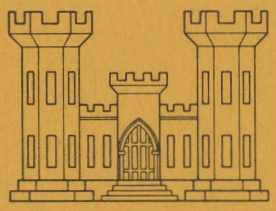

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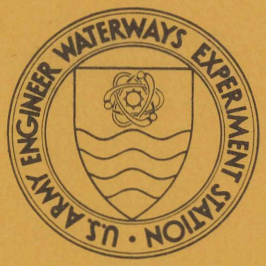

TECHNICAL REPORT D-78-13

AN AERIAL SURVEY OF WATERBIRD COLONIES ALONG THE UPPER MISSISSIPPI RIVER AND THEIR RELATIONSHIP TO DREDGED MATERIAL DEPOSITS

by

David H. Thompson, Mary C. Landin

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P. O. Box 631, Vicksburg, Miss. 39180

April 1978
Final Report

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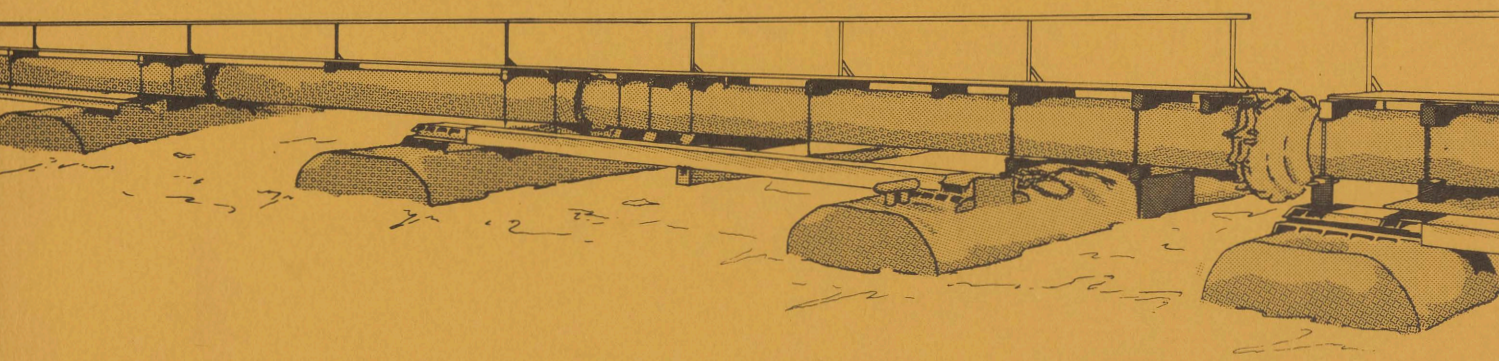

Prepared for Office, Chief of Engineers, U. S. Army
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Under DMRP Work Unit No. 4F01F

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30 June 1978

SUBJECT: Transmittal of Technical Report D-78-13

TO: All Report Recipients

1. The technical report transmitted herewith represents the results of Work Unit 4F01F regarding wildlife use of dredged material islands along the Upper Mississippi River. This work unit was conducted as part of Task 4F (Island Habitat Development) of the Corps of Engineers' Dredged Material Research Program (DMRP). Task 4F was part of the Habitat Development Project of the DMRP and had as its objective the investigation, evaluation, and testing of methodologies for habitat creation and management on dredged material islands.

2. Island habitat development has been studied by the DMRP throughout the United States through the evaluation of vegetation succession and animal use of existing dredged material islands. In many regions the most significant wildlife aspect of these islands is their use by colonial nesting sea and wading birds such as gulls, terns, egrets, herons, ibises, and pelicans. This wildlife resource, although generally inadvertently created, presents significant opportunity for habitat management and development that is consonant with continued dredged material disposal.

3. In the study reported herein, Work Unit 4F01F, an aerial survey of dredged material islands in the Mississippi River from Alton, Illinois, to St. Paul, Minnesota, was conducted. Although 328 above-water deposits were located, none were found to be used as nesting sites by colonial birds. Thirty-five colonies were located along the river but none were on dredged material. This lack of use by colonial species may be a result of unsuitable vegetation on the dredged material, more desirable natural areas near the river, and the possible disturbance of colonies by recreationists. The findings of this study are somewhat unusual in that dredged material islands in many parts of the United States are very heavily used by colonial nesters.

4. A national perspective of island habitat development is presented in a report entitled "Development and Management of Avian Habitat on Dredged Material Islands" (4F03), which synthesizes island habitat

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research in Upper Mississippi River, the Great Lakes (4F01A), New Jersey (4F01D), North Carolina (4F02), Florida (4F01C), Texas (4F01B), and the Pacific Northwest (4F01E).

JOHN L. CANNON
Colonel, Corps of Engineers
Commander and Director

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Dredged material	Waste disposal sites
Environmental analysis	Waterfowl

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Aerial surveys of 1040 km of the Upper Mississippi River, Locks and Dams 1-26, showed 35 active colonies of five species of larger waterbirds (great blue heron, great egret, black-crowned night heron, double-crested cormorant, and Forster's tern) nesting in the floodplain. In addition, green herons and yellow-crowned night herons are reported as nesting, although location by aerial survey was not possible due to cryptic coloration and nest placement beneath the tree canopy. No species were found nesting on dredged material.

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20. ABSTRACT (Continued).

In general, colonies were located on isolated insular natural sites on the east side of the river below dams and/or tributaries. Dredged material sites were found to be unsuitable for nesting because of high human recreational use of dredged material and the early succession of vegetation stages present.

SUMMARY

This study was designed to determine the locations of colonies and breeding populations of certain colonial waterbird species nesting within the floodplain of the Upper Mississippi River from Alton, Illinois (Lock and Dam 26), to St. Paul, Minnesota (Lock and Dam 1), and their relationship to dredged material deposits in the river.

The study area included 1040 km of Mississippi floodplain. Visits to Corps of Engineers District Offices revealed detailed records of deposit locations, while two complete aerial surveys in April and June of 1977, coupled with visits on the ground, were used to census colonies and describe colony sites. The survey was limited to nesting habitat and to the seven large or conspicuous waterbird species which could be located from the air.

Although 328 above-water deposits were located, none were found to be used by colonial birds as nesting sites, because (a) the deposits had vegetation unsuited to any of the species breeding within the study area, (b) there were many more suitable natural areas still available for nesting and (c) the deposits were excessively disturbed by recreationalists and nearby river traffic. Some deposits were used by migrating herring gulls and ring-billed gulls as resting areas. These findings help indicate why dredged material deposits are so important to the nesting of colonial birds elsewhere in the United States.

Active colonies of great blue herons (27), great egrets (18), black-crowned night herons (2), Forster's terns (3), and double-crested cormorants (2) were found. In addition, literature review and correspondence revealed colonies of yellow-crowned night herons (4) and green herons (1). Incomplete evidence suggests that populations of great blue herons, great egrets, black-crowned night herons and double-crested cormorants are declining in all parts of the study area, while least terns have been completely extirpated. Only Forster's terns and yellow-crowned night herons are increasing in population. The declines are especially marked below Lock and Dam #13 at Clinton, Iowa. The floodplain contains a significant fraction of the populations of colonial

waterbirds nesting within the five states bordering the study area.

While Forster's terns and double-crested cormorants nested in the pools or marshes above dams, the herons and egrets usually selected nest and colony sites located (a) in mature deciduous forest, (b) at the tops of tall trees, (c) just downstream from dams, (d) close to feeding areas, (e) close to water, (f) at the junctions of tributaries with the Mississippi River, (g) on the east side of the navigation channel, (h) far from human disturbance, (i) somewhat protected from wind, and (j) in the case of egrets, always in association with great blue herons. No dredged material deposits within the study area possess all of these preferred characteristics, but deposits with most or all of these features could be established. The most important factors relevant to managing dredged material deposit sites for birds are the establishment of large trees and freedom from human disturbance. Least terns and black-crowned night herons are the species most likely to utilize properly constructed and managed dredged material habitat.

PREFACE

This report presents the results of a study to determine the populations and locations of waterbird colonies along the upper Mississippi River, and the importance of dredged material islands to these colonies. The study was conducted as Work Unit 4F01F of the Dredged Material Research Program (DMRP), for the Office, Chief of Engineers, at the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi. This work unit is part of the Habitat Development Project (HDP), Dr. Hanley K. Smith, Manager.

This study was conducted under the general supervision of Dr. John Harrison, Chief, Environmental Laboratory (EL). The Director of WES during the study was COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown.

This report was written by Dr. David H. Thompson, EL and University of Wisconsin Center-Washington County, except for the sections describing the vegetation of heron and Forster's tern colonies, which were written by Mr. David L. Dralle, Environmental Resources Branch, U. S. Army Engineer District, St. Paul. Dr. Carl Taylor, Milwaukee County Museum, Wisconsin, and Mr. Dralle conducted botanical studies at selected colonies, and Dr. Taylor provided WES with voucher specimens of plant species. Invaluable assistance was provided during all phases of the study by Ms. Mary C. Landin, Biologist, WES, who served as Study Coordinator, did much preliminary data collection, and contributed to the manuscript. Dr. Robert F. Soots, Jr., Ecologist, WES and Campbell College, Buies Creek, North Carolina, accompanied the author on the first three days of the aerial survey and offered advice on survey techniques. The manuscript was reviewed by Dr. Soots, Dr. R. T. Huffman, Mr. C. W. Klimas, and Ms. L. Jean Hunt, WES. Mr. Richard Johnson, Wisconsin Department of Natural Resources, assisted in aerial observation and provided advice on heron biology.

The following amateur ornithologists flew as observers and helped ensure a complete survey: Messrs. Charles Mayhew, III, Jarrett Schmit, Dan Mertz, Jim Ruzycki, and Clair Bigler. Acknowledgements and thanks

also are extended to Mr. Ron Nicklaus, Wisconsin Department of Natural Resources, for providing an early draft of the "Heron-Egret-Cormorant Rookery Directory" of the Upper Mississippi River Conservation Committee. Special appreciation goes to Mr. Pete Ayer, an excellent pilot. Ms. Diane Merwin provided help in library research.

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AN AERIAL SURVEY OF WATERBIRD COLONIES ALONG THE UPPER MISSISSIPPI RIVER AND THEIR RELATIONSHIP TO DREDGED MATERIAL DEPOSITS

PART I: INTRODUCTION

1. With mounting pressures for the further development of navigation facilities in the Upper Mississippi River and for establishment of more industry along its banks, there has been an increased need for baseline data about wildlife of this region. Yet very little is known about the wildlife populations of the upper Mississippi floodplain except for fish and game species. To date, there have been no published studies of nesting sites and populations of colonial waterbirds along the upper Mississippi River, although the U. S. Fish and Wildlife Service has unpublished records partially compiled by Nicklaus (1977).

2. The present study is part of the Dredged Material Research Program (DMRP), sponsored by the Office, Chief of Engineers, Washington, D. C., which seeks to establish environmentally sound procedures for the disposal of the vast quantities of sediment that are dredged each year from rivers, harbors, and coastal waterways throughout the United States. Preliminary surveys of nesting populations of colonial waterbirds along the coasts of eastern and gulf states have shown that as natural islands used by nesting birds have become developed, islands formed by dredged material deposits have become increasingly important to the nesting of birds and maintenance of their populations. These findings raised the possibility that dredging operations by the Corps of Engineers could be modified to create and maintain favorable nesting habitat for colonial waterbirds. Since the Upper Mississippi River is an important waterway maintained by substantial dredging, it was only prudent that surveys of nesting sites and populations of birds should also be conducted there.

3. The present study was undertaken as a single-season survey with

the following limited objectives:

a. Locate and describe dredged material deposits.

b. Locate colonies of waterbirds within the floodplain.

c. Determine the importance of dredged material deposits to the colonial waterbirds located.

d. Determine past and present populations of colonies so that population trends could be established.

e. Determine the factors influencing colony site and nest site selection.

4. Although 21 species of colonial nesting waterbirds presently nest or formerly nested north of St. Louis within the five states surrounding the study area, this study analyzed populations of only the seven species of herons, egrets, terns, and cormorants that were actually found nesting within the floodplain. In addition, least terns are discussed because they formerly nested within the study area.

5. While feeding habitat is as important to the birds as nesting habitat, studies of feeding areas were beyond the scope of this study.

PART II: REVIEW OF LITERATURE

6. In recent years there have been a number of surveys of colonial birds conducted in the U. S. and Canada. These efforts have culminated in large coordinated surveys such as the seven regional surveys of the Dredged Material Research Program (Landin and Soots 1977), and a survey of the entire Atlantic seaboard of the U. S. (Custer and Osborn 1977). There have been many surveys of colonies in northern inland locations: in Tennessee (Pitts 1977), New York State (Benning 1969), Georgia (Hopkins and Murton 1969), Ohio (Moseley 1936), Ontario (Baillie 1947), Wisconsin (Harris and Matteson 1975, Anderson and Hamerstrom 1967, Williams 1957), Minnesota (Anonymous 1959, Green and Janssen 1975, Breckenridge 1959), British Colombia (Mark 1976), Utah (Mitchell 1975), Manitoba (Vermeer 1970, Vermeer and Hatch 1972, McLeod and Bondar 1953), Alberta (Wolfold and Boag 1971, Vermeer 1969a and 1969b), Great Lakes (Scharf 1977, Ludwig 1962 and 1966), North Central States (USFSER 1976), Saskatchewan (Vermeer and Anweiler 1970, Houston 1962), and throughout the continent (Lewis 1929, Lies and Behle 1966, Thompson 1933).

7. Although all of the colonial species considered in this report are waterbirds, there have been virtually no studies of colony distribution and locations along large river systems such as the Mississippi, with the notable exception of Hardy's (1957) and Downing's (1975) studies of the least tern. Indeed, the Upper Mississippi River was completely neglected as a region until 1977, when Nicklaus (1977) compiled information about known colonies and Thompson (1977 and this study) searched for unreported colonies. Only two colonies along the Upper Mississippi River have been studied in any detail: 793.7 (Norling 1977), and 833.4 (Adams et al. 1973). There are anecdotal or unpublished accounts of several other colonies located at River Miles 526.8 and 538.8 (Appendix B,Tables B2 and B3).

8. U. S. Fish and Wildlife Service personnel began counts of nests in some colonies as early as 1957. Although this work provides the basis for Nicklaus' (1977) report, the data remain scattered and unpublished.

9. Much information about the breeding distribution and timing of

migration has been published for the Upper Mississippi River in regional works, in American Birds and Audubon Field Notes, and by Partch (1972, 1975).

10. Background data concerning the flora, fauna, physical environment, and economy of the region can be found in Geraghty et al. (1973) and numerous environmental impact statements and assessments. While the information published in these sources is vast, it is badly in need of synthesis. Curtis (1959) is a classical reference for vegetation in the northern portion of the study area, while an environmental impact statement (USAEDSL 1975) provides supplemental information for the southern portion.

11. Although there have been a number of studies, summarized by Landin and Soots (1977), of the use of dredged material islands by colonial birds in coastal regions, there have been few studies of the flora and fauna on dredged material along the Upper Mississippi River. Olson (1975) studied the springtime use by birds of "spoil banks" in the Twin Cities area. The River Studies Center (1975) studied revegetation of dredged material near LaCrosse, while McMahon (1975) studied revegetation and other aspects of dredged material deposits. U. S. Army Engineer District, Rock Island, is presently conducting a study showing the effects of various depths of dredged material on survival and growth of trees in the Rock Island District.

PART III: STUDY AREA AND METHODS

12. The study area included the Mississippi River from Lock and Dam 26 at Alton, Illinois to Lock and Dam 1 in St. Paul, Minnesota, a total distance of 1040 km (Figures 1-6 and B1). It included the floodplain, which is the area between the high bluffs that border the river for most of its length. The maximum width of the floodplain varies from 11 km in the south to 6 km in the northern part of the study area.

Location of Dredged Material Deposits

13. Prior to aerial surveys, dredged material disposal sites were located and their ages established. Each of the three U. S. Army Engineer District Offices (St. Paul, Rock Island, and St. Louis) were visited and it was found that archives of disposal sites were quite complete since the construction of the locks and dams. Locations of emergent and submerged deposits and years of deposit were accurately plotted on Upper Mississippi River Navigation Charts (1975), and these charts were used during all flights to visually locate deposits.

Survey and Census of Bird Colonies

14. Table A1 in Appendix A lists the 21 species of large colonial birds that now nest or formerly nested in the regions surrounding the study area, excepting small species such as bank swallows (Riparia riparia). Using aerial survey techniques developed by Soots (R. F. Soots, Jr., ecologist, 1977, personal communication), the senior author was able to reliably find and census only those colonial species that nested above the canopy or that had non-cryptic coloration. Hence attention was focused on finding colonies of great blue herons (Ardea herodias) and great egrets (Casmerodius albus) in forested areas (Figure 7), and on finding ground-nesting gulls and white-plumaged terns in sandy areas, marshy areas, or wing dikes.

