EFFECTS OF MANAGEMENT PRACTICES ON WETLAND BIRDS:

BLACK TERN

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This report is one in a series of literature syntheses on North American wetland birds. The need for these reports was identified by the Prairie Pothole Joint Venture (PPJV), a part of the North American Waterfowl Management Plan. The PPJV adopted a goal to stabilize or increase populations of declining grassland-and wetland-associated wildlife species in the Prairie Pothole Region. To further that objective, it is essential to understand the habitat needs of birds other than waterfowl, and how management practices affect their habitats. The focus of these reports is on management of breeding habitat, particularly in the northern Great Plains.

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Species for which syntheses are available or are in preparation:

Eared Grebe
American Bittern
Virginia Rail
Sora
Yellow Rail
American Avocet
Willet
Long-billed Curlew
Marbled Godwit
Wilson's Phalarope
Black Tern
Marsh Wren
Sedge Wren
Le Conte's Sparrow
Nelson's Sharp-tailed Sparrow

EFFECTS OF MANAGEMENT PRACTICES ON WETLAND BIRDS:

BLACK TERN

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ORGANIZATION AND FEATURES OF THIS SPECIES ACCOUNT

Information on the habitat requirements and effects of habitat management on wetland birds were summarized from information in more than 500 published and unpublished papers. A ***range map*** is provided to indicate the relative densities of the species in North America, based on Breeding Bird Survey (BBS) data. Although the BBS may not capture the presence of elusive waterbird species, the BBS is a standardized survey and the range maps, in many cases, represent the most consistent information available on species' distributions. Although birds frequently are observed outside the breeding range indicated, the maps are intended to show areas where managers might concentrate their attention. It may be ineffectual to manage habitat at a site for a species that rarely occurs in an area. The species account begins with a brief ***capsule statement***, which provides the fundamental components or keys to management for the species. A section on ***breeding range*** outlines the current breeding distribution of the species in North America, including areas that could not be mapped using BBS data. The ***suitable habitat*** section describes the breeding habitat and occasionally microhabitat characteristics of the species, especially those habitats that occur in the Great Plains. Details on habitat and microhabitat requirements often provide clues to how a species will respond to a particular management practice. A ***table*** near the end of the account complements the section on suitable habitat, and lists the specific habitat characteristics for the species by individual studies. The ***area requirements*** section provides details on territory and home range sizes, minimum area requirements, and the effects of patch size, edges, and other landscape and habitat features on abundance and productivity. It may be futile to manage a small block of suitable habitat for a species that has minimum area requirements that are larger than the area being managed. The section on ***brood parasitism*** summarizes information on intra- and interspecific parasitism, host responses to parasitism, and factors that influence parasitism, such as nest concealment and host density. The impact of management depends, in part, upon a species' nesting phenology and biology. The section on ***breeding-season phenology and site fidelity*** includes details on spring arrival and fall departure for migratory populations in the Great Plains, peak breeding periods, the tendency to renest after nest failure or success, and the propensity to return to a previous breeding site. The duration and timing of breeding varies among regions and years. ***Species' response to management*** summarizes the current knowledge and major findings in the literature on the effects of different management practices on the species. The section on ***management recommendations*** complements the previous section and summarizes recommendations for habitat management provided in the literature. The ***literature cited*** contains references to published and unpublished literature on the management effects and habitat requirements of the species. This section is not meant to be a complete bibliography; a searchable, annotated bibliography of published and unpublished papers dealing with habitat needs of grassland birds and their responses to habitat management is posted at the Web site mentioned below.

This report has been downloaded from the Northern Prairie Wildlife Research Center World-Wide Web site, www.npwrc.usgs.gov/resource/literatr/wetbird/wetbird.htm. Please direct comments and suggestions to Douglas H. Johnson, Northern Prairie Wildlife Research Center, U.S. Geological Survey, 8711 37th Street SE, Jamestown, North Dakota 58401; telephone: 701-253-5539; fax: 701-253-5553; e-mail: Douglas_H_Johnson@usgs.gov.

Black Tern
(*Chlidonias niger*)

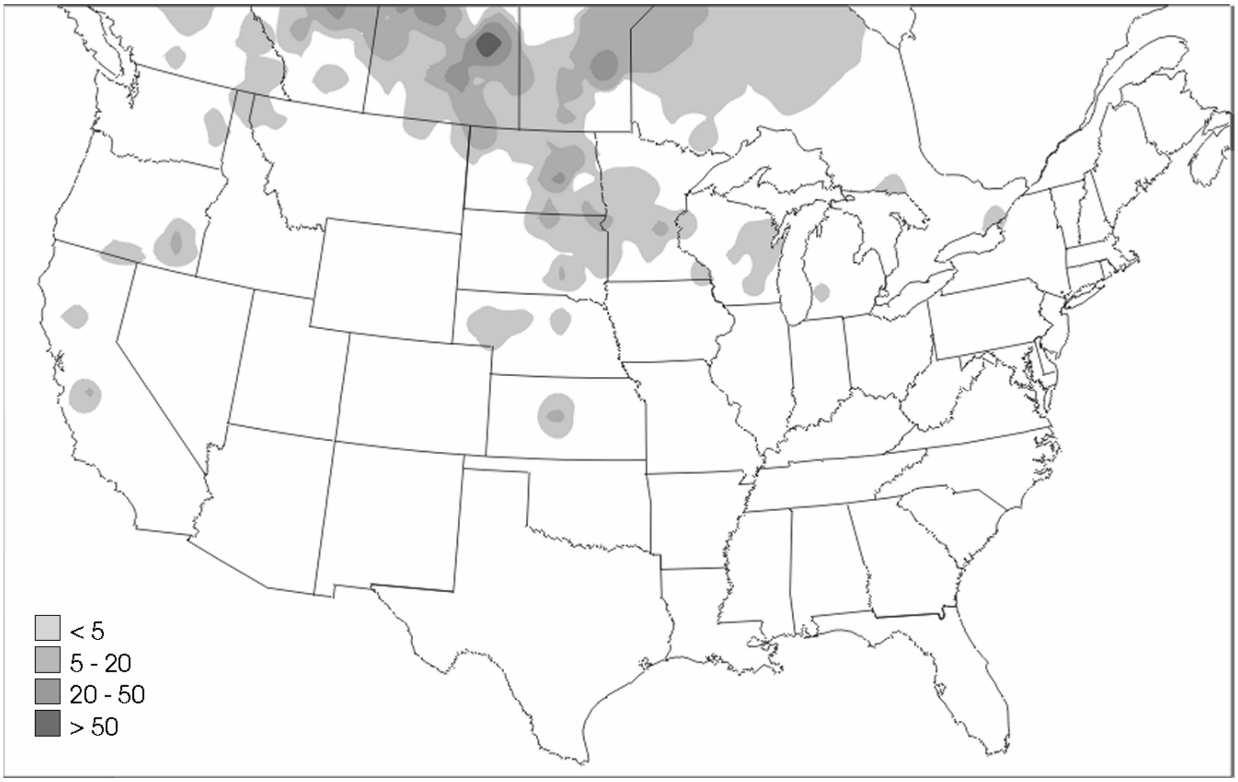

Figure. Breeding distribution of Black Tern in the United States and southern Canada, based on Breeding Bird Survey data, 1985-1991. Scale represents average number of individuals detected per route per year. Map from Price, J., S. Droege, and A. Price. 1995. The summer atlas of North American birds. Academic Press, London, England. 364 pages.

Keys to management are maintaining wetlands within large wetland complexes that contain nearly equal proportions of well-interspersed emergent vegetation and open water, maintaining stable water levels of >30 cm throughout the breeding season, and providing abundant nest substrates.

Breeding Range:

Black Terns breed in southeastern Yukon and from central Northwest Territories, throughout Alberta, Saskatchewan, southern Manitoba, southern Ontario, southern Quebec, and southern New Brunswick, south through western British Columbia, southern Washington, and southern Oregon, to northeastern and central California, northern Nevada, northern Utah, and southern Idaho, and east to western Wyoming, northcentral Montana, the eastern portions of North Dakota and South Dakota, central Nebraska, northern Colorado, through Minnesota and Wisconsin, and to northern portions of Michigan, Iowa, Illinois, Indiana, Ohio, Pennsylvania, New York, Vermont, and Maine. Isolated populations breed in central Kansas and in northern Manitoba (Dunn and Agro 1995, National Geographic Society 1999). (See figure for the relative densities of Black Terns in the United States and southern Canada, based on Breeding Bird Survey data.)

Suitable habitat:

Black Terns prefer fresh to slightly brackish semipermanent wetlands that have roughly equal proportions of well-interspersed emergent vegetation and open water, stable water levels throughout the breeding season, and abundant nest substrates (Bowman 1904; Rand 1948; Graber and Graber 1963; Stewart and Kantrud 1965; Weller and Spatcher 1965; Weller and Fredrickson 1973; Stewart 1975; Weber 1978; Johnsgard 1980; Tilghman 1980; Faanes 1981, 1982; Kantrud and Stewart 1984; Prince 1985; Chapman Mosher 1986; Carroll 1988; Powell 1991; Faber 1992*a*; Svedarsky 1992; Berkey et al. 1993; Niesar 1994; Dunn and Agro 1995; Faanes and Lingle 1995; Prescott et al. 1995; Teeuw 1995; Barrett and Kay 1997; Cooper and Campbell 1997; Hickey 1997; Mazzocchi et al. 1997; Naugle et al. 1999*a*, 2000). Other wetland types used by breeding Black Terns include seasonal and permanent wetlands (Stewart and Kantrud 1965; Faanes 1981, 1982; Weber et al. 1982; Niesar 1994; Faanes and Lingle 1995), as well as restored wetlands, flooded sedge (*Carex* spp.) meadows, lake margins, shallow river impoundments, river or island edges, river inlets, sewage lagoons, stock ponds, dugouts, wetlands within agricultural fields, and cultivated rice fields (Hoffmann 1954; Bent 1963; Stewart 1975; Tilghman 1980; Weber et al. 1982; Carroll 1988; Svedarsky 1992; Delehanty and Svedarsky 1993; Hartman 1994; Dunn and Agro 1995; Faanes and Lingle 1995; Graetz and Matteson 1996; Shutler et al. 2000; D. H. Johnson, *unpublished data*). Large areas of open water commonly are used for foraging (Svedarsky 1992, Delehanty and Svedarsky 1993). For example, in Minnesota, adults and fledglings moved from nest sites to open, sandy points on the edge of a nearby impoundment where fledglings were fed by the adults (Delehanty and Svedarsky 1993).

Black Terns commonly occupy wetlands that are within wetland complexes (Powell 1991; Naugle 1997; Naugle et al. 1999*a*, 2000; D. H. Johnson, *unpublished data*). Presence of Black Terns in South Dakota was positively related to the area of semipermanent wetlands and grassland within a 25.9-km^2 block around individual wetlands (Naugle 1997; Naugle et al. 1999*a*, 2000, 2001). Similarly, preliminary data from D. H. Johnson (*unpublished data*) indicated that Black Terns in North Dakota and South Dakota were more common in wetlands that had semipermanent wetlands within 0.4 km than in wetlands without semipermanent wetlands nearby. In another South Dakota study, the presence of Black Tern was positively related to the area of surface water within the wetland, wetlands that contained central expanses of open water composing >5% of the wetland area and surrounded by a peripheral band of emergent vegetation cover averaging $\geq$1.8 m in width, vegetation height, shoreline distance, and the presence of semipermanent wetlands within a 400-ha area of surveyed wetlands (Weber 1978). The presence of Black Terns in wetlands is negatively affected by percent woody vegetation present along wetland margins (Naugle et al. 1999*b*, Shutler et al. 2000).

Black Tern densities are highest on seasonal or semipermanent wetlands that have roughly equal proportions of well-interspersed emergent vegetation and open water (Weller and Spatcher 1965; Weller and Fredrickson 1973; Kantrud and Stewart 1984; D. H. Johnson, *unpublished data*). Preliminary analysis of data from D. H. Johnson (*unpublished data*) showed that in North Dakota and South Dakota, number of breeding pairs of Black Terns was highest in seasonal and semipermanent wetlands and was lowest in alkali wetlands. In Iowa, Black Tern densities peaked from 1 to 4 yr after a dry wetland reflooded, when the proportions of vegetation cover and open water were about equal (Weller and Spatcher 1965, Weller and Fredrickson 1973). Populations then declined steadily during the fifth and sixth years postflood as open water cover increased. In a South Dakota study comparing waterbird densities on wetlands modified for waterfowl production versus unmodified wetlands, Brady (1983) found that Black Tern densities were higher in modified wetlands than in unmodified wetlands. Modified wetlands consisted of a system of channels, ponds, and spoil islands that provided deep, open water and upland nesting cover for waterfowl. In Alberta, Prescott et al. (1993) reported that Black Tern densities were significantly higher in wetlands within cropland plots than in wetlands within plots of dense nesting cover.

Within suitable wetlands, nesting occurs in sparse or moderately dense stands of emergent vegetation or in open water with no emergent cover, where nests are placed on floating mats of vegetation (Tout 1902, Bowman 1904, Rockwell 1911, Harris 1931, Allen 1934, Cuthbert 1954, Bent 1963, Bergman et al. 1970, Stewart 1975, Bailey 1977, Beule 1979, Dunn 1979, Burger 1985, Powell 1991, Dunn and Agro 1995, Hickey 1997, Hickey and Malecki 1997, Mazzocchi et al. 1997). Nests in dense emergent vegetation are rare (Cuthbert 1954, Dunn 1979). Density of emergent vegetation or nest substrate availability appear to be more important factors in nest-site selection than plant type (Bergman et al. 1970, Dunn and Agro 1995, Naugle et al. 2000). Common emergent vegetation surrounding nests includes cattail (*Typha* spp.), bulrush (*Scirpus* spp. and *Schoenoplectus* spp.), or bur-reed (*Sparganium eurycarpum*) (Eifrig 1919, Provost 1947, Cuthbert 1954, Hoffmann 1954, Campbell 1970, Tilghman 1980, Chapman Mosher 1986, Firstencel 1987, Einsweiler 1988, Mossman et al. 1988, Manci and Rusch 1989, Faber 1990, Powell 1991, Dunn and Agro 1995, McCollough and McDougal 1996, Hickey 1997, Hickey and Malecki 1997, Mazzocchi et al. 1997, Naugle et al. 2000). Nesting also occurs among sedges, reed canary grass (*Phalaris arundinacea*), reeds (*Phragmites* sp.), water horsetail (*Equisetum fluviatile*), rushes (*Juncus* spp.), hairgrass (*Deschampsia* spp.), common threesquare (*Schoenoplectus pungens*), pond lilies (*Nuphar* sp.), waterlilies (*Nymphaea* sp.), pickerelweed (*Pontederia cordata*), broad-leaf arrowhead (*Sagittaria latifolia*), knotweed (*Polygonum* sp.), sweetflag (*Acorus americanus*), wild rice (*Zizania palustris*), and cultivated rice (Hoffman 1926, Harris 1931, Provost 1947, Cuthbert 1954, Hoffmann 1954, Eddy 1961, Parmelee 1961, Bent 1963, Salt and Salt 1976, Chapman Mosher 1986, Stern 1987, Faber 1990, Knutson 1991, Dunn and Agro 1995, McCollough and McDougal 1996, Mazzocchi et al. 1997). In South Dakota, vegetation density at nest sites decreased with increasing vegetation height, indicating that Black Terns nested in vegetation that was either short and dense or tall and sparse, affording overhead protection for chicks and aerial access for adults defending the nest (Naugle et al. 2000). In British Columbia, Black Terns nested in areas where the proportion of emergent vegetation was 10-70% (Chapman Mosher 1986). Sites with >70% vegetation were probably too dense to allow access to the surface of the water and sites with <10% vegetation were probably too sparse to provide cover from wind and wave action or from predators.

In New York, the factors best predicting the presence of a nest were density of dominant vegetation, horizontal cover 0.5 m above water, vegetation cover to water ratio, and water depth (Hickey 1997, Hickey and Malecki 1997). Of 26 nests, 85% were located in sparse (stems widely scattered with water visible through stem bases) to moderately dense (stems closer than sparse and water still visible through stem bases) vegetation, 85% were placed in areas where the mean horizontal cover 0.5 m above water was $\leq$50%, and 65% of nests were placed where the vegetation cover to water ratio ranged from 40:60 to 60:40. Although mean water depth at nest sites was not different from random points, mean water depth remained in the model due to its influence on vegetation and its importance to wetland management. Water depth at 26 nests ranged from 40 to 60 cm and averaged 48.2 cm. Knutson (1991) compared nest-site characteristics of 25 nest sites and 25 random sites in New York. Nest sites were surrounded by shallower water (mean of 40 cm vs. 60 cm), shorter vegetation (mean of 100 cm vs. 160 cm), and greater percent mud cover (mean of 6% vs. 1%) than random sites.

The most common nest substrate is a floating mat of residual vegetation (algae, submerged aquatic plants, or leaves and stems of emergent vegetation), but nests also are placed on abandoned muskrat (*Ondatra zibethicus*) houses or on muskrat feeding platforms, uprooted stalks of emergent vegetation, floating logs or boards, deserted nests of other wetland bird species (e.g., Pied-billed Grebe [*Podilymbus podiceps*], Red-necked Grebe [*Podiceps grisegena*], or American Coot [*Fulica americana*]), mudflats, sandbars, or artificial nest platforms (Job 1902; Bowman 1904; Rockwell 1911; May 1923; Hoffman 1926; Pittman 1927; Harris 1931; Peters 1941; Provost 1947; Cuthbert 1954; Hoffmann 1954; Boyer and Devitt 1961; Parmelee 1961; Bent 1963; Weller and Spatcher 1965; Bergman et al. 1970; Campbell 1970; Doane 1972; Stewart 1975; Salt and Salt 1976; Bailey 1977; Dunn 1979; Tilghman 1980; Faanes 1979, 1981, 1982; Burger 1985; Eichhorst and Reed 1985; Firstencel 1987; Skadsen 1987; Carroll 1988; Einsweiler 1988; Mossman et al. 1988; Faber 1990, 1992*b*, 1996; Knutson 1991; Powell 1991; Delehanty and Svedarsky 1993; Dunn and Agro 1995; Teeuw 1995; McCollough and McDougal 1996; Hickey 1997; Hickey and Malecki 1997; Mazzocchi et al. 1997). Some studies suggest that Black Terns avoid nesting on muskrat lodges that are being actively used by muskrats (Bergman et al. 1970, Dunn 1979). Black Terns may move chicks into an auxiliary nest if the primary nest has been disturbed (Cuthbert 1954, Dunn and Agro 1995).

