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THE FORSTER'S TERN IN MINNESOTA:
STATUS, DISTRIBUTION AND REPRODUCTIVE SUCCESS

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ABSTRACT

Forster's Terns (_Sterna forsteri_) were studied in Minnesota from 1985-1986 to determine abundance, breeding distribution, and reproductive success. In both years, the estimated breeding population was 900-1000 pairs. The Forster's Tern breeds throughout the western prairie wetlands and eastward through the prairie-woods transition including an extension into the central part of the state to the Twin Cities. The largest colonies were in Jackson, Nicollet, Todd, and Wright counties. Although the major colonies were found at sites traditionally used by Forster's Terns for most of this century, site occupancy in any given year was determined by water level and presence of suitable nest habitat. Reproductive success varied among colonies, ranging from 0.00 to 0.458 fledglings/breeding pair. High water levels, wind and wave damage and predation by Great Horned Owls (_Bubo virginianus_) were the primary factors that reduced reproductive success. Artificial nesting platforms were placed at four sites in 1986 to improve breeding success. Although usage rate was 54% at sites where terns were present, few juveniles survived to fledging. Platforms protected nests from water level-related nest failures but did not reduce egg and chick loss to predators. Reproductive success during this study was below that needed to maintain the population at its current size. To ensure conservation and appropriate management of this species in Minnesota, major colonies need to be monitored annually to estimate colony size and productivity.

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INTRODUCTION

Of approximately 38 species of terns in the world, only four traditionally nest in salt or freshwater marshes (Edwards 1982); one of these is the Forster's Tern (Sterna forsteri). Its breeding range is restricted to North America (A.O.U. 1983), and extends from British Columbia, across central Alberta, Saskatchewan, and Manitoba, to southern Ontario. In the United States it ranges from east-central Washington, south to southern California, and east through Nevada, Colorado, and northern Iowa to Michigan. Along the Atlantic Coast, Forster's Terns are found from southern New York, south locally to North Carolina, and along the Gulf coast from northern Tamaulipas, Mexico, and Texas east to southern Louisiana. There are no estimates of the total number of Forster's Terns in North America; estimates are crude even at the regional, state, and provincial levels.

Although historical accounts of Forster's Terns in Minnesota exist from as early as 1894, population size and breeding success of this species was unknown prior to this study. In 1984 the Forster's Tern was designated a species of "Special Concern" in Minnesota (Coffin and Pfannmuller 1988). This decision was based on records indicating this species does not occur as commonly on prairie marshes as it did 40-50 years ago and the observation that much apparently suitable habitat currently is not utilized. My study examined the distribution, abundance and reproductive success of Forster's Terns in Minnesota in 1985 and 1986; I asked the following questions: (1) what is the breeding distribution of Forster's Terns in Minnesota, (2) how many pairs breed in Minnesota, (3) what is their reproductive success, (4) what factors affect reproductive success, and (5) can reproductive success be improved with the use of artificial nesting platforms?

STUDY AREA

Census sites were selected from records obtained from the Minnesota Department of Natural Resources Colonial Waterbird Data Base (MNDR CWDB). Breeding pair estimates were made at 16 sites during the two years of my study. I initially selected and visited 11 locations reported to have $\geq$ 10 breeding pairs between 1980 and 1984; all of these were important historical nesting sites in Minnesota (MDNR CWDB). Nesting was discovered at an additional five new sites during my study and estimates on colony size are also included from these locations.

For each site I obtained information on wetland size and classification from MDNR Division of Waters. The Division of Waters classifies Minnesota's wetlands into five types, as defined by Shaw and Fredine (1956): Type 1 (seasonally flooded basin or flat), Type 2 (inland fresh meadow), Type 3 (inland shallow fresh marsh), Type 4 (inland deep fresh marsh), or Type 5 (inland open fresh water). In Minnesota, Forster's Terns nest in wetland types 3,4 and 5. A newer classification, adopted by the U.S. Fish and Wildlife Service, is described in Cowardin et al. (1979). Under this system, Type 3 is characterized by the habitat class Emergent Wetlands; Type 4 includes habitat classes Emergent Wetlands and Aquatic Beds; Type 5 is composed of habitat classes Aquatic Beds and Unconsolidated Bottoms. Emergent Wetlands are characterized by erect, rooted, herbaceous hydrophytes that are present for most of the growing season; these sites are semipermanently or seasonally flooded. Aquatic Beds are dominated by plants that grow mainly on or below the surface of the water for most of the growing season. Aquatic Beds, representing a diverse group of plant communities, require surface water for optimum growth and reproduction. They are best developed in relatively permanent water or under conditions of repeated flooding. The plants are either attached to the substrate or float freely. Water regimes are highly variable (e.g. irregularly exposed, seasonally flooded, permanently flooded). Unconsolidated Bottoms are those wetland and deepwater habitats with a vegetative cover of less than 30% and at least 25% cover of particles smaller than stones. Their water regimes include: permanently flooded, intermittently exposed and semipermanently flooded. Unconsolidated bottoms are characterized by lack of large stable surfaces for plant and animal attachment. Exposure to wave action is an important factor determining composition and distribution of organisms in these wetlands.

Census sites were as follows:

Agassiz National Wildlife Refuge (ANWR) (Type 4 wetland).-- This extensive wetland complex of over 32,390 ha is located in Marshall County, in the northwest corner of Minnesota (48° 19′ 55" N, 096° 00′ 49" W). Established in 1937, it is part of a chain of national wildlife refuges in the Mississippi Flyway managed to provide optimum habitat conditions for waterfowl production. Prior to my study, estimates for Forster's Terns ranged from 40-200 breeding pairs (MDNR CWDB).

