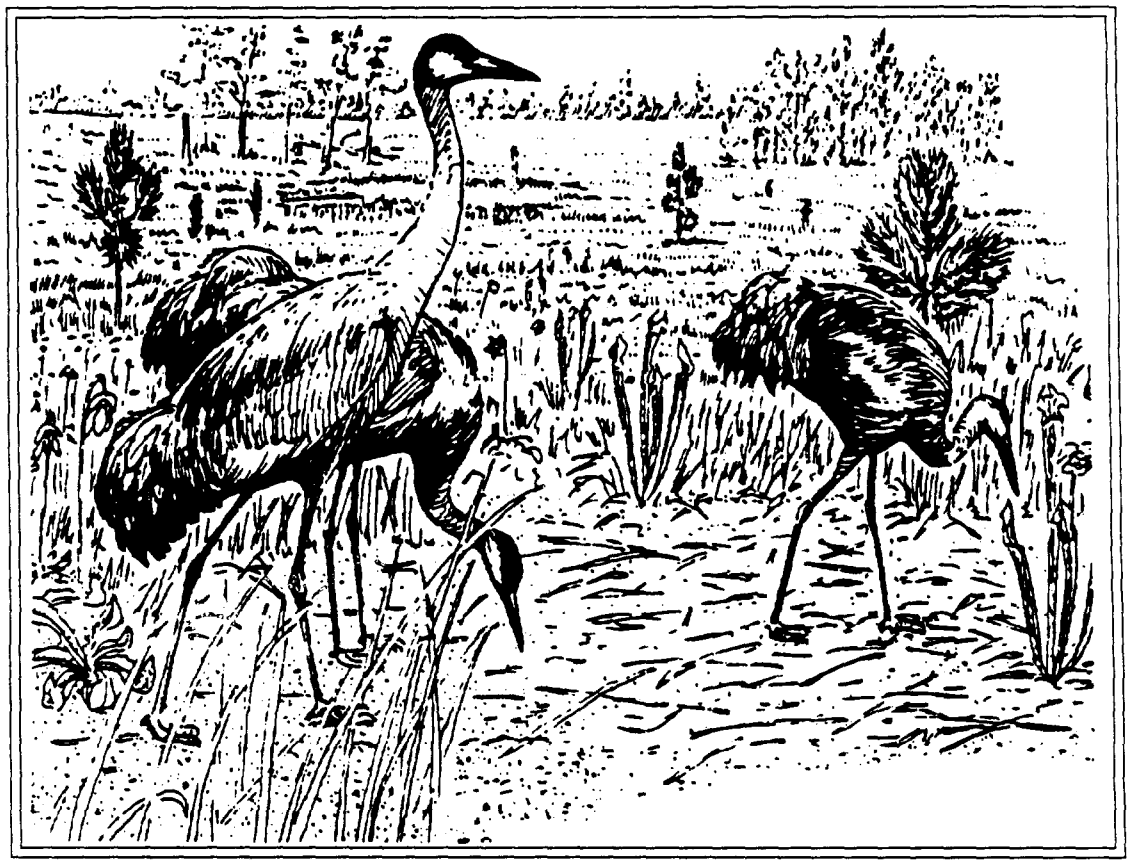
RECOVERY PLAN

Mississippi Sandhill Crane



U.S. Fish and Wildlife Service

MISSISSIPPI SANDHILL CRANE

Grus canadensis pulla

Third Revision

RECOVERY PLAN

(Original Approved: September 14, 1976)

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Approved: 
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Date: September 6, 1991

Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect the listed species. Plans are prepared by the U.S. Fish and Wildlife Service, sometimes with the assistance of recovery teams, contractors, State agencies, and others. Objectives will only be pursued and funds expended contingent upon appropriations, priorities, and other budgetary constraints. Recovery plans do not necessarily represent the views nor the official positions or approvals of any individuals or agencies, other than the U.S. Fish and Wildlife Service, involved in the plan formulation. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species' status, and the completion of recovery tasks.

Literature Citations should read as follows:

U.S. Fish and Wildlife Service. 1991. Mississippi Sandhill Crane Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 42 pp.

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EXECUTIVE SUMMARY

Current Status: The Mississippi sandhill crane, an endangered subspecies, has become reproductively isolated from other sandhill crane populations and is in danger of extinction. Major reasons for the decline include loss of habitat, human predation, and decreased natural recruitment. Decreased recruitment may be a product of human disturbance, habitat degradation, reduced genetic viability, reduced population size, toxins in the environment, as yet unidentified problems, or a combination of these factors.

Habitat Requirements and Limiting Factors: The Mississippi sandhill crane is currently restricted to a small area of Lower Coastal Plain pine savanna in Jackson County, Mississippi. The wet pine savanna is critical to the crane's habitat needs but forestry practices, agriculture, and human development have altered most of the original savanna habitat. The small amount of pine savanna habitat remaining could be a limiting factor.

Recovery Objective: The recovery objective is to maintain a genetically viable, stable, self-sustaining, free-living Mississippi sandhill crane population.

Recovery Criteria: Reducing the likelihood of extinction will require a self-sustaining population of cranes and suitable habitat. Preliminary estimates suggest the refuge population may require a minimum of about 130 to 170 cranes, consisting of about 60 nesting cranes per breeding season, for a continuous period of at least 10 years. Long term self-sustenance and stability will require a genetically viable population, high levels of natural recruitment, and cessation of the captive release program.

Actions Needed:

1. Maximize the quality and quantity of nesting habitat on and near the Refuge.
2. Increase natural recruitment in the wild population.
3. Increase the genetic viability of the subspecies.
4. Minimize human disturbance, especially to nesting cranes.
5. Stop human predation.
6. Continue to restore, improve, and maintain feeding and roosting habitats.
7. Limit or negate crane contact with potential toxins.

Total Estimated Cost of Recovery: Because the crane population must be increased and stabilized before it can be maintained, total costs can not be estimated at this time. However, costs through the next three fiscal years could exceed $2.5 M.

Date of Recovery: As the subspecies is in danger of extinction, the time to increase and stabilize the population cannot be projected. Once the population becomes self-sustaining, then at least 10 years will be required to judge whether the population has stabilized.

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PART I: INTRODUCTION

GENERAL DESCRIPTION

Sandhill cranes (*Grus canadensis*) are long-necked, compact, grayish-brown birds that, when erect, stand about 4 feet tall. In general, they resemble the great blue heron (*Ardea herodias*), but cranes are uniformly grayish (whereas most great blue herons have white on their heads and dark colored underparts). Adult sandhill cranes also have a distinctive reddish crown. Males and females are similar in appearance. Sandhill cranes have distinctive vocalizations, often described as loud and clattering.

Mississippi sandhill cranes (*G. c. pulla*) are an endangered subspecies. The only known wild population is on and near the Mississippi Sandhill Crane National Wildlife Refuge (MSCNWR or Refuge) in Jackson County, Mississippi. The Refuge includes about 19,000 acres; about 15,000 acres might be used by nesting cranes. As of 1990, about 106 cranes of all ages were believed to be on or near the Refuge. These cranes are long lived, in the wild reach reproductive age around 3 to 4 years of age, have large nesting territories, and frequently raise only one chick per year.

RANGE AND TAXONOMY OF *GRUS CANADENSIS*

Six sandhill crane subspecies are currently recognized. Three subspecies, lesser (*G. c. canadensis*), Canadian (*G. c. rowani*), and greater (*G. c. tabida*) sandhill cranes are northern migratory forms that generally nest in northern North America and the Soviet Union and in the winter migrate to the southern United States and in Mexico. In the southeastern United States, migratory sandhill cranes, mainly greater sandhill cranes, are found in the winter from Texas through Florida. In winter, a small number of migratory sandhill cranes inhabit southeastern Mississippi and infrequently they have been observed in the company of Mississippi sandhill cranes. The Florida (*G. c. pratensis*) and Mississippi (*G. c. pulla*) races are nonmigratory and nest in the southeastern United States. The Cuban (*G. c. nesiotes*) sandhill crane, also nonmigratory, nests in Cuba (Figure 1, Johnsgard 1983).

Oberholser (1974) reported that, as late as the 1890's, sandhill cranes nested along the coast in Texas as far south as central Texas (Calhoun County). These non-migratory populations were probably extirpated by 1900.

During the 1800's, nesting sandhill cranes were so plentiful in the marshes and prairies of southwestern Louisiana that they were considered a serious pest (McIlhenny 1943). Lowery (1974) summarized the knowledge of sandhill cranes in Louisiana and noted that the last known nesting cranes were reported in 1919 in Cameron Parish (extreme southwestern Louisiana).

