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Strategic Environmental Research and Development Program

Species Profile: Least Tern (*Sterna antillarum*), Interior Population, on Military Installations in the Southeastern United States

by Wilma A. Mitchell

Prepared for Headquarters, U.S. Army Corps of Engineers

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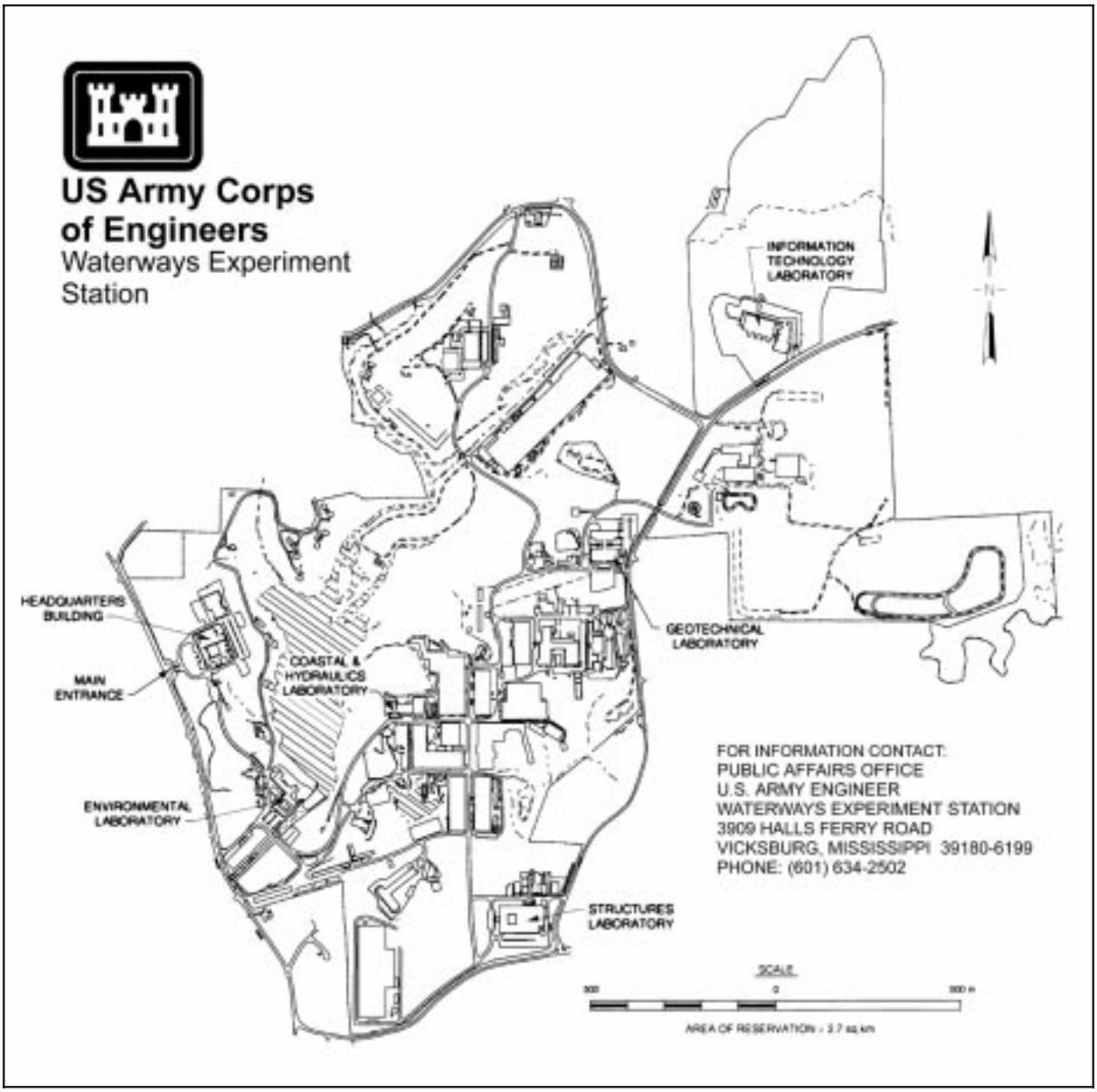

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Preface

The work described herein was authorized by the Strategic Environmental Research and Development Program (SERDP), Washington, DC. The work was performed under the SERDP study entitled "Regional Guidelines for Managing Threatened and Endangered Species Habitats." Mr. Brad Smith was Executive Director, SERDP.

This report was prepared by Dr. Wilma A. Mitchell, Natural Resources Division (NRD), Environmental Laboratory (EL), U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS.

Mr. Chester O. Martin, EL, WES, and Ms. Ann-Marie Trame, Land Management Laboratory, U.S. Army Construction Engineering Research Laboratories, Champaign, IL, were Principal Investigators for the regional guidelines work unit. Dr. Richard A. Fischer, EL, WES, managed and coordinated preparation of species profiles for this study. Report review was provided by Dr. Paul M. Mayer, University of Minnesota, and Dr. Sara H. Schweitzer, University of Georgia. WES technical review was provided by Mr. Martin and Dr. Fischer. Ms. Tiffany Cook, EL, provided valuable assistance in assembling species information.