Clearwater Lake (Type 5 wetland).--Located in Wright County (45° 18′ 03" N, 094° 07′ 13" W), this 1,500-ha lake is part of the Clearwater River watershed. Forster's Terns have nested at Clearwater Lake since at least 1962; in some years as many as 300 breeding pairs utilized this site (MDNR CWDB). During my study the lake was predominantly open water but contained some emergent vegetation and several floating mats of vegetation. The terns nested on one of the floating mats.

Coon Creek (Type 3 wetland).--Located in Lyon County (44° 19′ 01" N, 095° 57′ 27" W), this was one of the smaller sites censused (207 ha). Before my visits, other investigators found from two to 50-75 nests (MDNR CWDB).

Fisher Lake (Type 5 wetland).--Another of the smaller sites, Fisher Lake is 160 ha in size and is located in Scott County (44° 47′ 57" N, 093° 24′ 36" W). Forster's Tern colonies have ranged from 10-35 nests.

Lake Osakis (Type 5 wetland).--Located in Todd County (45° 52′ 24" N, 095° 08′ 24" W), this 2,740 ha lake was reported to be used by 1000 breeding pairs in 1981 and 1983. These are the second largest Forster's Tern colony size estimates on record in Minnesota (MDNR

CWDB). As at Clearwater Lake, Forster's Terns nested on floating mats of living and dead vegetation.

Lake Reno. (Type 5 wetland).--Located in Pope County (45^{o} 44'24" N, 95^{o} 24' 59" W). The first nesting record known for this 1540 ha site was 100 pairs reported in 1986.

Marsh Lake (Type 4 wetland).--This 2,470-ha lake is located in Big Stone County (45^{o} 11' 30" N, 096^{o} 07' 30" W). Forster's Terns were recorded breeding at this site for the first time in 1986.

Monogalia Game Refuge (Type 5 wetland).--This site, also called Mud Lake, is located in Kandiyohi County (45^{o} 3' 30" N, 094^{o} 46' 00" W). It is 1,019 ha in size. The first breeding record for Forster's Terns at this site was in 1985.

Mother Lake (Type 4 wetland).--Mother Lake in Hennepin County (44^{o} 53' 37" N, 093^{o} 14' 27" W), a 55-ha urban site, is located at the end of one of the Minneapolis/St. Paul International Airport runways. Forster's Terns have nested here since at least 1945. The largest colony recorded (70 nests) was found in 1981. Cattail (Typha sp.) is the dominant emergent vegetation. Noise levels are high due to the proximity and frequency of arriving and departing airplanes. Nests were built on muskrat houses and on floating dead vegetation.

North Heron Lake (Type 4 wetland).--This Jackson County lake (43^{o} 47' 51" N, 095^{o} 17' 10: W) was the southernmost colony site visited. It is also the Minnesota site with the oldest Forster's Tern nesting record, 1894 (Peabody 1896). The North and South Heron Lake wetland complex contains 3,340 ha. In 1942, 2,500 Forster's Tern pairs were estimated to be nesting at North Heron Lake (MDNR CWDB). This is the largest colony ever reported in Minnesota. Most nests at this site were on floating vegetation.

North Middle Lake. (Type 4 wetland).--This 885 ha lake is part of a large wetland complex in Nicollet County (44^{o} 18' 46" N, 94^{o} 09' 44" W). Five pairs of terns were found nesting here for the first time in 1985; none were present in 1986.

Swan Lake (Type 4 wetland).--This extensive wetland (3,784 ha) is located in Nicollet County (44^{o} 18' 24" N, 094^{o} 14' 51" W). It has approximately 113 km of shoreline and contains nine islands. Investigators have reported nests at this site since 1932 (MDNR CWDB). Emergent vegetation includes cattail (Typha augustifolia var. elongata) and bulrush (Scirpus sp.). Submerged vegetation usually was very dense by mid-summer, especially bladderwort (Utricularia vulgaris L. var. americana Gray), coontail (Ceratophyllum demersum L.), sago pondweed (Potamogeton pectinatus L.), and water milfoil [Myriophyllum spicatum L. var. exalbescens (Fernald) Jepson]. Much of the surrounding land is row-crop farming or grazed by dairy cattle (Schultz 1985). Forster's Tern nests were found on muskrat houses and floating vegetation.

Tamarac Lake (Type 5 wetland).--This 902 ha lake is located in Becker County (46^{o} 55' 23" N, 095^{o} 40' 21" W) in northwestern Minnesota. The only nesting record for this site was during my study in 1985. Nests were found on floating vegetation.

Thief Lake (Type 4 wetland).--Located about 12 km north of Agassiz National Wildlife Refuge, this is the northernmost site in the census. Situated in Marshall County (48^{o} 29' 18" N, 095^{o} 56' 59" W), it is 902 ha. Observers estimated as many as 200-500 breeding pairs at this site in the early 1980's (MDNR CWDB).

Upper Rice Lake (Type 4 wetland).--Located in Clearwater County (47^{o} 23' 42" N, 095^{o} 17' 34" W), this site is 753 ha in size. Forster's Tern nesting records date to 1932. The largest number of nests was recorded in 1985 during my study.

Wood Lake (Type 4 wetland).--This is another small (49 ha) urban site. It is located in Hennepin County (44^{o} 52' 36" N, 093^{o} 17' 35" W), and is bounded on the west by Interstate 35W. Although 100 nests were found in 1976, and adults have been seen each spring, no nesting occurred here in the early 1980's until 17 nests were discovered in 1984. Nests are typically built on floating vegetation.

