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STATUS AND DISTRIBUTION OF THE LEAST TERN IN OKLAHOMA

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Least Terns (*Sterna antillarum*) occur in small numbers over wide areas in the interior United States and are difficult to census. They occur in Oklahoma primarily from May to August, nesting on barren to sparsely vegetated salt flats and sand islands and bars. Their nests, slight depressions or scrapes, are widely spaced (usually more than 9 m apart) and are commonly placed on slight elevations close to driftwood or other objects. Ideal nest sites are relatively free from flooding with vegetation, logs, or rocks nearby to provide cover for chicks. Low levels of predation, minimal human disturbance, and concentrations of small fish less than 8 cm long are also important habitat components. Least Terns loaf on damp bars and mudflats, gathering at staging areas supporting high fish populations (e.g., mouths of tributary streams, floodplain wetlands, and reservoir shallows) before migrating to Central and South America.

In 1985 the United States Fish and Wildlife Service (Service) listed the interior population of the Least Tern as endangered (50 *Federal Register* 21,784-21,792). The reasons for listing were perceived low numbers, habitat loss, and human disturbance. The Service recognized the difficulty of assessing the exact population status of a species with widely scattered individuals. At the time of listing, fewer than 3,000 Least Terns had been censused in the interior United States and salt flats were thought to support most terns in Oklahoma.

ADULT LEAST TERNS, NEST AND EGGS

***Left photo** (Taken July 1987 by Aaron Archibeque)—An incubating adult is guarded by its mate at the mouth of the Canadian River on Sequoyah National Wildlife Refuge in Oklahoma.*
***Right photo** (Taken July 1987 by John Sidle)—A scrape containing two eggs on the Platte River in Nebraska.*

Being listed as endangered focused attention on the tern and census efforts soon increased. By 1987, improved techniques and coverage had facilitated documentation of about 5,000 Interior Least Terns, about half distributed along the Mississippi River, the rest widely scattered across the Rio Grande, Missouri, Arkansas, and Red river systems (Sidle et al. 1988). Although most potential tern habitat in the Great Plains had been surveyed, Oklahoma surveys were limited by difficult access and inadequate coverage of extensive but widely scattered potential nesting habitat (over 2,200 km of river and 7,270 ha of salt flats). In 1988, the Service and U.S. Army Corps of Engineers (Corps) began using airboats to census Least Terns along the major rivers of Oklahoma. Biologists reasoned that standardized airboat surveys would allow a fairly accurate comparison of tern densities and distribution among rivers and years. This information was needed to track population trends and to plan for recovery actions. In addition, summaries of breeding success, habitat trends, and potential threats were needed to assess the species' status.

This paper includes Least Tern census data and breeding distribution in Oklahoma from 1975 to 1992 and identifies potential habitat yet to be searched. Also assessed are habitat trends, fledging rates, threats, and recovery needs in Oklahoma.

NUMBERS, DENSITY, AND DISTRIBUTION

Between 1985 and 1992, almost all potential habitat in Oklahoma was surveyed for Least Terns (Fig. 1). Terns were widely distributed (Fig. 2 and Table 1), usually occurring in small colonies (10 pairs or fewer) or as singles and pairs. Islands occasionally supported high local densities, e.g., about 52-63 adults/ha on a man-made island in the Arkansas River in Tulsa in 1992 (Wood and Leslie 1992) and 46 adults/ha on a natural island at the mouth of the Canadian River in 1987 (Archibeque 1987). Regionally, the greatest densities of breeding terns were at Optima Lake sand spits in the panhandle (1.2 adults/ha in 1987, Boyd 1990); at Big and Little Salt Plains (0.1 adults/ha in 1990, Boyd 1990) and on the Cimarron River between Freedom and Waynoka (2.6 adults/km in 1990, Boyd 1990) in the northwest; on the Arkansas River between Tulsa and Muskogee (2.4 to 2.7 adults/km in 1991, U.S. Army Corp Eng. 1991; exclusive of Island in Zink Lake) in the northeast; on the Red River between the North Fork of the Red River and Burkburnett in the southwest (0.5 adults/km in 1991, Hill 1992a); and on the Red River between Karma and Hugo (0.8 adults/km in 1991, Hill 1992a) in the southeast.

