PROPAGATION OF WETLAND VEGETATION ON A RIPARIAN OVERFLOW AREA IN CENTRAL OKLAHOMA

By

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PREFACE

Experimental plantings were established on a riparian overflow area on the Deep Fork River in Lincoln County, Oklahoma. Five plantings were used: common cattail (Typha latifolia), scarlet rose mallow (Hibiscus militaris), black willow (Salix nigra), buttonbush (Cephalanthus occidentalis), and a mixture of the four species. Species were established on the overflow area in three study plots of Latin square design. Plantings were monitored weekly to determine survival rates. Analysis of Variance procedures and Least Significant Difference tests were used to evaluate plant survival.

Survival in all species decreased as the field season progressed. Survival rates declined abruptly between 3 July and 11 July 1984 due to decreased soil moisture content attributed to increased competition among plant propagules and naturally established vegetation. At the conclusion of the study, survival of black willow (23.7%) was statistically greater than that of common cattail, scarlet rose mallow, buttonbush, or a mixture of the four species.

Implications of natural and artificial establishment of vegetation are discussed as they apply to the Deep Fork River floodplain. Management implications and research alternatives for experimental planting studies on Deep Fork River overflow areas also are discussed.

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CHAPTER I

INTRODUCTION

Wetlands are defined by the U. S. Fish and Wildlife Service as lands which are:

> transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water.... [W]etlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin et al. 1979:3).

Many natural wetlands in the United States have been eliminated through human activities. Only 45% of the original U. S. wetland acreage remained in the 1970's (Tiner and Wilen 1983). Oklahoma has suffered substantial losses of natural wetlands and deep-water habitats. Of an estimated 111,880 ha of wetlands inventoried in the 1950's (Shaw and Fredine 1956), only 19% of the area remained in Oklahoma two decades later (Soil Conservation Service 1977). Generally, elimination of Oklahoma wetlands has resulted from land use changes and channelization (Barclay 1980), siltation (Featherly 1940), and inundation by reservoirs and farm ponds (Oklahoma Water Resources Board 1976).

Riparian ecosystems, containing plants and animals associated with floodplains, river bottomlands, and streambank communities, have been highly vulnerable to land use conversions. Brinson et al. (1981) reported that 70% of the original floodplain forest in the United States had been eliminated, primarily through conversion for urban and agricultural uses. Likewise, riparian habitat losses have been substantial in Oklahoma. Only 13% of the original riparian vegetation has remained unaltered along 200.8 km of two southcentral Oklahoma streams (Barclay 1980).

With past and continued losses of natural wetlands in Oklahoma, and increasing socioeconomic interests in wetlands, the importance of remaining wetlands has increased. Wetlands and deepwater ecosystems provide fish and wildlife habitats, flood control, water quality maintenance, ecosystem integrity, and socioeconomic benefits.

Most of the remaining natural wetlands in Oklahoma are located along the Deep Fork River of the North Canadian River (Oklahoma Water Resources Research Institute 1980). Approximately 80% of the Deep Fork River wetlands are components of riparian ecosystems threatened by land use changes. Clearing of bottomland hardwood forests for agriculture has been common within the floodplain. Reduction of original bottomland hardwood acreage has exceeded 80% along some reaches of the Deep Fork River in Creek, Okfuskee, and Okmulgee counties, Oklahoma (Brabander et al. 1986). In Lincoln County, many lacustrine and palustrine wetlands [as defined by Cowardin et al. (1979)] have been eliminated through drainage (T. Taylor, unpubl. manuscr.).

Partial channelization of the Deep Fork River between 1912 and 1923 made floodplain lands in Lincoln County available for agricultural uses. Floodplain lands downstream in unchannelized Creek County have remained covered by stands of bottomland hardwoods. Termination of channelization at the Lincoln-Creek County line and lack of channel maintenance in recent decades have caused severe overbank flooding upstream in Lincoln County (U. S. Fish and Wildlife Service 1979).

Flooding in Lincoln County is compounded by sediment runoff from heavy grazing and nature of the soils (Williams and Bartolina 1970). Runoff into the Deep Fork River has increased stream load and subsequent depositions of alluvial materials, which have decreased channel depth (U. S. Fish and Wildlife Service 1979). The effect of deposition of alluvium has been the further extension of the floodplain and increased overbank flooding, resulting in the formation of temporarily flooded overflow areas.

Losses of wetland habitat threaten many wildlife species (Shaw and Fredine 1956, Tiner and Wilen 1983), and must be counteracted through habitat management. Wetland habitat management has taken many forms. Fredrickson and Taylor (1982) have advocated the construction of moist soil impoundments which would provide aquatic vegetation suitable as wildlife food. However, construction can be costly; Fredrickson and Taylor (1982) estimated impoundment costs in 1977 to be $30 per linear meter for a levee 1.2 m high and 3 m wide. In addition, there are hidden costs related to labor and maintenance.

Wetland habitat management along the Deep Fork River has been limited. Most wetlands along the river are privately owned and have not been managed for wildlife, presumably for economic reasons. In addition, erratic flooding and associated sedimentation along Deep Fork River overflow areas have restricted use of heavy contruction equipment, often making habitat management impractical. The high water table of the overflow areas (Williams and Bartolina 1970) even restricts use of heavy equipment during periods of natural drawdowns. Hence, the severity of flooding makes levee maintenance impractical both in terms of cost and time.

The purpose of this study was to develop an alternative wetland management technique for the Deep Fork River overflow lands, and test the feasibility of this technique in a preliminary study. Guidelines for the technique were low cost to private landowners, no use of heavy equipment, and minimal yearly maintenance costs.

Establishment of vegetation on Deep Fork River overflow areas potentially offers management benefits. Since natural vegetation induces sedimentation and creates pools on floodplains (Chaimson 1984), artificially established vegetation should induce sedimentation to create pools on Deep Fork River overflow areas. Pools then would be managed for aquatic vegetation suitable as wildlife food. However, it was unknown whether vegetation could be successfully propagated on alluvial overflow areas.

This study tested the efficacy of establishing vegetation on Deep Fork River overflow lands. The objective of the study was to evaluate survival of artificially established vegetation that was tolerant of flooding and sedimentation and had high vegetative propagation potential.

CHAPTER II

DESCRIPTION OF STUDY AREA

The Deep Fork River Floodplain

The Deep Fork River of the North Canadian River (Figure 1) extends from its headwaters near Oklahoma City in Oklahoma County, Oklahoma, eastward to Eufaula Reservoir, Okmulgee County. The river flows over a sandstone derived unconsolidated bottom (U. S. Fish and Wildlife Service 1984). The slope is 1.14 m/km near the headwaters and 0.19 m/km near the mouth, with a mean of 0.38 m/km (Chesemore 1975). Discharge is highly variable; the Oklahoma Water Resources Board (1972) has recorded discharge values at the Beggs, Oklahoma station ranging from zero in 1939, 1954, and 1956, to 1,892 m^3/sec on 11 May 1943.

Climate in the study area is warm-temperate, and is characterized by high intensity rains, with most severe storms occurring in spring. Mean annual precipitation in Lincoln County is 87.48 cm, and mean monthly precipitation is greatest in May (13.06 cm) and June (11.46 cm) (Williams and Bartolina 1970). Mean monthly temperatures in the county range from 3.8 C in January to 28 C in August.