Nests are generally 2-6 cm high, 2-20 cm above water, placed in water 0.05-1.2 m deep, located in stands of emergent vegetation either adjacent to or within 0.5-2 m of open water, and are rarely placed near shore (Bowman 1904, Provost 1947, Cuthbert 1954, Eddy 1961, Parmelee 1961, Bent 1963, Campbell 1970, Stewart 1975, Bailey 1977, Dunn 1979, Firstencel 1987, Skadsen 1987, Stern 1987, Einsweiler 1988, Manci and Rusch 1989, Delehanty and Svedarsky 1993, Dunn and Agro 1995). Nest height above water varies with substrate, but nests on floating mats of vegetation are generally 2-5 cm above water (Bergman et al. 1970, Dunn and Agro 1995). Nests on muskrat lodges in Iowa averaged 7 cm above water (Weller and Spatcher 1965) and two nests on mud mounds in New York were 20 cm above water (Firstencel 1987). Width of nest substrates (e.g., old muskrat lodges, muskrat feeding platforms, cattail rootstalks, and floating mats of dead vegetation) vary from 28 cm to 2.8 m (Bergman et al. 1970, Dunn 1979, Dunn and Agro 1995). In Kansas, Black Terns nested in a moist soil impoundment; nests were not placed near (distance not specified) dikes (Parmelee 1961).

The main factors influencing nest success are nest substrate type and water depth (Weller and Spatcher 1965, Bergman et al. 1970, Chapman Mosher 1986, Dunn and Agro 1995, Teeuw 1995, Faber 1996). Nests placed near emergent vegetation or on taller, more stable nest substrates (e.g., muskrat lodges or muskrat feeding platforms) are less likely to be damaged from wind and wave action (Weller and Spatcher 1965, Bergman et al. 1970, Chapman Mosher 1986, Dunn and Agro 1995, Teeuw 1995). In British Columbia, nests that were completely surrounded by vegetation or that were on artificial nest platforms were more successful than nests in open water (Chapman Mosher 1986). In Minnesota, Faber (1996) also found that 23 nests on artificial platforms were more successful (65%) than 185 nests on natural substrates (44%). Also in Minnesota, unsuccessful nests had lower minimum water depths than successful nests (Faber 1992*a*, 1996). Only four of 21 nests with a minimum depth <30.5 cm hatched (Faber 1996).

Black Terns nest singly or in semicolonial groups ranging in size from two to hundreds (Job 1902, Bowman 1904, May 1923, Hoffman 1926, Pittman 1927, Provost 1947, Cuthbert 1954, Hoffmann 1954, Eddy 1961, Parmelee 1961, Bergman et al. 1970, Doane 1972, Bailey

1977, Beule 1979, Dunn 1979, Chapman Mosher 1986, Stern 1987, Einsweiler 1988, Mossman et al. 1988, Faber 1990, Powell 1991, Delehanty and Svedarsky 1993, Dunn and Agro 1995, McCollough and McDougal 1996, Barrett and Kay 1997, Cooper and Campbell 1997, Mazzocchi et al. 1997). Most nests either are found in small groups of 2-5 or are scattered throughout a wetland (Cuthbert 1954, Bent 1963, Bergman et al. 1970, Bailey 1977, Beule 1979, Dunn 1979, Chapman Mosher 1986). Multiple colonies composed of 20-30 nests each are occasionally found within a single large wetland (Pittman 1927, Provost 1947). Most nests are 3-30 m apart but some nests are occasionally ≤1 m from one another (Job 1902, Cuthbert 1954, Hoffmann 1954, Bent 1963, Doane 1972, Bailey 1977, Dunn 1979, Firstencel 1987, Dunn and Agro 1995, Teeuw 1995). Nests in close proximity to one another are usually visually isolated from each other (Dunn 1979). Of 82 nests surveyed in Wisconsin, 6% were 0-1 m apart, 25% were 1-5 m apart, 37% were 5-20 m apart, 16% were 20-50 m apart, and 16% were >50 m apart (Bailey 1977). In British Columbia, 62% of 339 nests were <20 m apart, 19% were 20-30 m apart, 9% were 30-40 m apart, and 10% were >40 m apart (Chapman Mosher 1986). When two nests were within 20 m of one another, the next-nearest nest commonly was 100 m distant. Mean internest distances in British Columbia varied significantly with vegetation type; in areas of hardstem bulrush (*Schoenoplectus acutus*) and cattail interspersed with open water, terns nested more solitarily (mean internest distance of 54 nests was 35.7 m) than in areas of reed canary grass (mean internest distance of 239 nests was 19.7) or water horsetail (mean internest distance of 46 nests was 16.8 m) (Chapman Mosher 1986). Provost (1947) found that nests on small (not defined) wetlands were more isolated than nests on large wetlands. Black Terns sometimes nest in association with Forster's Terns (*Sterna forsteri*) (Hoffmann 1954, Bergman et al. 1970). A table near the end of the account lists the specific habitat characteristics for Black Terns by study.

Area requirements:

Black Terns prefer wetlands >20 ha, although Black Terns have been observed on wetlands <6 ha in size (Provost 1947, Daub 1993, Dunn and Agro 1995, McCollough and McDougal 1996). Wetlands ≤5 ha in size may be more readily occupied when they are part of wetland complexes (Brown and Dinsmore 1986). Frequency of occurrence of Black Terns in Iowa exceeded 50% only in the two largest (11-20 ha and >20 ha) wetland size classes (Brown and Dinsmore 1986). In New York, Black Terns preferred to nest in wetlands containing >10 ha of habitat characterized by equal proportions of vegetation cover and open water, dense cover at 0.2 m above water, and sparse cover at 0.5 m above water (Hickey 1997). During the nesting season, the area within 2 m from the nest is defended and, during the fledgling period, temporary feeding territories (size not specified) are maintained (Eddy 1961, Dunn and Agro 1995).

Brood parasitism:

Only one author reported conspecific brood parasitism among Black Terns (Rockwell 1911). In Colorado, clutches with >3 eggs were thought to have been laid by more than one female; two nests contained five eggs and one nest contained six eggs (Rockwell 1911). Hoffmann (1954) observed a Forster's Tern nest that contained two Forster's Tern eggs and three 2-day old Black Tern young; the nest was most likely the result of inappropriate laying by the Black Tern.

Breeding-season phenology and site fidelity:

Arrival on the breeding grounds occurs from late March to early June, and fall migration begins in late July and continues through early October (Bowman 1904, Rockwell 1911, Pittman 1927, Provost 1947, Hoffmann 1954, Boyer and Devitt 1961, Parmelee 1961, Bent 1963, Campbell 1970, Doane 1972, Maher 1974, Salt and Salt 1976, Bailey 1977, Knapton 1979, Johnsgard 1980, Faanes 1981, Chapman Mosher 1986, Firstencel 1987, Janssen 1987, Stern 1987, Carroll 1988, Svedarsky 1992, Delehanty and Svedarsky 1993, Dunn and Agro 1995, Teeuw 1995, Hickey 1997, Mazzocchi et al. 1997). Upon arrival on the breeding grounds, birds gather at communal feeding and resting areas where courtship displays begin (Chapman Mosher 1986, Dunn and Agro 1995). Birds then disperse to nesting wetlands from mid- to late May (Dunn and Agro 1995). Black Terns abandon nesting wetlands in early August and gather for several weeks at open-water feeding sites (Chapman Mosher 1986, Dunn and Agro 1995). Black Terns do not breed until their second summer (Dunn and Agro 1995). Some terns attain black adult plumage by their second summer and some do not. Some terns delay breeding beyond 2 yr and occasionally adults remain on the wintering range and skip breeding for a year. Some 2- or 3-yr-old terns migrate to the breeding range but do not breed (Dunn and Agro 1995).

Most first clutches are initiated in late May or early June (Hoffmann 1954, Boyer and Devitt 1961, Stewart 1975, Chapman Mosher 1986, Stern 1987, Dunn and Agro 1995, Teeuw 1995, Hickey 1997, Mazzocchi et al. 1997). Black Terns commonly renest after the failure of an initial nest (Hoffmann 1954, Bent 1963, Bergman et al. 1970, Bailey 1977, Eichhorst and Reed 1985, Dunn and Agro 1995, Mazzocchi et al. 1997). Renests may be constructed at the previous site or within about 40 km from the initial site (Bailey 1977, Dunn and Agro 1995). Black Terns typically raise one brood per season (Dunn and Agro 1995, but see Doane 1972).

Although Black Terns generally exhibit weak site tenacity, some terns may return to a nest site in consecutive years, provided that water and vegetation conditions remain favorable (Bowman 1904, Bailey 1977, Dunn 1979, Carroll 1988, Dunn and Agro 1995). Low site fidelity may be related to changes in water level, vegetation density, and availability of nest substrates (Faanes 1979, Dunn and Agro 1995, Cooper and Campbell 1997). In Wisconsin, seven of 35 banded adult birds were observed at the same breeding site in successive years (Bailey 1977). Shifts in nest-site location for four recaptured, banded adult Black Terns from one year to the next ranged from 500 to 4000 m. No nest sites were reused in successive years (Bailey 1977). In Oregon, 15% of 506 banded adult Black Terns were recaptured in successive years (Stern 1987). Fifty-four terns nested at the same or at an adjacent colony in successive years. The remaining 22 returning terns nested in completely different colonies than the previous year. Although terns generally do not exhibit mate fidelity between years, a pair may mate again if both return to the same breeding site (Stern 1987, Dunn and Agro 1995). In Oregon, Stern (1987) found that all five pairs returning to the same wetland from one year to the next retained the same mate.

Species' response to management:

Little is known about the effects of burning, mowing, or grazing on Black Terns. Because wetland suitability varies with yearly fluctuations of water levels and subsequent changes in vegetation, Black Terns use different wetlands or different locations within wetlands from year to year (Bailey 1977, Carroll 1988, Dunn and Agro 1995). In South Dakota, Black Tern presence was positively correlated with the total area of semipermanent wetlands in the surrounding landscape (Naugle et al. 1999*a*, 2000, 2001). Thus, it is important to protect and maintain wetland complexes (Dunn and Agro 1995; D. H. Johnson, *unpublished data*). In Nebraska, successional changes (i.e., wooded vegetation encroachment) within the channel of the Platte River has reduced the quality of river edge vegetation formerly occupied by Black Terns (Faanes and Lingle 1995).

Black Terns prefer wetlands with stable water levels and roughly equal proportions of well-interspersed emergent vegetation and open water through the breeding season (Bowman 1904, Weller and Spatcher 1965, Weller and Fredrickson 1973, Stewart 1975, Carroll 1988, Svedarsky 1992, Dunn and Agro 1995, Barrett and Kay 1997, Mazzocchi et al. 1997, Naugle et al. 2000). Favorable water levels and proportions of vegetation cover and open water can be maintained by artificially manipulating water levels of wetlands or wetland complexes through the use of water control structures. A study in New York found that Black Terns recolonized artificially manipulated impoundments the year following reflooding, and peak populations occurred in the second and third years postflood; information on Black Tern use of wetlands >3 yr postflood was not given (Hickey 1997, Hickey and Malecki 1997).

Naugle et al. (2000) and Mossman et al. (1988) found that Black Terns avoided dense, monotypic stands of cattails. Following application of glyphosate (N-[phosphonomethyl] glycine) herbicide to control cattails in North Dakota wetlands, Black Tern abundance was positively correlated with area of open water and area of dead cattails (Linz and Blixt 1997). Experiments involving various methods of cattail control were described by Beule (1979). Methods used to create openings in stands of cattail included weather-resistant covers (black polyethylene tarps), mechanical crushing, herbicides (Amitrol T* [1H-1,2,4-triazole-3-ylamine], Radapon* or Dowpon* [both 2,2-dichloropropionic acid]), physical injury to plants, cutting cattail stems below the water's surface, scraping cattails and 5-10 cm of the soil surface, and wetland drawdowns. Amitrol T and Radapon were applied at rates ranging from 3.85 to 34 kg/ha. Application rates for Dowpon ranged from 5.6 to10 kg/ha. Cutting mature cattails $\geq$8 cm below the water's surface stopped the flow of air to the roots and was an effective control measure. Scraping dried wetlands removed the residual cattail stems and rhizomes located in the top layer (5-10 cm) of the soil. All of the methods described by Beule (1979) created openings in cattail stands. Black Terns nested in openings where floating debris was abundant.

Restored wetlands can provide nesting habitat for Black Terns (Svedarsky 1992, Delehanty and Svedarsky 1993). Black Terns nested in a newly restored wetland in Minnesota each year of a 3-yr study (Svedarsky 1992, Delehanty and Svedarsky 1993). The rapid colonization of the restored wetland was attributed to the availability of flooded, dead vegetation (Delehanty and Svedarsky 1993). In Iowa, Black Terns were present, but did not nest in wetlands that had been restored for 1-4 yr; the study did not examine restored wetlands older than 4 yr (VanRees-Siewert 1993, VanRees-Siewert and Dinsmore 1996). Preliminary analysis of data from D. H. Johnson (*unpublished data*) indicated that in North Dakota and South Dakota, Black Terns were more common in natural wetlands than in restored wetlands.

No cases of direct mortality of Black Terns due to toxic chemicals have been reported in the literature. In North Dakota, no young were reared from any of eight Black Tern nests that were monitored in a wetland that was sprayed with toxaphene (chlorinated camphene, 67-69% chorine) and oil at a rate of 2.3 kg/ha; eight juvenile birds were found dead, but dead birds were not necropsied to determine the cause of death (Hanson 1952). In New York, no chick

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*References to chemical trade names does not imply endorsement of commercial products by the Federal Government.

deformities were observed in seven eggs containing contaminant levels ranging from 2.07 to 6.39 parts per million (ppm) polychlorinated biphenyl (PCB), 1.14 to 4.83 ppm DDE (a metabolite of dichlorodiphenyltrichloroethane or DDT), 35.1 to 58.8 parts per billion (ppb) hexachlorobenzene, 19.2 to 90.7 ppb octachlorostyrene, and 0.01 to 0.04 ppm mirex (dodecachlorooctahydro-1,3,4-metheno-1H-cyclobuta[CD]pentalene) (Firstencel 1987). Organochlorine contamination of wetlands may be responsible for the thinning of Black Tern eggshells (Faber and Hickey 1973, Weseloh et al. 1997). Measurements of five Black Tern eggs collected from the Great Lakes region and from Louisiana during 1970 had significantly thinner eggshell indices (shell weight divided by the product of egg length times breadth) than measurements of 91 eggs collected before 1947; DDE, PCB's, dieldrin, and mercury levels from 107 eggs sampled from 18 avian species were all negatively correlated with eggshell indices (Faber and Hickey 1973). In Ontario, some degree of eggshell thinning occurred, but organochlorine levels were not significantly correlated with eggshell thickness (Weseloh et al. 1997).

A study conducted by Shealer and Haverland (2000) revealed that neither hatching success (proportion of nests from each treatment group that hatched >1 egg) nor fledging success (proportion of chicks fledged from all eggs that hatched) were negatively affected by investigator disturbance (repeated nest visits and trapping and banding adults). Black Tern mortalities due to utility wire collisions have been reported, but appear to occur infrequently (Thompson 1978, Dunn and Agro 1995).

Management Recommendations:

The management recommendations that follow are based on the species' habitat requirements and may apply to the community of wetland bird species as a whole. Further wetland loss and degradation should be avoided (Faanes 1979; Brown and Dinsmore 1986; Chapman Mosher 1986; Carroll 1988; VanRees-Siewert 1993; Peterjohn and Sauer 1997; Naugle et al. 2000, 2001). The long-term protection of wetlands can be achieved through conservation easements and purchases of wetland basins (Faanes 1979, VanRees-Siewert 1993, VanRees-Siewert and Dinsmore 1996, Haig et al. 1998, Weller 1999). The ideal management strategy for waterbirds is to maintain wetland complexes and large wetlands or lakes (Brown and Dinsmore 1986, Fredrickson and Reid 1986, Hickey 1997, Weller 1999, Naugle et al. 2000). Due to variation in water levels over seasons or years, wetland complexes are more likely to have at least some wetlands with water and plant regimes favorable to a particular species, thus ensuring diverse species' representation in a geographical area (Colwell and Oring 1988, Weller 1999). For Black Terns, provide areas of habitat ≥10 ha in size that have about equal proportions of well-interspersed emergent vegetation and open water, stable water levels throughout the breeding season, and abundant nest substrates (Chapman Mosher 1986, Faber 1992*a*, Dunn and Agro 1995, Cooper and Campbell 1997, Hickey 1997).

If feasible, manage wetland flooding/drawdown regimes to preserve appropriate emergent vegetation coverages and nesting substrates, and to provide stable water levels throughout the nesting season (Carroll 1988, Faber 1992*a*, Dunn and Agro 1995, Hickey 1997). Maintaining stable water levels decreases the probability of nest destruction due to rapidly rising water levels and decreases the probability of nest depredation (Chapman Mosher 1986, Faber 1992*a*, Hickey 1997). During the nesting season, maintain water levels >30 cm (Faber 1992*a*, Hickey 1997) and use a 4- to 6-yr cycle of drawdown, with reflooding occurring during years 2-5 (Hickey 1997). Water levels should be maintained higher than normal in the first year following reflooding in order to allow muskrat populations to recover (Hickey 1997). Removal of vegetation by muskrat herbivory benefits Black Terns by improving the interspersion of vegetation cover and open water and by increasing the availability of nest substrates (e.g., muskrat lodges, muskrat feeding platforms, and floating dead vegetation) (Hickey 1997).

Water-level control measures, discing, prescribed burning, and good muskrat populations may be used to control dense cattail stands and promote good interspersion of vegetative cover and open water (Hickey 1997). Beule (1979) provided additional recommendations for cattail control for three water depth zones: deep water (>76 cm; herbicides, cutting stems below the water's surface); intermediate water (30-76 cm; cutting stems below the water or on ice, mechanical crushing); and shallow water (2.5-30 cm; mechanical crushing, applying herbicides). Herbicide application may be an effective way to manage cattail growth when water-level manipulation, biological methods (e.g., muskrat herbivory, livestock grazing, or prescribed burning), or physical methods (e.g., mowing, discing, crushing, excavating) are not logistically or economically feasible (Linz and Blixt 1997). Rotate vegetation treatments within and among wetland complexes to achieve varied successional stages of emergent vegetation and to maintain avian diversity at a regional scale (Linz and Blixt 1997). Weller (1999) recommended the use of water level manipulation and fire rather than artificial methods to influence nutrient dynamics and natural plant succession because these were more ecologically and economically sound.