A 1991 airboat survey (Hill 1992a) on the Red River upstream from Denison Dam found significantly more terns (139-152) than reported by 1975 (Downing 1980) and 1984-85 (Locknane and Thompson 1988) aerial surveys (< 20 terns). The 1991 survey followed a scouring flood that created good habitat conditions along the entire river and Least Terns were found in about equal numbers upstream (139-152) and downstream (169) of the dam. Whether or not these birds breed every year along Red River, possibly in hundreds, is currently unknown. Their numbers may fluctuate widely with changes in nesting habitat from one year to the next (Hill 1992a).

From 1981 to 1992, Least Terns were found breeding at 88 locations on major rivers, at two sites on reservoir beaches or sand spits, and at three major salt flats. Two-thirds of the breeding sites were in the eastern half of Oklahoma and one-third in the west; however, surveys in the west were hampered by difficult access and the coincidence

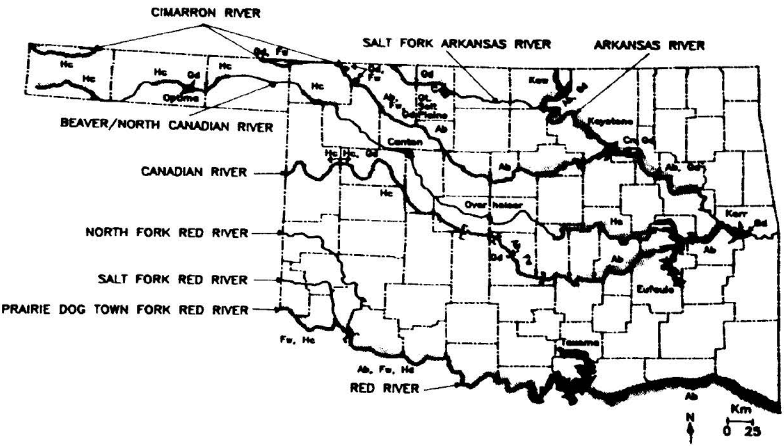

Figure 1. *Areas surveyed for Least Terns by fixed-wing aircraft (Fw), helicopter (Hc), canoe (Cn) airboat (Ab), and ground (Gd) access in Oklahoma from 1985-92.*

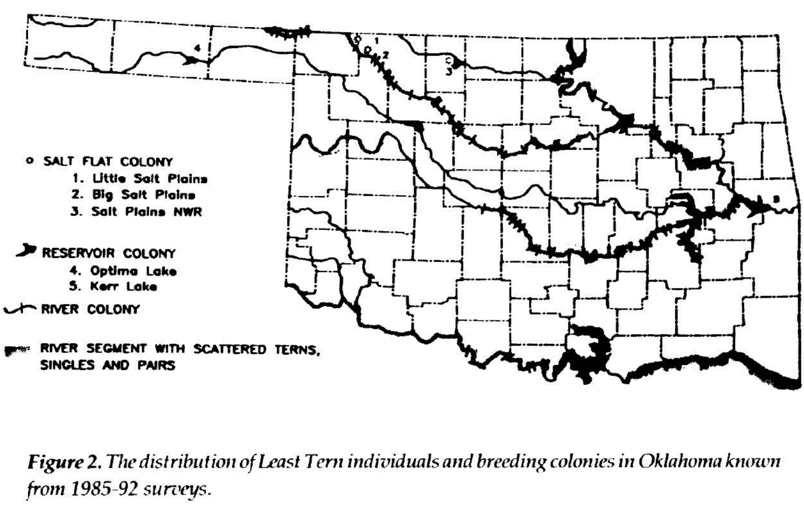

Figure 2. *The distribution of Least Tern individuals and breeding colonies in Oklahoma known from 1985-92 surveys.*

Table 1. Census data on populations of Least Terns in Oklahoma, 1975-1992.