The Deep Fork River was channelized from its headwaters near Oklahoma City to the Lincoln-Creek County line between 1912 and 1923 (Harper 1937). Lincoln County floodplain lands originally made

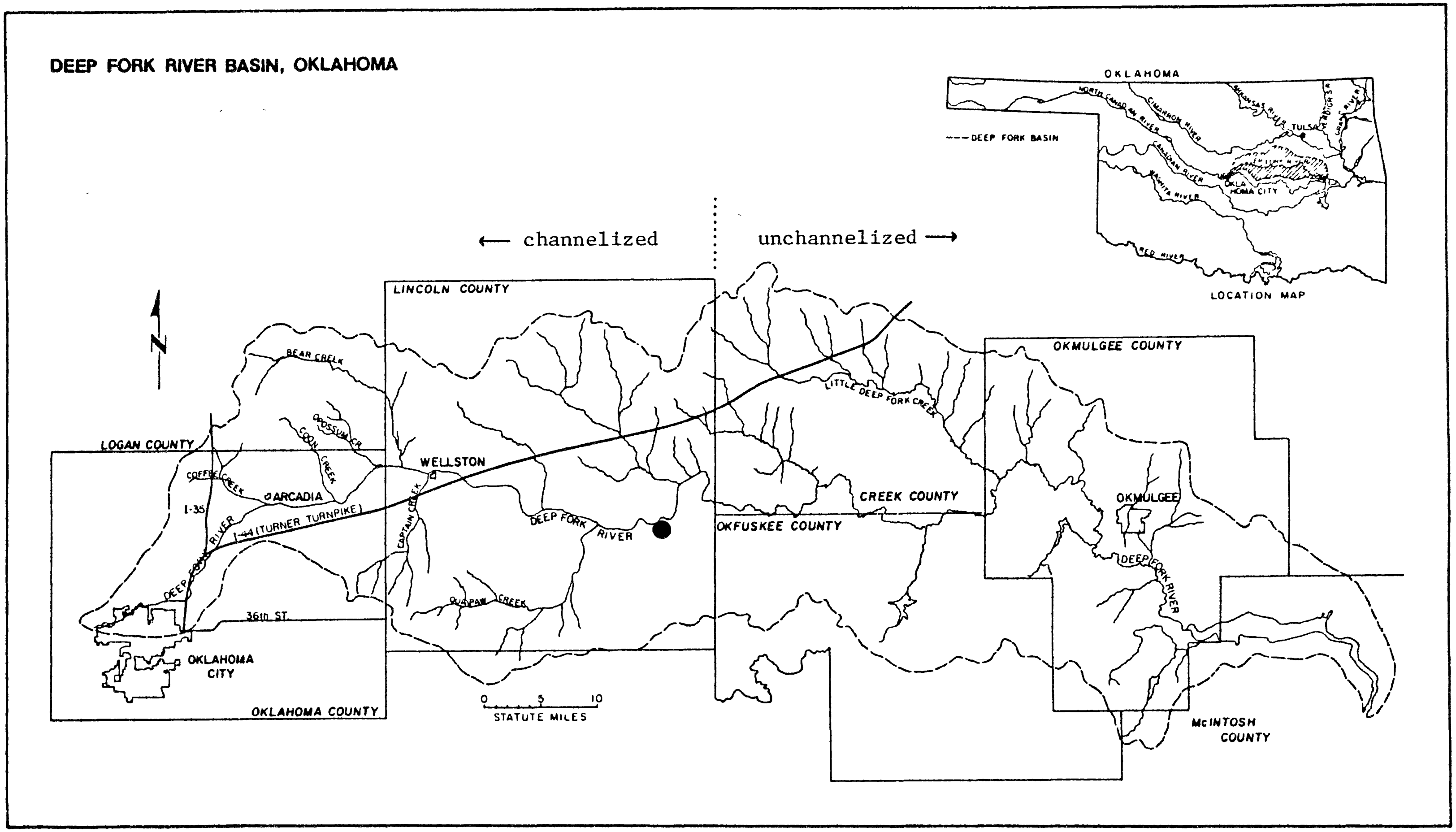

Figure 1. Deep Fork River basin, Oklahoma, depicting channelized and unchannelized segments of the river and location of the study site (●) (adapted from Oklahoma State University 1980).

available for agriculture as a consequence of channelization were used for row crops, pecan (Carya illinoensis) orchards, and pastures. The floodplain downstream (east) of the Lincoln-Creek County line has remained covered by bottomland hardwood forest. Termination of channelization at the Lincoln-Creek County line, plus lack of channel maintenance, has caused severe overbank flooding west (upstream) of the county line (U. S. Fish and Wildlife Service 1979).

Problems of flooding are compounded by sediment carried by runoff from the watershed. Heavy grazing, crop production, and petroleum development activities in Lincoln County have added to already severe problems of sheet and rill erosion (Williams and Bartolina 1970). Runoff into the Deep Fork River has increased stream load and decreased channel depth due to depositions of alluvial materials (U. S. Fish and Wildlife Service 1979). Harper (1937) documented the alluvial deposits at some portions of the channel as exceeding 1 m in depth, while Featherly (1940) found deposits exceeded 3 m. The overall effect of alluvial deposits and decreased channel depth has been to further increase overbank flooding. Shallow water habitats (overflow areas) formed from overbank flooding are common along the channelized segment but not the unchannelized portion of the Deep Fork River (U. S. Fish and Wildlife Service 1984).

Shallow water habitats adjacent to the channelized segment of the river are highly turbid, a condition attributed to frequent flooding, windy conditions, and a large population of carp (Cyprinus carpio) (U. S. Fish and Wildlife Service 1979). A scarcity of submergent and perennial emergent vegetation in the floodplain along the channelized segment also stems from high turbidity, fluctuating water levels, and carp foraging. The river and associated wetlands along the unchannelized segment of the Deep Fork River are less turbid, presumably due to the presence of riparian vegetation which acts as a buffer against surface runoff (Lowdermilk 1934, Hirsh and Segelquist 1978). The U. S. Fish and Wildlife Service (1984) considers the wetlands along the unchannelized segment of the river to be of moderate to high value for wildlife. Wetlands along the channelized segment of the river are less valuable to wildlife than wetlands in the unchannelized segment. Nonetheless, their importance to waterfowl and other forms of wildlife is great, and losses of these wetlands will have a significant impact on those resources (U. S. Fish and Wildlife Service 1984).

Description of Study Site

The study site (Figure 2) was located within a privately owned overflow area of the Deep Fork River in Lincoln County, 6.4 km east of Sparks, Oklahoma. The 194-ha site included a meander adjacent to a channelized portion of the Deep Fork River. Soils of the study site are classified as wet alluvial lands which vary in texture and are stratified with clay, loam, or sand (Williams and Bartolina 1970).

Duration of flooding on the study site varied from 8 to 10 months per year, with water heavily loaded with sediment. Natural drawdown typically occurred on the study site in late May to early June. The site occasionally was inundated following natural drawdown, although water rarely exceeded 10 cm deep or persisted more than one week.