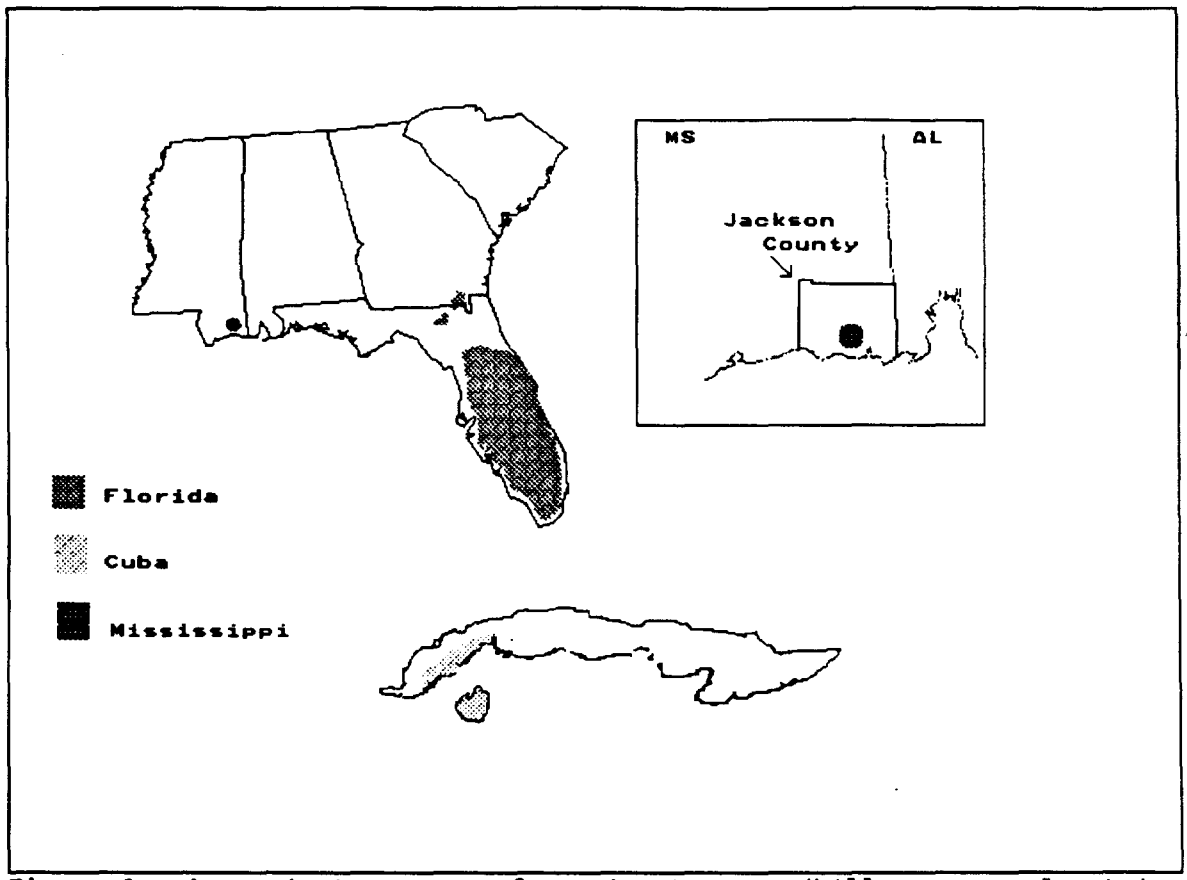

Figure 1. Approximate ranges of nonmigratory sandhill cranes. Inset is the Mississippi sandhill crane's range.

In Mississippi, nesting sandhill cranes were unreported until Leopold (1929) noted the cranes during a state game animal survey. Apparently, McIlhenney (1938) was unaware of Leopold's report, and believed he was describing the Mississippi cranes for the first time, when he reported nesting sandhill cranes in Jackson County, Mississippi. Strong (1969) found evidence that, as late as the 1920's, sandhill cranes may have nested just east of the Pascagoula River, near the Mississippi and Alabama border.

Imhof (1976) considered nesting sandhill cranes to be rare and local in extreme southwestern Alabama. The last reported nesting pair was observed in Baldwin County (just east of Mobile Bay) in 1960. The current status of nesting sandhill cranes in Alabama is unknown and Dusi (1986) believed the status of the breeding sandhill crane in Alabama should be "intensely investigated."

In Florida, Williams (1978) considered resident sandhill cranes to be threatened, and believed populations in the panhandle, which would include populations contiguous with the Alabama population, were

probably extirpated. He estimated the Florida population at about 4,000 individuals.

In Georgia, only one resident population is known. The Georgia cranes reside in the Okefenokee Swamp (Williams 1978). Bennett (1989b) estimated 403 cranes comprised the population and found that the population had become isolated from cranes in Florida. Bennett (1989b) believed the future status of the Georgia population was uncertain because human interference with the swamp's natural drought and fire cycles may adversely impact the cranes.

The current status of the Cuban sandhill crane (*G. c. nesiotes*) is unknown (Johnsgard 1983). It has been considered as endangered (King 1981), and Garrido (in King 1981) was cited (as of 1974) as having estimated the population of this subspecies at about 100 to 150 cranes. This population was believed to have been further fragmented into three separate populations.

Until 1972, resident sandhill cranes in the southeastern United States were considered to comprise a single subspecies (*G. c. pratensis*). Aldrich (1972) compared seven captive-raised cranes from Mississippi with seven captive-raised cranes from southern Florida and two from Georgia. He found Mississippi cranes were similar in size to the Georgia and Florida birds, but described the Mississippi birds as being "consistently much darker" than the Florida and Georgia cranes. On this basis, he described the Mississippi population as a distinct subspecies (*G. c. pulla*).

Historically, the *G. c. pulla* form would have included the Mississippi populations, probably the eastern Louisiana populations, and perhaps the western Louisiana and Texas populations. The *G. c. pulla* form probably intergraded with the *G. c. pratensis* form in Alabama or the panhandle of Florida. Because the populations have been so disrupted by recent human activities, it is impossible to assess to what extent the plumage coloration differences were a product of clinal variation.

Today, the Mississippi sandhill crane is largely confined to the Mississippi Sandhill Crane National Wildlife Refuge in southern Jackson County, Mississippi (Figure 2, back cover insert). The current range is believed to be limited to an area from the Pascagoula River (east), to about the Jackson County line (west), to about Simmons Bayou (south), to about 4 miles north of the town of Vancleave (north).

LISTING HISTORY AND CURRENT PROTECTION

The Mississippi and the Florida sandhill cranes were listed as rare in the 1968 list of Rare and Endangered Fish and Wildlife of the United States. After being described as a subspecies (Aldrich 1972), the Mississippi sandhill crane was added to the United States List of Endangered Fish and Wildlife (June 4, 1973). Valentine *et al.*, (1976) wrote the first recovery plan (approved by the Director, U.S. Fish and Wildlife Service in 1976). To date, this plan has been revised twice (Valentine *et al.*, 1979 and Valentine 1984).

In 1974, The Nature Conservancy (TNC) purchased 1,709 acres, which the Fish and Wildlife Service acquired in 1975 to establish the Mississippi Sandhill Crane National Wildlife Refuge (Refuge). Several other tracts were acquired by TNC, including 6,029 acres from St. Regis Paper Company in 1977. About 26,000 acres of land were described in the final rule (U.S. Fish and Wildlife Service 1977) that designated critical habitat for the Mississippi sandhill crane.

Presently, the Refuge totals approximately 19,273 acres (MSCNWR 1990). Although most of the proposed land for the original Refuge has been purchased, negotiations are continuing for a few key areas. Coastal habitat associated with the Grand Bay National Wildlife Refuge (GBNWR) has recently been acquired southeast of the original Refuge. Negotiations are being conducted to acquire more land in this area. A long-term goal may be to establish a second population of Mississippi sandhill cranes on the GBNWR.

In the 1970's, construction of Interstate Highway 10 (I-10) threatened the crane and its habitat. The National Wildlife Federation and the Mississippi Wildlife Federation filed a Federal court action against the Department of Transportation (DOT), Federal Highway Administration (FHA), and Mississippi Highway Department for violations of Section 7, Endangered Species Act of 1973, and Section 4(f) of the Department of Transportation Act. The Federation argued that I-10 bisected the crane's range, would jeopardize the existence of the crane, and would destroy or modify critical crane habitat.

The first decision (June 26, 1975), from the Southern District Federal Court, was that I-10 would not jeopardize the sandhill cranes. The case was appealed and the Circuit Court reversed (March 25, 1976) the decision and directed the District Court to issue an injunction restraining the DOT from further work on the disputed interchange. No decision was reached as to whether the FHA could be ordered to acquire lands to replace those taken by the highway project. The Department of Interior ruled that the DOT should purchase 1,960 acres of land adjacent to the interchange and along the Gautier-Vancleave Road to protect these lands from commercial and residential development. These lands were acquired and the interchange was built.

