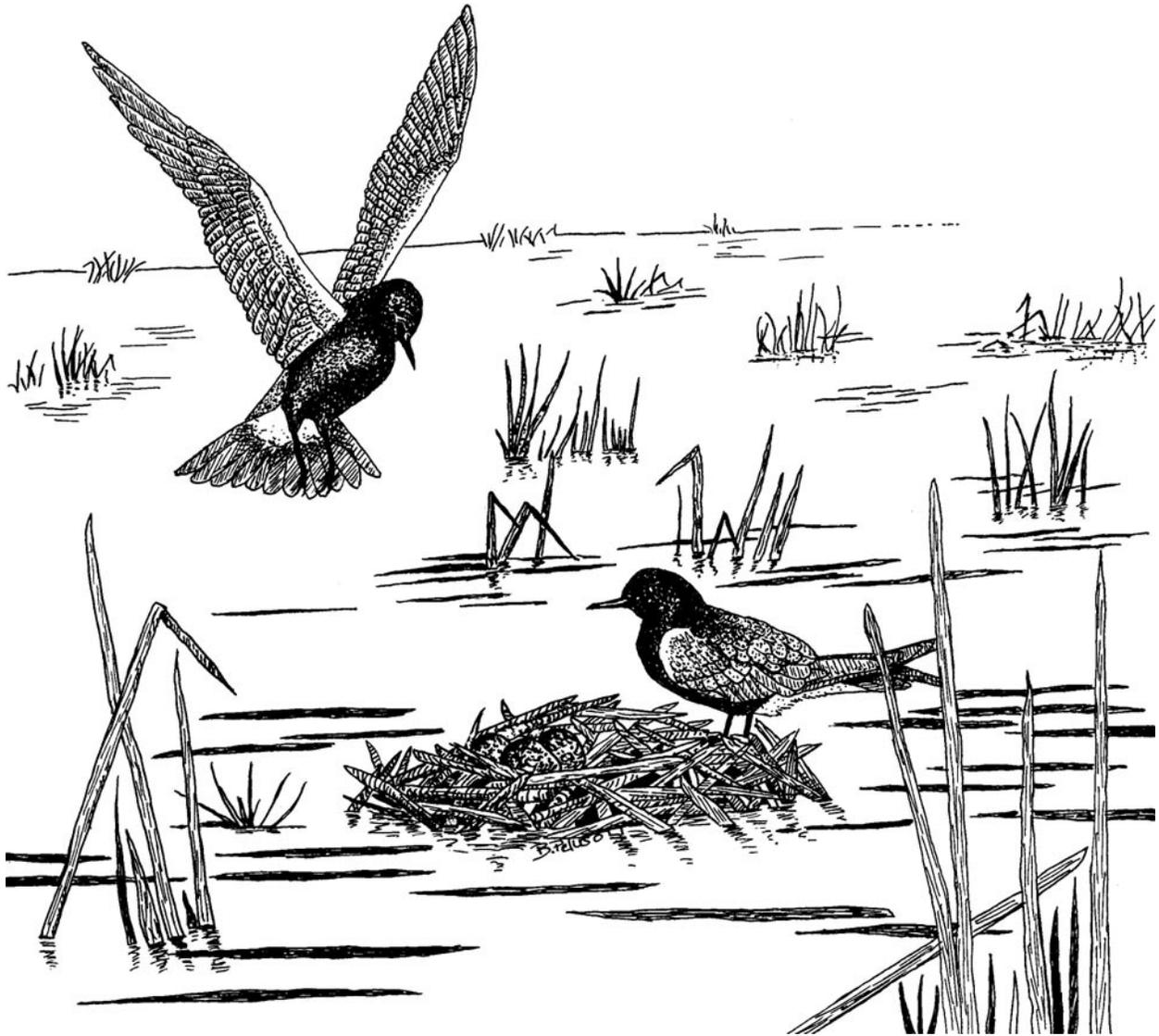


Black Tern (*Chlidonias niger surinamensis*): A Technical Conservation Assessment



**Prepared for the USDA Forest Service,
Rocky Mountain Region,
Species Conservation Project**

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COVER PHOTO CREDIT

Black tern (*Chlidonias niger surinamensis*) nest site. Artwork by Beth Peluso.

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF THE BLACK TERN

Status

The black tern (*Chlidonias niger surinamensis*) still occupies most of its former range. The continental population likely numbers in the low to mid hundreds of thousands and appears stable within the habitat that remains. However, given the severity of previous declines, conservation of the black tern still warrants serious concern. Primary conservation needs include tightening wetland protection laws, enhancing habitat protection programs and developing better population monitoring strategies.

Primary Threats

Loss of remaining wetland and grassland habitats to agriculture or other development is the greatest threat to black tern conservation. The threat beyond that of direct habitat loss is that cumulative impacts of drainage might degrade the natural heterogeneity of wetland landscapes to the point that black terns no longer use the remaining wetlands. Further loss of remaining grasslands is also a threat because wetlands in agrarian landscapes are at high risk of drainage. The U.S. Supreme Court in 2001 issued a judgment dubbed the SWANCC decision that effectively removed protection from 80 to 98 percent of wetlands in Region 2 that were formally protected under Section 404 of the Clean Water Act. The net result of the SWANCC decision has left the “Swampbuster” provision of the Food Security Act as the last line of defense for protecting wetlands that provide habitat for black terns. This is important because federal policy that drives land use change may place more pressure on public lands (e.g., national grasslands) to provide suitable habitat for species of concern. Some citizens who opposed grazing on public lands now consider it a new icon for conservation because ranchers that maintain profitability on native range are less likely to convert wetlands and grasslands to croplands.

Priority Conservation Elements and Management Considerations

Conservation of remaining wetland and grassland habitat will likely provide the greatest benefit to black tern populations. Broad scale conservation approaches are necessary to maintain naturally viable populations and to avoid intensive site-specific management typically required to artificially maintain small populations in degraded landscapes. Wetland protection programs that consider characteristics of entire wetland landscapes would be most effective because wetlands that do not correspond to broad scale habitat needs of black terns may not be suitable despite favorable local conditions. In regions where wetland loss and degradation has been severe, wetland restoration is a management option that would likely benefit black terns, perhaps as an effort complimentary to broad scale habitat conservation. Formation of an effective long-term monitoring program designed to enhance our knowledge of population status of black terns would reflect inherent variability in water levels, number of wet wetlands, and changing landscape patterns that influence black tern habitat use in space and time. Habitat models constructed using monitoring data should be based on multiple years of data and provide some indication of how frequently potential black tern habitat may be suitable.

Embedding demographic studies within regional population and habitat sampling schemes would enable researchers to model the demographic consequences of habitat management and make valid inferences over much broader areas. Priority demographic information needs are estimates of adult and chick survival. Furthering our understanding of black tern ecology may require research on the wintering grounds because we do not know whether population declines are solely the result of issues on the breeding grounds.

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the USDA Forest Service (USFS) Rocky Mountain Region (Region 2) (**Figure 1**; hereafter referred to as Region 2). The North American black tern (*Chlidonias niger surinamensis*) is the focus of this assessment because it is a sensitive species in Region 2. Within the National Forest System, a sensitive species is one whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance and/or habitat capability that would reduce its distribution.

Goal

This conservation assessment provides readers a thorough discussion of the biology, ecology, conservation status, and management of the black tern.

Assessment goals were to synthesize existing scientific knowledge of black terns, discuss broad implications of that knowledge, and outline future information needs. While the assessment does not seek to provide specific management recommendations, it does focus on consequences of changes in wetland landscapes that result from management (i.e., management implications). Furthermore, it cites management recommendations proposed elsewhere, and when those have been implemented, the assessment examines the success of their implementation.

Scope

This assessment examines the biology, ecology, conservation status, and management of black terns with specific reference to the geographic and ecological characteristics of Region 2. Although some literature may originate from areas outside the region, most information comes from within the region where black

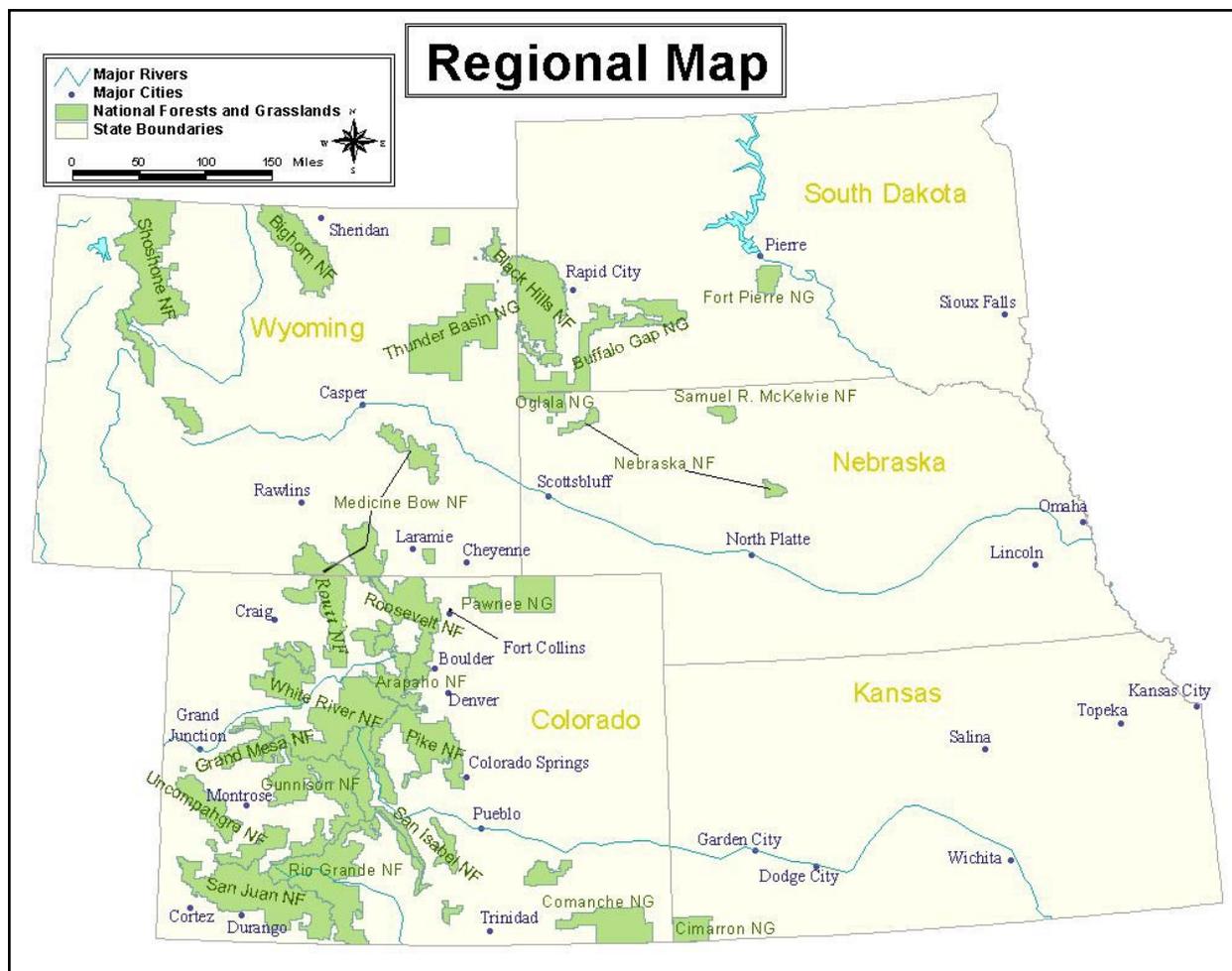


Figure 1. National forests and grasslands in the Rocky Mountain Region 2 of the USDA Forest Service (map courtesy of the USDA Forest Service Region 2).

terns are most abundant (e.g., Prairie Pothole Region of South Dakota and others). Refereed literature, non-refereed publications, and research reports were reviewed for the assessment. Not all publications on the black tern are referenced in the assessment, nor were all published materials considered equally reliable. This assessment emphasizes refereed literature as the accepted scientific standard.

Treatment of Uncertainty

Science is a rigorous, systematic approach to obtaining knowledge where competing hypotheses regarding how the world works are measured against observations. However, because descriptions of the world are always incomplete and observations limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Romesburg 1981, 1991). In this assessment, the strength of evidence for particular hypotheses is noted and alternative explanations described where appropriate.

Publication on the World Wide Web

To facilitate their use in the Species Conservation Project, species assessments are being published on the Region 2 Web site. Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, it facilitates their revision, which will be accomplished based on guidelines established by Region 2.

Peer Review

Assessments developed for the Species Conservation Project have been peer reviewed prior to release on the Web. This report was reviewed by two recognized experts and the coordinator of the Species Conservation Project with oversight from the Society for Conservation Biology. Peer review was designed to improve the quality of communication and to increase the rigor of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

The black tern is a species of moderate concern ([Shuford 1999] <http://www.r6.fws.gov/birds/blacktern/>

[sacp.htm](http://www.r6.fws.gov/birds/blacktern/sacp.htm); Accessed 22 January 2003) across much of its' range in North America. The North American black tern (*Chlidonias niger surinamensis*) was proposed for listing under the federal Endangered Species Act, but the U.S. Fish and Wildlife Service (USFWS) concluded that there was not enough information to make a determination (U.S. Fish and Wildlife Service 1991). The black tern was listed on the National Audubon Society's Blue List in from 1978 to 1986 (National Audubon Society in Tate 1981, 1986, Tate and Tate 1982) and was on the 1995 list of Migratory Nongame Birds of Management Concern in the U.S. (U.S. Fish and Wildlife Service 1995) However, the black tern is not listed as a "Bird of Conservation Concern" in Bird Conservation Regions that encompass Region 2 (U.S. Fish and Wildlife Service 2002; <http://migratorybirds.fws.gov/reports/bcc2002.pdf>; Accessed 15 February 2003).