	METHOD[1]	YR	ADULTS	DENSITY[2]	SOURCE
	ARKANSAS RIVER				
Unspecified segment including Salt Plains NWR	Fw	75	32	-	Downing (1980)
Kaw Dam to Hwy 18/Ralston, 96 km	Gd	85	2	*	Hoffman (1985)
	Gd	86	12	0.1	Hoffman (1986)
	Ab	88	12	0.1	J. Skeen fieldnotes
	Ab	90	21	0.2	U.S. Army Corps Eng. (1990)
	Ab	92	40-42	0.4	Hill (1992b)
Hwy 18/Ralston to Hwy 244/Tulsa, excluding Keystone Lake, 89 km	Gd	85	0	0	Hoffman (1985)
	Gd	86	0	0	Hoffman (1986)
	Ab,Cn	90	2	*	L. Hill fieldnotes
	Ab	92	25-28	0.3	Hill (1992b)
Island in Zink Lake/Tulsa, 1.2 ha	Gd	87	20	16.7	F. Pianalto fieldnotes
	Gd	88	30-32	25.0-26.7	F. Pianalto fieldnotes
	Gd	89	44-46	36.7-38.3	F. Pianalto fieldnotes
	Gd	90	44	36.7	F. Pianalto fieldnotes
	Gd	91	60	50.0	U.S. Army Corps Eng. (1991)
	Gd	92	62-76	51.7-63.3	Wood and Leslie (1992)
Hwy 244/Tulsa to Joe Creek/Tulsa, 12 km	Gd	81	20-24	1.7-2.0	F. Pianalto fieldnotes
	Gd	82	20-24	1.7-2.0	F. Pianalto fieldnotes
	Gd	83	6	0.5	F. Pianalto fieldnotes
	Gd	84	2-4	0.2-0.3	F. Pianalto fieldnotes
Joe Creek/Tulsa to Verdigris River/ Muskogee, 103 km	Gd	85	40-42	0.4	Hoffman (1985)
	Gd	86	76	0.7	Hoffman (1986)
	Ab,Gd	88	114-120	1.1-1.2	L. Hill fieldnotes
	Ab,Gd	90	140-144	1.4	U.S. Army Corps Eng. (1990)
	Ab,Gd	91	244-276	2.4-2.7	U.S. Army Corps Eng. (1991)
	Ab,Gd	92	188-256	1.8-2.5	Wood and Leslie (1992)
Hwy 59 Beach, Kerr Lake, 28 ha	Gd	82	20	0.7	Base (1985)
	Gd	81-91	6-18	0.2-0.6	L. Isley (pers. commun.)
	SALT FORK ARKANSAS RIVER				
Salt Plains NWR, 5,390 ha	Gd	77	160	*	Grover and Knopf (1982)
	Gd	78	270	*	Grover and Knopf (1982)
	Gd	82	108-158	*	Hill (1985)
	Gd	83	128-182	*	Hill (1985)
	Gd	84	96-134	*	Hill (1985)
	Gd	86	120-140	*	Boyd (1990)
	Gd	87	200-210	*	Boyd (1990)
	Gd	89	220	*	Boyd (1990)
	Gd	90	240	*	Boyd (1990)
	Gd	91	82+	*	Utych and Leslie (1992)
	Gd	92	136-180	*	S. Schweitzer (pers. comm.)
	CIMARRON RIVER				
Unspecified segment, including Big Salt Plains[3]	Fw	75	40	-	Downing (1980)
Beaver and Harper counties, 55 km	Gd	82	40	0.7	Boyd (1990)
	Gd	83	62	1.1	Boyd (1990)
	Gd	84	58	1.0	Boyd (1990)
	Gd	85	22	0.4	Boyd (1990)
	Gd	86	38	0.7	Boyd (1990)
	Gd	87	28	0.5	Boyd (1990)
	Gd	89	26	0.5	Boyd (1990)
	Gd	90	66	1.2	Boyd (1990)
	Fw	91	30	0.5	Boyd and Rupert (1991)
	Gd	92	36	0.6	Boyd (1992)
Woods County, 93 km	Fw	91	15	0.2	Boyd and Rupert (1991)
Big and Ltl. Salt Plains, 1,880 ha	Gd	77	100	*	Grover (1978)
Big Salt Plains, 1,110 ha	Gd	89	14	*	Boyd (1990)
	Gd	90	126	0.1	Boyd (1990)

Table 1, cont'd.