METHODS

Census techniques.--I completed most census activities during the first week of June in 1985 and 1986; efforts were timed to coincide with late incubation. A few sites were censused by other biologists (e.g. J. Mattson, ANWR; J. Schladweiler, N. Heron Lake (1986), N. Middle Lake, Monogolia, Marsh Lake; K. Haws, Tamarac Lake; N. Hiemenz, Reno Lake). All sites were censused both years, with two exceptions: Monongalia was censused only in 1985, and Marsh Lake in 1986. Colonies were reached either by boat or by wading from shore. Nests containing one or more eggs or young were counted. In three cases (part of a Swan Lake sub-colony and Agassiz National Wildlife Refuge in 1985; Coon Creek in 1986), I estimated the number of breeding pairs by counting numbers of adults exhibiting nest site attachment (i.e., taking flight and landing regularly in an area) and then dividing by two. This second approach was taken either when submerged vegetation was too dense to allow the use of a boat and the area was too large to wade through, or when timing of the visit was likely to disturb many chicks. In these cases, nest contents are not known.

Estimating breeding success.--To estimate reproductive success, I selected three colony sites in 1985 (Clearwater Lake, Mother Lake, and Swan Lake) and two colony sites in 1986 (Mother Lake and Swan Lake) to monitor on a regular schedule. In 1985, I visited Mother Lake once a week and Clearwater and Swan lakes twice a week. In 1986, Mother Lake was monitored once a week and Swan Lake six to seven times a week. Artificial nesting platforms at Swan Lake were visited once every 10 days. To minimize investigator disturbance, a floating muskrat house blind was used to observe nests at Swan and Clearwater lakes (Nuechterlein 1980). At Mother Lake, thick emergent vegetation prohibited use of the blind and both natural and platform nests were examined by wading to each nest.

Nests were monitored from late incubation through fledging or disappearance of the offspring. A sample of nests was selected for study: Clearwater Lake (24 in 1985), Mother Lake (11 in 1985; 7 in

1986), and Swan Lake (45 in 1985; 45 in 1986). Nests were marked with numbered wooden stakes tied to nearby cattail leaves. During each visit, the number of eggs and chicks was recorded in each monitored nest. The fate of each egg (e.g., nonviable, hatched, disappeared) and each chick (e.g., died, disappeared, fledged) was also recorded, as was any evidence of factors or agents that may have affected reproductive success (e.g., weather, predators, human disturbance). Chicks were banded with a USFWS aluminum leg band.

Three variables were used to measure breeding success: hatching success (chicks hatched/total eggs laid), fledging success (fledglings/total eggs laid), and reproductive success (fledglings/breeding pair). To estimate reproductive success for an entire colony, my assistants and I censused fledglings (juveniles seen in flight) at each site. We searched the entire lake at each monitored site, counted all fledglings seen, and divided by total breeding pairs at each lake. This was done during July of both years.

<u>Artificial</u> <u>nesting</u> <u>platforms</u>.--A total of 74 nest platforms was placed in potential tern nesting habitat during my study. I constructed platforms following the design of Techlow (1983) and placed 10 structures in two groups of five at Mother Lake on 7 May 1986. One group was located where terns were observed dropping into the vegetation. The other group was placed nearby, but in an area where no terns were observed. On 17 May, 27 nesting platforms were placed at Swan Lake in three groups: 15, 8, and 4. The group of 15 was placed

at a site where a large number of terns was seen taking flight and landing in the vegetation. The group of eight was placed at a site used by nesting terns in 1985. In an effort to attract terns to a previously unused location, I placed four platforms in an area where no terns were observed. Nesting platforms were in thick vegetation by late June, prohibiting the use of the floating blind, so they were monitored by boat. Additional platforms were constructed and placed at two other locations: staff placed 12 platforms at Wood Lake Nature Center in 1985 and 1986, and John Schladweiler, Minnesota DNR, placed 25 nesting platforms at North Heron Lake in 1986. Data from the Wood Lake and North Heron Lake nesting platforms are included in this study.

Water levels and rainfall.--Water level data were obtained at each of the three monitored sites. J. Erdmann of Wenck Associates, Wayzata, Minnesota, provided data for Clearwater Lake. At Mother Lake, I placed a calibrated metal pole in the water and recorded water height during each visit to this site. Swan Lake had two gauges; one placed by myself, and one placed by the Minnesota Department of Natural Resources. R. Schultz, MDNR hydrologist, provided water level data for Lake Osakis. Rainfall data were collected at Swan Lake from a rain gauge placed outside my cabin. I also obtained rainfall data from the State Climatology Office, MDNR Division of Waters, for Swan, Clearwater, and Mother lakes.

Statistical analysis.--None of the data was distributed normally, so non-parametric tests (chi-square test; Fisher's Exact Test) were used to analyze the data (Sokal and Rohlf 1981).

RESULTS

Population Distribution and Size

I recorded 817 and 893 Forster's Tern nests in Minnesota in 1985 and 1986 (Table 1). Based on these data, I estimate the total breeding population in Minnesota to be fewer than 1,000 pairs in both years.

While no major difference was found in the size of the total population between the two years, interseasonal variation in colony size occurred. The nests at Lake Osakis and Clearwater Lake comprised 40% of the total 1985 population (Table 1). In 1986, there were no Forster's Tern nests at those sites. The largest colony in 1985 (326 pairs), located at Swan lake, was approximately the same size in 1986 (316 pairs). At the same time, ANWR and North Heron Lake colonies greatly increased in number from 1985 to 1986. ANWR increased by about 250 pairs and North Heron Lake by almost 180. The other sites varied by fewer than 30 nests between years.

Colony sites in Minnesota were limited to wetland types 3 (1 site), 4 (9 sites), and 5 (6 sites). Of the non-urban sites used in 1985 or 1986, only one, Coon Creek, was small (207 ha). The rest were 700 ha or larger. The urban sites, Mother Lake and Wood Lake, were both small (55 and 49 ha, respectively).