Placing artificial nest platforms in a wetland may enhance Black Tern productivity (Chapman Mosher 1986; Faber 1990, 1992*b*, 1996; Dunn and Agro 1995; Weller 1999). Hickey (1997) suggested using artificial platforms in the first year following a drawdown cycle, when natural substrates were lacking. Platforms are used more often by Black Terns if dead vegetation is piled on the platforms, if platforms are placed in areas of emergent vegetation interspersed with open water, and if platforms are of the right size (Dunn and Agro 1995, Teeuw 1995). Chapman Mosher (1986) suggested that nesting platforms should be at least 12 cm by 20 cm. Black Terns in Minnesota nested on artificial platforms 81 cm by 81 cm in size more frequently than on platforms 61 cm by 61 cm in size (Faber 1992*b*).

If possible, utility wire lines should be placed several kilometers away from wetlands, waterfowl concentration areas, flyways, roosting areas, feeding areas, low passes, breeding areas, and especially paths between feeding and roosting or nesting areas (Thompson 1978).

Table. Black Tern habitat characteristics.

Author(s)	**Location**	**Habitat(s) Studied***	**Species-specific Habitat Characteristics**
Allen 1934	Northern U.S. (not specified)	Wetland	Preferred the open-water zone of wetlands
Bailey 1977	Wisconsin	Lake	Nested in and around large stands of hardstem bulrush (*Schoenoplectus acutus*); nests were constructed of cattail (*Typha* spp.), hardstem bulrush, or algae; 50% of 143 nests were placed on floating cattail rootstalks, 20% in live cattail stands (stands were 5-25 m in diameter), 14% on floating bulrush stems, 9% on mats of floating algae, and 7% on floating boards; the closest nest to shore was 25 m and all nests were within 1-2 m of open water; nested in loose groups of two to four pairs, but sometimes in groups of ≥10 pairs; two closest nests were 75 cm apart; of 82 nests surveyed in 1976, 6% were 0-1 m apart, 25% were 1-5 m apart, 37% were 5-20 m apart, 16% were 20-50 m apart, and 16% were >50 m apart
Barrett and Kay 1997	Northwest Territories	Wetland	Nested in hardstem bulrush 15 m from shore in a 3.75-km^2 wetland with an extensive (>300 m) sedge (*Carex* spp.) periphery, 50% open water, and water depth of 1 m
Bent 1963	Rangewide	Wet meadow, wetland	Occupied wetlands and wet meadows; nested in common reeds (*Phragmites australis*) that were either tall and thick or beaten down and partially open; nested on abandoned muskrat (*Ondatra zibethicus*) lodges, floating mats of reeds and

			sweetflag (*Acorus americanus*), old grebe (Podicipedidae) or American Coot (*Fulica americana*) nests, driftwood, or boards; nested in water 30-60 cm deep, but nests also were found in a wet meadow with only a few cm of water; although most nests were widely scattered, four nests were found in a radius of 4.5 m
Bergman et al. 1970	Iowa	Wetland	Of 197 nests, 53% were on floating cattail rootstalks, 25% on inactive muskrat lodges, 11% on muskrat feeding platforms, and 11% on dead floating emergent vegetation; individual substrates (e.g., muskrat lodge) never held more than one nest; nest bowls averaged 3.3 cm above water; nest substrates averaged 52.2 cm in diameter; nested in both open water and dense cattail stands; nests in open water were either on deteriorated muskrat lodges or on muskrat feeding platforms
Beule 1979	Wisconsin	Wetland	Nested in groups of three to five pairs in open areas of water with abundant floating dead vegetation; nests were not located in areas of live emergent vegetation
Bowman 1904	North Dakota	Wetland	Nested in wetlands ranging in size from 0.4 to 40 ha with good interspersion of open water and emergent vegetation; avoided wetlands that were overgrown with rushes (scientific name not given); nested in small (not defined) patches of open water surrounded by emergent vegetation; nests were placed on dead vegetation, piles of dead vegetation, or on abandoned muskrat

			lodges; water depth varied from 5 to >60 cm; colonies consisted of 12-50 pairs
Boyer and Devitt 1961	Ontario	Wetland	Nested on floating material such as logs, sticks, and mats of dead cattail stems
Brady 1983	South Dakota	Wetland, wetland (modified)	Densities were higher in dug-brood complexes (modified wetlands comprising a system of channels, ponds, and human-created islands to provide deep, open water and upland nesting areas for waterfowl) than in unmodified semipermanent wetlands
Brown and Dinsmore 1986	Iowa	Wetland	Preferred wetlands >5 ha; frequency of occurrence was >50% only in the two largest (11-20 ha and >20 ha) wetland size classes; occurred in smaller (<5 ha) wetlands when these were part of wetland complexes
Burger 1985	Minnesota	Wetland	Nested in areas of sparse (not defined) cattails, usually on floating nests that were loosely attached to vegetation stems, or less commonly on top of muskrat houses
Campbell 1970	British Columbia	Wetland	Nested among cattails on a floating mat of vegetation; water depth was 61 cm
Carroll 1988	New York	Lake, river, wetland, wetland complex	Nested on abandoned muskrat lodges, muskrat feeding platforms, floating cattail rootstalks, dead floating emergent vegetation, mats of floating algae, and floating boards; colonies occurred at mouths of rivers, wetlands, lake shorelines, and wetland complexes; nested in areas where open water and emergent vegetation were well interspersed

Chapman Mosher 1986	British Columbia	Lake, wetland complex	Nested in broad-leaved cattail (*T. latifolia*), hardstem bulrush, a mixture of water horsetail (*Equisetum fluviatile*) and beaked sedge (*C. rostrata*), and most frequently in reed canary grass (*Phalaris arundinacea*); nested in areas averaging 42% matted vegetation, 33% open water, and 25% standing vegetation (sample size not given); used areas where the proportion of standing vegetation was 10-70%; nested in areas where the area occupied by stalks of emergent vegetation was 10-50 cm^2/m^2; nested on floating boards, floating vegetation mats, or artificial nest platforms; nest success on artificial platforms was higher than nests placed on mats or boards; nest success was higher for nests in reed canary grass than for nests in hardstem bulrush due to greater protection from wind and wave action; hatching success was negatively affected by wind and wave action; fledging success was positively correlated with nesting in water horsetail; mean internest distances varied with vegetation type; terns nested more solitarily in areas of hardstem bulrush and cattail (mean internest distance of 54 nests was 35.7 m), more so than in areas of reed canary grass (mean internest distance of 239 nests was 19.7) or water horsetail (mean internest distance of 46 nests was 16.8 m); when two nests were within 20 m of one another, the next nearest nest commonly was 100 m distant; of 339 nests, distance to nearest neighbor was <20 m for 62%, 20-30 m for 19%, 30-40 m for 9%, and >40 m for 10%; one pair of nests was 1 m apart

Cooper and Campbell 1997	British Columbia	Wetland	Number of pairs per colony ranged from one to 60; most colonies contained 6-20 pairs
Cuthbert 1954	Michigan	Wetland	Nested mostly in hardstem bulrush and softstem bulrush (*Schoenoplectus tabernaemontani*), followed by cattail/bulrush mixture, cattail, cattail/yellow pond lily (*Nuphar lutea*) mixture, and bur-reed (*Sparganium eurycarpum*); nest substrates were floating dead plant material, floating logs or boards, abandoned muskrat lodges, and non-floating piles of dead bulrushes; of 27 nests, 85% were placed in water $\geq$0.6 m in depth; nested most commonly in thinly scattered bulrush $\leq$1 m from open water, although two nests were in dense cattails near a clearing made by muskrats; a colony of 17 nests were in an 8-ha tract and an additional 10 nests were scattered in five sets of two each; distances between nests ranged from 9 to 36 m; distances between the pairs of nests ranged from 90 to 200 m
Delehanty and Svedarsky 1993	Minnesota	Impoundment, wetland (restored)	Nested in a newly restored wetland in all 3 yr of study; used dead hardstem and softstem bulrush for nesting material; nested near the wetland edge in an area protected from the wind by emergent vegetation, trees, and a ridge; fledglings moved from the nests in the restored wetland to open, sandy points on the edge of the reservoir where they were fed by adults
Doane 1972	Wisconsin	Wetland	Colony contained 16 nests; one nest was on a mudflat; a few (actual number not given) nests were $<$1 m from one another

Dunn 1979	Ontario	Lake	Nested in live cattail stands of moderate density (described as standing ≥1 m tall and dispersed enough to allow a canoe to pass through); a few nests were located in thin, new cattail growth, but nests in dense, old cattail stands were rare; of 24 nests, 75% were built on mats of floating residual cattail, 17% on floating boards or logs, and 8% on cattail rootstalks; no nests were constructed on muskrat lodges or feeding platforms, although these substrates were abundant; the majority (actual percentages not given) of 25 nests were 2-5 cm tall, 25 cm wide, constructed of dead cattail over 1-1.2 m of water, on mats of dead vegetation averaging 8 m^2; and located 4 m from open water (range 0.5-12 m); spatial layout of nests was usually only two or three nests per 25 m^2, although a few nests were ≤3 m apart
Dunn and Agro 1995	Range-wide	Island, lake, rice field, river, sewage lagoon, wetland	Nested in shallow freshwater wetlands with emergent vegetation, including prairie wetlands, lake margins, river or island edges, sewage lagoons, restored wetlands, and cultivated rice fields; preferred to nest in semipermanent wetlands; used snags or posts for copulating, resting, and feeding fledglings; density of emergent vegetation and nest substrate availability were more important to nest-site selection than plant type or water depth; vegetation at most nests was sparse to moderately dense (described as dispersed enough to allow a canoe to pass through); nested in areas with 25-75% emergent cover; nest-site

			vegetation included cattail, bulrush (*Schoenoplectus* spp.), bur-reed, sedges, reed canary grass, water horsetail, rushes (*Juncus* spp.), hairgrass (*Deschampsia* spp.), pond lily (*Nuphar* spp.), and cultivated rice; floating dead vegetation was common at nest sites; water at nests was generally 0.5-1.2 m deep and few nests were near (not defined) shore; nested adjacent to or within 0.5-2 m of open water; also nested on artificial platforms; nest substrates were usually floating dead vegetation, floating rootstalks, floating boards, or floating muskrat feeding platforms; less common substrates were muskrat lodges, small mud mounds, rooted and flattened vegetation, or abandoned nests of other waterbirds; width of nest platforms ranged from 28 cm to 2.8 m; nests were usually 2-6 cm tall and 2-5 cm above water colonies commonly contained 11-50 nests, and ranged from two to hundreds of nests; most nests were 5-20 m apart but some were reported as close as 1 m; preferred wetlands or wetland complexes >20 ha, although were found in a 5.3-ha wetland; area ≤2 m of the nest was defended; temporary feeding territories maintained during the fledging period; when a site became unsuitable for nesting, birds were more likely to move to more distant (>5 km) sites than to closer (<1 km) ones

Eddy 1961	Minnesota	Lake	Nested in bulrush, waterlily (*Nymphaea* spp.), and cattail; water depth at 51 nests was 15-79 cm and nests were located in a 5.1-ha area; defended the area $\leq$2 m from the nest
Eichhorst and Reed 1985	Wisconsin	Lake	Renested on a deserted Red-necked Grebe (*Podiceps grisegena*) nest
Einsweiler 1988	Michigan	Impoundment, lake, wetland	Nested in cattail and bulrush; mean water depth at 34 nests was 24 cm during incubation and decreased to 20.5 cm during the nestling stage; 17 of 34 nests were on mud mounds in shallow (depth not given) water, 14 nests were on floating grass/sedge mats in deep-water areas, 2 nests were on deserted Pied-billed Grebe (*Podilymbus podiceps*) nests, and 1 was on an artificial nest platform
Faanes 1979	Wisconsin	Wetland	Of 52 nests, 51 were on mats of floating vegetation in the deep-marsh zone of a wetland; one was on a muskrat lodge; nest substrates were cattail (17 nests), river bulrush (*Schoenoplectus fluviatilis*) (16 nests), hardstem bulrush (12 nests), submerged aquatic vegetation (6 nests), and muskrat lodge (1 nest)
Faanes 1981	Minnesota, Wisconsin	Wetland	Occurred on large seasonal and semipermanent wetlands that supported an abundance of emergent vegetation; preferred to nest on floating mats of vegetation composed of submerged plants and emergent plant leaves
Faanes 1982	North Dakota	Wetland	Occurred in about equal numbers on semipermanent and permanent wetlands;

			occasionally used seasonal wetlands; 16 nests were observed either on mats of floating vegetation or on decaying muskrat houses
Faanes and Lingle 1995	Nebraska	River channel island, wetland	Occurred in semipermanent and seasonal wetlands; suitability of river edge vegetation was reduced due to wooded vegetation encroachment within the channel of the Platte River
Faber 1990 1992*a*, 1992*b*, 1996	Minnesota	Wetland	Nested in shallow (<46 cm) water among bur-reed, common threesquare (*Schoenoplectus pungens*), and cattail; nested on larger (81 cm by 81 cm) artificial platforms more frequently than on smaller (61 cm by 61 cm) platforms; nest success was greater on artificial platforms (65% of 23 nests) than on natural substrates (44% of 185 nests); successful nests had greater water depths than unsuccessful nests (49.7 cm vs. 39.9 cm in one year and 53.6 vs. 46.6 cm in the second year); only four of 21 nests with a minimum water depth <30.5 cm were successful; colony sizes ranged from 2 to 56 pairs
Faber and Hickey 1973	Louisiana, Michigan, Minnesota, Wisconsin	Lake	Measurements from five eggs sampled in 1970 had significantly thinner eggshell indices (shell weight divided by the product of egg length times breadth) than measurements from 91 eggs collected before 1947
Firstencel 1987	New York	Wetland	Nested in small (not defined) clearings within cattail stands; nests were typically located on mats of floating cattail rootstalks adjacent to

			open water, although some (number not given) terns nested on logs and mud mounds; eggs in nests on mud mounds were about 20 cm above water; nests on mud mounds were typically ≤8 m from one another
Graetz and Matteson 1996	Wisconsin	River, wet meadow, wetland	Occurred in wetlands, river edges, and flooded sedge meadows; breeding sites were dominated by bulrush (*Scirpus* spp. and *Schoenoplectus fluviatilis*), cattails, bur-reed, sedges, grasses (Poaceae), water plantain (*Alisma* sp.), and arrowhead (*Sagittaria* spp.)
Harris 1931	Nebraska	Wetland	Nested on floating mats of rushes in a small (1.4 m^2) open-water area in a stand of rushes; water was “chest deep” and four nests were 1.5 m apart
Hartman 1994	Indiana	Wetland, wetland (restored)	Occurred at one of 26 restored wetlands
Hickey 1997, Hickey and Malecki 1997	New York	Wetland complex	Most (97.5% of 50) nests were located in bur-reed or cattail and most (78% of 105) nests were placed on abandoned muskrat lodges or feeding platforms; 85% of 26 nests were located in sparse (stems widely scattered with water visible through stem bases) to moderately dense (stems closer than sparse and water still visible through stem bases) vegetation; horizontal cover 0.5 m above water at 85% of 26 nest sites was ≤50%, vegetation cover to water ratio ranged from 40:60 to 60:40 at 65% of 26 nest sites, and mean water depth at 26 nest sites was 48.2 and ranged from 40 to 60 cm; following drawdown of a

			wetland, terns recolonized impoundments the year following reflooding and peak populations occurred in the second and third years postflood; information on use of wetlands >3 yr postflood was not given
Hoffman 1926	Wisconsin	Lake	Nested on small hummocks or on floating mats of dead bulrush; nests were constructed of dead bulrush; six nests were found in a 21-m^2 area
Hoffmann 1954	Wisconsin	Lake	Nested in shallow (not defined) bays of inland lakes or shallow river widenings that contained cattails, bulrush, wild rice (*Zizania palustris*), pond lilies (*Nuphar* sp.), and pickerelweed (*Pontederia cordata*); nested on floating dead bulrush that gathered along the outer edges of cattail and bulrush stands, or on abandoned muskrat lodges or exposed mudflats; nested in loose colonies; most nests were $\geq$3 m apart, rarely 1.5 m apart
Job 1902	North Dakota	Lake	Nested on small mounds of floating vegetation; colonies contained about a dozen nests spaced 2-15 m apart
Johnsgard 1980	Nebraska	Impoundment, wetland	Nested in wetlands with stands of emergent vegetation interspersed with open water
D. H. Johnson, *unpublished data*	North Dakota, South Dakota	Wetland	Number of breeding pairs was highest in seasonal and semipermanent wetlands and was lowest in alkali wetlands; were more common in natural wetlands than in restored wetlands, and were more common in wetlands that had semipermanent wetlands within 0.4 km than in wetlands without semipermanent wetlands

			nearby
Kantrud and Stewart 1984	North Dakota	Wetland complex	Highest density was found in semipermanent wetlands, followed by seasonal, fen, temporary, and permanent wetlands
Knutson 1991	New York	Wetland	Nested on floating mats of broad-leaved arrowhead (*Sagittaria latifolia*), sedges, bulrush, cattails, knotweed (*Polygonum* sp.), or grasses; preferred to nest in shallow-marsh areas or in sedge meadows rather than deep-marsh areas; compared to 25 random sites, 25 nest sites had shallower water (mean of 40 cm vs 60 cm), shorter vegetation (100 cm vs. 160 cm), and greater mean percent mud cover (6% vs. 1%); mean percent vegetation cover (78% for nest sites) and mean percent open water (16% for nest sites) did not differ between nest sites and random sites; nest sites were dominated by broad-leaved arrowhead and sedges, whereas random sites were dominated by cattail
Linz and Blixt 1997	North Dakota	Wetland	Abundance was positively correlated with hectares of open water and with hectares of dead cattails following application of glyphosate herbicide to control cattails
Manci and Rusch 1989	Wisconsin	Wetland	Nested in cattail stands where the mean water depth was 29 cm; avoided water >50 cm deep
May 1923	New York	Lake	Nested on a sandbar on the shore of Lake Ontario; colony consisted of 6-7 pairs
Mazzocchi et al. 1997	New York	Wetland complex	Nested in stands of bur-reed and pickerelweed mixture and in stands of cattail; common

			submergent plant species at nests were duckweed (*Lemna* spp.), frogbit (*Hydrocharis* sp.), and algae; 54% of 37 nests were placed in emergent vegetation 26-50 cm tall; mean percent coverages at 37 nest sites were 43% emergent vegetation, 35% open water, 19% floating or submergent vegetation, and 3% shrubs; percent vegetation cover to water ratio ranged from 40:60 to 60:40 for 54% of 37 nests; 84% of 31 nests in both years were in sparse to moderately dense (not defined) vegetation; mean horizontal cover at 0.5 m above water was <21% at 81% of 37 nest sites; most common nest substrate was floating vegetation mats (58% of 151 nests), followed by artificial platforms (17%), abandoned muskrat houses (14%), uprooted pickerelweed stalks (10%), Pied-billed Grebe nests (1%), and floating logs (0.7%)
McCollough and McDougal 1996	Maine	Wetland	Colony sizes ranged from one to 23 pairs at 10 wetlands; nested in wetlands >25 ha in size
Mossman et al. 1988	Wisconsin	Wetland	Nested in areas with a mixture of emergent vegetation, mudflats, and shallow (not defined), open water; 71% of 173 nests were located on rhizomes of hardstem bulrush, 9% on artificial nest platforms, 9% on mats of residual bulrush or cattail stems, 7% on floating boards, 3% on mats of muskgrass (*Chara* spp.), and 1% on inactive nest structures of Red-necked or Pied-billed grebes; avoided dense (not defined) stands of cattails
Naugle 1997;	South Dakota	Wetland	Preferred semipermanent wetlands over seasonal