The Global and National Heritage Status Ranking for the black tern is 4 (apparently secure). Heritage status rankings for the black tern for states in USFS Region 2 vary from S1B (critically imperiled) in Kansas and Wyoming to S2B (imperiled) in Colorado or S3B (vulnerable) in South Dakota and Nebraska. In Wyoming, the black tern is further classified in the Wyoming Partners in Flight (PIF) Bird Conservation Plan as a Level I priority species that requires immediate conservation action (Cerovski et al. 2001). The black tern is classified as a Level II priority species in the PIF Draft Bird Conservation Plan for Montana (a border state to Region 2), but no other PIF plans completed for states in Region 2 list the black tern as a priority species (<http://www.blm.gov/wildlife/pifplans.htm>; Accessed 13 January 2003). Lastly, the black tern is ranked as a species of moderate concern (i.e., Rule 3b with an apparently stable population with known or potential threats) in the North American Waterbird Conservation Plan (Kushlan et al. 2002).

Regulatory Mechanisms, Management Plans, and Conservation Strategies

The black tern is currently protected under the Migratory Bird Treaty Act (1918), which prohibits the "pursuit, hunt, take, capture, kill, or transport" of any migratory bird or "any part, nest, or egg of any such bird" (<http://laws.fws.gov/lawsdigest/migtrea.html>; 16 U.S.C. 703; Accessed 15 January 2003). Although this act provides adequate protection against the illegal taking of a black tern in Region 2, federal policy and regulatory mechanisms that protect their wetland habitat from being drained are not secure. Rather, they are the frequent topic of fierce legislative debate and legal action.

To date, the black tern has been a non-target beneficiary of protection programs aimed at conserving habitat for upland nesting waterfowl. The most comprehensive of such habitat programs is the North American Waterfowl Management Plan (NAWMP) (<http://www.nawmp.ca/>; Accessed 12 March 2003). The goal of this plan is to implement biologically based conservation across priority landscapes through innovative partnerships. Partners have worked to conserve 2 million ha (5 million acres) of wetland ecosystems throughout North America. The U.S. Prairie Pothole Joint Venture (PPJV), a focus area of the NAWMP that encompasses eastern South Dakota in Region 2, has the primary goal of increasing waterfowl populations through habitat conservation projects (U.S. PPJV Implementation Plan Update <http://www.greatplains.org/npresource/2001/Impplan/IMPPLAN.HTM>; Accessed 14 March 2003). A second objective of this plan is to “*stabilize or increase populations of declining wetland/grassland-associated wildlife species in the Prairie Pothole Region, with special emphasis on non-waterfowl migratory birds*” (e.g., black terns).

Stewardship programs and incentives

Higgins et al. (2002) recommend accelerating wetland and grassland conservation with short- and long-term stewardship programs and incentives (e.g., conservation easements) to family ranchers as the last great chance to sustain the unique wetland-grassland character of the northern Great Plains. Managers are aware that a number of federal programs are available to protect, enhance, or restore wetland and grassland habitats. Among these programs are the “Partners for Fish and Wildlife” and “Landowner Incentive Program” implemented by the USFWS, the “Five Star Restoration Program” administered by the U.S. Environmental Protection Agency and the “Wetland Reserve Program” with oversight by the USDA Natural Resources Conservation Service, to name a few. These and other programs that have resulted in the protection of thousands of wetlands across Region 2 over the past few decades have undoubtedly benefited black terns.

In eastern South Dakota, easement and fee-title tracts (i.e., protected areas) encompass 13.9 percent (1.2 million ha) of land area and protect 19.8 percent of the wetlands (Naugle et al. 2001; data non-existent for the rest of Region 2). Naugle et al. (2001) found that 92.6 percent of wetlands suitable for mallards (*Anas platyrhynchos*) also provided suitable black tern habitat. Waterfowl conservation activities will constitute the primary mechanism for protection of non-target species

such as black terns until stable funding sources for a broad array of non-game taxa become available.

Biology and Ecology of the Black Tern

Systematics and species description

The black tern (*Chlidonias niger* Linnaeus 1758 [Order Charadriiformes, Family Laridae]) has a holarctic distribution with two subspecies: *C. niger niger* (European black tern) and *C. niger surinamensis* (Gmelin) (North American black tern) (Cramp 1985, Dunn and Agro 1995, American Ornithologists' Union 1998). The black tern is a small (23 to 26 cm, 50 to 60 g) dark tern (**Figure 2**), with blackish head, neck, and underparts (black in male than female), and greyish back, wings, and tail (whitish undertail coverts) in alternate (i.e., breeding season) plumage (Novak 1992, Dunn and Agro 1995, Shuford 1999). The bill is black, eyes are dark, and legs are dark reddish brown. In late summer and fall, underparts are blotched black and white during pre-basic molt (commonly seen in the late summer in Region 2). In basic (i.e., winter) plumage, the head, neck and underparts are white, and the upperparts are smoky grey (Shuford 1999). The juvenile bird has a white face, foreneck, breast and belly with an irregular black cap connected to a dark ear spot (**Figure 3**). First summer plumage (i.e., young of the year) is seen July through August in Region 2 and resembles adult basic plumage.

Distribution and abundance

In North America, black terns breed locally from the northern U.S. through central Canada (**Figure 4**; Peterjohn and Sauer 1997). Black terns are most abundant in high-density glaciated prairie wetland landscapes of Alberta, Saskatchewan, and Manitoba (Canada) and North Dakota, South Dakota, and Minnesota (U.S.) (Dunn and Agro 1995, Peterjohn and Sauer 1997). Breeding is sparse and patchy in the northeast and along the southern edge of the range (**Figure 4**; Dunn and Agro 1995). Although it still occupies most of its former range in the U.S., the black tern is now extirpated as a breeder from Missouri and Kentucky and nearly extirpated in Indiana and Pennsylvania (Robbins and Easterla 1992 and Palmer-Ball 1996 in Shuford 1999 State Reports). In Region 2, black terns are most abundant in the Prairie Pothole Region of eastern South Dakota (**Figure 4**) where Naugle et al. (2000) confirmed black terns nesting in 7.8 percent (32 of 412) of the semi-permanent wetlands surveyed. Black terns are less abundant but also breed in



Figure 2. Adult black tern in breeding plumage (incubating a nest).



Figure 3. Juvenile black tern near nest site.

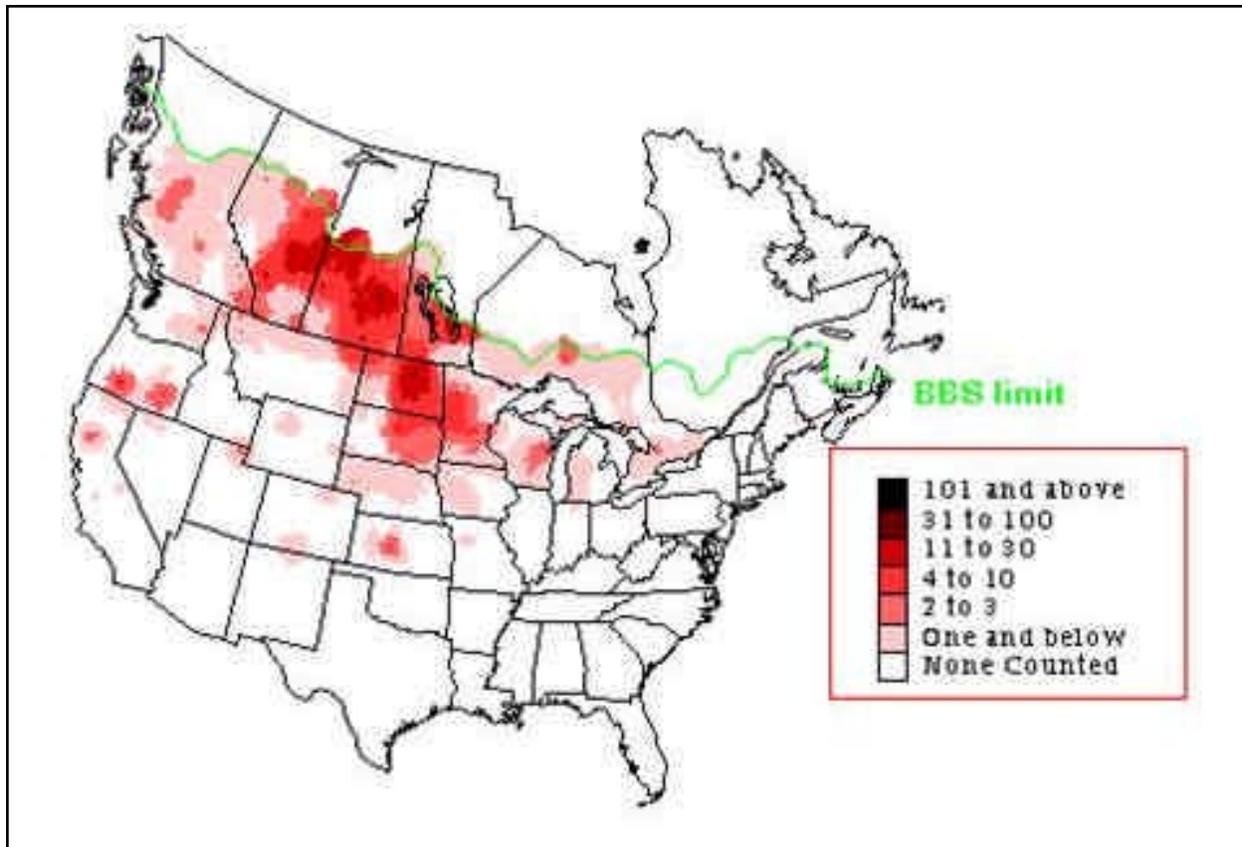


Figure 4. Relative abundance of black terns along Breeding Bird Survey routes in the United States and southern Canada (as shown in Peterjohn and Sauer [1997] and courtesy of Sauer et al. [2001]; USGS Patuxent Wildlife Research Center).

the Cheyenne Bottoms area of central Kansas, in north central and western Nebraska including the Sandhills, and in isolated pockets of Colorado and Wyoming (**Figure 4**).

Population estimate and trends

The North American Waterbird Conservation Plan provides the only available estimate of 100,000 to 500,000 breeding black terns in North America (Kushlan et al. 2002). This speculative estimate, derived from “the best professional judgment of species experts and information from the literature” (Kushlan et al. 2002), is conservative when compared to a statement by Shuford (1999) that the U.S. black tern breeding population is somewhere in the “low hundreds of thousands”. Shuford (1999) arrived at this estimate using the following information from the literature: 1) the largest breeding populations are likely in North Dakota (83,000 to 86,000 birds as estimated by Igl and Johnson 1997), South Dakota (see more on Peterjohn and Sauer [1997] below), and Minnesota (Baker and Hines 1996); 2) the greater extent of the breeding range in Canada vs. the

U.S. (**Figure 2**) and the large populations in the prairie provinces of Alberta, Saskatchewan and Manitoba (Dunn and Agro 1995, Peterjohn and Sauer 1997) suggest that the Canadian breeding population may be larger than that in the U.S.; and 3) an estimate of 2,873 to 14,996 breeding pairs in Ontario (Austen 1994) is the only regional estimate for any province in Canada that is suspected of holding thousands of breeding terns. In 1996, Cooper and Campbell (1997) found black terns colonizing new, managed wetlands and reported the outlook for the species in British Columbia to be quite encouraging. This scenario provides the reader an understanding of our meager grasp of the size of the black tern population in North America.

The best information on continental population trends (since 1966) is from the North American Breeding Bird Survey (BBS; Robbins et al. 1986). While the BBS is designed to survey passerine species, data are collected on all species encountered during surveys. Trends from the BBS are imprecise because 1) preferred wetland habitats are encountered infrequently along many BBS roadside routes; 2) semi-colonial

nesting habits concentrate black terns making effective sampling more difficult; and 3) black tern populations exhibit considerable annual fluctuations in response to water conditions (e.g., wet wetlands one year may be dry the next).

Although BBS trend estimates are imprecise for black terns, these data represent the only information available on the status and trends of the black tern at a broad geographic extent. While BBS trends are interpreted cautiously herein, they are substantiated with reasonable agreement using ancillary data (below). The BBS trend data indicate a survey-wide decline in black terns at an average rate of 3.1 percent annually (-61.1 percent total) from 1966 through 1996 (**Table 1** from Peterjohn and Sauer [1997]). Significant declines are indicated for the Eastern BBS Region, Canada, and survey-wide, while no populations experienced significant increases (**Table 1**). Long-term estimates reflect similar trends between 1966 and 1979 when most regions experienced significant declines and all significant trends in states, provinces, and physiographic strata were negative (**Table 1**). This time frame coincides with a period of extensive wetland losses over much of the range (Dahl 1990, 2000). Fewer declines are evident after 1980 (in Peterjohn and Sauer [1997]) when the only significant decline occurred in the Aspen Parklands of Canada, and black tern numbers increased significantly in the U.S. Black terns in Canada decreased at an average annual rate of -3.5 percent from 1980 to 1996, while the U.S. population showed no significant trend (Peterjohn and Sauer 1997).

The geographic distribution of population trends corresponds well with BBS trend estimates (**Figure 5**; from Peterjohn and Sauer [1997]). Declines prevail throughout most of the range, especially in the prairie provinces of Canada, where populations are large. Increases are centered from North Dakota across eastern Montana into parts of Saskatchewan, reflecting a non-significant increase in North Dakota between 1966 and 1996 (**Figure 5**). Reported increases in the northern Rocky Mountain region of British Columbia and the northern U.S. should be ignored because they are based on small sample sizes.

Peterjohn and Sauer (1997) also plotted annual indices as a way to evaluate temporal patterns in populations (**Figure 6**). Annual indices suggest survey-wide declines that are steepest through the mid-1970s, with more gradual declines continuing through the 1980s (**Figure 6A**), followed by a slight rebound after 1990. Populations in Alberta and Manitoba exhibit similar temporal patterns, while counts in

Saskatchewan exhibit considerable fluctuations but generally also have declined (**Figure 6B**). Populations in the U.S. display a somewhat different temporal pattern: a decline through the early 1970s, followed by stable trends in the 1980s, and then an increase after 1991 (**Figure 6C** and **Figure 6D**).

A temporal pattern likely exists between annual indices in the Aspen Parklands and Drift Prairie, two adjacent strata where black terns are most numerous during summer (**Figure 6E** and **Figure 6F**; Peterjohn and Sauer 1997). Populations in both strata generally declined through the 1980s, although counts in the more northerly Aspen Parklands exhibited considerable annual fluctuations (**Figure 6E** and **Figure 6F**). However, an increase in the Drift Prairie after 1991 corresponds with a decline of similar magnitude in the Aspen Parklands, particularly from 1991 to 1993 (**Figure 6E** and **Figure 6F**). By itself this pattern is uninformative, but when Peterjohn and Sauer (1997) compared the temporal pattern of change for black terns to that of mallards in the same region (**Figure 7**; $r = 0.74$, $P < 0.01$), together these correlative data suggest that regional changes in availability of suitable habitat is a factor related to declines in black tern populations.