Mississippi sandhill cranes are also protected by state regulations. Mississippi's Nongame and Endangered Species Act of 1974 provides "for the protection of nongame species threatened with extinction; to provide enforcement authority and penalties for violations of this Act; and for related purposes." Mississippi lists the Mississippi sandhill crane as an endangered bird.

GENERAL ECOLOGY AND POPULATION DYNAMICS

Nearly all of the reported Mississippi sandhill crane life history has been based on data collected in the mid-1900's on an extremely endangered population. However, where information gaps exist, it seems reasonable to

assume that the life history of a viable Mississippi population would be similar to life histories of the Florida and Georgia crane populations.

Steve Nesbitt (Florida Freshwater Fish and Game Commission, Gainesville, FL, pers. comm., 1991) reported Florida cranes can attain ages of about 20 years. He has not found evidence of reproductive senescence. Female cranes may form pair bonds when 3 years old, whereas some males may bond when 2 years old. First breeding is probably, on the average, a year or so later. Nesbitt (pers. comm.) also reported that about 64 percent of the Florida crane population was composed of adults and, coincidently, about 64 percent of the adult population was reproductively active. Bennett (1989b) found pairs accounted for about 74 percent of the sandhill crane population in Georgia.

Bennett and Bennett (1990) reported that 187 sandhill crane clutches in Georgia averaged about 1.9 eggs and no significant differences in clutch sizes were found between first and second clutches. Nesbitt (1988) found sandhill crane clutches in Florida averaged about 1.7 eggs/clutch and data for 127 Refuge nests suggests about the same average clutch size. Bennett and Bennett (1990) found renesting rates, after loss of the first clutch, varied from 6 to 80 percent, depending on availability of water.

Incubation begins as soon as the first egg is laid and the average incubation period is about 32 days (Bennett and Bennett 1990). Valentine (1981a) reported first nesting by Mississippi sandhill cranes peaked in early April. Nesbitt (pers. comm.) said about 38 percent of the eggs in the nests he studied survived to hatch. Based on 187 nests and 3 years of study, Bennett and Bennett (1990) reported an average of 57 percent of "nests" hatched, and Valentine (1981a) reported about 64 percent nest success for Mississippi cranes (meaning at least one egg survived, so their results are not directly comparable to Nesbitt's data).

Sandhill crane sex ratios are generally reported to be 1:1 males and females. Hatchlings are precocial and fledge in about 75 days. Nesbitt (pers. comm.) found about 57 percent of the hatchlings he studied survived to reach independence (about 290 days after hatching). Bennett and Bennett (1990) reported 34 of 74 (46 percent) "broods" survived to fledge. Bennett and Bennett (1990) reviewed the literature and, in fall surveys, found that about 6 to 14 percent of sandhill crane populations were comprised of first year juveniles.

Nesbitt and Williams (1990) reported that Florida sandhill cranes used nesting territories that averaged about 180 (± 71) hectares (ha). About 15,000 acres (about 6100 ha) of potential nesting habitat is on the Refuge. Assuming Mississippi cranes would need about the same areas for nesting territories as Florida cranes, then the Refuge might support 30 to 34 nesting pairs.

HISTORY OF THE WILD MISSISSIPPI POPULATION

Extensive habitat alteration and human take of cranes had already occurred by the time the cranes were first reported (Leopold 1929). The size and

extent of the original crane population in extreme southeastern Mississippi is unknown. Since 1929, the estimated numbers have not exceeded 100 birds (Table 1).

McIlhenny (1938) did not estimate the population, but his cooperators found 11 nests in the vicinity of Fontainebleau and counted 34 in one flock in April 1938. Beginning in January 1983, crane censuses have been conducted in January and October. The purpose is to estimate the minimum population and is used to monitor population trends. Since 1983, the minimum estimated population has averaged 40 cranes and estimates have ranged from 32 (October 1985) to 54 (October 1989) cranes (Table 1).

Table 1. Estimated abundance of Mississippi sandhill cranes and sources of estimates.

		ESTIMATED NUMBERS OF CRANES	
SOURCE	YEAR	WILD	RELEASED CAPTIVES
Leopold	1929	50 to 100	
Walkinshaw	1949	> 50	
Strong	1969	50 to 60	
Valentine	1975	30 to 50	
Refuge	1980	about 40	
Refuge	1981		9
Refuge	1982		12
Refuge	1983		4
Valentine	1984	about 40[1]	10
Refuge	1985		7
Refuge	1986	25 to 35[1]	3
Refuge	1987	45 to 55[1]	9
Refuge	1988	55 to 65[1]	13[2]
Refuge	1989	80 to 90[1]	29

[1] Includes previous years' released captive cranes
[2] Eleven of the 13 were male cranes

HISTORY OF THE CAPTIVE MISSISSIPPI SANDHILL CRANE POPULATION

The captive population has been established from wild Mississippi sandhill crane eggs that were collected from 1965 through 1977, 1981 and 1982, 1985 through 1987, and 1989, and hatched at the Patuxent Wildlife Research Center (PWRC), Laurel, Maryland. As of 1989, PWRC had 32 adult Mississippi sandhill cranes. Two other pairs of cranes were in captivity at the National Zoological Parks' Conservation and Research Center at Front Royal, Virginia.

Releases of captive-raised cranes began in 1981 and added a new component to the local population. Valentine (1984) estimated the 1983 Refuge population at around 40, plus 13 free-flying captive-raised birds. As of 1989, a total of 96 captive-reared cranes had been released. Fifty-three

were known to still be alive, 16 had disappeared, 25 were known to have died, and two displayed abnormal behavior and were returned to PWRC. Survival of captive-raised and subsequently released cranes is summarized in Table 2. As of June 1990, eight of the 1982 through 1985 year class captive-raised birds have attempted to nest.

Table 2. Survival of released captive-raised Mississippi sandhill cranes from 1980 through June 20, 1990 (data from MSCNWR).

Year Class	Number Released	Number Alive in June 1990	Percent Survival By Year Class	Total Percent Survival
80[1]	9	0	0	0
81	4	0	0	0
82	8	3	43	15
83	4	3	75	25
84	10	5	50	32
85	7	1	14	29
86	2	0	0	28
87	10	7	78	36
88	13	7	54	40
89	29	26	90	55
Totals	96	53		

[1]Year class cranes would be released in the following year, for instance, year class 1980 captive-raised cranes were released in 1981 and 1989 birds were released in 1990.

ECOLOGY

Habitats

Today, the three major plant communities on the Refuge (MSCNWR 1989) are savannas, swamps, and pine plantations. It is the unique savanna community that the cranes have historically depended upon for year-round use. Savannas are wet grasslands predominated by wiregrass (*Aristida* spp.) with scattered longleaf pine (*Pinus palustris*), slash pine (*P. elliottii*), and pond cypress (*Taxodium ascendens*) trees. Other common savanna plants include pitcher plants (*Sarracenia* spp.), sundews (*Drosera* spp.), clubmoss (*Lycopodium alopecuroides*), and pipeworts (*Eriocaulon* spp.).

The swamps are wooded depressions, locally called "ponds," dominated by cypress, longleaf, and slash pine trees, with an understory of swamp cyrilla (*Cyrilla racemiflora*), buckwheat tree (*Cliftonia monophylla*), wax myrtle (*Myrica cerifera*), and several species of holly (*Ilex* spp.).

In the 1950's, timber companies converted thousands of acres of savannas to slash pine plantations. As the pine trees matured, dense understories of wax myrtle, sweetbay (*Magnolia virginiana*), gallberry (*Ilex glabra*), and greenbriar (*Smilax* spp.) developed. These areas were not used by cranes. Some plantation habitats still exist on the Refuge.

Available habitat may become a limiting factor. About 6100 ha of potential nesting habitat is on the Refuge. As already noted, if Mississippi sandhill crane nesting territory needs are similar to Florida sandhill cranes, the Refuge might support only 30 to 34 nesting pairs. Long-term survival of the Mississippi sandhill crane will probably require a greater number of breeding pairs. A standing population of about 160 cranes will be needed to maintain the nesting population. It is not known if the Refuge can support this large of a crane population.

Nesting Habitat: The Mississippi sandhill crane normally nests as far as possible from sources of disturbance. The ideal nesting habitat can be characterized as an open area of grasses and sedges with perennial shallow water. The opening is surrounded by trees and shrubs and is large enough for the cranes to see potential predators and allow flight. Areas of water, grasslands, pastures, or open pine forests are often close to the nests.

Original nesting habitats were probably ideal. However, many miles of access roads, often bisecting the savannas, were built during the 1950's and 1960's. With the economic growth of coastal Mississippi, thousands of acres of nesting habitat were destroyed. Plantation pine forestry techniques destroyed nesting habitats. By the time protection was afforded the cranes, little ideal nesting habitat remained and nests were built in sub-optimal habitats (Table 3).