	METHOD[1]	YR	ADULTS	DENSITY[2]	SOURCE
	CIMARRON RIVER, cont'd.				
	Fw	91	11	*	Boyd and Rupert (1991)
	Gd	92	112	0.1	Boyd (1992)
Little Salt Plains, 770 ha	Gd	82	54	*	Boyd (1990)
	Gd	83	36	*	Boyd (1990)
	Gd	84	30	*	Boyd (1990)
	Gd	85	30+	*	Boyd (1990)
	Gd	86	70	*	Boyd (1990)
	Gd	87	52	*	Boyd (1990)
	Gd	89	72	*	Boyd (1990)
	Gd	90	110	0.1	Boyd (1990)
	Fw	91	11	*	Boyd and Rupert (1991)
	Gd	92	74	*	Boyd (1992)
KS line/NE Harper Co. to Hwy 64/ Plainview, 24 km	Ab	89	31	1.3	Hill (1992b)
Hwy 64/Plainview to Hwy 50/Freedom,	Ab	89	20	0.7	Hill (1992b)
27 km	Ab	92	23	0.8	Hill (1992b)
Hwy 50/Freedom to 281/Waynoka,	Ab	89	54	1.3	Hill (1992b)
41 km	Fw,Gd	90	84	2.6	Boyd (1990)
	Ab	92	72	1.8	Hill (1992b)
Hwy 281/Waynoka to Hwy 51/Lacey,	Ab	89	130	1.3	Hill (1992b)
101 km	Ab	92	93	0.9	Hill (1992b)
Hwy 51/Lacey to Hwy 77/Guthrie, 97 km	Ab	89	74-76	0.8	Hill (1992b)
Hwy 51/Lacey to Gould Bridge/Cashion	Ab	89	42	0.8	Hill (1992b)
56 km	Ab	92	42	0.8	Hill (1992b)
Gould Bridge/Cashion to Hwy 18/ Cushing, 120 km	Ab	89	61-63	0.5	Hill (1989)
Hwy 18/Cushing to upper Keystone L./ Mannford Ramp, 93 km	Ab	89	1	*	Hill (1989)
	BEAVER (NORTH CANADIAN) RIVER				
Optima Lake sand spits, 50 ha	Gd	84	30	0.6	Base (1985)
	Gd	85	40-46	0.8-0.9	Boyd (1990)
	Gd	86	52	1.0	Boyd (1990)
	Gd	87	60	1.2	Boyd (1990)
	Gd	88	38	0.8	M. Eddings (pers. comm.)
	Gd	89	0	0	Boyd (1990)
	Gd	90	0	0	Boyd (1990)
	Gd	91	15	0.3	Boyd (1992)
	Gd	92	16	0.3	Boyd (1992)
	CANADIAN RIVER				
TX border to Hwy 183/Taloga, 132 km	Hc	87	26	0.2	U.S. Fish & Wildl. Serv. (1986)
Hwy 283/Roll to Hwy 183/Taloga, 95 km	Hc	92	34	0.3	Hill (1992b)
Hwy 183/Taloga to I-44/Newcastle,	Fw	75	2	*	Downing (1980)
209 km	Hc	92	37-39	0.1	Hill (1992b)
I-44/Newcastle to Noble, 26 km	Fw,Gd	91	38	1.5	Byre (1991)
	Ab	92	12	0.5	Hill (1992b)
I-44/Newcastle to Purcell, 32 km	Gd	92	68	2.1	Byre (1992)
Jenkins Ave. at Norman	Gd	87	5	-	Bergey (1988)
	Gd	88	12	-	Bergey (1988)
Hwy 81/Union City to Byars Bridge, 109 km	Ab	90	105	1.0	Hill (1990)
Noble to Burlington Northern RR/ Sasakwa, 133 km	Ab	92	107-109	0.8	Hill (1992b)
Burlington Northern RR/Sasakwa to	Ab	90	69	0.7	Hill (1990)
upper Eufaula L./Indianola Ramp, 97 km	Ab	92	92	0.9	Hill (1992b)
Sam's Point, Eufaula Lake	Ab	92	25-30	-	Hill (1992b)
Eufaula Dam to mouth, including	Ab	88	62	1.4	Hill (1990)
Sequoyah NWR, 43 km	Ab	89	7	0.2	Hill (1990)
	Ab	90	12-14	0.3	Hill (1990)
	Ab	92	20-40	0.5-0.9	C. Heflebower (pers. comm.)
Mouth (on Sequoyah NWR), 2.3 ha	Ab,Gd	87	105	45.6	Archibeque (1987)

