sites as compared to 10 species on the recently channelized and 7 species on the previously channelized area (Appendix B-8).

Table 14. Frequency of occurrence for seedlings, shrubs, and herbs in Mingo Swamp and along the St. Francis River

	Seedlings		Shrubs		Herbs		All Stems	
	May	July	May	July	May	July	May	July
Mingo Swamp Control (50)[a]	7[b](14)[c]	6 (5)	5 (14)	5 (14)	11 (12)	11 (13)	28	21
Mingo Swamp Periodically impounded (50)	11 (29)	5 (13)	8 (28)	8 (20)	10 (33)	6 (20)	46	34
Mingo Swamp Drained (50)	10 (33)	9 (25)	6 (37)	10 (37)	11 (38)	11 (31)	49	47
St. Francis Unchannelized early successional (50)	12 (48)	11 (39)	8 (31)	7 (31)	17 (45)	12 (31)	50	44
St. Francis Unchannelized late successional (30)	8 (17)	8 (16)	9 (30)	10 (30)	12 (25)	10 (24)	30	30
St. Francis Recently channelized (50)	13 (35)	13 (31)	10 (29)	9 (26)	9 (36)	10 (34)	50	36
St. Francis Previously channelized (30)	7 (23)	3 (19)	7 (18)	6 (17)	6 (10)	5 (8)	30	24
St. Francis Leveed (30)	6 (30)	8 (21)	2 (3)	5 (9)	6 (22)	6 (14)	30	27

[a]Number of quadrats sampled on each site

[b]Number of species encountered

[c]Number of quadrats in which species occurred

Herb diversity was uniform between the three Mingo Swamp areas. Eleven species of herbs occurred on 12 control quadrats, 10 species on 33 quadrats on the periodically impounded and 11 species on 38 quadrats on the drained area (Table 14). Species that occurred on at least 10 percent of the quadrats were: control, violet (Viola sp.); impounded area, cursed crowfoot (Ranunculus sceleratus), sedge (Carex sp.) and lizard's tail (Saururus cernuus); and drained area, sedge, touch-me-not (Impatiens capensis), white grass (Leersia sp.), aster (Aster sp.) and lizard's tail (Appendix B-6).

Between May and July the composition of forest floor vegetation along the St. Francis River had few changes. The most obvious differences occurred on the leveed area where seedling species increased from 6 to 8 and on the previously channelized area where the total number of species decreased from 7 to 3 (Table 14).

Stem density (stems/m^2) of seedlings, shrubs, and herbs in Mingo Swamp were higher where surface water was not present during the growing season. Stem densities on plots with seedlings in May were 3.57 for control, 5.58 for periodically impounded, and 38.78 for drained areas. In July the mean seedling densities were 4.40 stems/m^2 on control, 3.07 on periodically impounded and 6.96 on the drained areas. Densities of herbs were high on both periodically impounded (32.12 stems/m^2) and on the drained areas (38.21 stems/m^2), but low on the control (11.16 stems/m^2) (Table 15, Appendix B-6). In both May and July samples, shrub densities on the drained area were greater ($P < 0.05$) than shrub densities on the control.

Between May and July ground cover or the sum of the densities for seedlings, shrubs, and herbs decreased in Mingo Swamp. The combined densities were greater ($P < 0.05$) on both periodically impounded and drained areas than

Table 15. Stem density (m^2) for seedlings, shrubs, and herbs in Mingo Swamp and along the St. Francis River

	Stems/m^2							
	Seedlings		Shrubs		Herbs		All stems	
	May	July	May	July	May	July	May	July
Mingo Swamp								
Control (50)[a]	3.57 (8.72)[b]	4.4 (6.8)	9 (239.23)	4.14 (10.74)	11.16 (155.24)	9.53 (59.43)	11.07 (247.84)	9.71 (57.3)
Periodically impounded (50)	5.58 (17.82)	3.07 (3.74)	8.57 (32.55)	4.5 (11.31)	32.12 (1,388.73)	16.8 (229.22)	31.78 (1,234.52)	13.7 (217.97)
Drained (50)	38.78[d] (2,985.98)	6.96 (37.04)	36.1[d] (1,252.43)	30.27[d] (928.48)	38.21 (2,725.14)	18.38 (427.31)	83.02 (5,831.18)	39.65 (844.05)
F-values[c]	11.73	3.06	16.46	23.27	2.63	1.08	33.55	28.52
St. Francis River								
Unchannelized early successional (50)	16 (3.78)	8 (1.3)	7 (1.1)	7 (2.53)	33 (73.08)	20 (17.93)	52 (69.08)	27 (13.92)
Unchannelized late successional (30)	5 (0.93)	3 (0.16)	29 (13.26)	18 (3.48)	67 (215.6)	39 (50.21)	89 (158.81)	51 (32.95)
Recently channelized (50)	31[ef] (18.7)	17[ef] (5.46)	11[f] (7.65)	8[f] (1.35)	66[e] (1,521.17)	31[e] (18.79)	107[e] (130.13)	51[e] (19.90)

(continued)

Table 15. Concluded

	Stems/m^2							
	Seedlings		Shrubs		Herbs		All stems	
	May	July	May	July	May	July	May	July
Previously channelized (30)	72[ef] (412.3)	11[ef] (3.37)	27[e] (67.91)	18[e] (22.31)	16[ef] (26.26)	11[f] (19.99)	83 (298.38)	26[f] (19.33)
Leveed (30)	97[ef] (269.08)	14[ef] (9.9)	4[f] (1.33)	2[f] (0.22)	69 (427.61)	7[ef] (4.28)	149[ef] (745.48)	16[ef] (7)
F-values	23.86	8.33	10.92	10	3.1	6.41	8.72	15.23

[a] Number of quadrats sampled on each site.
[b] Variance.
[c] Analysis of variance based on data adjusted with variance stabilizing transformation, $\sqrt{x+1}$.
[d] Mean stem count significantly different ($P \leq 0.05$) from mean stem count on control for Mingo Swamp data.
[e] Mean stem count significantly different ($P \leq 0.05$) from mean stem count on unchannelized early successional sites for St. Francis River data.
[f] Mean stem count significantly different ($P \leq 0.05$) from mean stem count on unchannelized late successional sites for St. Francis River data.

on the control area in May. By July the density on the drained area was greater ($P < 0.05$) than on the control area but densities between the control and periodically impounded areas were not different ($P > 0.05$).

Density of seedlings was greater ($P < 0.05$) on recently channelized, previously channelized and leveed areas than on early successional and late successional unchannelized areas in both May and July (Table 15). The May stem counts for shrubs on recently channelized and leveed areas were lower ($P < 0.05$) than stem counts for the late successional sites on unchannelized areas, but were not different ($P > 0.05$) from the densities on early successional sites on unchannelized areas (Table 15). Density of shrubs on the previously channelized area was higher ($P < 0.05$) than the density on the early successional area but was not different ($P > 0.05$) from densities on the late successional area. Shrub density on recently channelized and leveed areas were lower ($P < 0.05$) than densities on the late successional unchannelized area but not different ($P > 0.05$) from shrub densities on the early successional unchannelized area (Table 15).

Recently channelized areas had greater ($P < 0.05$) densities of herbs in May than did early successional unchannelized areas, but densities of herbs on the late successional unchannelized area were not different ($P > 0.05$) (Table 15, Appendix B-9). Herb density on the previously channelized area was greater ($P < 0.05$) than the density on the late successional unchannelized area but not different ($P > 0.05$) than density on the early successional unchannelized area. Density of herbs on the leveed area was not different ($P > 0.05$) from densities on either unchannelized area.

Herb densities declined on all St. Francis areas by July. Densities of herbs on the recently channelized area was higher ($P < 0.05$) than the density of herbs on the early successional unchannelized area but not different ($P > 0.05$)

from the herb density on the late successional unchannelized area (Table 15). Densities of herbs on previously channelized and leveed areas were lower ($P < 0.05$) than the density of herbs on the late successional unchannelized area, but not different ($P > 0.05$) from the density of herbs on the early successional unchannelized area.

Vegetation on and Adjacent to Spoil Banks

The percent frequency of occurrence (30.2 percent) for all types of vegetation between the channel and the spoil with non-riverine soils was greater ($P < 0.05$) on the recently channelized area than on previously channelized area in May. Percent frequency of occurrence for all vegetation classes in May was not different ($P > 0.05$) between the previously and recently channelized areas where spoil was of riverine origin (Table 16, Appendix B-10). On the recently channelized area, forbs were the most frequently encountered plant group on both spoil types, but trees were most common on the previously channelized area where willows, silver maples and cottonwoods formed a stand of dense saplings. Grasses, sedges, and forbs were more abundant in July on the recently channelized area and percent frequency of occurrence for all vegetation types increased to 78.8 percent where spoil material was riverine and to 56.2 percent where spoil material was non-riverine (Table 16).

Frequency of occurrence for all types of vegetation on spoils banks of non-riverine origin was greater ($P < 0.05$) on previously channelized than on the recently channelized sites (Table 16). Grasses, sedges, shrubs, and forbs were most common on the previously channelized site, but only forbs occurred regularly on the recently channelized area. Between May and July the relative abundance of grasses and sedges increased on the previously channelized area, but the relative abundance of forbs and shrubs decreased on the recently channelized area. The percent frequency of occurrence for vegetation on

Table 16. Percent frequency of occurrence for vegetation on St. Francis River spoils

Transect location	Recently channelized				Previously channelized	
	Riverine source		Non-riverine source		Non-riverine source	
	May	July	May	July	May	July
Between channel and spoil						
Grasses and sedges	5.8[a]	45 [a]	3 [b]	26.2[a]	0 [ab]	---
Forbs	17.7[a]	32.5	20.7 [b]	28.2	0.5[ab]	---
Shrubs	1 [a]	1.3	5.7[ab]	1.5	0.8 [b]	---
Trees	0.5[a]	0 [a]	0.8 [b]	0.3[a]	19.8[ab]	---
Total	25	78.8[a]	30.2 [b]	56.2[a]	21.2 [b]	---
Top of spoil						
Grasses and sedges	7.2[a]	25.5[a]	0.3[a]	5.8[a]	32.5[a]	65 [a]
Forbs	11 [a]	43.2[a]	2.7[a]	6.2[a]	16.5[a]	10.8[a]
Shrubs	0.2[a]	0.7[a]	0.2 [b]	0 [b]	24.5[ab]	12.5[ab]
Trees	0.5[a]	1.2	0.2 [b]	0.3	2.2[ab]	0.5
Total	18.9[a]	70.6[a]	3.4[a]	12.3[a]	75.7[a]	88.8[a]
Between spoil and woods						
Grasses and sedges	6.3[a]	16.8[a]	---	---	17.7[a]	18 [a]
Forbs	23.2	66.5[a]	---	---	20.3	8.2[a]

continued

Table 16. (Concluded)

Transect location	Recently channelized				Previously channelized	
	Riverine source		Non-riverine source		Non-riverine source	
	May	July	May	July	May	July
Shrubs	4.2[a]	2.7[a]	---	---	32.3[a]	35.3[a]
Trees	1.8[a]	1 [a]	---	---	8.3[a]	3.5[a]
Total	35.5[a]	87 [a]	---	---	78.6[a]	65 [a]

[ab]Like superscripts indicate significant differences ($P < 0.05$) between the frequency of occurrence of plants at different locations along the St. Francis River where substrates are of riverine or non-riverine origin. Comparisons are made within the same plant groups, within the same month, and within the same transect location.

recently channelized sites was greater ($P < 0.05$) on spoils of riverine origin than on spoils of non-riverine origin.

Plant establishment occurred readily on spoil banks of riverine origin. Some plants became established on spoils formed from non-riverine sources, but densities and diversity was less. Although the landowner on the recently channelized area broadcasted fescue (Festuca sp.), lespedeza (Lespedeza sp.), and ryegrass (Elymus sp.), on the site with riverine spoil, these three plants were not encountered.

In both May and July percent frequency of occurrence for all types of vegetation between the spoil banks of riverine origin and the remaining woodland on the recently channelized area was less ($P < 0.05$) than percent frequency of occurrence for all vegetation types on the previously channelized area (Table 16).