Naugle et al. 1999*a*,*b*, 2000, 2001			wetlands; presence was positively related to the area of semipermanent wetlands and grassland in the 25.9 km^2 area surrounding a wetland; dominant emergent vegetation at nest sites included cattail (65% of 20 sites), bulrush (20%), and bur-reed (15%); preferred wetlands that had about equal proportions of emergent vegetation and open water; vegetation height and density were lower at nest sites than at sites outside the colony; at nest sites, vegetation density decreased with increasing vegetation height; presence was negatively affected by the extent of woody vegetation along wetland margins
Parmelee 1961	Kansas	Wetland (diked)	Nested on floating mats of green rushes (species not specified) in "knee deep" water; did not nest near (not defined) dikes
Peters 1941	New Brunswick	Lake	Two nests found in a shallow (not defined) lake on mounds of vegetation
Pittman 1927	Saskatchewan	Wetland	Nested in groups of 20-30 on mats of floating residual vegetation
Powell 1991	Minnesota	Wetland, wetland complex	Nested on semipermanent wetlands 15-50 ha in size with 5-95% open water and patches of sparse to moderately dense (not defined) emergent cover; vegetation was dominated by bulrush; nested on mats of floating dead bulrush in the interior of the wetland; three colonies contained 4, 10, and 15 pairs; colonies occurred only on wetlands within wetland complexes
Prescott et al. 1993	Alberta	Cropland, dense	Densities were significantly higher in cropland

		nesting cover (DNC; idle seeded-native), mixed-grass pasture, tame pasture, wetland	plots that contained wetlands than in DNC plots that contained wetlands
Prescott et al. 1995	Alberta	Wetland	Most abundant in large (>8 ha) fresh wetlands, followed by medium (1-8 ha) fresh wetlands, medium saline wetlands, small (<1 ha) fresh wetlands, small saline wetlands, and large saline wetlands
Provost 1947	Iowa	Idle tallgrass, tallgrass pasture, wetland, wet-meadow pasture	Nested in scattered groups of 10-20 at the edge of rushes and bur-reed in water >60 cm deep; nests were loose structures of floating dead vegetation or algal mats; commonly nested on small (not defined) wetlands, but the nests were more isolated than on large wetlands
Rockwell 1911	Colorado	Wetland	Nested on floating mats of dead cattails 3 m from shore in a patch of sparse (not defined) cattail cover amidst otherwise dense cattails in water ≤1 m deep; also nested on top of a wooden duck blind that was floating at the edge of the cattails and in 1-m deep open water
Salt and Salt 1976	Alberta	Wetland	Nested on a raft of reeds (*Phragmites* sp.) and grasses in shallow (<60 cm) water
Shutler et al. 2000	Saskatchewan	Cropland, DNC (idle seeded-native, idle seeded-tame), wet meadow, wetland	Were present in areas of conventional tillage (applications of herbicides and tillage [≥3 times per year] to control weeds), minimum-tillage (reduced tillage [<3 times per year] and direct seeding into previous year's crop stubble), and organic farming (cultivation and crop rotation);

			presence was negatively affected by percent woody vegetation present along wetland margin
Skadsen 1987	South Dakota	Wetland	Nested on floating mats of cattails in water 91-122 cm deep
Stern 1987	Oregon	Wetland	Nesting habitats included deep-water (40-60 cm) sites dominated by hardstem bulrush, intermediate water depths (15-30 cm) dominated by sedges and rushes, and shallow-water (<15 cm) sites dominated by tufted hairgrass (*D. caespitosa*)
Stewart 1975	North Dakota	Impoundment, lake, stock pond, wetland	Occurred in wetlands with stands of emergent vegetation with adjacent areas of open water; habitats included wetlands and lakes, shallow river impoundments, and occasionally large stock ponds; bred most frequently in fresh and slightly brackish semipermanent wetlands, followed by fresh seasonal wetlands, fresh permanent wetlands, and fen wetlands; nests were constructed of floating dead vegetation (algae, submerged aquatic plants, or leaves and stems of emergent vegetation) and were located in moderately dense (not defined) emergent vegetation or in open water with no cover; water depth at 41 nests averaged 43 cm and ranged from 10 to 86 cm
Stewart and Kantrud 1965	North Dakota	Wetland	Highest densities were found on seasonal wetlands with clumps of emergent cover interspersed with open water, and on fresh through brackish semipermanent wetlands with closed stands of emergent cover

Svedarsky 1992	Minnesota	Idle mixed-grass, idle mixed-grass/tame, idle tallgrass, idle tame, impoundment, wetland (restored)	Nested in a restored wetland in an area that had equal amounts of open water and emergent vegetation; foraged in areas of open water
Teeuw 1995	Ontario	Wetland	Nested in areas where the proportions of emergent vegetation and open water were about equal; occupied stands of emergent vegetation ranging in size from 45 by 30 m to 100 by 100 m; of 38 nests, 15 were on floating mats of vegetation, 15 on artificial nest platforms, 5 on mud mounds, and 3 on floating boards; 25 of 38 nests were located in small (ranged in size from 1.5 m by 1.5 m to 9 m by 12 m) open water pools within stands of emergent vegetation; mean water depth at nests ranged from 32 cm for 12 nests to 61 cm for 22 nests; 38 nests averaged 12 m from the open water of a large bay; internest distance of 38 nests averaged 11 m
Tilghman 1980	Wisconsin	River, wet meadow, wetland	Nested in wetlands, river edges, and flooded sedge meadows in areas dominated by cattail, bulrush, and sedges; emergent vegetation cover ranged from 51 to 75% in over 85% of 205 occupied sites; nests substrates were floating peat mats, muskrat feeding platforms, dead floating cattails, or floating cattail rootstalks
Tout 1902	Nebraska	Wetland	Nested in small areas of open, shallow (not defined) water

VanRees-Siewert 1993, VanRees-Siewert and Dinsmore 1996	Iowa	Wetland (restored)	Were present in wetlands that had been restored for 1-4 yr, but no nests were found; the study did not examine restored wetlands older than 4 yr
Weber 1978, Weber et al. 1982	South Dakota	Cropland, idle mixed-grass, idle shortgrass, idle tallgrass, mixed-grass pasture, shortgrass pasture, stock pond, tallgrass pasture, tame hayland, wetland, woodland	Preferred semipermanent wetlands with emergent vegetation; most frequently occurred in semipermanent wetlands, followed by stock ponds, seasonal wetlands, and dugouts; presence was positively related with hectares of surface water, presence of semipermanent wetlands within 400-ha of surveyed wetlands, wetlands with central expanses of open water composing >5% of the wetland area and surrounded by a peripheral band of emergent vegetation cover averaging ≥1.8 m in width, vegetation height, and shoreline distance
Weller and Fredrickson 1973	Iowa	Wetland	Density peaked the year of reflooding when the areas of open water and emergent vegetation were roughly equal; in the 7 yr following reflooding, populations declined steadily as emergent vegetation became flooded and open water cover increased
Weller and Spatcher 1965	Iowa	Wetland	Nested on muskrat feeding stations, floating mats of dead vegetation, floating rootstalks, or dense beds of submerged, rooted aquatic vegetation; nests in emergent vegetation were better protected from the wind; nests on muskrat feeding stations averaged 7 cm above water; numbers peaked 3-4 yr following reflooding, when open water and emergent vegetation were well interspersed

*In an effort to standardize terminology among studies, various descriptors were used to denote the management or type of habitat. “Idle” used as a modifier (e.g., idle tallgrass) denotes undisturbed or unmanaged (e.g., not burned, mowed, or grazed) areas. “Idle” by itself denotes unmanaged areas in which the plant species were not mentioned. Examples of “idle” habitats include weedy or fallow areas (e.g., oldfields), fencerows, grassed waterways, terraces, ditches, and road rights-of-way. “Tame” denotes introduced plant species (e.g., smooth brome [*Bromus inermis*]) that are not native to North American prairies. “Hayland” refers to any habitat that was mowed, regardless of whether the resulting cut vegetation was removed. “Burned” includes habitats that were burned intentionally or accidentally or those burned by natural forces (e.g., lightning). In situations where there are two or more descriptors (e.g., idle tame hayland), the first descriptor modifies the following descriptors. For example, idle tame hayland is habitat that is usually mowed annually but happened to be undisturbed during the year of the study.

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Effects of Management Practices on Wetland Birds:
Bibliography on Survey Methods for Black Tern

The most common survey method for Black Terns is a count of birds, either from shore or a canoe. Nests usually are located by observing adult terns as they travel to and from nests or by observing their behavior in relation to a researcher's disturbance. Methods for capturing, banding, and building nest platforms are included in the annotated bibliographies.

Annotated articles

Bailey, P. F. 1977. The breeding biology of the Black Tern (*Chlidonias niger surinamensis*). M.S. thesis. University of Wisconsin, Oshkosh, Wisconsin. 67 pages.

Arrival dates, nest substrates, incubation times, survival of young, growth measurements of young, and site fidelity of Black Terns (*Chlidonias niger*) were studied on Rush Lake in Wisconsin in 1976 and 1977. Nests were located by traversing the lake on a motorized boat. Black Terns were trapped and banded. Terns were trapped on their nests using modified gull traps (Weaver, D. K., and J. A. Kadlec. 1970. A method for trapping breeding adult gulls. Bird Banding 41:28-31.). The trap was described as an open bottomed box with a V-entrance on one side that extended about 10 cm into the center of the trap. The trap was made of 1.27 cm (½ inch) hardware cloth and measured 36 cm x 30 cm x 18 cm with an entrance width of 4-5 cm. An observer remained at a trap until a bird returned and entered the trap; most captures took 10-15 minutes of waiting in the boat, at a distance of about 50 m from the nest. To study chick development, barriers were erected around some nests, but these were later removed when it was clear that chicks remained within 25 m of the nest until fledged. These barriers were made from nylon garden mesh and measured 93 cm x 93 cm x 90 cm. Birds were banded with U.S. Fish and Wildlife Service aluminum bands. Adults were banded on the left leg, whereas chicks were banded on the right leg. Birds later were identified using binoculars and a 15-60 power spotting scope. Morphological measurements of birds and eggs were taken using a vernier caliper, and eggshells were measured using a Starrett micrometer. Weights of adults and chicks also were recorded.

One hundred forty-three nests were found during 1976 and 1977. Nests were located on floating cattail rootstalks (50%), live cattail stands (20%), floating bulrush stems (14%), mats of floating algae (9%), and floating lumber (from hunting blinds; 7%). Seven of 35 banded birds were observed at the breeding site the next year; four birds were recaptured.

Baker, R., and J. Hines. 1996. Black Tern sightings in Minnesota 1990-1995. Loon 68:137-140.

Observations of Black Terns and Black Tern nests were compiled for the period 1990-1995 in Minnesota. A poster was distributed to public offices that gave the species' description, explanation of the survey, and instructions to the public for reporting sightings. Observations were obtained from the general public and from state and federal wildlife agency staff. An occupied nest or the presence of fledglings indicated a confirmed nest. This method was used to determine population distribution in the state of Minnesota. This program produced 454 unique locations of Black Terns within Minnesota, representing 321 (12%) of the state's 2,594 townships and 71 (82%) of 87 counties. Sighting concentrations existed in two areas: a band running through counties containing high numbers of lakes and wetlands (Becker, Otter Tail, Douglas, Kandiyohi, and Meeker counties) and around the Twin Cities area, which was probably a reflection of greater numbers of observers in that area. The use of a "wanted" poster proved to be a successful way of gathering information on the distribution of Black Terns.

Bergman, R. D., P. Swain, and M. W. Weller. 1970. A comparative study of nesting Forster's and Black terns. Wilson Bulletin 82:435-444.

The nesting biology of Black Terns and Forster's Terns was studied in Palo Alto (Rush Lake) and Clay (Dan Green Slough) counties, Iowa, from 1966 to 1968. Cover maps of wetland vegetation and open water were made from measurements taken on the ice during winter and spring. Nests were located with the aid of a canoe. Clutch size, height of nest bowl above water, origin of nest substrate, composition of nest substrate, diameter of nest substrate at water level, and species and relative abundance of vegetation surrounding each nest were recorded. Nests were successful if at least one egg hatched and appeared to have survived at the nest site.

Of 285 nests found, 53% were on floating cattail rootstalks, 25% were on inactive muskrat lodges, 11% were on muskrat feeding platforms, and 11% were on dead floating emergent vegetation.

Beule, J. D. 1979. Control and management of cattails in southeastern Wisconsin wetlands. Wisconsin Department of Natural Resources, Madison, Wisconsin. Technical Bulletin No. 112. 39 pages.

Birds were counted by two observers who simultaneously walked along different portions of a standardized 2-km transect route (width of transect not given). Four counts were conducted between 15 and 25 April and a second set of four counts was conducted between 15 and 25 May each year. Counts were not conducted during rain, snow, or winds >24 km/hr. Nest searches were conducted once a year from mid-May to mid-June. Nest searching was conducted by four persons wading through an area of 1.5-1.8 m at 3-4-m intervals.

Brady, E. N. 1983. Birds on modified wetlands in eastern South Dakota. M.S. thesis. South Dakota State University, Brookings, South Dakota. 39 pages.

The value of dug brood complexes to non-waterfowl breeding bird species was evaluated. Dug brood complexes consisted of a system of channels, ponds, and spoil islands constructed on wetlands to provide deep, open water and upland nesting areas for waterfowl. This study examined the values of these complexes to non-waterfowl breeding bird species composition, density, and production. The study was conducted on seven wetland basins on waterfowl production areas in Day and Clark counties in eastern South Dakota during the summers of 1981 and 1982. The mean wetland basin area of wetlands studied in Day County was 27 ha, whereas the mean wetland basin area studied in Clark County was17 ha.

The seven basins were separated into two plots. One plot (modified plot) included the dug brood complex and a 50 m area surrounding the modification. The other plot (natural plot) was similar in area and vegetation to the modified plot and was located as far away from the modified plot as possible. Birds were surveyed using belt transects (40 m wide) during 15-26 June 1981 and 7-16 June 1982. Six transects of varying length (based on area of each wetland; mean transect length was 222 m for 42 transects) were surveyed on each of the seven wetlands, three on the modified plot and three on the natural plot. Transects on the modified plots of each wetland were equal in length to the transects conducted on natural plots within the same wetlands. All birds heard or observed within the transects were recorded. Surveys were conducted between 0600 and 0830 hr and between 1800 and 2130 hr. Surveys were not done when winds were >25 km/hr or in rain. Taped recordings of the calls of Virginia Rail, Sora, Yellow Rail, and King Rail were used to detect individuals of these species in 1982. Calls of these species were played from stations (how many per wetland was not specified) that were at least 60 m apart. At each station, calls of each species were played in the following manner: three groups of three rail calls for a total of nine calls, followed by a listening period of one minute in between calls. The number of rails responding to calls was recorded at each station. Nest searches were conducted on 42 islands in the modified wetlands (nest searching method was not specified). Species, clutch size, and distance to the shoreline were recorded for each nest.

Counts of bird species were based on the number of indicated pairs (Stewart, R. E., and H. A. Kantrud. 1972. Population estimates of breeding birds in North Dakota. Auk 89:766-788.). The majority of indicated pairs were observed as segregated pairs or as territorial males. However, segregated pairs and lone females of Wilson's Phalarope were recorded as indicated pairs. In species for which sex could not visually be determined, such as Black Tern, the number of indicated pairs was calculated as the number of individuals counted divided by two. Rallidae species were recorded as the number of audibly responding rails per hectare.

A total of 38 species of birds were recorded on the transects. The most abundant species on modified plots in 1981 in decreasing order were Red-winged Blackbird, Common Yellowthroat, and Song Sparrow. The most abundant species on natural plots in decreasing order were Red-winged Blackbird, Marsh Wren, and Common Yellowthroat. In 1982, the most abundant species occurring on both natural and modified plots were Red-winged Blackbird, Marsh Wren, and Common Yellowthroat. The mean densities for wetland birds on modified plots was 14.39 pairs/ha, compared to 17.35 pairs/ha on natural plots. Mean species diversity (Shannon-Weaver) values for modified and natural plots were 1.68 and 1.54, respectively. Species richness values averaged 4.69 and 4.31 species on modified and natural plots, respectively. Mean evenness values for modified and natural plots were 0.95 and 0.89, receptively. No significant differences in species diversity, species richness, and evenness were found between the two treatments. Significant differences in these variables were found among the seven wetland basins. Basins with the highest diversity and species richness had vegetation approaching hemi-marsh conditions.

Brown, M., and J. J. Dinsmore. 1986. Implications of marsh size and isolation for marsh bird management. Journal of Wildlife Management 50:392-397.