The colony sites were located in the southern and western portions of the state, from as far north as Thief Lake to southernmost North

Heron Lake, west as far as Coon Creek, with Wood Lake at the eastern edge of the range. Several sites were in the Minneapolis/St. Paul metropolitan area (Mother and Wood lakes).

Breeding Success in Natural Nests

Overall mean clutch size was identical in the two years (Table 2). Mean clutch size varied among sites from 1.07 at Mother Lake in 1985 to 2.74 at Clearwater Lake in 1985. There were significant differences in clutch sizes among sites. Clutch size was smaller at Mother Lake than at Clearwater Lake ($X^2 = 106.39$, df = 2, $p < 0.001$) or Swan Lake ($X^2 = 55.32$, df = 2, $p < 0.001$). Clutches at Swan Lake were smaller than at Clearwater in 1985 ($X^2 = 46.61$, df = 3, $p < 0.001$). There also was a significant difference in clutch size between years at Mother Lake ($X^2 = 19.02$, df = 2, $p < 0.001$), and at Swan Lake ($X^2 = 13.14$, df = 3, $p < 0.005$). Larger clutches were recorded at both sites in 1986.

During the study hatching success ranged from 0-33% (Table 3). In 1985, hatching success was significantly lower at Mother Lake than at Clearwater Lake ($X^2 = 9.55$, df = 1, $p < 0.005$), and Swan Lake (Fisher's Test, $p = 0.012$), but there was no significant difference between hatching success at Clearwater and Swan lakes that year (Table 2; $X^2 = 3.76$, df = 1, $0.1 > p > 0.05$). In comparing the 1985 Clearwater Lake data with 1986 data from Swan and Mother lakes, there was no significant difference in hatching success between Clearwater Lake and Swan Lake ($X^2 = 0.0042$, df = 1, $p < 0.9$), and the difference in success at Clearwater Lake was not significant from Mother Lake (X^2 = 3.28, df = 1, 0.10> p > 0.05). In 1986 hatching success at Swan Lake was not very significantly different from Mother Lake (X^2 = 3.48, df = 1, 0.10 > p > 0.05).

Fledging success varied from 0-17% during the two breeding seasons (Table 3). Fledging success at Clearwater Lake was significantly different from Swan Lake in 1985 (X^2 = .570, df = 1, p < 0.025), and was significantly greater than Mother Lake (Fisher's Exact Test, p = 0.030). In comparing Clearwater Lake results in 1985 with 1986 data from Swan and Mother Lakes, Clearwater Lake was significantly higher than Swan Lake in fledging success (X^2 = 5.04, df = 1, p < 0.025), but there was no significant difference from Mother Lake (Fisher's Exact Test, p = 0.053). In 1986 fledging success at Swan Lake was not significantly different (Fisher's Exact Test, p = 0.416; Table 3) from that at Mother Lake despite the fact that no chicks fledged at Mother Lake.

Reproductive success ranged from 0.458 chicks produced/pair at Clearwater Lake in 1985 to 0 chicks/pair at Mother Lake in both years (Table 3). In 1985 reproductive success at Clearwater Lake was significantly higher than at Swan Lake (Fisher's Exact Test, p = 0.005) and Mother Lake (Fisher's Exact Test, p = 0.000). The 1985 reproductive success at Clearwater Lake was significantly higher than 1986 success at Swan Lake (Fisher's Exact Test, p = 0.004), but not the

1986 Mother Lake success (Fisher's Exact Test, $p = 0.065$).

Breeding Success on Artificial Nesting Platforms

Wood Lake was the only site where platforms were tested in 1985. None was used by Forster's Terns for nesting. In 1986, 25 (34%) of the 74 platforms were used by Forster's Terns: 7 at North Heron Lake, 13 at Swan Lake, 5 at Mother Lake and 0 at Wood Lake. Two other species also nested on the platforms. Franklin's Gulls (Larus pipixcan) used two nesting platforms at North Heron Lake, and Black Terns (Chlidonias niger) used one nesting platform at Swan Lake. Three nesting platforms were used by Franklin's Gulls or Forster's Terns at North Heron Lake, but the nests were destroyed by predators before being positively identified. Muskrats (Ondatra zibethicus) used the structures as feeding sites at Mother Lake in 1986. Canada Geese (Branta canadensis) loafed on the platforms at Wood Lake.

The average clutch size on nesting platforms varied among sites. At Mother Lake, it was 2.60; at Swan Lake, it was 2.38; and at North Heron Lake it was 3.00. Clutch size on nesting platforms at North Heron Lake was not significantly higher than at Swan Lake (Fisher's Exact Test, $p = 0.650$) or Mother Lake (Fisher's Exact Test, $p = 1.00$). Intrasite comparisons of natural and platforms nests at Swan and Mother Lakes did not reveal any significant differences in clutch size.

A total of 18 nests on platforms was monitored at Mother Lake (5) and Swan Lake (13) in 1986. Almost all eggs (93%) did not hatch; three chicks hatched but only one survived to fledging. Reproductive success on nesting platforms was 0.000 at Mother Lake and 0.077 at Swan Lake. Fledging success was not significantly different between nesting platforms and natural nests at Mother Lake (Fisher's Exact Test, $p = 1.00$) or at Swan Lake (Fisher's Exact Test, $p = 0.372$).