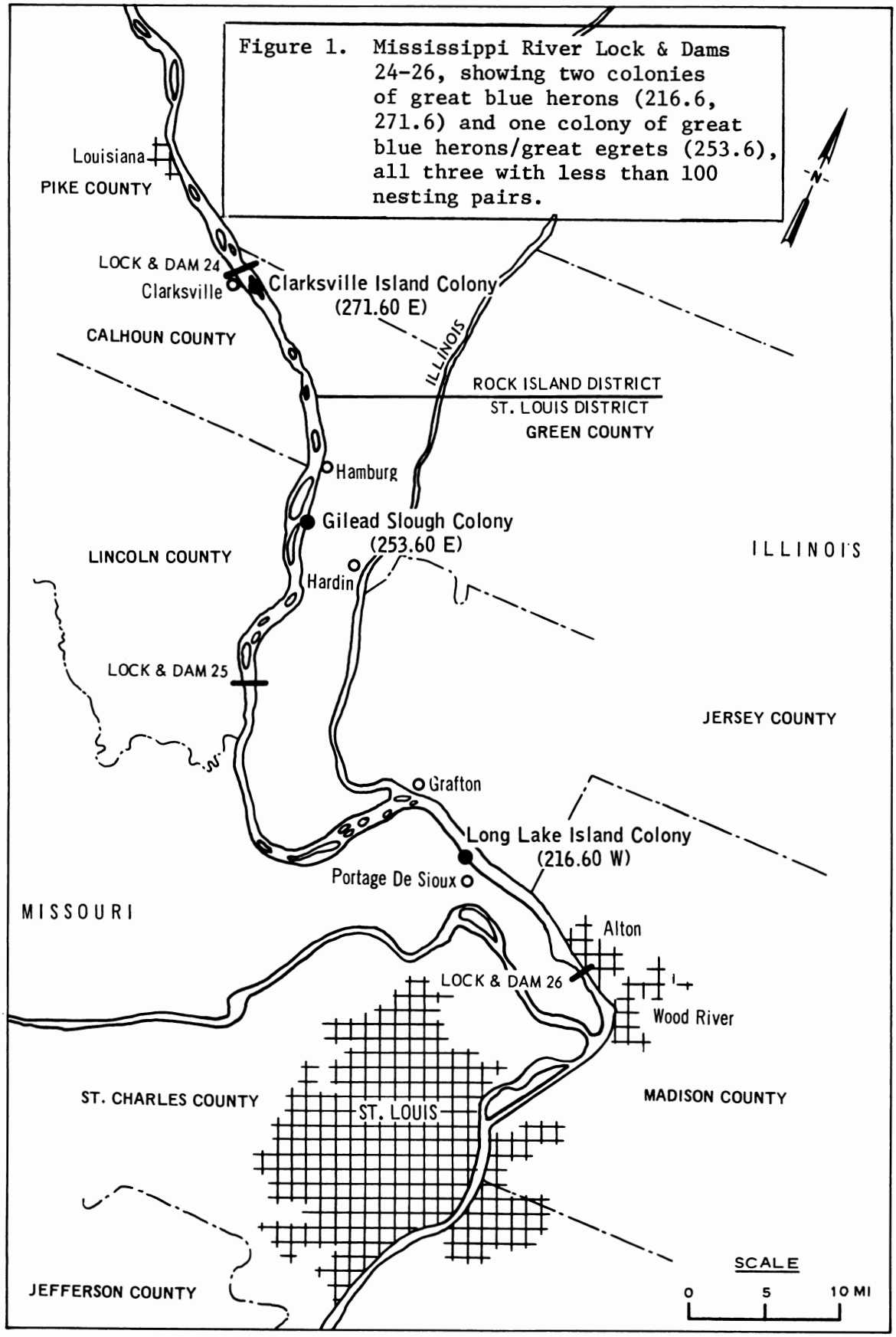
Figure 1. Mississippi River Lock & Dams 24-26, showing two colonies of great blue herons (216.6, 271.6) and one colony of great blue herons/great egrets (253.6), all three with less than 100 nesting pairs.
Louisiana
PIKE COUNTY
LOCK & DAM 24
Clarksville
Clarksville Island Colony
(271.60 E)
CALHOUN COUNTY
ILLINOIS
ROCK ISLAND DISTRICT
ST. LOUIS DISTRICT
GREEN COUNTY
Hamburg
Gilead Slough Colony
(253.60 E)
LINCOLN COUNTY
ILLINOIS
Hardin
LOCK & DAM 25
JERSEY COUNTY
Grafton
Long Lake Island Colony
(216.60 W)
Portage De Sioux
MISSOURI
Alton
LOCK & DAM 26
Wood River
ST. CHARLES COUNTY
ST. LOUIS
MADISON COUNTY
JEFFERSON COUNTY
SCALE
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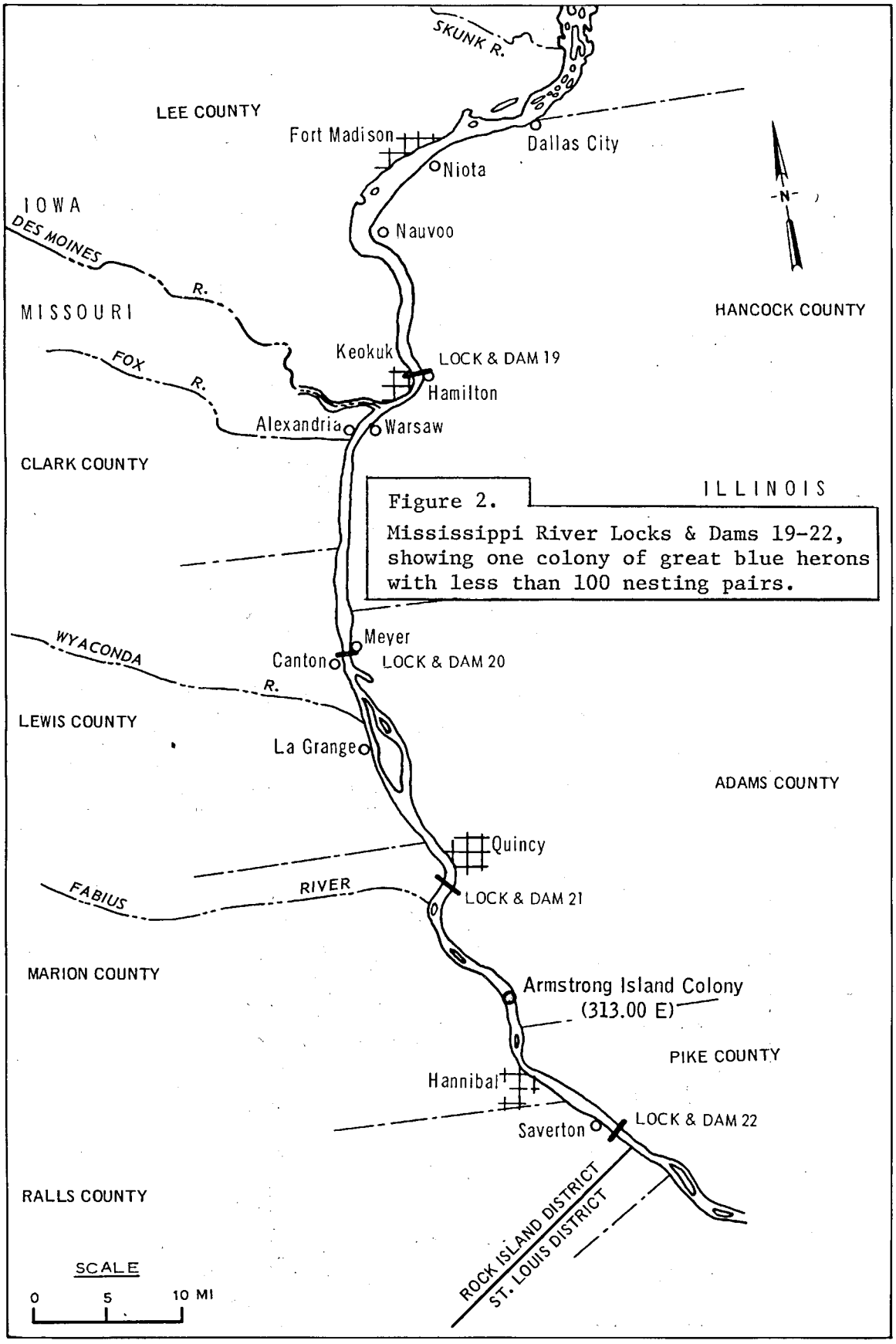

Figure 2.
Mississippi River Locks & Dams 19-22, showing one colony of great blue herons with less than 100 nesting pairs.

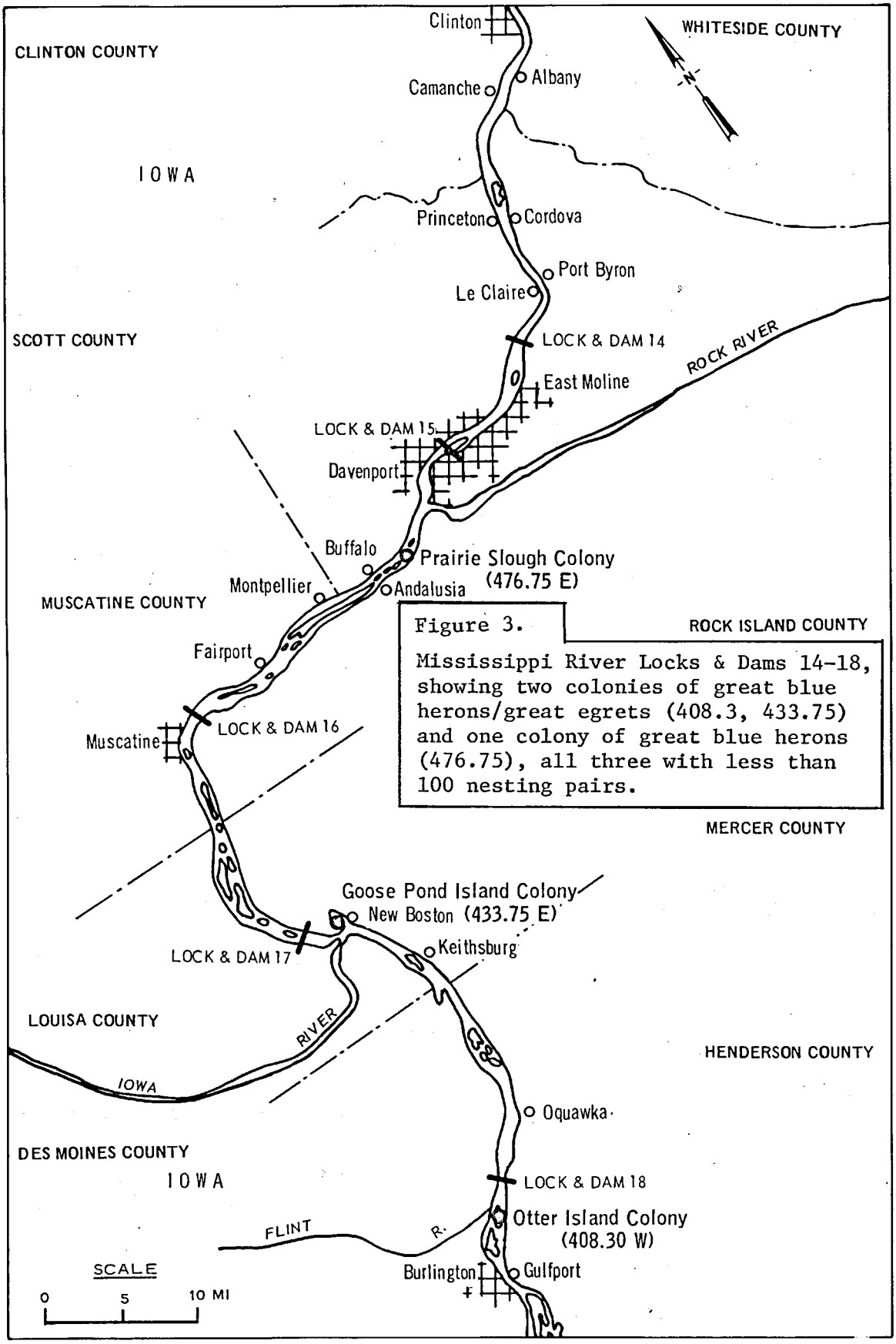

Figure 3.

Mississippi River Locks & Dams 14-18, showing two colonies of great blue herons/great egrets (408.3, 433.75) and one colony of great blue herons (476.75), all three with less than 100 nesting pairs.

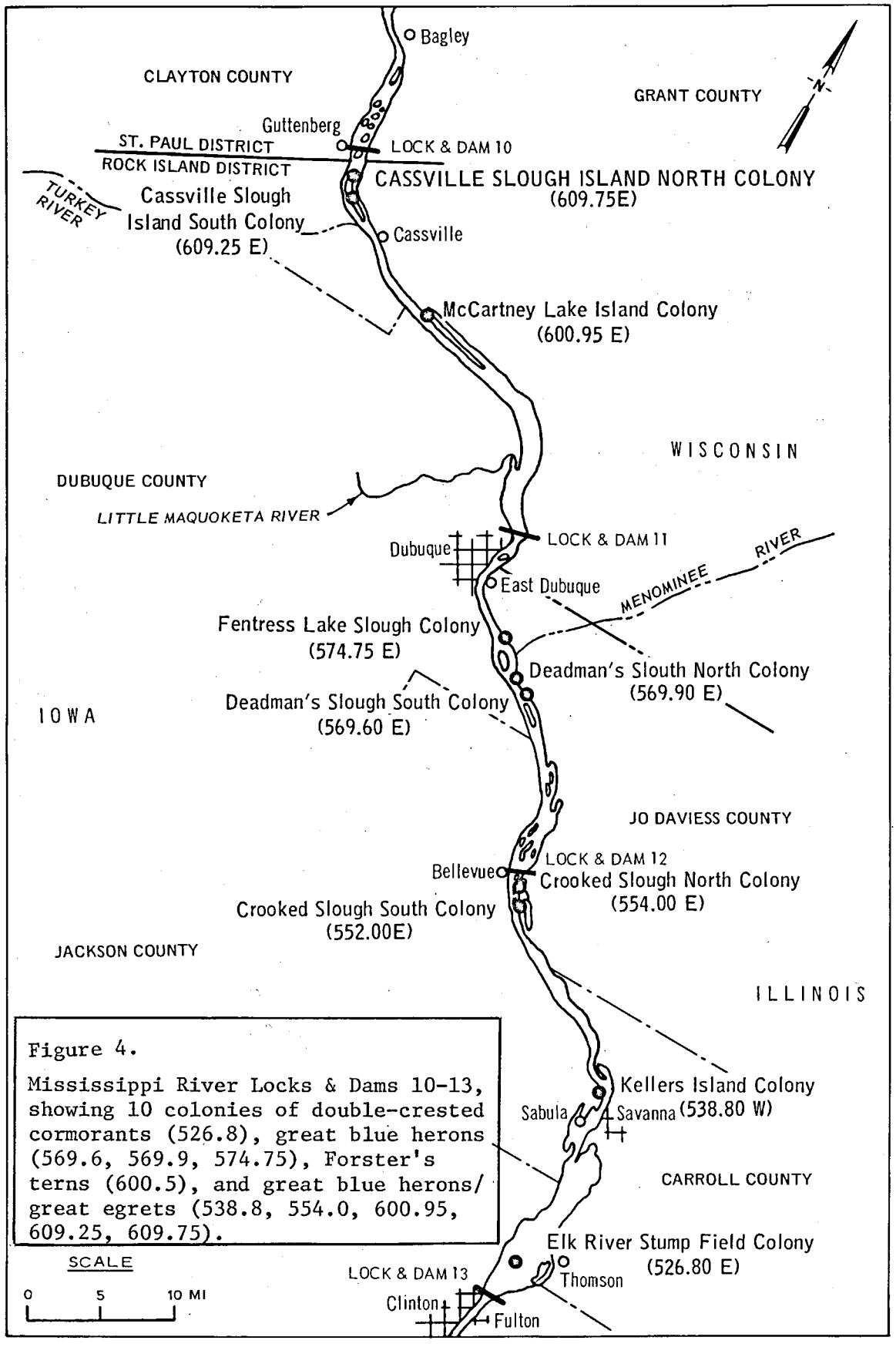

Figure 4.

Mississippi River Locks & Dams 10-13, showing 10 colonies of double-crested cormorants (526.8), great blue herons (569.6, 569.9, 574.75), Forster's terns (600.5), and great blue herons/ great egrets (538.8, 554.0, 600.95, 609.25, 609.75).

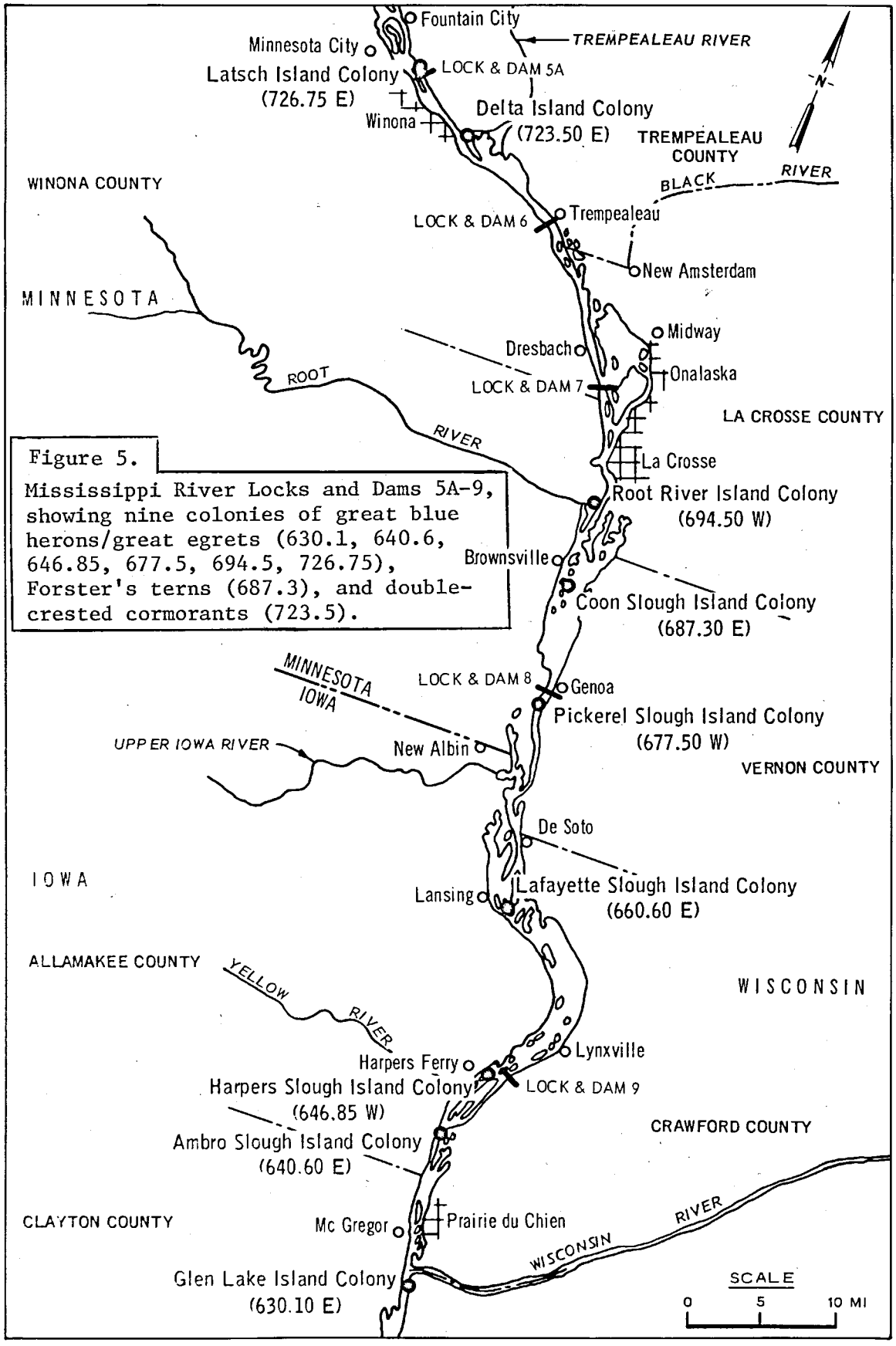

Figure 5.
Mississippi River Locks and Dams 5A-9, showing nine colonies of great blue herons/great egrets (630.1, 640.6, 646.85, 677.5, 694.5, 726.75), Forster's terns (687.3), and double-crested cormorants (723.5).