Three general regions presently contain all of the known nesting areas: the Gautier and Fontainebleau Units of the Refuge, and an area north of Ocean Springs and west of Old Fort Bayou (see Figure 2, back cover insert). These areas total about 15,000 acres.

Use of five types of nesting habitats have been documented (Table 3).

Table 3. Nesting habitats (n = 124) described from 1965 to 1988 (MSCNWR and J. Valentine, pers. comm.).

Habitat	Number of Nests	Percent of Total
Open Savannas	58	46%
Swamp Edges	45	36%
Pine Plantations	12	10%
Forest Edges	8	6%
Cleared Lands	2	2%

Because the original Lower Coastal Plain savannah nesting habitat has been altered, to what extent the crane's current use of habitat for nesting resembles the original use is unknown. However, J. Valentine (pers. comm.) believes some of the existing habitat resembles original habitat and believes good unused nesting habitat exists on the Refuge. S. Nesbitt (pers. comm.) noted that the Mississippi habitat resembles habitat used by nesting sandhill cranes near Ft. Myers, Florida.

Foraging habitat: During the summer months, cranes feed on the natural foods found in the savannas, swamps, and open forest lands. Prey probably includes adult and larval insects, earthworms, crayfish, small reptiles, amphibians, especially frogs, and perhaps small birds and mammals. The birds also feed on roots, tubers, seeds, nuts, fruits, and leaves.

During the fall, winter, and early spring, most of the cranes feed on small corn and chufa (*Cyperus esculentus*) fields, pastures, and pecan orchards found within several miles of the nesting range. There are about 12 farms and pastures where cranes regularly forage, depending on crops and season. In early fall, corn fields are used, but as the kernels become scarce, the cranes switch to other fields. Chufa, an introduced plant, has become the main crop planted on the Refuge and is used by the cranes throughout the year (R. Ingram, USFWS, pers. comm., 1990). Pecan orchards are most often visited between September and December. Later, cranes often forage, probably for earthworms, in the burned pine forests and cleared areas of the Refuge.

Zwank *et al.*, (1988) compared the foraging preferences of wild and captive released sandhill cranes on farms near the Refuge. They found that released and wild cranes differed both in choice of crop types and use of crop types through time. Native cranes used pecan orchards more than captive cranes and captive cranes frequented corn fields more often and for longer time periods than native cranes.

Several Refuge crop units have been planted with corn and winter ryegrass. These crop units now consistently attract both wild and released cranes in greater numbers than the outlying farms. In addition to providing food during the winter, the Refuge crops also reduce the risk of the cranes being shot or injured off the Refuge. Food may be a limiting factor, especially for chicks.

Roosting Habitat: The marshes in the Bluff Creek, Bayou Castelle, and Paige Bayou areas provide the main winter roosts. Marshes have fresh to slightly brackish water and the vegetation is mainly sawgrass and needlerush. Artificial freshwater ponds, on and off the Refuge, are also used as roosting habitats. Other known roosts include savannas, open forests, pastures, and moist clearings in the foraging areas. During the breeding season, paired cranes roost near the nest.

Life History

Nesting: The age when wild Mississippi sandhill cranes attain sexual maturity is unknown. J. Valentine (pers. comm.) has data that shows some Mississippi cranes first lay eggs between the ages of 3 and 6 years. S. Nesbitt (pers. comm.) said some male Florida cranes become sexually active when 2 years old but females mature a year or so later.

Mated cranes defend nesting territories. Territory size is probably dependent upon several factors, such as age of the cranes, quality and type of the habitat, and perhaps the density of cranes. Only one pair of cranes has been observed to nest per season in each open savanna. Conversely, in

areas such as Ben William's swamp, where clearings are separated by forested areas, cranes have nested within one-half mile of each other.

Nesting territories are usually used for more than 1 year and some territories have been used for much longer periods of time (Table 4). Conversely, there have been periods of 4 to 6 years between nestings on a particular territory. Some nesting territories have been abandoned. Probable causes have included invasion of trees and shrubs into the clearings, highway and road construction, wildfire, and the death of a breeding pair of cranes.

Table 4. Numbers of years when specific nesting territories have been known to be active and numbers of nesting attempts during that period (data courtesy of J. Valentine).

Number of Years	Number of Nests
17	12
16	8
15	13
15	8
10	10

Within a nesting territory, new nests are usually located fairly close to nests from previous years. Valentine (1981a,b) reported that the same nests have been used for up to 3 consecutive years. Dummy or start nests are frequently built by Mississippi sandhill cranes (Valentine and Noble 1970) and also by Florida sandhill cranes (Layne 1981a). Layne reported that the false nests were sometimes used by adults and chicks for resting and roosting. Layne speculated that the extra nests might be related to the more aquatic nesting of the southern races and dummy nests might confuse predators.

Reproduction: Clutches on the MSCNWR have averaged 1.70 eggs (n = 125). First clutches generally hatch from May 1 through May 20 (Table 5).

Table 5. Wild Mississippi sandhill crane first clutches (n = 68) and hatching periods.

Time Period	Number of Clutches	Percent of Total
April 2 - April 17	6	8
April 18 - April 30	10	15
May 1 - May 20	39	57
May 21 - later	13	19

The earliest estimated laying date was March 2 (based on eggs that hatched on April 2). The latest hatching date, thought to be a result of renesting, was August 10. Prior to 1982, no hatching was recorded before

April 18. Since then, 27 percent of the 19 successful nests hatched between April 2 and 17. An overview of Mississippi sandhill crane reproduction is provided in Table 6.

Through 1988, seventy-three of 142 wild eggs (51 percent) have hatched. However, since 1982 hatching success seems to have decreased (Table 7). Data has been collected for 70 eggs that failed to hatch (Table 8).

Table 6. History of Mississippi sandhill crane reproduction from 1979 through 1990 (MSCNWR data).

	Number of		Viable[1]	Wild Eggs	Percent	Eggs From PWRC		Wild Chicks	Eggs To
Year	Nests	Eggs	Eggs	Hatched	Viable	Eggs	Hatched	Fledged	PWRC
79	4	7	5	0	71	0	0	0	0
80	2	3	2	0	67	0	0	0	0
81	5	8	5	0	62	0	0	4[2]	1
82	5	9	5	3	56	3	1[3]	0	2
83	5	7	0[4]	0	0	4	4	1[5]	0
84	4	7	4	2	57	2	1	2	0
85	7	13	5[4]	4	56	1	1	0	1
86	5	9	6	4	67	1	1	1	1
87	11	18	8	7	44	2	2	15[5]	2
88	6[6]	8	4	2	50	2[3]	0	0	0
89	12	16	10[4]	7	71	2[3]	0	2	2
90[7]	12	21	16	9[8]	79[8]	0	0	?	16[9]

[1]Eggs that were alive at day 20; percent viability estimates will be underestimates because an early dead embryo would be classified as not viable based on floating egg tests. [2]J. Valentine (pers. comm.) believes that all 4 cranes were migrants mistaken for fledgling Mississippi sandhill cranes. [3]Chick died within 24 h after hatching. [4]Eggs were destroyed by predators and viability was not assessed. [5]Chicks hatched from eggs from PWRC. [6]Spring of 1988 was the second worst recorded drought in Jackson County, MS. [7]This represents data up to, and including, August 20, 1990. [8]Two nests with 3 eggs were still being incubated. [9]These data included eggs with 5 dead embryos and 3 infertile eggs.

Table 7. Numbers and percentages of eggs that hatched in nests of wild cranes.

Time Period	Total Eggs	Eggs Hatched	Percent
Before 1982	78	50	64
1982 and After	64	23	36

Table 8. Numbers of eggs (n = 70) that failed to hatch in the wild and probable causes for the failure. [J. Valentine (pers. comm.)]

Number of Eggs	Probable Causes
43	addled for unknown reasons (infertility, etc.)
9	deserted (eggs cracked or punctured, human disturbance, or unknown causes)
7	missing for unknown reasons
5	cracked as a result of human disturbance
3	preyed upon by crows as a result of human disturbance
2	pecked by a crane
1	preyed upon by crows

Thirteen of 119 clutches laid by wild cranes have been considered renestings (Valentine, pers. comm.). Cranes have renested after their eggs were removed, after the nest was abandoned, and after a chick died. Productivity has been low in the Mississippi population. Since 1980, only 11 subadults have been seen during the winter months and J. Valentine (pers. comm.) believes 4 cranes identified as subadults in 1981 were migrant greater sandhill cranes.

Using estimated populations based on the winter counts, the ratio of juveniles to adults in Mississippi has been very low, generally no greater than 2.3 juveniles per 100 adults. Comparatively, the ratio of juveniles to adult cranes in wild populations of other sandhill crane subspecies has been much greater [Drewien (1973) reported 15:100; Littlefield and Ryder (1968) reported 8 to 10:100; Layne (1983) reported 27.7:100, Bennett and Bennett (1990) reported 12:100].