This report was prepared under the general supervision of Dr. Michael F. Passmore, Chief, Stewardship Branch, NRD; Dr. Dave Tazik, Chief, NRD; and Dr. John Harrison, Director, EL.

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Species Profile: Least Tern, Interior Population
(*Sterna antillarum*)

Photo by Roger L. Boyd, Baker University, Baldwin City, KS.

Taxonomy

Class	Aves
Order	Gruiformes
Family	Laridae
Genus/species	*Sterna antillarum*
Other Common Names	Brown's tern, obs. (Banks 1988)

Description

The least tern is the smallest North American tern, with a body length of approximately 23 cm (9 in.) and a wingspread of 51 cm (20 in.) (National Geographic Society 1983). The sexes are similar in appearance. The breeding adult has a black crown and nape, white forehead, black-tipped bill, gray back and dorsal wing surfaces, and snowy white underwing surfaces. In flight, the black wedge on the outer primaries and the short, deeply forked tail are conspicuous.

Immature birds have darker plumage than adults, black eye stripes, white foreheads, and dark bills (National Geographic Society 1983). The juvenile is pinkish-buff above with brownish U-shaped markings on the feathers; it has a dusky crown, black eye stripe, and dark shoulder bar on the wings. The first-summer bird is similar to the adult but retains the eye stripe and shoulder bar and has a dark bill and legs and dusky primaries.

Status

Legal designation

Federal. The least tern was listed as endangered in 1985 in the following States: Arkansas, Colorado, Iowa, Illinois, Indiana, Kansas, Kentucky, Louisiana (Mississippi River and tributaries north of Baton Rouge), Mississippi (Mississippi River), Missouri, Montana, North Dakota, Nebraska, New Mexico, Oklahoma, South Dakota, Tennessee, and Texas (U.S. Fish and Wildlife Service 1985). The interior least tern was recognized as a subspecies (*S. a. athalassos*) in 1983 (American Ornithologists' Union 1983). However, no consistently distinctive differences in morphology, behavior, or biochemistry have been found to distinguish it from other subspecies (Massey 1976, McCament and Thompson 1987, McCament-Locknane 1988). Because of the taxonomic uncertainty of least tern subspecies in the United States, the U.S. Fish and Wildlife Service did not list the subspecies but instead designated as endangered those populations of least terns occurring in interior North America (Sidle and Harrison 1990).

State. The interior population of the least tern is listed as endangered under State laws in all of the States named above except Colorado, Louisiana, Mississippi, and Montana (Sidle and Harrison 1990). Although not legislatively designated as endangered in North Dakota, the least tern is regarded as endangered by the State Game and Fish Department and conservation organizations within the State.

Military installations

The applicability of this species profile is limited in the southeastern United States because only a few military installations are located on suitable rivers within the range of the interior least tern.[1] However, installations with breeding populations or suitable nesting habitat in other sections of the United States should benefit from this account. Table 1 shows the status of the interior least tern on several military installations within its range. In the third column, "potential" indicates that habitat existing on the installation provides potential nest sites, especially where terns are currently nesting in surrounding areas.

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1 The species will be referred to as the interior least tern when information applies only to inland populations.

Table 1
Known Status of Interior Least Terns on Military Installations

Status	Installation	Status on Installation
AR	Fort Chaffee	Forages over navigation channel.
KS	Kansas Army Ammunition Plant	Potential.
	Sunflower Army Ammunition Plant	Migrant; Potential.
	Fort Riley	Potential.
NE	Cornhusker Army Ammunition Plant	Migrant.
NM	White Sands Missile Range	Documented onsite (Daisan Taylor, Personal Communication, 1997).

Distribution and numbers

The least tern is a migratory species with inland populations that historically bred along the Mississippi, Missouri, Arkansas, Ohio, Red, and Rio Grande river systems and rivers of central Texas (Sidle and Harrison 1990). The breeding range extended from Texas to Montana and from eastern Colorado and New Mexico to southern Indiana. Incidental occurrences have been reported from Michigan, Minnesota, Wisconsin, Ohio, and Arizona (Campbell 1935, Jung 1935, Mayfield 1943, Phillips et al. 1964, Monson and Phillips 1981, Janssen 1986).

The least tern continues to breed in the river systems named above, but its distribution is generally restricted to less altered river segments, reservoirs, and refuges (Sidle and Harrison 1990) (Figure 1). On the Mississippi River, it occurs almost entirely in the lower valley from south of Cairo, IL, to Vicksburg, MS (Sidle et al. 1988). Surveys by the U.S. Army Corps of Engineers (Landin et al. 1985, Rumancik 1985, 1986, 1987, 1988; M. Smith 1986) and Missouri Department of Conservation (J. Smith 1985, 1986, 1987, 1988; Smith and Renken 1990) indicated that about one-half of all interior least terns occur along 1,100 km (683 miles) of the lower Mississippi River.