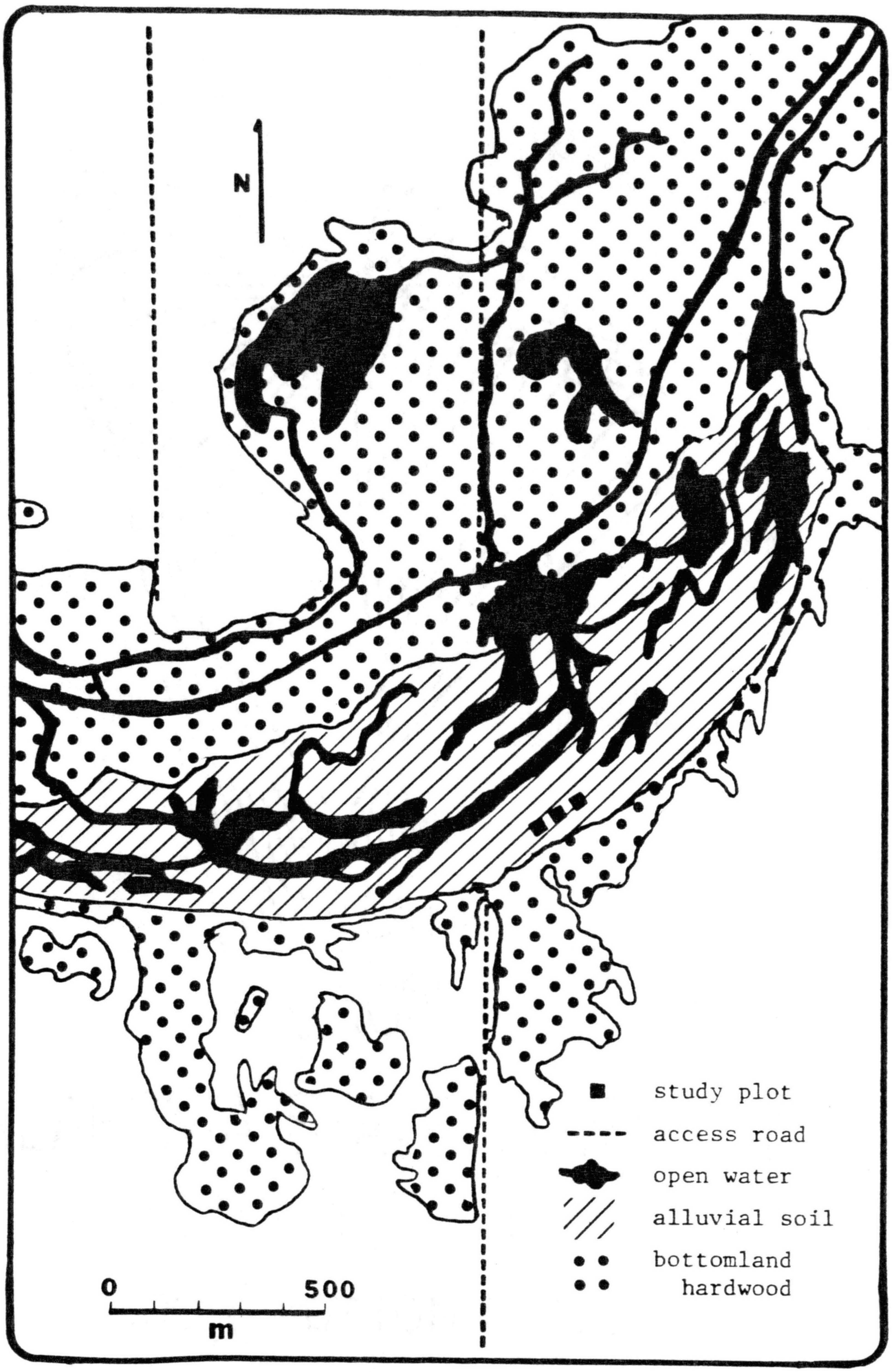

Figure 2. Study site depicting location of study plots.

Vegetation on the study site ranged from bottomland hardwood forest to seasonal emergent plant communities. The bottomland hardwood forest was typified by eastern cottonwood (Populus deltoides), green ash (Fraxinus pennsylvanica), and American elm (Ulmus americana). Black willow (Salix nigra) and buttonbush (Cephalanthus occidentalis) were abundant along the margins of the overflow area.

Composition of the emergent vegetation community of the overflow area was observed from fall 1982 to spring 1985. In September 1982, the overflow area primarily consisted of alluvial mudflats sparsely vegetated by scarlet rose mallow (Hibiscus militaris). The study site was inundated during the winter of 1982 and periodically throughout the 1983 growing season. Scarlet rose mallow, a perennial, persisted through inundation, and again dominated the site during the 1983 growing season. Following a natural drawdown, the overflow area was colonized by emergent vegetation such as flatsedge (Cyperus strigosus), smartweeds (Polygonum coccinium, P. persicaria, and P. pensylvanicum) and pigweed (Amaranthus palmeri). Stands of wild millet (Echinochloa crusgalli) were seeded by the landowner following natural drawdown.

The study site was inundated during the winter of 1983 until late May 1984. The site again was colonized by flatsedge, smartweeds, and pigweed during low water conditions during the 1984 growing season. Flatsedge was the dominant species on the overflow area, with heights of some individual plants exceeding 2.5 m by August of 1984. Scarlet rose mallow was present on the study site, but was less abundant than emergent species. Black willow seedlings and common cattail (*Typha latifolia*) stands also naturally established on the study site.

Final observations of the study site were made in March 1985 following natural drawdown. Flatsedge stalks persisted from the 1984 growing season, but no new growth was yet evident. Development of common cattail shoots was noted. No black willow seedlings were known to have survived from the previous growing season. Scarlet rose mallow clumps again persisted at the study site.

CHAPTER III

METHODS

Selection of Species

Species were selected for experimentation following a literature review and preliminary studies. Criteria for selection were flood and sedimentation tolerance, adaptability to alluvial soil, and obtainability. Preliminary survival studies were conducted during 1983. Herbaceous species used were flatsedge and scarlet rose mallow. Woody species included buttonbush, swamp privet (*Forestiera acuminata*), black willow, and green ash. Plant propagules were obtained at the study site; cuttings from all species were collected with a machete, with the exception of flatsedge, which was transplanted. Propagules were pushed 30-40 cm into the alluvium. No statistical analysis procedures were used to evaluate the 1983 data. Two woody and two herbaceous species were selected to test for propagation in 1984; common cattail, scarlet rose mallow, black willow, buttonbush, and a mixture of the four species.

Experimental Design

The Latin square experimental design was chosen for this study for several reasons. The design allows treatment effects to be studied from small-scale experiments, such as preliminary and pilot experiments (Neter and Wasserman 1974). The Latin square also reduces the effects that two sources of uncontrolled variations have on treatment error (Cox 1958, Neter and Wasserman 1974). Hence, its application is appropriate in natural systems where environmental gradients exist.

Species were assigned positions in three study plots of randomized Latin square design (Figure 3). The Latin square design was chosen to test the effects of row and column positions on survival rates of species because of potential soil moisture gradients. Each plot contained 100 plant propagules per species to allow plant survival to be estimated within 10% standard error with 95% confidence. Blocks within plots contained 20 propagules per species. Mixed species blocks contained five propagules of each of the four species.

Collection of Propagules

Plant propagules were collected from two sites. Common cattail, buttonbush, and black willow were obtained from Lake Carl Blackwell, Payne County, Oklahoma, where a technician was available to collect propagules. Common cattail was collected during dormancy as recommended by Kadlec and Wentz (1974). Buttonbush and black willow were collected prior to planting. Scarlet rose mallow, an herbaceous species, was obtained on the study site because of its availability and to reduce stress to the propagules.

Dormant common cattail rhizomes were collected on 9 March 1984 from Lake Carl Blackwell. Rhizomes were excavated with a shovel and

PLOT

ROW	Plot 1: Col 1	2	3	4	5	Plot 2: Col 1	2	3	4	5	Plot 3: Col 1	2	3	4	5
1	C	W	X	B	M	B	W	M	X	C	M	W	B	C	X
2	M	B	C	X	W	X	B	W	C	M	W	B	X	M	C
3	X	M	B	W	C	W	M	C	B	X	C	M	W	X	B
4	B	C	W	M	X	M	C	X	W	B	X	C	M	B	W
5	W	X	M	C	B	C	X	B	M	W	B	X	C	W	M

COLUMN

C = Common Cattail
M = Scarlet Rose Mallow
W = Black Willow
B = Buttonbush
X = Mixture

Figure 3. Study plots 1, 2, and 3 depicting species positions.

packed in plastic trash bags. The bags were transferred to a cold room (approximately 4 C) at Oklahoma State University. Rhizomes remained in cold storage until 24 May 1984.

Cuttings from scarlet rose mallow, black willow, and buttonbush were collected using a machete. Black willow and buttonbush were collected 23 May 1984 from Lake Carl Blackwell. Young basal growth of black willow and young terminal branches of buttonbush were selected. The woody cuttings were trimmed of leaves to reduce transpiration, then cut into 30-45 cm sections. Cuttings were placed in plastic trash bags and transported to the cold room. On 24 May 1984, common cattail rhizome sections 20-30 cm long were placed into small plastic bags in groups of twenty; black willow and buttonbush propagules were tied into bundles of twenty. These species were transferred from cold storage to the study area on 25 May 1984. Scarlet rose mallow cuttings were collected by sectioning plants with a machete at the study site on 25 May 1984.

Establishment of Wetland Vegetation in Alluvial Soil

Planting began when water on the overflow area receded to avoid potential washouts of propagules. The propagules were established in previously assigned positions in three plots on the alluvial mudflats of the study area (Figure 2). The plots measured 15 m x 15 m and were spaced at 30 m intervals. Each species was randomly assigned five blocks, each containing twenty propagules. Mixed species blocks contained five propagules of each of four species.

Planting techniques were modified from Hunt et al. (1978) and Rafaill and Vogel (1978). Common cattail rhizomes were planted 5-10 cm below soil surface using a machete to create an opening in the alluvium. Cuttings 30-45 cm long of scarlet rose mallow, black willow, and buttonbush were pushed into the substrate with 15-20 cm projecting above the surface. Propagules were not treated with rooting hormones or sealants.

Propagules within each block were marked with flagging tape and plastic nursery tags bearing row and column coordinates. Blocks within study plots were designated by row and column coordinates. Propagules were monitored weekly for survival during the field season. Evidence of new growth also was recorded. Qualitative observations of soil moisture regimes and environmental conditions were made.