Mortality and Population Decline

Habitat Loss: As already noted, the human population in southeastern Mississippi, especially along the coast, has increased dramatically. Construction of roads and power lines and commercial and residential development have accompanied the increased human population. In the mid-1950's, timber companies acquired or leased lands for pine tree production. Slash pine was planted on thousands of acres during the 1950's and 1960's. To encourage tree growth in wet situations, savannas were drained and in some areas seedlings were bedded and furrowed. Access roads and fire breaks were constructed. Wild fires were suppressed. The pine plantations formed dense stands that precluded nesting and feeding by cranes.

Eight paved roads and highways transect or border the Mississippi sandhill crane's range. The adverse effects have been:

(1) direct loss of lands;
(2) noise, vibration, and visual disturbance;
(3) pollution;
(4) eased public access to the cranes;
(5) development along the highway route; and
(6) direct mortality.

Direct Mortality: Reports of shootings in the 1960's and 1970's were sporadic, but this mortality probably exceeded recruitment to the population. Between July 1966 and June 1967, three reliable reports of shootings were received and one crane was shot in October 1974. During 1983, two cranes were found shot. These killings exceeded the annual recruitment rate.

In 1978, a crane was killed either by a vehicle or an airplane near the end of the Gulf Park Estates Airport. In 1982, a captive-released crane was struck and killed by a car on Interstate Highway 10 and another crane was killed on the Gautier-Vancleave Road.

A released crane was found dead on the Refuge in January 1981. Death may have been accidental or caused by an interspecific conflict. A dead crane was found below a power line in 1989. Aside from one or two captive-released cranes known to have been killed by free-running dogs, and predation by a bobcat when the birds were being held in a pen, predation on living adult cranes has not been documented. However, predation is a natural phenomena and dead cranes that have been found may have been killed by predators.

Flooding, caused by heavy rainfall, has killed eggs and chicks (McIlhenny 1938). In April 1980, heavy rainfall may have inundated two nests with eggs. Flash floods regularly occur and nests in low lying areas have been flooded. Hurricanes come ashore along the Mississippi Coast about once every 3 to 5 years. Crane mortality caused by the winds and rains associated with hurricanes has not been documented but loss of birds, eggs, and nests are certainly possible. Conversely, spring and summer droughts are common. Lack of drinking water could cause chick mortality.

Pollution, Disease and Parasites: The area is subjected to the usual pollutants associated with major highways. Until fairly recently, fire ant eradication with Mirex was common. A crane found dead in 1974 contained 0.14 parts per million (ppm) of Mirex in the breast muscle and 0.22 ppm in the brain. Roadsides are often treated with herbicides.

Since 1981, eighteen cranes have been necropsied by the National Wildlife Health Research Center (NWHRC, Madison, Wisconsin). Six of these birds were diagnosed as having biliary hyperplasia and five of the six with biliary hyperplasia had adenocarcinomas. In four cases, the tumors could have caused death. Similar tumors are very rare among wild birds and tumors have not been documented among the PWRC cranes.

The most commonly identified causes of tumors include:

(1) infectious agents such as viruses or parasites,
(2) xenobiotic or naturally occurring toxins, and
(3) genetic predisposition.

Although the causative agent has not been established, because both tumors and biliary hyperplasia have been found in each case, a toxin may be indicated (Couvillion *et al.*, 1991). The susceptibility of the Mississippi sandhill crane to the toxins may be increased by the loss of genetic variability.

A captive-released crane, struck by a vehicle, had a nematode infestation in the proventriculus and small intestine. Another released crane that died in 1982 had a severe infestation (probably *Cappillaria* sp.) of the tongue. The lesions may have prevented the crane from feeding. Another emaciated wild crane died after being found. An unknown type of hepatitis was diagnosed as the cause of death.

Genetic Viability and the Captive Population: Poor hatching success and some debilities in captive chicks may have resulted from a lowered level of genetic heterozygosity. In 1988, four of six wild chicks that hatched died within 24 hours after hatching. One other chick pipped the shell but failed to fully hatch. Also, two of 9 chicks that hatched in 1989 died within 24 hours after hatching. Whether the 1988 chick survival problems were caused by an unusual drought, human interference, loss of genetic heterozygosity, or other factors is unknown. Recent information (October 1990) provided by H. Dessauer (Louisiana State University Medical Center, New Orleans, Louisiana) suggests that there has been a loss of heterozygosity in the Mississippi sandhill crane population (Table 9). The genotype of the Mississippi sandhill crane has been studied by blood electrophoresis of 31 proteins (Table 10, G. Gee, unpubl. data, November 1990, Patuxent Wildlife Research Center, Laurel, Maryland).

Table 9. Comparison of genetic diversity among cranes (H. Dessauer, pers. comm.).

Species	% Heterozygosity[1]
Greater Sandhill Crane (*G. c. tabida*)	5.6
Florida Sandhill Crane (*G. c. pratensis*)	6.5
Georgia Sandhill Crane (*G. c. pratensis*)	2.4
Mississippi Sandhill Crane (*G. c. pulla*)	1.9
Whooping Crane (*Grus americana*)	4.0
Siberian Crane (*Grus leucogeranus*)	2.8
Sarus Crane (*Grus antigone*)	2.4

[1] Average heterozygosity in vertebrates is about 5% (Nevo 1978).

Table 10. Genotypes at polymorphic loci of samples from 4 populations of sandhill cranes (G. Gee, pers. comm.).

	Sandhill Crane Population			
Enzyme	Mississippi	Florida	Georgia	Greater
ICD	cc	cc	bc, cc	cc
GK	cc,ff	ef,ff	ef,ff	ff
EST-1	bb,cc	cc	cc	bb,bc
PEP-B	bb,cb,cc	ab,bb	aa,ac,ca	bb,bc,cc,cd
PEP-C	ab,bb,bb,bd,cc	aa,ab,bb	aa,ab,bb	aa,ab,bb
MPI	dd,de,ee	dd	dd,de,ee	bd,dd,de
PGM-1	cc	cc	cc	cc

Non-migratory sandhill crane populations along the Gulf Coast have been isolated by human activities. Because of the distances involved, maintenance of genetic diversity by natural intergradation is improbable. In an effort to maintain the remaining genetic variability of Mississippi sandhill cranes, maximum outbreeding techniques are being used with birds in the captive population. Restoring natural intergradation with the Florida and/or Georgia populations is being studied.

Currently, the second egg is removed from each wild nest that contains two viable eggs. The removed viable eggs are hatched in captivity. The goal is to include as many lineages as possible in the captive flock. Currently, about 140 semen samples are maintained at PWRC and some increase in genetic variability can be achieved through artificial insemination with sires from distant lines. Releases of subadults with various heritages and the substitution of captive produced eggs for addled wild eggs will enhance the population and, to a certain extent, enhance the wild population's genetic variability.

Population Modeling:

If we assume that the Refuge could support 30 to 34 nesting pairs, then Nesbitt (pers. comm.) suggested that the "standing crane population" needed to support 60 to 68 nesting cranes might be estimated by:

$$P_{(a)(b)} = 60 \text{ to } 68$$

where,

P = the standing population of all ages of cranes, with a sex ratio assumed to be 1:1,

a = the adult portion of the standing population (cranes 3 years old or older,

and

b = the portion of the adult population that is reproductively active.

Nesbitt (pers. comm., 1991) reported that, coincidently, these parameters were similar for Florida cranes (a and b = 0.64). Bennett (1989b) reported that about 74 percent (b = 0.74) of the adult Georgia crane population was reproductively active. Solving for P, using the range of values reported above, suggests that a standing Refuge population of about 127 to 166 cranes will be required.

If 30 crane nests per year on the Refuge could be attained, and if nesting parameters were similar to those for Georgia and Florida cranes, then perhaps:

(30 nests)(1.8 eggs)(38% egg survival)(57% hatchling survival) = 12 cranes.

Depending on the parameters used in the standing population model, 12 juvenile cranes would probably represent an annual recruitment of about 7 to 9 percent. Bennett and Bennett (1990) reported annual recruitment rates for Georgia cranes ranged from about 8 to 12 percent. However, data for wild Mississippi sandhill cranes suggests that annual mortality of adults may be about 15 percent per year. If these estimates are correct, then natural recruitment would not be sufficient to prevent decline of the free-living population.

PART II: RECOVERY

A. Recovery Objective

The recovery objective is to maintain a genetically viable, stable, self-sustaining, free-living Mississippi sandhill crane population.

Criteria for attaining the objective are: (1) cessation of the need for captive-raised cranes, (2) attaining a free-living, stable, and self-sustaining standing population which demonstrates stability and self-sustenance for at least 10 continuous years, and (3) providing the habitat required to support the crane population.

The estimated required standing population (total free-living crane population of all ages of cranes) will be determined from continually updated population dynamics and minimum viable population models.