Surveys from major inland waterways showed a total of 4,800 least terns in 1987 (Sidle and Harrison 1990). Although there are no historic data for comparison, early descriptions indicate that the interior least tern was more common than it is today (Hardy 1957, Burroughs 1961).

Life History and Ecology

The interior least tern nests in colonies on riverine sand and gravel bars and islands near shallow-water feeding areas. Despite habitat instability and susceptibility to predation, least terns tend to be long-lived. The oldest known least tern was 21 years old (Massey and Atwood 1978), and banded terns as old as 15 and 17 years have been recaptured by Renken and Smith (1995).

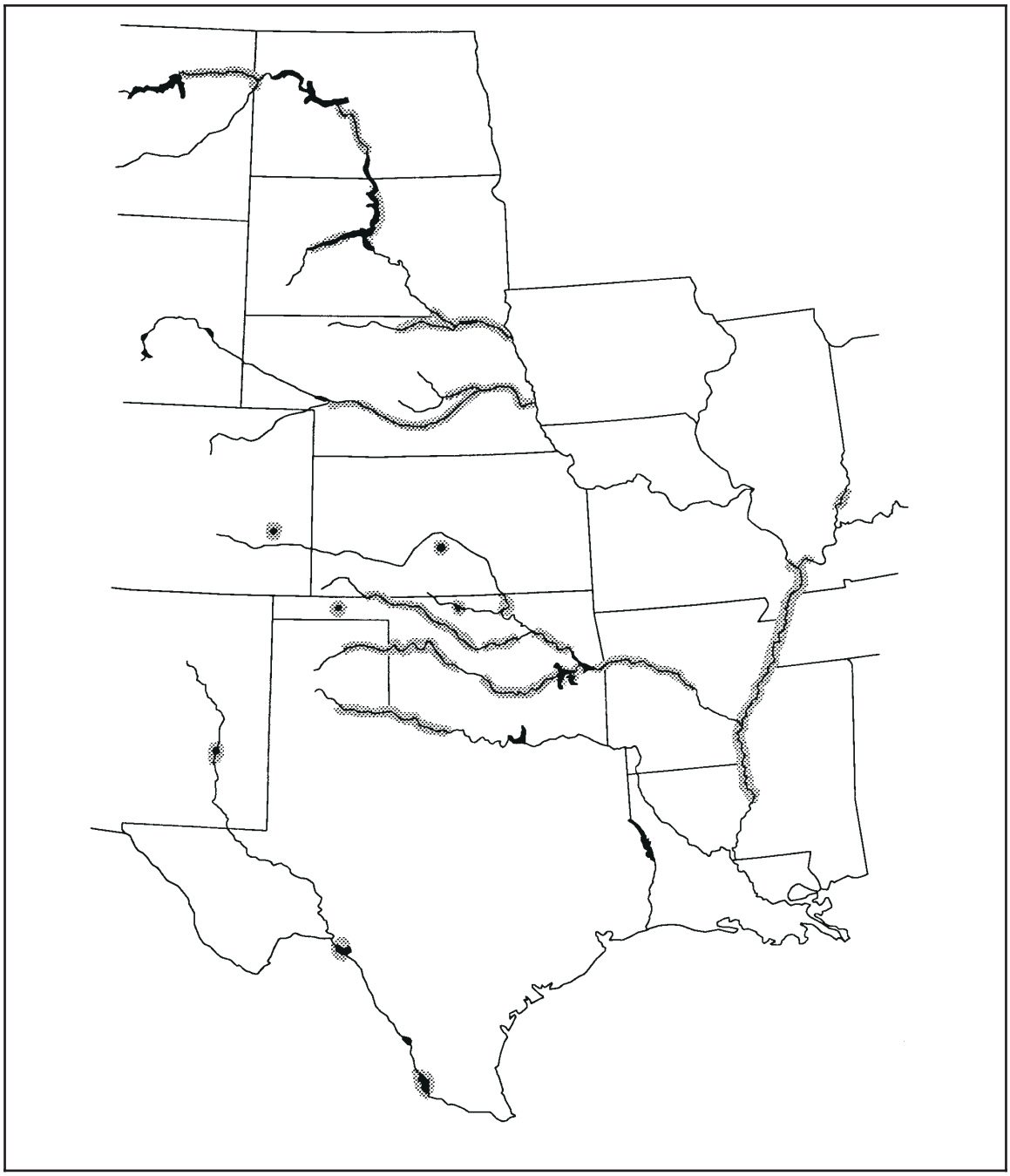

Figure 1. Breeding distribution of the interior least tern in the United States

Migration

Least terns winter in Central America and northern South America (National Geographic Society 1983). Migratory routes have not been clearly defined for spring or fall; and it is not known whether interior least terns follow major river systems during migration, migrate directly north or south, or have migration routes separate from coastal least terns (Sidle and Harrison 1990).