Factors Causing Reproductive Failure

Natural nests.--The most common fate of unhatched eggs during the two years of the study was disappearance (Tables 4, 5). Of 282 unhatched eggs, 172 (61%) disappeared. In 1985, Mother Lake had a significantly higher number of eggs that disappeared compared to both Swan and Clearwater lake (Fisher's Exact Test, $p = 0.004$; $p < 0.001$, $X^2 = 25.71$, $df = 1$, $p < 0.001$); in 1986, Mother Lake did not have a significantly higher number of missing eggs than Swan Lake ($X^2 = 1.45$, $df = 1$, $p > 0.10$). Deserted eggs (36) accounted for 13% of the unhatched eggs. This category included clutches found intact but cold and eggs displaced from the nest following a storm or rise in water level. In 1985 a significantly greater number of eggs was deserted at Clearwater Lake than Swan Lake (Fisher's Exact Test, $p = 0.00$); a significant difference in deserted eggs found at Clearwater and Mother lakes that year was also found (Fisher's Exact Test, $p = 0.043$). Only four eggs (< 2%) were nonviable.

Of chicks that did not fledge, disappearance also was the most common fate. Seventy chicks hatched and 47 (67%) disappeared (Tables

4, 5). There was no significant difference between the number of chicks that disappeared at Clearwater Lake and Swan Lake in 1985 ($X^2 = 3.19$, df = 1, $0.10 > p > 0.05$). Almost a third of the chicks (31.5%) fledged. Only one chick (<2% of all chicks from monitored nests) was known to be killed by a predator. The chick was found with a neck wound and other chicks from adjacent unmonitored nests were found decapitated. Another 1.4% of the chicks were found dead of unknown causes.

Platform nests.--Of the 41 eggs that did not hatch, 32 (78%) disappeared, 7 (17%) were deserted and 2 (5%) were nonviable. No nests were destroyed by storms. I believe predators ate eggs (e.g. Black-crowned Night Heron (*Nyeticorax nycticorax*); mink *Mustela vison*) or caused desertion (e.g. Great Horned Owl (*Bubo virginianus*) by disturbing adult birds at night. Although chick mortality was limited to two individuals, both deaths were probably caused by predators.

DISCUSSION

Population Distribution and Size

In Minnesota Forster's Terns breed throughout the western prairie wetlands and eastward through the prairie-woods transition including an extension into the central part of the state to the Twin Cities. The largest colonies were found in Jackson, Nicollet, Todd and Wright counties. Although I estimated a breeding population of 900-1000 pairs in the 1985-1986 censuses the accuracy of this figure is influenced by the following circumstances: (1) some colonies with < 10 breeding pairs found between 1980 and 1984 were not censused; (2) some colonies may have been undiscovered, especially small ones, and thus were not included in this census; (3) some estimates were made late in the breeding season when chicks already were mobile (e.g. North Heron Lake); and (4) some estimates were made from birds in flight because the site was too large or contained vegetation too dense to penetrate by boat.

Although there is no estimate of the total number of Forster's Terns that nest in North America, a few regional figures are available [e.g., Kress et al. (1983) recently reported 3,100 pairs in the northeastern United States]. In the area surrounding Minnesota, several states and provinces have assessed Forster's Tern population size. For example, Wisconsin has monitored its Forster's Tern population for a number of years. Forster's Terns are endangered in Wisconsin and the Wisconsin DNR has placed out nesting platforms for Forster's Terns since 1979; the population increased from approximately 300 breeding pairs in 1979 to 800 breeding pairs in 1984 (Kearns 1985). K. Fruth, Wisconsin DNR (pers. comm.), attributed this increase to high reproductive success on nesting platforms. However, the population declined to around 400 pairs in 1985 and 1986 following high water levels and associated habitat deterioration (S. Mattson pers. comm.). In 1987, the number of breeding terns again increased to approximately 900 pairs, but reproductive success was poor following mink predation (K. Fruth pers. comm.).

In Iowa, fewer than 100 breeding pairs of Forster's Terns have been present each year since at least 1975 (J. Dinsmore pers. comm.). Iowa's Forster's Tern population has not been designated with special status.

The North Dakota Chapter of the Wildlife Society lists the Forster's Tern as a "watch" species (R. Kreil, North Dakota DNR pers. comm.). No population estimates are available, but this species is considered uncommon (Stewart 1975). The Forster's Tern has not been given a special status designation in South Dakota and no population estimate is available in this state (G. Vandel, South Dakota DNR, pers. comm.)

Forster's Tern population estimates are available for the Canadian provinces of Ontario and Manitoba. Ontario population estimates range from 200 pairs (C. Weselow pers. comm.) to 300-400 pairs (M. McNicholl pers. comm.). Manitoba's most recent population estimate for Forster's Terns, based on an aerial survey, was approximately 1,100 pairs (Koonz and Rakowaski, 1985).

There are several reasons for the paucity of accurate population estimates for Forster's Terns. Their nests can be difficult to census because they often are spread out among emergent vegetation, requiring investigators to walk or pole a boat through areas unsuited for a motor or oars. The nests also may be distributed over a large wetland complex so that censusing can be very time-consuming, sometimes taking several days for a particularly large area such as Swan Lake. In addition birds may change colony sites from year to year (McNicholl 1975) making location of all active colonies difficult on an annual basis. Finally, Forster's Terns usually nest in colonies, but they also may nest singly or in very small groups. In an area with many wetlands, it is difficult to find all nesting pairs. In Minnesota, the Forster's Tern has been one of the least-thoroughly censused colonial waterbird species (Guertin and Pfannmuller 1985).

Although Forster's Terns utilize a range of wetland type colonies they were most often found in Type 4 wetlands which are characterized by large stable stands of dense emergent vegetation and extensive open water for foraging. Nests were almost always constructed on rooted cattail bases but at several lakes (e.g. Thief, Upper Rice Lake) they were located in dense stands of bulrush. My study and historical data indicate that Forster's Terns may prefer Type 5 wetlands when habitat conditions are favorable. Two of the largest and densest colonies were found on floating cattail mats in lakes Osakis and Clearwater. The reproductive success estimate for Clearwater Lake was the highest recorded for all sites measured. MNDR CWBB records show these lakes have been used many seasons during this century. Despite intermittent favorable conditions these sites are susceptible to change when lake levels rise and vegetation mats are destroyed by storms as occurred betwen 1985 and 1986. Therefore, it appears that, when available, Forester's Terns will select large mats of vegetation on large lakes with open water. These sites are probably very productive on a periodic basis. The middle class of wetlands is consistently used and may on average have much lower reproductive success. These sites appear very vulnerable to several species of predators and nest destruction by major summer storms. Although Forster's Terns periodically utilize small wetlands characterized by shallow water and emergent vegetation these sites appear less than ideal because of increased risk of predators, poor food base and greater sensitivity to drought.