A second comparison of temporal patterns of change in black tern populations and aerial May pond counts (i.e., index to wet wetland abundance) in the Canadian prairies (**Figure 8**; $r = 0.25$, $P < 0.05$; Peterjohn and Sauer [1997]) also suggests that settling patterns of black terns are related to habitat availability (see **Figure 9**; Niemuth and Solberg [2003] later in text for similar findings in the U.S.). Researchers in North Dakota have linked BBS data with digital wetland information to produce spatially explicit planning maps that depict locations of potential suitable black tern habitat across most of the state (N. D. Niemuth, unpublished data, with a map shown in Beyersbergen et al. 2004). Clearly, a priority information need, is to establish a black tern survey that would yield population and habitat information across the species range (see Inventory and monitoring and Information Needs sections).

Seasonal movement patterns

Breeding season

Variable wet-dry cycles in the northern Great Plains make prairie wetland conditions inherently unpredictable (Winter 1989). Displacement of dabbling ducks (*Anas* spp.) by drought has been well documented through increases in bird numbers north of the prairies and decreases on the northern prairie

Table 1. Breeding Bird Survey population trend estimates for black terns during three time periods for all states, provinces, strata and regions where they have occurred on >14 routes over the entire survey period (1966 to 1996). Trend is represented as average percent change per year (as published by Peterjohn and Sauer [1997]).

Area	1966-1996				1966-1979			1980-1996		
	Trend	P	N	R.A.	Trend	P	N	Trend	P	N
Alberta	-0.3	0.93	47	5.58	0.3	0.94	19	-3.2	0.08	43
Manitoba	-6.5	0.18	23	5.22	-7.8	0.30	10	-1.1	0.54	19
Minnesota	-2.4	0.55	40	1.97	-5.6	0.11	23	4.9	0.66	31
North Dakota	2.0	0.54	29	7.53	-13.0	0.01	14	9.2	0.19	27
Ontario	-3.2	0.67	19	0.18	-13.2	0.01	10	1.6	0.84	16
Saskatchewan	-4.3	0.09	45	9.46	-6.6	0.05	25	-1.7	0.53	32
South Dakota	-2.7	0.57	14	1.84	-31.4	0.06	13	14.3	0.01	12
Wisconsin	-2.3	0.46	26	0.63	-1.8	0.71	23	1.0	0.84	13
Great Lakes Plain	-8.8	0.06	16	0.30	1.2	0.88	15	-4.8	0.36	8
Great Lakes Transition	-2.4	0.54	23	1.86	-7.2	0.10	15	-2.7	0.63	20
Northern Spruce-Hardwoods	-6.1	0.22	18	0.10	-15.7	0.00	13	-0.6	0.95	7
Aspen Parklands	-3.7	0.07	79	9.30	-5.2	0.06	32	-3.4	0.04	68
Drift Prairie	-1.4	0.54	51	8.96	-12.3	0.00	32	9.6	0.07	42
Glaciated Missouri Plateau	1.5	0.84	25	2.89	-2.9	0.77	15	9.1	0.46	19
Black Prairie	-0.5	0.93	27	1.71	-7.2	0.17	16	9.1	0.49	21
Eastern BBS Region	-6.1	0.00	74	0.32	-7.9	0.01	52	-1.9	0.56	47
Central BBS Region	-2.0	0.23	103	2.56	-13.0	0.00	58	7.2	0.10	85
Western BBS Region	-2.7	0.21	128	2.90	-4.5	0.07	62	-0.7	0.71	101
United States	-0.9	0.55	154	1.24	-11.9	0.00	98	9.1	0.02	112
Canada	-3.5	0.04	151	2.83	-5.6	0.02	74	-1.9	0.23	121
Survey-wide	-3.1	0.04	305	1.97	-7.5	0.00	172	1.3	0.45	233

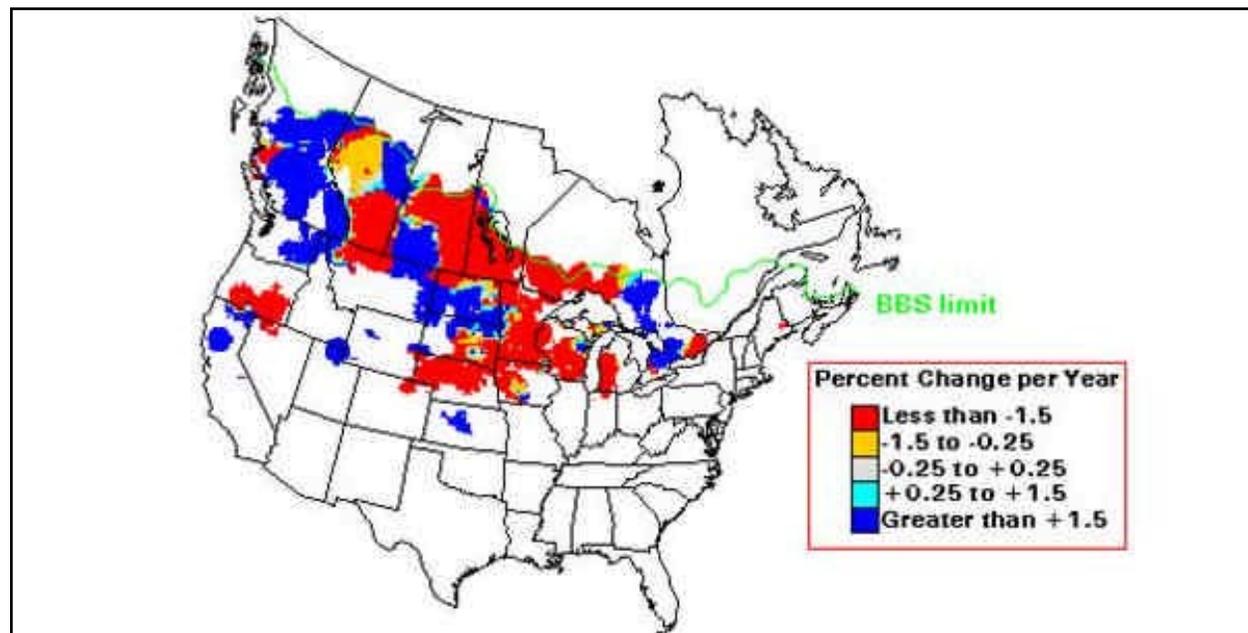


Figure 5. Population trends of the black tern, 1966 to 1996. The map presents regions of consistent population change, grouped into categories of declining, indeterminate, and increasing trends (as shown in Peterjohn and Sauer [1997] and courtesy of Sauer et al. [2001]; USGS Patuxent Wildlife Research Center).

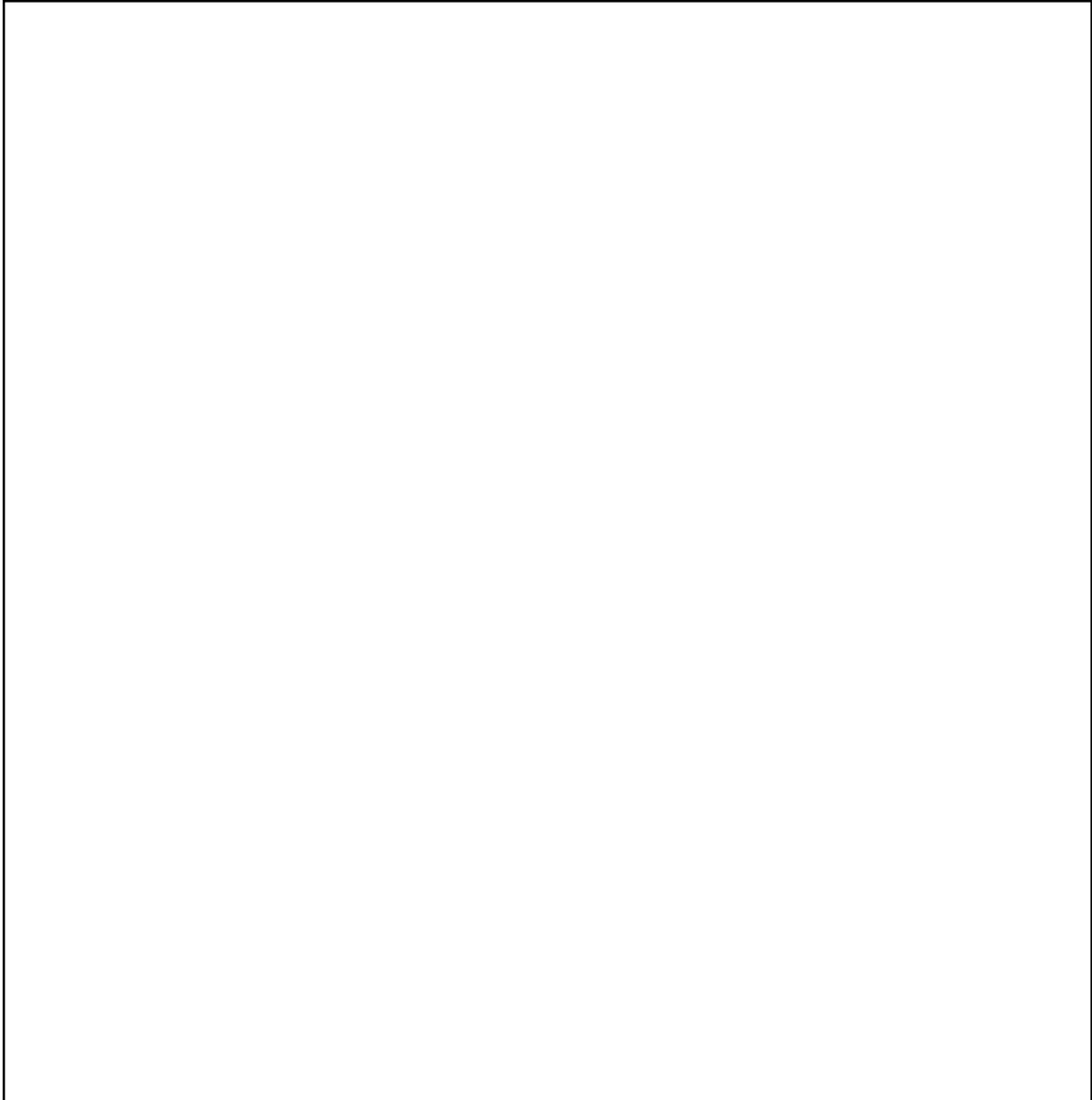


Figure 6. Breeding Bird Survey annual indices for black tern populations (from Peterjohn and Sauer 1997).

breeding grounds (Stewart and Kantrud 1973, Krapu et al. 1983). Depending on the severity of the drought in any given year, a portion of ducks may attempt to nest (Swanson and Duebbert 1989). However, female ducks that initiate nests in dry years do not persistently re-nest as they do in wet years (e.g., Pospahala et al. 1974). Instead, they join flocks of molting males early in the breeding season (Swanson et al. 1985). Although much less is known about how black terns respond to variable wet-dry cycles, low nest site fidelity is likely a similar function of annual fluctuations in wetland availability

(**Figure 7** and **Figure 8** in Peterjohn and Sauer [1997]; **Figure 9** in Niemuth and Solberg [2003]), vegetation height and density, and availability of suitable nest sites (Dunn and Agro 1995, Naugle et al. 2000). In eastern South Dakota, half (11 of 22 semi-permanent wetlands) of the sites where black tern nests were monitored in 1995 were devoid of birds in 1996 because available nest sites became inundated (Naugle et al. 2000). Although these birds likely nested elsewhere that year, a highly mobile species like the black tern that is suited to dynamic wetland conditions makes monitoring

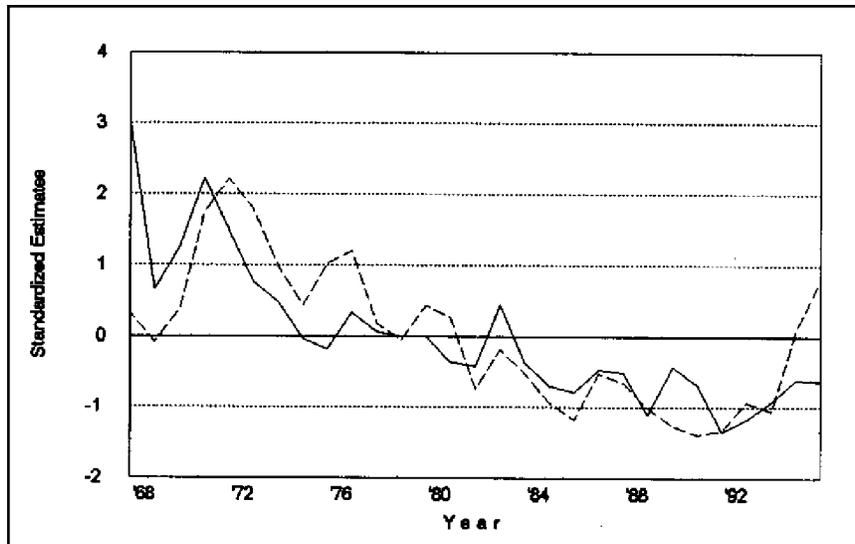


Figure 7. Temporal patterns of change for black tern (solid line; Breeding Bird Survey data) and mallard (dashed line; Breeding Season Aerial Survey) populations in the prairie provinces of Canada (from Peterjohn and Sauer [1997]).