ANIMAL COMMUNITIES

Mammalian Response to Habitat Conditions

Small mammals. White-footed mice (Peromyscus sp.) were caught more often than any other small mammal regardless of trap site (Table 17, Appendix C-1). Peromyscus were most abundant in Mingo Swamp on the drained area where 64 were taken during the six trap periods. From 32 to 20 were taken on other sites in Mingo Swamp. Along the St. Francis River from 20 to 29 Peromyscus were taken on sites without levees. On the leveed area only 2 were caught and on the unchannelized area more were taken in leveed woods. Spoil areas produced 5 white-footed mice on recently channelized sites and 10 on previously channelized sites.

Golden mice (Ochrotomys nuttalli) were trapped on periodically impounded and drained areas in Mingo Swamp, but only on the unchannelized early successional

Table 17. Number of small mammals trapped in Mingo Swamp and along the St. Francis River in 1975-1976

	Peromyscus sp.	*Ochrotomys nuttalli*	*Mus musculus*	*Blarina brevicauda*	*Cryptotis parva*	Total	No. trap nights	Catch/ night
Mingo Swamp								
Control	20	0	0	0	0	20	2,130	0.009
Periodically impounded	32	5	0	1	0	38	2,148	0.017
Drained	64	1	1	1	0	67	2,145	0.031
St. Francis River								
Forests near channel								
Unchannelized-woods early successional	24	1	0	0	0	25	1,071	0.023
Unchannelized-woods late successional	24	0	0	0	0	24	1,080	0.022
Leveed woods	0	0	0	0	0	0	1,061	0
Recently channelized spoil bank	5	0	12	0	0	17	1,073	0.015
Previously channelized spoil bank	10	0	11	4	0	15	1,079	0.013
Forests away from channel								
Unchannelized early successional	22	0	0	0	0	22	1,074	0.02

continued

Table 17. Concluded

	Peromyscus sp.	*Ochrotomys nuttalli*	*Mus musculus*	*Blarina brevicauda*	*Cryptotis parva*	Total	No. trap nights	Catch/ night
Unchannelized late successional	29	0	0	0	0	29	1,075	0.02
Recently channelized	21	0	0	0	0	21	1,074	0.01
Previously channelized	20	0	0	1	0	21	1,077	0.01
Leveed	2	0	0	0	1	3	1,075	0.002

site along the St. Francis River (Table 17). Seven short-tailed shrews (Blarina brevicauda) were taken on four sites: periodically impounded (1), drained (1), along previously channelized sections on spoil banks (4), and in forests away from previously channelized sections (1). One house mouse (Mus musculus) was trapped in forests near the channel on both drained and previously channelized areas but 12 were taken in forests near the recently formed channel.

Trapping success was highest on the drained area in Mingo Swamp (0.031 mice/night) and lowest on the leveed area (0.002 mice/night) and on the control (0.009 mice/night) (Table 17). Success rates were next highest (0.02 to 0.023) on forested sites with either early or late succession.

Eleven other species of mammals other than mice or shrews occurred along the St. Francis River (Appendix C-2). Raccoons (Procyon lotor), river otter, gray squirrels (Sciurus carolinensis), fox squirrels (Sciurus niger), swamp rabbits (Silvalagus aquaticus), and cottontail rabbits (Silvalagus floridanus) were most widely distributed.

Avian Response to Habitat Conditions

Forest birds. More species occurred within Mingo Swamp on the periodically impounded site (46) than on either the control (38) or drained areas (37) (Table 18, Appendix C-3). The absence of waterfowl and herons on the drained area was the most obvious difference between the three Mingo Swamp sites. Neither the species observed/survey or the individuals observed/hour were different ($P > 0.05$) between these sites.

About the same number of bird species were seen in forests along unchannelized, channelized, or leveed sections of the St. Francis River (Table 18, Appendix C-4). There were 14.1 species/survey on early successional channelized sites, 15 species/survey on late successional unchannelized sites,

Table 18. Number and diversity of birds in Mingo Swamp and along the St. Francis River. Data are from six two hour surveys on Mingo and six one hour surveys on the St. Francis River

	Number		
	Species/survey	Total species	Individuals/hour
Mingo Swamp			
Control	14.16	38	15.5
Periodically impounded	16.13	46	19.5
Drained	15	37	14
St. Francis River			
Forests near channel			
Unchannelized-woods early successional	14.1 [a]	41	48.1 [a]
Unchannelized-woods late successional	15 [a]	46	53.3 [a]
Leveed woods	12.6 [a]	37	22.1 [abc]
Recently channelized spoil bank	3.6 [b]	17	5.8 [bc]
Previously channelized spoil bank	6 [b]	21	14 [bc]
Forests away from channel			
Unchannelized early successional	11.1 [a]	42	40 [ab]

continued

Table 18. (Concluded)

	Number		
	Species/survey	Total species	Individuals/hour
Unchannelized late successional	12.6 [a]	33	36.5 [ab]
Recently channelized	14.6 [a]	35	36.3 [ab]
Previously channelized	13.1 [a]	35	25 [abc]
Leveed	11.1 [a]	33	29.6 [abc]

[abc] On St. Francis River sites like superscripts indicate statistically equal means as determined by Duncan's new multiple-range test

and 12.6 species/survey on leveed areas. None of these differences were significant ($P > 0.05$). Where riparian habitat was disrupted by both tree removal and dredging, fewer species and fewer numbers of birds were seen. Only 3.6 species were observed per hour along recently formed spoil banks but 6.0 species per hour occurred along spoils from previous channelization (Table 18). These numbers were significantly less ($P \leq 0.05$) than the average number of birds encountered in undisturbed forests near the natural channel regardless of successional stage.

Bird populations were not affected by channelization in woods away from the river channel where forests were not disturbed by clearing and dredging. Number of species encountered per hour were 11.1 in early successional stages and 12.6 in late successional stages on unchannelized sites, 14.6 on recently channelized, 13.1 on previously channelized and 11.1 on leveed areas. Differences in number of species on these sites were not significant ($P > 0.05$).

The average number of birds observed per hour in forests away from the river channel were not different ($P > 0.05$) between the five St. Francis areas: early successional unchannelized (40.0) and late successional unchannelized (36.5), recently channelized (36.3), previously channelized (25.0) and leveed areas (29.6) (Table 18). When all spoil sites are compared to all forested sites regardless of location or treatment, fewer ($P \leq 0.05$) species used spoil sites. Likewise, fewer ($P \leq 0.05$) numbers of birds used spoil sites per hour than occurred on any wooded sites (Table 18).

Wood ducks. Habitat destruction along the St. Francis River adversely affected breeding wood ducks. One wood duck was present on each 0.5 km of unchannelized stream where forest cover was sparse, but our sampling indicated that densities were less where more forest remained (Table 19). One duck was encountered on each 0.6 km of stream with intermediate forest and one was seen

Table 19. Number of wood ducks on different habitat types along the St. Francis River in March, April, and June 1976

	Number of wood ducks				
	Pairs	Singles	Total	Broods	km/bird[a]
Unchannelized					
1 ha/km (4)[b] Sparse	16	35	67	0	0.5
16 ha/km (11) Intermediate	24	7	55	0	0.6
20 ha/km (11) Extensive	12	12	36	0	0.9
Recently channelized					
Main channel (11)	0	0	0	0	0
Backwater (2)	5	2	12	0	0.5
Previously channelized					
Main channel (11)	0	0	0	0	0
Backwater (5)	6	7	19	2	0.8
Leveed					
Main channel (11)	11	11	33	1	1.0
Backwater (5)	5	9	19	0	0.8

[a] $\bar{X}$ distance traveled for each bird observed

[b] Length of sample along stream type

on each 0.9 km of stream with extensive forest. No ducks occurred on the recently channelized or previously channelized segments, but backwater cutoffs adjacent to the recently channelized areas had densities comparable to densities on the unchannelized stream. One duck was encountered for each 0.5 km of backwater on the recently channelized area, but 0.8 km were traversed for each duck seen on backwaters of previously channelized and leveed areas.

Only three broods were recorded: two on the backwaters of the previously channelized area and one on the main channel of the leveed area. Only 15 migrant waterfowl other than wood ducks occurred on backwaters along the recently chennelized and leveed sections of the river.

Wintering waterfowl. Aerial census of wintering waterfowl indicated little use of the St. Francis River regardless of site. No waterfowl were observed on or within 1 km of the river channel in November or December 1975. Only 65 waterfowl were near the river in January 1976: 50 ducks on the unchannelized areas, 12 Canada geese (Branta canadensis) on backwaters along the previously channelized areas and 3 Canada geese on the leveed area. In February 1976, 200 Canada geese and 400 ducks were on the unchannelized area and 3 Canada geese and 25 ducks were on the leveed area.

Raptors, herons, and kingfishers. On the average one raptor was encountered for each 6.6 km of stream where riparian habitat was sparse or extensive, but with intermediate cover, only 5.5 km of stream were traversed for each raptor (Table 20). On backwaters of recently channelized areas one raptor was seen for each 1.2 km of stream, but on the previously channelized areas 33 km of the main channel and 15 km on the backwaters were traversed for each raptor. No raptors occurred along the new channel.

Herons and belted kingfishers (Megaceryle alcyon) occurred on most areas but the leveed area was used least. Only two herons flushed from the main

Table 20. Numbers of raptors, herons, and kingfishers on different habitat types along the St. Francis River in March, April, and June 1976

	Raptors		Herons		Kingfishers	
	Total No.	km/bird[a]	Total No.	km/bird[a]	Total No.	km/bird[a]
Unchannelized						
1 ha/km (11)[b] Sparse	5	6.6	2	16.5	5	6.6
16 ha/km (11) Intermediate	6	5.5	3	11	3	11
20 ha/km (11) Extensive	5	6.6	3	11	6	5.5
Recently channelized						
Main channel (11)	0	0	2	16.5	3	11
Backwater (2)	5	1.2	1	33	5	6.6
Previously channelized						
Main channel (4)	1	33	0	0	4	8.25
Backwater (5)	1	15	0	0	2	16.5
Leveed						
Main channel (11)	1	33	2	16.5	0	0
Backwater (5)	0	0	0	0	0	0

[a]Distance traveled for each bird observed
[b]Length of sample along stream type

channel on leveed sites whereas herons did not occur on the previously channelized areas and fewer herons occurred on recently channelized than on unchannelized areas (Table 20).

Kingfishers were most abundant on the unchannelized sections, but their abundance was greater than either raptors or herons on the channelized areas. The lack of kingfishers on the leveed area is undoubtedly related to unfavorable conditions for nesting and feeding when extensive areas are flooded.

DISCUSSION

EFFECTS OF SITE AND WATER REGIMES ON VEGETATION

Management and/or development of lowland hardwood habitats may have very obvious or very subtle effects. Channelization results in immediate losses of riparian habitat that are apparent when the right of way is cleared before channel construction. This initial impact is less than the subsequent clearing of riparian forests by landowners once the channel reduces the depth of flooding and the number of times an area is inundated annually. The reduction in flooding such as occurred near Dekyn's Store in southeastern Missouri (Table 4) was sufficient to encourage landowners to clear forests for rowcrops. Forests are continually being cleared in southeastern Missouri (Korte and Fredrickson 1977), but losses occur more rapidly where drainage is improved. After channelization, 78 percent of the remnant forest was cleared along the St. Francis River, but only 7 percent of the forest was cleared on unchannelized sections.

In southeastern Missouri many kilometers of wildlife habitat occur along drainage ditches where narrow bands of forest were established on spoil materials. In many cases, forest cover is re-established quickly and the composition and density of vegetation gradually resembles the native forest as succession proceeds. Forest cover established on St. Francis River spoils where the channel was dredged across meanders or where the spoil materials were from non-riverine sources was very different from the composition of native vegetation before channelization. Even after 8 years, vegetation was sparse and few trees

were present on spoil banks. Vegetation immediately adjacent to these spoils was characteristic of the local successional forests and so dense that one encountered difficulty when walking through the area. Undoubtedly, the nutrient poor materials (Appendix A-2) and the lack of flooding on spoils are factors that restricted the establishment of native forest vegetation on these sites. Farmers along channelized sections also complain of loss of fertility when spoil materials erode from spoils and cover fertile lowlands. These spoil banks may not provide forested habitats with the typical local flora for many years if ever.