Statistical Analyses

An Analysis of Variance model (Steel and Torrie 1980) was used to analyze variations in survivorship among species compiled over all plots, blocks within plots, and observations (Appendix A). Variances in species survival among upstream (plot 1), midstream (plot 2), or downstream (plot 3) study plots were evaluated. Row and column effects within plots also were tested. Where the F-value was significant, protected Least Significant Difference tests (Steel and Torrie 1980) were used to evaluate differences in plant survival (Appendix B).

Variations in species survival compiled for all plots and blocks within plots were analyzed for each observation date (Appendix A). Least Significant Difference tests also were used to evaluate survival rates among species for individual observation dates (Appendix B).

CHAPTER IV

RESULTS

Species survival in the 1983 field season was greatest for scarlet rose mallow and black willow (Table I). Survival of scarlet rose mallow was lower in plots established later in the growing season. Analysis of Variance procedures and Least Significant Difference tests were not performed on 1983 data, as previously stated.

Plant propagules were established 25 May 1984 under moist soil conditions. Floodwaters inundated the study plots on 1 June 1984, and the study site was inaccessible the following week. The propagules were then examined weekly from 13 June until 5 August 1984. Weed control was not implemented in the study plots; hence, plots were rapidly colonized by smartweed, pigweed, and flatsedge. Despite the precautions of marking and flagging, propagules were difficult to locate on the study site after 5 August 1984, and observations were terminated.

Soil moisture regimes in the study plots varied during the field season (Table II). Soils in the plots initially were moist to saturated. However, soil moisture decreased as the season progressed. The soil surface was dry and cracked from late July until the conclusion of the study.

TABLE I

SPECIES SURVIVAL IN THE 1983 DEEP FORK RIVER VEGETATION ESTABLISHMENT STUDIES

SPECIES	NUMBER ESTABLISHED	NUMBER SURVIVED	SURVIVAL (%)
PLOT A[1]			
Buttonbush	8	0	0.0
Swamp Privet	5	0	0.0
Black Willow	8	3	37.5
Green Ash	15	0	0.0
Flatsedge	8	5	62.5
Scarlet Rose Mallow	5	5	100.0
PLOT B[2]			
Black Willow	21	1	4.8
Scarlet Rose Mallow	7	3	42.7
PLOT C[3]			
Scarlet Rose Mallow	24	6	25.0

1 Plot A established 6/30/83 and observed through 8/9/83.

2 Plot B established 8/10/83 and observed through 10/14/83.

3 Plot C established 8/27/83 and observed through 10/14/83.

TABLE II

SUMMARY OF SOIL MOISTURE REGIMES IN THE STUDY PLOTS DURING THE 1984 FIELD SEASON

DATE (1984)	PLOT	SOIL MOISTURE REGIME
25 May	1	surface moist
	2	saturated
	3	saturated
1 June	1	newly inundated
	2	same
	3	same
13 June	1	surface moist
	2	saturated
	3	saturated
20 June	1	surface dry, underlying soil moist
	2	moist
	3	saturated
27 June	1	newly inundated
	2	same
	3	same
3 July	1	inundated < 10 cm; row 3 saturated
	2	saturated
	3	saturated
11 July	1	surface dry, underlying soil moist
	2	surface moist; column 5 drier
	3	surface moist; columns 1 and 2 dry
19 July	1	surface dry, underlying soil dry
	2	same
	3	same
31 July	1	surface dry, underlying soil dry
	2	same
	3	same
5 August	1	surface dry, underlying soil dry
	2	same
	3	same

Data collected prior to 13 June 1984 were not analyzed because of missing observations. All other observations were included in the analysis (Appendix A). Variations among species survival means over all observations were significant (F=38.04). Effects of study plot positions on species survival also were significant (F=16.74). Variations among rows and columns within plots did not significantly affect plant survival.

Differences in mean species survival among study plots were evaluated with Least Significant Difference tests (Appendix B). Mean survival for all species over all observations in study plot 1 was significantly less than survival means in plots 2 and 3.

Mean survival among species (calculated in all blocks within plots over all observations) evaluated with Least Significant Difference tests indicated that overall mean survival of black willow was significantly greater than the other species (Appendix B). Survival means for all blocks within plots for each observation date also were analyzed with Least Significant Difference tests (Appendix B). Mean survival in scarlet rose mallow was lower than the other species on 13 May 1984, but by 11 July mallow survival was higher than other species. Black willow had the highest mean survival at the conclusion of the field season (5 August 1984); whereas, survival means for the other species were not statistically different.

Survival in all species was high at the onset of the study, but decreased as the field season progressed (Figure 4). Fluctuations in initial percent survival of scarlet rose mallow, black willow, and

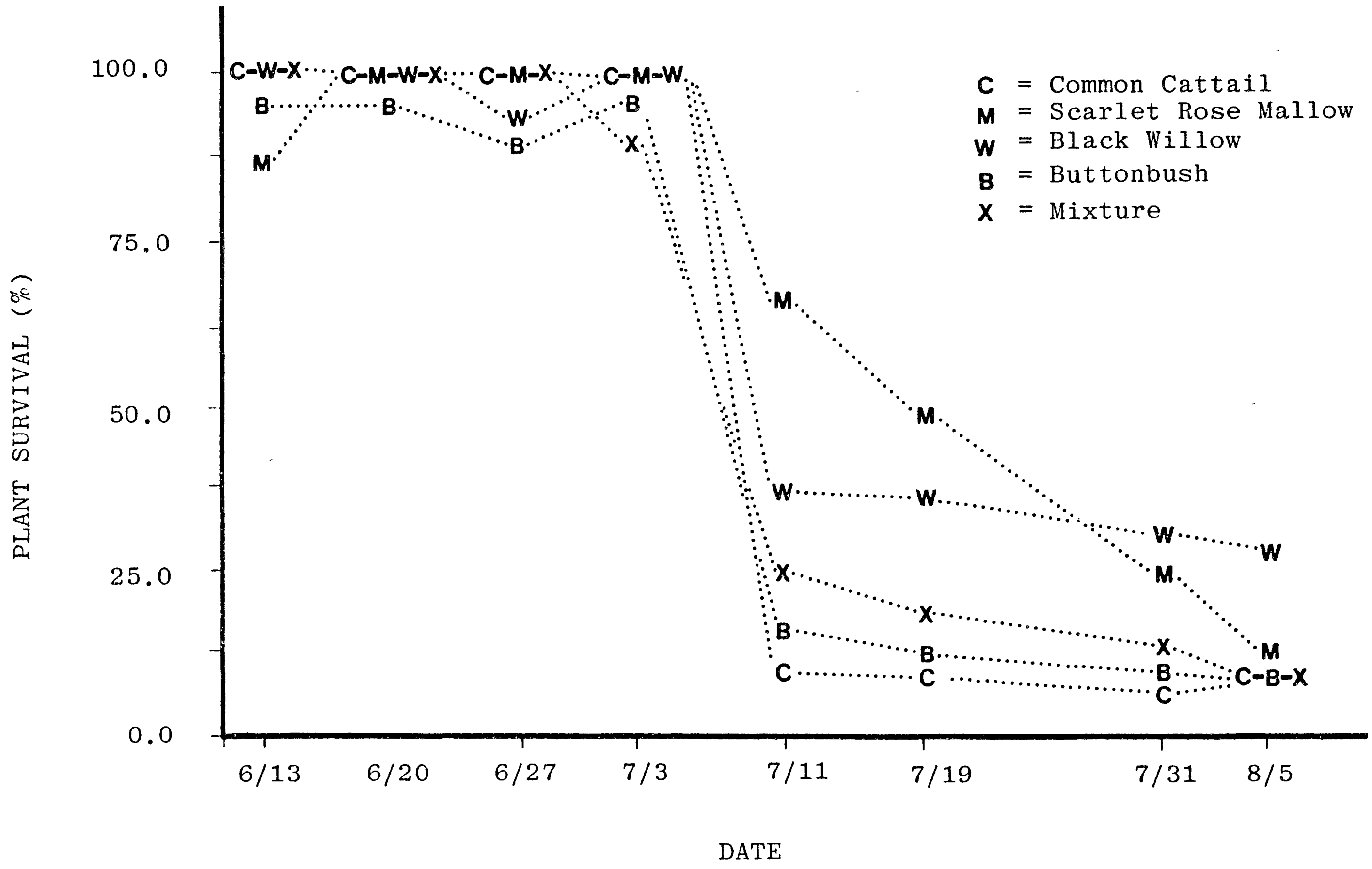

Figure 4. Percent survival of species propagules established on the Deep Fork River overflow area during the 1984 field season.

buttonbush (Figure 4) are attributed to calculating percent survival from mean values. Survival in all species declined abruptly between 3 July and 11 July 1984, presumably due to competition for soil moisture among plant propagules and natural vegetation such as flatsedge, smartweeds, and pigweed. The decrease in available soil moisture also was attributed to falling river level, lack of rainfall, and increased ambient air temperature. Percent survival of black willow was considerably greater (23.7%) than the other species at the conclusion of the study; the remaining species had percent survival values less than 8% (Table III).