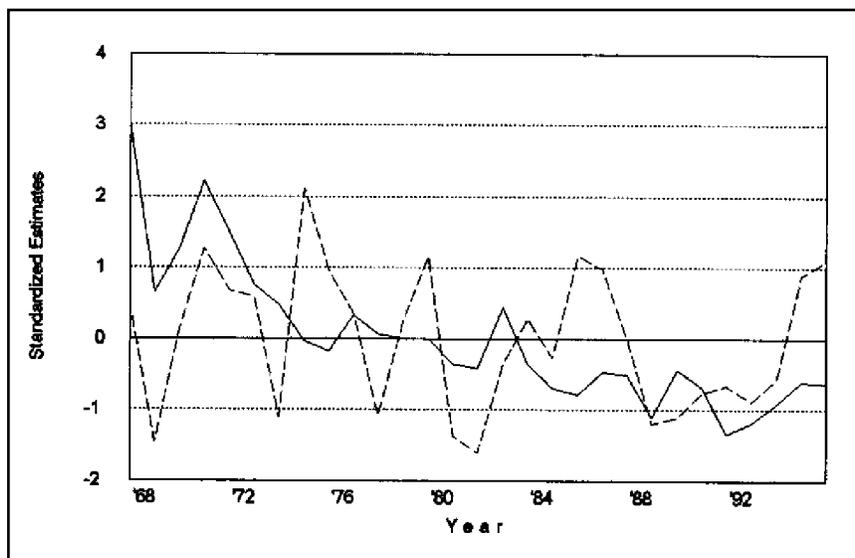


Figure 8. Temporal patterns of change for black tern (solid line; Breeding Bird Survey data) populations and wetland counts (dashed line; Breeding Season Aerial Survey) in the prairie provinces of Canada (from Peterjohn and Sauer [1997]).

population status and trends difficult. High variability in wetland hydrologic cycles also necessitates a broad scale approach to wetland protection to ensure that a steady-state of suitable wetland conditions exists somewhere within the region at all times (Naugle et al. 2000).

Migration

Migratory patterns and habitat use during migration are poorly understood and locations of pre-

migratory and migratory stopover sites are not well documented. The black tern ranked low on a scale of vulnerability to oil pollution in the Northeast Pacific because of the species' rarity there (King and Sanger 1979). However, a large oil spill or other catastrophic event (e.g., hailstorm) where large numbers of terns concentrate during migration or winter could dramatically affect population levels. During migration, black terns are present throughout the interior of North America south of the breeding range, along both coasts and the interior of Middle America, along the Atlantic

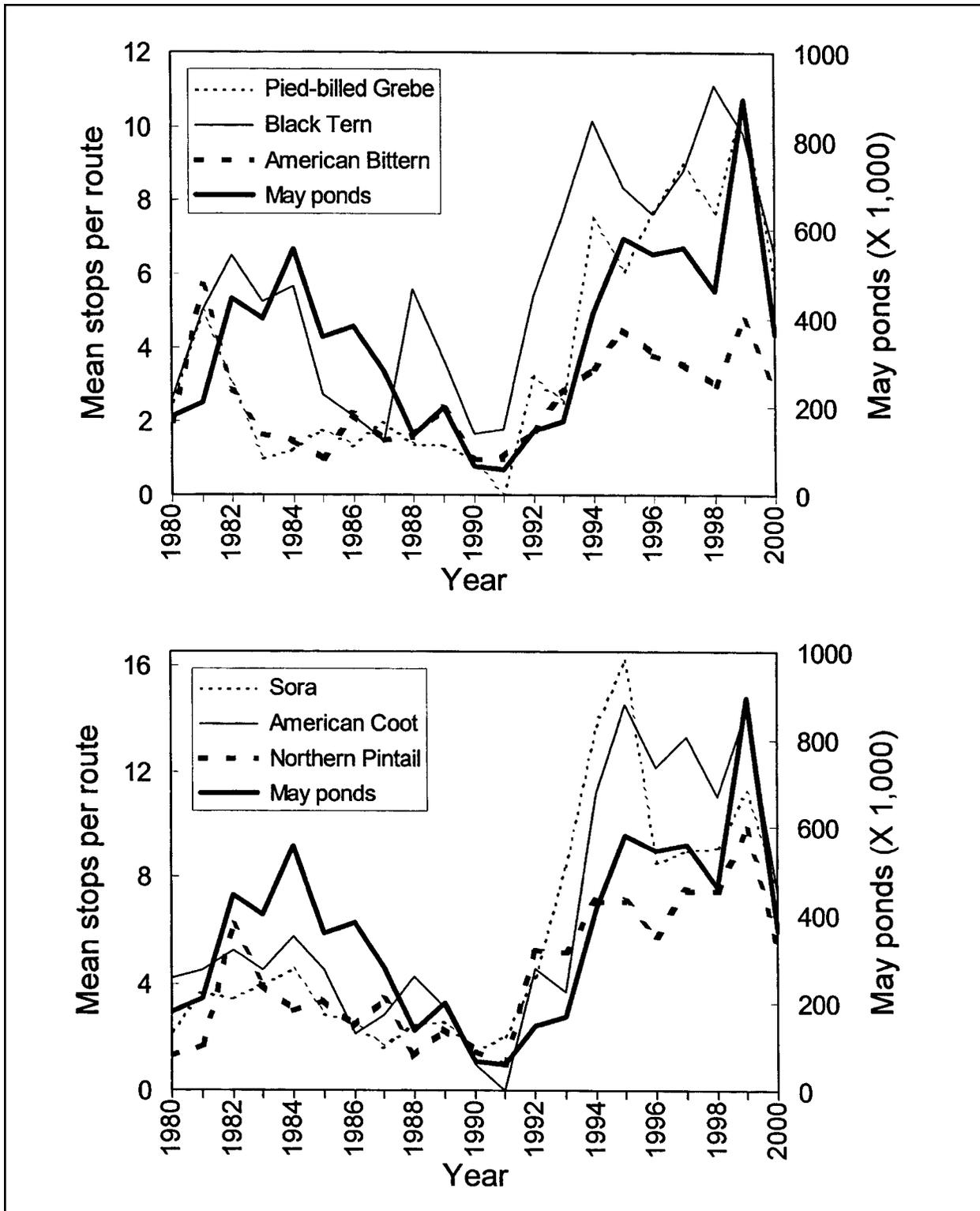


Figure 9. Estimated number of May ponds (Waterfowl Breeding Ground Population and Habitat Surveys [Smith 1995]) and population index (mean number of stops with birds per Breeding Bird Survey route) for six waterbird species in north-central North Dakota, 1980-2000 (from Niemuth and Solberg [2003]). Note the strong temporal correlation ($r = 0.68$) between May ponds and the number of black tern detections.

coast from Nova Scotia south to Florida, the West Indies, and Trinidad, and in northern South America east to French Guiana and south to Ecuador and Peru, and often far out at sea (Dunn and Agro 1995, American Ornithologists' Union 1998, Shuford 1999). The species is casual to accidental in the Hawaiian Islands, Alaska (Wrangell, and Walker Lake in the Brooks Range), Newfoundland, Prince Edward Island, Clipperton Island, Bermuda, Chile, Brazil, Uruguay, and northern Argentina (Shuford 1999).

Winter

Movements and habitat use of black terns during winter are poorly understood and important wintering locations are not well documented. Generally, in winter black terns are found in marine waters, mostly within <30 km of land (Dunn and Agro 1995, Shuford 1999). They are also found in coastal areas and productive freshwater lakes, usually near coastlines. This species winters mainly in marine and marine-coastal areas in the Americas along the Pacific Coast from southern Mexico east and south to Peru and on the Atlantic coast from eastern Panama east along northern South America to French Guiana (Dunn and Agro 1995, American Ornithologists' Union 1998). The species' abundance off the Pacific Coast is variable, with the Gulf of Panama an important area of concentration (Dunn and Agro 1995).

Black tern breeding biology

Black terns usually migrate to breeding areas in flocks of a few hundred birds, occasionally up to tens of thousands (Dunn and Agro 1995). Birds then spend one to several weeks at communal feeding and resting sites where courtship displays begin. A reasonable estimate for when birds disperse to nest wetlands in Region 2 is mid- to late May. Black terns have a monogamous mating system and typically nest semicolonally, clustering nests in favored marsh substrates (**Figure 10**; see Local and broad scale habitat section that follows). The number of clustered nests varies widely from two to hundreds of nests (average range 11 to 50 [Dunn and Agro 1995]) spaced an average of 5 to 20 m apart. Nests are small cups, which may be saturated with moisture, built on floating substrates of matted or decaying marsh vegetation, detached rotting masses, logs and boards, muskrat (*Ondatra zibethicus*) houses or feeding platforms, peat mats, lily pads, or abandoned nests of other species (e.g., grebes, American coot [*Fulica americana*]) (**Figure 11**; Shuford 1999).

Nest site selection and nest building are rapid, with the time from colony occupation to egg laying being as little as four days (Dunn and Agro 1995). A reasonable estimate of clutch initiation for Region 2 is late May to mid-June (Dunn and Agro 1995, D. Naugle, unpublished data). Initial nesting attempts are quite synchronized, but reneesting attempts frequently prolong the season (Bergman et al. 1970). Average clutch size is 2.6 ($n = 2,297$ as compiled by Dunn and Agro [1995]; but see Demography section for estimates from Servello [2000] that account for undocumented reneesting attempts in all studies reviewed by Dunn and Agro [1995]). Most nests hatch late June to early July and young fledge mid- to late July (Dunn and Agro 1995). Low nest site fidelity (Dunn and Agro 1995) is likely a function of annual variation in water conditions and vegetation structure, two factors that influence availability of suitable nest substrates (see Local and broad scale habitat section that follows). Nests and chicks are often lost to bad weather, wind and wave action, and changing water levels (Shuford 1999); however, these are uncontrollable natural events that have not likely been elevated above expected levels by humans.

Food habits

Black terns are primarily insectivorous on the breeding grounds where they capture insects at or near the water surface, but fish comprise a large part of the diet in some habitats (Dunn and Agro 1995). Both parents feed chicks and primary summer insect foods include damselflies (Odonata) and dragonflies, but also mayflies (Ephemeroptera), caddisflies (Trichoptera), beetles (Coleoptera), moths (Lepidoptera), dipterans, grasshoppers, crickets, amphipods and others (Dunn and Agro 1995 from [Cuthbert 1954, Goodwin 1960, Dunn 1979, Chapman-Mosher 1986]). Black terns also feed opportunistically on small fish (2 to 3 cm in length) in summer where available, but many palustrine wetlands have none. Food habits are related to breeding biology in that a male black tern will carry a small fish (or large insect) in his mouth while aerially displaying to a female during pair bond formation (commonly called a "fish flight" [Cuthbert 1954, Goodwin 1960, Dunn and Agro 1995]). During migration, black terns may concentrate on swarming insects, but dietary composition (frequency of insects versus fish) varies widely (Clapp et al. 1983). In winter, black terns in marine environments are largely piscivorous, foraging on small fish that are driven to the surface by predators (Dunn and Agro 1995). In European black terns, fish may dominate the diet by mass and provide an important source of calcium (Beintema 1997).



Figure 10. Typical setting where a black tern might build a nest on floating dead cattails or atop a muskrat (*Ondatra zibethicus*) house.



Figure 11A. Black tern nests built on vegetative substrates in deep water.



Figure 11B. Black tern nests built on vegetative substrates in shallow water.

Local and broad scale habitat

The black tern nests in shallow, highly productive freshwater wetlands with emergent vegetation (e.g., palustrine emergent wetlands, edges of riverine systems). Nest wetlands occur most commonly in open grassland landscapes, but may be located in forested systems at elevations between 1220 and 2000 m (Campbell et al. 1990 and Shuford 1998 in Shuford 1999). Although they may nest in a forested system (much more rare), black tern wetland use in grassland landscapes decreases as the extent of woody vegetation encompassing wetland perimeter increases (Naugle et al. 1999a). Faanes and Lingle (1995) and Shutler et al. (2000) also note the negative effects of woody plant encroachment on black terns. Palustrine emergent semi-permanently flooded wetlands (i.e., PEMF; Cowardin et al. 1979) are the most commonly used wetland type for nesting (72 percent of nests in North Dakota [Stewart and Kantrud 1984] and 94 percent in South Dakota [Naugle et al. 2000] were found in this wetland type). Although black terns in eastern South Dakota foraged extensively in an additional 6.9 percent (29 of 418) of seasonally-flooded wetlands (PEMC; Cowardin et al. 1979), they nested in only two (Naugle et al. 2000).

Local habitat

Weller and Spatcher (1965) describe the hemi-marsh stage (50:50 open water to emergent vegetation) as a point in the wetland cycle that provides optimal nesting opportunities for most wetland obligate species including black terns. Numerous other studies also report that black terns select wetlands in the hemi-marsh stage for nesting (Tilghman 1980, Hickey and Malecki 1997, Mazzocchi et al. 1997). Using a vegetation profile board (Nudds 1977, Haukos et al. 1998) to compare height and density of emergent vegetation at nest and random wetlands, Naugle et al. (2000) also reconfirmed that suitable nesting substrates occur within regenerating or degenerating wetlands. More importantly, analyses of local vegetative conditions within wetlands also indicate that vegetation structure, rather than species of emergent vegetation, largely dictates suitability of substrates for nesting black terns. During nest construction, use of floating dead and/or standing live vegetation including, but not limited to the following species are common: cattails (*Typha* spp.), bulrushes (*Scirpus* spp.) rushes (*Juncus* spp.), sedges (*Carex* spp.), burreed (*Sparganium* spp.), spikerushes (*Eleocharis* spp.), pickerelweed (*Pontederia* spp.), smartweeds (*Polygonum* spp.), reed-canary grass (*Phalaris arundinacea*), arrowhead (*Sagittaria* spp.), spatterdock (*Nuphar* spp.), water lilies (*Nymphaea*

spp.), wild rice (*Zizania aquatica*), and others (e.g., Dunn and Agro 1995).

Naugle et al. (2000) found that height and density of vegetation were lower at random and at nest sites within colonies than at random sites outside colonies, indicating that black terns typically nest in more sparsely vegetated areas. An interaction between vegetation height and density within nest sites also indicated that black terns nest in either short-dense or tall-sparse vegetation (Naugle et al. 2000). Either type of vegetation structure provides black tern chicks with refuge from aerial predators (Chapman-Mosher 1986, Dunn and Agro 1995, Hickey and Malecki 1997) and affords adults rapid aerial access for defending nests. Dense, monotypic stands of cattail, which often form in wetlands in agricultural landscapes (Kantrud 1986), severely reduce wetland habitat suitability at a local scale (Linz and Blixt 1997). Although philopatry in black terns is considered low (Dunn and Agro 1995), wetlands support breeding black terns in consecutive years when favorable marsh conditions persist (Naugle et al. 2000).