A stable and self-sustaining population must be genetically viable. Genetic viability requires that captive-raised cranes represent the full range of genetic heterozygosity remaining in the Mississippi sandhill crane gene pool. Some level of continual intergradation with other southeastern crane populations also may be required.

B. Outline Narrative

1. Develop population dynamics and minimum viable population models for the Mississippi sandhill crane. Sufficient life history and genetic information for southeastern nonmigratory sandhill cranes probably exists for these models. If not, the missing information needs to be recognized and attained. These models are essential to guiding the recovery of the wild crane population and management of the MSCNWR.

    1.1 Restoration of the standing population. Along with habitat restoration, one of the most critical recovery elements is restoration of the wild flock to the levels suggested by the population models. Preliminary models suggest that the population should include about 130 to 170 cranes. Continued releases, probably for at least 10 years, of captive-raised Mississippi sandhill cranes will be needed to achieve this task. The captive-raised cranes should constitute the range of genetic heterozygosity remaining in the Mississippi sandhill crane gene pool.

2. Restore, improve, and maintain nesting, feeding, and roosting habitats within the Refuge. The Refuge, established in 1975, contains most of the currently used nesting habitat. Nestjng habitat may become a limiting factor. Continued and intensified management is needed to return the altered habitat to pine savanna and to maintain savanna habitat. However, the timing of management activities must be carefully assessed to ensure that cranes are not disturbed during a critical period.

2.1 Complete acquisition of Refuge lands. The Refuge acquisition boundary was delineated to include about 22,000 acres; as of 1990, about 19,000 acres have been included in the Refuge. The population dynamics models may indicate a larger Refuge is needed.

2.1.1 Acquire suitable habitats within the proposed boundaries or near the Refuge. The population dynamics models may indicate that a larger Refuge is required to support a self-sustaining wild crane population. Tracts that might be acquired include: Section 27, T6S, R8W (adjacent to the Ocean Springs Unit, partially acquired as of 1990); and Sections 27 and 28, T7S, R7W (adjacent to the Fontainebleau Unit, not acquired as of 1990). The "Meyer property" in Section 6 of the Gautier Unit, and an area known as the "Weber Combined Nesting Area," should be acquired or included as a conservation easement with the U.S. Forest service.

2.2 Increase and improve active and potential nesting sites. The population models will likely find nesting area to be a critical limiting factor. Past pine plantation management, the exclusion of fire, and the draining of savannas have greatly reduced nesting habitat on the Refuge. Priorities need to be assigned to potential nesting habitat and the habitat needs to be restored as fast as possible.

2.2.1 Hand-clear trees at swamp edges, savannas, and within forests; burn where and when needed. To minimize disturbance, the prime nesting habitats should be cleared outside of the nesting season. Prescribed burning is a natural and efficient method of maintaining a savanna habitat and should be used as needed.

2.2.2 Retain tree and brush buffers to separate territories. The buffers will maximize the nesting habitats by reducing visibility and perhaps reduce territorial conflicts between crane pairs nesting close to one another. Trees also provide shade during hot summer days.

2.2.3 Improve water economy. These activities should include consultation with professional hydrologists. Mitigate the effects of timber company drainage ditches, roadside ditches, firebreaks, and roads that alter the natural wetlands ecology. However, care must be taken to avoid creating wet areas that flood. These areas might be used by nesting cranes.

2.2.3.1 Monitor and improve water control structures and levees. Five water control structures have been built. Road levees have been raised and lengthened. The effects of these management schemes on water control need to be determined, and necessary modifications need to be made.

2.2.3.2 Reestablish water sheet flow. Geological processes have created complex drainage patterns. Human manipulations have diverted and accelerated drainage. Small ditches should be plugged. Road maintenance requires careful planning to maintain natural runoff rates. When fighting fires, fire plow use should be limited and carefully used to ensure that drainage is not increased. If possible, discing instead of plowing should be used. When fire plows are used, the ditches should be rehabilitated that year.

2.2.3.3 If needed, dig small ponds in the vicinity of nesting territories. Severe droughts during the breeding season are not uncommon and drinking water for chicks may become scarce. To provide relatively permanent water, small ponds should be dug in the vicinity of nesting habitats that lack natural ponds. These ponds or wetlands might be added by plugging ditches and swells with low level berms on upland sites. However, care must be used to ensure nesting habitat is not destroyed and that the potential nesting habitat is not prone to flooding.

2.2.3.4 Construct wetlands in the Ocean Springs Unit. The Refuge has entered into a Memorandum Of Understanding with the Mississippi Gulf Coast Regional Wastewater Authority for the development of a wastewater irrigation treatment facility on the Ocean Springs Unit. Current plans (1990) call for the ground cover to revert to a fire-maintained grassland.

2.3 Increase and improve feeding and roosting habitats. Clear and thin the pine forest to provide open habitat for feeding and roosting use by cranes. As A. Bennett (Agassiz NWR, Middle River, MN, pers. comm., 1991) pointed out, creating and managing roosting habitat can be a valuable tool for manipulating crane movements. Ensure that these actions do not unduly disturb the cranes.

2.3.1 Harvest timber in selected areas to create openings. If possible, stands of timber ready for commercial sale should be sold. Care should be taken to ensure that heavy equipment use is limited to dry periods. Timbering must not create drainage problems.

2.3.2 Thin the pine forests and burn when necessary. Thin timbered areas to provide feeding and loafing areas. Leave scattered large pines to encourage use of the habitat by red-cockaded woodpeckers.

2.3.3 Burn grasslands, when possible in the summer, to reduce brush cover. Use fire to maintain areas that have been cleared. These areas should be burned on a rotational basis to reduce brush and pine regeneration. Before humans began managing the Coastal Plain, summer fires were natural and a fire maintained plant community evolved. To encourage the natural flora, late (after chicks fledge) summer fires should be used.

2.3.4 Maintain the existing, or plant tree and brush cover along highways, to buffer noise and movement of vehicles. As J. Layne pointed out (Archbold Biological Station, Lake Placid, FL, pers. comm., 1990), these vegetated buffers may decrease accidental mortality by forcing the cranes to fly higher when encountering highways. Where needed, maintain or encourage a vegetational buffer between human activities and crane habitat.

2.4 Increase and improve winter foraging habitats. Farm crops are heavily used by Mississippi sandhill cranes. However, cranes in the Okeefenokee Swamp do not rely on farm crops and farm crops may not be needed for Mississippi cranes once the Refuge's habitats have been restored.

2.4.1 Provide crop units at selected locations in all Refuge units. During the winter, Mississippi sandhill cranes have been foraging in privately owned fields north of the Refuge. To limit the cranes' time off the Refuge, and thus, to reduce the risk of shootings, it is necessary to provide crops on the Refuge.

2.4.1.1 Plant domestic grains, tubers, and other foods. In 1990, 10 acres of corn, 25 acres of chufa, 10 acres of wheat, 2 acres of clover, and 12 acres of sorghum were planted on the Refuge.

2.4.1.2 When needed, scatter grain and other foods. If crop failures or a scarcity of food during harsh winters occurs, then grain should be scattered at the crop units.

3. Increase recruitment, reduce mortality, and enhance heterozygosity. Despite Refuge management and protection, the number of wild, not captive-raised, cranes on the Refuge has decreased since the 1960's. All but two of the known active territories are presently located on the Refuge. Because of geographical isolation, there has been no immigration or emigration of Mississippi sandhill cranes with other southeastern United States crane populations.

3.1 Minimize human contact with wild nesting cranes. Circumstantial evidence strongly suggests that mortality of crane eggs and young increases as human contact with the wild nesting cranes increases. This correlation generally holds true for all wild nesting birds and research has shown that, for some avian species, one human visit to a nest may increase its chances of being preyed upon by 100 percent. To maximize the recruitment of wild cranes to the population, human interference with nesting cranes should be minimized. If possible, no human activities should be undertaken that would disturb nesting cranes. If this is not possible, then the contact must be kept to a minimum, even for research and management activities.

3.2 Maximize heterogeneity and releases of captive-raised cranes. The natural genetic interchange among southeastern sandhill crane populations needs to be restored. The genetic variability of the captive-raised cranes must be maximized. This may be accomplished by careful intergradation among southeastern sandhill cranes, probably while they are in a captive environment. Captive Mississippi sandhill crane lineages need to be carefully assessed and care taken to maximize the genetic diversity from captive crane reproduction. Release of 20 or more captive-raised cranes per year will be needed until a self-sustaining wild crane population has been attained.

3.2.1 Convene a workshop to estimate the requirements for a minimum viable Mississippi sandhill crane population and the level of genetic exchange needed to reestablish natural levels of intergradation. As soon as possible, convene a workshop to: (1) assess what is known about the Mississippi sandhill crane's genetics, (2) estimate the minimum viable population required for the crane's survival, and (3) advise on the best methods to reestablish a reasonable level of genetic exchange among southeastern resident sandhill crane populations. This workshop should include a minimum of three experts on population genetics and conservation biology.