The influence of marsh area and isolation on species richness of marsh birds was examined for 30 marshes throughout northwestern and northcentral Iowa from 1983-1984. Marshes were either seasonals or semipermanents, ranging from 0.2 to 182 ha. Avian censuses were conducted using 18 m fixed-radius circular plots centered in the emergent vegetation zone. Tape recordings of cals were used to detect secretive birds. Nest-searching was conducted within 13 m of the circular plot. Twelve variables were measured to determine the degree of marsh isolation: distance to nearest marsh <5 ha in size; distance to nearest marsh 5-20 ha in size; distance to nearest marsh >20 ha in size; number of marshes within 1 km; number of marshes within 3 km; number of marshes within 5 km; total area of marshland within 1, 3, and 5 km; and total area of lakes within 1, 3, and 5 km.

Twenty-five bird species were recorded. Of the 12 isolation variables, area of marshland within 5 km of each site was the only one to show a significant relationship with species richness, and then only in 1983.

Chapman Mosher, B. A. 1986. Factors influencing reproductive success and nesting strategies in Black Terns. Ph.D. dissertation. Simon Fraser University, Burnaby, British Columbia. 154 pages.

Factors affecting reproductive success, coloniality, and timing of breeding for Black Terns were examined at the Creston Valley Wildlife Management Area (hereafter referred to Creston Valley, 6800 ha) near Creston, British Columbia, from 1981 to 1984.

Nests were located by following compass bearings of adults as they approached their nests. Nests were accessed by canoe or by foot. Nests were marked by wrapping masking tape around the stalk of vegetation that was nearest to the nest. A number assigned to the nest was written on the masking tape flap. Masking tape was used to minimize visibility of markers. Nest locations were plotted on a field map. Nests were visited three times per week. Hatching success was defined as the proportion of nests that hatched at least one egg. Total hatching success was defined as the proportion of all eggs laid that hatched, and fledging success was the proportion of nestlings that survived to fledge. In order to determine fledging success, some nests were enclosed with hardware cloth (2 squares per cm, with a height of 0.35 m and a diameter of 0.5 m), to prevent chicks from escaping. Fiberglass screening was placed on the bottom one third of the enclosure to prevent chicks from pushing their bills through the mesh. Terns in Six Mile slough were surveyed aerially. Methods of bird survey in other study sites were not specified.

A graduated stick was placed in each of the three study areas in Creston Valley to measure the relative plant height above water. Measurements were done at weekly intervals. In both 1983 and 1984, vegetation was measured prior to nest building in May and following fledging of chicks in August. Proportions of open water, standing vegetation (stalks of plants), and matted vegetation (floating vegetation or algal mats) were measured along a 50-m belt transect that was 8 cm wide. Both occupied and previously occupied areas (areas not occupied in the current year, but were occupied in other years of the study) were sampled. Line transects were started at one corner of the area used by terns and continued along randomly assigned compass bearings, with proportions of open water, standing vegetation (stalks of plants), and matted vegetation (floating vegetation or algal mats) recorded in each meter. At the end of the transects, random numbers were used to move between 1 and 100 steps at a 90-degree angle to the original bearing and a new transect line was begun using the original bearing. This process continued until the far end of the occupied area was reached. Next, the bearing was reversed 180 degrees and the entire series was then repeated until the starting edge again was reached.

Density (total number of stalks/m^2 for each plant species) and area of standing live vegetation were measured using a 1 x 1 m quadrat made from copper tubing. Quadrats were placed through the middle of the breeding area by moving a random distance between 1 and 10 paces from the previous quadrat along a previously selected bearing. Area occupied by each plant species within the quadrat was measured by taking the diameter of each of the four cornermost stalks within the quadrat. Diameter of stalks was measured (instrument used to measure diameter not specified) at the water's surface. The measured diameters were plugged into a mathematical formula to obtain the area of a circle (used for hardstem bulrush, water horsetail, and reed canarygrass), equilateral triangle (used for sedges), and a modified ellipse (used for cattail). Areas occupied by the four measured stalks were then averaged and this number was multiplied by the number of stems of each species in the quadrat. Finally, the average area occupied by stalks per m^2 was then calculated for all quadrats.

Internest distances were measured using a 0-30 and 15-150-m rangefinder and locations of nest sites were mapped. Nesting dispersion also was calculated (Hammond, R., and P. McCullagh. 1978. Techniques in geography. Clarendon Press, Oxford, England.).

Artificial floating nest platforms were constructed and placed in the marsh. Platforms varied in size from 1 x 1 m to 1 x 2 m. Platforms consisted of a wooden base with styrofoam packed under the board such that it floated above the water's surface. Barriers 2 cm in height (construction material of barrier not specified) were placed along the edge of the platform to prevent eggs from rolling off of the platform.

Fifteen man-made nests (using natural materials) were constructed at each of the three study areas in order to study egg loss due to wave action and water-level fluctuation. Nests were placed in association with varying densities of vegetation in each of the study areas. Japanese quail eggs were emptied and refilled with materials in an attempt to mimic developed eggs and freshly laid eggs. Developed eggs were filled with an alcohol and water mixture to the proper weight and floating characteristics of a developed Black Tern egg. Freshly laid eggs were filled with sand to the proper weight. Other eggs were made by using the empty shell as a mold to form an egg from fiberglass resin. Eggs were attached to nearby stalks with string. Each nest received one fresh and one developed egg and were checked on weekly intervals. An additional trial was run during the third week of the experiment with an unmodified quail egg to test the effect of the strings on the washout potential of eggs.

Two hundred ninety-two nests were observed in Creston Valley during the study, and 34 nests were found in Elizabeth Lake during 1984. Fledging success was significantly inversely correlated with the height of plants; success was greatest in the areas with the shortest plants. Fledging success was positively correlated with nesting in water horsetail, which was shorter and denser (number of stalks per m^2) than other emergent plants. Hatching success was significantly negatively affected by wind and wave action. Nests located in areas covered by >75% vegetation were more protected from wind and wave action and survived better than nests located in areas covered by <75% vegetation.

Nesting occurred in areas averaging 42% matted vegetation, 33% open water, and 25% standing vegetation (sample sizes for vegetation measurements were not given). Birds avoided areas in which the proportion of standing vegetation was >70%. These areas may have been too dense to allow access to the surface of the water. Nests also were not placed in areas in which the proportion of standing vegetation was <10%. Vegetation in these areas may have been too sparse to provide cover from wind and wave action or from predators.

Cooper, J. M., and R. W. Campbell. 1997. Surveys of selected and traditional Black Tern (*Chlidonias niger*) colonies in British Columbia in 1996. Colonial Waterbirds 20:574-581

Surveys of Black Tern breeding colonies were conducted in southcentral, central, and northeastern British Columbia from late May to early July 1996. Two new and 30 historic colonies were surveyed. Surveys were conducted by experienced biologists and birders. Observers provided either a maximum count of flying terns or a count of nests by either wading through the colony or from a boat. Due to high water levels, most observations were made from canoes, kayaks, or from land. Wetlands chosen for surveys were based on availability of historical data and accessibility to observers.

Thirty-two active colonies were surveyed, resulting in 975 flying adults, 133 nests, and an estimated 501 nesting pairs.

Survey method suggestions:

1) Survey accessible colonies periodically on the ground and estimate breeding pairs by counting nests.

2) Survey from the air, but then use ground-based counts to refine population estimates. Aerial surveys may indicate large numbers of flying terns, but may overestimate the actual number of nests.

Daub, B. C. 1993. Effects of marsh area and characteristics on avian diversity and nesting success. M.S. thesis. University of Michigan, Ann Arbor, Michigan. 37 pages.

Daub examined the relationship between marsh area, species richness, and nesting success in 20 marshes located near Minnedosa, Manitoba, from 1991-1992. All marshes were semipermanent or permanent, and ranged in size from 0.1-19.3 ha. Avian censuses were conducted along the perimeter of marshes by placing a randomly chosen, 100 m x 15 m transect, along which nest-searching also occurred. The 15 m portion of the transect included 5 m of emergent vegetation and 10 m of open water. Each transect was walked for 45 min. Each marsh was surveyed three times during the breeding season, about every two weeks. Playback calls were used to elicit responses from American Bittern, Virginia Rail, Yellow Rail, and Sora at the beginning, middle, and end of each transect during every survey. Nesting success was determined using the Mayfield method. Measured marsh characteristics were water depth, vegetative composition (line-intercept technique), and width of vegetation growing in standing water.

Twenty-eight bird species were recorded, and 12 species were found nesting. Number of nesting species showed no relationship to marsh area or other measured marsh characteristics (water depth, vegetative composition, and width of vegetation growing in standing water). A significant positive relationship existed between marsh area and species richness. Other marsh characteristics were unrelated to species diversity. A list of area dependent, area independent, and possibly area dependent species was given.

Dunn, E. H. 1979. Nesting biology and development of young in Ontario Black Terns. Canadian Field-Naturalist 93:276-281.

The habitat use, egg characteristics, growth, food habits, and fledging of Black Terns were studied at a 15-ha marsh on the north side of Long Point, Lake Erie, Ontario, in 1975 and 1976. In 1975, 23 nests in four groups were studied and in 1976, 32 nests in five groups were studied. Observations were made from a canoe. Nests and eggs were marked and measured, eggs were weighed, and fences were placed around the nest during incubation to keep the young from leaving the nest-site during development. Nests were marked using tagged 2-m stakes pushed into the mud, and eggs were marked with indelible felt-tip markers. Fences were made of hardware cloth and were 0.4-0.5 m in diameter and 0.3 m tall. Adults were captured using a roofed version of the fence that had a entrance hole at the top. Adult and young Black terns were banded with U.S. Fish and Wildlife Service aluminum bands. Colored bands were used on the adults at first, but were never visible. The chicks were weighed and tarsus, ulna, skull, culmen, and feathers were measured. A few observations of nests were made from a blind mounted to an anchored rowboat. Twenty-five nests were found; 75% of nests were built on floating dead cattail, 17% were on floating boards or logs, and 8% were on cattail rootstalks.

Dunn, E. H., and D. J. Agro. 1995. Black Tern (*Chlidonias niger*). A. Poole and F. Gill, editors. The birds of North America, No. 147. The Academy of Natural Sciences, Philadelphia, Pennsylvania; The American Ornithologists' Union, Washington, D.C.

Distinguishing characteristics, distribution, systematics, migration, habitat, food habits, sounds, behavior, breeding, demography and populations, conservation and management, appearance, measurements, and priorities for future research were summarized for the Black Tern. Suggested regional survey techniques included stratified random sampling or standardized surveys of all suitable wetlands.

Eddy, J. 1961. Nesting habits of the Black Tern. Flicker 33:3-4.

The nesting success, nesting habitat, incubation, appearance, behavior, and food habits of Black Terns were reported. The study was conducted on Lower Bottle Lake, Hubbard County, Minnesota, 1960. The author located and observed 51 nests from a canoe and from a platform built in a tree on a nearby hill. Fifty-one nests were located in an area of approximately 5.6 ha. Bird territories and movements were determined using binoculars and a 30-power scope from the tree platform.

Eichhorst, B. A., and J. R. Reed. 1985. Renesting of a Black Tern. North American Bird-Bander 10:8.

A Black Tern renested following the destruction of an initial nest at Rush Lake, Wisconsin during 1984. It was captured (exact method not specified) while night-lighting, and was banded (type of band not specified) on 26 June 1984.

Einsweiler, S. S. 1988. Black Tern nesting biology in Cheboygan County, Michigan. M.S. thesis. Central Michigan University, Mount Pleasant, Michigan. 43 pages.

Nest-site characteristics, population size, clutch size, egg morphology, nest success, hatching success, and chick morphology and development were studied in Dingman Marsh, Michigan, from 1984 to 1986. Historical and current nesting habitats were assessed. From a list of historical Black Tern observations, wetlands to survey were chosen based on wetland accessibility and vegetation characteristics. Sites were visited periodically from 22 June to 15 August 1984 to determine presence of Black Terns. For each colony located, several days were spent counting individuals, searching for nests, and determining whether any juveniles were present. Nests were located by searching immediate areas where adults landed. Nests also were located using a systematic search of areas where the birds were concentrated. Nests were checked daily from a rubber raft or on foot to determine nest fate. Juveniles were detected by observing birds in flight. Some sites were not surveyed thoroughly due to remote access. Percent cover and species composition of vegetation were sampled, and water depth was recorded within 16 randomly selected 1-m^2 plots within a 20 x 30 m area at each site.

In 1985 and 1986, Black Tern biology was studied mainly at Dingman Marsh, an artificial waterfowl management impoundment. Water levels in the marsh were manipulated to promote waterfowl nesting. Vegetation in the marsh included grasses (genus not specified), sedges (*Carex* spp.), cattail (*Typha* spp.), and dead shrubs. Nests were located by observing adult terns and by systematically searching an area with a rubber raft. Shallow areas were searched on foot. Nests were marked with flagging, surrounded (2 m diameter) by a fence of large-mesh chicken wire, and checked daily. Fences were erected to prevent chicks from escaping so that chick development could be studied. Fencing was painted brown or green and woven into the surrounding vegetation for camouflage. To aid in preventing chicks from escaping, a 20-cm tall strip of screening was placed at water level for the length of the fence. Eggs were marked with enamel paint in a manner that indicated laying sequence, measured using dial calipers, weighed to the nearest 0.1 g, and floated to determine the stage of development and date of incubation initiation. Chicks were banded with U.S. Fish and Wildlife Service aluminum bands, weighed daily, and were individually marked on the head with enamel paint to keep track of hatching sequence. Measured nest-site characteristics were diameter and height of the nest, water depth, and nest substrate.

During the study, Back Terns nested in four of the five wetlands that historically had breeding populations. The largest population for the Indian River site was 20 individuals, down from 70 in 1946. Cheboygan Marsh had 50 individuals in 1974, but only 8 in 1986. At Dingman Marsh, three pairs and two juveniles were observed in 1984, 25 pairs were observed in 1985, and 30 pairs were counted in 1986.

Faanes, C. A. 1979. Status of the Black Tern in Western Wisconsin. Passenger Pigeon 41:124-128.

Black Tern breeding populations were monitored in seven wetlands in central St. Croix and southern Polk counties, Wisconsin, from 1975 to 1977. Surveys for breeding pairs and nests were done from a canoe or on foot using binoculars. The nest or territory of each pair was marked on field maps. Breeding pairs were determined based on territorial defense or upon discovering an active nest. Each wetland was surveyed 5-7 times during the breeding season.

A total of 90 Black Tern pairs were observed. There was a 57.2% decrease in the observed population during the study period. Of 52 nests, 51 were on mats of floating vegetation in the deep marsh zone of the wetland; one was on a muskrat (*Ondatra zibethicus*) lodge.

Faber, R. A. 1992. Incubation behavior and artificial nest structure usage in Black Terns nesting along the Mississippi River. Unpublished report to Minnesota Department of Natural Resources, St. Paul, Minnesota. 27 pages.

Black Tern nest-site characteristics, nest success, and artificial nest platform use were studied along the Upper Mississippi River National Wildlife and Fish Refuge and in the Trempealeau National Wildlife Refuge, Minnesota from 1990-1992.   Nests were located by canoe and were marked with a numbered wooden stake placed 1.5-3 m from the nest. Water depth was recorded at each nest. Nests were checked every 2-5 d. A nest was successful if at least one young was observed. One wetland was surveyed for Black Terns by airboat in mid-June and another in mid-July 1991.

Two sizes of artificial nesting platforms were installed in four wetlands in 1990 and five in 1991. Platforms were constructed of a 5 x 5 cm pine lumber frame measuring either 81 x 81 cm or 61 x 61 cm. The frame was then covered with 2.54-cm mesh chicken wire. A ring of hardware cloth was added to the platforms in 1991 to hold nest materials in place. Platforms were anchored by a 1.8-3 m long nylon cord tied to a wooden pole that was driven into the wetland bottom. Dead vegetation was added to the platform to make the chicken wire just touch the water's surface. Platforms were installed in early May and wetlands were checked for nesting beginning in early June.

Over the two years, a total of 12 nest attempts occurred on ten large platforms, whereas only four attempts occurred on ten small platforms. Eight of ten large platforms were used and only four of the small platforms were used. The hatching rate was not different between large and small platforms. Hatching success was significantly greater on platforms (89%, n = 9) than on natural substrates (52%, n = 69) in 1990 only.

NOTE: Survey methods were consistent among the following related articles.

Faber, R. A. 1990. Habitat requirements and causes of breeding failure in Black Terns. Report to the Bladin Faculty Fellowship Program, Minnesota Private College Research Foundation. Saint Mary's College of Minnesota, Winona, Minnesota. 16 pages.

Faber, R. A. 1990. Nesting ecology of the Black Tern on the Upper Mississippi River National Wildlife and Fish Refuge and the Trempealeau National Wildlife Refuge. Unpublished report to U.S. Fish and Wildlife Service, St Mary's College, Winona, Minnesota. 13 pages.

Faber, R. A. 1992. The Black Tern: effects of water level fluctuations on hatching success, and a census of nesting on pools 5 and 7. U.S. FWS grant agreement 14-16-003-91-984 final report. Unpublished report to U.S. Fish and Wildlife Service, St Mary's College, Winona, Minnesota. 16 pages.

Firstencel, H. 1987. The Black Tern (*Chlidonias niger*): breeding ecology in upstate New York and results of pesticide residue analysis. M.S. thesis. State University New York, Rockport, New York. 63 pages.

Black Tern colonies were studied at Yanty Creek Marsh (3.6 ha) along Lake Ontario in northern New York during 1983-1984. Breeding success, observations of depredation and competition, and pesticide contamination of eggs were examined. The wetland was visited 28 times (1-5 times per week) from 19 May to 6 August 1983 and 40 times during the same time period in 1984. Visitation hours ranged from early morning to after sunset. Arrival dates were determined by periodically walking along Yanty Creek nature trail. After Black Terns arrived at the study site, a canoe was used to observe the colony. Nests were located by walking through the wetland and observing adult tern behavior. After watching a pair of terns from a distance and noting where they landed, the author moved closer by foot or canoe. This would elicit threatening calls that increased in intensity as the nest was neared. Adults would fly low over the cattails and hover over the nest in between attacks, which aided in pinpointing nests. Nests were marked with numbered flags, but as the vegetation of the wetland grew, nests were marked with sticks 1-2 m tall and locations plotted on field maps. At each nest visit, number of eggs and the number of dead or live chicks were recorded.