Numerous competing hypotheses have been formulated to explain nest site selection, but manipulative experiments to test hypotheses are lacking. Suitable sites shelter nests from wave action, provide escape cover for flightless young, and provide cover for incubating adults without reducing their ability to detect approaching predators (Chapman-Mosher 1986, Dunn and Agro 1995, Hickey and Malecki 1997). Likewise, dense vegetation is usually avoided because adults lack rapid aerial access to defend nests (Naugle et al. 2000). Hickey and Malecki (1997) surmised that black terns seek optimal locations away from edges of water and uplands to reduce effects of predators and wave action. Water depth at nest sites is highly variable (**Figure 11**) with no clear link to habitat suitability (Brown and Dinsmore 1986, Stern 1987, Hickey and Malecki 1997, Mazzocchi et al. 1997). Bergman et al. (1970) and Dunn (1979) found little evidence of relationships between habitat characteristics at nest sites and black tern nest success. Despite a myriad of competing hypotheses, the need for adequate nest substrate is well known (Weller and Spatcher 1965, Bergman et al. 1970, Chapman-Mosher 1986, Dunn and Agro 1995, Beintema 1997).

Broad scale habitat

Most black tern habitat research has focused on local habitat issues (e.g., vegetation in and around nest site) without regard to the role of broad scale factors in evaluations of habitat suitability. Conservation planners

confronted with preserving entire ecosystems require broad scale studies that direct wetland conservation over broad geographic regions to complement what has been learned at local scales. Pioneering research by Brown and Dinsmore (1986), involving 30 wetlands in northwest Iowa, demonstrated that black tern habitat use was related positively to wetland area (i.e., area-dependent species) and negatively to isolation of wetland habitat (also see Tyser [1983] for marsh bird species-area relationships). In Iowa's remnant wetland landscapes, Brown and Dinsmore (1986) found that black terns were absent from wetlands <5 ha in area and were absent from >50 percent of wetlands surveyed, except those in the largest size class (>20 ha in area). Of 17 waterbird species surveyed, black tern occupancy rates were most greatly affected by wetland isolation, decreasing 90 percent in wetlands intermediate in size (11 to 20 ha; Brown and Dinsmore 1986). As a result, they recommended that additional wetland acquisitions be juxtaposed to existing wetland complexes for maximum habitat benefits. Brown and Dinsmore (1986) also recommended that complexes be large enough to include different stages of Weller and Spatcher's (1965) marsh cycle. Similarly, Naugle et al. (1999a) reported that black terns did not use semi-permanent wetlands <3 ha in size despite the presence of a vegetative hemi-marsh condition in non-glaciated landscapes in western South Dakota; black terns bred in 30 percent, 50 percent and 36 percent of semi-permanent wetlands that were 3 to 9.9, 10 to 20, and >20 ha in size, respectively. Large concentrations of breeding black terns have been recorded in semi-permanent wetlands >20 ha in size in the Sandhills of Nebraska (D. Naugle, unpublished data).

Naugle et al. (1999c, 2000, 2001) further investigated the importance of broad scale habitat features by integrating remotely sensed wetland and land cover data with a black tern habitat suitability model. The model was developed using nest survey data from 834 seasonal and semi-permanent wetlands in eastern South Dakota that were stratified by physiographic domain, wetland density and wetland area. Analyses indicated that black terns were an area-dependent species that occupied large ($x = 18.9$ ha) wetlands located within high-density wetland complexes. Rather than simply concluding that black terns use large wetlands without considering variability in broad scale habitat features, Naugle et al. (1999c, 2000) found that size of wetlands used by black terns was related to characteristics of the surrounding wetland complex. Black terns used smaller (6.5 ha) wetlands located in high-density wetland landscapes (**Figure 12**; landscape type *d*) composed of large

and small wetlands more than those in homogeneous landscapes containing predominately large (landscape type *c*; 15.4 ha area) or small wetlands (landscape type *b*; 32.6 ha). Low wetland density landscapes (landscape type *a*) composed of primarily small wetlands, where few semi-permanent wetlands occur and potential food sources are spread over large distances, were not widely inhabited by black terns. This is important because wetlands that do not correspond to broad scale habitat requirements may not be suitable despite favorable local conditions.

Relationships between broad scale features and habitat suitability also indicated that black terns were less likely to nest in wetlands within landscapes where >50 percent of grasslands were tilled for agricultural production. At first glance, this relationship is less intuitive than those directly involving wetlands because black terns nest over water. However, recent advances in the field of landscape ecology (Turner 1989, Turner and Gardner 1991, Forman 1995) indicate that the matrix (e.g., adjacent uplands) often influences ecosystem function by altering within-patch (e.g., wetland) dynamics. In northern prairie ecosystems, pesticide and fertilizer runoff and siltation from agricultural lands alter wetland vegetation composition (Kantrud 1986, Gleason et al. 2003) and reduce invertebrate abundance (Novak 1992, Dunn and Agro 1995, Gleason et al. 2003). Naugle et al. (2000) speculated that grassland abundance was a surrogate measure reflecting the negative impacts of agricultural activities on potential black tern nest wetlands. Findings of Beintema (1997), who indicated that agricultural tillage decreases diversity of invertebrate forage available to wetland avifauna, reinforce the contention that human-induced modifications in upland habitats influence processes within wetlands.

When Naugle et al. (2000, 2001) linked their model with locations of 14,840 easement and fee-title (protected wetlands) tracts, they found that acquisitions intended to protect habitat for waterfowl also protected 45 percent of wetlands suitable for nesting and foraging black terns in the glaciated portion of Region 2. Naugle et al. (2001) warn managers that those who view wetlands as individual, disjunct patches quickly devalue the importance of small wetlands as suitable habitat because a single large wetland may contain more species than one of smaller size. When viewed as components of a larger landscape, however, small wetlands increase the suitability of wetland landscapes for nesting black terns. Modeling simulations indicate that the loss of small wetlands to further drainage would decrease the suitability of larger remaining wetlands

(Naugle et al. 2001). As a result, Naugle et al. (2000, 2001) recommend that wetlands be acquired not only to consolidate suitable habitat within protected core areas but also to ensure that core areas coalesce to preserve connectivity among regional wetland landscapes.

Demography

The limited demographic work on black terns to date has focused primarily on monitoring the nesting and hatching success at individual colonies (all local scale studies; Bergman et al. 1970, Bailey 1977, Chapman-Mosher 1986, Einsweiler 1988, Laurent 1993, Hickey 1997, Mazzocchi et al. 1997). This focus was likely based on the notion that breeding success was the major factor responsible for the species decline and because other vital rates (i.e., survival, reneating, fledging success) are more difficult to estimate. Although nest success estimates vary markedly (e.g., range = 0.29 to 0.96 [Servello 2000]), previous studies were not designed to regionally assess limiting factors that influence population demographics. Servello (2000) published the only existing model to evaluate sensitivity of population growth rate for North American black terns using vital rate estimates from the literature. As a result, text in this section largely reflects findings from Servello (2000), the only population-level information

that also incorporates what we know about demography of black terns on a local scale.

Servello (2000) used a deterministic age-structured model to rank the influence of reproductive and survival variables on black tern population growth rate (r). Baseline estimates used in Servello (2000; **Table 2**) and the reported variability in estimates capture the current state of knowledge for the following demographic variables: black tern nest success (**Table 3**), clutch size (**Table 4**), hatching rate, reneating rate, proportion of two-year-old terns breeding, chick survival to fledging (**Table 5**), annual sub-adult survival and annual adult survival.

Nest success and clutch size

Nest success rates are well known relative to other vital rates and range widely from 0.29 to 0.96 (**Table 3**). A potential bias exists in estimates because initial and replacement nests, which may have different success rates, are pooled in unknown proportions in previous studies (**Table 3**). Servello (2000) used 0.50 as the baseline estimate (**Table 2**) in his model. Most estimates of annual clutch size are between 2.7 to 2.9, with four lower estimates of 2.4 to 2.6 (**Table 4**). Dunn and Agro (1995) calculated overall average clutch size of 2.6

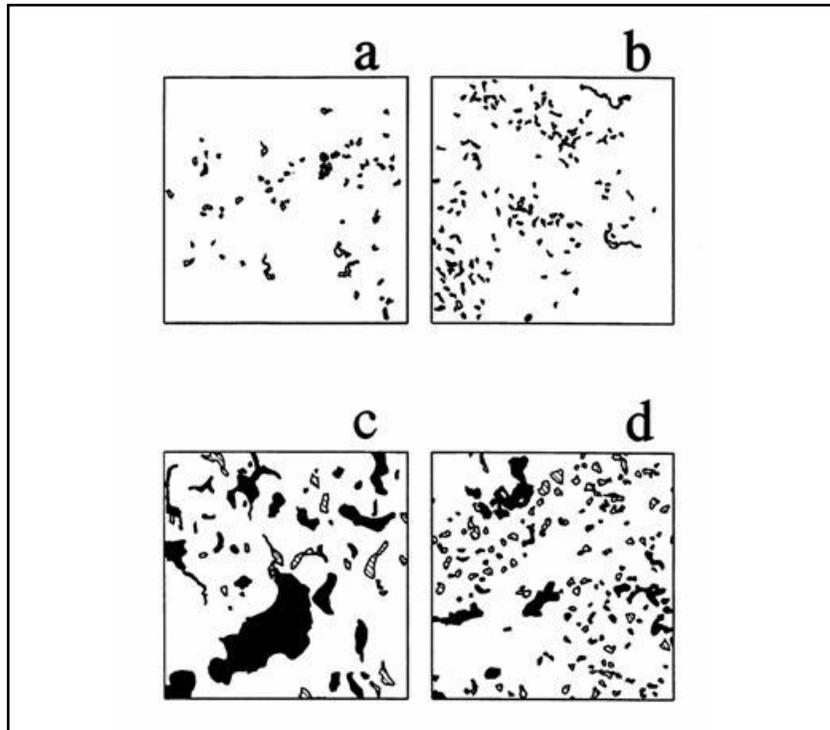


Figure 12. Examples of four landscape types that characterize structure of the wetland community surrounding surveyed wetlands. Solid polygons depict semipermanent wetlands while hatched polygons are seasonal wetlands. Each square is 25.9-km² (10-mi²) in area (as shown in Naugle et al. [1999c]).

Table 2. Baseline values and ranges for model parameters used in a population model for black terns (as modified from Servello [2000]).

Parameter	Baseline value	Range
Nest success	0.5	0.29-0.96
Clutch size of initial nest	2.8	2.60-2.96
Clutch size of renests	2.38	2.21-2.52
Hatching rate	0.89	0.77-0.95
Renesting rate	0.5	
Chick survival to fledging	0.44	0.20-0.67
Sub-adult survival	0.57	
Adult survival	0.87	0.69-0.88
Longevity (age class)	17-18	
Proportion of two-year-old terns breeding	1.00	

Table 3. Estimates of nest success (proportion of nests with ≥ 1 hatched egg) for black terns in studies that reported on >25 nesting attempts (adapted from Servello [2000]).

Location	Number of years	Number of nests (range)	Estimate of annual nest success (range)	Source
British Columbia	4	0.67 to 0.96	28 to 105	Chapman-Mosher (1986)
Minnesota	1	0.71	63	Laurent (1993)
Wisconsin	1	0.34	38	Bailey (1977)
Iowa	1	0.29	192	Bergman et al. (1970)
New York	2	0.36 to 0.46	59 to 100	Mazzocchi et al. (1997)
New York	2	0.45 to 0.46	49 to 52	Hickey (1997)

Table 4. Clutch size estimates for black terns (from Servello [2000]).

Location	Number of years	Number of nests (range)	Estimate of annual nest success (range)	Source
New York	2	2.8 to 2.9	59 to 100	Mazzocchi et al. (1997)
New York	2	2.85 to 2.87	50 to 55	Hickey (1997)
New York	1	2.6	50	Goodwin (1960)
New York	1	2.6	24	Firstencel (1987)
Wisconsin	1	2.91	41	Bailey (1977)
Iowa	1	2.6	151	Bergman et al. (1970)
Michigan	2	2.91 to 2.96	74 to 99	Einsweiler (1988)
British Columbia	4	2.4 to 2.9	28 to 105	Chapman-Mosher (1986)

using pooled data from 10 studies. Servello (2000) uses 2.8 as a baseline value with a range of 2.60 to 2.96 for the clutch size of original nesting attempts (**Table 2**). This baseline value is higher than that reported in Dunn and Agro (1995) to account for undocumented renesting attempts in all studies reviewed.

Hatching rate and renesting

Information on the proportion of eggs laid that hatch is poor for black terns. The two reported estimates

are 73 percent (Hickey 1997) and 89 percent (Bailey 1977). Hickey (1997) states that 73 percent may be a low estimate because of limited monitoring. Estimates for other tern species vary widely such as Nisbet et al. (1990) who studied roseate terns (*Sterna dougallii*) and reported that the proportion of eggs laid that hatch varied from 77 to 95 percent over four years. Servello (2000) used a baseline value of 89 percent and a range of 77 to 95 percent (**Table 2**). Renesting by black terns appears to be common (Bergman et al. 1970, Bailey 1977, Chapman-Mosher 1986). However, little quantitative

Table 5. Estimates of chick survival rate (hatch to fledging) for black terns and other *Sterna* species (adapted from Servello [2000]).

Species	Chick Survival Rate	Number of estimates or years	Source
Black tern	0.48	1	Hickey (1997)
Black tern	0.31 to 0.64 ¹	2	Einsweiler (1988)
Black tern	0.12	1 ²	Bailey (1977)
Black tern	0.55 to 0.67	4	Chapman-Mosher (1986)
Common tern	0.19	1 ²	McKernan and Cuthbert (1989)
Common tern	0.22 to 0.45	2	Morris et al. (1976)
Common tern	0.54 to 0.61 ³	2	Safina et al. (1988)
Common tern	0.61 to 0.89	3	Langham (1972)
Roseate tern	0.76 to 0.95 ³	2	Safina et al. (1988)
Least tern	0.27 to 0.83 ³	4	Smith and Renkin (1993)
Gull-billed tern	0.46	1 ⁴	Eyler et al. (1999)

¹Based on a 27-day nestling period, which is excessive (Dunn and Agro 1995) and would make these values underestimated.