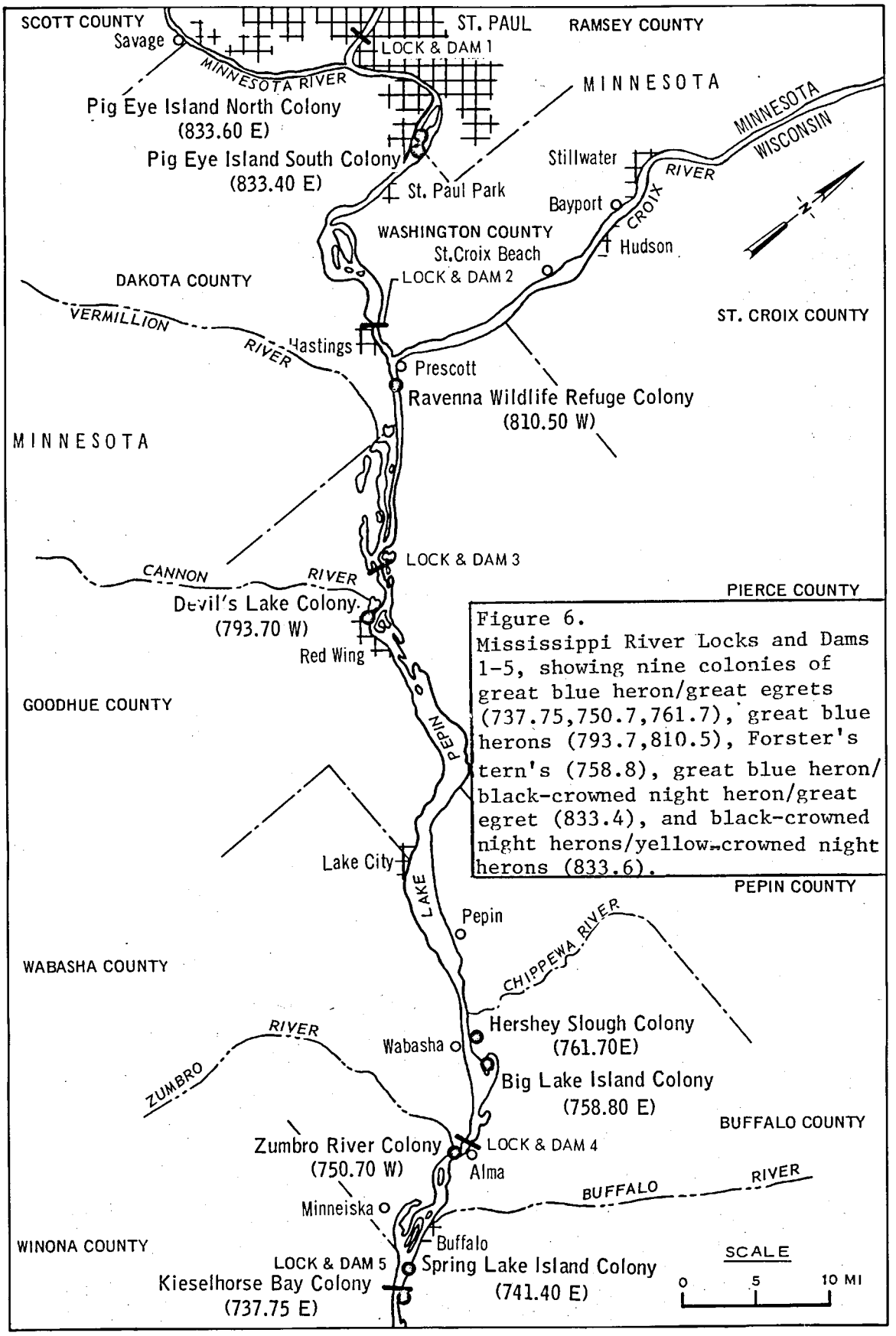

Figure 6.
Mississippi River Locks and Dams 1-5, showing nine colonies of great blue heron/great egrets (737.75,750.7,761.7), great blue herons (793.7,810.5), Forster's tern's (758.8), great blue heron/black-crowned night heron/great egret (833.4), and black-crowned night herons/yellow-crowned night herons (833.6).

Figure 7. An aerial view of great blue heron and great egret nests in the upper Mississippi River floodplain.

15. Two complete aerial surveys of the study area were made using a Cessna 172 aircraft (Figure 8). Each took about five days to complete progressing from south to north to minimize differences in nesting phenology due to the advancing season. The first aerial survey was flown in the last half of April, 1977, before the foliage was fully developed, in order to locate and census great blue herons. The second aerial survey was made during June to locate and census the later-nesting species such as egrets, gulls, and terns.

16. To conserve time, attention was limited to forests, islands, marshes, sandy areas, and dead trees standing in water, ignoring small woodlots, developed or agricultural lands, and open water (Figure 9). In several places where river-bottom forest was particularly extensive, or where the floodplains of tributaries joined the Mississippi floodplain, surveys were made from the Mississippi River to the first highway or railroad tracks paralleling the river. Usually these boundaries were located form 0.8 km to 1.6 km from the riverbank. All dredged material deposits were flown over and searched. In effect, virtually all good heron, gull, tern, and cormorant nesting habitat within the floodplain was surveyed. Heron colonies along the floodplains of the Illinois, Wisconsin, and Black Rivers for 5, 121, and 16 km, respectively, from the main channel of the Mississippi River were also searched.

17. Two or three experienced observers were always included in the survey so that habitat on both sides of the aircraft was observed. While searching for herons on the first series of flights, the plane was flown at 113-129 km/h and about 60 m above the treetops. Where the forest was sufficiently wide, transects 0.8-km wide were flown between prominent landmarks, oriented parallel to the river.

18. During the second flight the plane was flown 15 m above virtually every sandbar and dredged material deposit along the entire length of the study area, in attempts to flush and observe least terns (Sterna albifrons) or common terns (Sterna hirundo) nesting in the sand, or gulls nesting in sparse vegetation. All marshy areas were flown at a similar speed and altitude looking for Forster's terns (Sterna forsteri), with

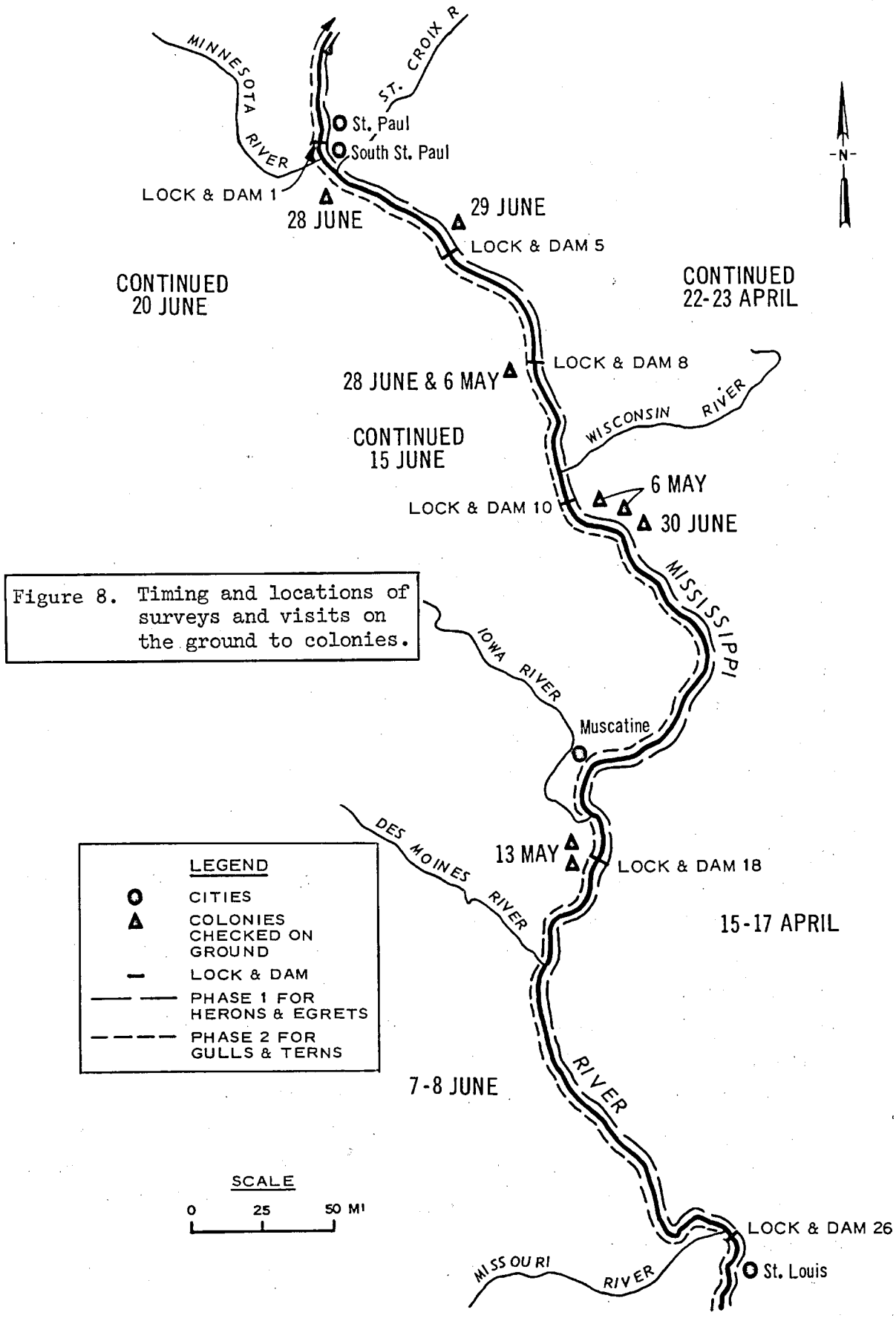

Figure 8. Timing and locations of surveys and visits on the ground to colonies.

Figure 9. Typical view of the floodplain showing main channel, channel islands, marshes, river-bottom forest, and sloughs.

aerial transects spaced approximately 305 m apart. Whenever a gull or tern was observed flying near suitable nesting areas, a turn was made for another low-level pass. While not flying over suitable habitat for gulls and terns during the second survey, the search procedure for herons was resumed.

19. After each aerial survey, colonies were visited on the ground for the purpose of verifying population counts, determining phenology of nesting, sampling vegetation within the colony, observing nearby dredged material deposits, and looking for disturbances. A total of eight great blue heron colonies and one Forster's tern colony were visited.

20. The number of breeding pairs in each colony were counted by observing from the airplane, by analyzing aerial photographs, or during a tree-by-tree examination from the ground. At four colonies of great blue herons and great egrets, and at one colony of Forster's terns, all three of these methods were employed, providing an estimate of the accuracy of the census. Based on these comparisons, the populations reported here are considered accurate to $\pm$10 percent in most cases.

21. Four large heron colonies (677.5, 694.5, 737.75, and 833.6) could not be censused in the time available by any of these methods because nesting occurred below the top of the canopy and foliage was already partly developed. For these colonies, reliance on recent censuses reported by Nicklaus (1977) and Adams et al. (1973) was necessary.

22. The most accurate method for censusing Forster's terns was a combination of aerial and ground counts made between 15 and 29 June, since this allowed detection of outlying nests and elimination of inactive nests. For the tern colonies not visited on the ground (660.6 and 687.3), the number of nests counted from the air was multiplied by correction factors based on experience with tern colony 741.4, which had been counted by three different methods.

23. Between 7 June and 20 June, nesting success was studied for tree nesting species by three observers by counting the number of young per nest while flying 30 m over treetops (Figure 7).

24. The location of colonies is described precisely in this report by reference to the "River Mile" above the mouth of the Ohio River, and

also by reference to a lateral distance to the east or west side from the center of the navigation channel (Table B1, Appendix B). All colonies in this report are referred to by River Mile, but for some colonies located imprecisely through literature review or correspondence, a range of numbers is given or a ± symbol precedes the colony number.

Description of Vegetation at Colony Sites

25. Observations during overflights and analyses of aerial photos permitted general description of vegetation of colonies and identification of some species of nesting trees. More detailed studies were made during ground-level visits to the seven heron colonies. Heights of trees were estimated and tree species and condition (live or dead) was noted, either for all trees with nests or for a random sample of 10 trees containing nests.

26. At three of these sites, a detailed analysis of the plant community within which nesting occurred was undertaken on 28-30 June 1977, employing the point-centered quarter method. Ten points at 100-foot intervals within the circumference of each heronry were sampled. Only live trees with a diameter breast height (DBH) of at least 10 cm were selected for measurement. Voucher specimens were collected at the three sites and duplicate reference collections are housed at the Milwaukee Public Museum Herbarium and at WES.

27. Vegetation within one Forster's tern colony (741.4) was analyzed during a visit at ground level, but a formal sampling method was not employed because of the uniformity of the vegetation. The vegetation of this colony was compared to that of the other Forster's tern colonies during low-level overflights and by close range photo analyses.

PART IV: RESULTS AND DISCUSSION

Description of Dredged Material Deposits

28. Disposal sites for dredged material are common along the Upper Mississippi River. A total of 328 above-water sites were located, averaging one every 3.2 km. Only 22 percent of the deposits are located on the mainland; the rest are on islands (Figure10). The size varied from circular mounds about 100 m in diameter to banks up to 2.8 km long (Figure 11). The sites were always located beside the navigation channel. There were only six above-water sites in the St. Louis District, 114 in the Rock Island District, and 208 in the St. Paul District, with an average separation of 26.1, 4.4, and 1.8 km between deposits. The volume of dredging increases as one moves upstream, since the river is shallower closer to its headwaters.

29. Disposal sites for material dredged from the Upper Mississippi River navigation channel can be classified as follows:

1. Deep Water
    a. emergent deposits (islands or sandbars)
    b. submerged deposits
2. Wetlands (in shallow water)
3. Uplands (above water level)
    a. forested areas
    b. treeless areas
    c. temporary storage areas for use as construction material

The location of disposal sites varies from District to District. In the St. Louis District, nearly all deposits were placed in deep water. Normally, these deposits remained submerged, but with the abnormally low water levels prevailing during the spring of 1977, some of these were emergent. There are only six upland sites in treeless areas in the entire District. In the Rock Island District, the material was placed only in upland areas, usually in stands of trees 25-30 years old, but there were some sites in treeless areas as well. When the deposit reached a depth of over 1.5 m, the trees were often killed.

Figure 10. Island made from dredged material deposit.

Figure 11. Dredged material deposits forming a long bank.

There was only one wetlands disposal site, on Arsenal Island (River Mile 482.7). The St. Paul District disposed of dredged material above water, either on the shore or on islands. A few deposits were in forested areas, causing death of trees, but most were in unforested areas. Both the St. Paul and the Rock Island Districts used dredged material for beaches, parks, land-fill, construction fill, and building of levees.

30. The great majority of sites had no protection or containment and were relatively low mounds with a very gradual slope. There were only a few diked sites in the St. Paul District in or near St. Paul. The only riprapped site was Arsenal Island in the Rock Island District. The St. Paul District had a small number of artificially revegetated sites (Dralle, 1977, personal communication).

31. The volume of dredging has declined in recent years throughout the study area, from an initial maximum after the dams were finished. Dredging initially was most frequent below the locks and dams, but gradually moved downstream. Presently, most dredging activity is centered at the upper reaches of the pools, where long chains of islands or peninsulas reach along either side of the channel into the pool.

32. In all districts, the dredged material consists mostly of sand and some gravel. Since the myriad sandbars of the virgin river have been mostly covered by water backed up by dams, few sandy areas remain other than the dredged material deposits. These made ideal beaches and are consequently heavily used by people. The lower elevation deposits, if left alone, would usually become revegetated within several years; however, heavy use retards revegetation and many sites receive new deposits annually.

Study of Bird Colonies

Species and Populations

33. The number of colonies found and their populations are shown in Table 1, while the locations of most colonies are shown in Figures 1-6. Since great egrets always nested with great blue herons and because of other interspecific associations, there was a total of 32 heron and

Table 1

Species and Breeding Populations of Colonial Waterbirds Found Nesting Within the Study Area in 1977

Species	No. of colonies	Total no. of pairs	Mean no. of breeding pairs/colony
Great blue heron (*Ardea herodius*)	27	3746	138.7
Great egret (*Casmerodius albus*)	18	698	38.8
Black-crowned night heron (*Nycticorax nycticorax*)	2*	560*	280.0
Forster's tern (*Sterna forsteri*)	3	34	11.3
Double-crested cormorant (*Phalacrocorax auritus*)	2	16	8.0

* Data taken from Nicklaus (1977) since accurate counts were impossible in an aerial survey.

egret colonies, and a total of 37 colonies of all species. Exact locations of colonies and additional details are given in the tables of Appendices A and B.

34. Because green herons (Butorides striatus) nest below the top of the canopy, no attempt was made to search for their nests. Since only one colony containing 12 nests was found through correspondence (Nicklaus 1977) at River Mile 535.5 (west side), this species will receive no further attention in this report.

35. It is likely that black terns (Chlidonias niger) probably nest within the floodplain in small numbers, although no attempt was made to locate their nests. One active bald eagle (Haliaeetus leucocephalus) nest (River Mile 599.9, 0.55 E) and one active osprey (Pandion haliaetus) nest (River Mile 723.8, 1.2 E) were found. No nests of gulls, terns (except Forster's tern, Sterna forsteri), pelicans, ibises, or other species of herons and egrets were detected from the aircraft (Appendix B, Table B1). Important dates in the breeding cycle of each species are summarized in Table 2.

36. Numerous flocks of herring gulls (Larus argentatus) and ring-billed gulls (Larus delawarensis) were seen loafing on small sandbars, often near human settlements. Many of these birds were immature.