During the first summer, researchers approached within 3 m of nests by using an umbrella camouflaged with cattails as a blind. Two people would walk into position with the umbrella. One person remained near the nest while the second person walked back to the canoe with the terns in pursuit. After returning to the nest, the adults disregarded the motionless person with the umbrella. The researcher remaining at the nest noted the number of chicks present. In the second summer, a floating blind was made from a wooden pallet setting on air-filled inner-tubes with a chicken-wire roof that was woven with cattails. Thirteen chicks were banded in 1984 using size 2 colored leg bands from the National Band and Tag Company.

Ten nests were located in the wetland in 1983, whereas 14 were located in 1984 (one was considered a renest). Nests were located in small clearings within cattail stands, and some were located next to open water. Most nests were on piles of dead cattail vegetation, over a dense growth of cattail roots that formed a floating mat. Nests closest to open water had the highest depredation and abandonment rates in both years.

Graber, R. R., and J. W. Graber. 1963. A comparative study of bird populations in Illinois, 1906-1909 and 1956-1958. Illinois Natural History Survey Bulletin 28:383-528.

Information on the habitat use, distribution, and abundance of the birds of Illinois were presented. The study compared a bird survey conducted from 1956-1958 to the original study done by Gross and Ray in 1906-1909. The census method required two observers to record birds within transects 100 yards wide. Three zones were examined: northern, central, and southern Illinois. Habitats censused were plowed fields, cropland (soybeans, oat, wheat), pasture, idle grassland, idle, mixed and pure stands of hay, marshland, shrubby areas, orchards, forests, and residential areas. Population densities for species in summer and winter for each habitat and for each zone are given.

Graetz, J. L., and S. W. Matteson. 1996. The status of Black Terns in Wisconsin, 1995. Passenger Pigeon 58:241-248

Roadside surveys and nest searches for Black Terns that were first conducted from 1980 to1982 were repeated in 1995 in 19 counties in Wisconsin. Over 300 wetland sites were surveyed. Each transect consisted of 15 5-minute stops at sites where most of the wetland could be seen. Surveys were conducted once between 25 May and 24 June, between 0600 and 1900 by volunteers or state agency personnel. Surveys did not occur when winds were >32 km per hr or in rain. Each surveyor received instructions for the survey, data sheets, transect stop location descriptions, county road maps indicating locations of stops, and 7.5' or 15' topographic maps with stop locations and areas to be surveyed indicated. The abundance index was calculated as the total number of Black Terns counted in 15 stops. Nest searches were conducted by 2-4 people in canoes during the incubation stage in June. At wetlands containing only a few terns, nests were located by observing Black Tern behavior. For this survey, the abundance index was calculated as the total number of nesting pairs counted per wetland.

Abundance indices for routes differed significantly among years. Of 13 routes, 10 declined from the early 1980s to 1995, two increased and one remained stable. The remaining six routes had declining trends, although these were not significantly different from the overall distribution. Number of individuals detected in 1995 declined by 65% from the mean number detected in the early 1980s. The number of roadside stops where Black Terns were detected in 1995 decreased by 53% compared to the average in 1980-1982. Although the overall number of nests found were similar between 1980-1982 and 1995, numbers of pairs in two counties, Oneida/Vilas and Ashland, were significantly less in 1995 than in 1980-1982. In Columbia County, there was a non-significant increase in the number of breeding pairs, but the number of locations in which pairs were found decreased by 60% (i.e., more birds were found, but were concentrated in fewer locations). St. Croix County had similar numbers of breeding pairs in 1995 and 1980-1982, but all of the birds were found in one location. In 1980-1982, birds were dispersed in three locations. The total number of occupied sites in the entire study area decreased by 70% between the two time periods.

Hanowski, J. M., G. J. Niemi, A. R. Lima, and R. R. Regal. 1997. Response of breeding birds to mosquito control treatments of wetlands. Wetlands 17:485-492.

The effects of two mosquito (Culicidae) control measures were studied in southcentral Minnesota in 1988, 1990, and 1991-1993. The two mosquito larvicides used were methoprene (trade name Altosid) and *Bacillus thuringiensis israelensis* (Bti; applied as Vectobac-G granules). These two methods were commonly used to control emergence of adult mosquitos and were considered safe in terms of toxicity (rat [*Rattus*] oral LD50 for methoprene was >34,000 mg/kg). The study objective was to determine if mosquito control treatments affected bird species density and/or composition by altering food availability. Twenty-seven wetlands were selected for study that met the following criteria: (1) had not been previously treated for mosquitoes, (2) were >1 ha in size, (3) cattails (*Typha* spp.) or shrub vegetation suitable for Red-winged Blackbirds were present; and (4) not part of or near road rights-of-way. Wetlands were permanent, type 3 (n=14) or 4 (n=9) wetlands (Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deep water habitats of the United States. U.S. Fish and Wildlife Service. Office of Biological Services, Washington, D.C., USA. FWS/OBS-79/31.). Bti and methoprene were applied to wetlands by helicopter six times during the spring and summer, 1991 to 1993. Rates of application for Bti and methoprene were 1.0-1.8 kg/ha. The initial application was made when mosquito larvae were first detected. Subsequent applications were made after each 1.5 cm or greater rainfall event or after three weeks, whichever came first.

Birds were surveyed using the point count method (Reynolds, R. T., J. M. Scott, and R. A. Nussbaum. 1980. A variable-circular plot method for estimating bird numbers. Condor 82:309-313.). The number of points sampled per site corresponded to the area of each wetland. Adjacent points within a wetland were a minimum of 225 m apart and 125 m from the wetland edge. Birds were counted at each point for 10 minutes followed by a 2-minute playback of the calls of the Virginia Rail and Sora. Birds were counted within a 100 m radius of the census point and in most cases the 100 m radius was entirely within the wetland. On a few smaller sites only the birds within the wetland were counted. Counts were conducted by trained observers and were conducted only in good weather.

Cover types and watershed size were determined using digitized topographic maps. In 1991, habitats within the wetlands were open water (average of 35% across all sites), live cattails (19%), sedge (*Carex* spp.; 14%), and grass (11%). Watershed size ranged from 4 to 8623 ha and wetland size ranged from 2 to 53 ha. Water depths were measured under Red-winged Blackbird nests to document the overall pattern of water depth from 1988 to 1993, but these measurements were not presented in this paper.

An indirect effect of the treatments to wetland bird species was a reduction of invertebrate prey items. Only four bird species showed significant differences in abundance between control and treatment wetlands, and these differences were not consistent among years. Significant differences in abundance were not found, or differences were too inconsistent to make conclusions, for Killdeer, Barn Swallow, Cliff Swallow, Tree Swallow, Swamp Sparrow, Red-winged Blackbird, Yellow-headed Blackbird, Common Grackle, and American Goldfinch. The authors concluded that birds were not affected by mosquito control treatments in the first three years of treatment. Differences in moisture regimes during the study also may have had confounding effects. The authors stated that a possible reason for the lack of treatment effect in the study is that individual species abundance in wetlands vary annually and this change is greater than would be expected from mosquito control treatments.

Hartman, M. R. 1994. Avian use of restored and natural wetlands in northcentral Indiana. M.S. thesis. Purdue University, West Lafayette, Indiana. 98 pages.

Differences in avian community composition between natural and restored wetlands were studied in Indiana during 1993 and 1994. In 1993, 13 restored and four natural wetlands were studied. In 1994, 13 restored and three natural wetlands were studied. Objectives of the study were to (1) determine avian use of recently (3-5 yr since restoration) restored and natural wetlands; (2) determine specific abiotic and biotic variables that were influencing habitat use; (3) develop predictive models of bird species diversity (BSD), bird species richness (BSR), and breeding bird species richness (BBSR) based on abiotic and biotic variables; and (4) determine if different bird guilds share similar habitats.

Bird surveys were conducted bi-weekly from late April to early August in 1993 and from early May to mid-July in 1994. The author also revisited five wetlands in 1994 that were first surveyed in 1993. Surveys were conducted 3 hr after sunrise and 3 hr prior to sunset. Surveys were not conducted in inclement weather. Waterfowl were surveyed before entering the wetland using a spotting scope. Taped calls of Sora, Virginia Rail, Pied-billed Grebe, American Bittern, and Least Bittern were played at a minimum of 1 location per wetland (detailed methods of playback calls not given). The perimeter of each wetland was walked and all birds seen or heard within a 10-m radius of the border (not defined) were recorded. Nest searches (precise method not specified) also were conducted after the survey was complete.

Vegetation sampling was conducted in May, mid-June, and mid-July in 1993 and in early May in 1994. Two permanent transects were established on each wetland and three habitat categories were delineated: open water, border, and upland. The transects crossed at a central point in the wetland and they extended 10 m beyond the water line. Five sampling sites were established in each habitat category. At each point, species of emergent vegetation was identified, measured (height), and the number of stems were counted within a 0.25-m^2 area. An estimate of the coverage of floating plants and a measurement of water depth also were conducted. Emergent, submergent, and floating-leaved plants were collected using a 10.16-cm diameter PVC pipe made into a core sampler. Plant samples were identified, dried, and weighed. Upland plants were sampled by counting the number of stems within a 0.25 m^2 area and classifying them as grasses, sedges (Carex spp.), or forbs.

Macroinvertebrate sampling was conducted in late May and early July, 1993, and in late May, 1994. Sampling points were the same locations as those used for vegetation, except upland sites (determination of the location of sampling points in upland sites was not specified). Two methods were used for sampling invertebrates, a sweep net was passed just below the water surface for a length of 1 m, and a benthic core sample of the top 5 cm was taken using the same tube used for the vegetation sampling. Macroinvertebrates were identified, counted, dried, and weighed.

Conductivity, salinity, and water temperature readings were taken at the central point of each wetland at the time of vegetation sampling.

Aerial photographs were used to assess the percent emergent vegetation, wetland size, and distance to nearest body of water.

Eighty-four bird species were found on all wetlands. Twenty-seven species nested on the study wetlands. There was no significant difference in BSD, BSR, or BBSR between restored and natural wetlands in either year or between years. No significant difference existed between BSD, BSR, or BBSR and restored wetland age. Mean BSD was significantly higher in 1993 than in 1994. Area and inter-wetland distance were significant predictors of BSR and BSD in 1993, but inter-wetland distance was not a predictor for BSR in 1994 and neither variables were significant predictors of BSD in 1994. Area was a significant predictor of BBSR.

Hickey, J. M. 1997. Breeding biology and population dynamics of the Black Tern in western New York. M.S. thesis. Cornell University, Ithaca, New York. 160 pages.

This thesis begins with a literature review. Chapter one deals with habitat availability and preferences, chapter two concerns reproductive success and population dynamics, and chapter three deals with management recommendations for Black Terns.

Chapter 1. Nesting habitat associations, habitat availability, and preferences.

A nest-site selection model was developed for Black Terns nesting in the Iroquois National Wildlife Refuge and adjoining Tonawanda and Oak Orchard state wildlife management areas in western New York in 1994 and 1995. The wetland complex was 7,963 ha in size. Nest site data were collected from 26 nest sites and 31 random points; a 12-m radius around each nest or random point comprised the sampling plot, along with a 4-m radius subplot. All plots were sampled from 31 May to 17 June 1994. Within the 12-m radius plot, data collected were cover type (open water, emergent vegetation, scrub/shrub, or forest); dominant vegetation; vegetation density; and percent cover-to-water ratio. In the 4-m radius subplot, vegetation height; horizontal cover at 0.2 m, 0.5 m, and 1.0 m above water level; and water depth were measured in the four cardinal directions. Horizontal cover was measured by estimating the amount of a board (to the nearest 20%) that was obscured by vegetation at a particular height. Additional habitat features measured at nests and at random plots were the distance from the nest or plot center to a small water pool (open water ≥3 m in diameter intersecting the 12-m radius plot), large water pool (seasonally permanent open water ≥0.4 ha), cover change (major standing vegetation change), marsh edge (permanent marsh edge like upland or a dike), nest/random (nearest nest or random plot), vegetation (clump of vegetation from the edge of the nest bowl), and number of sides the nest is surrounded by vegetation within 1 m.

In 1995, habitat availability was measured by categorizing emergent vegetation first into two broad habitat quality levels: Favorable Available Nesting Habitat (FAH) and Unfavorable Habitat (UH) and then classifying all FAH into four finer habitat quality levels. FAH was defined as having 50:50 vegetation cover-to-water ratio, dense cover at 0.2 m above the water, and sparse cover at 0.5 m above the water. Emergent vegetation not meeting these criteria were considered UH. FAH was classified into four finer levels: 1) Highly Favorable Habitat (HFH)--when the model predicted ≥0.50 probability of a nest site being present and suitable nest sites were available; 2) Favorable Habitat (FH) – model predicted ≥0.50 probability of a nest site being present and suitable nest sites were not available; 3) Unfavorable Habitat (UH) – model predicted <0.50 probability of a nest site being present and suitable nest sites were available; and 4) Highly Unfavorable Habitat (HUH) – model predicted <0.50 probability of a nest site being present and suitable nest sites were not available. Random points and nest sites were sampled within FAH to determine whether FAH was being selected in proportion to its availability.

A total of 50 nests were located. The factors best predicting the presence of a nest were density of dominant vegetation, horizontal cover 0.5 m above water, vegetation cover-to-water ratio, and water depth. This model correctly classified 81% of the nest sites and 74% of the random plots sampled. Black Terns nested in sparse (stems widely scattered with water visible through stem bases) to moderately dense (stems closer than sparse and water still visible through stem bases) vegetation 85% of the time, whereas random plots were more often in the sparse and very dense (cannot see water through stem bases) vegetation categories. Nests were more often placed in areas where the mean horizontal cover 0.5 m above water was ≤50% and where the vegetation cover-to-water ratio was in the medium (40:60- 60:40) category. Although mean water depth of nest sites was not different from random points, it remained in the model due to its influence on vegetation and its importance to wetland management. Most nests floated above 40-60 cm of water.

Chapter 2. Reproductive success and population dynamics

The objectives of this chapter were to study nesting effort and success of Black Terns in New York, examine pre-fledging survival, and develop a model to assess population dynamics. Nest searches were done on foot or by canoe starting in late May and concluding by early June in both years. A flagged stake was placed 4 m north of each nest. Nests were checked at 7-10 day intervals until they were hatched, abandoned, or destroyed. The estimated number of nesting pairs was derived from nest count data (see thesis for additional detail). Nests were successful if at least one egg hatched. A nest was considered probably successful if all eggs were missing near the hatch date and adult behavior indicated that there were young nearby. Chicks were radiomarked (attached to #2 U.S. Fish and Wildlife Service bands) to estimate survival. Counts of fledglings were performed in July every few days (whether these were done on foot or by canoe were not specified) in order to determine fledgling success.

Overall Mayfield nest success was 45.6% (n = 105 nests). Over 70% of all nest failures were attributed to weather or predation. Nest success was not related to unit size, size of nest area, nest density, nor to any habitat variable or water depth. Nest success also was not related to the median distance to small water pools, large water pools, or to the nearest Black Tern nest. Nests closer to a dominant cover change and permanent marsh edge were more successful than nests farther from these two variables. Maintaining stable water levels was important to nest success.

Hickey, J. M., and R. A. Malecki. 1997. Nest site selection of the Black Tern in western New York. Colonial Waterbirds 20:582-595.

A nest-site selection model was developed for Black Terns that nested in the Iroquois National Wildlife Refuge and adjoining Tonawanda and Oak Orchard state wildlife management areas in western New York in 1994 and 1995. Nest areas were observed and potential nest sites (how potential sites were determined was not specified) were mapped prior to nest searches in order to make nest searching more efficient. Nest site data were collected from 26 nest sites and 31 random points; a 12-m radius around each nest or random point comprised the sampling plot, along with a 4-m radius subplot. Within the 12-m radius plot, data collected were cover type (open water, emergent vegetation, scrub/shrub, or forest); dominant vegetation; vegetation density; and percent cover-to-water ratio. Vegetation height; horizontal cover at 0.2 m, 0.5 m, and 1.0 m above water level; and water depth were measured in the four cardinal directions 4 m from the nest or random point. In 1995, habitat availability was measured by categorizing emergent vegetation first into two broad habitat quality levels: Favorable Available Nesting Habitat (FAH) and Unfavorable Habitat (UH) and then classifying all FAH into four finer habitat quality levels. FAH was defined as having 50:50 vegetation cover-to-water ratio, sparsely to moderately dense cover, and vegetation height of <1 m. Emergent vegetation not meeting these criteria was considered UH. FAH was classified into four finer levels: 1) Highly Favorable Habitat (HFH)-- when the model predicted ≥0.50 probability of a nest site being present and suitable nest sites were available; 2) Favorable Habitat (FH) – model predicted ≥0.50 probability of a nest site being present and suitable nest sites were not available; 3) Unfavorable Habitat (UH) – model predicted <0.50 probability of a nest site being present and suitable nest sites were available; and 4) Highly Unfavorable Habitat (HUH) – model predicted <0.50 probability of a nest site being present and suitable nest sites were not available. Random points and nest sites were sampled within FAH to determine whether FAH was being selected in proportion to its availability.

A total of 50 nests were located. The factors best predicting the presence of a nest were density of dominant vegetation, horizontal cover 0.5 m above water, vegetation cover to water ratio, and water depth. This model correctly classified 81% of the nest sites and 74% of the random plots sampled. Black Terns nested in sparse (stems widely scattered with water visible through stem bases) to moderately dense (stems closer than sparse and water still visible through stem bases) vegetation 85% of the time, whereas random plots were more often in the sparse and very dense (water not visible through stem bases) vegetation categories. Nests were more often placed in areas where the mean horizontal cover 0.5 m above water was ≤50% and where the vegetation cover to water ratio was in the medium (40:60- 60:40) category. Although mean water depth of nest sites was not different from random points, it remained in the model due to its influence on vegetation and its importance to wetland management.

Hoffman, P. W. 1927. Home life of the Black Tern in Wisconsin. Wilson Bulletin 39:78.

The nesting behavior and methods for capturing and banding Black Terns were discussed. The work was conducted at Big Muskego Lake, Waukesha County, Wisconsin, in June, 1926. Observers in a rowboat captured chicks using an oval-shaped dip net that was 21 cm long, 15 cm wide, and 10 cm deep, and that was attached to a pole 76 cm long. Since the chicks did not dive, capturing them was not difficult, especially in open water. No details were given about the capture of adults, or the handling or banding of adults or chicks.

Knutson, M. G. 1991. Characteristics of Black Tern (*Chlidonias niger*) nesting habitat at Lakeview Wildlife Management Area, New York. Kingbird 41:228-236.