The more subtle effects of channelization that are related to changes in fertility, soil texture, surface water, soil moisture, and water table are difficult to assess during a single growing season. One obvious method of determining these effects would be long-term studies on the St. Francis sites. A more practical method is to compare how management within Mingo Swamp or on the leveed area has changed the composition, density, and growth of vegetation or animal populations and use these findings plus published information to predict potential changes on channelized sites.

Annual pulsations or the depth of surface water, extent of inundation, frequency of flooding, and soil moisture during the growing season all appear to be important factors that control vegetation within Mingo Swamp. The reported effects of flooding on germination and growth supports the hypothesis that water conditions during the growing season are important in determining species composition on a site. For example, tupelo gum seeds germinated in sand after an area was drained (Shunk 1939:565) or in potted soil when moist-drained or in the absence of soil when seeds were under water (DeBall and Naylor 1972:504). Tupelo seed failed to germinate in flooded potted soils regardless

of temperature or aerations. Germination of southern red oak, willow oak, and laurel oak (Q. laurifolia) was not delayed after soaking in water, but germination was delayed in overcup oak. Nor did soaking for 32 days in darkness reduce viability of sycamore (Platanus occidentalis), elm, red maple, silver maple, cottonwood (Populus deltoides) or black willow (Hosner 1957:69).

In Mingo Swamp, germination of elms apparently was good on the drained area because more seedlings occurred there than on either the control or impounded site (Appendix B-2). Conditions on all the St. Francis sites were favorable for the germination of ash (Appendix B-7). So few seedlings of any species occurred on the control that conditions conducive for germination must nor occur regularly. During this study, the unusually heavy rainfall during the summer probably detered germination because flooding was extensive and occurred later in the season than normal. Variations in weather conditions such as rainfall contribute to the pulsations of swamps. Differences in conditions that are conducive to germination within a localized area are important factors that determine species distribution and growth. The diversity of responses by plants and the diversity of specific conditions within a localized area make single sample assessments of habitat changes difficult in dynamic swamp habitats.

Once seeds have germinated, mortality related to flooding may be high for both water tolerant and non-water tolerant species. Water tupelo seedlings had 87 percent survival after complete inundation from late February to 1 July, but survival dropped to 32 percent when inundation lasted until 1 August (Kennedy 1970:254). Oak seedlings had 90 percent survival after four months of winter flooding (Hall 1962:191). When totally submersed, cypress seedlings ceased growing but growth resumed when seedlings were no longer covered (Welch 1932:213). Complete inundation for two weeks killed most seedlings with leaves, but seedlings resprouted if root damage was not severe

(Broadfoot and Williston 1973:587). Hardwood seedlings with the entire crown above water probably benefit from flooding because growth is enhanced. On non-forested sites in Mingo Swamp, few hardwoods were established on dry sites. On moist sites, hardwoods were established and growth was enhanced by flooding if the crown was not covered (Knauer 1977:131).

Growth of each plant species is influenced by fertility and O_2 and CO_2 concentrations. Forest soils in bottomland forests are acid and leaching of nutrients is commonplace. In acid soils, ions such as Al, Fe, Mn, Cu and Zn occur in increasing quantities as pH decreases and may reach concentrations that are toxic to plants. In contrast, when soils have a high pH, these ions form inert oxides and hydroxides and the toxicity no longer occurs. At low pH levels the solubility of ions such as Fe, Cu, Mn, Zn is so low that these ions are unavailable to plants. Phosphate availability is highest in many soils when the soil is neutral or slightly acid, but availability declines as the soil becomes either strongly acid or alkaline. In clay and silty soils surface area to volume is much higher than in sandy soils and results in a higher potential acidity.

Flooding influences survival of trees by limiting the exchange of O_2 and CO_2. Both swamp tupelo (Nyssa sylvatica) and water tupelo had poorer growth and reduced dry weight in stagnant water where CO_2 concentrations were high and O_2 concentration was low than in soils flooded by moving water (Harms 1973:190). Transpiration by bald cypress seedlings was high after 30 days of flooding, but both transpiration rates and recovery rates of white oak (Quercus sp.), swamp chestnut oak (Q. prinus), red oak (Q. borealis) and overcup oak seedlings declined. Increased transpiration by overcup oak probably was related to a new crop of leaves (Parker 1950:460). The development of adventitious roots by cottonwood, sycamore, and ash seedlings when flooded may explain their higher

survival as compared to cherrybark oak, pin oak and hackberry. On Mingo, lower sites are flooded longer, more often, and to a greater depth with standing water and lack species such as American elm, mulberry, and shagbark hickory (Table 8). Mortality of these less water tolerant species may explain the lower diversity of trees on control and impounded sites.

Photosynthesis and transpiration were reduced in leaves of pecan seedlings that were subjected to soil moisture extremes. The severity and duration of soil saturation and concurrent atmospheric conditions determined the severity of transpiration reduction (Loustalot 1945:530).

Depletion of available soil moisture affects growth of many crop plants and atmospheric conditions play an important role in how plants respond to flooding. Insufficient soil moisture and lack of flooding reduced growth rates significantly in four bottomland trees before the wilting point was reached (Dickson and Hosner 1965:305). Species specific characteristics such as turgor pressure in leaves may determine the wilting point (Slayter 1957:626). Cottonwood used large amounts of soil moisture when available, but when soil moisture dropped to low levels the need for moisture was reduced concurrently (Bonner 1967:3). Sycamore, sweetgum and Nuttall oak (Quercus nuttallii) exhibited somewhat less sensitive control of water loss in response to moisture stress. Mean annual basal area growth of pin oak, red maple, shumard oak, sweetgum, overcup oak, and willow oak in Mingo Swamp reflect water conditions on sites that were managed differently (Table 13). Dormant season flooding in greentree reservoir management can be expected to enhance growth of overcup oak and willow oak, but pin oak growth remains constant.

Seedlings of river birch and red maple recover height growth rates rapidly on saturated soils with 50 percent sunlight and high soil temperature. Sycamore recovered height growth rapidly, but American and winged elm recovered at

moderate rates (McDermott 1954:41). Root and stem diameter and height growth in sycamore, sweetgum, and Nuttall oak seedlings were reduced when soils were saturated for 10 to 12 weeks and when soil temperatures increased rapidly (Bonner 1966:1). Flooding had no effect on twig growth of sandbar willow (Salix interior), black willow, pecan (Carya illionensis), or hackberry (Bonck and Penfound 1944:474).

Mortality of mature lowland hardwood trees commonly occurs when trees are flooded for extended periods during the growing season. Mortality from flooding occurs even though hardwoods in southern river bottoms can use twice the water provided by rainfall in a normal growing season and growth is reduced if they get less than they can use (Broadfoot and Williston 1973:585). The mortality is related to the high demand for oxygen by trees during the growing season and when the rapid depletion of oxygen in warm motionless water reduces the oxygen available for uptake by roots (Broadfoot and Williston 1973:586). One year of constant flooding had little effect on lowland species (Green 1947:118), but in cases where water levels cover the root crown, survival of all species was nil after four years of constant flooding. When root crowns were flooded periodically for more than 54 percent of all growing seasons, 39 woody species suffered mortality. As flooding was reduced, some species survived (Hall and Smith 1955:285). Trees that were flooded by new dams on the Mississippi River maintained growth rates similar to those occurring before dam closure. When mortality occurred it was aburpt and not as a gradual deterioration in growth and vigor (Green 1947:120). Drought may also result in mortality to lowland hardwood species as it did in the early 1950's. Drainage and the resultant low water table intensified the effects of drought (Broadfoot and Toole 1958:276).

These types of differing conditions can be expected on the basis of soil fertility and types and variations in rainfall, inundation, soil moisture, and surface flooding that occur in Mingo Swamp and along the St. Francis River. The final effect of these complex interactions resulted in the higher importance values for pin oak and overcup oak on both control and periodically impounded areas where the mean soil moisture was 75 percent of field capacity and depth of flooding was greater during the growing season (Figure 5, Table 8). In contrast, shumard oak has a higher importance value on drained areas where flooding is uncommon during the growing season (Figure 5, Table 8). Even though conditions are similar between these sites, the subtle differences must give some species a competitive advantage over others. Species such as willow and shumard oak that are adapted to slightly less flooding and lower soil moisture during the growing season probably will compete more successfully and become more important along channelized sections of the St. Francis River as the time since channelization increases. Concurrently, overcup oak, pin oak, cypress, and tupelo, or any other water tolerant species will decrease in importance on these same sites.

Herbaceous growth is indicative of conditions on a site during the growing season whereas the presence of trees and shrubs reflect conditions over a longer period. The most obvious impact of flooding on herbaceous growth within the lowland hardwood system is their absence on most flooded sites (Table 14). Higher elevations are conspicuous because of their dense vegetative cover when shade tolerant species are present. As few as 12 of 50 quadrats had herbs on the Mingo control where flooding occurred during the growing season and the canopy was closed. As many as 45 of 50 quadrats had herbs along the St. Francis River on unchannelized early successional sites.

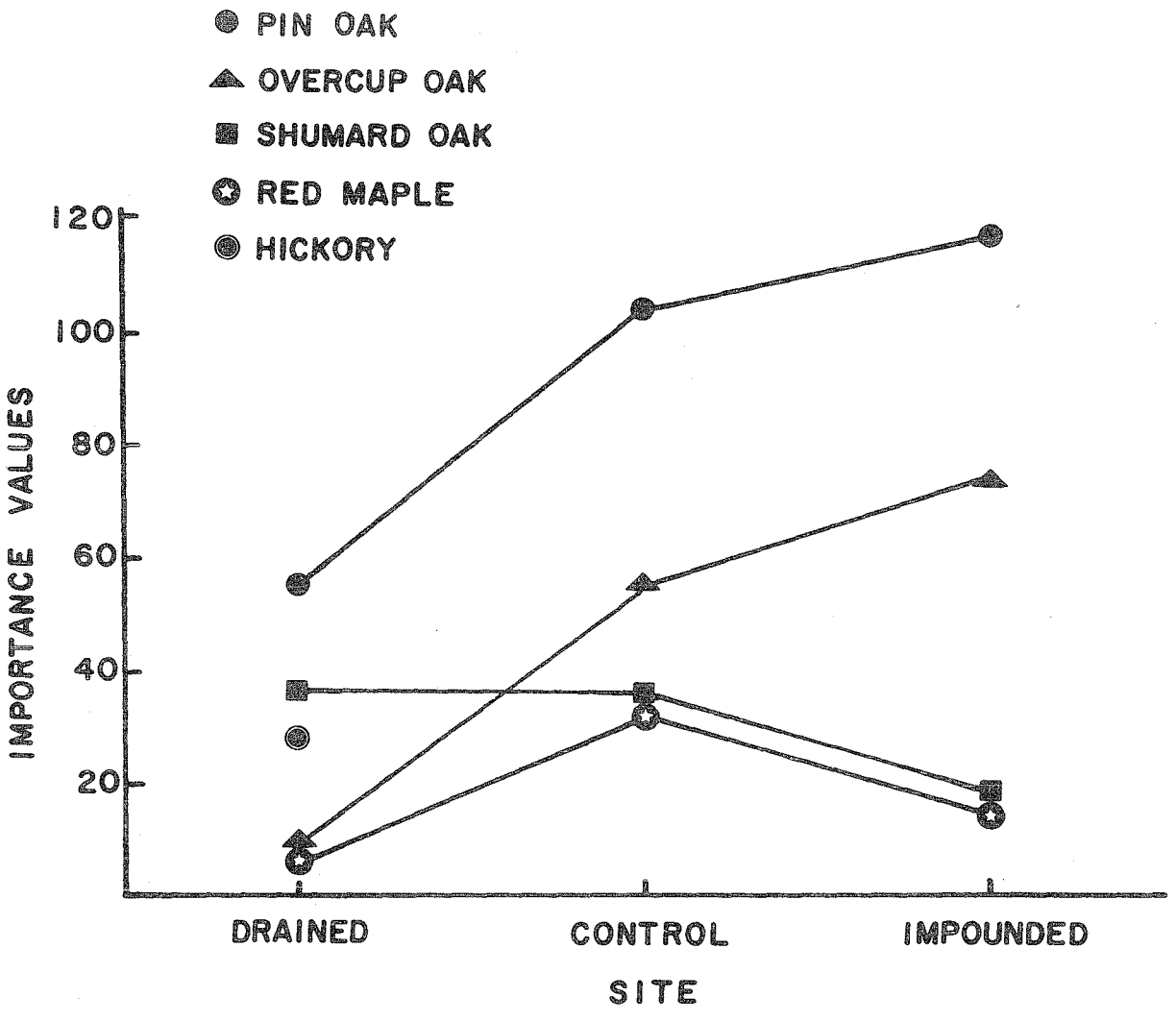


Figure 5. Relationship between importance values for five species of hardwoods, and treatments representing different water regimes within Mingo Swamp.