New growth in black willow and buttonbush propagules was good initially, but declined as the field season progressed (Figure 5). New growth in scarlet rose mallow propagules was not evident until 27 June 1984 when new growth abruptly increased, followed by a steady decrease throughout the remainder of the study (Figure 5).

TABLE III

SPECIES SURVIVAL AT THE CONCLUSION OF THE 1984 DEEP FORK RIVER VEGETATION ESTABLISHMENT STUDY

Species	Mean[1]	Survival (%)[2]
Common Cattail	1.20	6.0
Scarlet Rose Mallow	1.53	7.7
Black Willow	4.73	23.7
Buttonbush	1.13	5.7
Mixture:	1.13	5.7
common cattail	0.00	0.0
scarlet rose mallow	0.33	1.7
black willow	0.13	0.6
buttonbush	0.67	3.4

1 Mean number of living propagules in all blocks in all plots on 5 August 1984.

2 $\frac{\text{Mean} \times 100}{20}$

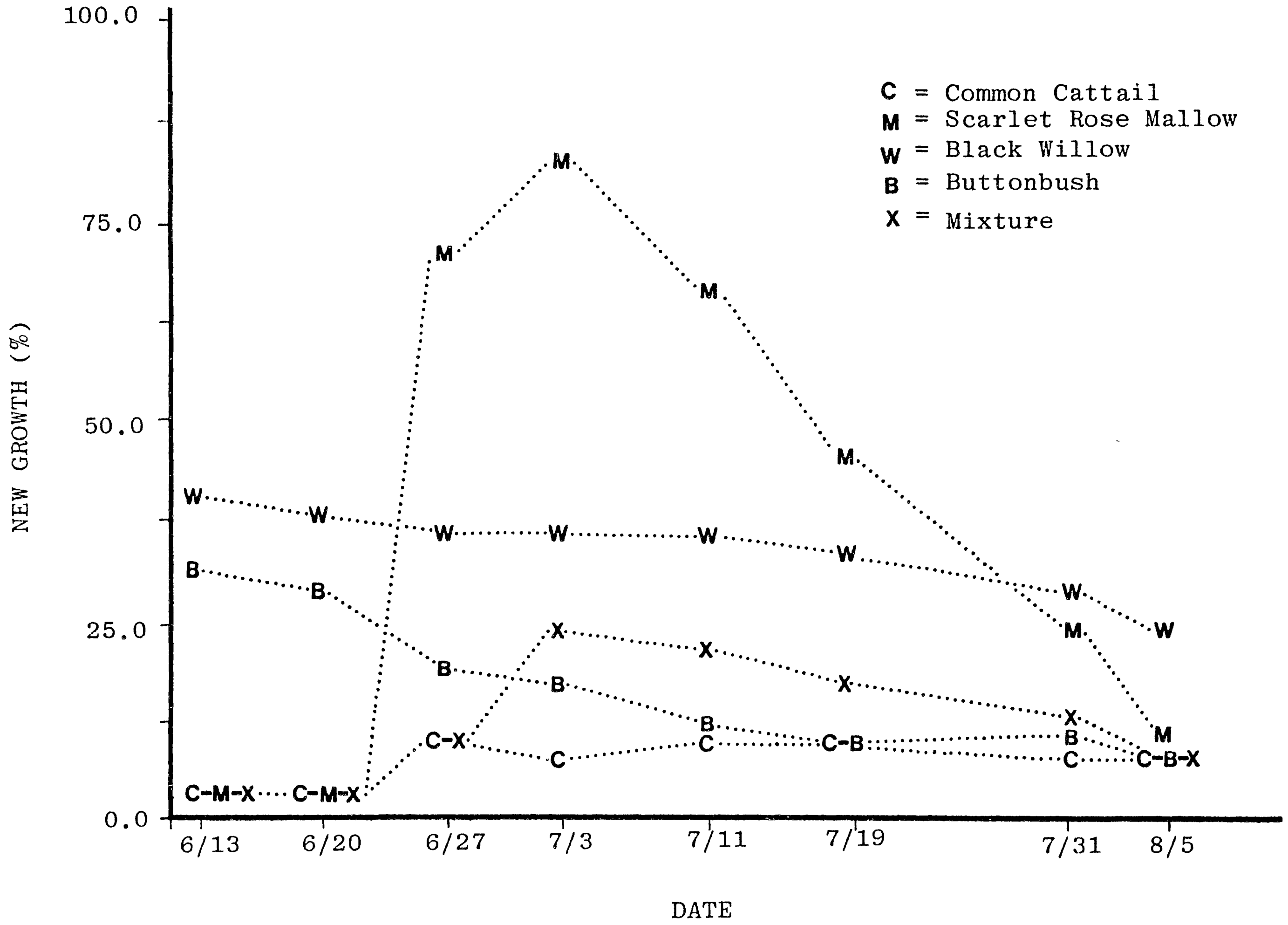

Figure 5. Percent new growth of species propagules established on the Deep Fork River overflow area during the 1984 field season.

CHAPTER VI

DISCUSSION

Effect of Species Position on Plant Survival

An attempt was made in this study to select similar locations for plot replicates; however, variations within and among study plots were possible. The Latin square design allowed row and column effects to be tested in this study to determine whether position of species within plots influenced plant survival. Although soil moisture content occasionally varied among rows and columns within plots, row and column positions did not significantly affect species survival (Appendix A). Therefore, variances in soil moisture content within study plots were not significant.

Variances in soil moisture content also were noted among study plots. Throughout much of the field season, plot 1 was drier than plots 2 or 3. Mean species survival in plot 1 was significantly lower than survival means in plots 2 and 3; this difference was attributed to soil moisture variances among plots.

Survival of Experimental Plantings

Common cattail displayed poor survival (6.0%). Obtaining propagules from an area other than the study site may have influenced survival. However, ecotypic variations in common cattail are not great, due to its wide distribution (McNaughton 1966). The attempt to establish common cattail should not have been impaired by environmental conditions on the Deep Fork River overflow area. Rootstock propagation of cattail is optimal when soils are inundated 3 cm (Bedish 1967). Common cattail is extremely tolerant of flooding (Hall et al. 1946), although it can be susceptible to winter inundation (Mathiak 1971). More likely, reduced viability of cattail propagules resulted in poor survival. Although collection during dormancy is recommended, storing common cattail rootstock approximately 12 weeks probably reduced viability due to anaerobic conditions.

Scarlet rose mallow has been considered intolerant of turbidity (Kadlec and Wentz 1974); however, it is dominant on Deep Fork River overflow areas where turbidity often limits macrophyte establishment (U. S. Fish and Wildlife Service 1979). Scarlet rose mallow is extremely flood tolerant (Hall et al. 1946) and persists on the study site throughout the year.

Survival of scarlet rose mallow propagules in the 1984 study (7.7%) was relatively low compared to survival rates in the preliminary studies (Table I). Decreased survival probably resulted from decreased soil moisture content, since the site was drier in 1984; propagules in both the preliminary and present studies were drought stressed as the field season progressed. New growth in scarlet rose mallow propagules was not evident until 27 June 1984. Propagules typically wilted and lost terminal growth before new lateral growth developed.

Black willow displayed the highest survival (23.7%) of all the species. Initially, more black willow propagules sprouted than any other species, but later was surpassed by scarlet rose mallow. However, when soil moisture content decreased as the field season progressed, black willow, but not scarlet rose mallow propagules were able to survive.