Great blue herons and great egrets

37. For purposes of comparison between north and south, the study area was divided into halves at Lock and Dam 13 near Clinton, Iowa. There were more colonies in the northern half of the study area and these colonies tended to be larger than those in the southern half. The mean number of pairs per colony of both species combined for the northern half was 11.5 compared to 46.7 for the southern half. Hence population densities differed between the two regions, as shown in Figure 12. In the northern half, the mean number of great blue heron and great egret pairs per linear mile of floodplain was twelve, compared to one pair per mile in the southern half. Both species exhibited the same population trends, although the lower densities in the south were more pronounced for great egrets. South of Clinton, only three of seven

Table 2

Observed Breeding Dates for Eight Colonial Birds Nesting in the North-Central States

Species	Arrival in Area	Occupation of Colony	Egg Laying	Incubation (Days)	Hatching	Fledging	Source
Double-crested cormorant	Mid-Mar - End Mar (IL, MN)	≤ 4/17/77 (IL)	May 7 - July 11 (ND, MN)	24.5-29	?	?	Roberts (1932) Palmer (1962) Kleen (1975)
Great blue heron	1st-2nd Wk Mar (MN)*	Immediately upon arrival	Mid Apr - 1st Wk May (MN)	28	Apr 25 - 2nd Wk June (MN)	1st WK July - 3rd WK Aug (MN)	Pratch (1972) Norling (1977) Bent (1926)
Green heron	Apr 10 (MN)- 1st Wk May (IL)	?	May 9 (WI) - June 11 (MN)	19-21	June 12 (MN)	?	Roberts (1932) Palmer (1962)
Great egret	3/21/73 (WI) - 4/3/62 (IL)	April 7 (WI) >4/22/77 (WI)	≤4/15/77 (IL) - May 7 (WI)	23-24	June 3 (WI)	?	Chipman (1973)

* Some remain throughout the winter in the south of the study area.
** Date estimated.
Note: 1977 dates were determined by this study. The state of observation is shown in parentheses, while underlined dates are for colonies located within the study area.

(Continued)

Table 2 (Continued)

Species	Arrival in Area	Occupation of Colony	Egg Laying	Incubation (Days)	Hatching	Fledging	Source
							Graber (1962) Bent (1926); Johnson (Unpubl. 1977)
Black-crowned night heron	Apr 5 (MN)-15 Apr (WI)	Early May (WI)	Late Apr (MI, MN) - May 29** (WI)	24-26	May 28 (MN)- June 26 (WI)	?	Johnson (unpubl.) Gross (1923) Palmer (1962) Roberts (1932)
Yellow-crowned night heron	May 1 (IL)	5/10/58	?		about June 17	?	Fawks and Petersen (1961) Theodore (1955) Breckenridge (1958)
Forster's tern	Apr 17 earliest (MN)	?	5/25 (MN) - 6/8 (MN); First half June, 1977**	23	Last Wk June - 1st (WI); Wk July 1977	7/25/60 1st Wk Aug 1977 (WI)	Roberts (1932) Bent (1921) Lupient (1960)

(continued)

Table 2(Concluded)

Species	Arrival in Area	Occupation of Colony	Egg Laying	Incubation (Days)	Hatching	Fledging	Source
Least tern (at St. Louis)	5/27/72 - Early June	6/10/72 - 7/15/72 (renesting)	<6/17/72	14-16	7/1/72 - 7/4/72	<7/30/72	Dick Anderson (1978, Audubon Soc. of Missouri, St. Louis, MO - personal communication) Hardy (1957) Bent (1921)

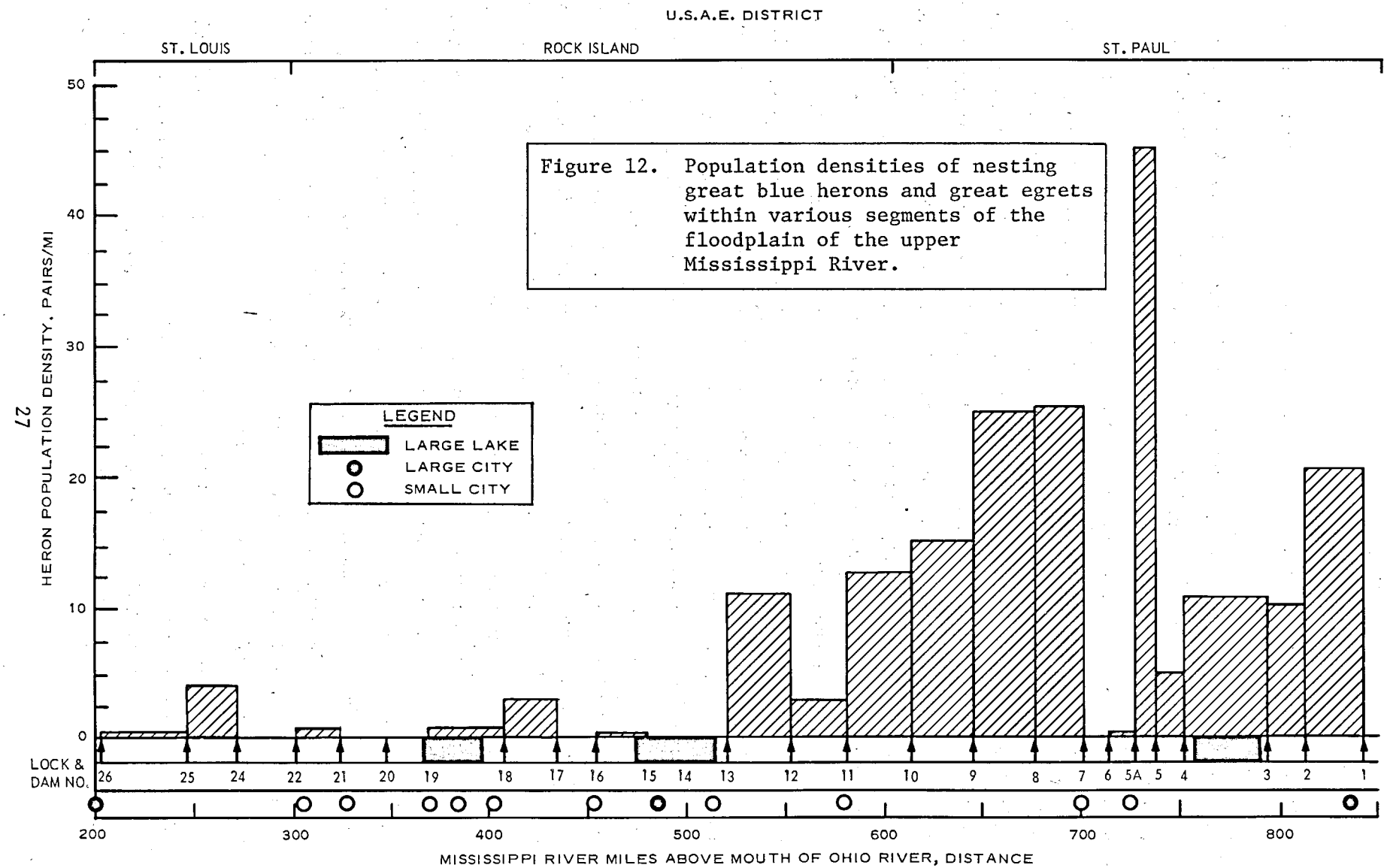

Figure 12. Population densities of nesting great blue herons and great egrets within various segments of the floodplain of the upper Mississippi River.

colonies contained egrets, while north of Clinton, 15 of 20 colonies contained egrets.

38. The most useful sources of population records were Audubon Field Notes, and American Birds, which were searched from 1948-1977. Records of past populations were found for only 22 colonies of great blue herons and great egrets. These records are summarized in Tables B2 and B3 of Appendix B. Records for the other 10 colonies located by this survey did not exist. Most records fall within two time periods: 1948-1959, and 1968-1976. If records were present from both of these periods, comparisons were made to establish long-term population trends. In many cases records existed only from 1968, and only short-term trends could be established. Populations at two colonies, 694.5 and 793.7, have been counted for five or more consecutive years.

39. Since the population fluctuated widely at these colonies from one year to the next, the following arbitrary criteria were adopted. A colony which increases or decreases in breeding pairs or nests by more than 50 percent of its first-known population is considered to be "increasing" or "decreasing", respectively. Colonies increasing or decreasing by lesser amounts are considered to be "stable". Some judgement was required in designating "extinct" colonies, and several reports of old colonies, considered erroneous, were excluded from the analyses. "Extinct colonies" and "newly established colonies" are considered, by definition, to represent only long-term trends.

40. Population trends for both species are summarized in Tables 3 and 4. The colonies listed under short-term trends (since 1968), are different colonies from those listed under long-term trends (since 1942). Great blue herons showed a slight population increase in the northern half of the study area since 1942 and since 1968. However, they show evidence of a slight population decline since 1942 and since 1968 in the southern half of the study area.

41. Noteworthy was the marked decline of Colony 216.6 from about 90 nests to only four nests in a short period of years, the decline of Colony 433.75 from 600-700 nests in 1957 to 89 nests in 1977 and the extinction of two colonies, probably since 1968. Considering the whole

Table 3

Population Trends of Great Blue Herons
at Individual Colonies

Portion of study area	Time Period	Number of colonies					
		Newly Established	Increasing	Stable	Decreasing	Extinct	Total
North half	From 1942	4	2	1	0	5	12
	From 1968	-	3	1	1	-	5
South half	From 1942	0	0	1	1	2	4
	From 1968	-	0	0	1	0	1
Total		4	5	3	3	7	22

Table 4

Population Trends of Great Egrets
at Individual Colonies

Portion of study area	Time Period	Number of colonies					
		Newly Established	Increasing	Stable	Decreasing	Extinct	Total
North half	From 1942	4	0	0	3	4	11
	From 1968	-	1	2	0	-	3
South half	From 1942	0	0	1	0	7	8
	From 1968	-	0	0	0	-	0
Total		4	1	3	3	11	22

study area as a unit, great blue heron populations are declining slightly.

42. Great egrets appeared to be decreasing in the north since 1968. Although four new colonies appeared to balance four extinctions of colonies, three of these four new colonies contained three or fewer pairs of egrets. In the southern half of the study area little information was available except from Mayfield (1948). Careful comparison of Mayfield's report with locations of presently known colonies revealed a substantial decline in both populations and numbers of colonies, with at least seven colonies disappearing between 1948 and 1977, and no new colonies being established to counterbalance these losses.

43. The maximum distance between colonies was 154 km, but not all of this contained good habitat. However, Table 5 shows five segments of the river which contained apparently suitable feeding or nesting areas which harbored no colonies. Two short gaps averaging 10.5 km in length occurred in the north, while five longer gaps averaging 37.4 km in length were observed in the southern half. Egrets showed more discontinuous distribution than great blue herons, with only three colonies of great egrets in the entire southern half. In addition, egrets seemed to avoid cities since colonies of great blue herons without any great egrets occurred below the cities of St. Paul, Dubuque, Rock Island, and Quincy.

44. Observations from aircraft revealed an average of 3.0 young per successful nest for great blue herons (518 nests in 27 colonies) and 2.6 for great egrets (73 nests in 7 colonies), with very few inactive nests observed (Tables B4 and B5, Appendix B). The number of young per successful nest ranged from 1-5 in the herons and 1-4 in the egrets, and the averages for separate colonies ranged from 2.3 to 4.3 for herons and from 2.3 to 2.9 for egrets. Only 569.9 had a large proportion of empty nests.

45. Although recoons frequently prey on great blue herons and great egrets (Ivanovs 1968, Teal 1965, Vermeer and Hatch 1972), no predators were observed nor any mortality definitely attributable to predators in the eight colonies visited on the ground. Norling (1977) observed no predation in 793.7 during his four-year study there.

Table 5

Segments of the Upper Mississippi River With No Known Great Blue Heron or Great Egret Colonies, Yet Containing Exceptionally Good Nesting Sites

River Miles of Segment	Total Miles of Segment	Below Lock and Dam No.	Tributary Rivers Within Segment	Forest
217-242	25	25	Cuivre R.	Yes
284-301	17	22	Salt R.	Yes
313-365	52	19	Fox R.	Yes
		20	Des Moines R.	
		21	Wyaconda R.	
			Fabius R.	
			North R.	
434-457	23	16	None	Extensive
503-523	20	13	Wapsipinicon R.	
707-714	7	6	Black R.	Extensive
834-848	14	1	Minnesota R.	Mostly Urban

Night herons

46. Only two colonies of black-crowned night herons (Nycticorax nycticorax) were found, at River Miles 833.4 and 833.6 in an industrialized area south of St. Paul. The continued existence of two nests reported at River Mile 538.8 (Harlan 1943) could not be determined from the air. One colony active in 1960 at River Mile 721.4 was not found after an aerial search of its exact location, and is presumed extinct. More colonies may exist since this species is difficult to locate from the air.

47. Yellow-crowned night herons (Nyctanassa violacea) have nested at approximately six locations within the northern two-thirds of the study area since 1955 (Table B6, Appendix B). The birds nested as single pairs or in colonies with up to five nests. No observations of this species were made in the course of the present study. The colony at River Mile 698.7 became inactive during the summer of 1974 (Peter Smith, 1978, USFWS, Longlake NWR, Moffit, ND, personal communication). Smith believes that increased human activity in the area, plus Dutch elm disease that defoliated screening vegetation, contributed to abandonment of the colony. The colony may have moved to a remote wooded area at River Mile 694.5, where a number of adults and young birds were observed during the summer of 1974 at about the same time that 698.7 became active.

Forster's terns

48. Forster's terns were recorded for the first time in the Upper Mississippi River plain nesting at three locations in the northern half of the study area, and unconfirmed nesting sites with similar vegetation were found at two other locations (Table 6 and Appendix B, Table B1).

49. The colony at 741.4 was visited on the ground on 29 June (Figure 13). The nests observed there were similar to those described by Bergman et al. (1970) for Forster's terns nesting in Iowa. The 19 nests were built either on low mounds of vegetation apparently placed by the birds themselves (14), on deteriorated muskrat lodges (4), or on floating logs (1). The nests floated on water averaging 55 cm deep. Since the bottom of the nest cup averaged only 8.7 cm above the water surface, many of the nests

Figure 13. A Forster's tern colony located in marsh, and showing nests built up above the surrounding flooded areas.

Table 6

Populations and Locations of Forster's Terns
Nesting within the Study Area

County Location River Mile	Pool No.	Number of Breeding Pairs Counted	Distance to Main Channel (km)	Distance to Nearest Dredged Deposit (km)	Distance to Nearest Road or Habitation (km)	Distance above Nearest Dam (km)
600.5	11	?	0.8	2.4	0.8	28.2
660.6	9	5	0.6	4.2	1.1	20.5
687.3	8	10	0.5	0.6	1.8	13.1
741.4	5	19	1.8	2.1	0.2	5.3
758.8	4	?	1.5	1.8	1.3	9.7
Mean		?	1.0	2.0	1.0	15.4

had moist linings. Distance to the nearest neighboring nest ranged from 0.36 m to over 9 m, but the majority were less than 3 m apart. Two muskrat lodges supported two nests each. Thirteen of the nests had eggs and six appeared to have chicks, although only one chick was actually located. Clutch sizes ranged from one to four and averaged 2.7.

50. Bergman et al. (1970) found an average clutch size of 2.5 in northwestern Iowa. Nesting appeared to be progressing normally, since clutch size was normal, young were hatching, and only one dead embryo was found. At least one chick must have fledged since Faber (personal communication, 1977, St. Mary's College, Winona, MN) observed one Forster's tern with immature plumage when he visited the colony in early August.

51. All five locations were well-isolated from disturbances. Nests were located far from trees where raptorial birds might perch. Surrounding vegetation protected the low nests from natural wave action or boat wakes. Access was difficult by either boat or on foot because the terns nested among dense vegetation in shallow water, surrounded by deeper water, and far from the main channel.

Interior least tern

52. Using aerial survey techniques known to be effective in locating least tern colonies (Downing 1975), no least terns were observed.

53. According to Hardy (1957), the least tern formerly ranged in summer along the Mississippi River as far north as Dubuque, Iowa (Hardy 1957). Downing (1975) found the greatest concentration of least terns (about 600 birds in 11 colonies) in the 242 km of the Mississippi River between Osceola, Arkansas, and Cairo, Illinois. However, sightings along the river north of St. Louis, where it attempted to breed in 1969, 1971 (eight pairs), and 1972 (Clawson, 1977, personal communication), Kleen and Bush 1971, 1972). Nesting has not occurred on Mosenthien Island since 1972. If breeding occurred in 1977, the terns should have been detected during the flights of 7-20 June since they arrive at St. Louis between 27 May (D. Anderson, 1978, personal communication, Audubon Soc. of Missouri, St. Louis) and early June (Hardy 1957). Apparently, the least tern has been extirpated from the study area as a breeding species.

Double-crested Cormorants

54. Only two colonies of double-crested cormorants (Phalacrocorax auritus) were found, consisting of 12 (colony at 526.8) and five (colony at 723.5) breeding pairs. Production of young at the southern colony (526.8) appeared good when observers flew over on 14 June (Figure 14). The number of active nests was the same as on 16 April, and three young per nest were seen, which compares favorably with reproductive success in colonies elsewhere in the United States (Gross 1944).

55. The cormorants were not as well protected from disturbance as the terns because they were more visible and easier to approach by boat, but they were isolated from traffic areas. The colony at 526.8 was located 1.9 km from the main channel, and 2.3 km from a habitation or road. The colony at 723.5 was located 1.9 km from the nearest dredged material deposit, 2.4 km from the main channel and 0.4 km from the nearest road or habitation.

56. No direct impact of dredged material deposits on the two cormorant colonies was detected. In the southern half of the study area two colonies are known to have disappeared (Appendix B, Table B3). The population of the colony at 723.5 has declined from 25 to 12, while the colony at 723.5 has declined from 13 pairs in 1976 to five in 1977 (S. Cornelius, 1977, personal communication, Trempealeau NWR, Trempealeau, WI). This decline was in part due to the destruction of all nests by winds in July 1976.

Factors Influencing Colony and Nest Site Selection

57. Important physical features of all colonies and their surroundings were observed, and characteristics common to most colonies are described in the following statements. Since the majority of colonies located consisted of great blue herons and great egrets, more detailed analysis was possible and ten factors influencing site selection were identified for these two species.

Figure 14. Double-crested cormorant colony, showing birds on nesting platforms and boxes.