When surface water is present, flooded sites may be covered with floating aquatics such as Lemna and Spirodella. After surface water disappears from the depressions in summer, few, if any, plants are established here. Undoubtedly, shade, a dense mat of leaves, and the possible quick drying of the surface soils restrict plant germination and growth.

The number of species of herbs, seedlings, and shrubs in relation to water depth indicated that water has an important impact on species occurrence in swamp habitats (Figure 6). General patterns of distribution are apparent; few species occur where depth of flooding is greatest. However, variations in distribution also occur frequently. For example, species normally considered less water tolerant, such as silver maple, may occur on sites where only water tolerant species are expected.

The plants encountered in this study represent a continuum of species with a distribution from the wettest to the dryest sites (Figure 7). On the lowest sites that are flooded the longest, most frequently, and to the greatest depths, bald cypress, tupelo, buttonbush, planer tree, and swamp privet are most abundant. As elevations increase or as flooding frequency and depth is somewhat less, overcup oak, red maple, water locust, and bitter pecan occur. Then pin oak, sweetgum and willow oak become increasingly abundant on sites that are flooded regularly during the dormant season, but surface water is not so deep and rarely is present past mid-summer. Sites nearest the high water mark are flooded occassionally and have shagbark hickory, American elm, and red mulberry. True aquatic plants are not abundant because water is present only temporarily although flooding may be continuous during an entire growing season. Some species have a wide tolerance for moisture and occur throughout the area, but each has a specific tendency to occur in

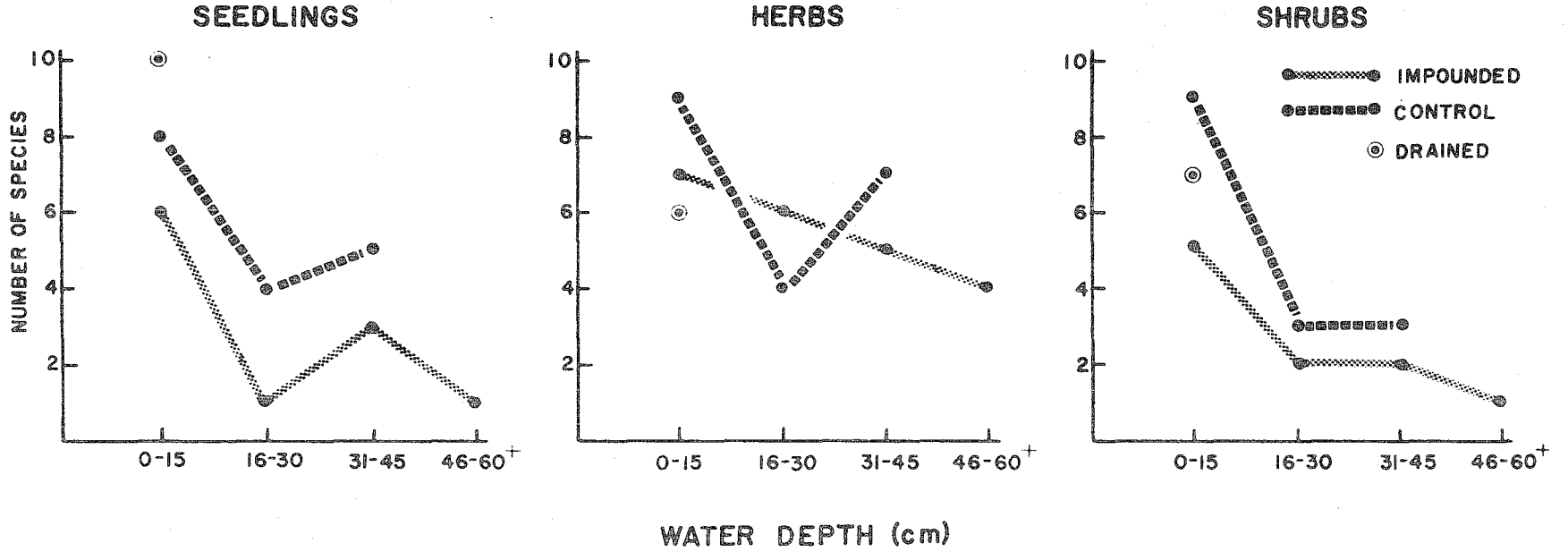


Figure 6. Number of seedlings, herbs, and shrubs in relation to water depth in Mingo Swamp.

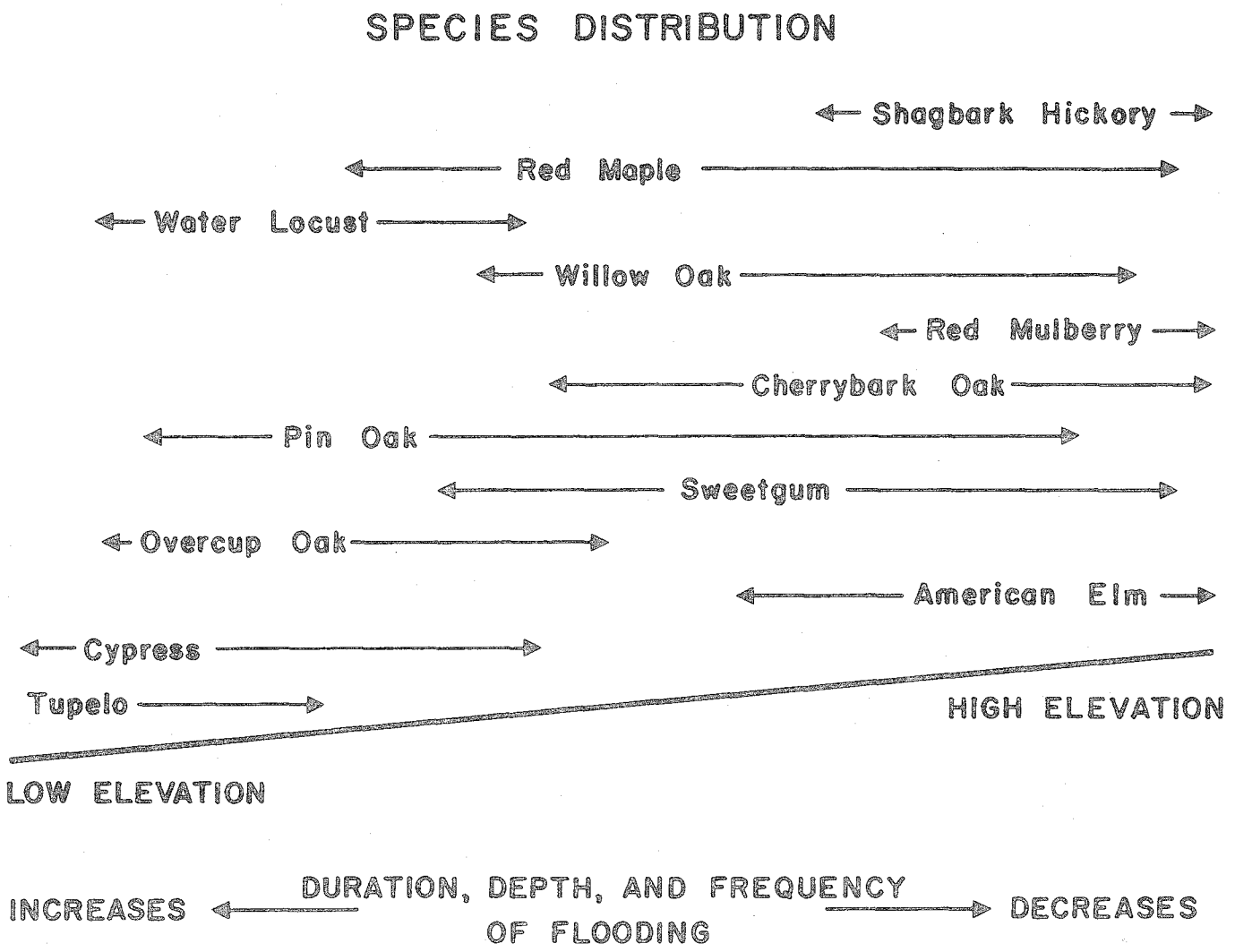


Figure 7. Distribution of lowland hardwood trees in relation to depth, duration, and frequency of flooding.

greater abundance on either wet or dry areas. In this study, more species occurred on the sites with the shallowest water.

EFFECTS OF WATER REGIMES AND CHANNELIZATION ON ANIMAL COMMUNITIES

Mammalian Response to Flooding

Habitat quality for small mammals probably is better on drained sites because more herbaceous vegetation is present for cover and food and because water levels are lower and inundation is less frequent. Trapping success was highest on drained areas and suggested that populations of Peromyscus were highest when flooding was reduced.

Trapping success need not reflect population size. Trapping success for mammals was more closely correlated with food availability than with actual population levels (Fitch 1954:47). In this study, seedling, shrub and herb density was higher on drained areas and provided food and cover for reproduction and escape from predators. Because snap-trapping was restricted to ridges after the impoundments were flooded, some mammals probably were more vulnerable on these dryer sites. Interestingly, both trapping success and seedling, shrub and herb densities on the periodically impounded area was intermediate between control and drained areas. Eighteen (48 percent) of the small mammals trapped on the periodically impounded area were trapped in December or during the first trap period after the impoundment was flooded. On control and on drained areas, only three (15 percent) and six (27 percent) of all catches were made in December (Appendix C-1).

Small mammals forced onto ridges may be more susceptible to predation and/or trapping and may face starvation if food is limited when inundation occurs. Flooding adversely affected populations of small mammals in Oklahoma (Blair 1939:306). Individually marked Peromyscus leucopus apparently

were eliminated by floods because reinvasion of the area was by unmarked individuals (Turner 1966:390). Numbers, size of home range, or movements within the study area were unchanged for white-footed mice on flooded sites in Ohio where leaf litter reached the saturation point (Ruffer 1961). A three week period of flooding produced a 70 percent decrease in the combined population of the partially arboreal species Peromyscus gossypinus and P. nuttalli, but short-term flooding (eight days) caused only slight changes in their populations (McCarley 1959).

Mammalian Response to Channelization and Leveed Lands

Mammal populations are impacted immediately by channelization when the right of way is cleared for channel construction. Small mammal populations were low on spoil banks of channelized sites until vegetative cover was present in June and August. The lowest catch rates for small mammals occurred on the leveed area. Undoubtedly, small mammals are eliminated during floods because the entire area between the levee is flooded. Populations probably have little chance for recovery because there is too little time between floods for reinvasion and population growth.

Forested lands between levees provide important habitat, but the value for animals is less than might be predicted on size alone because flooding has an adverse effect on population stability and growth.

Immediately after channelization riparian habitat is non-existant along the new channel and species such as river otter (Lutra canadensis), mink (Mustela vison), beaver, and muskrat (Ondatra zibethicus) disappear. Both leveed areas and backwater cutoffs provide good habitat for these semiaquatic species.