Table 1, cont'd.

	METHOD[1]	YR	ADULTS	DENSITY[2]	SOURCE
		RED RIVER			
West TX border to Denison Dam, 483 km	Fw	75	15	*	Downing (1980)
	Hc	84	4	*	Locknane and Thompson (1988)
	Fw	85	8	*	Locknane and Thompson (1988)
N. Fork to Hwy 277/Burkburnett, 103 km	Ab	91	52-57	0.5	Hill (1992a)
Hwy 277/Burkburnett to Hwy 81/Terral, 119 km	Ab	91	30-36	0.3	Hill (1992a)
Hwy 81/Terral to I-35/Thackerville, 129 km	Ab	91	57-59	0.4-0.5	Hill (1992a)
Denison Dam to Hwy 78/Karma, 50 km	Ab	91	4	0.1	Hill (1992a)
Hwy 78/Karma to Hwy 271/Hugo, 100 km	Ab	91	82	0.8	Hill (1992a)
Hwy 271/Hugo to Hwy 37/Albion, 74 km	Ab	91	35	0.5	Hill (1992a)
Hwy 37/Albion to AR, 77 km	Ab	91	48	0.6	Hill (1992a)

[1]Gd-ground
Fw-fixed-wing
Hc-helicopter
Ab-airboat
Cn-canoe

[2]# adults per km (river) or per ha (salt flat or reservoir)

[3]Also known as Edith Salt Plains or Cargill Solar Plant.

* = less than 0.1
- = insufficient information to calculate density

of surveys with floods that inundated tern nesting habitat.

In 1975, Downing (1980) counted only 89 Least Terns from fixed-wing surveys of about 45% of Oklahoma's major rivers. Subsequent ground and boat surveys have found significantly more birds. The maximum number of adult terns counted in Oklahoma during a single year was 1,216-1,431 (author's conservative estimate to compensate for possible double counting) in 1992 when approximately 85 percent of principal habitat (major salt flats and rivers) was surveyed. Accounting for unsurveyed principal and marginal habitat, I estimated that Oklahoma supported about 1600 to 1800 adult Least Terns in 1992.

Although most principal habitat has been surveyed within the last three years, gaps exist for marginal habitat. Areas remaining to be surveyed include a few reservoir beaches, the North Canadian River between Fort Supply and Shawnee (565 km), the Salt Fork of the Arkansas River downstream from Great Salt Plains Dam (166 km), and the North Fork (219 km), Salt Fork (113 km), and Elm Fork (156 km) of the Red River. However, these rivers may be too narrow to attract breeding terns.

HABITAT TRENDS

Salt flats—About half of the salt flats at Salt Plains National Wildlife Refuge was inundated in 1941 by the 3,517 ha conservation pool of Great Salt Plains Lake. Between 1941-1991, about 405 ha of additional flats were degraded by encroachment of vegetation, primarily salt cedar (*Tamarix gallica*), along the eastern edge (R. Krey, pers. comm.). Sibley (1812) described this area in the early 1800s as a river running through unvegetated salt flats; 1941 aerial photos show the same (R. Krey, pers. comm.). Today it is a swath of trees and shrubs about 3 km wide. As water enters Great Salt Plains Lake, it slows and deposits silt, creating an ideal seed bed for salt cedar.