In spite of extreme tolerance of mature buttonbush plants to harsh environmental conditions (Green 1947, Yeager 1949, DeGruchy 1956), buttonbush propagules displayed poor survival in both the preliminary and present studies. Propagules sprouted early in the 1984 field season, but died as soil moisture content decreased. However, buttonbush cuttings have been propagated successfully along the Kings River in California (Parnell 1978); cuttings rooted well and were tolerant of both flooding and sedimentation.

The mixture of species served to test for allelopathy, which has been documented in some aquatic plants. Evidence exists that common cattail eliminates other vegetation through crowding and shading or through exuding toxins (Bedish 1967). However, Grace (1983) found that allelopathy in common cattail primarily was limited to exclusion of seedlings of itself and other species. However, no common cattail survived in the mixture during the present study, thus no conclusions can be drawn regarding allelopathy. No species survived well in the mixture; buttonbush propagules had the highest survival (3.4%) compared to the other species. Further studies would be necessary, though, to ascertain whether buttonbush is allelopathy.

Limiting Factors on Plant Establishment

Establishment of aquatic macrophytes may be affected by water depth, substrate, fluctuations of water levels (Bell 1956, Lantz 1974), available nutrients, water hardness (Hynes 1972), light attenuation caused by turbidity, grazing, and presence of toxins and pollutants (Davis and Brinson 1980). Aeration of roots is important for survival in woody species (Teskey and Hinckley 1977), although several saltwater species are capable of taking up oxygen through leaves (Sculthorpe 1967). Soil composition also may influence vegetation establishment. Since clay soils, such as those found in Deep Fork River alluvial deposits, are hard when dry and contribute to turbidity when inundated (Kadlec and Wentz 1974), plantings are not easily established. Turbidity and reduced light attenuation also limit plant establishment along the Deep Fork River floodplain (U. S. Fish and Wildlife Service 1979).

Size and type of species are important considerations when establishing vegetation in flood-prone areas (Whitlow and Harris 1979). Flooding of Deep Fork River overflow areas is a limiting factor for establishing many species. However, flooding during the dormant season has little or no effect on survival of most mature woody species (Silker 1948, Hall and Smith 1955, Broadfoot 1967). Hall and Smith (1955) found that survival of black willow and buttonbush decreased with increased depth and duration of inundation. Root adaptations also are considered critical to flood tolerance in woody species (Hook and Brown 1973). Sedimentation associated with flooding has altered plant communities of the Deep Fork River bottomlands (Harper 1937, Featherly 1940, Chesemore 1975).

Natural Establishment of Wetland Vegetation

Although aquatic macrophytes can reproduce both sexually and vegetatively, most species rely heavily on vegetative propagation since flowering often is unsuccessful in aquatic environments (Sculthorpe 1967). Mechanical fragmentation of vegetative structures is thus an important propagation method in some macrophyte species (Hutchinson 1975). Many emergent species, including common cattail and willows, have seeds which are dispersed by wind, thus allowing for rapid colonization when suitable substrates are available. The reproductive modes of species used in this study are summarized below.

Buttonbush reproduces by seeds and transplants; cattails reproduce by transplants, rootstocks, rhizomes, and seeds (Kadlec and Wentz 1974). Flowering only occurs in cattails when resources are abundant (Grace 1980). Common cattail seeds germinate well under reduced oxygen conditions, but oxygen is required for proper shoot and chlorophyll development (Moyle 1945). Black willow reproduces by seeds and transplants. Although reproduction in scarlet rose mallow has not been well documented, seed production was observed during the present study.

The ability for a species to colonize bare soil areas is advantageous for natural establishment. The wind-dispersed seeds of willows (*Salix* spp.) and cottonwoods (*Populus* spp.) are adapted for rapid colonization of bare areas such as alluvial mudflats. Perennial emergents such as cattails and mallows also invade bare areas quickly (Kadlec and Wentz 1974). Buttonbush, common cattail, and *Hibiscus trionum*, an exotic mallow, were found to be early successional species of drained lake beds (Lake Tonganoxie and Lake Fegan in Kansas) (McGregor and Volle 1950).

Invasion depths of aquatic macrophytes were studied in artificial marshes in New York Dane (1959). Cattail (*Typha* spp.) invaded at 66 cm water depth, buttonbush was established at 51 cm, and willows at 30-46 cm. Hosner and Minckler (1963) observed that succession of bottomland hardwood forests in Illinois was retarded in poorly drained areas. Buttonbush, water tupelo (*Nyssa aquatica*), and bald cypress (*Taxodium distichum*) were the early successional species. Perennial flatsedges (*Cyperus* spp.), annual emergents, and amphibious and terrestrial forms of *Scirpus* spp., *Amaranthus* spp., and *Euphorbia* spp. were the primary successional species on exposed mudflats along river lowlands in India (Rai and Datta Munshi 1982).

Black willow and other members of the family Salicaceae traditionally are considered pioneer species. The colonization of river floodplains by willows (*Salix* spp.) promotes deposition of sediment and organic materials, which makes conditions favorable for cottonwood (*Populus* spp.) succession (Daubenmire 1968). Black willow is tolerant of both sedimentation and inundation and grows well in alluvial soils. Growth is greatly enhanced by moist soil conditions (Green 1947, McLeod and McPherson 1973).

Scarlet rose mallow often is considered a pest species and has not been studied thoroughly. However, another mallow species, Hibiscus palustris, became dominant following a June drawdown of an Ohio marsh (Meeks 1969). Hibiscus tiliaceus is considered a primary successional species in mangrove swamps in Nigeria (Edwards and Ekundayo 1982).

Common cattail rapidly colonizes bare mudflats; establishment may be impeded in those impoundments where a constant water level is maintained (Kadlec 1962), but may be favored by drawdown conditions (Belonger 1969). Cattail can be outcompeted on drier substrates by sedges (Carex spp. and Scirpus spp.) (Kadlec 1962).

Artificial Establishment of Wetland Vegetation

Propagule survival on the study site apparently decreased when plantings were drought stressed. Survival could be increased through the use of several techniques not employed in this study. Irrigation, diking, and weed management, for example, can increase available soil moisture thereby improving survival (Anderson et al. 1984, Goldner 1984). Use of rooting hormones, sealants on cuttings, and prerooting dormant propagules also can enhance survival (Swenson and Mullens 1985).

Successful establishment of wetland vegetation thus depends upon several factors. Transplants and cuttings were preferred to seeding in this study, as recommended for planting sites subject to extreme environmental conditions such as erosion, sedimentation, and flooding (Woodhouse et al. 1974). Timing of propagule collection and planting also affects establishment success. Common cattail transplants in this study were collected during dormancy, since this reduces propagule stress (Kadlec and Wentz 1974, Swenson and Mullens 1985).

Time and cost also are important considerations when establishing wetland vegetation. A few outdated cost estimates exist for collecting and planting wetland vegetation. However, time estimates for this study indicated that collection rates were 200-250 propagules/worker/hour for woody cuttings, 300 propagules/worker/hour for scarlet rose mallow cuttings, and 150-200 propagules/worker/hour for common cattail. Use of a back-hoe on firm substrates could facilitate collection of transplants (Woodhouse et al. 1974).

Management Implications of Artificially Established Wetland Vegetation

Successful establishment of wetland vegetation on Deep Fork River overflow areas has several management implications. The use of vegetation to induce sedimentation is feasible; Chaimson (1984) documented deposition of river-borne materials downstream from a willow clump. The United States Army Corps of Engineers has used vegetation in conjunction with revetments on the Missouri River to provide stabilization and add wildlife benefits (Allen 1979). Established vegetation along Deep Fork River overflows also could reduce erosion; vegetation can trap sediments, provide soil stabilization, and enhance infiltration of soil (Bailey and Copeland 1961, Sigafoos 1964, Carter et al. 1979, Dean 1979).

Successful establishment of vegetation on Deep Fork River overflow areas also can provide food and cover for wildlife. Species in this study were selected for tolerance to flooding and sedimentation, but also in part for potential wildlife values. Mallow (Hibiscus spp.) and buttonbush seeds are eaten by waterfowl (McAtee 1918, Mabbott 1920). Beaver eat common cattail (Hamerstrom and Blake 1939), buttonbush (Johnson 1927), and black willow (Atwood 1938). Muskrats rely heavily on common cattail (Johnson 1925, Hamerstrom and Blake 1939), but also use buttonbush (Johnson 1925). Cattails (Typha spp.) provide substrate for aquatic insects (Froehne 1938). When inundated, buttonbush and black willow create good habitat for young fish (Whitlow and Harris 1979).