²Two years pooled.

³Calculated from mean number of fledglings per nest/mean number hatched per nest by author.

⁴Three years pooled.

data exist on renesting efforts because late-nesting and renesting pairs cannot be distinguished without marked birds (Massey and Atwood 1981, Mazzocchi et al. 1997). Servello (2000) found the best information exists for *Chlidonias niger niger* where Macikunas (1993) reported that there were no replacement clutches laid by adults that lost clutches after the midpoint of incubation or in the last one-third of the breeding season. The average relay interval was short (8 days, range = 3 to 15 days), and while second replacement clutches were rare, they did occur. Given the uncertainty of this estimate, Servello (2000) examined effects of renesting rate on conclusions derived from sensitivity analysis of other vital rates. He reduced the baseline value and range for clutch size of initial nests by 15 percent and had to assume that nest success, hatching rate, and tern survival were equal for all nests due to a lack of field data.

Chick, sub-adult and adult survival

Three of four reports of chick survival in black terns are biased (Bailey 1977, Chapman-Mosher 1986, Einsweiler 1988) because nest enclosures prevented normal brood movements to cover (Goodwin 1960) and in one case the enclosure may have increased mortality (Bailey 1977). Servello (2000) used a minimum value of 0.20 for chick survival based on approximate lower estimates for common terns (*Sterna hirundo*; McKernan and Cuthbert 1989) and least terns (*Sterna antillarum*; Smith and Renkin 1993) terns and a maximum value of 0.67 reported by Chapman-Mosher (1986). The midpoint baseline value used in Servello (2000) was

0.44, which was similar to that reported by Hickey (1997). Servello (2000) used data for other tern species because there are no data on sub-adult or adult survival in black terns. Baseline sub-adult survival used in models was 0.57 (assumed to be equal for initial-nesting and renesting pairs) and adult survival was 0.87 (range = 0.69 to 0.88).

Longevity and age at first breeding

Only scant data exist for longevity and age at which black terns first breed (Servello 2000). For models, Servello (2000) assumed a conservative longevity of 17 years but also examined sensitivity of *r* to this assumption. Existing evidence indicates that few one-year-old black terns return to the breeding grounds and that returning two- to three-year-old individuals do not always breed (**Figure 13**; Cramp 1985). Inconsistent effort in the first year on the breeding grounds is common in other tern species (see summary by Servello [2000]). In the absence of quantitative data, Servello (2000) assumed that all two-year-old terns breed, but also evaluated the importance of this assumption with sensitivity analyses (**Figure 13**).

Sensitivity analyses

Servello (2000) began his model with a population of 1,000 females and a stable age distribution calculated from a life table analysis. Sensitivity was estimated using percent change in *r* resulting from a 10 percent increase in a variable's value and percent change in *r*

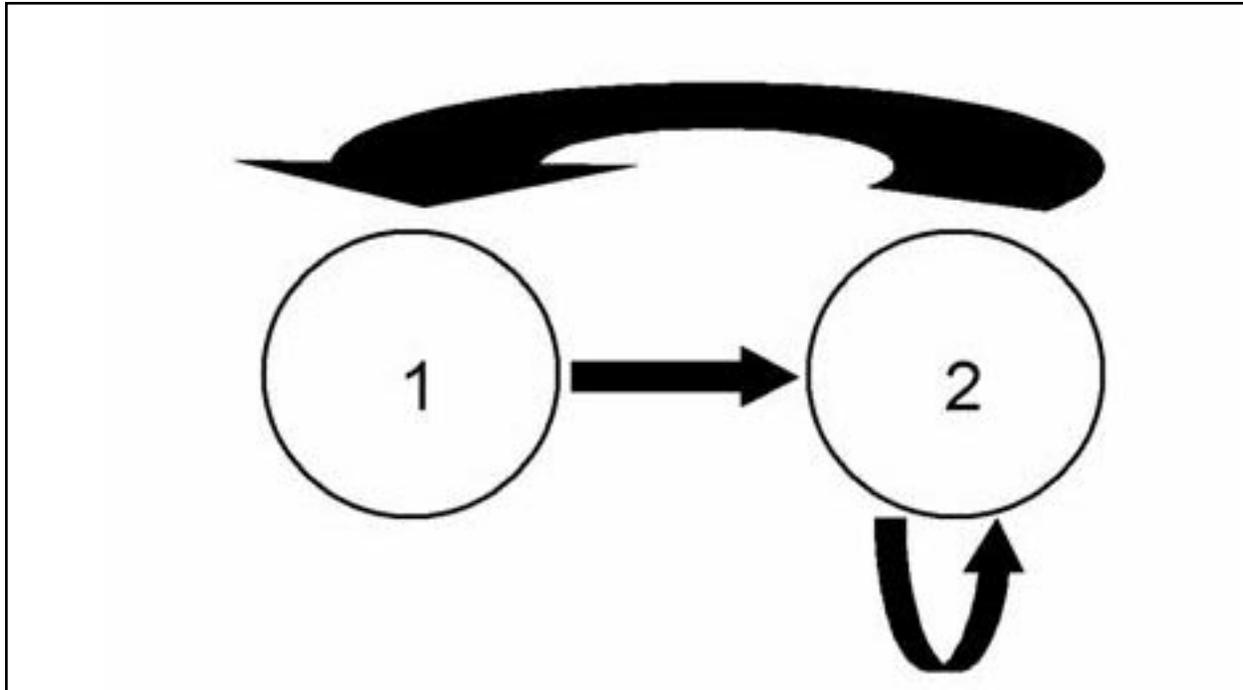


Figure 13. Life cycle diagram for the black tern where age class 1 is juveniles (0 to 1 year of age) and age class 2 is adults (>1 year of age). Arrows connecting life stages (circles) represent vital rates in the matrix model. Note the absence of a feedback loop for class 1 because juvenile black terns do not return to breed until 2 years old. The model by Servello (2000) also allowed for variation in the breeding rate of two-year-old black terns because those returning to breeding colonies for the first time may not breed (see text for model details).

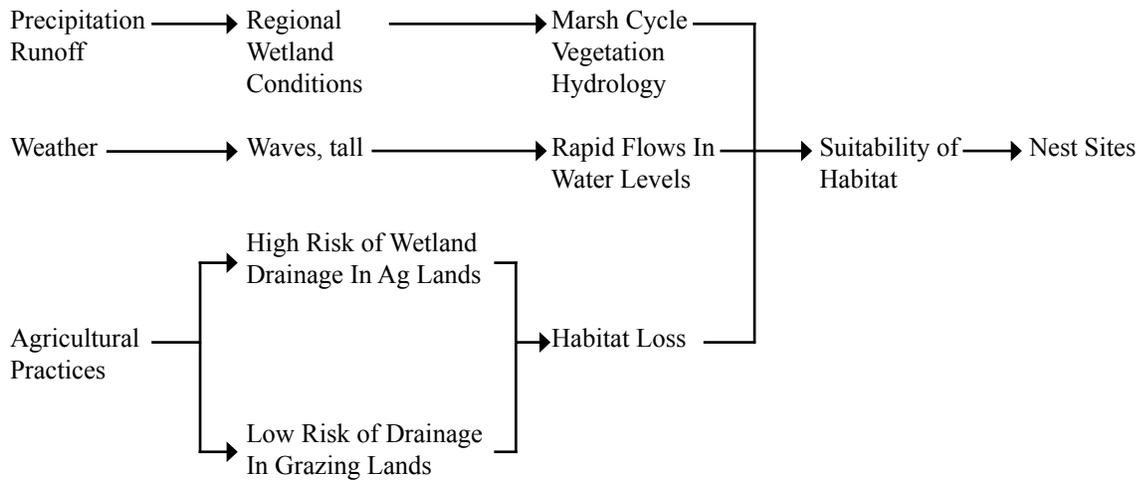
resulting from an increase in the value of a variable by an increment equal to 10 percent of the range of field estimates for that variable (Caswell 1989). When parameter estimates were changed equally in sensitivity analyses (10 percent change from baseline), population growth rate was more sensitive to adult (168 percent increase in r) and sub-adult survival (62 percent) than to reproductive estimates (4 to 31 percent; Servello [2000]). This finding indicates that survival is likely a key component in maintaining populations of this long-lived species. However, this difference was generally less (33 to 38 percent) when sensitivity was measured relative to the typical variation in estimates in wild populations. In the latter case, nest success and chick survival rates were highly variable in black terns and more variable than adult survival rates for terns in general, which resulted in similar sensitivity estimates for these three parameters and suggests they all have high potential for influencing growth rates in black terns (Servello 2000). Servello (2000) represents the most comprehensive sensitivity analysis possible, and points out the current lack of knowledge in many areas. Despite uncertainties, his findings are consistent with the natural history of a long-lived species. Until information gaps are filled and new analyses indicate otherwise, findings from Servello (2000) reiterate the importance of broad

scale habitat conservation to provide options for birds at vital life stages.

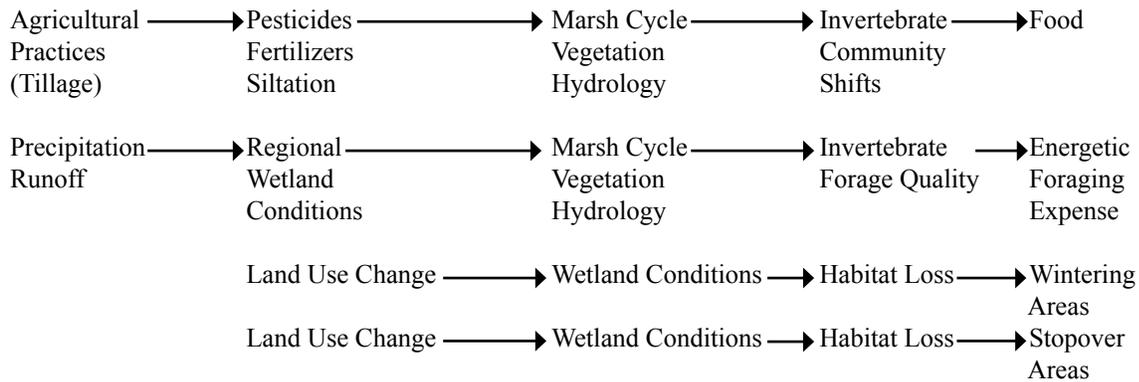
Community ecology

Relationships between black terns and other members in their community are poorly understood because most research has not focused on interactions with other species. The following discussion highlights what little is known. The envirogram in **Figure 14** (after Andrewartha and Birch [1984]) illustrates the known pathways between black terns and their environment. The literature provides little conclusive evidence of the effects of predation on black tern populations. Anecdotal information suggests that avian and mammalian species such as American crow (*Corvus brachyrhynchos*), common raven (*Corvus corax*), great horned owl (*Bubo virginianus*), ring-billed gull (*Larus delawarensis*), mink (*Mustela vison*), raccoon (*Procyon lotor*), long-tailed weasel (*Mustela frenata*) and others prey upon nests (Novak 1992, Dunn and Agro 1995), but no comprehensive research has been conducted on this topic. Novak (1992) postulated a cumulative effects scenario whereby the degradation of remaining black tern habitat could alter food webs and vegetative structure of wetlands. Most recently, Gleason et al.

RESOURCES



MALENTITIES



PREDATORS



BLACK TERN

Figure 14. An envirogram that outlines processes affecting the black tern. Processes are divided in three centra: 1) resources are processes that influence habitat suitability, 2) malentities are items that negatively impact the bird without harming themselves, and 3) predators increase their own fitness at the expense of the bird.

(2003) found through sediment-load experiments that burial depths of 0.5 cm caused a 92 percent reduction in total seedling emergence and a 99 percent reduction in total invertebrate emergence. Gleason et al. (2003) corroborates the evidence from Europe (Beintema 1997) that perturbations in upland habitats (e.g., tillage) decrease diversity of invertebrate forage in wetlands for black terns. A reduction in wetland plant diversity also makes wetlands more susceptible to invasions of exotic species such as purple loosestrife (*Lythrum salicaria*). Whitt et al. (1999) in Michigan found that purple loosestrife-dominated wetland habitats supported higher passerine bird densities, but lower overall avian diversity than other wetland vegetation types. Whether black terns would readily nest in loosestrife-dominated

wetlands is unknown, but once established purple loosestrife is difficult to control and almost impossible to eradicate (Malecki et al. 1993). Gleason et al. (2003) call for land management strategies that prevent erosion of cropland topsoil from entering wetlands.

CONSERVATION

Threats

Habitat loss of remaining wetlands

Loss of remaining wetland habitats for agriculture or other development is the greatest threat to black tern conservation. The newest wetland status and trends

report (Dahl 2000) indicates that 54 percent of wetlands in the conterminous U.S. have been lost. The five states within Region 2 are representative of the rest of the country, having lost an estimated 35 to 50 percent of their historic wetlands (Colorado [50 percent], Kansas [48 percent], Wyoming [38 percent], Nebraska and South Dakota [35 percent each]). The pace of wetland loss in the U.S. has slowed. Net annual wetland losses from 1985 to 1995 averaged 47,370 ha (117,000 acres), a pace of loss 60 percent lower than from the mid-1970s to the mid-1980s and 74 percent lower than from the mid-1950s to the mid-1970s (Tiner 1984, Dahl 2000). The periods of greatest wetland losses coincide with the greatest known declines in black tern populations (Peterjohn and Sauer 1997; see Population estimate and trends section). Freshwater emergent wetland, the principle habitat type for black terns, has declined by the greatest percentage (-25 percent or 3.3 million ha) of any freshwater wetland type (Dahl 2000). Wetland loss in southern Canada appears to be of similar magnitude to that in the U.S. (Gerson 1988 as cited by Shuford 1999). The threat beyond that of outright habitat loss is that cumulative impacts of drainage degrades an otherwise favorable complex of wetlands (e.g., suitable wetland vegetation in some ponds) to the point that black terns no longer perceive it as suitable breeding habitat (Naugle et al. 2000).