Interior least terns arrive at breeding areas from late April to early June and remain for 4 to 5 months (Youngworth 1930, Hardy 1957, Wycoff 1960, Faanes 1983, Wilson 1984). Banding studies indicate that breeding site fidelity is probably high for the interior least tern, as it is for least terns of coastal California (Atwood et al. 1984), and that birds tend to return to the vicinity of their hatching or former breeding sites (Smith 1987, Mayer and Dryer 1990, Smith and Renken 1990). The majority of juvenile least terns appear to leave colonies within 3 weeks of fledging (Thompson and Slack 1984), and departure by both adults and juveniles is usually complete by early September (Bent 1921, Stiles 1939, Hardy 1957).

Reproduction and development

The interior least tern nests in colonies (terneries) on islands, sandbars, beaches, salt flats, and man-made structures. Courtship occurs at or near the nest site (Tomkins 1959) and includes nest scraping, postures, vocalizations, an aerial display referred to as the fish flight, and copulation (Hardy 1957, Wolk 1974, Ducey 1981).

The nest is a shallow depression that holds two or three eggs (Hardy 1957, Anderson 1983, Faanes 1983, Smith 1985, Sweet 1985, Kirsch 1990). The eggs are pale to olive-buff and speckled or streaked with dark purplish-brown, chocolate, or blue-gray markings (Hardy 1957). Egg-laying begins by late May; incubation is shared by both sexes and usually lasts 20 to 25 days (Moser 1940, Hardy 1957, Faanes 1983, Schwalbach 1988). The precocial chicks hatch within 1 day of each other and are brooded for a week. Fledging occurs at 3 weeks, but parental care continues until juveniles leave the colony (Hardy 1957; Tomkins 1959; Massey 1972, 1974). Renesting may occur as late as August in the lower Mississippi River Valley (Landin et al. 1985).

The ephemeral habitat selected by the interior least tern contributes to nest and chick loss. Therefore, annual reproductive success may vary greatly at sites along a particular river or shoreline (Hill 1985; Kirsch 1987, 1988, 1989; Schwalbach 1988; Dirks 1990; Mayer and Dryer 1990). Along the Missouri River, fledglings per pair dropped from 0.94 in 1988 to 0.42 in 1989 at nesting sites in North Dakota (Mayer and Dryer 1990) but rose from 0.44 to 0.55 during the same seasons at sites in South Dakota (Dirks 1990). Kirsch (1987, 1988, 1989) found highly variable annual fledging rates along the lower Platte River in Nebraska; variations from 0.29 to 0.71 to 0.47 fledglings per pair occurred in 1987, 1988, and 1989, respectively. Data indicate that interior populations should remain stable if the annual fledging rate is maintained at 0.5 fledgling per pair (Hill 1985, Smith and Renken 1993). However, the Missouri River Biological Opinion (U.S. Fish and Wildlife Service 1990) requires an average productivity rate of 0.7 fledglings per pair to avoid jeopardy.

Food habits

Least terns feed on a wide variety of small fishes. The most important fishes for inland populations are species of *Fundulus* (topminnow), *Notropis* (shiner), *Campostoma* (stoneroller), *Pimephales* (minnow), *Gambusia* (mosquitofish), *Morone* (bass), *Dorosoma* (shad), *Lepomis* (sunfish), *Carpoides* (carpsucker), and *Blonesox* (Hardy

1957, Schulenberg et al. 1980, Rumancik 1988, Wilson et al. 1989, Smith and Renken 1990). In addition to these, *Cyprinella lutrensis* (red shiner), *Cyprinus carpio* (common carp), *Hybognathus placitus* (plains minnow), and *Ictalurus punctatus* (channel catfish) are utilized by interior least terns nesting on Oklahoma salt flats (Schweitzer and Leslie 1996).

Prey size may be more important than species preference (Moseley 1976). Body length of fishes caught by adult least terns ranges from 2.5 to 9.0 cm (1 to 3.5 in.) (Massey 1974, Moseley 1976, Schulenberg et al. 1980). Adult terns usually consume fishes longer than 4 cm (1.6 in.) (Massey 1974, Moseley 1976) and bring the smaller fish to the nest. Chicks on Oklahoma salt flats accepted fish from 1.3 to 2.6 cm (0.5 to 1.0 in.) in length (Schweitzer and Leslie 1996), while chicks in sand pits of central Nebraska ate cyprinids up to 3.8 cm (1.5 in.) long (Wilson et al. 1993).

Terns, in general, dive into standing or flowing water to secure their prey and have a maximum diving depth of less than 1 m (3 ft) (Salt and Willard 1971, Eriksson 1985). Eriksson (1985) categorized least terns as surface plungers because they search for prey while flying 5 to 10 m (16 to 33 ft) above the water's surface and plunge into the water to capture detected prey (Moseley 1976). Least terns catch their prey just below the surface of the water and either eat the fish while flying or carry it to the nest to feed their mate and chicks (Atwood and Kelly 1984).

Although fish is the basic dietary item, invertebrates are occasionally consumed by least tern adults and chicks (McDaniel and McDaniel 1963, Wilson et al. 1993). In Nebraska sand pits near the Platte River, adults sitting on nests captured flying insects and occasionally picked crawling insects from the sand (Wilson et al. 1993).