Although the population estimates for Minnesota were similar in 1985 and 1986, distribution of the birds was different for each year, especially at lakes Osakis and Clearwater. The main change at these two locations in 1986 was loss of nesting habitat. In 1985 the birds nested on dense, bog-like floating mats of dead and living vegetation composed primarily of cattails. In 1986, these mats were not present. At both lakes Osakis and Clearwater, water levels rose in 1986 about the time Forster's Terns initiated nesting. For example, the water level in Clearwater Lake and Lake Osakis was approximately 0.40m higher in spring 1986 than in 1985. I believe the high water levels at Clearwater Lake and Lake Osakis either submerged the mats or caused them to break apart and float away. In 1980 similar mats broke loose from the substrate in Clearwater Lake and clogged the outlet, causing flooding (R. Froyen, Clearwater Lake resort owner, pers. comm.). I searched Lake Osakis and Clearwater Lake for alternative colony sites, and it was apparent that other nesting habitat was not available; most of the area of the two lakes was open water.

In 1986, it appeared that some terns changed colony sites from the previous year. The three largest colonies in 1986 were at Swan Lake, ANWR, and North Heron Lake. Estimates at the latter two sites were notably larger (approximately 6x) then those recorded in 1985. Additionally a colony of approximately 100 pairs was reported (Shedd and Wilson 1987) at Lake Reno in Pope County and Jean Hushagen, Minnesota DNR wildlife technician, found 205 adults and "nests" at Thief Lake more than a month after K. Haws located only 1 nest at the same site (K. Haws, pers. comm.); apparently late or renesting occurred here. Although we do not know if any of the approximately 300 pairs from Clearwater Lake and Lake Osakis moved to ANWR, North Heron Lake, Lake Reno, or Thief Lake, it appears to be a reasonable possibility.

Breeding Success

Clutch size.--Nests at Mother Lake had the lowest mean clutch size of any censused colony in both years. It is unclear why this was so. Reasons for small clutch size at the time of the census may include: (1) many eggs were lost to predators prior to the census, (2) birds were in the process of relaying after losing an earlier clutch, (3) the constant disturbance of low-flying airplanes disrupted laying. Clutch sizes recorded at the other colonies are comparable to those reported by Bergman et al. (1970) in Iowa colonies.

Hatching Success.--In this study, hatching rate was as high as 33% (Swan Lake natural nests, 1986) and as low as 0% (Mother Lake 1985).

McNicholl (1982) found hatching rates of only 5-15% in Manitoba. In South Dakota, Houston (1962) reported 66% hatching success, and in, California, Coulter found a 65% egg hatch rate (McNicholl 1982). Results from this and other studies indicates high variability in hatching rate for this species. Although I documented egg loss to predators and during storms, this component of breeding success needs additional study.

Fledging success.--Fledging success in Minnesota was variable among sites and between years. The success (approximately 40%) recorded at Clearwater Lake in 1985 is the highest estimate in the literature for this species. Bergman et al. (1970) reported 12% nest success, and McNicholl (1982) found 14% nest success in 1968 but only 1% in 1969.

Reproductive success.--Fledging and reproductive success figures were probably under estimated in this study. If disturbed, chicks may permanently leave the nest soon after hatching (Rockwell 1911) and can be very difficult to locate in the surrounding vegetation (Peabody 1896). I did not document the construction of auxillery nests as reported by Cuthbert (1954) for Black Terns (*Chlidonias niger*) but believe Forster's Terns may also build these structures. In addition Forster's Terns are thought to leave the colony soon after fledging (McNicholl 1971; Techlow 1983).

The highest estimate recorded in this study, 0.458 fledglings/ pair, is below the 1.1 fledglings/pair needed to maintain a population of Common Tern as its current size (Nisbet 1978; DiCostanzo 1980). Because no data are available on Forster's Tern life expectancy and mortality rates the actual level of reproductive success required to sustain the Minnesota Forster's Tern population is not known. Other Forster's Tern researchers report reproductive success rates of 1.33 fledglings/pair (Techlow 1983) (this includes artificial nesting platform nests), and 0.143 fledglings/pair (McCaskie and Pugh 1964). McNicholl (1982) found that 7% of all eggs fledged in 1968; 0% survived to this stage in 1969.

Because few studies have estimated reproductive success in Forster's Terns it is difficult to generalize about chick survival to fledging; survival does, however, often appear to be below 1 fledgling/pair. Data on other species of marsh nesting terns also indicate low fledging success for terns nesting in wetland habitats. For example McCaskie and Pugh (1964) reported reproductive success of Black Terns at 0.833 fledgling/pair. Of special interest is the study by Burger and Lesser (1979) who found marsh-nesting Common Terns (S. hirundo) from only two of 11 colonies approached a reproductive success rate of one fledgling/pair; they suggested that marsh-nesting Common Terns may have lower reproductive success than terns that utilize the typical terrestrial habitat. In contrast, fledging success rates of 0.61 to 1.61 fledglings/pair have been reported for ground nesting colonies of Common Terns in California (Ohlendorf et al. 1985) and Nisbet (1978) found that Common Terns in Massachusetts produced 1.1

fledglings/pair between 1940-1956.