Great blue herons and great egrets

58. Preferred plant communities and nesting trees. The herons and egrets usually nest at the tops of the trees of the mature bottomland hardwood forests dominated by silver maple (Acer saccharinum) and American elm (Ulmus americana), or sometimes in trees of subclimax species greater than 18 m tall (Figure 15). In the Midwest, large American sycamores (Platanus occidentalis) are used where this species occurs. Nests of the three southernmost colonies found in this study were located in sycamore trees. In Ohio, great blue herons show "some preference for sycamore trees" (Moseley 1936), while Bent (1926) reported that great blue herons in Michigan nested in giant sycamore trees. However, sycamores are found only in the southern half of the study area, and are relatively uncommon even there (USAEDSL 1975). North of River Mile 271.6, sycamore was replaced as a nesting tree by other deciduous trees typical of the floodplain forest. The colony at 408.3 was the only colony where herons nested entirely in eastern cottonwood (Populus deltoides). The colony at 433.75 was the southernmost example of nesting in a forest dominated by silver maple. From this colony northward to Minneapolis, herons and egrets always nested in forests where silver maple was the most dominant species or one of the common species. Other trees commonly used for nesting north of River Mile 433.75 were American elm, green ash (Fraxinus pennsylvanica), and eastern cottonwood.

59. In the colony at 833.4, Adams et al. (1973) found that great blue herons and great egrets showed some preference for American elms as nest sites, and that this preference was not due to height of the trees alone. While black willows (Salix nigra) and eastern cottonwoods were nearly as tall as the elms, the black willows tended to have filmsy branches, and the crowns of the eastern cottonwood canopies were too dense. Apparently those towering above the surrounding canopy were preferred.

60. The herons and egrets nested more commonly in live trees than dead trees. Dead nesting trees exceeded 15 percent of the total in only 9 out of 27 colonies. Colonies with dead nesting trees were common along River Miles 539-630 and 762-833. The proportion of dead nesting trees reached a maximun at the colony at 569.9 where all or most of the nesting

Figure 15. Vegetation in a heron colony.

trees were dead, and deceased gradually to the north. Of the 78 nest trees observed in three colonies all of the 12 dead trees were American elms, identified by their characteristic shape.

61. Table 7 summarizes the dominant tree species and their relative importance for the three northern colonies sampled by the point-centered method. All three sites have typical, mature, floodplain forest. At all three colonies, silver maple was the most important species in the canopy, followed by American elm and green ash. Moving northward, the diversity decreased, while the importance of American elm increased, and the completeness of the canopy cover increased. The diversity of the southernmost site which was sampled can probably be attributed to (a) its southern latitude, (b) greater topographic variation than at the other two sites, and (c) death of many trees which opened the canopy. Details for each colony sampled are given in Appendix B, Tables B7-B9, and below.

62. In the colony at 600.95 local relief was variable, with 1 to 2 m differences in elevation noted between parts of the colony. The variations in topography allowed species such as green dragon (Arisaema dracontium), red oak (Quercus rubra), and hackleberry (Celtis occidentalis). The site also had larger open areas, more deadfalls, and more dead standing trees than the other two sites, but dead trees were not sampled. Average forest canopy cover was about 50 percent. Poison ivy (Rhus radicans), observed at eight of ten sampling points, dominated both the ground cover and the understory. It was also important in the canopy since it grew on the trunks and lower branches of most trees, and into the tops of most dead trees and some live trees. Other lianas, in addition to the rank growth of poison ivy, made travel very difficult.

63. The forest of the colony at 677.5 was less open than the previous colony (600.95) but was still dominated by mature trees of 18-24 m in height. Canopy cover was about 60 to 75 percent. Varying degrees of openness were noted at six of the ten sampling points. A considerable amount of deadfall caused some of the open areas. The dominant species of the more open understory was wood nettle (Laportea canadensis) reported at nine out of ten sample points. Associated species found in shady

Table 7

Importance Values for Species of Trees in Three Heron and Egret Colonies Located along the Mississippi River in Wisconsin and Minnesota

Tree Species	South End Colony #600.95	Colony #677.5	North End Colony #810.5
Silver maple (*Acer saccharinum*)	134.2	128.5	128.5
American elm (*Ulmus americana*)	86.1	106.8	113.8
Green ash (*Fraxinus pennsylvanica*)	11.8	51.6	57.7
Red oak (*Quercus rubra*)	40.4	0	0
Swamp white oak (*Quercus bicolor*)	6.5	13.1	0
River birch (*Betula nigra*)	12.8	0	0
Hackberry (*Celtis occidentalis*)	6.4	0	0
Total	298.2	300	300
Total Basal area: sq m/ha	40.4	255.3	115.0
Trees/ha	156	1,057	342

areas of the canopy included bog-hemp (Boehmeria cylindrica), Aster sp., cutgrass (Leersia virginica), and clearweed (Pilea pumila). Many vines were found including Grape (Vitis sp.) and poison ivy. Both American elm and green ash trees were reproducing at this site. The largest trees of all three sites were found here.

64. The colony at 810.5 was situated over a low-lying riverine alluvial information. The forest had closed canopy made up of mature trees 18-24 m high. Few trees rising above the general canopy level were noted from either the air or the ground. There were no wind-felled trees and few dead trees. The extremely dense understory, more uniform than at the previous two sites, consisted almost exclusively of wood nettle. Practically no reproduction of the mature forest trees was occurring. The colony size had a basal area of 115 m^2/ha, which was substantially higher than other riverine forests. Undisturbed riverine stands tend to have a high total basal area, with an average of 39.4 m^2/ha in Wisconsin (Curtis 1959), and 50.2 m^2/ha in a study of 34 flood-plain forest sites along the Missouri River in North Dakota.

65. Preferred nesting height. Both the herons and egrets usually nested within 3 m of the tops of the tallest trees.

66. Proximity to dams. Since the herons nested in forests and the forest was best preserved and least flooded just below dams, one might predict that heronries will be found in the forested region that typically extends about 16 km below dams. Table 8 shows that this prediction is fulfilled (Figures 1-6). Of 25 dams, five have heronries located less than 3.2 km downstream, 11 have heronries less than 8 km downstream, and 17 have heronries less than 16 km downstream. This preference for dams might have been even stronger, except that a third of the dams have cities or towns nearby which may have discouraged nesting.

67. Proximity to feeding areas. Most colonies were located near shallow oxbow lakes and sloughs and also within several km of extensive marshland. Herons were nearly always seen feeding in the shallow water immediately surrounding the colony.

Table 8

The Tendency of Great Blue Herons and Great Egrets to Nest Below Dams

Basis of Comparison	Less than 16 km Below Dams	Greater than 16 km Below Dams	Total
km of Mississippi River	403	637	1040
No. of Heronries Expected	10.5	16.5	27
No. of Heronries Found	17	10	27

$\chi^2=6.58$, $p < 0.01$ (one-tailed test)

Table 9

The Tendency of Great Blue Herons and Great Egrets to Nest Near River Junctions

Basis of Comparison	Within 4 km of River Function	Greater than 4 km from River Junction	Total
km of Mississippi River	344	696	1040
No. of Heronries Expected	8.9	18.1	27
No. of Heronries Found	15	12	27

$\chi^2=6.23$, $p < 0.01$ (one-tailed test)

68. Proximity to water. All but three of the 27 colonies were located within 100 m of a body of water. Fifteen were located on islands, and another six were located on peninsulas. However, on a small island facing the heavily traveled main channel, only one colony was located and only two other colonies out of 27 are within 160 m of the edge of the main channel. No colonies were located on small islands completely surrounded by easily navigable water; the smallest island in the main channel of the river containing a heronry was 2.9 km long by 0.6 km wide. Colonies were often located below dams and tributaries (Tables 9 and 10).

69. Proximity to river junctions and dams. Fifty-six percent of the herons and egrets frequently nested within 4 km of river junctions and dams, but only 33 percent of the river distance was included there. Conspicious deltas laced with forested islands occurred at the river junctions. Egrets showed a greater preference for dam sites over junctions than did the herons. These tendencies for herons and egrets to nest near dams and tributaries have exceptions. Ten dams out of 25, and 27 out of 43 junctions, had no associated heronries, while four small heronries were not associated with either dams or junctions. Most of these exceptions occurred in the southern half of the study area.

70. Preferred side of navigation channel. Two-thirds of the 27 heron and egret colonies were located on the east side of the navigation channel which forms the border between states (Appendix B, Table B1). If the assumption is made that colonies should be equally distributed on either side, then this preference for the east side is not quite statistically significant ($X^2 = 3.0$, $0.10 > \rho > 0.05$). However, this preference is statistically significant ($p < 0.05$) if double-crested cormorant, black-crowned night heron or Forster's tern colonies are included, all of which were located on the east side.

71. Barriers to human disturbance. Evidence of the need for isolation of colonies comes from a consideration of shooting incidents, responses of birds to intrusion, the isolated locations of colonies, and relocation of colonies.

72. No instances were observed of shooting of herons in the eight colonies visited on the ground, nor were any shooting incidents in the

Upper Mississippi River colonies in 1977 reported. However, shooting of herons prior to 1977 has been reported for colonies at 216.6 (Girard, 1977, personal communication) and 476.75 (Mumford 1959). In both instances the colonies were located near cities and within 370 m of the

Table 10

Number of Pairs of Great Blue Herons and Great Egrets Found Nesting in Different Types Of Locations Found in the Study Area

Colony Location	No. of Colonies	Total No. of Pairs	Mean No. of Pairs Per Colony
Both Below Dams (less than 16 km) and Near Junctions (within 8 km)	10	1519	152
Only Below Dams	7	1344	192
Only Near Junctions	6	528	88
Neither Below Dams nor Near Junctions	4	355	89
Total	27	3746	--
Overall mean			130

main channel.

73. The reactions of adult herons to intrusion by humans into the colony varies from colony to colony. At the five colonies on the Mississippi River that were visited during May, great blue herons flushed at a mean distance of 55 m (range 34-61 m), the approximate distance from which first observations of nests in the colony could be made. Some continued to fly about the nests, occasionally briefly touching down, while others roosted in groups in trees beyond the colony. In one colony (433.75), great egrets appeared more tolerant than the herons, remaining in their nests when observers were under their trees. In contrast to Mississippi River colonies is the large heronry in Horicon Marsh (Dodge County, WI), which has been protected and visited by government personnel for many years. Here, the flushing distance for great blue herons on 12 May, 1977, was only 18 m, and many birds returned to sit on their nests while observers stood talking underneath the nesting trees. This contrast in behavior between the Horicon Marsh and Mississippi River colonies suggests that adult great blue herons may become habituated to benign human intrusion. Miller (1943) reported of great blue herons that "when molested, they may become quite tame."

74. The reactions of adults also vary with the stage of breeding. During four ground checks made in June, adults were much more tolerant than they had been in May and paid little attention, feeding their young while observers stood underneath.

75. The reaction of young great blue herons to human intrusion varied with their age. In May the young frequently regurgitated their last meal when observers walked near their nesting trees, but in late June observers had to strike the nesting trees with branches so that the nearly-fledged young would stand and be counted. Sometimes even this stimulus did not elicit standing, and few fish were regurgitated.

76. Despite relatively easy access from nearby cities or recreation sites, little evidence was found of human visits to colonies other than occasional shotgun shell casings that may have been left during the hunting season. At the colony at 609.25 dredged material deposits formed vegetation-free corridors penetrating to within 200 m of the nesting

trees. These corridors open onto a 1.5-km long deposit which forms an excellent beach near a state park. Nevertheless, no signs of human disturbance were observed in this colony.

77. During low passes with the aircraft, few great blue herons or great egrets flushed from their nests, and many incubating or brooding adults did not even stand.

78. More distant human activities, such as river traffic, should be distinguished from direct human intrusion into colonies, or from persecution. Consideration of the colony sites selected by herons and egrets showed that the birds avoided human activities occuring at a distance. Only one heronry was located closer than 0.3 km to a summer cottage, and woods separated the two. The colonies at 833.4 and 833.6 (Figure 16) were about 0.5 km from industry, but there are woods and one or two streams between the colonies and the industry. All the other colonies are separated from humans by greater distances and by the natural barriers of water and dense vegetation. All were further than 160 m from traveled roads. The nests in most colonies can be seen from only about 100 m away when trees are fully leafed, and the birds themselves attract little attention.

79. While the herons and egrets seem to avoid nesting close to human activities, complete avoidance is impossible because of the scattered fields, towns, bridges, highways, railroads and industries within the floodplain. Four colonies are located within 3.2 km of a large city, and 14 are located within 3.2 km of a large structure or industry.

80. When established colonies are disturbed, they may move gradually, or relocate nearby (Kerns and Howe 1967). The colony at 677.5 has gradually moved to the SSW as trees in the north end have been abandoned and new nesting trees selected at the opposite end. Movement since trees were tagged in about 1972 has been 66 m from the north and 179 m from the south, away from a power plant and Lock and Dam 8 (located 1.6 and 2.4 km distant),away from a concentration of trees dying from Dutch elm disease, and away from the navigation channel. The colony cannot continue movement much longer because of its southern boundary is only 35 m from the forest edge. The colony at 600.95 is moving outward from

Figure 16. Colony of great blue herons, great egrets, and black-crowned night herons, near an industrial site.

a center of old dead trees apparently killed by Dutch elm disease. Cochrane (1977, NWR, Alma WI, personal communication) reported that the colony at 761.7 moved about 100 m after a storm downed nesting trees several years ago, while Norling (1977) reports that the colony at 793.7 shifted northward in 1975 and 1976.

81. Three colonies have apparently relocated to new locations less than 10 km away (Appendix B, Table 32). The colony at ± 808.75 moved from the Ravenna Wildlife Management Area onto a high-quality stand of timber on private land.

82. Protection from wind. Violent thunderstorms occur within the study area during the summer. Fallen nests were observed in four of the eight heron colonies that were visited on foot. Many of these nests may have fallen during the non-breeding season. However, in the colony at 600.95, it was observed on 30 June that 17 of the 178 nests counted on 17 April had recently fallen. Three of these nests fell with the entire nesting tree. In all, 21 chicks were found dead in, under, or near these nests and four additional dead young were hanging from branches. This colony is relatively open to the wind due to death of nesting trees in the center and to location on a narrow island only 260 m in width. Fallen nests have been observed in other studies of Mississippi River colonies.

83. Although the birds usually nested near the tops of tall trees, often in trees rising above the average canopy level, most nesting trees were partially screened from open areas by other trees. No colonies were located on wooded bluffs overlooking the river or on small islands surrounded on all sides by expanses of open water.

84. Interspecific associations. Since great blue herons arrived first in the colonies, great egrets always selected sites with the herons already nesting. However, egrets did not nest at nine sites selected by herons.

Night herons

85. Black-crowned night herons nested in a wide variety of vegetation, with nest heights ranging from water level to 49 m (Palmer 1962). In the midwest the birds frequently selected small trees or tree species typical of subclimax communities (Adams et al. 1973, Bjorklund 1975,

Faaborg 1967, Hoffman and Prince 1975, Johnson 1977, Moseley 1936, and Nickell 1966).

86. In the colony at 833.6, where vegetation had been disturbed some years earlier by heavy equipment, the herons nested in maples (188 nests), green ashes (131 nests), eastern cottonwoods (71 nests), boxelders (40 nests), American elms (28 nests), and willows (4 nests). However, the birds preferred green ash, thus placing a larger number of nests (3.9 nests per tree) in green ash trees, which showed only 16.3 percent dominance, than in other tree species (Adams et al. 1973).

87. In the nearby colony at 833.4, where green ash showed only 9.4 percent dominance, the herons placed their nests in maples (38 nests), boxelders (30 nests), green ashes (26 nests), American elms (8 nests), and an eastern cottonwood (Adams et al. 1973). Again, the birds seem to prefer green ash, although this preference could not be fully expressed because of the low dominance of this tree in the community.

88. The herons nested below the top of the canopy, making them hard to find from aircraft. Hoffman and Prince (1975) found that nest heights in Michigan were approximately two-thirds the height of nest trees. In the colony at 833.6, 93.3 percent of the black-crowned night herons nested between 6.4 and 12.2 m, although trees in the forest ranged to about 15 m. In the colony at 833.4, 94.7 percent were found within the same height range, although trees ranged to 22 m (Adams et al. 1973). This preference for nesting below the top of the canopy partially explains why the black-crowned night herons nested below great blue herons and great egrets. This selection of a moderate nest height occurs whether or not the other species of herons are present, and even though larger trees are available.

89. Yellow-crowned night herons also nest in a variety of vegetation and habitats. In the United States they often nest in willows, close to water, and near lush river swamps (Palmer 1962). They may nest in small or large colonies, but also may nest as single pairs in regions wehre they are extending their range (Palmer 1962). Theodore (1955) observed a nest (colony at 698.7) near LaCrescent, MN, in a large green ash tree about 15 m from the ground. The nest had at least two

young chicks on June 14.

Forster's terns

90. Forster's terns nest in extensive marshes at widely scattered locations in the five states bordering the study area.

91. Each of the five sites found in this study occurred in the marshes located from the middle of pools to the headwaters of pools (Table 6). The three sites where nests were observed averaged 13.0 km above dams.

92. All colonies were located on island-like patches of emergent vegetation growing in water about half a meter deep. Nests were built in small patches of open water, presumably cleared by muskrats. These open areas were nevertheless surrounded by vegetation which protected the nests from waves. Arrowheads (Sagittaria spp), reed grass (Phragmites australis), and three-square (Scirpus fluviatilis) were the emergent macrophytes growing most densely in water 0.3-1.3 m deep and where wind and wave actions were not strong enough to prevent establishment of emergent plants. In areas of open water around the emergent plant community, pondweeds (Potomogeton spp.),naiads (Najas spp.), coontail (Ceratophyllum spp.), watermilfoils (Myriophyllum spp.), water-lilies (Nymphaea spp.), and duckweeds (Lemma spp.) occurred. The emergent plant communities formed dense islands of vegetation dominated by broadleaf arrowhead (Sagittaria latifolia) and narrowleaf arrowhead (Sagittaria rigida). Also present were dense pockets of broadleaf cattail (Typha latifolia).

Double-crested cormorants

93. In the Upper Mississippi River floodplain, double-crested cormorants nested in small isolated groups of tall, dead trees standing in the pools above dams. The colony at 526.8 was located in the middle of the pool formed by Lock and Dam No. 13, 6.8 km upstream from the dam. The nests are built in two dead oak trees, which were probably killed when the pool was formed (Figure 14). These were the only two trees standing in the entire area. Artificial nest platforms were placed there in late 1975 and birds were observed nesting on them in 1977.