Research Alternatives

Low propagule survival in this study indicates that alternatives are needed if vegetation is to be successfully established on Deep Fork River overflow areas. Concentration on propagation of black willow and scarlet rose mallow is recommended for further plant establishment studies, based on their survival rates during the 1983 and 1984 field seasons. Application of rooting hormones and sealants, or prerooting dormant cuttings also are recommended to enhance propagule survival in future studies.

Natural vegetation also could improve Deep Fork River mudflats for wildlife. The emergent vegetation which colonized the study site during a natural drawdown provided cover and a potential food source for wildlife. Woody vegetation could be established in conjunction with natural growth to induce sedimentation and influence creation of pools via water current manipulation. Woody vegetation also would provide soil stabilization.

Use of native species is recommended for future plant establishment studies, since further research is needed regarding management of native wetland species (Whitlow and Harris 1979, Shields and Palermo 1982). Future studies also should recognize the need for research concentration into life history information, taxonomic investigations, and improved management techniques.

CHAPTER VI

SUMMARY

Many natural wetlands in Oklahoma and other states have been eliminated through land use conversions, siltation, and inundation. Riparian wetlands especially have been vulnerable. Most riparian wetlands in Oklahoma are located along the Deep Fork River. Deep Fork River wetlands also have been threatened by land use changes. Reduction of habitat along some reaches of the river have exceeded 80% (Brabander et al. 1986). Management of existing wetlands can mitigate loss of habitat. However, wetland management along the Deep Fork River must be geared toward private landowners.

The purpose of this study was to develop a management technique for Deep Fork River wetlands. The objective of the study was to test whether wetland vegetation could be artificially established on riparian overflow lands. Vegetation could then be used to induce sedimentation and create pools on the overflows areas.

Two herbaceous and two woody wetland species were selected for planting based on a literature review and preliminary vegetation establishment studies. The plantings used were common cattail, scarlet rose mallow, black willow, buttonbush, and a mixture of the four species. Propagules were established in three study plots of Latin square design on a 194-ha study site. Propagules were observed weekly throughout the field season for survival and new growth. Data were evaluated using Analysis of Variance procedures and Least Significant Difference tests.

Survival of black willow (23.7%) was significantly greater than for other species at the conclusion of the field season. Propagule survival declined with increased competition for soil moisture among propagules and natural vegetaiton. Decreased soil moisture content also was attributed to falling river level, lack of rainfall, and increased ambient air temperature. Black willow traditionally is a pioneer species of bare areas, such as Deep Fork River alluvial lands. Its ability to colonize areas rapidly may account for the higher survival rate.

Survival of propagules potentially could increase through use of several techniques not employed in this study. Use of rooting hormones, sealants on cuttings, and prerooting dormant cuttings are recommended for future plant establishment studies on Deep Fork River overflow areas. Further studies with black willow and scarlet rose mallow also are recommended.

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APPENDIX A

ANALYSIS OF VARIANCE PROCEDURES FOR

MEAN PLANT SURVIVAL

APPENDIX A-1

ANALYSIS OF VARIANCE PROCEDURE FOR EFFECTS OF PROPAGULE POSITIONS ON SPECIES SURVIVAL OVER ALL OBSERVATIONS

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
MODEL	30	300.67000000	6.92 *	0.0001
PLOT	2	48.44666667	16.74 *	0.0001
ROWS IN PLOTS	12	20.89500000	1.20	0.3113
COLUMNS IN PLOTS	12	11.11375000	0.64	0.7966
SPECIES	4	220.21458333	38.04 *	0.0001
ERROR	44	63.68416667		
CORRECTED TOTAL	74	364.35416667		

* Denotes statistical significance

APPENDIX A-2

ANALYSIS OF VARIANCE PROCEDURE FOR EFFECTS OF PROPAGULE POSITIONS ON SPECIES SURVIVAL ON 13 JUNE 1984

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
MODEL	38	4983.00000000	15.59 *	0.0001
PLOTS	2	38.00000000	2.28	0.1169
ROWS IN PLOTS	12	100.00000000	1.00	0.4685
COLUMNS IN PLOTS	12	100.00000000	1.00	0.4685
SPECIES	4	4521.33333333	135.64 *	0.0001
PLOT-SPECIES INTERACTION	8	178.66666667	2.68	0.0202
ERROR	36	300.00000000		
CORRECTED TOTAL	74	5238.00000000		

* Denotes statistical significance

APPENDIX A-3

ANALYSIS OF VARIANCE PROCEDURE FOR EFFECTS OF PROPAGULE POSITIONS ON SPECIES SURVIVAL ON 20 JUNE 1984

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
MODEL	38	12.66666667	1.00	0.5012
PLOTS	2	0.66666667	1.00	0.3779
ROWS IN PLOTS	12	4.00000000	1.00	0.4685
COLUMNS IN PLOTS	12	4.00000000	1.00	0.4685
SPECIES	4	1.33333333	1.00	0.4203
PLOT-SPECIES INTERACTION	8	2.66666667	1.00	0.4529
ERROR	36	12.00000000		
CORRECTED TOTAL	74	24.66666667		

* Denotes statistical significance

APPENDIX A-4

ANALYSIS OF VARIANCE PROCEDURE FOR EFFECTS OF PROPAGULE POSITIONS ON SPECIES SURVIVAL ON 27 JUNE 1984

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
MODEL	38	153.86666667	2.70 *	0.0017
PLOTS	2	13.54666667	4.52	0.0177
ROWS IN PLOTS	12	15.44000000	0.86	0.5930
COLUMNS IN PLOTS	12	16.64000000	0.93	0.5324
SPECIES	4	1.33333333	7.15 *	0.0002
PLOT-SPECIES INTERACTION	8	42.85333333	5.46 *	0.0002
ERROR	36	53.92000000		
CORRECTED TOTAL	74	207.78666667		

* Denotes statistical significance

APPENDIX A-5

ANALYSIS OF VARIANCE PROCEDURE FOR EFFECTS OF PROPAGULE POSITIONS ON SPECIES SURVIVAL ON 3 JULY 1984

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
MODEL	38	127.22666667	13.22 *	0.0001
PLOTS	2	13.30666667	26.26 *	0.0001
ROWS IN PLOTS	12	3.04000000	1.00	0.4685
COLUMNS IN PLOTS	12	3.04000000	1.00	0.4685
SPECIES	4	31.28000000	30.87 *	0.0001
PLOT-SPECIES INTERACTION	8	76.56000000	37.78 *	0.0001
ERROR	36	9.12000000		
CORRECTED TOTAL	74	136.34666667		

* Denotes statistical significance

APPENDIX A-6

ANALYSIS OF VARIANCE PROCEDURE FOR EFFECTS OF PROPAGULE POSITIONS ON SPECIES SURVIVAL ON 11 JULY 1984

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
MODEL	38	2014.82666667	7.93 *	0.0001
PLOTS	2	280.50666667	20.98 *	0.0001
ROWS IN PLOTS	12	100.64000000	1.25	0.2868
COLUMNS IN PLOTS	12	90.24000000	1.12	0.3716
SPECIES	4	1382.74666667	51.70 *	0.0001
PLOT-SPECIES INTERACTION	8	160.69333333	3.00	0.0109
ERROR	36	240.72000000		
CORRECTED TOTAL	74	2255.54666667		

* Denotes statistical significance

APPENDIX A-7

ANALYSIS OF VARIANCE PROCEDURE FOR EFFECTS OF PROPAGULE POSITIONS ON SPECIES SURVIVAL ON 19 JULY 1984

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
MODEL	38	1470.72000000	8.21 *	0.0001
PLOTS	2	378.56000000	40.14 *	0.0001
ROWS IN PLOTS	12	59.92000000	1.06	0.4209
COLUMNS IN PLOTS	12	72.32000000	1.28	0.2731
SPECIES	4	719.94666667	38.17 *	0.0001
PLOT-SPECIES INTERACTION	8	239.97333333	6.36	0.0001
ERROR	36	169.76000000		
CORRECTED TOTAL	74	1640.48000000		