Avian Response to Channelization

Waterfowl. Waterfowl are attracted to sites where floating logs create loafing areas and where adequate cover is available. Wood ducks probably did

not use channelized sections of the St. Francis because these areas lack the important features that attract waterfowl such as emergent plant cover at marshy interfaces or within timbered habitats (Cowardin 1969:840). In New York, a potentially important source of duck food in the form of aquatic invertebrates was available in greentree reservoirs during April, May and June (Krull 1969:119). Waterfowl movements into flooded timber in New York during fall days were more common than the movements from timbered areas (Thompson et al. 1968). Acorns were predominant in early samples from those areas, but invertebrates increased in later samples. In Illinois wood ducks (Aix sponsa) and herons increased use of an area after water rose one meter (Yeager 1949). The changes in flooding after channelization along the St. Francis River will adversely affect the distribution and abundance of aquatic invertebrates because the types of habitats described above will be reduced. The reduction in invertebrate foods will have a major impact on the potential for breeding in wood ducks and hooded mergansers.

The lack of use by wintering waterfowl in habitat along the St. Francis River during the winter of 1975-76 probably was influenced by the lack of surface flooding because rainfall was below normal. The presence of the Mingo National Wildlife Refuge and the Duck Creek Wildlife Management Area may influence the use of adjacent wetlands. Under favorable conditions these public lands tend to hold birds. When food resources are depleted or when deep flooding makes food unavailable, waterfowl begin using row crops on private lands or other habitats where conditions are favorable for feeding.

Forest birds. Where forests remain intact after channelization, no significant changes occur in species diversity of forest birds nor in the number of individuals observed per hour. The few species and the small number

of individuals encountered on spoil areas are undoubtedly related to the lack of vegetative diversity. Herons and waterfowl and some woodland birds such as carolina chickadee (Parus carolinensis) and tufted titmouse (Parus bicolor) are conspicuously absent from spoil areas. Herons and waterfowl are also absent on drained areas where surface water does not accumulate. Possibly more extensive sampling would show differences in species composition similar to those that occurred on channelized areas in Vermont (Possardt and Dodge 1978). Swallows and spotted sandpipers (Actitis macularia) were more abundant on channelized areas whereas unchannelized areas had more warblers, thrushes, and vireos.

ALTERNATIVES FOR WATER RESOURCE DEVELOPMENTS

Because channelization is effective in reducing maximum river stages and frequency of flooding, agricultural interests will continue to seek improved drainage. Resource workers must consider alternatives that are acceptable to agricultural interests, but have lesser impacts on wildlife and fishery resources. The results of this study make two issues clear. Forest habitat will disappear after channelization unless it is purchased for public ownership or unless landowners have some incentive to maintain forests. Even if forested areas are purchased or protected from clearing, their value as examples of lowland ecosystems or as wildlife habitat will gradually change from a dynamic wet system where flooding is common to a dryer system where flooding occurs infrequently. Maintenance of wetter systems would require a program of controlled water management to duplicate the pulsations of water within swamps. The expertise for such management is restricted by our lack of understanding. More information is required on the complex responses of plants and animals to pulsations in lowland hardwood wetlands. In addition, the operational characteristics of present day management systems

usually promote stability of water regimes rather than dynamic changes. Some good riparian habitat remains along stream meanders that were cut off from the original stream during channelization. These areas should be protected and the potential for water management within the cutoffs should be investigated. On the basis of agricultural development that has occurred on other southeastern Missouri areas with drainage improvements, cutoffs will change rapidly after channel construction. Forest cover will decrease and the channel will become silt filled, particularly at the lower end. In many cases, the entire meander may be filled and farmed.

In situations similar to those that occur on the St. Francis or other lowland rivers where overflows are a part of the normal cycle, snagging and clearing or levees are two alternatives that potentially reduce flooding. The effects of snagging and clearing was not investigated during this study, but impacts on stream habitat and stream dwelling organisms are obvious. A reduction in flooding as a result of snagging and clearing would lead to additional clearing of habitat by landowners. The final effect of snagging and clearing may resemble the effects of channelization because the impacts on habitat and wildlife resources may be similar for the general area even though the original modification of the channel is quite different.

Levee systems as an alternative to channelization are desirable because forest between the levees are less likely to be cleared. A leveed system is undesirable because the dynamic nature of water regimes are lost. Whereas stability is a problem on managed areas, the consistency of fluctuations in water levels is a problem within leveed systems. The two extremes in water levels occur regularly, but intermediate water levels occur rarely. During flooding, water levels are likely to be deeper than before levee construction, but at other times, the area may be dry. The two extremes in conditions are

too common and the intermediate stages of water conditions occur too rarely to duplicate the natural water fluctuations in lowland hardwood systems. The consistency in the water fluctuations tend to favor some plant species and preclude population expansion of some mammalian forms. Some highly desirable species like the river otter do well within leveed areas and are probably more abundant here than in any area in Missouri. Likewise, conditions must be optimal for tupelo because they grow to unusual size between the levees.

CONCLUSIONS

Riparian habitat was reduced or changed in several ways as a result of channelization. The initial clearing of forested habitat for the channel was less than clearing by private landowners once drainage was improved. Forest area along the St. Francis River decreased by 78 percent and stream length decreased by 56 percent following channelization. On unchannelized areas during the same time interval, forest area decreased from 1 to 6 percent. Backwaters that were separated from the new channel and blocked at the upstream end continued to provide good riparian habitat, but these sites are less valuable for species that require moving water. As time from date of channelization increased, these areas became silt filled and eventually the downstream end was no longer connected with the man-made channel. Landowners may fill the cutoffs and/or eliminate much of the riparian habitat adjacent to the cutoffs.

Water conditions had an important impact on the swamp ecosystem. Changes in water regimes such as surface soil moisture, and depth, duration and frequency of inundation had an important impact on the occurrence and distribution of plants in Mingo Swamp and along the St. Francis River. Sites that were inundated for the longest intervals had plants that were the most tolerant to flooding. Differences in species composition between control and drained sites in Mingo Swamp probably are indicative of the changes in plant and animal life that are likely to occur after channelization. Because channelization did

reduce flooding along the St. Francis River, riparian habitat will gradually include fewer water tolerant species. Sites that were flooded consistently lacked herbaceous plant growth and those that were moist longest were more likely to have water tolerant species. Once established the tolerance of bottomland trees to flooding was evident in their basal growth rates. Basal growth of overcup oak was best on periodically impounded sites and the less water tolerant willow oak grew best on drained sites. Pin oak growth was similar on control and periodically impounded sites, but apparently drained sites are too dry for good growth.

White-footed mice were the most abundant small mammal taken in snap-traps. Apparent populations were highest on drained sites, about equally abundant on sites that were flooded intermittently, and least abundant on leveed sites where flooding occurred regularly over the entire area between the levees. On sites that were flooded periodically, many mice were caught immediately after flooding if traps were placed on dry areas. Results of trapping may reflect how easily a species was trapped rather than how abundant they were.

Bird populations were adversely affected by channelization in two ways. Semi-aquatic birds and waterfowl rarely used dredged channels or drained areas because surface water was lacking. On spoil banks where forest habitat was reduced, both the number of species and the number of birds were fewer than in adjacent habitats. Where forests are undisturbed, species composition and bird numbers were similar regardless of location in Mingo Swamp or along the St. Francis River.

The re-establishment of riparian vegetation along channelized sections of the St. Francis River is largely dependent on the origin of spoil materials. The more fertile materials taken from riverine sources provide a substrate that is more conducive to plant growth than the less fertile materials from

non-riverine sources. Establishment of plants is so slow on non-riverine materials that even after eight years the sites were dominated by grasses and other plants that are adapted to xeric sites with low fertility.

Channelization does reduce flooding and benefits agricultural production of rowcrops. Even if additional forest areas were not cleared for rowcrops after channelization, habitat changes may occur that reduce the potential of the habitat to support some species. As time since date of channelization increases, the vegetation would gradually resemble a dryer system and the animal populations would change accordingly. Levees provide an alternative to channelization, but in this case the habitat will change too. The extensive flooding that normally occurs annually adversely effects many mammalian and some bird populations.

RECOMMENDATIONS

The adverse impacts of stream channelization on wildlife resources make other developmental alternatives more desirable. In situations where channel modifications are made, some provisions should assure that some riparian habitat remains on meanders that were cut off from the new channel as well as in the general area where development occurred. Either some lands must be purchased for public ownership or landowners must have incentives to protect riparian habitat. Management will be necessary to assure that conditions necessary for wetland habitats will be maintained.

Levees on both sides of a stream are probably the best alternative to channelization if the entire batture is in public ownership. Forest habitat will be modified by the changes in water regimes, but loss of forest cover would be nil.

Managers of lowland hardwood forests should be cognizant that drainage modification for farming or for greentree reservoir management will gradually change the composition of a forest. Attempts to duplicate the dynamic nature of water fluctuation within swamps should be made in order to maintain factors that promote the establishment and growth of desirable wetland plants.

Quick and accurate assessments of environmental changes as a result of water resource developments are desirable to provide information for management decisions on wildlife areas and to predict project impacts. Although no

sampling system can adequately assess changing conditions in dynamic systems, the following techniques are suggested to monitor changes resulting from man's impact on water regimes. Gross habitat changes in forest habitat were estimated from aerial photos and on site inspection along the St. Francis River. These findings indicated the type and magnitude of changes that occurred in forest habitat along a lowland stream.

Data on plant distribution, composition and growth are probably the most valuable to predict changes in both plant and animal communities. Data collection on animal populations is time consuming and often measures behavioral characteristics more than actual numbers. For example, the results from snap-trapping did not warrant the time required for the meagre results. Because habitat determines animal species presence and abundance, vegetative information can provide a better insight into how animal populations respond. A combination of small quadrats along line transects provide a quick assessment of composition and extent of vegetative cover. The point-center quarter method works well for determining woody composition, and increment cores provide a means of assessing growth. A good environmental assessment requires concurrent information on frequency, depth and duration of flooding, water table, surface soil moisture, and fertility. By restricting sampling to seedlings and trees, field time would be reduced. Responses by shrubs and herbs could be predicted with a combination of published information and on site data from trees and water conditions. Tree basal growth is indicative of general flooding conditions and future changes in growth could be predicted.

Early morning bird surveys in forested habitat are not as time consuming as mist netting or detailed analysis of plots and are adequate to assess major changes in numbers of birds or number of species in relation to habitat manipulations. The time spent in surveys by boat along waterways were less

productive. The differences in numbers and species encountered in the boat surveys probably are no more accurate than estimates by one or two on site inspections by an experienced biologist.