Nest-site characteristics of Black Terns were studied at Lakeview Wildlife Management Area in Jefferson County, New York, during 1990. The wetland was searched for nests on 22 June 1990 (no search methods given). Habitat variables were measured within 1-m^2 plots ≤10 m from 25 nest sites and at 25 random plots located along interior open water/closed marsh edges. A comparison of nest sites to random points located in the interior open water/closed marsh edges was done due to the inaccessibility of interior marsh areas. Vegetation data were collected on 8 and 13 July. Water depth; maximum vegetation height above water; percentages of vegetation cover, open water and mud; and dominant plant species were recorded within each plot.

Black Tern nest sites were in shallower water than random sites (mean of 0.4 m vs 0.6 m) and vegetation was shorter at nest sites than at random sites (1.0 m vs. 1.6 m). Percent cover of vegetation (mean of 78% for nest sites) and open water (mean of 16% for nest sites) did not significantly differ between nest sites and random sites, but nest sites had more percent mud than random sites (mean of 6% vs. 1%).

Linz, G. M., D. L. Bergman, D. C. Blixt, and W. J. Bleier. 1994. Response of Black Terns (*Chlidonias niger*) to glyphosate induced habitat alterations on wetlands. Colonial Waterbirds 17:160-167.

Glyphosate (RODEO®) herbicide was applied to cattail-(*Typha* spp.)dominated wetlands in northeastern North Dakota and the effects on Black Tern populations were determined from 1990 to 1993. The main objectives were to compare numbers of Black Terns using treated versus untreated wetlands and to describe the relationship between Black Tern numbers and the following variables: wetland size; wetland area; and the percentages of open water, dead emergent vegetation, and live emergent vegetation. During 1990-1992, Black Terns were counted in early June and again in mid-July. In 1993, wetlands sprayed in 1991 were counted only once in early June. Surveys were conducted between local sunrise and 5 hr after sunrise by one or two observers in 1990 and by two of three experienced observers in 1991-1993. In 1990, observers walked around the wetland, recording any Black Terns seen. In 1991-1993, observers walked to 8 point stations around the wetland, waited for one minute and then counted Black Terns for 5 minutes. Surveys were not conducted in rain or in winds exceeding 24 km/hr. Wetland size and percent vegetation cover were determined using aerial photographs.

Linz, G. M., and D. C. Blixt. 1997. Black Terns benefit from cattail management in the northern Great Plains. Colonial Waterbirds 20:617-621.

The effect of herbicide application to large cattail stands on Black Tern populations was studied on 24 wetlands (17 treated, 7 control) in northeastern North Dakota from 1990 to 1993. Bird counts were conducted between sunrise to 5 hr after sunrise by two observers at eight count locations around each wetland. Birds seen as researchers walked from one count station to the next and for 6 minutes after arriving at each count station were reported. The wetland area and coverage of open water coverage were determined using infrared aerial photographs.

Black Tern abundance was positively correlated to hectares of open water and to hectares of dead cattails. Abundance also was positively related to the number of Mallards, Blue-winged Teal, Redheads, and Yellow-headed Blackbirds.

Manci, K. M., and D. H. Rusch. 1989. Waterbird use of wetland habitats identified by infrared aerial photography. Pages 1045-1058 in R. R. Sharitz and J. W. Gibbons, editors. Freshwater wetlands and wildlife. Proceedings of a symposium held at Charleston, South Carolina, March 24-27, 1986. U.S. Department of Energy, Office of Scientific and Technical Information, Oak Ridge, Tennessee.

Wetland bird use of emergent and open-water habitats in Horicon Marsh, Wisconsin, were examined during the summers of 1981 and 1982. One of the objectives of the study was to determine whether infrared aerial photographs could be used to identify wetland habitats. Another objective was to identify habitats used by wetland birds from early April to mid-August. Infrared aerial photographs were taken in June. Wetland birds were censused weekly on 25 1-ha plots located along roads and on 25 1-ha plots along airboat routes. Details on spacing of plots or the technique for marking plots were not given. Routes along roads were censused weekly from the first week in April to mid-August in 1981 and 1982; airboat routes were censused weekly from the third week in May through mid-August in both years. Censuses along roads occurred between 0700 and 1100 hours, whereas censuses along airboat routes occurred between 1100 and 1400 hours. A cassette recorder was used to note the habitat in which each bird was found and the number and, if possible, sex and age of each bird. Taped calls were used to elicit responses from rails, bitterns, and wrens. One playback count seven minutes in length (additional details on playback counts were not given) was conducted within each plot. Any other birds calling or flushed during the seven-minute stop also were recorded. Bird activity (feeding, resting, locomotor, preening, alert, or social displays) was noted to determine if certain behaviors occurred in specific habitats. Bird activities were observed weekly from the 25 1-ha plots on road routes (bird activity was often disrupted by the airboats). Routes were randomized each week such that birds were observed during all hours of daylight. Birds were observed through binoculars or a spotting scope from the truck window or platform in the truck bed. Following a two-minute pause at each plot, observers recorded species, sex and age (if possible), habitat, and activity for individual birds using the "scan" sampling method (Altmann, J. 1974. Observational study behavoir: sampling methods. Behaviour 49:227-265.). The "scan" method notes bird activity when first observed. Open-water habitat categories were water-filled, man-made ditch (mean water depth of 82 cm), clear deepwater (mean water depth of 50 cm), turbid deepwater (mean water depth of 52 cm), and shallow water (mean water depth of 20 cm). Five major emergent plant habitats were identified: deep-water cattail (*Typhus* spp.; mean water depth of 29 cm), dry cattail (mean water depth of 3 cm), shallow-water cattail (mean water depth of 7-10 cm), river bulrush (*Schoenoplectus fluviatilis*; mean water depth of 7-10 cm), and sedge (*Carex* spp.; <7 cm water depth). In general, water-filled ditches were used by birds more than expected based on availability. Shallow water was the next most selected habitat.

Mazzocchi, I. M., J. M. Hickey, and R. L. Miller. 1997. Productivity and nesting habitat characteristics of the Black Tern in northern New York. Colonial Waterbirds 20:596-603.

Nesting habitat characteristics and productivity of Black Terns were studied at the Perch River Wildlife Management Area (WMA) in Jefferson County, New York, in 1995 and 1996. A nest was classified as successful if at least one egg was confirmed hatched; as probably successful if there were no chicks in the nest but adult behavior indicated that chicks were nearby; or as unsuccessful if the nest or eggs were missing, destroyed, or abandoned prior to the expected hatch date. Population size was estimated from nest count data. Given that Black Terns will not renest sooner than eight days after failure of the first clutch, the cumulative number of known nest failures ≥8 days prior to each initiation date was subtracted from the cumulative number of nests initiated. This difference was then plotted against time, and the maximum point on this curve was estimated to be the population size. Habitat characteristics of 20 and 17 nest sites were sampled in 1995 and 1996, respectively. Habitat sampling was conducted from 25 May to 16 June 1995 and from 29 May to 3 July 1996. The following measurements were taken: dominant emergent vegetation; dominant floating/submergent vegetation; density; cover:water ratio (%); vegetation height (cm); horizontal cover (%) at 0.20 m, 0.50 m, 0.75 m, and 1 m; water depth (cm); distance to nearest large open water pool (m); distance to nearest cover change (m); distance to nearest marsh edge (m); and distance to nearest Black Tern nest. The nest site selection model developed by Hickey (1997) at the Tonawanda Complex was tested at the Perch River WMA. The estimated population size was 45 nesting pairs in 1995 and 77 nesting pairs in 1996.

Mossman, M. J., A. F. Techlow, III, T. J. Ziebell, S. W. Matteson, and K. J. Fruth. 1988. Nesting gulls and terns of Winnebago Pool and Rush Lake, Wisconsin. Passenger Pigeon 50:107-117.

Nest searches were conducted on wetlands in Winnebago and northern Fond du Lac counties, Wisconsin, in May and June, 1984-1986. Nest sites were located from the air. Data on Black Terns came from one day-long survey in June in which a person followed a standardized route over the lakes in an unmotorized skiff.

One hundred seventy-three nests were located on Rush Lake. Black Terns nested in areas with a mixture of emergent vegetation, mudflats, and shallow, open water.

Naugle, D. E., K. F. Higgins, and S. M. Nusser. 1999. Effects of woody vegetation on prairie wetland birds. Candian Field-Naturalist 113:487-492.

Avian use of wetlands surrounded by woody vegetation was studied throughout South Dakota during the summers of 1995 and 1996. A grid of 25.9 km^2 cells was overlaid onto a geographic information system constructed of National Wetland Inventory (NWI) data for eastern South Dakota. Wetlands in western South Dakota were randomly selected using 7.5 minute NWI maps, because wetlands west of the Missouri River had not yet been digitized. An average of two seasonal and two semipermanent wetlands were surveyed for birds within 216 randomly selected cells. An adequate sample of all wetland sizes were surveyed. Wetland area was estimated using either the NWI maps and a planimeter or using the GIS. During surveys, the proportion of emergent vegetation within wetlands was estimated visually (Daubenmire, R. F. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33:43-64.), and these values were used as covariates. Categories for the percentage of vegetated area within wetlands were 0, 1, 2-5, 6-25, 26-50, 51-75, 76-95, and >95.

Birds were surveyed for 8 minutes within 18-m fixed radius circular plots. Tape recordings of the calls of Virginia Rail, Sora, Least Bittern, and American Bittern were broadcast to elicit responses from these secretive species. A 3-minute continuous loop tape was played. It consisted of 25 seconds of male territorial calls of each of the four species followed by 5 seconds of silence and was played for 2 minutes at each circular plot. The third minute of calling repeated 10 seconds of calls for each species, interspersed with 5 seconds of silence. Calls were broadcast during the 3-5 minute period of each 8-minute survey. The number of circular plots surveyed per wetland increased with increasing wetland area and were dispersed evenly throughout the wetland. Coverage ranged from 100% of small (not defined) wetlands to <1% of large wetlands. When no vegetation was present in the wetland, birds were surveyed before approaching the wetland. Species detected outside of plots or while moving between plots were recorded and the entire wetland perimeter was traversed to ensure that each species present in the wetland was recorded. Surveys were done from sunrise to 1000 h or 1800 h to sunset and were not conducted during rain or high (≥24 km/hr) winds. Species using woody vegetation along wetland margins also were noted. The proportion of the wetland edge occupied by woody vegetation was categorized as <1%, 1-5%, 6-25%, 26-50%, 51-75%, 76-95%, and >95%.

Wetland bird species richness decreased as the proportion of woody vegetation along the wetland perimeter increased. An initial decline of wetland bird species richness occurred at the point when >25% of the wetland perimeter was occupied by woody vegetation. The most significant declines of wetland bird species richness occurred when the wetland perimeter was >75% covered with woody vegetation. The negative impact of woody vegetation on wetland bird species use was not completely understood, but authors suggested negative impacts may include perches for predatory raptors, and parasitic Brown-headed Cowbirds.

Naugle, D. E., K. F. Higgins, M. E. Estey, R. R. Johnson, and S. M. Nusser. 2000. Local and landscape-level factors influencing Black Tern habitat suitability. Journal of Wildlife Management 64:253-260.

Local- and landscape-level factors influencing habitat suitability for Black Terns were studied in eastern South Dakota from 1995 to 1997. The authors divided eastern South Dakota into three regions, Prairie Coteau, Central Lowlands, and Missouri Coteau. National Wetland Inventory data was used to locate and classify wetlands, and wetland easements, waterfowl production areas, and wildlife refuges were mapped. Landsat Thematic Mapper imagery was used to classify upland areas. Investigators surveyed 416 semipermanent and 418 seasonal wetlands (wetland classification by Cowardin, L. M., T. L. Shaffer, and P. M. Arnold. 1995. Evaluation of duck habitat and estimation of duck population sizes with a remote-sensing-based system. U.S. Fish and Wildlife Service Biological Science Report 2.). Investigators walked a zig-zag pattern within each wetland and then walked the perimeter to count Black Terns present. Nesting colonies were detected by observing Black Tern defensive behavior. Mobbing behavior and alarm calls by Black Terns were used to locate nests. The outermost nest locations defined colony boundaries. Wetlands occupied in 1995 were revisited in 1996 to determine whether Black Terns used wetlands in consecutive years. Vegetative wetland stage (e. g., degenerating vs. open marsh) was recorded. Percent cover of vegetation (<1%, 1-5%, 6-25%, 26-50%, 51-75%, 76-95%, and >95%), vegetation pattern (open marsh, concentric rings of vegetation, highly dispersed vegetation, or closed marsh), land use surrounding the wetland (cropland, grassland, or mixed), and grazing intensity (idle to heavily grazed) were recorded for each wetland. At 10 randomly selected nesting wetlands, vegetation height and density were recorded at two randomly selected nest sites, two random points within a colony, and two locations outside the colony. A 2.4-m vegetation profile board was used to estimate vegetation density in the four cardinal directions 5 m from the nest. The proportion of each 0.2-m interval on the board that was covered by emergent vegetation was recorded. Predictor variables in a stepwise discriminant function analysis were wetland area, shoreline length, and total area and density of wetlands for four wetland classification categories (temporary, seasonal, semipermanent, and permanent; Stewart, R. E., and H. A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. Resource Publication 92. U.S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife. 57 pages.).

Of 412 semipermanent wetlands, Black Terns were recorded on 106 (26%); nesting was confirmed on 32 (8%) wetlands, and 74 (18%) wetlands were used for foraging. Of 418 seasonal wetlands, only 2 (<1%) were used for nesting and 29 (7%) were used for foraging.

Important factors in wetland suitability according to the discriminant function analysis were wetland area (ranked most important), total semipermanent wetland area, and grassland area. Suitable wetlands were larger (mean of 18.9 ha vs. 6 ha) than unsuitable wetlands and suitability was positively related to the area of semipermanent wetlands and surrounding grassland.

Niesar, S. L. 1994. Vertebrated richness of Waterfowl Production Areas in the Prairie Pothole region of Minnesota. M.S. thesis. South Dakota State University, Brookings, South Dakota. 104 pages.

Avian abundance and diversity were measured to determine biodiversity on 23 Waterfowl Production Areas in the Prairie Pothole Region of Minnesota in 1993. Estimates of breeding bird numbers were determined by censusing birds along 40-m wide belt transects from 15 May through 30 June 1993 (whether counts were done on a daily basis and the exact length of transects was not specified, but see below). Transects crossed all vegetation cover types at each study site. Transects were set up such that 30% of each habitat type was sampled on each study site. Cover types recorded during censusing were tame grass, native grass, brush, woodland, wetland, and "other." Brush was considered any woody growth <1.5 m tall. Woodland included stands of trees >1.5 m tall. "Other" habitats were habitats not often encountered but utilized by bird species on specific sites (e.g., power lines, plowed fields, food plots, etc.). Brush made up <1% of the study area and native grass patches were not of sufficient size to support a diverse population. All birds detected within the 40-m belt were identified and recorded and the cover type occupied by each bird was noted. Species were identified by sight or sound and were counted from 30 minutes before sunrise to about four hours after sunrise. Counts were not conducted on days when the wind speed was >15 km/hr or during heavy rain. Birds that were observed <30 times were not discussed in the results/discussion section. The summary for this article included habitats used by individual bird species.

Peterjohn, B. G., and J. R. Sauer. 1997. Population trends of Black Terns from the North American Breeding Bird Survey, 1966-1996. Colonial Waterbirds 20:566-573.

Breeding Bird Survey (BBS) data were summarized for Black Terns for the period 1966-1996. Black Terns were most numerous on BBS routes in the northern Great Plains, from Minnesota and South Dakota, north across the prairie provinces of Canada. Small numbers of terns were recorded elsewhere. Although BBS trend estimates were considered imprecise due to Black Terns' semi-colonial nesting habits and annual population fluctuations, trends showed a consistent decline in numbers from 1966 to 1996. Significant declines occurred from 1966 to 1979, with fewer declines noted after 1980. Following 1980, the only significant decline occurred in the Aspen Parklands of Canada, whereas Black Terns significantly increased in the

United States. Recent increases in population trends mainly occurred in North Dakota and across eastern Montana and into southern Saskatchewan; increases also were noted in the northern Rocky Mountains of British Columbia. However, increases in the northern Rocky Mountains of British Columbia and the northern United States were based on small sample sizes and the authors noted that results should be viewed with caution.

Counts along BBS routes may be affected by fluctuations in wetland conditions. For instance, fluctuating water levels may force birds into remaining suitable habitat, which may increase or decrease counts, depending on whether the remaining suitable habitat was near a BBS route.

Management Suggestions:
–Improve BBS route information for Black Terns by expanding routes into more of the tern's breeding range.
–Specific wetlands could be surveyed in a stratified random sampling design to provide monitoring information for Black Terns. These surveys would need to be conducted across the entire breeding range.
–Individual birds need to be marked to document the geographic extent of bird movements over time.
–Identify important areas for maintaining breeding populations.

Prince, H. H. 1985. Avian communities in controlled and uncontrolled Great Lakes wetlands. Pages 99-120 *in* H. H. Prince and F. M. D'Itri, editors. Coastal Wetlands. Lewis Publishers, Inc., Chelsea, Michigan.

Breeding bird use of four Great Lakes coastal wetlands was compared between wetlands with and without artificial water control mechanisms from 1980 to 1983. The study areas were located in Michigan. Two wetlands had natural water fluctuations and two wetlands were artificially controlled. Three of the four wetlands had established emergent vegetation. The fourth wetland had been restored from agricultural use three years prior to the study, so vegetation was in developmental stages.

A total of 24 belt transects (30 m in width and totaling 11,000 m) were established on a random basis in the four wetlands. Sample areas were equal among the four wetlands. Vegetation was measured, and nest, flush, and call counts were made along the transects. Above-ground primary productivity of emergent plants was measured by weighing dried stem samples from cattails and by counting stem densities in a series of 1-m^2 plots. Ratios of emergent vegetation cover to open water were estimated.