Other

Nest predation by coyotes (*Canis latrans*) can substantially reduce reproductive success, especially during periods of low water when river sandbars may become connected to the shore (Smith and Renken 1990). Coyotes destroyed 30 of 31 nests on one island in the Mississippi River Valley during the summer of 1987 (Smith and Renken 1993). Other known mammalian predators are raccoons (*Procyon lotor*), domestic dogs (*Canis familiaris*) (Smith and Renken 1993), and striped skunks (*Mephitis mephitis*) (Schulenberg and Ptacek 1984), red fox (*Vulpes vulpes*) and mink (*Mustela vison*) (Kirsch 1996).

Known avian predators are the barred owl (*Strix varia*) (Smith and Renken 1990), American crow (*Corvus brachyrhynchos*) (Smith and Renken 1993), American kestrel (*Falco sparverius*) (Dinsmore et al. 1993), and gulls (*Larus* spp.) (Schulenberg and Ptacek 1984). Potential avian predators in the Southeast include the great blue heron (*Ardea herodias*), great horned owl (*Bubo virginianus*), Mississippi kite (*Ictinia mississippiensis*), and other raptors.

Survival rates for adult least terns appear to be high in the interior population. Adult annual survival was 85 percent from 1987 through 1992 in the upper Mississippi River

Valley (Renken and Smith 1995). That is the same rate found for least terns breeding on the Texas coast (Thompson 1982) and is similar to the 88-percent survival rate calculated for least terns of coastal California (Massey et al. 1992).

Animal Species Co-occurring with the Interior Least Tern

Interior least terns nest in the same areas as piping plovers (*Charadrius melodus*) in the Missouri River system (Faanes 1983, Dryer and Dryer 1985, Nebraska Game and Parks Commission 1987, Ducey 1988, Schwalbach 1988) and as snowy plovers (*C. alexandrinus*) and American avocets (*Recurvirostra americana*) in the Arkansas River system (Grover and Knopf 1982, Hill 1985). Although occupying the same nesting areas, interior least terns tend to place nests at elevations higher above river level than do piping plovers (Ducey 1981, Faanes 1983). Nesting piping plovers can usually be found near nesting least terns at artificial sites such as sand and gravel pits.

Habitat Requirements

Meandering rivers on broad flat floodplains offer the most suitable habitat for interior least terns. These rivers have high sedimentation rates and slow currents that result in the formation of sandbars and shallow water areas suitable for nesting and feeding (Whitman 1988). Many of the sandbars chosen for nesting in the Mississippi River basin are not connected to the shore and can be considered islands (Mississippi Department of Wildlife, Fisheries, and Parks, Undated).

Nesting habitat

Typical riverine nesting habitat consists of unvegetated or sparsely vegetated sand and gravel bars within a wide unobstructed river channel (Sidle and Harrison 1990). The nest is placed in an open sandy area, gravelly patch, or exposed flat with small stones, twigs, or pieces of wood and debris lying near the nest. Nesting areas are usually located on higher elevations away from the water's edge, as nesting begins when river flows are high with only small amounts of sand exposed. Nests may be as close together as a few meters or widely scattered up to hundreds of meters apart (Stiles 1939, Hardy 1957, Anderson 1983, Ducey 1988, Kirsch 1990, Smith and Renken 1990).

An important feature of nesting habitat is the presence of large amounts of driftwood (e.g., sticks, twigs, bark) deposited by receding river levels (Smith and Renken 1991). Nests in the Mississippi River Valley were often distributed along an elevational gradient where drift material was deposited, and 52 percent of the nests located from 1986 through 1989 were 25 cm (10 in.) or less from drift material. Other debris that may be near nest scrapes include plant materials such as roots and dried plants (Ducey 1988).

The kind and quantity of vegetation present in the nesting area vary among sites and geographic locations. Nesting areas in the Arkansas River drainage of northwest Oklahoma contained small patches of inland salt grass (*Distichlis spicata*), sea purslane (*Sesuvium verrucosum*), and tamarisk (*Tamarix gallica*), an exotic species (Hill and Talent 1990); the fly-ash deposits used by terns in Iowa hosted only scattered clumps of kochia (*Kochia scoparia*) (Dinsmore et al. 1993). However, nesting areas on the Platte River in central Nebraska showed 2.3-percent shrub cover, which consisted of cottonwood (*Populus deltoides*), black willow (*Salix nigra*), and interior willow (*S. interior*) (Faanes 1983). Although some plant cover was present in the nesting area, nest sites were generally barren of vegetation. Studies conducted by Ducey (1988) in the Rainwater Basins Area of Nebraska showed that 31 percent of nest sites had associated plant growth; willow (*Salix* sp.) shrubs and bulrush (*Scirpus* sp.) were the most common plants, and cattail (*Typha* sp.) was the tallest.