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APPENDIX A: SOIL DATA

Table A-1. Physical properties and textural classification of soils on high and low sites within Mingo Swamp and along the St. Francis River

	Percent							
	Sand		Silt		Clay		Texture	
	High	Low	High	Low	High	Low	High	Low
Mingo Swamp control	24.6	26.8	38.0	46.0	37.2	27.2	clay loam	clay loam
Mingo Swamp periodically impounded	31.6	23.2	52.4	42.4	16.0	34.4	silt loam	clay loam
Mingo Swamp drained	25.6	21.6	49.6	20.6	24.8	57.8	loam	clay
St. Francis unchannelized early successional forest	18.4	15.2	58.4	47.6	23.2	37.2	silty clay loam	silty clay loam
St. Francis unchannelized late successional forest	15.6	27.6	55.6	46.0	28.8	26.4	silty clay loam	loam
St. Francis recently channelized								
Undisturbed forest	23.2	15.2	52.4	50.0	24.4	34.8	silt loam	silty clay loam
River to spoil -								
Spoil from riverine source	29.6		54.0		16.4		silt loam	

continued

Table A-1. (Continued)

	Percent							
	Sand		Silt		Clay		Texture	
	High	Low	High	Low	High	Low	High	Low
Spoil from non-riverine source	35.2		44.8		20.0		loam	
Top of spoil -								
Spoil from riverine source	67.6		26.4		6.0		sandy loam	
Spoil from non-riverine source	71.2		23.2		5.6		silt loam	
Spoil to forest -								
Spoil from riverine source	59.2		29.6		11.2		sandy loam	
St. Francis previously channelized								
Undisturbed forest	25.6	41.6	48.0	29.6	26.4	28.8	loam	clay loam
River to spoil -								
Spoil from non-riverine source	29.2		56.0		14.8		silt loam	
Top of spoil -								
Spoil from non-riverine source	55.2		35.6		9.2		sandy loam	

continued

Table A-1. (Concluded)

	Percent							
	Sand		Silt		Clay		Texture	
	High	Low	High	Low	High	Low	High	Low
Spoil to forest -								
Spoil from non-riverine source	58.8		34.0		7.2		sandy clay loam	
St. Francis leveed	69.6	69.6	18.0	18.0	12.4	12.4	sandy loam	sandy loam

Table A-2. Fertility of soils on high and low sites in Mingo Swamp and along the St. Francis River

	Kg/ha									
	Calcium		Magnesium		Potassium		pH		Cation Exchange Capacity	
	High	Low	High	Low	High	Low	High	Low	High	Low
Mingo Swamp Control	1,456	672	672	302	175	134	4.4	4.4	18.5	16.5
Mingo Swamp Periodically Impounded	224	2,464	246	750	94	186	4.4	4.6	10.5	19.0
Mingo Swamp Drained	560	3,696	179	1,120	112	349	4.3	5.0	12.0	22.0
St. Francis unchannelized early successional forest	3,024	2,016	672	627	188	190	5.2	4.8	14.5	14.5
St. Francis unchannelized late successional forest	2,800	2,464	739	795	193	220	5.3	4.9	14.5	15.5
St. Francis recently channelized										
Undisturbed forest	1,904	2,240	739	750	179	184	4.7	4.9	16.0	15.5
River to spoil -										
Spoil from riverine source	1,680		571		108		5.0		10.0	

continued

Table A-2. (Continued)

	Kg/ha									
	Calcium		Magnesium		Potassium		pH		Cation Exchange Capacity	
	High	Low	High	Low	High	Low	High	Low	High	Low
Spoil from non-riverine source	2,128		762		134		5.1		12.5	
Top of spoil -										
Spoil from riverine source	1,344		482		81		5.2		8.0	
Spoil from non-riverine source	1,120		448		90		5.2		7.5	
Spoil to forest -										
Spoil from riverine source	1,568		515		108		5.2		9.0	
St. Francis previously channelized										
Undisturbed forest	2,128	2,912	884	862	184	233	4.8	4.9	16.0	18.0
River to spoil -										
Spoil from non-riverine source	2,016		739		213		5.5		10.5	

continued

Table A-2. (Concluded)

	Kg/ha									
	Calcium		Magnesium		Potassium		pH		Cation Exchange Capacity	
	High	Low	High	Low	High	Low	High	Low	High	Low
Top of spoil -										
Spoil from non-riverine source	1,232		437		99		4.9		8.0	
Spoil to forest -										
Spoil from non-riverine source	1,232		448		110		5.0		9.0	
St. Francis leveed	2,912	2,016	941	694	204	164	5.5	4.9	13.5	12.5

APPENDIX B: VEGETATION DATA

Table B-1. Tree species in samples on control, periodically impounded, and drained areas in the Mingo Swamp and/or unchannelized, recently channelized, previously channelized, and leveed areas along the St. Francis River

Scientific names	Common names
Acer negundo	Box Elder
Acer rubrum	Red Maple
Acer saccharinum	Silver Maple
Aesculus glabra	Red Buckeye
Assimina triloba	Pawpaw
Betula nigra	River Birch
Carpinus caroliniana	American Hornbeam
Carya cordiformis	Bitternut Hickory
Carya illinoensis	Pecan
Carya laciniosa	Big Shellbark
Carya ovata	Shagbark Hickory
Carya tomentosa	Mockernut Hickory
Celtis laevigata	Sugarberry
Celtis occidentalis	Hackberry
Cephalanthus occidentalis	Buttonbush
Cercis canadensis	Redbud
Cornus stricta	Stiff Dogwood
Crataegus viridis	Green Hawthorne
Diospyros virginiana	Persimmon
Forestiera acuminata	Swamp Privet
Fraxinus pennsylvanica	Green Ash
Fraxinus profunda	Pumpkin Ash
Gleditsia aquatica	Water Locust
Ilex decidua	Deciduous Holly
Juglans nigra	Black Walnut
Lindera benzoin	Spicebush
Liquidambar styraciflua	Sweetgum
Morus rubra	Red Mulberry
Nyssa aquatica	Water Tupelo
Nyssa sylvatica	Blackgum or Swamp Tupelo

Continued

Table B-1. (Concluded)

Scientific names	Common names
Planera aquatica	Planer Tree
Platanus occidentalis	Sycamore
Populus deltoides	Cottonwood
Populus heterophylla	Swamp Cottonwood
Quercus falcata var. pagodaefolia	Cherrybark Oak
Quercus lyrata	Overcup Oak
Quercus michauxii	Swamp Chestnut Oak
Quercus palustris	Pin Oak
Quercus phellos	Willow Oak
Quercus rubra	Red Oak
Quercus shumardii	Shumard Oak
Quercus velutina	Black Oak
Salix nigra	Black Willow
Taxodium distichum	Bald Cypress
Ulmus alata	Winged Elm
Ulmus americana	American Elm
Ulmus rubra	Slippery Elm

Table B-2. Mean stems per m^2 for seedling species that occurred on at least 10 percent of the quadrats on control, periodically impounded, or drained areas in the Mingo Swamp. Means based on number of quadrats where seedlings were present

Species	F-value[a]	Control			Periodically impounded			Drained		
		$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats
					Sample 1 (May)					
Acer rubrum		2	---	8	5	3.37	7	7	25	2
Acer sp.		---	---	---	2	---	1	4	0.28	13
Cephalanthus occidentalis		---	---	---	3	1.36	5	---	---	---
Fraxinus sp.		---	---	---	2	0.14	7	29	27.46	14
Quercus sp. (red oak)		---	---	---	3	0.20	12	6	---	1
Ulmus sp.		4	0.92	4	2	---	5	31	104.17	24
All seedlings	11.73	3.57	8.72	14	5.58	17.82	29	38.78[b]	2985.98	33
					Sample 2 (July)					
Fraxinus sp.		4	4	2	2	---	4	10	5.38	11
Quercus sp.		---	---	---	2	0.06	8	6	---	1
Ulmus sp.		---	---	---	---	---	---	3	0.64	5
Unknown seedling		4	---	1	2	---	1	2	0.06	8
All seedlings	3.06	4.4	6.8	5	3.07	3.74	13	6.96	37.04	25

[a]Analysis of variance based on data adjusted with variance stabilizing transformation, $\sqrt{x+1}$.
[b]Mean stems per m^2 significantly different from mean stems per m^2 on control area.

Table B-3. Shrub species in samples on control, periodically impounded, and drained areas in the Mingo Swamp and/or unchannelized, recently channelized, previously channelized, and leveed areas along the St. Francis River

Scientific names	Common names
Amorpha fruticosa	False Indigo
Amplelopsis arborea	Pepper-vine
Bignonia capreolata	Cross-vine
Brunnichia cirrhosa	Buckwheat Vine
Campsis radicans	Trumpet Creeper
Desmodium spp.	Tick Trefoil
Menispermum canadense	Moonseed
Parthenocissus quinquefolia	Virginia Creeper
Rhus radicans	Poison Ivy
Rosa spp.	Rose
Rubus allegheniensis	Common Blackberry
Sambucus canadensis	Common Elderberry
Smilax glauca	Greenbrier, Catbrier
Trachelospermum difforme	Climbing Dogbane
Vaccinium spp.	Blueberry
Vitis rotundifolia	Muscadine Grape
Wisteria fructescens	Wisteria

Table B-4. Mean stems per m^2 for shrub species that occurred on at least 10 percent of the quadrats on control, periodically impounded, or drained areas in the Mingo Swamp. Means based on number of quadrats where shrubs were present

Species	F-value[a]	Control			Periodically impounded			Drained		
		$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats
					Sample 1 (May)					
Brunnichia cirrhosa		2	---	3	4	1.22	7	---	---	---
Campsis radicans		7	7.97	13	6	1.11	21	4	4	3
Rhus radicans		---	---	---	4	---	1	35	35.19	36
Trachelospermum difforme		4	---	2	6	2.56	9	---	---	---
All shrubs	16.46	9	239.23	14	8.57	32.55	28	36.1[b]	1252.43	37
					Sample 2 (July)					
Campsis radicans		4	1.67	9	3	0.45	12	4	1.2	5
Parthenocissus quinquefolia		4	---	1	---	---	---	4	2.24	5
Rhus radicans		---	---	---	6	---	1	29	25.45	36
Unknown shrub		2	---	6	---	---	---	2	---	1
All shrubs	23.27	4.14	10.74	14	4.50	11.31	20	30.27[b]	928.48	37

[a]Analysis of variance based on data adjusted with variance stabilizing transformation, $\sqrt{x+1}$.
[b]Mean stems per m^2 significantly different from mean stems per m^2 on control area.

Table B-5. Herb species in samples on control, periodically impounded, and drained areas in the Mingo Swamp and/or unchannelized, recently channelized, previously channelized, and leveed areas along the St. Francis River

Scientific names	Common names
Allium spp.	Garlic
Amaranthus arenicola	Amaranth (genus name)
Ambrosia spp.	Ragweed
Arisaema dracontium	Green Dragon
Arisaema triphyllum	Jack-in-the-Pulpit
Arundinaria gigantea	Giant Cane
Asclepias perennis	Milkweed
Aster spp.	Wild Aster
Bidens spp.	Beggar-ticks
Boehmeria cylindrica	False Nettle
Brunnichia cirrhosa	Buckwheat Vine
Carex spp.	Sedge
Commelina communis	Day-flower
Dioscorea villosa	Wild Yam
Erigeron spp.	Daisy Fleabana
Eupatorium serotinum	Late Boneset
Galium spp.	Bedstraw, Cleavers
Geranium spp.	Wild Geranium
Impatiens spp.	Touch-me-not
Leersia virginica	White Grass
Lemna spp.	Duckweed
Lycopus virginicus	Bugle-weed, Water Horehound
Oxalis stricta	Wood Sorrel
Panicum spp.	Panic Grass
Peltandra virginica	Peltandra
Phytolacca americana	Pokeweed
Pilea pumila	Clearweed
Polygonum lapathifolium	Nodding Smartweed
Proserpinaca spp.	Mermaid-weed

continued

Table B-5. (Concluded)

Scientific names	Common names
Ranunculus spp.	Buttercup, Crowfoot
Ruellia spp.	Ruellia
Saururus cernuus	Lizard's-tail
Solanum nigrum	Black Nightshade
Spirodela spp.	Duckweed
Trifolium hybridum	Alsike Clover
Urtica spp.	Nettle
Viola spp.	Violet
Wolffia spp.	Water-meal

Table B-6. Mean stems per m^2 for herb species that occurred on at least 10 percent of the quadrats on control, periodically impounded, or drained areas in the Mingo Swamp. Means based on number of quadrats where herbs were present

	F-value[a]	Control			Periodically impounded			Drained		
		$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats
					Sample 1 (May)					
Aster sp.		---	---	---	---	---	---	13	35.11	6
Carex sp.		9	1	2	38	120.6	16	32	39.81	20
Impatiens capensis		2	---	1	2	---	1	7	5.88	16
Leersia sp.		---	---	---	2	---	2	33	171.6	12
Ranunculus scleratus		---	---	---	11	3.55	23	4	1.33	3
Saururus cernuus		9	46.92	4	16	44.18	6	8	12.56	5
Viola sp.		3	0.56	5	16	---	1	60	---	1
Unknown herb		3	0.92	4	3	0.33	4	4	1.33	3
All herbs	2.63	11.16	155.24	12	32.12	1388.73	33	38.21	2725.14	38
					Sample 2 (July)					
Aster sp.		---	---	---	---	---	---	7	8.24	5
Carex sp.		4	1.33	3	16	14.16	14	14	11.42	20
Impatiens capensis		3	1	2	---	---	---	4	0.71	8
Leersia sp.		---	---	---	---	---	---	20	110	4
Ranunculus scleratus		---	---	---	---	---	---	2	---	1

continued

Table B-6. (Concluded)

Species	F-value[a]	Control			Periodically impounded			Drained		
		$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats
					Sample 2 (July)					
Saururus cernuus		10	19.36	5	18	82.40	5	7	17.58	4
Viola sp.		4	2	4	2	---	1	26	---	1
Unknown herbs		4	4	2	2	0.64	5	2	---	1
All herbs	1.08	9.53	59.43	13	16.8	229.22	20	18.38	427.31	31

[a]Analysis of variance based on data adjusted with variance stabilizing transformation, $\sqrt{x+1}$.