Factors Influencing Breeding Success

<u>Storms</u>.--Wave action, storms and rain caused the loss of a number of nests. This was most noticeable at Swan Lake in 1986. In one sub-colony, 16 of 19 nests disappeared during a four day period in mid-June when two major storms occurred. On 15 June 1986 a major storm twisted and broke off live trees as far as 10 m above ground in a forested area adjacent to Swan Lake. The storm deposited 8 cm of rain and hail on the town of Nicollet, (G. Leonard, pers. comm.) which borders the southern edge of Swan Lake. After that storm and several other less severe storms, at least 34 nests disappeared. I did not re-census the lake, so not all damage was discovered.

Runoff also affected nesting areas after initial storms were over. Although flash flooding may occur soon after a storm I found that water levels often continued to rise for days after the storm. High water levels were an important factor influencing breeding success at several Minnesota colonies. Forster's Terns nested at Mother Lake in 1986, but after heavy rains and an increase of at least 18 cm inches in water depth 8 days after the previous nest check, eight monitored nests were lost, and other nests that were not monitored probably were lost as well. Many nests were built on the lower portions of muskrat houses and were flooded. A few eggs at Clearwater and Swan lake also were submerged. In 1985, six eggs were submerged at Clearwater Lake after water levels rose. A two egg clutch fell into the water in 1986 at

Swan Lake when the cattail base on which the nest was built turned over. At lakes Clearwater and Osakis, high spring water levels apparently prevented Forster's Terns from breeding in 1986. Mitchell (1941) also documented a Forster's Tern nest that was destroyed by a rise in the water level and wave action. Fox (1960) reported that a Forster's Tern nest on an island was destroyed when the island was completely innudated by water after a heavy rain. However, Zuranich (1963) found that 20 Forster's Terns nests in Kansas were unaffected by gradually rising water. Although water levels rose 0.7 m, the nests floated freely and rose with the water level.

Predators.--Although only one chick from monitored nests was found dead from predation I observed other evidence of predation during general field observations during both years of the study. In 1985 one chick was found dead with a neck wound; another chick was found decapitated. Both chicks were nearly fledged and were found at Clearwater Lake. Four dead chicks were found at Swan Lake in 1985, one with two puncture wounds approximately 2.5 cm apart. The same day, an egg was found with a single puncture. At the same site, a decapitated adult was found. In 1986, pieces of two adults were found at Swan Lake: one head, three wings and two backs with tails. Decapitated birds are characteristic of Great Horned Owl kills. Vermeer (1970) found seven decapitated adults in a California (L. californicus) and Ring-billed gull colony, and feathers of a Great Horned Owl in the same area. In 1986 a Great Horned Owl was seen once at Swan Lake during the breeding season, and several were seen at Mother Lake both during and after the breeding season. Mink also may have been a predator on the Forster's Terns at Mother Lake (Errington, 1967).

Other possible predators on Forster's Terns include snapping turtle (Chelydra serpentina), especially on chicks, Great Blue Heron (Ardea herodias) (Bent 1917), and Black-crowned Night Heron which are known to eat Roseate Tern chicks (Collins 1970). American Coots Fulica americana) (Burger 1973), Northern Harriers (Circus cyaneus) (Burger 1974), raccoon (Procyon lotor; Nickell 1964), Red-tailed Hawks (Buteo jamaicensis; Vermeer 1970), and Red-winged Blackbirds (Agelaius phoeniceus; Pessino 1968) are also tern and/or gull predators. American Coots and Black-crowned Night Herons were common at the colony sites and both nested within Forster's Tern colonies.

Although nests located in wetlands are vulnerable to wave and storm damage and to aquatic and aerial predators, natural selection theory predicts that individuals utilizing this habitat encounter greater benefits than costs (Burger 1974; McNicholl 1982). For example, marshes provide an abundant and diverse food supply (e.g. fish, insects) (Weller 1981). Nesting in marshes over water also decreases the chance of predation from mammals such as foxes (Vulpes vulpes) and skunks (Mephitis mephitis). The advantages of abundant food and protection from mammalian predators presumably outweigh the disadvantages of avian predation and wave and storm damage for marsh-nesters.

This and other studies of marsh-nesting terns have demonstrated that reproductive success in these species is relatively low in comparison to terrestrial-nesting terns. However, the mean reproductive success in one or two breeding seasons cannot be taken alone as a measure of fitness. It also depends on the total reproductive success of the individual over a lifetime. For example, if there are no major storms or incidents of predation during two breeding seasons in a Forster's Terns's lifespan of perhaps 10 years [the average lifespan of the Common Tern (Austin, 1942); no information is available for the Forster's Tern], their reproductive success may be very high during other years. Because life expectancy is relatively high, each adult can fail to produce young during a number of seasons and still replace itself in one successful year. Alternatively, Forster's Terns may have a significantly longer lifespan than Common Terns and may need to produce fewer young per season. Finally, there is the important possibility that reproductive success in Minnesota wetlands used to be much better. With drainage of marshes and destruction of edge habitat, birds encounter fewer wetlands in which to nest, and marshes flood more easily because they lack the buffer of surrounding wetlands.