3.2.2 Implement the recommendations of the experts convened in 3.2.1.

3.2.3 Increase the captive breeding population. Carefully assess the practice of removing eggs from wild nests and continue to increase the breeding population at PWRC only if the genetic viability of the Mississippi sandhill crane population will be enhanced and the benefits outweigh the costs to natural reproduction. The original (1965) goal was 10 breeding pairs. Currently (May 1990) there are 13 egg producing females (4 producing naturally and 9 artificially inseminated). There are 13 adult males mated to the 13 females and 10 non-producing birds.

3.2.3.1 Continue transfer of wild eggs. Only if the genetic viability of the Mississippi sandhill crane population will be enhanced, eggs from lineages poorly represented in the captive gene pool should be sent to PWRC.

3.2.4 Improve avicultural techniques. Optimum techniques should be developed for insuring survival of eggs and chicks, pairing, feeding, and inducing reproduction.

3.3 Solve problems with low recruitment of wild birds. Currently (1990), annual natural recruitment into the wild population is very low, averaging one or less cranes per year. The failure of wild cranes to fledge young might be attributed to: human interference, sub-optimal habitats, a severely depleted natural population, a loss of natural genetic viability, a change in the weather cycle, or other unknown factors. Recommendations have already been outlined in this plan to study and, if needed, correct problems in these areas. If, after having addressed these topics, natural recruitment continues to be a problem, then studies must be undertaken to find the cause.

3.4 Monitor releases and other techniques. Captive-released cranes have been color banded and some have been equipped with radio transmitters. These cranes have been monitored by telemetry and visual observations. Colored legbands have been used to identify individuals. It is important that the methods of affixing both legbands and radio transmitters do not impair the survivability of the birds. Captive cranes should be allowed to form flock associations before being released on the Refuge.

3.4.1 Refine captive-reared cranes release techniques. Gentle release and conditioning facilities will be located and constructed to minimize the potential for adverse physical and behavior impacts to captive-reared

birds. These facilities will also facilitate social interaction between captive and wild cranes.

3.4.2 Evaluate techniques. Refine methodologies as experience increases. Use the techniques that least affect the birds and yield results.

3.5 Reduce wild crane mortality. Mortality of wild cranes currently exceeds natural recruitment. Activities on the Refuge need to be continually assessed for probability of causing mortality.

3.5.1 Minimize human contact. (ref: 3.1)

3.5.2 Improve environmental conditions. (ref: 2.2)

3.5.3 Determine mortality factors. Whenever possible, identify causes of mortality. Actual and suspected causes of death include shootings, collisions with vehicles, and killings by dogs, owls, and bobcats.

3.5.4 Continue to affix color bands and, if not harmful to the cranes, radio transmitters to the juvenile cranes. If the criteria to minimize human contact are met, and ensuring that the capture and handling does not threaten the birds, cranes between 55 and 70 days of age may be captured, banded, and have safe radio-transmitters attached.

3.5.5 Increase law enforcement activities. During the winter when cranes are feeding on private lands, patrols by the Fish and Wildlife Service and State agents should be increased. Special attention may be needed in the vicinity of Simms and Eglin roads (J. Valentine, pers. comm.).

3.5.6 Improve public relations. The Refuge and its cranes continue to be resented by a small segment of local residents.

3.5.6.1 Continue and expand public education programs. Emphasis should be placed on reaching people who live near the Refuge. Presentations explaining the Refuge and cranes should be given in the communities that surround the Refuge. A visitor center with displays has been completed. The exhibits explain many facets of the Refuge and the crane's life history. In 1990, more than 1600 people visited the Refuge, which underscores the opportunity to increase public education.

3.5.6.2 Expand contact with landowners near the Refuge, especially those that own or lease land used by cranes.

3.5.7 Reduce any unnatural levels of mortality.

3.5.7.1 Minimize power line construction and oil and gas exploration activities. Section 7 consultations must evaluate any proposed power line construction or oil and gas exploration.

3.5.7.2 Monitor and control crane diseases. All dead cranes should be sent to the U.S. Fish and Wildlife Service's National Fish and Wildlife Health Center, Madison, Wisconsin, for necropsy.

3.5.7.2.1 Determine the causative agent or agents responsible for the abnormally high incidence of tumors. Workshops have been held annually from 1987 through 1990 to develop a research plan for determining the causative agent(s).

3.5.7.2.2 Develop a plan of corrective action to reduce the incidence of tumors in the flock. Develop plans of corrective action if a causative agent is identified as a result of Task 3.5.7.2.1.

3.5.7.3 Evaluate natural predators on the Refuge and control only when necessary.

3.5.7.3.1 Manage lands to reduce predation. Reestablish and maintain the natural open savanna habitat.

3.5.7.3.2 Reduce unnatural predation. Predation by dogs on released cranes has been documented. Control of feral dogs on the Refuge needs to be continued. Control methods should only be those methods not potentially harmful to cranes. Natural predation by horned owls, bobcats, coyotes, and perhaps an eagle, has been suspected.

3.5.8 Continue crane rehabilitation efforts. Local veterinarians cooperate in animal health issues. PWRC provides valuable assistance and advice. Refuge personnel have been trained in crane first-aid.

4. Monitor the response of wild cranes to habitat management actions. Population growth is essential if the crane population is to survive. The population trend must be monitored and used to determine the success or failure of the various management projects.

4.1 Estimate the wild population, including sex and age components. Survival and mortality ratios and changes in total population numbers are indicators of whether the wild population is increasing. Petersen Index type of analyses could be used with the ratio of marked to unmarked cranes to form indices of population trend.

4.1.1 Conduct fall and winter crane abundance surveys. Fall and winter abundance surveys have provided a useful measure of crane population trends.

4.1.2 Monitor fledgling productivity. By observing wintering cranes at feeding sites, count first year birds as a measure of chick survival.

4.1.3 If deemed consistent with 3.1, conduct nest searches. Use utmost care to ensure that human activities do not decrease the nesting success of wild cranes. If at all possible, nests searches should be done from aerial surveys. The number of active nests is another indicator of population trends.

4.1.4 Monitor the success of the captive release program. The release of captive-raised cranes has been the most successful program to increase the Refuge's crane population.

4.1.5 Mark and release adult wild cranes. If consistent with 3.1, and if the actions do not jeopardize wild cranes, adults may be captured in walk-in traps, color marked, and fitted with radio transmitters. These activities will provide information on movements, roost and nest locations, habitat uses, and daily activity patterns.

4.2 Determine if sandhill cranes still nest in Baldwin or Mobile Counties, Alabama. Imhof (1976) reported sandhill cranes in Baldwin County in June 1960. Since then, there have been no reports of cranes during the nesting season, but no directed search for nesting cranes has been made. Migrant cranes spend the winter in the area. Breeding cranes, if they still exist, could be a valuable source to increase the genetic diversity

of the Mississippi population (and *vice versa*). Dusi (1986) recommended that the status of breeding sandhill cranes in Alabama be intensely investigated.

4.2.1 Interview residents. Area residents and bird-watchers in southern Baldwin and Mobile Counties may know of nesting cranes or cranes that are present during the spring and summer months. As a first step, area residents and bird-watchers should be polled.

4.2.2 Conduct searches for nesting cranes. There are a few fairly large potential nesting sites that should be searched to determine whether resident cranes may still exist.

5. Review potential for establishing one or more breeding populations within the historic range. A 1986 review of high altitude infrared photography, from the Appalachicola Basin of Florida west to the Mississippi River Basin, for possible sandhill crane habitat revealed that the habitat has virtually disappeared in the lower Gulf Coastal Plain (W. McDearman, Mississippi Museum of Natural Sciences, pers. comm.). Unless suitable habitat is acquired in the very near future, the opportunity for establishment of additional populations will be seriously jeopardized. However, population dynamics models and minimum viable population models should be used to ensure that the habitat acquisition will contribute to the survival of the Mississippi sandhill crane.

5.1 Manage Grand Bay National Wildlife Refuge for reestablishment of a crane population. Part of the Grand Bay National Wildlife Refuge (GBNWR) has been acquired. Efforts are underway to acquire a larger Federal land holding in this area. The cost and biological effectiveness of establishing a Mississippi sandhill crane population on the GBNWR needs to be assessed with respect to recovery of the Mississippi sandhill crane.

6. Plan, update, and implement a comprehensive research program to address: (1) reduced natural recruitment, (2) loss of genetic viability, (3) tumor rate, and (4) habitat enhancement. A research review panel should be convened. The panel should review proposed research to ensure that the research contributes to recovery of the Mississippi sandhill crane. Research proposals should be subjected to peer review. A research plan should be developed (Appendix II). The plan should rank research needs and should be reviewed annually. Research projects should be added, continued, or terminated as deemed appropriate.