Table B-7. Mean stems per m^2 for seedling species that occurred on at least 10 percent of the quadrats on unchannelized, recently channelized, previously channelized or leveed sections of the St. Francis River

Species	F-value[a]	Early Successional Unchannelized			Late Successional Unchannelized			Recently Channelized			Previously Channelized			Leveed		
		$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats
								Sample 1 (May)								
Acer negundo		11	11.18	7	4	---	1	---	---	---	2	---	1	---	---	---
Acer rubrum		11	7.38	23	---	---	---	---	---	---	---	---	---	---	---	---
Acer sp.		---	---	---	---	---	---	20	---	36	24	164.92	4	16	---	1
Betula nigra		7	1.31	22	---	---	---	---	---	---	3	1.78	3	---	---	---
Carya sp.		---	---	---	3	0.14	8	2	---	2	2	---	1	---	---	---
Illex decidua		6	6.96	5	---	---	---	2	---	1	---	---	---	---	---	---
Fraxinus sp.		5	1.41	23	4	1.8	7	13	6.84	28	51	145.25	22	29	24.23	29
Lindera benzoin		4	1.88	10	2	0.44	3	---	---	---	---	---	---	---	---	---
Morus rubra		2	---	5	---	---	---	---	---	---	---	---	---	---	---	---
Nyssa aquatica		5	11.11	3	---	---	---	---	---	---	---	---	---	---	---	---
Quercus sp.		---	---	---	---	---	---	2	---	2	---	---	---	46	117	26
Ulmus sp.		2	0.11	9	---	---	---	2	---	1	---	---	---	30	45.71	26
Unknown seedling		2	0.33	7	---	---	---	4	---	1	9	6.68	10	---	---	---
All seedlings	23.86	16	3.78	48	5	0.93	17	31[bc]	18.7	35	72[bc]	412.3	23	97[bc]	269.08	30
								Sample 2 (July)								
Acer rubrum		7	3.93	6	---	---	---	---	---	---	---	---	---	4	2.4	5
Acer sp.		6	2.55	15	2	---	2	11	3.28	26	---	---	---	---	---	---

Continued

Table B-7. (Concluded)

Species	F-value[a]	Early Successional Unchannelized			Late Successional Unchannelized			Recently Channelized			Previously Channelized			Leveed		
		$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats
Betula nigra		3	0.49	9	---	---	---	---	---	---	2	0.16	5	---	---	---
Carya sp.		2	---	1	2	0.16	7	---	---	---	---	---	---	---	---	---
Illex decidua		2	0.24	5	---	---	---	2	---	1	---	---	---	---	---	---
Fraxinus sp.		4	1.92	15	2	0.64	5	9	4.7	18	10	3.59	19	7	1.9	20
Lindera benzoin		4	2.9	9	2	---	1	2	---	1	---	---	---	---	---	---
All seedlings	8.33	8	1.3	39	3	0.16	16	17	5.46	31	11[bc]	3.37	19	14[c]	9.99	21

[a]Analysis of variance based on data adjusted with variance stabilizing transformation, $\sqrt{x+1}$.
[b]Mean stem count significantly different ($P \leq 0.05$) from mean stem count for unchannelized area (Column 1).
[c]Mean stem count significantly different ($P \leq 0.05$) from mean stem count for unchannelized area (Column 2).

Table B-8. Mean stems per m^2 for shrub species that occurred on at least 10 percent of the quadrats on unchannelized, recently channelized, previously channelized or leveed sections of the St. Francis River

Species	F-value[a]	Early Successional Unchannelized			Late Successional Unchannelized			Recently Channelized			Previously Channelized			Leveed		
		$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats
							Sample 1 (May)									
Bignonia capreolata		6	1.51	16	13	7.75	20	5	3.11	3	---	---	---	---	---	---
Brunnichia cirrhosa		---	---	---	---	---	---	5	2.35	10	---	---	---	5	1	2
Campsis radicans		2	0.44	3	3	1	8	4	0.35	12	6	11.04	5	---	---	---
Desmodium sp.		---	---	---	11	14.42	11	---	---	---	---	---	---	---	---	---
Menispermum canadense		---	---	---	4	1.33	3	---	---	---	---	---	---	---	---	---
Parthenocissus quinquefolia		9	10.92	---	3	1.44	5	---	---	---	2	---	2	---	---	---
Rhus radicans		9	9.67	4	16	8.18	25	17	54.01	9	33	108.99	13	---	---	---
Smilax sp.		2	0.25	4	3	1.78	3	3	0.56	5	4	---	1	---	---	---
Vitis sp.		3	0.92	4	3	0.96	5	3	0.47	6	4	3.11	3	2	---	1
Unknown shrub		4	1.33	4	---	---	---	5	5.78	3	---	---	---	---	---	---
All shrubs	10.92	7	1.1	31	29	13.26	30	11[c]	7.65	29	27[b]	67.91	18	4[c]	1.33	3
							Sample 2 (July)									
Bignonia capreolata		6	1.61	14	11	3.92	17	2	0.19	15	---	---	---	2	---	2
Brunnichia cirrhosa		---	---	---	---	---	---	---	---	---	---	---	---	2	---	2

continued

Table B-8. (Concluded)

Species	F-value[a]	Early Successional Unchannelized			Late Successional Unchannelized			Recently Channelized			Previously Channelized			Leveed		
		$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats
Campsis radicans		2	---	3	2	---	7	4	0.53	13	2	0.44	3	2	---	1
Desmodium sp.		---	---	---	9	1	2	---	---	---	---	---	---	---	---	---
Menispermum canadense		---	---	---	4	---	2	---	---	---	---	---	---	---	---	---
Parthenocissus quinquefolia		11	69.78	3	2	0.25	4	---	---	---	---	---	---	---	---	---
Rhus radicans		10	28.64	6	10	2.67	23	9	9.28	8	23	34.99	12	---	---	---
Smilax sp.		3	2.56	5	2	---	2	4	---	1	2	---	1	---	---	---
Vitis sp.		2	0.28	8	4	2.06	8	3	0.71	6	2	---	1	---	---	---
Unknown shrubs		---	---	---	7	11.11	3	3	1	2	---	---	---	3	1	2
All shrubs	10	7	2.53	31	18	3.48	30	8[c]	1.35	26	18[b]	22.31	17	2[c]	0.22	9

[a]Analysis of variance based on data adjusted with variance stabilizing transformation, $\sqrt{x+1}$.
[b]Mean stem count significantly different ($P \leq 0.05$) from mean stem count for unchannelized area (Column 1).
[c]Mean stem count significantly different ($P \leq 0.05$) from mean stem count for unchannelized area (Column 2).

Table B-9. Mean stems per m^2 for herb species that occurred on at least 10 percent of the quadrats on unchannelized, recently channelized, previously channelized or leveed sections of the St. Francis River

Species	F-value[a]	Early Successional Unchannelized			Late Successional Unchannelized			Recently Channelized			Previously Channelized			Leveed		
		$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats
							Sample 1 (May)									
Arisima dracontium		13	18.75	15	---	---	---	---	---	---	---	---	---	---	---	---
Aster sp.		2	---	1	17	51.44	5	37	82.04	18	16	12.44	3	---	---	---
Boehmeria cylindrica		---	---	---	2	---	1	---	---	---	3	0.44	3	---	---	---
Carex sp.		4	3.58	4	9	20.33	4	69	492.82	12	---	---	---	---	---	---
Commelina communis		---	---	---	8	9.31	7	---	---	---	---	---	---	10	---	1
Impatiens sp.		22	129.2	5	---	---	---	---	---	---	---	---	---	---	---	---
Leersia sp.		12	64.64	6	52	158.99	20	17	169	2	4	3.11	3	6	---	1
Pilea pumila		4	0.5	13	31	415.13	6	16	64.32	11	38	---	1	67	429.23	15
Saururus cernuus		---	---	---	26	16	2	24	21.56	15	---	---	---	---	---	---
Viola sp.		24	42.9	26	6	2.79	11	13	35.66	10	6	16	2	---	---	---
Unknown herb		3	0.74	15	10	13.2	10	13	22.73	13	9	18.92	4	37	99.56	13
All herbs	3.1	33	73.08	45	67	215.6	25	66[b]	152.17	36	16[bc]	26.26	10	69	427.61	22
							Sample 2 (July)									
Asclepias perennis		---	---	---	---	---	---	---	---	---	---	---	---	2	0.44	3
Aster sp.		4	---	1	6	3.75	9	17	11.46	18	12	0.44	3	8	12	3

continued

Table B-9. (Concluded)

Species	F-value[a]	Early Successional Unchannelized			Late Successional Unchannelized			Recently Channelized			Previously Channelized			Leveed		
		$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats	$\bar{X}$	s^2	No. Quadrats
Boehmeria cylindrica		---	---	---	8	31.37	7	7	7.68	13	26	---	1	2	0.25	4
Carex sp.		3	0.44	3	6	6.8	5	32	49.25	8	---	---	---	---	---	---
Commelina communis		---	---	---	10	11.76	5	---	---	---	---	---	---	3	1.78	3
Impatiens sp.		13	1	2	---	---	---	---	---	---	---	---	---	---	---	---
Leersia sp.		10	42.25	4	31	47.42	20	---	---	---	6	---	1	2	---	1
Pilea pumila		---	---	---	2	---	2	2	---	1	---	---	---	---	---	---
Saururus cernuus		---	---	---	17	1	2	12	4.65	14	4	6.25	4	10	---	2
Viola sp.		17	12.74	21	5	1.6	9	8	20.8	5	---	---	---	6	---	1
Unknown herb		3	0.33	4	6	---	1	15	62.42	7	---	---	---	3	1	2
All herbs	6.41	20	17.93	31	39	50.21	24	31[b]	18.79	34	11[c]	19.99	8	7[c]	4.28	14

[a]Analysis of variance based on data adjusted with variance stabilizing transformation, x+1.
[b]Mean stem count significantly different ($P \leq 0.05$) from mean stem count for unchannelized area (Column 1).
[c]Mean stem count significantly different ($P \leq 0.05$) from mean stem count for unchannelized area (Column 2).