94. The colony at 723.5 was located at the upstream end of the pool

formed by Lock and Dam 6, 14.8 km above the dam. This colony was located in 1976 on two low, small islands, where nests were built 3-5 km above the ground, primarily in dead river birch (Betula nigra) (S. Cornelius, 1976, Upper Mississippi River Wildlife and Fish Refuge, Tempealeau, WI, personal communication).

95. The colony that formerly nested on the Clarksville Refuge (Pool 24) in the mid-1960's was located in dead trees standing in a marsh (USAEDSL 1975).

PART V: CONCLUSIONS

Population Trends

96. A knowledge of population levels and trends of colonial bird species is essential background before any attempt to manage existing sites or create new habitat through judicious placement of dredged material can be made.

97. In establishing population trends the following kinds of evidence have been evaluated: (a) population density comparison, (b) population trends at individual colonies, including newly established and extinct colonies, (c) gaps in distribution, (d) production of young, and (e) independent observations of other ornithologists. When making population density comparisons between the north and south halves of the study area, it seems reasonable to assume that both halves orginally supported equal densities of colonial birds, because the floodplain is a relatively uniform region. This uniformity also makes the identification of gaps in distribution more meaningful.

98. Of the seven colonial species found or formerly occurring, great blue herons, great egrets, and black-crowned night herons are declining in population in the study area, and least terns have probably been extirpated from the study area. Only Forster's terns and yellow-crowned night herons are expanding their ranges and populations. Because of the scarity of data, variations between observers and rather large normal fluctuations in the populations from one year to the next, these conclusions must be considered tentative.

99. Aerial surveys were shown to be reliable for location of great blue heron and great egret colonies. Reliability was not as good for the other species observed in this study. However, all known reported colonies were located as well as several additional colonies.

100. A general decline in population seems apparent from past documentation of existing colonies and the marked differences in population distribution and abundance from north to south. Erdman and Graber

(1977, personal communications) found declines of great blue herons and great egrets in Wisconsin and Illinois, respectively.

101. The importance of the apparent southern area decline is evident when consideration is given to the five factors:

a. Williams (1957), reported no heron colonies in Wisconsin closer than 50 km to the Mississippi River floodplain.
b. Black (1977, personal communication) reported only one other heron colony in Iowa outside the floodplain.
c. Henderson (1977) reported few colonies existing in Minnesota south of St. Paul outside the floodplain.
d. Regions bordering the floodplain are upland with very little marsh areas available for waterbirds.
e. Relatively few undisturbed or undeveloped areas suitable for waterbirds exist outside the upper river floodplain.

102. Another factor worthy of note was reported by Geraghty et al. (1973). Water turbidity in the tributaries feeding the river often exceeded 1900 ppm, which may decrease efficiency in feeding in visability dependent waterbirds. Krebs (1974), Stewart (1949), Owen (1960), Norling (1977), and Grubb (1977), showed data supporting the concept of harmful effects of turbidity on capture of prey.

103. At the turn of the century, great egrets were nearly extirpated because of hunting for their plumes. Between 1910 and 1935 their numbers rebounded remarkably, and by 1939 the great egrets were observed breeding again within the study area (River Mile $\pm$ 721.5) for the first time since 1880. Allen (1957) reported that by 1935, their number began to decrease in Florida because of drought and habitat destruction. In 1947 and 1948 there was a substantial northward dispersal of egrets observed throughout the eastern United States including Wisconsin (King 1949). New or greatly enlarged colonies were observed in the southern half of the study area in 1943 (Harlan 1943) and 1948 (Mayfield 1948). Consequently, the 1943-1948 period may represent a population "high," which possibly reduces the importance of the seven extinct colonies found in the southern half of the study area.

104. Black-crowned night herons face an insecure future for this species within the study area, but obviously more complete population data is needed for a firm assessment. The black-crowned night heron

has been declining throughout middle North America (Arbib 1975), including Minnesota (Adams et al. 1973) and St. Louis (Anderson and Bauer 1968). Price (1977) and Allen (1938) listed in separate studies land development, human persecution, natural calamities, and toxic chemicals as reasons for declines in Ontario and New York. However, these birds seem to tolerate nearby human activity, since the two colonies are close to a barge fleeting area, and because colonies within cities have been reported (York 1957).

105. Yellow-crowned night herons moved northward in recent years (Palmer 1962), first breeding within the study area in 1955 (Theodore 1955). The reason for their expansion is unknown.

106. Lack of published reports of Forster's terns nesting within the study area, and the apparant lack of utilization of favorable habitat, suggests that this tern is presently invading new marshlands that were created by construction of dams in the 1930's.

107. Least terns never bred in large numbers within the study area. The localized pattern of distribution was attributed by Hardy (1957) to three factors: (a) the presence of large, dry sandbars where they lay their eggs in a slight depression on the bare sand, (b) the existence of favorable water levels during the nesting season, and (c) the availability of small fish that they catch in shallow water areas of the river.

108. The least tern has also declined on the Gulf, Atlantic, and Pacific coasts (USDI 1973). The decline was first caused by depredations of plume hunters and more recently from loss of sandy nesting habitat due to development or disturbance (USDI 1973). The tern is also threatened by dam construction (Hardy 1957, Downing 1975), which submerges sandbars or inhibits their formation downstream. This explains why the last nesting close to the study area at St. Louis occurred just below the southernmost dam. The few sandy areas that remain within the study area, mostly dredged material deposits, are too heavily used by people to serve as suitable colony sites.

109. The extinction of two cormorant colonies in the southern half of the study area, plus the decrease in recent years by over 50 percent

of the two remaining colonies indicates a population decline for this species. Cormorant populations have decreased dramatically elsewhere in the north central states during the last two decades (Anderson and Hamerstrom 1967, Arbib 1975). They are on the endangered species lists of Wisconsin, Missouri, and Illinois. Since there is only one known colony in Illinois (526.8), and only seven in Wisconsin (including 723), the colonies within the study area contain a significant fraction of the breeding populations in these two states. Population declines in this species have been attributed to accumulation of toxicants (Gress et al. 1973, Anderson et al. 1969), water pollution (Anderson and Hamerstrom 1967), specialized food habits, human intrusion (McLeod and Bondar 1953), persecution (Anderson and Hamerstrom 1967, McLeod and Bondar 1953, Gross 1944), loss of nesting trees, and predation of eggs and nestlings by gulls (Tom Erdman, 1977, Richter Museum, U. W. - Green Bay, WI, personal communication; Kury and Gochfeld 1975).

110. The lower species populations south of Clinton, Iowa, are correlated with the following environmental conditions which were more severe or advanced in the south: (a) urbanization (Figure 12), (b) serious pollution of the Mississippi River (Geraghty et al. 1973), (c) clearing of floodplain forests, (d) drainage and diking of the floodplain, (e) frequency of deepwater pools behind dams which are unsuitable as feeding areas (Figure 12), (f) number of wildlife refuges or undisturbed large tracts of forest, (g) underwater depositing of dredged material, (h) and volume of barge traffic (USAEDSL 1975). Any or all of these factors may contribute to a decline.

Factors Influencing Colony and Nest Site Selection

111. Studies of colony and nest site selection by colonial birds are important to the management of these birds. If one can accurately define the necessary characteristics of colony sites, then new colonies can be located more easily, future changes in colony sites can be predicted, determination of critical habitat can be made, nesting success of birds in specific colonies can be predicted, and new refuges or

nesting habitat for the birds can be created.

112. The ten factors previously discussed apparently determine nest site and colony site selection for herons and egrets. Management of sites or any dredged material disposal operations that would consider waterbird habitat should meet these colony requirements. Purchase or protection of existing colonies should involve two aspects: (a) obtaining enough land to allow a buffer to disturbance, and (b) obtaining land with existing suitable habitat to allow a colony room to expand or to relocate.

113. The requirement for extensive marshes appeared to limit the Forster's tern to marshes in pools above dams, in areas of water about 0.5 m deep and covered by luxurient emergent vegetation that provides nesting material, anchorage for nests, hiding places for chicks, roosting sites while off the nest, shelter from wind and waves, and little human disturbance. Since the terns observed nested within small clearings in the vegetation or on old lodges, both resulting from muskrat activity, the distribution of terns along the Mississippi River may be related to muskrat populations.

114. Managing for Forster's terns would require meeting these habitat requirements. Since dam construction created the desired habitat and no changes are anticipated in this, little management would be necessary.

115. Locations of double-crested cormorant colonies appear to be determined by nearby availability of deepwater feeding areas, dead trees standing in water, and seclusion.

Importance of Dredged Material to Nesting of Colonial Birds

116. Since dredged material deposits along the Upper Mississippi River are neither used for nesting nor feeding by colonial birds, they do not appear to affect these birds in any significant way. Three reasons why the deposits are not used for nesting are apparent.

117. The deposits have vegetation unsuited to any of the species breeding within the study area. Deposits were not found that reached the climax forest stage used by great blue herons and great egrets. However, some of the older deposits may have reached the subclimax seral stages suited to green herons, night herons, or cormorants. Similarly, underwater deposits that might be colonized by Forster's terns probably cannot aquire emergent vegetation because of disturbance from wakes and current.

118. The species of colonial birds that are most likely to use disposal sites in early stages of natural succession, such as gulls, least terns, and common terns do not presently breed along the Upper Mississippi River, although the least tern could become reestablished in its former range northward to central Iowa. Although dredged material deposits are used as loafing areas by ring-billed and herring gulls, the disposal sites are not critical habitat since gulls are adaptable and many natural loafing sites are also used.

119. Since there is so much suitable vegetation for herons, egrets, and Forster's terns in natural areas as compared to on disposal sites, it is improbable that birds would select disposal sites.

120. The large numbers of people attracted to sandy disposal sites probably deter nesting on or near these sites. Furthermore, most deposit sites are close to the main channel where all forms of human disturbance are more frequent. Dredged material deposits are usually too small to allow sufficient vegetation to develop to screen the colony from view.

121. No direct harmful effects of dredged material deposits on colonial birds were observed, primarily because the birds usually nest far from the edge of the navigation channel where the deposits are placed. However, there are six colonies of great blue herons located within 320 m of deposits that may be threatened by the attraction of people to the area. At present people are doing no harm, but the record of past persecution indicated that a whole colony could be eliminated by shooting.

122. Killing trees near a colony by dredging material deposition could reduce the amount of protective vegetation that screens the nests from view and that protects nests and nesting trees from being blowndown during severe storms. At present these effects are minimal but the deposits near these colonies should not be enlarged or used as deposit sites in the future.

123. All of the studied colonial species in the floodplain are dependent to a greater or lesser degree upon the health of the aquatic ecosystems of the Mississippi River and its backwaters. Dredging cannot be isolated from the broader context of river traffic, cargo handling facilities, dam reconstruction, and economic development of the floodplain spurred by improvements in the waterway. All of these forms of development will have impacts on colonial birds and the nesting, feeding, and other life requirements.

124. Dredged material deposits usually placed underwater or adjacent to the riverbank are not suitable nesting habitat for least terns. Downing (1975) found only one colony of five pairs using deposits adjacent to the shore on the Lower Mississippi River, but he found that the terns readily used deposits placed on stabilized islands, or in midstream. Hence, changes in dredging procedures, coupled with exclusion of people, could create favorable nesting habitat for the terns within the study area.

125. The relative tolerance of black-crowned night herons for disturbance, plus their preference for smaller nesting trees, makes this species more likely to nest on dredged material deposits than any other ardeid species. However, due to the large number of forested areas available for nesting, it seems unlikely that their populations are limited by lack of nesting areas.

126. Due to its endangered status and extirpation from former nesting sites in the Upper Mississippi River, the least tern species deserves special attention. Because of its habit of nesting on sandbars, it would be the first species to benefit from a habitat improvement project using dredged material. Sandy disposal sites on islands should be maintained free of vegetation and posted as off limits. New

islands possibly could be created and managed for least terns in the first 100 miles above St. Louis.

127. Other species of herons and egrets are less likely to benefit from management of dredged material deposits. Since many suitable natural areas for nesting remain, the emphasis should be placed on preserving these areas rather than on creating new nesting areas. However, some of the gaps in distribution of herons and egrets may have resulted from lack of nesting areas. If further research conforms this, then management of dredged material deposits could be one means of establishing new nesting areas. Islands intended for use by herons would have to be at least 0.5 km in diameter, low in elevation to encourage growth of vegetation, and allowed to develop trees without further dumping for many decades.

128. Cormorant nesting areas could be created by depositing dredged material among trees so as to kill them.

129. With any of these species, the new habitat created should not be connected with the mainland, and should be as far as possible from the navigation channel. Long-distance transport of dredged material from the navigation channel is expensive, but it may not be necessary to ensure the isolation of colonies. In some pools long islands border the navigation channel. If dredged material were transported by pipe across these islands to the far side, creating a new island there, the conspicuousness and accessibility of these new islands to people seeking bathing beaches would be minimized.

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APPENDIX A: SPECIES OF BIRDS AND PLANTS LISTED IN THE TEXT

Table A1

Colonial Waterbirds Presently or Formerly Nesting Within the Five States Bordering the Study Area*

Species Name		Adequacy of survey	Factors Affecting Visibility from Aircraft
Common	Scientific		
White pelican	*Pelecanus erythrorhynchos*	Good	Nests on ground, white plumage.
Double-crested cormorant	*Phalacrocorax auritus*	Good	Nests in dead trees.
Great egret	*Casmerodius albus*	Good	Nests in top of canopy, white plumage.
Snowy egret	*Egretta thula*	Fair	Nests below top of canopy, white plumage.
Cattle egret	*Bubulcus ibis*	Fair	White plumage, nests below top of canopy.
Great blue heron	*Ardea herodius*	Good	Dark plumage, nests at top of canopy.
Little blue heron	*Florida caerulea*	Poor	Dark plumage, nests below top of canopy.
Green heron	*Butorides striatus*	Poor	Not very colonial, nests below canopy top.
Black-crowned night heron	*Nycticorax nycticorax*	Fair	Nests below top of canopy, some white plumage.

* No further south than St. Louis.

Table A1 (concluded)

Species Name		Adequacy of survey	Factors Affecting Visibility from Aircraft
Common	Scientific		
Yellow-crowned night heron	*Nyctanassa violacea*	Poor	Nests below top of canopy, little white plumage.
Least bittern	*Ixobrychus exilis*	Poor	Dark plumage, small, usually not colonial.
Herring gull	*Larus argentatus*	Good	Some white plumage, ground nester.
Ring-billed gull	*Larus delawarensis*	Good	Some white plumage, ground nester.
Franklin's gull	*Larus pipixcan*	Good	Some white plumage, ground nester.
Bonaparte's gull	*Larus philadelphia*	Good	Some white plumage, ground nester.
Least tern	*Sterna albifrons*	Fair	Some white plumage, nests on sand.
Common tern	*Sterna hirundo*	Fair	Some white plumage, nests on sand.
Forster's tern	*Sterna forsteri*	Good	Some white plumage, nests on marsh vegetation.

Table A2

List of Common and Scientific Names of Species Mentioned in the Text.

Common Name	Scientific Name
Vegetation	
Black willow	*Salix nigra*
Eastern cottonwood	*Populus deltoides*
River birch	*Betula nigra*
Swamp white oak	*Quercus bicolor*
Silver maple	*Acer saccharinum*
American elm	*Ulmus americana*
Green ash	*Fraxinus pennsylvanica*
Bur oak	*Quercus macrocarpa*
American sycamore	*Platanus occidentalis*
Pin oak	*Quercus palustris*
Poison ivy	*Rhus radicans*
Virginia creeper	*Parthenocissus quinquefolia*
Grape	*Vitis* sp.
Boxelder	*Acer negundo*
Green dragon	*Arisaema dracontium*
Red oak	*Quercus rubra*
Hackberry	*Celtis occidentalis*
Bog-hemp	*Boehmeria cylindrica*
Cutgrass	*Leersia virginica*

(continued)

Table A2 (Continued)

Common Name	Scientific Name
Clearweed	*Pilea pumila*
Nettles	*Urtica* spp.
Wood nettle	*Laportea canadensis*
Arrowheads	*Sagittaria* spp.
Reed grass	*Phragmites australis*
Three-square	*Scirpus fluviatilis*
Pondweeds	*Potomogeton* spp.
Naiads	*Najas* spp.
Coontail	*Ceratophyllum* spp.
Watermilfoils	*Myriophyllum* spp.
Waterlillies	*Nymphea* spp.
Duckweeds	*Lemna* spp.
Broadleaf arrowhead	*Sagittaria latifolia*
Narrowleaf arrowhead	*Sagittaria rigida*
Broadleaf cattail	*Typha latifolia*
Red pine	*Pinus resinosa*
Avifauna	
Bank swallow	*Riparia riparia*
Least tern	*Sterna albifrons*
Common tern	*Sterna hirundo*
Forster's tern	*Sterna forsteri*
Great blue heron	*Ardea herodias*
Great egret	*Casmerodius albus*
Double-crested cormorant	*Phalacrocorax auritus*

(continued)

Table A2 (Concluded)

Common Name	Scientific Name
Avifauna (continued)	
Bald eagle	*Haliaeetus leucocephalus*
Osprey	*Pandion haliaetus*
Black tern	*Chlidonias niger*
Cattle egret	*Bubulcus ibis*
Green heron	*Butorides virescens*
Common grackle	*Quiscalus quiscula*
Grey heron	*Ardea cinerea*
Yellow-crowned night heron	*Nyctanassa violacea*
Black-crowned night heron	*Nycticorax nycticorax*
Mammals	
Raccoon	*Procyon lotor*
Muskrat	*Ondatra zibethicus*