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PART III: IMPLEMENTATION SCHEDULE

The following Implementation Schedule outlines actions and estimated costs for the recovery of the Mississippi Sandhill Crane. It is a guide for meeting the objectives discussed in this plan. These actions, when accomplished, should protect the crane's habitat and promote recovery.

Priorities in column one of the following implementation schedule are assigned as follows:

1. Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

2. Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

3. Priority 3 - All other actions necessary to meet the recovery objective.

Key to Acronyms Used in This Implementation Schedule

NWR - National Wildlife Refuge
PWRC - Patuxent Wildlife Research Center
FWE - Fish and Wildlife Enhancement (Endangered Species Division)
USFS - U. S. Forest Service
MDWFP - Mississippi Department of Wildlife, Fisheries, and Parks Commission
ANHP - Alabama Natural Heritage Program
LNHP - Louisiana Natural Heritage Program

IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($K)			COMMENTS
				USFWS		Other	FY 1	FY 2	FY 3	
				Region	Program					
1	1.0	Population Modeling	0.5	4	FWE/NWR		5			
1	1.1	Increase Standing Population	10.0	4/8	NWR/PWRC		600	600	200	Use Existing Program Funds
1	2.2	Restore Nesting Habitats	Ongoing	4	NWR	USFS MDWFP	30	30	30	Use Existing Program Funds
1	3.1	Minimize Disturbance	Ongoing	4	NWR					No Cost
1	3.2	Maximize Heterogosity	5	4/8	NWR PWRC		40	40	40	
1	3.2.1	Experts for Restoration of Genetic Interchange	0.5	4	FWE NWR		6			
1	3.3	Enhance Natural Recruitment	Ongoing	4	NWR					Research Costs as in 6.0
1	3.4	Monitor Releases and Other Techniques	Ongoing	4	NWR		10	10	10	Use Existing Program Funds
1	3.5	Reduce Mortality	Ongoing	4	NWR	MDWFP	75	75	75	In Part, Use Existing Funds
1	6.0	Research	Un known	4/8						Responsibilities & Costs to be Determined.

IMPLEMENTATION SCHEDULE (Continued)

PRIORITY #	TASK #	TASK DESCRIPTION	DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($K)			COMMENTS
				USFWS		Other	FY 1	FY 2	FY 3	
				Region	Program					
2	2.1	Acquire Other Suitable Habitat	Unknown	4	NWR		200	200	200	
2	2.2	Improve Nesting Habitat	Ongoing	4	NWR		50	50	50	
2	4.0	Monitor the MSCNWR Crane Population	Ongoing	4	NWR		40	40	40	Use Existing Program Funds
2	4.2	Alabama Cranes Survey	1	4	FWE	ANHP	2			Funded
2	5.0	Establish Other Viable Populations	Unknown	4	FWE NWR	ANHP MDWFP LNHP	4	4	4	
3	2.4	Increase and Improve Winter Foraging Habitats	Ongoing	4	NWR	USFS MDWFP	20	20	20	Use Existing Program Funds
3	3.2	Improve Avicultural Techniques	Ongoing	4/8	NWR PWRC		25	25	25	

APPENDIX 1. Review of Recovery Accomplishments Through November 1989.

1. Complete acquisition of the Refuge. 1990 = 19,273 acres

2. Restore savannas and marsh areas. "Cleared" refers to mechanical clearing activities.

	Acres	
Year	Burned	Cleared
1979 -	500	250
1980 -	1005	1300
1981 -	4257	40
1982 -	260	10
1983 -	3155	55
1984 -	2100	417
1985 -	4392	45
1986 -	7595	286
1987 -	6388	760
1988 -	5194	790
1989 -	6000	?

3. Plug drainage and road ditches. Ongoing, but could be increased and accelerated. Hydrologists need to be consulted for recommendations on how to reestablish the sheet flow characteristic of the area before the savannah habitat was disrupted.

4. Hand clear openings.

Year	Acres
1980 -	275
1981 -	525
1982 -	125
1983 -	0
1984 -	25
1985 -	25
1986 -	25
1987 -	100
1988 -	250
1989 -	100

5. Retain tree and shrub buffers to separate territories. Accomplished during the hand-cutting operations listed above.

6. Plant pine trees or retain cover adjacent to highways. Accomplished along established roads. Additional planting is still required along Interstate Highway 10.

7. Construct water control structures.

Year
1980 - Five structures
1983 - 4,900 linear feet of road levee raised
1985 - Drainage ditches were plugged.
1986 - Three wetland cells were constructed, two roost ponds were created.
1987 - One roost pond was constructed.
1988 - About 12 acres of wetlands were created.
1989 - Three roost ponds were created.

8. Improve natural pine stands as feeding habitats. Progress has been made through annual burning and thinning of timber stands.

9. Provide winter feeding areas.

Year	Acres
1979	33
1980	30
1981	50
1982	24
1983	21
1984	30
1985	38
1986	37
1987	30
1988	> 54
1989	54

10. Improve and maintain habitats on private lands.

11. Improve and maintain habitats on the DeSoto National Forest.

12. Provide protection to cranes, nests, and habitats. The landfill dump located adjacent to Refuge has been closed. Most windrows on the Refuge have been bulldozed out. Roads and all crane territories have been closed to the general public. Borrow pits in critical habitat have been closed.

13. Monitor response of cranes to habitat management and protection.

Two graduate students with the Louisiana Cooperative Wildlife Research Unit (LCWRU) conducted research on the movements of released cranes and made periodic surveys to determine populations and use of winter feeding and roosting grounds (1980-82). Intensive ground and aerial surveys using Refuge personnel and volunteers have been conducted in January and October since 1983. Routine counts on the wintering grounds and roosting grounds were made by Refuge and volunteer personnel.

14. Survey nesting territories.

Year	Search Hours*	Nests Found
1979	40	4
1980	71	2
1981	135	5
1982	85	5
1983	133	5
1984	156	4
1985	250	7
1986	170	5
1987	100	11
1988	130	6
1989	190	12

* includes only walking or horseback ground searches.

A graduate student from the University of Southeastern Louisiana studied the nest site characteristics of native and introduced cranes on the Refuge.

15. Survey productivity by conducting fledgling counts

Year	Fledglings
1980	1
1981	4*
1982	0
1983	1
1984	2
1985	0
1986	1
1987	2
1988	0
1989	2

* J. Valentine (pers. comm.) believes these four birds were probably migrant sandhill cranes.

16. Increase crane numbers and heterozygosity by releases and other methods.

To date, all efforts to increase crane numbers and heterozygosity have been by removing wild eggs, hatching the wild eggs and captive-raised eggs at PWRC, and releasing captives on the Refuge.

17. Review potential for reestablishing one or more additional breeding populations within the historical range.

A study was proposed in 1964 to reintroduce sandhill cranes into Louisiana (Valentine 1964). Mississippi and Florida crane eggs were collected, which began the Fish and Wildlife Service's captive propagation efforts (Lynch Aviary in Lafayette, Louisiana; Monte Vista NWR, Colorado; and PWRC).

However, the Mississippi sandhill crane was declared an endangered species and plans to reintroduce to Sabine NWR were postponed because other activities had higher priority. Since then, all captive propagation has been directed toward increasing the MSCNWR population.

APPENDIX 2. Review of Needed Research.

1. Population Modeling

   1.1 Use existing data to develop population dynamics and minimum viable population models.

2. Habitat Restoration

   2.1 Monitor crane habitat use patterns on the Refuge and compare these patterns through time as habitat is restored.

3. Genetic Viability

   3.1 Evaluate the genetic resources of *G. c. pulla*.

   3.2 Compare the genetic similarities of *Grus canadensis pratensis* and *G. c. pulla*.

   3.3 Complete the *G. c. pulla* semen, blood and serum, and tissue banks.

   3.4 Develop a program to ensure optimal use and protection of the existing genetic diversity in the *G. c. pulla* population.

   3.5 Compare the immunocompetence of wild *G. c. pratensis* and *G. c. pulla*.

4. Natural Recruitment

   4.1 Using existing data and literature bases, assess the relationship between human disturbance and nesting success.

   4.2 Compare egg viability and incubation profiles between wild and captive cranes. Assess the environmental conditions on the Refuge in relation to incubation behavior.

   4.3 Develop and test incubation telemetry.

   4.4 Monitor parental and juvenile behavior. Test the efficacy of predator enclosures.

   4.5 Use radio telemetry to monitor wild crane juveniles.

5. Toxins and Tumors

   5.1 Monitor Mississippi sandhill cranes on the Refuge for tumors.

   5.2 Continue contaminant studies on and near the Refuge.

6. Captive Cranes

6.1 Improve captive propagation and release techniques.

6.2 Monitor the behavior of released captive cranes.

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