Inadequacy of regulatory mechanisms and conservation measures

Policy and regulatory mechanisms that protect wetlands from drainage are not secure, but rather they are frequently the topic of fierce legislative debate and legal action. Wetland protection laws were further eroded in January 2001. Prior to January 2001, Section 404 of the Clean Water Act assigned authority to the U.S. Army Corps of Engineers to issue permits for the discharge of dredge or fill material into “waters of the United States”, effectively providing federal protection for almost all the nation’s wetlands (Petrie et al. 2001). On 9 January 2001 the U.S. Supreme Court issued a judgment dubbed the SWANCC decision (Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers) that reduced protection of “isolated” wetlands under Section 404 of the Clean Water Act. The Court interpreted that Corps jurisdiction is not “waters of the United States”, but rather is restricted to navigable waters, their tributaries, and wetlands that are adjacent to navigable waterways and tributaries. This decision left “isolated” wetlands unprotected. In Region 2, Tiner et al. (2002) estimated from samples of digital National Wetland Inventory data that 80 to 98 percent of wetlands (predominantly Palustrine emergent wetlands

[Cowardin et al. 1979]) were “isolated” in the Prairie Pothole Region of eastern South Dakota (98 percent isolated), the Rainwater Basin in Nebraska (84 to 85 percent) and the Black Thunder area in Wyoming (80 to 81 percent). The U.S. Supreme Court further concluded that the use of migratory birds (such as black terns that use multiple “isolated” wetlands within a season) to assert jurisdiction exceeds the authority that Congress had granted the U.S. Army Corps of Engineers under the Clean Water Act (van der Valk and Pederson 2003).

Importance of the Food Security Act

The most important federal provision for wetlands protection following the SWANCC decision is the 1985 Food Security Act as amended in 1990 and 1996 (commonly known as the “Farm Bill”) because the Wetland Conservation Subtitle (commonly known as “Swampbuster”) excludes agricultural producers from receiving federal subsidies (i.e., government payments) if they destroy wetlands for crop production. Unlike Section 404 of the Clean Water Act, Swampbuster is an economic disincentive rather than a regulatory mechanism, and therefore has no effect where converted wetlands will not be used to grow agricultural crops, or where the landowner does not receive farm program benefits (Petrie et al. 2001). In western parts of Region 2, where wetland protection laws are weaker, a high proportion of wetlands are found on non-agricultural grazing lands (Petrie et al. 2001). In the eastern portion of Region 2, most isolated wetlands are currently located in agricultural land where most producers are enrolled in Farm Bill programs. The agricultural community repeatedly challenges “Swampbuster” provisions in an attempt to soften the legislation (Johnson et al. 1996). The net result of the SWANCC decision has left “Swampbuster” as the only significant federal program protecting wetlands that provide habitat for species such as the black tern.

Wetland drainage and social perceptions

Federal Farm Bill regulations that continually shape social perception and ecological integrity will largely determine the fate of remaining wetlands in Region 2. Wetlands within native prairie landscapes (e.g., grazing lands) are generally at low risk of drainage because ranchers value them for stock water and forage. Conversely, wetlands embedded within cropland landscapes often incur high rates of sedimentation and are much more likely to be a source of contention with landowners as they try to farm around sites locally referred to as “nuisance wet spots”. This negative perception of wetlands in cropland has led to high rates

of wetland drainage in eastern South Dakota, the most important landscape for black terns in Region 2 (see Distribution and abundance section for other important areas). Eastern South Dakota has retained a majority (~65 percent) of its wetland resource, with nearly one million basins covering 840,000 ha (2.1 million ac) or ~10 percent of the land base (Johnson and Higgins 1997). Wetland complexes still commonly exceed densities of 40 wetlands/km² (100 wetlands/mile²), where median wetland size is only 0.2 ha (0.5 ac) and less than 5 percent of all wetlands are >2 ha (5 ac) in size (Johnson and Higgins 1997). A heightened awareness of wetland protection regulations is critical in maintaining black tern populations because 78 percent of wetlands remain at risk of drainage (Estey 1998, Naugle et al. 2001). Projections indicate that deregulation of small wetlands <0.4 ha (<1 acres) in agricultural fields could result in drainage of up to half of the remaining wetlands (Johnson et al. 1996).

The Farm Bill and habitat conservation: an economic dilemma

The Farm Bill presents an economic dilemma for farmers and ranchers because current provisions are heavily weighted to commodity production that provides monetary incentive to bring more marginal land into production (Connor et al. 2001). The current westward expansion of cropland has the direct effect of moving wetland drainage interest into formerly secure habitats (Higgins et al. 2002). The most evident change is the westward expansion of soybeans into regions formerly considered too dry to grow soybeans just 60 years ago. Development of drought-resistant, genetically modified soybeans (commonly referred to as GMOs) has accelerated the conversion of wetland and grassland habitats used by nesting black terns. In South Dakota alone, soybean acreage now exceeds that of corn, and soybean production is largely responsible for the sharp increase in agricultural crop receipts when compared to those for livestock since the 1980s (Higgins et al. 2002). Agricultural interests in Minnesota and Iowa, where ~1 percent of native prairie wetland and grassland habitats remain, have built 32 soybean and corn (i.e., ethanol) industrial plants to process crops, despite low commodity prices and crop surpluses (Higgins et al. 2002). Recent construction of five processing plants in Nebraska and an additional four in South Dakota suggests that habitat losses will likely continue as new crop varieties are developed that entice producers to farm marginal, drought-prone western soils. Trends in Farm Bill policy that drive land use change ultimately place more pressure on our public lands (e.g., national grasslands) to provide suitable habitat for species of concern.

Grassland loss, drainage risk and agricultural runoff

The most important aspect of grassland loss to black terns is that wetlands within cropland are at a higher risk of drainage than those in grassland (Johnson et al. 1996, Higgins et al. 2002; see previous section Wetland drainage and social perceptions section to understand why). A potential secondary but poorly understood effect of grassland habitat loss suggests that pesticide and fertilizer runoff into wetlands surrounded by agricultural tillage decreases diversity and abundance of invertebrate foods used by black terns (see Local and broad scale habitat section for details). In the U.S., we have some information to indicate that pesticide and fertilizer runoff and siltation from agricultural lands alter wetland vegetation composition (Kantrud 1986, Gleason et al. 2003) and reduce invertebrate abundance (Novak 1992, Dunn and Agro 1995, Gleason et al. 2003). However, Naugle et al. (2000) could only speculate that grassland abundance in his models explained the negative impacts of intensive agriculture on habitat suitability because nobody has studied foraging behavior and chick survival in agricultural and grassland landscapes in the U.S. One study from Europe found that loss of diversity in food organisms (and loss of safe nesting places) to be the likely cause(s) for declines in European black tern populations (Beintema 1997). Specifically, he found a higher risk of chick starvation where temporary shortages in prey diversity are the result of eutrophication of surface waters from agricultural runoff. Beintema (1997) concluded that his findings warrant additional investigation in the North American prairie region.

Related issues of unknown importance

Almost nothing is known about the genetics of black tern populations. An apparently stabilized breeding population indicates that broad scale habitat protection efforts have had a positive influence on the population. Very small and localized breeding populations outside the core of the species range, such as those in the northeastern U.S., may be isolated and thus vulnerable to unpredictable events (e.g., single weather event, loss of an important wetland, genetic isolation).

Human disturbance is often cited as a potential threat, but little information has been gathered to investigate this issue. A literature review by Shuford (1999) indicated that brief disturbance to black tern colonies by humans has little to no known effects compared to potential impacts of prolonged disturbance

which are unknown but likely negative (see Inventory and Monitoring section). Prolonged disturbances at individual colonies may be an important issue in some circumstances; however, this is a minor issue when compared to that of habitat loss because major breeding areas are located in rural agricultural landscapes.

Black terns have died of botulism, but this disease and others are not known to be major threats to populations (Hands et al. 1989, Dunn and Agro 1995). A long life span, the effect of adult survival on population trends, and a dependence on invertebrate and vertebrate prey items that concentrate chemicals, all give reason to be concerned about potential impacts of chemical toxicity. To date, Dunn and Agro (1995) and Weseloh et al. (1997) indicate that chemical toxicity is generally not a problem in black terns, but that pesticides may reduce favored insect foods. Shuford (1999) reported that data are inadequate to assess the impacts of agricultural chemicals on black terns in their core breeding range.

Grazing as a non-issue

Grazing is a compatible land use in prairie wetland landscapes that support breeding black terns. Attitudes towards grazing as a land management treatment have come full circle in the minds of many natural resource managers. Managers that used to be against grazing now consider it to be one of the new icons for wetland and grassland conservation (Higgins et al. 2002). This paradigm shift has occurred because ranchers that can maintain profitability on native range are less likely to convert grassland to cropland.

One of the greatest benefits of grazing to black terns may be a reduction in sedimentation of wetlands associated with tillage landscapes. Managers should be mindful that season-long grazing can create poor nesting and brood rearing conditions if cattle are permitted to wade in wetlands used by black terns. An expensive and time-consuming solution is to fence cattle away from wetlands. Rather, most authors recommend rotational grazing systems over season-long grazing treatments in tallgrass and mesic mixed grassland zones (Clark et al. 1943, Owensby et al. 1973, Barker et al. 1990, Sedivec et al. 1990, Naugle et al. 2000). Rotational grazing systems enable managers to control timing of treatments to enhance range condition on public lands. For example, Owensby et al. (1973) found that forage production and range condition were higher on deferred-rotation pastures than on season-long pastures in Kansas. Many authors also note that grasslands are more susceptible to season-long or multiple periods of grazing in areas outside the tallgrass prairie zone. Zhang

and Romo (1994) reported that mixed grasslands should be grazed only once annually and that grazing should be deferred until peak annual growth had been attained.

Black Tern Conservation Status in Region 2

Breeding Bird Survey trend data (see Population estimate and trends section) indicate that black tern numbers declined sharply from 1966-1980. Most population trends were reversed during the 1990s, causing trend estimates over the 1980-1996 interval to become more positive (Peterjohn and Sauer 1997). The species still occupies most of its former range, and the continental population likely still numbers in the low to mid hundreds of thousands. The population appears stable with habitat that remains, and thus the black tern was not listed as a "Bird of Conservation Concern" within Region 2 (U.S. Fish and Wildlife Service 2002; <http://migratorybirds.fws.gov/reports/bcc2002.pdf>; Accessed 15 February 2003). The tenuous and political nature of regulatory mechanisms that protect wetlands dictates constant attention of natural resource professionals to the status of wetlands and black terns. Furthermore, existing habitat conservation measures are inadequate to halt the loss and degradation of prairie wetlands and grasslands that represent primary black tern breeding habitats. Given the severity of previous declines, conservation of the black tern still warrants serious concern, and efforts should be undertaken to tighten wetland protection laws, enhance habitat protection programs (e.g., easement programs), and develop better population monitoring strategies.

Potential Black Tern Management in Region 2

Habitat conservation and restoration

Conservation of remaining wetland and grassland habitat will likely provide the greatest benefit to black tern populations. Higgins et al. (2002) recommend that the last chance to preserve vast wetland landscapes for waterbirds is to accelerate protection of remaining wetland and grassland habitats using stewardship and incentive programs to family ranchers. This philosophy is of vital importance because it also protects wetland habitats that otherwise are vulnerable to drainage when native grassland is converted to cropland. Conservation efforts on small "postage stamp" tracts of native wetland and grassland habitats that remain in Minnesota and Iowa are a harsh reminder that it is more economical to conserve native habitats than to attempt to restore biological integrity once native habitats have been

lost. This type of broad scale approach to conservation is necessary to maintain naturally viable populations and to avoid intensive site-specific management that is required to artificially maintain small populations in degraded landscapes.

In regions where wetland loss and degradation have been severe, wetland restoration is a management option that would likely benefit black terns, perhaps as an effort complimentary to broad scale habitat conservation. Hydrology of most prairie wetlands can be restored easily by plugging drainage outlets and/or breaking underground drainage tiles. Wetlands revegetate by natural recolonization after hydrology is restored. Portions of the seed bank of restored wetlands usually remain intact, but typically contain fewer species and fewer seeds than those of natural wetlands (Galatowitsch and van der Valk 1996). Sedge meadow is the most difficult vegetation zone to restore to a dynamic state (Galatowitsch and van der Valk 1996). Literature is available (e.g., Galatowitsch and van der Valk 1998) that details the technical aspects of prairie wetland restorations.

Limited research indicates that black terns sometimes re-colonize restored wetlands (Delphey and Dinsmore 1993, Dunn and Agro 1995). In Minnesota, Delehanty and Svedarsky (1993) found that black terns re-colonized a drained wetland one year after reflooding, and peak numbers occurred in the second and third years following restoration. Hickey and Malecki (1997) reported black tern use of artificial water impoundments, which are functionally similar to restored wetlands. Additional waterbird research conducted in the southwest portion of the Prairie Pothole Region indicates that many waterbird species readily colonize restored wetlands (Delphey and Dinsmore 1993, Hemesath and Dinsmore 1993, VanRees-Siewart and Dinsmore 1996). However, in one of these instances (VanRees-Siewart and Dinsmore 1996) black terns used but did not nest in restored wetlands in Iowa. Galatowitsch and van der Valk (1998) list the black tern as an "Infrequent Breeding Animal of Restored Wetlands". Wetland restorations juxtaposed to existing wetland complexes will likely maximize habitat benefits for black terns (Brown and Dinsmore 1986, Naugle et al. 2000). The relative importance of wetland area, isolation, and the surrounding landscape on habitat suitability for black terns is available (with numerical guidelines needed to initiate a restoration) in a preceding section entitled Local and broad scale habitat.

Habitat and vegetation management within wetlands

An array of intensive management techniques has been developed for black tern populations that are critically imperiled outside the primary breeding range (e.g., eastern U.S.). Most management prescriptions attempt to emulate hydrologic and vegetative dynamics within individual sites that would otherwise occur naturally in a functioning wetland complex. Managers must compare the efficacy of intensive site-specific management designed to artificially maintain small populations in degraded landscapes to that of broad scale conservation measures that maintain naturally occurring populations. Assorted broad scale habitat conditions throughout Region 2 will dictate an appropriate strategy.

In western New York, Hickey (1997) recommended that habitats in impoundments managed for black terns be in unbroken patches of vegetation >10 ha in area and that habitat patches be >20 ha in large wetland units. The Tonawanda complex in western New York is managed for black terns by draining and disking to favor burreed growth and muskrat invasions (Hickey 1997, Hickey and Malecki 1997). Hickey (1997) recommended that managers use a four to six year drawdown cycle followed by flooding in years 2 and 5. Black terns reportedly colonize impoundments the year following reflooding, with peak numbers in the second and third years after flooding (Hickey and Malecki 1997). Hickey (1997) also recommended that elevated perches be created to provide resting and feeding areas in potential black tern habitat.