Artificial Nesting Platforms

I documented that Forster's Terns will use nesting platforms in Minnesota wetlands, but I was not able to use these structures to increase reproductive success. Use of nesting platforms was 34% (25

Forester's Tern nests on 74 platforms). This figure is low compared to use rates reported by Techlow (1982); there were several factors that affected this estimate. To determine if they would be attracted by nesting platforms and nest in a new area, I placed some platforms at spots where no Forster's Terns were nesting. At Mother Lake, one of these sites was near (within 100 m) nesting Forster's Terns. The other area at Swan Lake was several hundred m from nesting Forster's Terns. Other researchers (Techlow 1982) had success in attracting Forster's Terns from as far as 3 km from the nearest colony in this manner, but used 10 or more nesting platforms to do so. A second factor that caused use of nesting platforms to be low is that no terns used the nesting platforms at Wood Lake. In 1985, no terns nested there at this site, and by the second year that the platforms were out, they were in dense vegetation rather than the more open vegetation that Forster's Terns appear to favor. Finally, at North Heron Lake, several thousand Franklin Gulls nested there with the terns and used some of the nesting platforms intended for Forster's Terns. Looking only at the three groups of nesting platforms that were used by Forster's Terns, 56% were used for nesting, considerably higher than the 34% reported for all platforms.

Reproductive success was not good on nesting platforms at the two monitored sites. Although reproductive success on nesting platforms may have been reduced by a severe storm in the Swan Lake area on 26 June, I believe selective predation on platform nests was the most significant factor limiting chick survival. Greatest losses of eggs occurred where I suspected mink and Black-crowned Night Heron predation. The platforms were easily accessible to mink and may have made nests more obvious to the night herons. Platforms appeared to increase survival of nests during most storms but decreased productivity when predators were present.

Conservation of Forster's Terns in Minnesota.--The current status of Forster's Terns in Minnesota is that of "Special Concern". In this study I estimated a current breeding population of 900 to 1,000 pairs, which appears to be significantly lower than the largest previous estimate of 2,500 pairs in 1942 (MDNR CWDB). However, because terns may change colony sites between years, it is necessary to look at the surrounding states and provinces to understand the population dynamics in a given area. Unfortunately, most of the surrounding states and provinces do not have population estimates for Forster's Terns.

In this study, the highest Forster's Tern colony reproductive success estimate was 0.458 fledglings/breeding pair; it is not known if this is a low, average, or high rate. It also is not known if the population will remain stable at this rate. Other Minnesota colonies had much lower rates, including one with zero reproductive success. I recommend there should be an annual spring visit and nest census of the historically imortant breeding sites (e.g. Swan Lake, Clearwater Lake, Lake Osakis, Agassiz National Wildlife Refuge, and North Heron Lake), and a late June to mid-July fledgling count. These visits will result in an estimate of reproductive success for each site and for the state breeding population. I also recommend additional study of nesting platforms, as these were occupied quickly in areas where nesting was occurring naturally. Platforms should not be used at sites where predation is common. Finally, I recommend protecting traditional colony sites against permanent drainage so that Forster's Terns will continue to have alternative nesting habitat available during a range of environmental conditions.

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TABLE 1

Forster's Tern colony sizes in Minnesota: 1985-1986

Site	County	1985 Census Date	1985 No. Nests	1986 Census Date	1986 No. Nests
Agassiz NWR	Marshall	June	50	June	300
Clearwater Lake	Wright	6/3	132	6/4	0
Coon Creek	Lyon	6/2	0	6/24	5
Fisher Lake	Scott	6/3	0	6/3	0
Lake Osakis	Todd	6/5	198	6/4	0
Lake Reno[1]	Pope	--	--	June	100
Marsh Lake[2]	Big Stone	--	--	June	6
Monogalia[2]	Kandiyohi	June	9	--	--
Mother Lake	Hennepin	6/4	27	6/7	43
N. Heron Lake	Jackson	6/2	29	6	207
N. Middle Lake[2]	Nicollet	June	5	7/11	0
Swan Lake	Nicollet	6/12-19	326	6/9-13	318
Tamarac Lake[3]	Becker	June	28	6/5	2
Thief Lake	Marshall	6/6	0	6/5	1
Upper Rice Lake	Clearwater	6/6	13	6/5	1
Wood Lake	Hennepin	6/4	0	6/7	10
Total Nests			817		893

1 censused by N. Hiemenz
2 censused by J. Schladweiler
3 censused by K. Haws

TABLE 2

Clutch size of Forster's Terns in Minnesota in 1985, 1986

Colony Site	Date	No. Nests	Clutch Size
Clearwater Lake	6/3/85	134	2.74
Lake Osakis	6/5/85	198	2.47
Mother Lake	6/4/85	27	1.07
	6/7/86	43	1.79
N. Heron Lake	6/2/85	29	2.28
Swan Lake	6/12/85	254	2.20
	6/9/86	318	2.41
Upper Rice Lake	6/6/85	13	2.54
Wood Lake	6/7/86	10	2.50
TOTAL SAMPLE SIZE	1985	655	
	1986	371	
TOTAL MEAN CLUTCH SIZE	1985	2.22	
	1986	2.23	
TOTAL MODAL CLUTCH SIZE	1985	3	
	1986	3	

TABLE 3

Forster's Tern breeding success in 1985, 1986

Colony Site	Year	Hatching Success	Fledging Success	Reproductive Success
Clearwater Lake	1985	0.328	0.172	0.458
Mother Lake	1985	0.000	0.000	0.000
	1986	0.200	0.000	0.000
Swan Lake	1985	0.198	0.060	0.156
	1986	0.333	0.053	0.125

TABLE 4
Fates of unhatched Forster's Tern eggs and unfledged chicks: A summary

Site	Year	Monitored nests	Total eggs	Unhatched eggs	Chicks hatched	Unfledged chicks
Clearwater Lake	1985	24	64	43	21	10
Mother Lake	1985	11	22	22	0	0
	1986	7	18	16	2	2
Natural:		2	5	4	1	1
Platforms:		5	13	12	1	1
Swan Lake	1985	45	116	93	23	16
	1986	45	106	79	27	22
Natural:		32	75	50	25	21
Platforms:		13	31	29	2	1
TOTALS						
Natural		149	282	212	70	48
Platforms		18	44	41	3	2