APPENDIX B: TABULATIONS OF DATA FOR ACTIVE AND EXTINCT COLONIES

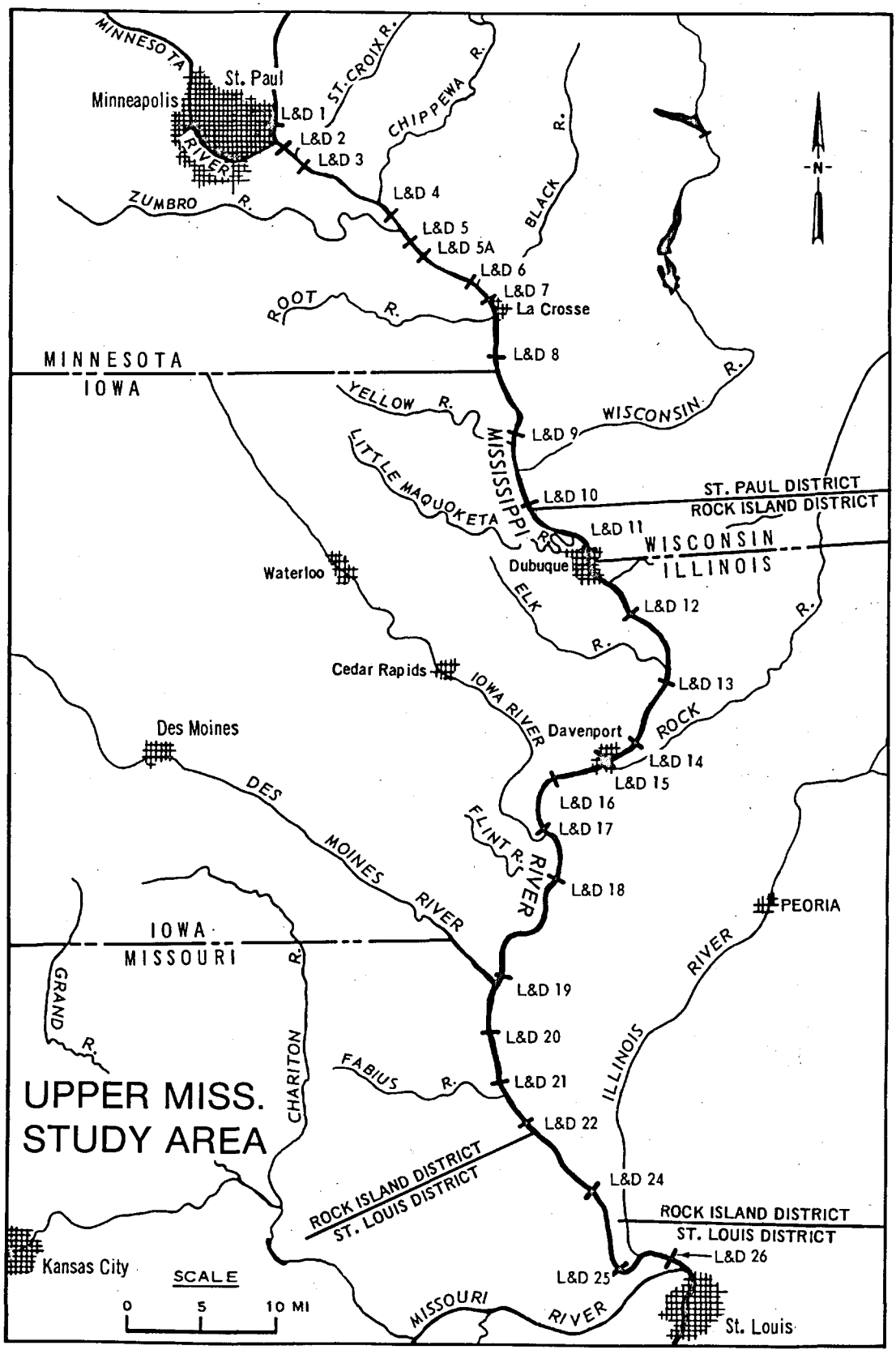
MINNESOTA
St. Paul
Minneapolis
ST. CROIX R.
CHIPPEWA R.
BLACK R.
L&D 1
L&D 2
L&D 3
L&D 4
L&D 5
L&D 5A
L&D 6
L&D 7
La Crosse
L&D 8
L&D 9
L&D 10
L&D 11
L&D 12
L&D 13
L&D 14
L&D 15
L&D 16
L&D 17
L&D 18
L&D 19
L&D 20
L&D 21
L&D 22
L&D 24
L&D 25
L&D 26
ZUMBRO R.
ROOT R.
MINNESOTA
IOWA
YELLOW R.
WISCONSIN R.
MISSISSIPPI R.
LITTLE MAQUOKETA R.
ST. PAUL DISTRICT
ROCK ISLAND DISTRICT
WISCONSIN
ILLINOIS
Dubuque
Waterloo
ELK R.
Cedar Rapids
IOWA RIVER
Davenport
ROCK R.
Des Moines
DES MOINES RIVER
FLINT R.
RIVER
PEORIA
IOWA
MISSOURI
GRAND R.
CHARITON R.
FABIUS R.
ILLINOIS RIVER
UPPER MISS.
STUDY AREA
ROCK ISLAND DISTRICT
ST. LOUIS DISTRICT
ROCK ISLAND DISTRICT
ST. LOUIS DISTRICT
Kansas City
SCALE
0 5 10 MI
MISSOURI RIVER
St. Louis
-N-

Figure B1

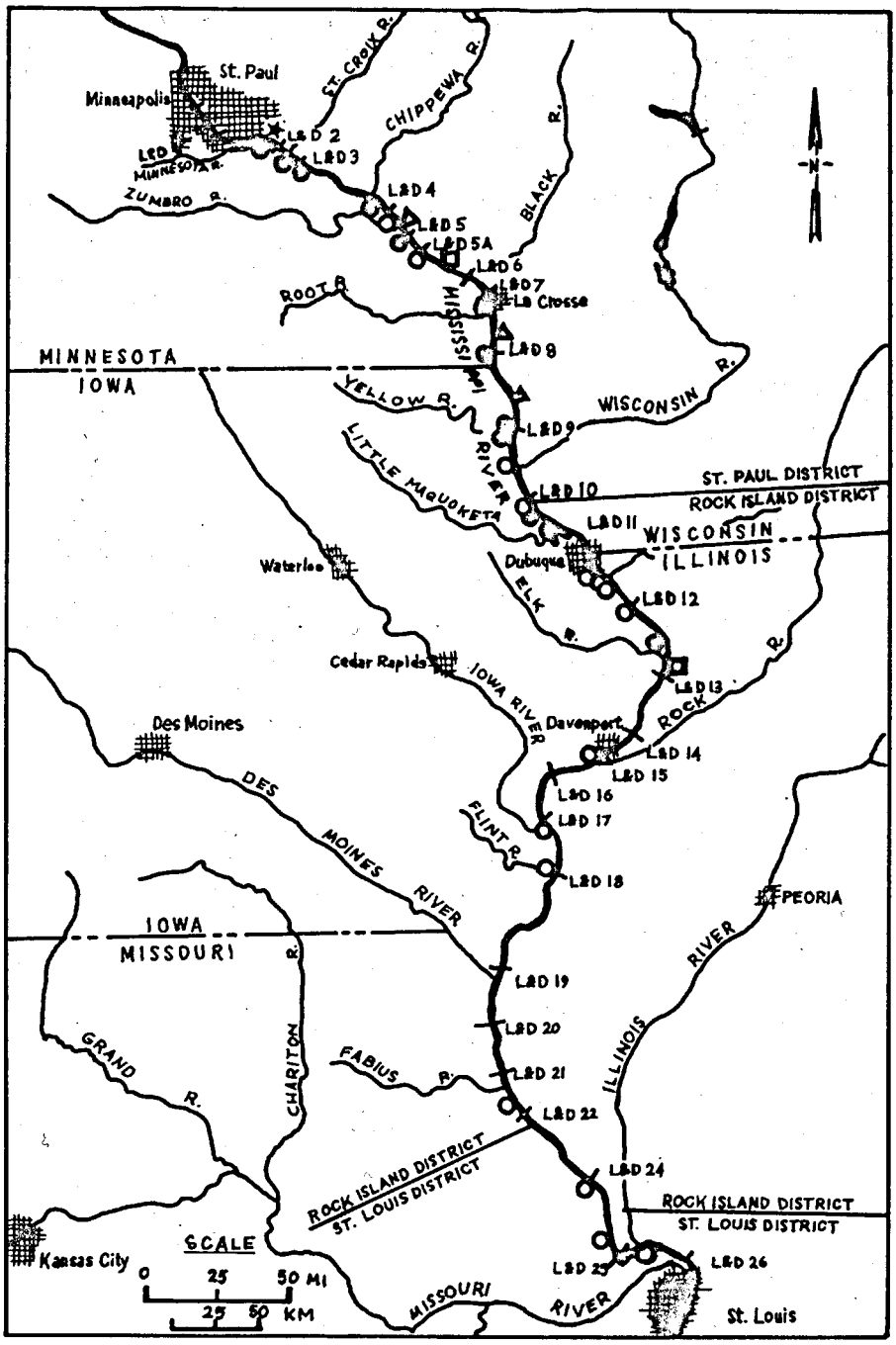

Fig. B2. Map of the upper Mississippi River showing the study area and the locations of colonies. Open circles = colonies of Great Blue Herons (often including Great Egrets) with fewer than 100 pairs; closed circles = colonies of Great Blue Herons (often including Great Egrets) with more than 100 pairs; open triangles = colonies of Forster's Terns; open squares = colonies of Double-crested Cormorants; closed star = colony of Black-crowned Night Herons with more than 100 pairs. All colonies of the same species are shown on the same side of the river, regardless of the side they actually nested on.

Explanation of abbreviations and Symbols used in Tables in Appendix B:

BCNH	black-crowned night heron
DCC	double-crested cormorant
E	east side of center of main channel of Mississippi River
FT	Forster's tern
G	census by observations at ground level
GBH	great blue heron
GE	great egret
P	census from aerial photograph
R	river
V	census by visual count from aircraft
W	west side of center of main channel of Mississippi River
YCNH	yellow-crowned night heron
+	this number of pairs actually counted, but more probably exist.
±	approximately
*	data taken from Nicklaus (1977)

Table B1

Nesting Sites Within the Upper Mississippi River Floodplain Used by Colonial Birds in 1977

Location			Census					
Colony No. and River Mile	Distance From Center of Channel Toward E. or W. Bank in mi.	Nearby Geographical Feature	Bird Species	No. Pairs	1977 Census Date and Method	Principal Plant Species Used for Nesting	Distance to Nearest Dredged Deposit in mi.	Remarks
216.6	0.65 W	across from Chautauqua	GBH	4	7 June,V	single sycamore	1.8	ground check made
253.6	0.4 E	below Hamburg	GBH	58	15 April,P			
			GE	14	15 April,P	sycamore	0.1	
271.6	0.4 E	below Lock & Dam 24	GBH	70	15 April,V	sycamore	0.5	
313.0	0.4 E	on Armstrong Island	GBH	22	15 April,V	deciduous trees	0.5	
408.3	0.35 W	on Otter Island	GBH	40	13 May, G			ground check; logging and cabins nearby
			GE	8	13 May, G	cottonwood	0.5	
433.75	0.4 E	mouth of Iowa River	GBH	63	13 May, G			ground check made
			GE	26	13 May, G	silver maple green ash	0.15	
476.75	0.3 E	below mouth of Rock River	GBH	22	16 April, V	deciduous trees	3.75	near urban area
-526.8	0.8 E	near Thomson	DCC	12	16 April, V	dead oak trees	1.2	surrounded by water; 32 adults present
538.8	0.5 W	above Sabula	GBH GE	226 3+	16 April, P 6 June, P	deciduous trees	0.5	
554.0	0.4 E	on Savannah Proving Grounds	GBH GE	145+ 1+	17 April, P 6 June, P	deciduous trees	0.5	logged areas nearby

(Continued)

Table B1 (Continued)

Location			Census					
Colony No. and River Mile	Distance From Center of Channel Toward E. or W. Bank in mi.	Nearby Geographical Feature	Bird Species	No. Pairs	1977 Census Date and Method	Principal Plant Species Used for Nesting	Distance to Nearest Dredged Deposit in mi.	Remarks
569.6	0.5 E	mouth of Little Menominee River	GBH	19	17 April, V	deciduous trees	2.5	
569.9	0.7 E	mouth of Little Menominee River	GBH	21	17 April, V	dead deciduous trees	2.25	14 nests empty on 14 June; nests previously used and in good condition. Cause of desertion not determined.
574.75	0.3 E	below Dubuque	GBH	44	17 April, V	dead deciduous	0.7	house 600 feet away
600.5	0.6+ E	across from Waupeton	FT	?	30 June, V	?	1.5 ±	possible nesting area
600.95	0.35 E	across from Waupeton	GBH	176	17 April, P	silver maple	1.9	ground check; many nests
			GE	2+	14 June, P	American elm red oak		
609.25	0.2 E	above Cassville	GBH	141	6 May, G	silver maple		ground check; heavy recreation nearby
			GE	3	6 June, V	elm	0.1	
609.75	0.3 E	above Cassville	GBH	78	6 May, G	silver maple		ground check made
			GE	4	6 June, V	elm green ash	0.25	
-630.1	0.45 E	mouth of Wisconsin R.	GBH	71	17 April, V	elm*		new colony; many GE roosting
			GE	1	14 June, V	silver maple	0.95	
640.6	0.4 E	across from Effigy Mounds National Monument	GBH	145	22 April, V	elm*		
			GE	3+	6 June, P	silver maple	1.9	
646.85	0.3 W	below Lock & Dam 9	GBH	203+	22 April, P	elm*	0.5	boat landing across river
			GE	39+	8 June, P	silver maple		

(Continued)

Table B1 (continued)

Location			Census					
Colony No. and River Mile	Distance From Center of Channel Toward E. or W. Bank in mi.	Nearby Geographical Feature	Bird Species	No. Pairs	1977 Census Date and Method	Principal Plant Species Used for Nesting	Distance to Nearest Dredged Deposit in mi.	Remarks
660.6	0.5 E	power plant at Lansing	FT	5	6 June, P	broadleaf cattail arrowleaf	2.5	
677.5	0.1 W	below Lock & Dam 8	GBH GE	580* 200*	before 1977 before 1977	silver maple elm green ash	0.15	ground check; colony moving to SSW
687.3	0.4 E	below Brownsville	FT	10	30 June, V	broadleaf cattail arrowleaf	0.35	
694.5	0.4 W	below LaCrosse	GBH GE	505±* 90±*	before 1977 before 1977	silver maple* elm* green ash*	0.2	near urban area; silver maple 57 percent (J. E. Elder, per. comm.)
723.5	1.4 E	below Winona	DCC	5	15 June, V	dead deciduous	1.2	surrounded by water; wind destroyed nests in 1976.
726.75	0.5 E	across from Winona	GBH GE	12 1	15 June, V 15 June, V	deciduous trees	0.8	near urban area
737.75	0.5 E	below Lock & Dam 5	GBH GE	294* 146*	Winter, 75-76,G Winter, 75-76,G	silver maple* American elm* eastern cottonwood; green ash	0.2	under study by Dr. Ray Faber
741.4	1.2 E	below Buffalo	FT	19	29 June, G	arrowleaf broadleaf cattail	1.3	ground check; 0.2 mi. from houses

(Continued)

Table B1 (Concluded)

Location			Census					
Colony No. and River Mile	Distance From Center of Channel Toward E. or W. Bank in mi.	Nearby Geographical Feature	Bird Species	No. Pairs	1977 Census Date and Method	Principal Plant Species Used for Nesting	Distance to Nearest Dredged Deposit in mi.	Remarks
750.7	0.4 W	mouth of Zumbro R.	GBH GE	61 3+	23 April, P 20 June, P	silver maple* American elm* eastern cotton-wood;* green ash*	1.1	
758.8	1.0± E	below Wabasha	FT	?	20 June, V	arrowleaf cattail	1.1±	several birds seen in typical habitat but no nests or pairs seen
761.7	0.8 E	below mouth of Chippewa R.	GBH GE	187+ 27+	23 April, P 23 April, P	silver maple* American elm* eastern cottonwood* green ash*	1.0	only 8 GE nests seen 29 June
793.7	0.55 W	mouth of Cannon R.	GBH	274	23 April, P	American elm red elm bur oak black ash green ash silver maple	0.5	canopy very open; logging nearby; studied by Wayne Norling, who provided nesting substrate data
810.5	0.5 W	below Hastings by Vermillion R.	GBH	186+	23 April, P	eastern cottonwood river birch silver maple American elm green ash	0.6	ground check; logging nearby; colony moved 1.5 mi.
833.4	0.2 E	on Pig Eye Island	GBH BCNH GE	99 128+	23 April, P 23 April, P	green ash* silver maple* boxelder* eastern cottonwood* American elm* willow*	1.0	near industrial area; Studied by Dr. Dwain Warner
833.6	0.35	on Pig Eye Island	BCNH YCNH	462* a few *	Summer, 1973,G Summer, 1973,G	silver maple* green ash* eastern cottonwood* boxelder* American elm* willow*	1.25	near industrial area; Studied by Dr. Dwain Warner

Table B2

Histories of Colonies of Birds in the Upper Mississippi Floodplain Active in 1977

Colony No. and River Mile	No. of Breeding Pairs or Active Nests before 1977 (year)	No. of Breeding Pairs in 1977	Source	Remarks
216.6	90± GBH (1971)	4 GBH	personal communication, 1977, H. Belz, III, Vice Pres., Hager Hinge Co., St. Louis, MO	Frequently disturbed colony. All 90 nests were in sycamore trees 24-30 in high. Studied from treetop blind by student H. Michael Stewart, Principia College, Elsah, IL. Most of nests downed by heavy snows in winters of 1973-74 or 1974-75. Shooting of herons occurred here (Personal communication, 1977, G. T. Girard, Instructor Principia College, Elsah, IL).
433.75	600-700 GBH & GE (1957) "285 Great blues" (1958) 20 GE (1958)	63 GBH 26 GE	Nolan (1957) Nolan (1958) Mumford (1959)	"The 1956 ratio of BGH to GE was 2 to 1, and the 1957, 20 to 1 (Nolan 1957)." GBH declined since 1957 (Nolan 1958). "40 birds" assumed to be 20 nesting pairs of GE. GBH increased 5-10% over 1958 (Mumford 1959). In 1960, GE increased 20% (Mumford 1960). Dredged material deposits from 0.25-1.6 km distant deposited during 1952-1955, 1960-76.
476.75	34 GBH (1959)	22 GBH	Mumford (1959) Mumford (1960)	"At Rockford, a total of 34 GBH nests was an increase over last year despite the fact that the rookery was shop up in 1958." (Mumford 1959)
526.8	25 DCC (<1946) 11 DCC (1961) 15 DCC (1975)	12 DCC	Kleen (1974) Kleen(1975)	Some artificial nesting platforms used in 1975; none used in 1977.

Note: References cited in the appendices are included in the Literature Cited section following the main text.
Explanation of abbreviations and symbols used in this table are given on page B2.