Three nest searches were conducted on each wetland in each year. An early-season search was conducted between late April and mid-May, a mid-season search was done between the last week in May and mid-June, and a late-season search was done between late June and mid-July. Each belt transect was divided into 5-m search zones; one person searched for nests in each zone (article did not specify whether person was on foot or in a boat). Nest variables recorded were species, status of eggs/young, height, nesting substrate, and location along the transect. Recorded calls were used to detect Sora, Virginia Rail, American Coot, and Common Moorhen. Call counts were conducted at 100-m intervals along belt transects between sunrise and 1100 hours at 2-week intervals from May through September. Counts were not made when winds exceeded 16 km per hr. Recorded calls were played at each station using speakers aimed in opposite directions. The direction and estimated distance (how this was determined was not specified) were recorded for one minute after the tape was stopped. Number of calls of individual species and length of call playbacks were not specified. Large wading birds and waterfowl were counted biweekly along each belt transect in conjunction with call playback counts.

A total of 907 nests were found over the four-year period. The number of species nesting and nest density were significantly, negatively related with the percent of open water per 100 m of transect.

Shealer, D. A., and J. A. Haverland. 2000. Effects of investigator disturbance on the reproductive behavior and success of Black Terns. Waterbirds 23:15-23.

The effects of repeated nest visits on parental attendance and nest success of Black Terns were studied in Horicon National Wildlife Refuge, Wisconsin, in 1999. Other objectives were to develop protocols for trapping and banding adult and nestling Black Terns that minimized the risk of nest desertion and to evaluate the use of enclosures for obtaining reliable estimates of reproductive success. The population was not previously exposed to large amounts of human disturbance. Nest sites were located visually from refuge roads and dikes or from a canoe. Nests were marked with surveyors' tape >1 m from the nest. Each nest was visited at least twice to determine nest fate. Nests were assigned to four treatment groups: 1) high disturbance - nests visited every 4 days to examine nest contents and weigh eggs, and where researchers attempted to trap and band both members of a pair; 2) moderate disturbance - nests visited every 4 days, and where only one adult of a pair was trapped and banded; 3) low disturbance - nests visited every 4 days, and no attempts were made to trap and band adults; and 4) minimal disturbance - nests were not revisited after clutch completion until the time of hatching, and no attempts were made to trap and band adults.

Terns were trapped on the nest between day 2 and 19 of incubation using a modified Potter trap (no citation given) with a wire mesh floor to prevent the bird from damaging the eggs. Terns were removed from the trap and transported >20 m away from the nest for processing. Terns were weighed to the nearest 0.5 g with a spring scale, and the following body measurements were recorded: head and bill length, exposed culmen, unflattened wing (wing chord) length, and tail length. Terns were then banded using U.S. Fish and Wildlife Service aluminum bands and one to three celluloid color bands. Undertail coverts and underwings were marked with a nontoxic magic marker to allow researchers to identify the tern easily. The marker wore off in 1-3 d. Researchers recorded the time for the bird to return to the vicinity of the nest (either flying directly overhead lower than 10 m or landing within 10 m of the nest site) and time to land and resume incubation. Effects of disturbance on productivity were measured using two variables: 1) percent hatched - percentage of eggs hatched from all nests in a particular treatment group, and 2) hatching success - proportion of nests from each treatment group that hatched >1 egg. A subset of nests were enclosed for studies of chick growth and fledging success (proportion of chicks fledged from all eggs that hatched). Enclosures were made from wire fencing (1 cm mesh), and each enclosure was circular and measured about 25 cm high by 70-80 cm in diameter.

No significant differences existed among disturbance groups for either hatching success or fledging success. Neither trapping of adults nor repeated nest visits promoted nest desertion or lowered hatching success compared to the minimal disturbance treatment group. Fledging success was unaffected, and perhaps even enhanced by enclosing nestlings with fencing relative to unfenced nests.

Adults should not be trapped on the nest prior to day seven of incubation (preferably, not before day ten of incubation). Nestlings should be banded on the day of hatching with size 1A bands. Enclosures for reproductive success studies should be erected after the first egg has pipped and should be placed around the entire brood. Adults readily landed inside enclosures to feed and brood nestlings. Natural material should be added to the inside of the enclosure to provide cover for the chicks. Monitor enclosures daily. To prevent chicks from pushing their bills through the mesh and injuring their heads, sew a strip of fabric to the inside bottom of the enclosures.

Shutler, D., A. Mullie, and R. G. Clark. 2000. Bird communities of prairie uplands and wetlands in relation to farming practices in Saskatchewan. Conservation Biology 14:1441-1451.

Effects of conventional farming, organic farming, and minimum-tillage farming practices on composition of avian communities were compared to untilled areas in southcentral Saskatchewan in 1996 and 1997. Fields used in the study were within a 200-km radius of Saskatoon. Conventional farming involved the use of agrochemicals and tillage (>3 times per year) to control weeds. Organic farming involved tilling more frequently than for conventional farming (exact number of times fields were tilled was not specified), but without the use of agrochemicals; chemicals had not been used for at least 4 years. Minimum-tillage farming involved reduced tillage (<3 times per year) and direct seeding into the previous year’s crop stubble. Untilled areas were lands taken out of crop production; some were seeded to nesting cover or planted for hay production, and they were not tilled and had no or low chemical applications. Vegetation was a combination of native and tame species.

Fixed-radius (100-m radius) point counts were conducted within cereal fields, usually wheat, in untilled fields, and in wetlands. In cereal fields, a buffer zone of 100 m was allowed around point counts where possible. In small wetlands, the entire wetland was censused, including noncrop margins. In large wetlands, plots were semicircular with a fixed radius of 100 m and included noncrop margins within the radius. Birds flying over plots were not counted in the survey unless they were swallows flying <2 m above the wetland. Surveys were conducted between 12 June and 19 July 1996 and between 2 June and 4 July 1997, between 0430 and 0930 hours. Surveys were not conducted during heavy wind (speed not specified) or rain. Most plots were surveyed twice during each year of the study, and the order of plot visits was reversed between the two surveys to reduce bias from time of day. In uplands, all birds seen or heard within the plot in a five-minute interval were recorded. Playback calls were used for Pied-billed Grebe, American Bittern, Virginia Rail, and Sora; an extra five minutes were spent listening for responses to playback calls (detailed methods of playback calls were not given). Characteristics of point counts were noted, such as whether a buffer zone included wetlands, trees, or hedgerows. The number of wetlands, the area of wetland basin plus noncrop margins, and area of woody vegetation were summarized for the quarter section (64 ha) in which a plot was located. These characteristics were measured both on the ground and from digitized aerial photos. Wetland plots had to be at least 0.5 m deep in June 1996 and occupy a basin <10 ha. Area of basin included open water, wet meadow, and emergent vegetation. Area of water was defined as the area of open water estimated in July. Percent margin woody was the area occupied by trees and shrubs. Complexity was a subjective score that rated wetlands according to the variety of habitats.

Untilled areas contained the most individuals and had the highest diversity than did farms. Among uplands, minimum tillage fields had more individuals and species than did organic or conventional fields. Organic fields had slightly more individuals and species of birds than did conventional fields. Among wetlands, organic fields had higher relative abundance than minimum tillage or conventional fields. Upland birds were more numerous and diverse in areas with nearby wetlands. Wetland birds were more numerous and diverse in areas with high diversity in habitat types.

Stern, M. A. 1987. Site tenacity, mate retention, and sexual dimorphism in Black Terns. M.S. thesis. Oregon State University, Corvallis, Oregon. 45 pages.

Site tenacity, mate retention, sexual dimorphism, and behavior in Black Terns were studied at Sycan Marsh, Lake County, Oregon, from 1982 to 1984. All nesting habitat within the marsh was searched three times per week for nests (detailed methods not given). Nests were located by observing adult behavior. Adult Black Terns were captured and banded (no detailed methods were given for banding) after clutches were complete. Birds were captured at the nest site using a cylindrical cage of hardware cloth (no dimensions given; modified after Burger 1971, Dunn 1979).

A total of 779 adult terns were banded; the overall rate of recapture of Black Terns was 15% (n = 506).

Svedarsky, W. D. 1992. Biological inventory of a multi-purpose flood control impoundment in northwestern Minnesota and potentials for nongame and game bird management. Final Report. Northwest Agricultural Experiment Station, University of Minnesota, Crookston, Minnesota. 115 pages.

The flora, fauna, and hydrology of the Burnham Creek Wildlife Management Area (175 ha) in northwestern Minnesota were described. Data were collected in 1990 and 1991. The management area began as a multipurpose flood control project that was completed in 1988. The study area consisted of upland habitats, a restored wetland, and a flood storage impoundment. The project was designed to reduce flooding in the Burnham Creek Watershed while providing wildlife benefits. Most of the study area had been cultivated in the past.

Birds were surveyed using three methods: general censuses throughout the field season, breeding bird survey transects, and nest searching. General bird censuses occurred whenever the study site was visited from early March until wetlands completely froze over, which was late November in 1990 and late October in 1991. General censuses were done from a vehicle using a spotting scope. Seventy-nine census visits were conducted in 1990 and 72 in 1991. Two to three census visits were conducted weekly with the majority (60%) of them occurring in the morning. Bird species, approximate number of birds, location, and behavior all were recorded.

Upland habitats were nest-searched using a cable-chain drag. Wetlands were searched by two to three people wading abreast through the wetland. Wetlands were searched on 4, 7, 10 June; 22, 26, 28 June; and 9, 12 July. Upland and wetland nests were located by observing locations of flushing adult birds; nests were marked with flags placed 10 m from the nests. Dominant vegetation and 100% vertical obstruction readings (Robel pole) were recorded at nest sites. Nests were checked weekly to determine nest fates.

Four breeding bird transects were conducted along permanently marked north-south transects 1000 m long and 50 m wide. Transects were marked using numbered steel posts placed at either end of each transect. Breeding bird transects were run on 4 and 26 June 1990 and 29 May, and 16 and 21 June 1991.

Sixty bird species nested on the study area. The aspen/brush fen habitat had the greatest number (38) of species recorded during breeding bird censuses, followed by wheatgrass/timothy (14), and the restored wetland and needlegrass/sideoats grama habitats with 12 species each.

Teeuw, M. P. 1995. Management efforts for the declining Black Tern (*Chlidonias niger*) population in Presqu'ile Bay in 1995. Unpublished report, Presqu'ile Provincial Park, Ontario, Canada. 81 pages.

Population monitoring, nest success, and habitat characteristics of Black Terns were investigated at Presqu'ile Marsh (124 ha), Murray Canal Marsh (40 ha), and the Brighton Yacht Club (65 ha) Marsh in Presqu'le Provincial Park in Ontario, Canada, during 1995. Behavior and number of Black Terns were recorded with the aid of binoculars from shore or from a boat two to three times per week. A "disturbance count" was made by summing the number of Black Terns involved in an alarm response. An estimate of the breeding population was based on the number of nests found. Black Tern behavior was used to locate nests. Nests were marked with wooden stakes and flagging and plotted on a map of the study area. Nests were checked three times per week. Boating disturbances to the colony were noted. Three types of artificial nest platforms were installed (54 total platforms). One platform style consisted of a piece of styrofoam (4 x 60 x 60 cm) sandwiched in between two pieces of wood (2 x 5 x 60 cm) and attached to a border (2 x 15 x 60 cm). A second style was made of four 60-cm long ABS pipe connected with four elbows and attached to fence wire with cattails woven through the wire. A third type was constructed of 60 x 60 x 3 cm wooden planks with a 2-cm tall edge placed around the planks to prevent eggs from rolling off the surface. Platforms were secured in place by bricks tied to polypropylene rope. Interplatform distances ranged from 5 to 20 m.

Tilghman, N. G. 1980. The Black Tern survey, 1979. Passenger Pigeon 42:1-8.

Black Tern populations were measured throughout Wisconsin using roadside surveys and intensive wetland surveys during 1979. Volunteers from birding groups along with state and federal agency personnel conducted the surveys. Wetlands for the roadside survey were selected as a subsample of wetlands where volunteers had seen Black Terns previously within the volunteers' respective counties. Wetlands that were partially or entirely visible from the roadside were selected. Roadside surveys were conducted immediately after sunrise on clear days from 25 May to 24 June, 1979. Surveys were not conducted in rain or when winds were greater than 20 mph. At each site, Black Terns were counted for 5 minutes. An index of abundance for each county was calculated by averaging the number of Black Terns counted. Differences in abundance between counties could not be compared because of differences in observers and effort. Furthermore, the index could not account for differences in the number of suitable nesting wetlands within each county. Wetland surveys were conducted from 25 May to 24 June, 1979 in the morning hours. Numbers of Black Terns were counted by observers on foot or in canoe. Three areas were searched for nests by canoe or on foot to estimate the percentage of adults being observed in the wetland survey. Other information recorded during wetland surveys included type of wetland, major vegetation, percent cover of emergent vegetation, and how the wetland was being used (for nesting or for foraging). The authors noted that determining trends in numbers would be hampered by movements of birds from one area to another and by differences in observers and effort.

A total of 79 roadside surveys were conducted. Black Terns existed at more than 205 wetlands throughout the state. The highest roadside abundance index was calculated for Marinette County, which averaged 26 Black Terns per stop. Of 248 intensive wetland survey sites, only 29 had large (>20) Black Tern populations. Seventy-five percent of the 29 areas with the largest populations were listed as “marshes”; other habitat types were stream edges, flooded sedge meadows, and open water areas.

VanRees-Siewert, K. L. 1993. The influence of wetland age on bird and aquatic macroinvertebrate use of restored Iowa wetlands. M.S. thesis. Iowa State University, Ames, Iowa. 96 pages.

Bird species richness, breeding bird species, and re-vegetation of restored wetlands ranging in age from 1 to 4 yr were studied in northern Iowa from 1991 to 1992. On each wetland, 3 census stations were established. The first was placed along a random compass bearing and the other two were evenly spaced from this point. The stations were located in the middle of the emergent vegetation zone or at the water’s edge if the wetland had no emergent vegetation. Birds were censused five times each year between May and June. Counts were made between sunrise and 0900 hours and were not conducted during inclement weather. Waterfowl pairs were counted before the basin was entered. All birds seen or heard during a six-minute counting period within 20-m radius plots were recorded (Edwards, D. K., G. L. Dorsey, and J. A. Crawford. 1981. A comparison of three avian census methods. Studies in Avian Biology 6:170-176.). Halfway through the counting period, a tape recording of the calls of Sora, Virginia Rail, Least Bittern, and American Bittern were played to elicit responses from these secretive species. The tape included 30 seconds of continuous calls of each species. Birds that were seen or heard outside of the counting interval or point radius were included on a species list. Wetlands were searched for nests weekly in 1991 and bi-weekly in 1992. The author searched the emergent vegetation and 30 m of the surrounding upland by foot in a zig-zag pattern. The vegetation was scanned for nests or flushing birds. A species was considered breeding if an active nest was found, a brood was seen, or an individual was present in three of five visits.

The vegetation was measured in mid-July using the releve method (Mueller-Dombois, D., and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, Inc. New York, New York. 547 pages., Galatowitsch, S. M. 1993. Site selection, design criteria and performance assessment for wetland restorations in the prairie pothole region. PhD dissertation. Iowa State University, Ames, Iowa. 124 pages.). Wetland age, wetland area, percent emergent vegetation cover, and vegetation cover pattern were recorded for each plant species in the wetland. Vegetation cover patterns for each wetland were as follows: 1) <5% emergent vegetation, marginal band of vegetation <2 m in width; 2) centrally located areas of open water surrounded by a band of emergent vegetation >2 m in width; 3) centrally located areas of dense emergent vegetation surrounded by a peripheral band of open water; 4) emergent vegetation covering >95% of the wetland basin. A detailed cover map of each wetland was drawn and the total percent emergent vegetation was visually estimated.

Aerial photographs were used to measure wetland area, and the history of each wetland was obtained from landowner surveys and the Iowa Department of Natural Resources.

Of 42 bird species detected on restored wetlands, 33% were waterfowl, 24% shorebirds, 17% bitterns and herons, 11% songbirds, 5% grebes and coots, 5% rails, and 5% were terns. Fifteen species nested in restored wetlands.

Weller, M. W., and L. H. Fredrickson. 1973. Avian ecology of a managed glacial marsh. Living Bird 12:269-291.

The effects of habitat changes due to wetland cycles on bird diversity and abundance were examined at Rush Lake from 1964 to 1971. Rush Lake is a 160 ha, semipermanent wetland in northern Iowa. Objectives of the study were to record plant and avian succession through a wetland cycle, clarify a typical wetland habitat cycle, to experimentally lengthen the typical wetland habitat cycle, and to describe the form and function of a discrete, natural ecosystem. Water levels in the lake were experimentally manipulated. Water level drawdowns were done in 1964 and in 1971 to allow vegetation to germinate. The wetland began to be reflooded in 1965. Vegetation cover was quantified using aerial photos and by pacing the area of vegetation and open water on the ice in the winter. Vegetation parameters, bird counts, and muskrat counts were conducted along three 30-m wide belt transects running through the wetland. Belt 1 was about 1039 m long, belt 2 was 247.5 m long, and belt 3 was 495 m long. A crew of three to six persons waded through the belt transects searching for nests and recording birds (no other detail on how surveys were conducted was given). The time of year and day when transects were surveyed was not specified. As the length of inundation increased, the percentage of water cover increased. Changes in basin shape, water depth, and muskrat (*Ondatra zibethica*) feeding and lodge-building activities affected the percentage of open water in the wetland.

Peak densities of most bird species occurred when emergent cover-to-water ratios were about 50:50. Bird species diversity was greatest when the emergent cover-to-water ratios were between 50:70-70:50. Bird diversity was highest when there were many small pools that were highly interspersed. Low bird densities occurred in dry vegetation conditions (1964 and 1971) and in open marsh conditions (1969 and 1970). These two conditions met the habitat requirements of only a few species.

Weller, M. W., and C. S. Spatcher. 1965. Role of habitat in the distribution and abundance of marsh birds. Iowa State University Agriculture and Home Economics Experimental Station Special Report No. 43. 31 pages.

Wetland succession and its influence on the distribution of habitats and marsh birds were studied on Goose (54 ha) and Little Wall (110 ha) lakes in Hamilton County, Iowa, from 1958 to 1963. Drought had resulted in dry conditions in both lakes by 1956, but both wetlands were full of water by 1962. Coverages of vegetation and open water were estimated using aerial photos and by pacing out areas on the ice in the winter. Marsh-nesting bird populations were estimated by counts of territorial males or nests. Three to five counts of territorial males and nests were done each spring on clear, quiet mornings. No other details were given for survey or nest searching methods. Vegetation changes of the wetlands as they progressed from completely dry to a 50:50 ratio of vegetation cover to open water to open water/lake-like conditions were described. Populations of most bird species peaked when the vegetation cover-water ratio was about 50:50.