The size of nesting areas and the number of nests within a colony depend on water levels and the extent of associated sandbars (Sidle and Harrison 1990). Sandbars have a greater possibility of colonization by least terns if river levels remain low during the breeding season. Smith and Renken (1991) found that sites were more likely to be used by interior least terns in the Mississippi River Valley adjacent to Missouri if sites were continuously exposed for at least 100 days during the breeding season. Along the lower Mississippi River with its many large sandbars, nesting areas are often several hundred hectares in size and several hundred meters from the water (Rumancik 1987, 1988). However, variations in river flow may alter the sizes of nesting areas and the number of nests per colony. Along a stretch of the Missouri River, the average size of nesting sandbars was 12 ha (29.6 acres) in 1986 and 31 ha (76.6 acres) in 1987; nest elevation and nest-to-water distance differed by a factor of three in both years. Smith and Renken (1990) found Mississippi River colonies that averaged 100 nests per colony when habitat was restricted by high water early in the nesting period, but which averaged only 19.3 nests per colony during a year of more moderate river levels.

In the absence of suitable riverine habitat, interior least terns will nest on available artificial sites. Those used by terns include dike fields along the Mississippi River (Smith and Stucky 1988, Smith and Renken 1990), sand and gravel pits (Kirsch 1987, 1988, 1989), ash disposal areas of power plants (Wilson 1984, Johnson 1987, Dinsmore et al. 1993), and reservoir shorelines (Chase and Loeffler 1978, Neck and Riskind 1981, Boyd 1987, Schwalbach 1988). The extent to which artificial habitats have replaced natural habitat is unknown (Sidle and Harrison 1990). Where suitable habitat has been severely reduced in the upper Platte River channel (Sidle et al. 1989), sand and gravel pits provide the only nesting habitat for interior least terns (Lingle 1989). On the lower reach of the Platte River, the percentage of least terns nesting on pit sites adjacent to the river depended on the flow and amount of exposed sandbar habitat (Kirsch 1987, 1988, 1989).

It is assumed that least terns would select nesting areas based on habitat suitability. A study conducted by Kirsch (1996) on the lower Platte River in Nebraska found that least terns selected nest sites on large midstream sandbars in wide channels and on large sandpit sites created by gravel dredging adjacent to the river. However, terns did not prefer

one habitat over the other and did not use all potentially available sandbar and sandpit sites. These habitats appeared to provide opportunity for population increase since they were not fully occupied. However, productivity was poor because chick survival was low, which was primarily due to nest predation. Therefore, Kirsch (1996) cautioned against inferring that the availability of suitable habitat ensures the potential for population persistence of an endangered species.

Foraging habitat

The species of fish captured by least terns are usually shallow-water surface schoolers (Wilson et al. 1993) that may be found in water no deeper than 62 cm (24 in.) (Hill 1985). Therefore, primary foraging sites are considered to be the shallow waters of lakes, ponds, rivers, and streams with an abundance of small fishes (Fisk 1978, Bull and Farrand 1990). However, least terns nesting on sand islands in the lower Mississippi River have been found to forage in adjacent waters exhibiting a wide range of depths, including the main channel, side channels, sloughs, and tributaries (Smith and Renken 1990). Least terns nesting in natural habitats forage near the colony, usually within 100 m (55 ft) (Faanes 1983) to 250 m (820 ft) (Jernigan et al. 1978), whereas those nesting on artificial sites, such as sand and gravel pits, may fly as far as 3.2 to 6.4 km (2 to 4 miles) to fish (Talent and Hill 1985).

In California, least terns have been described as "opportunistic" foragers, shifting feeding sites in response to localized concentrations of suitable prey (Atwood and Minsky 1983). Tibbs (1995) reported abundances of forage fish species in tern foraging habitats around sand islands on the lower Mississippi River with highest fish densities in the shallow, interface habitats directly adjacent to the islands. Renken and Dugger (1996) found strong annual variations in habitat use around these islands over a 3-year period. Deep-water habitats were used predominately in 1993; shallow-water habitats were used more heavily in 1994; and both were used nearly equally in 1995. However, the variation in tern foraging behavior between and among years was most likely related to hydrologic cycles on the river, as hydrology was highly variable during the study (Renken and Dugger 1996).

Critical or essential habitat

A major threat to survival of the interior least tern is the actual and functional loss of riverine sandbar habitat (Sidle and Harrison 1990). Channelization and impoundment of rivers have directly eliminated nesting habitat, and changes in river flow to accommodate reservoir operations and barge traffic downstream further reduce the amount of quality breeding habitat. The main habitat types used by the interior least tern for nesting and foraging include lake and reservoir shorelines, riverine sandbars and gravel pits, and river channel environments. In the Recovery Plan (Sidle and Harrison 1990), habitat considered essential for the recovery of the interior least tern is described and mapped for segments of the Missouri, Mississippi, Arkansas, and Pecos river systems. In the Southeastern Region, essential habitat includes the Mississippi River from Vicksburg, MS, northward to Missouri and Illinois, and the Arkansas River from west of Dardanelle Lake to Little Rock, AR.