Table B-10. Plant species in samples on or adjacent to spoil banks on recently channelized and/or previously channelized sections of the St. Francis River

Scientific names	Common names
Abutilon theophrasti	Velvet Leaf
Acalypha virginica	Three-seeded Mercury
Acer negundo	Box Elder
Acer saccharinum	Silver Maple
Agrostis hyemalis	Hair Grass, Tickle Grass, Winter Bent Grass
Alopecurus carolinianus	Foxtail
Amaranthus arenciola	Amaranth
Ambrosia artemsiifolia	Common Ragweed
Amorpha fruticosa	False Indigo
Andropogon virginicus	Broom Sedge
Antennaria neglecta	Everlasting, Pussy-toes
Aster spp.	Wild Aster
Betula nigra	River Birch
Bidens spp.	Beggar-ticks
Bromus japonicus	Brome Grass
Campsis radicans	Trumpet Creeper
Carex spp.	Sedge
Carya spp.	Hickory
Celtis occidentalis	Hackberry
Chenopodium album	Lamb's Quarters
Cirsium spp.	Thistle
Conyza canadensis	Horseweed
Cornus spp.	Dogwood
Cynodon dactylon	Bermuda Grass
Cyperus spp.	Galingale
Digitaria ischaemum	Crab Grass
Digitaria sanguinalis	Crab Grass
Diodia virginiana	Buttonweed
Diospyros virginiana	Persimmon

continued

Table B-10. (Continued)

Scientific names	Common names
Echinochloa crusgalli	Barnyard Grass
Eragrostis reptans	Love Grass
Erigeron spp.	Daisy, Fleabane
Eupatorium rugosum	White Boneset
Eupatorium serotinum	Late Boneset
Euphorbia spp.	Spurge
Fraxinus spp.	Ash
Geranium carolinianum	Wild Geranium, Crane's Bill
Gratiola neglecta	Hedge Hyssop
Hordeum pusillum	Little Barley
Juncus spp.	Rush
Lactuca spp.	Lettuce
Leersia oryzoides	Cut Grass
Lespedeza spp.	Bush Clover
Liquidambar styraciflua	Sweetgum
Lonicera spp.	Honeysuckle
Morus rubra	Red Mulberry
Oenothera laciniata	Evening Primrose
Oxalis stricta	Wood Sorrel
Panicum dichotomiflorum	Panic Grass
Panicum lanuginosum	Panic Grass
Paspalum floridanum	Paspalum
Paspalum pubiflorum	Paspalum
Phytolacca americana	Pokeweed
Platanus occidentalis	Sycamore
Polygonum lapathifolium	Knotweed
Polygonum pennsylvanicum	Pinkweed
Populus deltoides	Cottonwood
Ranunculus arbortivus	Small-flowered Crowfoot
Rhus glabra	Smooth Sumac
Rhus radicans	Poison Ivy
Rorippa islandica	March Cress, Yellow Cress

continued

Table B-10. (Concluded)

Scientific names	Common names
Rosa spp.	Rose
Ruellia strepens	Wild Petunia
Rubus allegheniensis	Common Blackberry
Rumex spp.	Dock, Sorrel
Salix spp.	Willow
Sambucus canadensis	Common Elder
Senecia spp.	Groundsel
Smilax spp.	Catbrier, Greenbrier
Solanum nigrum	Black Nightshade
Solidago spp.	Goldenrod
Trifolium hybridum	Alsike Clover
Triodanis perfoliata	Venus' Looking-glass
Ulmus spp.	Elm
Urtica spp.	Nettle
Verbena stricta	Vervain
Veronica peregrina	Speedwell
Viola spp.	Violet

APPENDIX C: ANIMAL DATA

Table C-1. Number of small mammals captured during snap-trapping in Mingo Swamp and along the St. Francis River in 1975-76

	Number caught						
	1975		1976				
	Oct.	Dec.	Feb.	Apr.	Jun.	Aug.	Total
Mingo Swamp							
Control	4	3	5	2	2	4	20
Periodically impounded	8	18	2	2	5	3	38
Drained	12	6	6	5	21	17	67
St. Francis River							
Forests near channel							
Unchannelized early successional	4	0	2	0	15	4	25
Unchannelized late successional	0	1	1	3	12	7	24
Leveed	0	0	0	0	0	0	0
Spoil-recently channelized	1	2	0	0	3	11	17
Spoil-previously channelized	2	1	0	0	5	7	15
Forests away from channel							
Unchannelized early successional	2	0	2	2	11	5	22
Unchannelized late successional	3	3	1	3	11	8	29
Recently channelized	3	0	1	3	14	0	21
Previously channelized	1	0	0	0	14	6	21
Leveed	1	0	0	0	0	2	3

Table C-2. Mammals present on control, periodically impounded and drained areas in the Mingo Swamp. (Presence determined by trapping, sightings, tracks, scats, or other sign)

Species	Control	Periodically impounded	Drained
Opossum	X	X	X
Short-tailed Shrew		X	X
Raccoon	X	X	X
Bobcat	X	X	X
Eastern Gray Squirrel	X	X	X
Eastern Fox Squirrel	X	X	X
Beaver	X	X	
White-Footed Mouse	X	X	X
Deer Mouse			X
Cotton Mouse	X	X	X
Golden Mouse		X	X
House Mouse			X
Muskrat		X	
Swamp Rabbit	X	X	X
Whitetail Deer	X	X	X
Total	10	13	13

Table C-3. Birds present on control (C), periodically impounded (I), and drained (D) areas during bi-monthly, two-hour bird surveys in the Mingo Swamp.

Species	October	December	February	April	June	August
Great Blue Heron		C				
Green Heron					I	
Yellow-crowned Night Heron				I		
Mallard		I	C	C		
Gadwall				C		
American Wigeon		I				
Blue-winged Teal				CI		
Wood Duck	I		C	CID	I	
Turkey Vulture	C	C	C	I	I	C
Red-shouldered Hawk	CI	CID	CI	I	I	
Peregrine Falcon		D				
Barred Owl						D
Wild Turkey				ID		
Yellow-billed Cuckoo	C D				CID	CID
Ruby-throated Hummingbird						D
Yellow-shafted Flicker	ID	CID	ID	I		
Pileated Woodpecker	CID	I	CID	CID	D	ID
Red-bellied Woodpecker	CID	CID	CID	CID	CID	I
Red-headed Woodpecker		I				
Hairy Woodpecker	C	D	C D	C D		
Downy Woodpecker	C D	ID	CID	CID	ID	C D
Crested Flycatcher					CI	
Acadian Flycatcher	D			I	CID	CID
Wood Pewee					CID	I
Blue Jay	CID	C D	C D	CID		
Crow	CI	C D	CID	CID	CI	I
Carolina Chickadee	CID	CID	C D	CI	CID	CID
Tufted Titmouse	CID	CID	CID	CID	CID	C D
White-breasted Nuthatch	D		C		C	

continued

Table C-3. (Concluded)

Species	October	December	February	April	June	August
Brown Creeper	I	C D	CI	I		
Winter Wren	CI	I	I			
Carolina Wren	CID	CID	CID	CID	CID	ID
Mockingbird					I	
Catbird					I	
Brown Thrasher					I	
Robin			ID	D		
Wood Thrush		C		D	D	D
Blue-gray Gnatcatcher					CID	
Golden-crowned Kinglet	I	CID	I			
Ruby-crowned Kinglet	ID	I		C D		
Starling					I	
Yellow-throated Vireo					C	
Red-eyed Vireo					CI	CID
Philadelphia Vireo					I	D
Prothonotary Warbler					CI	
Northern Parula					C D	
Yellow-rumped Warbler	D			ID		
Bay-breasted Warbler	I					
Kentucky Warbler						D
Yellowthroat						D
Yellow-breasted Chat					C	
Red-winged Blackbird				I		
Rusty Blackbird	CID	I		CID	D	
Purple Grackle					I	D
Cowbird	C D			I	ID	
Cardinal		D	D	CID	CID	CID
Goldfinch				ID		
Rufous-sided Towhee						C

Table C-4. Number of census periods in which a bird species occurred near or away from the active channel of the St. Francis River: UNRC (unchannelized, forested control for recently channelized); UNPC (unchannelized, forested control for previously channelized); RC (spoil banks, recently channelized); PC (spoil banks, previously channelized); and L (forested, leveed). Arabic numerals indicate number of six bimonthly surveys during which the species was recorded.

	Number of census periods					Number of census periods				
	UNRC	UNPC	RC	PC	L	UNRC	UNPC	RC	PC	L
Green Heron					1					
Yellow-crowned Night Heron	1					1	1			1
Canada Goose	1				1					
Mallard				1	1				1	
Wood Duck	2	3		1	2	2		2	3	2
Red-tailed Hawk									1	
Red-shouldered Hawk	2	1				1	2	3	1	
Barred Owl		1			1		1		1	1
Long-eared Owl							1			
Bob-white Quail		1		1						
Killdeer			1	1	1					
Woodcock					1			1		1
Mourning Dove	2	2	1	3	4	2	1	3	1	2
Yellow-billed Cuckoo	3	2			2	2	1	3	1	1
Chimney Swift		1								
Ruby-throated Hummingbird		1	1			1				
Belted Kingfisher	1	2	2		1					
Yellow-shafted Flicker	1	3			3	1	3	3	4	3

continued

Table C-4. (Continued)

	Number of census periods					Number of census periods				
	UNRC	UNPC	RC	PC	L	UNRC	UNPC	RC	PC	L
Pileated Woodpecker	2	3			2	2	2	2	1	2
Red-bellied Woodpecker	2	6			4	3	5	4	6	4
Red-headed Woodpecker	1	1			1		1			
Yellow-bellied Sapsucker					1	1		2		
Hairy Woodpecker	2	1				1	2	1	3	
Downy Woodpecker	2	3			4	1	5	3	4	4
Crested Flycatcher		1	1					1	1	1
Eastern Phoebe				1						
Acadian Flycatcher	2	1	1		1	2	2	2	2	3
Wood Pewee						1	1	1		1
Barn Swallow	1	1	2							
Blue Jay	2	2	1	5	1	1	3	3	5	2
Common Crow	5	4	1	1		3	3	2	4	2
Carolina Chickadee	3	1			3	4	6	4	3	3
Tufted Titmouse	3	2		1	4	2	4	3	4	5
Brown Creeper	1	1			1	1	1	1	2	
Winter Wren					1	1			1	
Carolina Wren	4	4	1	1	4	3	6	6	5	5
Mockingbird			1							
Catbird										1
Brown Thrasher		1		1		1		1		

continued

Table C-4. (Continued)

	Number of census periods					Number of census periods				
	UNRC	UNPC	RC	PC	L	UNRC	UNPC	RC	PC	L
Robin	1	4		1	1	2	1	2	2	
Wood Thrush					1	1			1	1
Hermit Thrush						1		1		
Swainson's Thrush									1	
Olive-backed Thrush						1				
Gray-cheeked Thrush										1
Eastern Bluebird	1	1								
Blue-gray Gnatcatcher	2	1				1				1
Golden-crowned Kinglet									1	
Ruby-crowned Kinglet	2	1		1		2	2	3	1	1
Loggerhead Shrike	1									
Starling		3								
White-eyed Vireo	3			1		1		1	1	
Yellow-throated Vireo		1			1		1			
Red-eyed Vireo			1		1	3		1	3	1
Philadelphia Vireo		1								
Warbling Vireo										1
Black and White Warbler							1			
Prothonotary Warbler	3	1			2	1	1			1
Worm-eating Warbler	1									
Northern Parula					1	1				1

continued

Table C-4. (Continued)

	Number of census periods					Number of census periods				
	UNRC	UNPC	RC	PC	L	UNRC	UNPC	RC	PC	L
Magnolia Warbler						1				
Black-throated Green Warbler								1		
Bay-breasted Warbler						1		1		
Louisiana Waterthrush										1
Kentucky Warbler								1		
Yellowthroat		1								
Yellow-breasted Chat	2		1	2	2	1			1	
Red-winged Blackbird	4		1	3	2	1		1		
Rusty Blackbird	2	2			1		2	3	1	
Brewer's Blackbird		1							1	
Common Grackle	1	1			2	1	1		1	5
Cowbird	3	2				2	1	2	1	2
Cardinal	5	6	1	3	4	3	5	5	5	3
Indigo Bunting	1	2	2	2	1	1	1		1	
Purple Finch		3				1				1
Goldfinch		2								
Rufous-sided Towhee		1						1		
Dark-eyed Junco	1	1					1			
Tree Sparrow				1	1					
Chipping Sparrow				1						

continued

Table C-4. (Concluded)

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U.S. Fish & Wildlife Service-WELUT
Drake Creekside #1
4625 Redwing Road
Fort Collins, Colorado 80526

	Number of census periods					Number of census periods				
	UNRC	UNPC	RC	PC	L	UNRC	UNPC	RC	PC	L
Field Sparrow	1		1	4						
White-throated Sparrow	4	4			2		1	2		2
Fox Sparrow	1	1				1	1			
Song Sparrow	1									
Total (all surveys)	41	46	17	21	37	42	33	35	35	33

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The Department works to assure the wisest choice in managing all our resources so each will make its full contribution to a better United States—now and in the future.

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FISH AND WILDLIFE SERVICE
OFFICE OF BIOLOGICAL SERVICES

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Water Resources Analysis
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