* Denotes statistical significance

APPENDIX A-8

ANALYSIS OF VARIANCE PROCEDURE FOR EFFECTS OF PROPAGULE POSITIONS ON SPECIES SURVIVAL ON 31 JULY 1984

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
MODEL	38	600.18666667	3.93 *	0.0001
PLOTS	2	116.82666667	14.55 *	0.0001
ROWS IN PLOTS	12	62.32000000	1.29	0.2645
COLUMNS IN PLOTS	12	56.72000000	1.18	0.3353
SPECIES	4	255.68000000	15.92 *	0.0001
PLOT-SPECIES INTERACTION	8	108.64000000	3.38	0.0054
ERROR	36	144.56000000		
CORRECTED TOTAL	74	744.74666667		

* Denotes statistical significance

APPENDIX A-9

ANALYSIS OF VARIANCE PROCEDURE FOR EFFECTS OF PROPAGULE POSITIONS ON SPECIES SURVIVAL ON 5 AUGUST 1984

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
MODEL	38	349.14666667	2.65 *	0.0020
PLOTS	2	40.50666667	5.85 *	0.0063
ROWS IN PLOTS	12	31.28000000	0.75	0.6920
COLUMNS IN PLOTS	12	47.68000000	1.15	0.3553
SPECIES	4	147.25333333	10.63 *	0.0001
PLOT-SPECIES INTERACTION	8	82.42666667	2.98	0.0115
ERROR	36	124.64000000		
CORRECTED TOTAL	74	473.78666667		

* Denotes statistical significance

APPENDIX B

LEAST SIGNIFICANT DIFFERENCE TESTS

FOR MEAN PLANT SURVIVAL

APPENDIX B-1

LEAST SIGNIFICANT DIFFERENCE TEST FOR STUDY PLOT POSITION EFFECTS ON MEAN PLANT SURVIVAL

GROUPING[1]	PLOT	MEAN SURVIVAL[2]
|	3	11.8350
|	2	11.5750
|	1	10.0150

alpha=0.05 DF=44 MSE=1.44737
critical value of T=2.01537
Least Significant Difference=0.68579

1 Means with the same line are not significantly different.

2 Mean survival out of 20 propagules within a plot for all species in all blocks over all observation dates.

APPENDIX B-2

LEAST SIGNIFICANT DIFFERENCE TEST FOR VARIANCES AMONG MEAN SPECIES SURVIVAL

GROUPING[1]	SPECIES	MEAN SURVIVAL[2]
|	Scarlet Rose Mallow	13.2667
|	Black Willow	12.8083
|	Common Cattail	10.6250
|	Buttonbush	10.4417
|	Mixed Species	8.5667

alpha=0.05 DF=44 MSE=1.44737
critical value of T=2.01537
Least Significant Difference=0.88535

1 Means with the same line are not significantly different.

2 Mean survival out of 20 propagules by species for all blocks within plots over all observation dates.

APPENDIX B-3

LEAST SIGNIFICANT DIFFERENCE TEST FOR VARIANCES AMONG MEAN SPECIES SURVIVAL ON 13 JUNE 1984

GROUPING[1]	SPECIES	MEAN SURVIVAL[2]
|	Common Cattail	20.0000
|	Black Willow	20.0000
|	Mixed Species	20.0000
|	Buttonbush	19.6667
|	Scarlet Rose Mallow	17.3333

alpha=0.05 DF=36 MSE=8.33333
critical value of T=2.02809
Least Significant Difference=2.1378

1 Means with the same line are not significantly different.

2 Mean survival out of 20 propagules by species for all blocks within plots.

APPENDIX B-4

LEAST SIGNIFICANT DIFFERENCE TEST FOR VARIANCES AMONG MEAN SPECIES SURVIVAL ON 20 JUNE 1984

GROUPING[1]	SPECIES	MEAN SURVIVAL[2]
|	Common Cattail	20.0000
|	Scarlet Rose Mallow	20.0000
|	Black Willow	20.0000
|	Mixed Species	20.0000
|	Buttonbush	19.6667

alpha=0.05 DF=36 MSE=0.333333
critical value of T=2.02809
Least Significant Difference=0.42756

1 Means with the same line are not significantly different.

2 Mean survival out of 20 propagules by species for all blocks within plots.

APPENDIX B-5

LEAST SIGNIFICANT DIFFERENCE TEST FOR VARIANCES AMONG MEAN SPECIES SURVIVAL ON 27 JUNE 1984

GROUPING[1]	SPECIES	MEAN SURVIVAL[2]
|	Common Cattail	20.0000
|	Scarlet Rose Mallow	20.0000
|	Mixed Species	20.0000
|	Black Willow	18.6000
|	Buttonbush	18.3333

alpha=0.05 DF=36 MSE=1.49778
critical value of T=2.02809
Least Significant Difference=0.90632

[1] Means with the same line are not significantly different.

[2] Mean survival out of 20 propagules by species for all blocks within plots.

APPENDIX B-6

LEAST SIGNIFICANT DIFFERENCE TEST FOR VARIANCES AMONG MEAN SPECIES SURVIVAL ON 3 JULY 1984

GROUPING[1]	SPECIES	MEAN SURVIVAL[2]
A	Common Cattail	20.0000
A	Scarlet Rose Mallow	20.0000
A	Black Willow	20.0000
B	Buttonbush	19.5333
C	Mixed Species	18.3333

alpha=0.05 DF=36 MSE=0.253333
critical value of T=2.02809
Least Significant Difference=0.37274

[1] Means with the same line are not significantly different.

[2] Mean survival out of 20 propagules by species for all blocks within plots.

APPENDIX B-7

LEAST SIGNIFICANT DIFFERENCE TEST FOR VARIANCES AMONG MEAN SPECIES SURVIVAL ON 11 JULY 1984

GROUPING[1]	SPECIES	MEAN SURVIVAL[2]
|	Scarlet Rose Mallow	13.3333
|	Black Willow	6.9333
|	Mixed Species	4.2000
|	Buttonbush	2.2000
|	Common Cattail	1.4667

alpha=0.05 DF=36 MSE=6.68667
critical value of T=2.02809
Least Significant Difference=1.9150

1 Means with the same line are not significantly different.

2 Mean survival out of 20 propagules by species for all blocks within plots.

APPENDIX B-8

LEAST SIGNIFICANT DIFFERENCE TEST FOR VARIANCES AMONG MEAN SPECIES SURVIVAL ON 19 JULY 1984

GROUPING[1]	SPECIES	MEAN SURVIVAL[2]
A	Scarlet Rose Mallow	9.3333
A	Black Willow	6.7333
B	Mixed Species	3.0667
B	Buttonbush	1.6000
B	Common Cattail	1.4667

alpha=0.05 DF=36 MSE=4.71556
critical value of T=2.02809
Least Significant Difference=1.6081

1 Means with the same line are not significantly different.

2 Mean survival out of 20 propagules by species for all blocks within plots.

APPENDIX B-9

LEAST SIGNIFICANT DIFFERENCE TEST FOR VARIANCES AMONG MEAN SPECIES SURVIVAL ON 31 JULY 1984

GROUPING[1]	SPECIES	MEAN SURVIVAL[2]
│	Black Willow	5.4667
│	Scarlet Rose Mallow	4.6000
│	Mixed Species	1.8000
│	Buttonbush	1.4000
│	Common Cattail	0.8667

alpha=0.05 DF=36 MSE=4.01556
critical value of T=2.02809
Least Significant Difference=1.484

1 Means with the same line are not significantly different.

2 Mean survival out of 20 propagules by species for all blocks within plots.

APPENDIX B-10

LEAST SIGNIFICANT DIFFERENCE TEST FOR VARIANCES AMONG MEAN SPECIES SURVIVAL ON 5 AUGUST 1984

GROUPING[1]	SPECIES	MEAN SURVIVAL[2]
| (group 1)	Black Willow	4.7333
| (group 2)	Scarlet Rose Mallow	1.5333
| (group 2)	Common Cattail	1.2000
| (group 2)	Buttonbush	1.1333
| (group 2)	Mixed Species	1.1333

alpha=0.05 DF=36 MSE=3.46222
critical value of T=2.02809
Least Significant Difference=1.378

1 Means with the same line are not significantly different.

2 Mean survival out of 20 propagules by species for all blocks within plots.

2

VITA

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