Floods, drought, and ground water depletions affect salt cedar establishment. Seeds germinate under many conditions but seedlings persist only on areas where there is moisture within 2.5 cm of the soil surface for about 6 weeks (Tomanek and Ziegler 1961). Submergence of young seedlings for fewer than 6 weeks has no effect on survival (Cooper 1963).

Recent bank erosion and channel movement along the Cimarron River has increased flooding of nests at Little Salt Plains in northwest Woods County (Boyd 1990). The impact of this flooding on vegetative encroachment is unknown. Widespread but short-term sheet flooding regularly inundates nests on the salt flat at Salt Plains Refuge (Grover and Knopf 1982, Hill 1985, Utych and Leslie 1992); however, salt cedar does not appear to be establishing itself toward the interior of the flats where streams are ephemeral.

Reservoirs—Nesting habitat is scarce at Oklahoma's 34 major impoundments. There are few spits, islands, or shorelines of bare, unconsolidated substrate. At Kerr Lake in Sequoyah County, the Corps maintains about 6 ha of a 28-ha beach for Least Terns by annual raking of vegetation (L. Isley, pers. comm.). Sand spits at Optima Lake provided terns nesting sites from 1984 to 1988 and in 1991 and 1992, but were inundated in 1989 and 1990. Reservoir level is unregulated and the "lake" is becoming a marsh. A substantial lake level elevation is needed for water to overtop the spillway. Engineers and hydrologists speculate that the reservoir never filled due to lowered ground water tables, decreased runoff, and below average precipitation in the interval between the start of planning (1936), construction (1966), and operation (1978).

Rivers—Substantial reservoir and channel construction occurred in Oklahoma between 1950 and 1980 (Oklahoma Water Resources Board 1984:12). I determined that about 710 km of river habitat was lost by mainstem impoundments and channelization on the Arkansas, Salt Fork Arkansas, Cimarron, North Canadian, Canadian, and Red rivers in Oklahoma. Additional habitat has degraded due to operation and maintenance of mainstem and tributary projects and to water withdrawals, especially in western Oklahoma. Controls on rivers have limited the amount of sand for island and bar formation. Most of the total sediment entering major reservoirs (90 to 99%) is not released to the downstream environment, and for hundreds of miles downstream, sediment deposition is less than that for the same discharge prior to dam construction (Williams and Wolman 1984). Dams also have altered the timing and reduced the frequency and magnitude of scouring floods essential for channel maintenance. High flows are important in controlling channel size and vegetation in these alluvial channels (Schumm and Lichty 1963; Williams and Wolman 1984).

Channel width downstream from many dams has narrowed considerably (Williams and Wolman 1984), affecting Least Terns. On most remaining high elevation islands, herbaceous vegetation has been replaced by permanent shrubs and trees, a condition unsuitable for nesting.

On the Canadian River, lack of downstream releases from Sanford Dam (Lake Meredith), 129 km upstream from the Oklahoma border, has caused channel narrowing by vegetation encroachment (Stinnett et al. 1987). Wetlands and agricultural lands now occur in areas that once were flooded shifting sands capable of supporting primarily annual plants (Fig. 3). In August 1820, Edwin James described the Canadian River near the 100th meridian (the present Texas/Oklahoma border near Antelope Hills) as a bare sandy riverbed 800 to 3200 m wide (Thwaites 1905). In 1984 this segment of river averaged only 104 m wide (Table 2). Along a 330 km segment west of I-35, from 1953 to 1983, the area of sand plus open water decreased from 72% of the historic