Impacts and Causes of Decline

The decline in interior populations of the least tern is apparently the result of habitat alteration and destruction. Channelization, irrigation, and the construction of reservoirs and pools have contributed to the elimination of much sandbar nesting habitat in the Missouri, Arkansas, and Red river systems (Funk and Robinson 1974, Hallberg et al. 1979, Sandheinrich and Atchison 1986). Along the lower Mississippi River, dike construction has created many sandbars on which nesting colonies are located (Landin et al. 1985; J. Smith 1985, 1986, 1987; Rumancik 1986, 1987, 1988, 1989). However, dike field terrestrialization, which reduces tern habitat, is occurring at some nesting sites (Smith and Stucky 1988).

Changes in riverflow to accommodate reservoir functions, such as barge traffic and hydroelectric power generation, create problems for terns nesting in remaining habitats. For example, regulation of dam discharges on the Missouri River changes the seasonal riverflow patterns and may reduce the available nesting habitat (Nebraska Game and Parks Commission 1985, Schwalbach et al. 1988). Historically, peak flows occurred in spring and early summer; then sandbars became available for nesting as water levels decreased in summer (Stiles 1939, Hardy 1957). The current demand for reservoir functions is unpredictable; therefore, when high flow periods extend into the normal nesting period, interior least terns are forced to nest in poor quality locations, thus reducing their potential for reproductive success.

Human disturbance also reduces the reproductive success of interior least terns and thus contributes to population decline (Mayer and Dryer 1988, Smith and Renken 1990). Many of the larger rivers have become centers for recreational activities, especially those in mid-America with sandbars large enough to serve as beaches. Sand and gravel pits and other artificial nesting sites are subjected to a high level of human disturbance.

Military maneuvers that occur on riverine sandbars and lake shorelines will disturb interior least tern nesting habitat. Habitat degradation is likely to occur if maneuvers are prolonged, or conducted just prior to nesting, and may result in unsuitable nesting and foraging areas. This also applies to artificial sites that are known to be used by breeding interior least terns.

Management and Protection

Recovery plan

The primary objective of the recovery plan is to increase the population of the interior least tern to levels consistent with its removal from the endangered species list (Sidle and Harrison 1990). The recovery plan outlines strategies to protect and manage essential habitat and increase the population to approximately 7,000 birds throughout its range.

Management techniques emphasized by the recovery plan to protect and manage the interior least tern include the following:

a. Identify predators and implement control measures.

b. Restrict public use within nesting areas and enforce regulations.

c. Manage water levels and river flows to protect nesting habitat.

d. Modify or eliminate construction activities that adversely impact reproductive success.

e. Manage areas to maximize survival during migration.

f. Provide permanent protection and management of breeding habitat.

Management techniques

The recovery plan places strong emphasis on predator management during the nesting season. Although predation is high in some areas, specific predators are not always known. Predators should be identified so that appropriate measures can be taken to remove or manage them. Suggested measures include elimination or relocation of identified predators and erection of electric fences around nesting areas (Sidle and Harrison 1990). Electric fences have been used to protect nesting coastal populations of the least tern (Massey and Atwood 1980, 1982; Minsky 1980), and solar-powered electric fences have been built around nesting areas of inland populations in Oklahoma (Koenen et al. 1996b). Creation of suitable nesting sites may also reduce impacts from predation by decreasing nest density and redistributing terns so that large colonies do not experience catastrophic reproductive losses (Mayer 1993).

Public use within nesting areas should be restricted and enforced during the breeding season. Disturbance caused by foot traffic and recreational vehicles may destroy eggs and chicks or inhibit territory establishment, feeding behavior, incubation, or courtship behavior (Schwalbach 1988, Lingle 1989, Kirsch 1990, Smith and Renken 1990). Techniques that have been successful include posting, restricted access, and fencing (Massey and Atwood 1979; Morris 1979, 1980; Larkins 1984). Because strict enforcement may be impractical, a public relations effort should be conducted to reach potential visitors to an area. Mayer (1993) described a program in which intensive media coverage and one-on-one contact with sportsmen greatly enhanced efforts to protect restricted areas on the Missouri River. Volunteer “tern wardens” have also been effectively used to patrol nesting areas and explain restrictions to visitors (McCulloch 1982).

Riverflow regimes should be developed to protect sandbar nesting habitat, prevent destruction of nests and young, and maintain the nutrient base necessary for the production of prey species. The recovery plan (Sidle and Harrison 1990) suggests managing water levels early in the spring by submerging nesting habitat when terns begin establishing territories, thus forcing them to locate nests on higher ground that would be safe throughout the nesting season. However, for this management to be effective, sufficient habitat must be available above the fluctuation zone. High water levels in spring discourage vegeta-

tion growth and increase the deposition of coarse sediments, both of which keep sandbars free of vegetation (Currier et al. 1985, O'Brien and Currier 1987).

Smith and Renken (1993) suggested that sandbars and sand islands could be modified or restored to produce additional nesting habitat in the Mississippi River Valley. Those used by nesting interior least terns tend to be exposed above the river for 100 or more continuous days during the nesting season (Smith and Renken 1991). Therefore, sandbars and islands that are exposed for a fewer number of continuous days could be elevated to provide at least 100 continuous days of exposure above the water level (Smith and Renken 1993).