(Continued)

Table B2 (Continued)

Colony No. and River Mile	No of Breeding Pairs or Active Nests before 1977 (year)	No of Breeding pairs in 1977	Source	Remarks
538.8	10 GE (1941) 167 ± GBH (1943) 250+ GE (1943) 2 BCNH (1943) 0 GE (1945) 0 GE (1949) 205 GBH & GE (1976)	226 GBH 3+ GE	King (1949) Harlan (1943) King (1949) Stewart (1949) Personal communication, 1977, T. D. Atkins, USFWS, Savannah, IL	In 1942 estimated to contain 1500 individual GBH & GE. "It is claimed that GBH moved into this rookery in 1944, causing its abandonment by the egrets in 1945." (King 1949) Nests counted and mapped first time, Feb. 1977. 195 nests in 33 trees and 10 fallen nests.
554.0	125± GBH & GE (1976)	145+ GBH 1+ GE	Personal communication, 1977, Prof. W. E. Southern, N. Ill. U., DeKalb IL	Nests counted in winter 1976-77; logging conducted nearby same winter.
574.75	96 GBH & GE (1976)	44 GBH	Personal communication, 1977, T. D. Atkins, USFWS, Savannah, IL	Nests counted and mapped first time March 1977 by USFWS: 78 nests in 27 trees, and 18 fallen nests.
600.95	175 GBH (1957) 75 GE (1957)	176 GBH 2+ GE	Personal communication, 1978, J. R. Lyons, USFWS, Cassville, WI.	
609.75	"217" GBH (1956) 57 GBH (1957) 25 GE (1957)	78 GBH 4 GE	Williams (1957) J. R. Lyons	Not clear whether Williams or Lyons refer to 609.25 or 609.75 or both.
630.1		71 GBH 1 GE	Nicklaus (1977)	New colony

(Continued)

Table B2 (Continued)

Colony No. and River Mile	No. of Breeding Pairs or Active Nests before 1977 (year)	No. of Breeding Pairs in 1977	Source	Remarks
677.5	1000 GBH & GE (1973) 600 GBH (1974-76) 200 GE (1974-76)	Not censused		Since nesting trees were tagged in about 1972, nests have been relocated to the SSW. The N end has moved 66 m to the S, and the S end has moved 179 m to the S (author's observations).
694.5	Some GBH (≤ 1959) 0 GE (1959) 303 GBH (1972) 87 GE (1972) 336 GBH (1973) 45 GE (1973) 452 GBH (1974) 42 GE (1974) 446 GBH (1975) 70 GE (1975) 462 GBH (1976) 66 GE (1976) 474 GBH (1977) 97 GE (1977)	Not censused	Anonymous (1959) Personal communication, 1978, W. W. Olson, Asst. Mgr. LaCrosse District, USFWS, LaCrosse, WI	Eleven flightless young from five nests were collected by J. Elder, USFWS, Twin Cities, MN, on 2-3 June, 1976, for pesticide analysis. (Personal communication, 1977, J. Elder).
723.5	13 DCC (1976)	5 DCC	Personal communication, 1977, S. Cornelius, USFWS, Trempealeau, WI Tessen 1976	All young destroyed by windstorm, July 20-25, 1976. New colony.
726.75	12 GBH 1 GE			Previously unreported, probably a new colony.
737.75	100+ GBH (1968) 20± GE (1968) 551 GBH & GE (1972) 587 GBH & GE (1975) 520 GBH & GE (1976) 469 GBH & GE (1977)	Not censused	S. Cornelius Personal communication, 1978, R. Faber	In 1972, 256 nest tree stems; and additional 56 nests doubtful. Nests of 1975 were counted in following winter; 231 nest tree stems. In July 1976, 67% of nests GBH, 33% GE, 75% of nests active. Presently being studied by R. Faber, Assistant Professor, St. Mary's College, Winona, MN, who provided winter counts for 1976 & 1977 breeding seasons.

(Continued)

Table B2 (Continued)

Colony No. and River Mile	No. of Breeding Pairs or Active Nests before 1977 (year)	No. of Breeding Pairs in 1977	Source	Remarks
750.7	Some GBH (< 1959) Some GE (< 1959) 65 GBH (1976)	61 GBH 3+ GE	Anonymous (1959) S. Cornelius	 Heronry is at least 8 years old. In 1976, 71 nests were located in 39 trees, with >90% of nests active. Colony may have moved from 748.4, a site last seen active in 1968 with 100 GBH and 30 GE nests.
761.7	30 GBH (1956) 300± GBH (1968) 50± GE (1968) 389 GBH & GE (1972) 407 GBH & GE (May 1976)	187+ GBH 27+ GE	Williams (1957)	The Colony reported by Williams was not found, and probably has moved 3-6 km to present location at 761.7. 185 nest tree stems tagged. In Sept. 1975 wind downed some nest trees. Approximately 70% of nests GBH, 30% GE, and 75% of nests active. Twelve flightless young from nests were collected by J. Elder on 2-3 June, 1976, for pesticide analysis.
793.7	167 GBH (1973) 5 GE (1973) 261 GBH (1974) 13 GE (1974) 159 GBH (1975) 1 GE (1975) 154 GBH (1976) 0 GE (1976)	274 GBH 0 GE	Norling (1977)	Nuclear generating plant began generating in 1973, 5 km away. Colony disturbed in 1975 by repeated observations from a blind.
810.5	250-300 GBH (1955) 100 GE (1955) some GBH (1964) some GBH (1966)	186+ GBH	Personal comminication, 1977, C. Henderson, Nongame Supervisor, DNR, St. Paul, MN	Colony apparently moved recently from River Mile ±808.7 (west side) to 810.5 (west side).

(Continued)

Table B2 (Concluded)

Colony No and River Mile	No. of Breeding Pairs or Active Nests before 1977 (year)	No. of Breeding Pairs in 1977	Source	Remarks
833.4	51 GBH (1973) 68 GE (1973)	99 GBH 128+ GE & BCNH	Adams et al. (1973)	Censused each year by D. Warner, Bell Museum of Natural History, Univ. of Minnesota. Ten flightless young from four nests were collected by J. Elder on 7 June 1976, for pesticide analysis.
833.6	462 BCNH (1973)	not censused	Adams et al. (1973)	Censused each year by D. Warner, Museum of Natural History, Univ. of Minnesota, St. Paul.

Table B3

Colonies of the Floodplain of the Upper Mississippi River

Previously Known But Not Found During the 1977 Aerial Survey*

River Mile of Colony	Nearby Geographical Feature	No. of Breeding Pairs, Species, (and year)	Source	Remarks
238±	Lock & Dam 25	40 GBH (19??)	Personal communication, 1977, D. Goering, Cottey College, Nevada, MO	Located on an island on the west side near the dam. Exact location not given.
269-393	Within 50 mi. of Quincy, Ill. on Miss. R.	4 colonies GE (1948)	Mayfield (1948)	"...Four new or greatly enlarged colonies, the largest with 150 nests." No GE found within this stretch, and only two GBH colonies, the largest with 70 pairs.
275±	Clarksville Refuge, Pike Co., MO	15 DCC (1965)	USAEDSL (1975)	Nests were constructed in dead trees standing in a marsh. Birds returned in 1966 and 1967 but did not nest. Abandonment "believed to be caused by increased traffic in the area associated with construction of a cement plant and the lack of water at the nesting site."
416±	Oquawka, IL	30 DCC (1958)	Nolan (1958)	
449-470	Muscatine Co., Iowa	Some GE (1948)	Mayfield (1948)	Reported nesting on the Miss. R. island of this county where they had not been found before. No heron or egret colonies found in this county.

Note: Explanation of abbreviations and symbols used in this table are given on page B2.
For yellow-crowned night herons, see Table B6, Appendix B.

(Continued)

Table B3 (Continued)

River Mile of Colony	Nearby Geographical Feature	No. of Breeding Pairs, Species, (and year)	Source	Remarks
470-507	Scott Co., Iowa	Some GE (1948)	Mayfield (1948)	Reported nesting on Miss. R. islands of this county, where they had not been found before. No GE found in this county, but one colony of GBH was located.
522.2	Just below Lock & Dam 13	25 GBH, GE, YCNH (19??)	Personal communication, 1977, Mary Landin, Waterways Expt. Station, Vicksburg, MS, and Nicklaus (1977)	Area thoroughly searched 16 April, 1977. One mile N of Clinton & Fulton; a disturbed area. Species composition is speculative.
628	Below mouth of Wisconsin R.	25 GBH (1961)	M. Tansy, 1978, USFWS, Cassville, WI, personal communication	Located on W. side of channel. Not found in 1963 or 1964, but search was early in season. Colony 630.1 may be a velocation of 628.
709	Black River	35-40 GBH (1970-72)	Personal communication, 1977, P. Smith, USFWS, Long Lake NWR, Moffit, ND, and R. Nicklaus, Wisconsin DNR, LaCrosse, WI.	Both Smith and Nicklaus may describe the same colony. Smith describes it at R.M. 709 "west of Lytles." Nicklaus locates it on the Black R. bottoms 3-4 mi. from the Mississippi R. and 0.5 mi. N. of Highway 93, with 35-40 nests.
719.6	Below Winona	Some BCNH (19??)	Nicklaus (1977)	In Delta Fish & Fur Farm, WI. This may be the same colony as 721.4.
721.4	Below Winona	Some BCNH (1960)	Cornelius, personal communication	The exact location was thoroughly searched from the air on 22 April and 15 June but no birds or nests seen.

(Continued)

Table B3 (Continued)

River Mile of Colony	Nearby Geographical Feature	No. of Breeding Pairs, Species, (and year)	Source	Remarks
721.5	Below Winona	? GBH	Nicklaus (1977)	In Delta Fish & Furm Farm. A colony of GE, GBH, DCC, and BCNH was reported by Gabrielson in the same general area as Nicklaus location at 721.5. This is the site of the first nesting of GE in Wisconsin since 1880. "The (GE) nests were situated about 35 feet from the water in birch trees, the bases of which were inundated, but the trees had not yet been killed (Gabrielson 1939)."
738.5	Lock & Dam 5, Buffalo Co., Wis.	?(?)	Nicklaus (1977)	This area was searched thoroughly for GE or GBH. Since it is close to the colony at 737.75, it may have been at 737.75 with its position reported imprecisely. Or, it may have moved from 738.5 to 737.75.
748.4	Below Zumbro R.	100 nests (1960)	Personal communication, 1977, S. Cornelius, Trempealeau NWR, Trempealeau, WI	In 1974 & 1975, large dredged material deposits were placed next to this site. Cornelius not able to locate it since 1968, and search for it was made thoroughly. These birds probably move to 750.7, which has roughly the same population and first was found in 1969. Location 750.7 is more typical of heron colony sites than 748.4 in that it is closer to a dam and river junction, and further from the channel.

(Continued)

Table B3 (Concluded)

River Mile of Colony	Nearby Geographical Feature	No. of Breeding Pairs, Species, (and year)	Source	Remarks
808.75±	Hastings, MN	50-100 GBH GE	Personal communication, 1977, G. Henderson, non-game supervisor, Minn. DNR, St. Paul.	Moved to 810.5. Another letter from Henderson numbers this colony at 250-300 pairs GBH and 100 pairs GE in 1955.

Table B4

Great Blue Herons: Average Number of Young Produced per Successful Nest in Colonies within the Upper Mississippi River Floodplain

Colony No. and River Mile	Average No. of Young Produced Per Successful Nest	No. of Successful Nests Counted	No. of Unsuccessful Nests (with no Young)	1977 Date of Aerial Count
216.6	4.3	3	0	7 June
253.6	2.9	8	?	7 June
271.6	2.9	16	?	7 June
313.0	2.7	13	1	8 June
408.3	2.8	12	0	8 June
433.75	3.6	14	0	8 June
476.75	3.0	18	4	14 June
538.8	3.0	32	1	14 June
554.0	3.0	32	2	14 June
569.6	3.6	10	0	14 June
569.9	2.9	10	14	14 June
574.75	3.6	23	0	14 June
600.95	3.4	26	1	14 June
609.25	3.3	22	1	14 June
609.75	3.1	9	1	14 June
630.1	3.0	23	1	14 June
640.6	2.5	24	2	14 June
646.85	2.8	30	0	14 June
677.5	2.7	35	0	15 June
694.5	2.8	30	0	15 June
726.75	3.3	3	2	15 June
737.75	2.67	27	0	15 June
750.7	2.67	15	1	20 June
761.7	2.29	28	2	20 June
793.7	2.76	17	3	20 June
810.5	2.29	24	3	20 June
833.4	2.93	14	0	20 June

Table B5

Great Egrets: Average Number of Young Produced per Successful Nest in Colonies within the Upper Mississippi River Floodplain

Colony No. and River Mile	Average No. of Young Produced Per Successful Nest	No. of Successful Nests Counted	No. of Unsuccessful Nest (with no Young)	1977 Date of Aerial Count
646.85	2.3	1	0	14 June
677.5	2.6	24	0	15 June
694.5	2.9	13	0	15 June
737.75	2.5	15	0	15 June
750.7	2.3	6	0	20 June
761.7	2.6	6	0	20 June
833.4	2.6	8	0	20 June

Table B6

Locations of Nests of Yellow-crowned Night Herons along the Upper Mississippi River

Place	Approximate River Mile	Year	No. of breeding Pairs or Nests	Remarks	Source
East St. Louis, MO	South of study area	1959	?	Nested	Mumford 1959
New Boston, IL	433	1959	3 pairs	Nested	Mumford 1959
New Boston, IL	433	1960	small numbers	Nested	Mumford 1959
Davenport, IA	±482	1959	?	Nested	Mumford 1960
Near Reno, Houston Co., MN	Reno is 681.2	1960	single nest		Green & Janssen (1975)
Houston Co., MN (0.75 mi west of channel)	694.8		3 nests	New colony	Nicklaus 1977
Near LaCrescent Houston Co., MN	698.7	1975	2-5 nests	First reported nesting in MN in 1955. Small colony has remained regularly active since 1955. Decreasing (Nicklaus, 1977)	Nicklaus (1977); Green & Janssen (1975) Theodore (1955).
Estreme SE corner of MN (Houston Co.)	±699	1958	at least 2 pairs	Beginning to nest on May 10; again this spring.	Breckenridge (1958a)
LaCrescent, Houston Co., Mn		1958	2 nests	Two nests were successful, where this northern nesting outpost of the species has existed for several years.	Breckenridge (1958b)
LaCrescent, Houston Co., Mn		1959	2-3 pairs	Again present where they have nested for past several years.	Breckenridge (1959)
Houston Co., Mn		1960	3 nests	Found on July 9; two nests contained young.	Lupient 1960
Houston Co., Mn		1976	?	Return to nesting site after one year absence.	Tessen 1976
LaCrosse Co., WI		1973	?	Successful nesting.	Maley 1973
Near South St. Paul Dakota Co., MN	833	1964	single nest		Green & Janssen (1975)
Near South St. Paul Dakota Co., Mn	833	1965	single nest		C. Henderson, 1977 personal communication
Pig's Eye Island	833	1970's	?	?	

Table B7

Results of Vegetation Sampling by Point-centered Quarter Method at Colony 600.95*

Species	No. Points of Occurrence	No. of Trees	Total Basal Area	Relative Frequency,%	Relative Density,%	Relative Donimance,%	Importance Value
Silver maple (Acer saccharinum)	9	14	5961	34.6	35.0	64.8	134.2
American elm (Ulmus americana)	9	15	1293	34.6	37.5	14.0	86.1
Red oak (Quercus rubra)	4	4	1383	15.4	10.0	15.0	40.4
River birch (Betula nigra)	1	2	373	3.8	5.0	4.0	12.8
Green ash (Fraxinus pennsylvanica)	1	3	44	3.8	7.5	0.5	11.8
Swamp white oak (Quercus bicolor)	1	1	165	3.8	2.5	0.2	6.5
Hackberry (Celtis occidentalis)	1	1	10	3.8	2.5	0.1	6.4
TOTALS	26	40	9229	99.8	100.0	98.4	298.2

Total distance = 1049 Trees/ha = 156 Average basal area per tree = 230.7

Average distance 26.2 Basal area per acre = 14534

*Grant County, Wisc: Bottomland woods; along Mississippi River; river mi 600.95; 30 June 1977

Table B8

Results of Vegetation Sampling by Point-centered Quarter Method at Colony 677.5*

Species	No. Points of Occurrence	No. of Trees	Total Basal Area	Relative Frequency, %	Relative Density, %	Relative Dominance, %	Importance Value
Silver maple (Acer saccharinum)	7	15	4820	35.0	37.5	56.0	128.5
American elm (Ulmus americana)	7	15	2956	35.0	37.5	34.3	106.8
Green ash (Fraxinus pennsylvanica)	5	8	565	25.0	20.0	6.6	51.6
Swamp white oak (Quercus bicolor)	1	2	267	5.0	5.0	3.1	13.1
TOTALS	20	40	8608	100.0	100.0	100.0	300.0

Total distance = 808 Trees/ha = 1057 Ave. basal area per tree = 215.2

Average distance = 10.1 Basal area per ha = 91890

*Houston County, MN : Bottomland woods; across Mississippi River fm Genoa, WI; river mi 677.5; 30 June 1977

Table B9

Results of Vegetation Sampling by Point-centered Quarter Method at Colony 810.5*

Species	No. Points of Occurrence	No. of Trees	Total Basal Area	Relative Frequency,%	Relative Density,%	Relative Dominance,%	Importance Value
Silver maple (Acer saccharinum)	8	15	6742	34.8	37.5	56.2	128.5
American elm (Ulmus americana)	9	18	3567	39.1	45.0	29.7	113.8
Green ash (Fraxinus pennsylvanica)	6	7	1686	26.1	17.5	14.1	57.7
TOTALS	23	40	11995	100.0	100.0	100.0	300.0

Total distance 709.8 ft Trees/ha = 342 Ave. basal area per tree = 300

Ave. distance 17.7 ft Basal area per acre = 41382

*Dakota County, MN: Bottomland woods; ca. 1/2 mi. E of Hwy 31; near Vermillion River; river mi 810.5 W; 28 June 1977

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Thompson, David H
An aerial survey of waterbird colonies along the Upper Mississippi River and their relationship to dredged material deposits / by David H. Thompson, Mary C. Landin. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.
vii, 67, [29] p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; D-78-13)
Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under DMRP Work Unit No. 4F01F.
Literature cited: p. 62-67.

1. Aerial surveys. 2. Dredged material. 3. Environmental analysis. 4. Upper Mississippi River. 5. Waste disposal sites. 6. Waterfowl. I. Landin, Mary C., joint author. II. United States. Army. Corps of Engineers. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; D-78-13.
TA7.W34 no.D-78-13