Managers wary of applying techniques from New York to wetlands in Region 2 may benefit from studies that evaluate effects of timing of drawdown and reflooding on marsh vegetation in prairie wetlands. Although the response of black terns was not measured, Merendino et al. (1990) found that season of drawdown (15 May, 15 June, 15 July, 15 August) affected the abundance, species richness and flowering of wetland vegetation. Overall, shoot densities (with alkali bulrush [*Scirpus maritimus*] as the dominant species) and number of flowering shoots were highest in the 15 May drawdown. In contrast, cattail dominated the 15 June drawdown, and purple loosestrife reached maximum densities. Mid-summer (15 July) and late-summer (15 August) drawdowns were characterized by low species abundance and absence of seed production

(Merendino et al. 1990). When vegetation was subjected to four reflow depths (0 cm, 15 cm, 30 cm, 50 cm depths) the following summer, Merendino and Smith (1991) found that early season drawdowns (May and June) allowed perennial plants time to develop rhizomes capable of producing shoots under flooded conditions. Alkali bulrush and hardstem bulrush (*Scirpus lacustris*) in early drawdowns (May and June) tolerated deeper (30 to 50 cm) flooding than in late (July and August) drawdowns (0 to 15 cm). Thus, May drawdowns maximized shoot, cover and seed production of desirable species (bulrushes) during the first season and allowed deeper flooding the following year (Merendino and Smith 1991). These guidelines provide insight into timing of drawdowns and reflooding that would initiate vegetative characteristics conducive to black terns for nesting in the following years (assuming adequate nest substrates).

Linz et al. (1994, 1995, 1996a, 1996b) and Linz and Blixt (1997) recommend use of aerially-sprayed glyphosate herbicides to increase marsh use by black terns (and reduce abundance of crop-depredating blackbird populations) by opening up cattail-dominated wetlands. Researchers believed that herbicides could be used with a creativity and precision difficult to achieve with other methods, with an eight to ten year time interval between successive treatments (cost of endorsed products are available in Linz and Blixt [1997]). Side effects of glyphosate herbicides are purported to be minimal, but managers should read and follow label directions prior to any applications.

Dunn and Agro (1995) and Shuford (1999) indicated that black terns may use artificial nest platforms, and that nest success may or may not be higher on artificial versus natural nest sites. Faber (1992, 1996) documented higher nest success on artificial platforms than on natural substrates along the Mississippi River in 1990, but results were equivocal for the combined period 1989 to 1991. Hickey (1997) recommended that more information be collected before conclusions are made regarding the value of artificial platforms. Lastly, Hickey (1997) speculated that a monofilament gull enclosure or a protective chick shelter might be useful in deterring predators in black tern colonies. Although this has never been tested for black terns, Kruse et al. (2001) did evaluate wire mesh predator enclosures and chick escape shelters as a means of increasing nest success and chick survival in ground-nesting piping plovers (*Charadrius melodus*) and least terns along the Missouri River. Piping plover apparent nest success increased significantly from 34.4 percent to 61.6 percent with use of predator enclosure cages. Chick

shelters were not used by either species and appeared to provide no benefit to chick survival (Kruse et al. 2001). Efficacy of these and similar techniques will likely need to be evaluated on a species-by-species basis.

Inventory and monitoring

Ecologists often discuss formation of a long-term monitoring program designed specifically for waterbirds (<http://www.mp2-pwrc.usgs.gov/cwb/>; Accessed 10 March 2003) to enhance our knowledge of population status beyond that currently available from BBS estimates (see Population estimate and trends section). Effective waterbird monitoring activities should reflect inherent variability in water levels, number of wet wetlands, and changing broad scale patterns that influence black tern habitat use in space and time. For example, Niemuth and Solberg (2003) found that the number of black terns counted along 13 BBS routes in North Dakota was positively correlated with the number of wet wetlands (**Figure 9**). Correlations were weaker when the number of wetlands was lagged one year, suggesting that the distribution of black terns shifts in response to water availability rather than increase locally (Niemuth and Solberg 2003). Such findings indicate that wetland habitats must be protected and managed over large geographic areas to ensure that suitable habitat is available under different hydrologic conditions. Habitat models constructed using monitoring data should be based on multiple years of data and provide some indication of how frequently potential black tern habitat is likely to be suitable.

In spring, black terns tend to be grouped during migration and at staging areas (Dunn and Agro 1995); despite such concentrations, spring is not the optimal time to survey black tern populations because bird use of migration and staging sites varies annually, and the probability of missing important areas is high. Rather, monitoring protocols should employ a stratified random sampling design (by geographic region, wetland type, wetland density and land use) to determine the breeding status of black terns during the nesting season. Thematic Mapper Imagery and National Wetland Inventory digital data exist (<http://wetlands.fws.gov/webstat.gif>; Accessed 12 March 2003) for the most important wetland areas in Region 2. The sampling design would likely be a wetland-based survey stratified by geographic region, wetland density (or area), water regime and land use to ensure that surveys assess the range of habitats available to breeding black terns (Naugle et al. 2000). Such a survey would also likely target multiple waterbird species to justify survey costs. Alternatively, waterbirds could be surveyed at the same

wetlands that the USFWS has used to monitor waterfowl populations for the past 15 years (4-mile² waterfowl surveys). Spatially explicit conservation planning tools constructed from 4-mile² monitoring data are used to prioritize acquisition and easement programs and target habitats for management treatments. Efforts to merge waterbird monitoring with current sampling schemes already in place for waterfowl would necessitate agreements between multiple state and federal agencies. Regardless of whether waterbird surveys are merged with those for waterfowl, the waterfowl surveys already present an adequate assessment of annual water conditions and habitat loss for black terns.

The black tern is a vagile species that usually breeds in semi-permanent wetlands (Naugle et al. 2000), but may fly up to 4 km from the nest wetland (Chapman-Mosher 1986) to forage in surrounding wetlands. A wetland-based monitoring program during the breeding season would likely necessitate that surveyors differentiate between black tern nesting and foraging wetlands. Evidence that brief disturbances have little to no effect on black tern colonies is valuable data because nesting black terns elicit a behavioral response to disturbance that may be useful in a long-term monitoring program (Shealer and Haverland 2000). Surveyors that wade within 50-100 m of a nesting colony are met by a flight of black terns that “mob” the intruder by swooping down silently then pulling up with harsh alarm calls, sometimes striking their targets (Dunn and Agro 1995, D. Naugle, personal experience). In stark contrast, surveyors can walk within a few meters of a black tern foraging outside its nest wetland as if the bird was oblivious to surveyor presence. A similar technique is useful for nests whereby a surveyor initiates a disturbance but then slowly backs out of the wetland, pinpointing locations as incubating birds return to their nests. The latter technique may have research design implications for demographic studies (see Demography section) when investigators need to find nests in both sparse and dense vegetation.

Information Needs

Regional population and habitat surveys

A priority information need is establishment of a regional black tern survey that would yield population and habitat information across the species’ range. Information from detailed site studies is not useful for regional population or habitat monitoring because birds readily change colony sites. Rather, a monitoring protocol in areas with extensive breeding habitat should employ a stratified random sampling design

(e.g., Stewart and Kantrud 1972, Naugle et al. 2000) to monitor population change and to identify locations of priority habitats used by black terns during the nesting season. Alternatively, monitoring all potential sites may be feasible in areas of Region 2 that have limited habitat availability (e.g., Wisconsin approach to monitoring black terns [Tilghman 1980]). A well-designed, broad scale survey will necessitate maintenance of digital wetland databases (e.g., National Wetland Inventory data) and remotely sensed land cover information. This type of data will need to be created where none currently exist. A regional survey approach would likely target multiple waterbird species to justify costs. Secretive or rare species might require different sampling methods (e.g., electronic call-playback techniques) to detect their presence and/or estimate abundance. A basic assessment of habitat conditions at survey locations (e.g., percent of wetland area ponding water, ratio of vegetation cover to open water) is invaluable for explaining variation in species annual settling patterns. Population information from survey data would provide a clear picture of the health of regional populations and spatially explicit conservation planning maps constructed from survey data would be a powerful tool for prioritizing easement and acquisition programs (i.e., target where we spend limited conservation dollars). Regional habitat models likely to yield the best information are those that incorporate multi-scale approaches. Resulting habitat models could be used to assess inherent variability in the system to predict how frequently black tern habitat is likely to be suitable.

Population demographics data

Progress in understanding black tern ecology requires that regional survey information be supplemented with demographic data. The highest priority information need from Servello (2000) is measurement of adult survival rates because they are critical for interpreting existing and future breeding success information. Banding efforts to measure adult survival would have to be intensive and region-wide because bird movement among sites would likely result in low annual re-encounter rates of marked individuals. The second priority is to characterize chick survival rates because population productivity measurements, which require both nest success and chick survival data, will be needed to compare breeding success among study areas and over time (Servello 2000). This is a difficult task because black tern chicks swim away and hide when approached. Nevertheless, Nisbet (1997) contends that North American researchers should be able to use techniques developed by European biologists who have studied black tern chick survival

and growth. A third priority is a better understanding of the contribution of reneating to annual productivity because the combination of reneating rate, frequency of reneating, relationships to incubation stage and nest loss date, clutch size for replacement nests and temporal patterns of nest success may substantially influence productivity estimates (Servello 2000). In contrast, clutch size, hatching rate, and the proportion of breeding two-year-old terns should be lower research priorities because variation in these parameters has relatively little influence on population growth (Servello 2000). While there remains a need for monitoring black tern nest success, Servello (2000) recommends that future work in this area focus on understanding factors limiting nest success. Embedding demographic studies within regional population and habitat sampling schemes would enable researchers to model the demographic consequences of habitat selection and make valid inferences over much broader areas.

Wintering grounds

Readers of this assessment may note that much of what is known about black terns on their North

American breeding grounds comes from areas where biologists are numerous but birds are sparse (e.g., New York). Likewise, we know very little about the ecology and survival of black terns on the wintering grounds where they spend six to seven months of each year. Wintering black terns are distributed across marine and marine-coastal habitats off Central America and northern South America (Dunn and Agro 1995, American Ornithologists' Union 1998). In Europe, population declines have been more pronounced in the west than east and in more degraded than in less degraded habitats (Beintema 1997), suggesting that local factors acting on the breeding grounds have been important contributors (Nisbet 1997). In North America, however, there is less evidence for variation in population trends across regions and across habitats (Peterjohn and Sauer 1997). Hence, it is less clear that causes of the population decline should be sought solely in local factors acting during the breeding season. Nisbet (1997) recommends studying black tern foraging, diet and nutrition in relation to habitat and water quality, and prey populations, citing the success of similar work conducted in Europe (Beintema 1997).

DEFINITIONS

Botulism — a bacteria that causes disease outbreaks, killing thousands of waterbirds each year.

Degenerating wetland — a marsh phase that results when prolonged deep-water flooding causes the elimination of emergent vegetation.

Demography — the study of the structure and growth of an animal population.

Conservation easement — a voluntary agreement whereby a conservation entity pays a willing landowner for a portion of his property rights.

Extirpated — a term used when an organism no longer occurs in a portion of its former range.

Fee-title lands — those lands owned outright by the government.

Genetically modified crops — genetically modified plants that have altered genomes so they perform differently than previous strains. For instance, strains are altered to withstand harsh environmental growing conditions that would otherwise be beyond the plants natural means (e.g., drought tolerance).

Glyphosate herbicide — a broad spectrum, non-selective systemic herbicide that is effective in killing all plant types. It is absorbed through plant leaves and soft stalk tissue, after which treated plants die in a few days or weeks.

Heritage status rankings — a system developed by NatureServe, The Nature Conservancy, and the Natural Heritage Network to assess the relative conservation status of a species on global (G), national (N) and state (S) levels. Ranks are defined as critically imperiled (1), imperiled (2), vulnerable to extirpation or extinction (3), apparently secure (4), and demonstrably widespread, abundant, and secure (5).

Hydrology — the study of the distribution, abundance, and cycling of water in wetlands. Wetland hydrology largely dictates the length of inundation in wetlands, which in turn partially determines black tern habitat use.

Landscapes — kilometers-wide mosaics of land use that repeat themselves over time. A second definition of a landscape is as an area of land containing a mosaic of *habitat* patches, within which a particular focal habitat patch is embedded (e.g., wetlands). Landscapes generally occupy a spatial scale intermediate between an organism's home range and its regional distribution. There is no "absolute size" for a landscape because each organism scales the environment differently (i.e., a salamander and a black tern view wetland complexes at different scales).

Matrix — the most extensive and connected habitat type, and therefore it plays a dominant role in landscape function (e.g., tillage agriculture surrounding wetlands in an agrarian environment).

Monogamous — a mating system in which a male breeds with only one female for the season (e.g., black terns).

Palustrine — wetlands that are commonly referred to as marshes, ponds, swamps, and bogs. Cowardin et al. (1979) defines a palustrine system as any non-tidal wetland dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and any such wetland that occurs in tidal areas where salinity due to ocean-derived salts is low.

Patches — discrete units of habitat. Like the landscape, patches comprising the landscape must be defined relative to the question asked. From an ecological perspective, patches represent discrete areas with homogeneous conditions that are relevant to a species (e.g., semi-permanent wetlands during nesting).

Philopatry — the tendency of an organism to return to its place of birth or to use a particular nesting site year after year.

Piscivorous — a species that eats fish.

(*r*) — the symbol for population growth rate (see Demography).

Regenerating wetland — a phase in the marsh cycle when water returns to a dry wetland and emergent vegetation expands by vegetative propagation (see Degenerating wetland).

Scale — the spatial or temporal dimension of an object or process. Many ecologists use natural history attributes of the organism to assess scales relevant to species of interest (e.g., distance black terns forage from nest wetlands).

Seed bank — the viable seed present in wetland sediment at any given time. Seeds reaching or produced in a wetland when conditions are unfavorable for establishment may remain viable in sediment for years.

Thematic Mapper (TM) Imagery — the most common type of satellite imagery used to classify land use in wildlife study. Spatial resolution of TM imagery is 30 m.

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