Methods that may be used to create or enhance habitat for interior least terns include the following: (a) creation of islands (Parnell et al. 1986, Smith and Renken 1991, Hill 1993); (b) deposition of sand, gravel, and/or debris (Smith et al. 1991); (c) construction of nesting rafts (Dunlop et al. 1991); (d) eradication of vegetation (Worsham et al. 1974, Kress 1989, Smith et al. 1991); (e) prescribed burning of vegetation (Smith et al. 1991); and (f) erection of sand drift fences (Mayer 1993). The last three methods would be more feasible for use on an installation, as they are less costly and labor intensive than the creation of habitat. Most installations with riverine habitat do not contain river segments long enough to make sandbar creation a viable alternative. However, vegetation removal does require frequent repetition.

To provide permanent protection of essential breeding habitat may require that some habitat be purchased in fee title or placed under a protective easement, cooperative landowner agreement, or memorandum of agreement/understanding among Federal agencies and private organizations (Sidle and Harrison 1990). These two latter aspects of management will necessarily involve the cooperation and assistance of personnel from agencies outside the installation.

Inventory and Monitoring

Census methods

Aerial, boat, and ground surveys, as well as combinations of these methods, have been employed to count interior least terns and locate potential nesting habitat (Downing 1980, Landin et al. 1985, K. Smith 1986, Smith and Renken 1991). Smith and Renken (1991) used a combination of survey methods when studying populations in the Mississippi River Valley adjacent to Missouri. Two systematic aerial surveys were flown during the breeding season (May and June/July) to locate and map potential nesting habitat. Systematic ground surveys were conducted from June through August to count nests and evaluate habitat suitability. In following years, sites were monitored during the nesting season to record population data and habitat changes.

Population surveys should be conducted on clear to partly cloudy days with no precipitation. A start time at approximately 0800 hours and finish time by 1800 hours will

ensure adequate visibility. Aerial surveys will probably be unfeasible for installations with limited riverine or lakeshore habitat. If used, however, surveys by fixed wing aircraft or helicopter should be flown from 30 to 60 m (100 to 200 ft) above the ground at speeds of 55 to 120 kph (35 to 75 mph) (Landin et al. 1985, K. Smith 1986).

Boat surveys can be used on rivers with islands or large sandbars (Landin et al. 1985), but ground surveys should be conducted on large flat expanses of sandbars or shorelines in which nest visibility would be limited from a boat. Ground surveys should be systematic, with several observers walking abreast on transects to check all available habitat for nests (Smith and Renken 1990). Biological data collected at each site include numbers of adults, pairs, nests (active and inactive), eggs per nest, flightless young, and fledglings (Schwalbach et al. 1988). Nest sites may be marked for ease of relocation if areas are to be seasonally monitored; Smith and Renken (1990) placed wire flags and wooden tongue depressors with visible numbers near the nest scrape.

Habitat assessment techniques

Riverine sandbars and lake shorelines should be assessed for potential habitat on installations that lie within the Arkansas, Missouri, Mississippi or Red river systems. Habitat variables to be measured at these sites include the following: (a) nesting area size and height of habitat (e.g., sandbar or island) above water level; (b) percent, type, height, and distribution of vegetative cover; (c) dominant plant species; (d) soil substrate at nests; and (e) water level fluctuations (Sidle and Harrison 1990, Smith and Renken 1991). The presence of drift material (e.g., logs or sticks) and its distance (centimeters) from the nest may also be recorded (Smith and Renken 1991). Data should be collected on the occurrence and abundance of prey species and the likelihood of food being a limiting factor.

Remote sensing techniques such as aerial videography (Sidle and Ziewitz 1990) and satellite imagery can be used to quantify breeding habitat. Historic aerial photographs or hydrographic surveys may be useful in determining the previous extent of potential habitat and changes in the vegetation (Rodekohr and Engelbrecht 1988, Sidle et al. 1989, Koenen et al. 1996a). The regional U.S. Fish and Wildlife Service office should be contacted for information that may have been obtained from remote sensing of the area.

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13. ABSTRACT ***(Maximum 200 words)***

The least tern (*Sterna antillarum*) is a neotropical migrant species that primarily breeds along coastal waterways of the United States and winters in Central and South America. The interior population of the least tern was listed as Federally endangered in 1985 by the U.S. Fish and Wildlife Service, primarily due to habitat alteration and destruction. Interior least terns are the smallest of North American terns and breed and nest in colonies on riverine sand and gravel bars along major river systems in the central United States. Although few southeastern U.S. military installations are located on rivers within the range of the interior population, installations with suitable habitat in other sections of the United States should benefit from this profile. This document is one of a series of Species Profiles being developed for threatened, endangered, and sensitive species inhabiting southeastern United States plant communities. The work is being conducted as part of the Department of Defense (DoD) Strategic Environmental Research and Development Program (SERDP). The report is designed to supplement information provided in plant community management reports for major United States plant communities found on military installations. Information provided on the interior population of the least tern includes status, life history and ecology, habitat requirements, impacts and causes of decline, habitat assessment techniques, inventory and monitoring, and management and protection.

14. SUBJECT TERMS

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