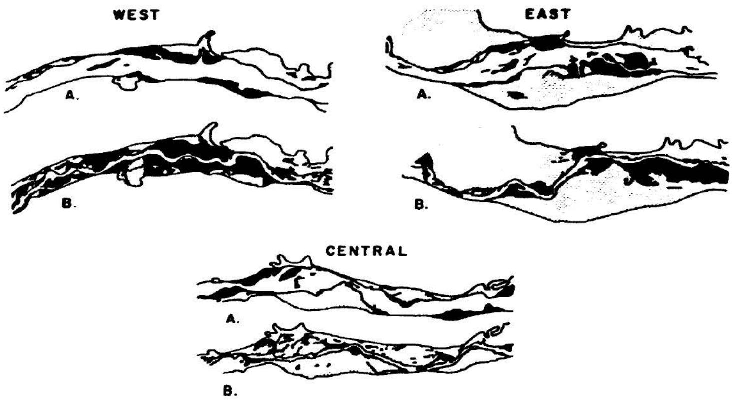

Figure 3. Floodplain changes on the Canadian River, Oklahoma, west of I-35 between 1953-54 (A) and 1981-84 (B). The western half of the river in Oklahoma (330 km) was broken into three regional segments (west, central, and east) of equal length. Representative reaches (15 km) within segments are depicted. The active channel of water and bare sand used by Least Terns (unshaded) has narrowed, replaced by woody and herbaceous wetland vegetation (shaded) and agricultural land (stippled). (Used with permission from Stinnett et al. 1987.)

floodplain to 23% (Stinnett et al. 1987).

Table 2. Measurements from 1979-84 black-and-white aerial photos of potential Least Tern nesting habitat in the active channels of the Cimarron (300 km), Canadian (330 km), and Red (366 km) rivers of western Oklahoma (longitude 97°40′ to 100°). The length of each river is divided into segments roughly one-third long. (Adapted from Stinnett et al. 1987.)

	CIMARRON RIVER			CANADIAN RIVER			RED RIVER		
SEGMENT	n[1]	W[2]	ha/km[3]	n	W	ha/km	n	W	ha/km
West	40	82	8.1	57	104	10.2	55	65	6.3
Central	48	183	18.0	76	175	17.3	64	233	23.0
East	57	154	15.2	41	358	35.6	62	239	23.6
TOTAL	145	140	13.8	174	215	21.3	181	180	17.8

[1]Number of 1609 m long (1 mi) consecutive sample plots.
[2]Mean width of the active channel in meters.
[3]Hectares of dry, sparsely vegetated sand per km of stream.

floodplain to 23% (Stinnett et al. 1987).

Other than normal seepage under and through the dam, Lake Meredith has never made a downstream release since completion in 1964. Numerous water retention structures in the basin also impact flows in the Canadian River. Average annual stream discharge at the U.S. Geological Survey stream gauge near Canadian, Texas (40 km upstream from the Oklahoma border), has been reduced to one-sixth of that prior to reservoir control, 88 vs. 549 cubic feet/second (cfs). Streamflow records show a maximum discharge of 122,000 cfs prior to upstream impoundment, compared to 14,600 cfs after reservoir completion. Principal sources of water to the Canadian River are now tributary inflow and springs. Low flows prevail throughout most years, playing little role in floodplain formation or maintenance.

No flows or low flows also prevail on the Beaver, Red, and Cimarron rivers in western Oklahoma where irrigation pressure since settlement has lowered ground water tables. In 1984, channel width and area of potential Least Tern nesting substrate were smallest in the westernmost reaches of western Oklahoma rivers (Table 2). Although there are no mainstem dams on the Cimarron River in western Oklahoma, the channel is filling with vegetation and attempts to clear sandbars by disking and applying herbicides have met with limited success (Boyd 1990). Without regular scouring flows, manual manipulation of vegetation in most cases will require a concerted yearly effort.

In northeast Oklahoma, scouring flows have decreased on the Arkansas River (U.S. Fish and Wildlife Service 1989). Historically (1944-1965), bankfull or out-of-bank scouring flows on the Arkansas River occurred every 1 to 5 years at Ralston and Tulsa. Since completion of Kaw (1976) and Keystone (1965) dams, peak discharges at Ralston and Tulsa have met or exceeded bankfull flows only once in 16 and 27 years, respectively (U.S. Fish and Wildlife Service 1989).

In southern Oklahoma, the impact of Denison Dam (completed in 1944) on scouring flows of the Red River is uncertain (Hill 1992a). During the past 20 to 40 years the Red River has met or exceeded bankfull capacity almost every year at Burkburnett (upstream of the dam) and DeKalb (downstream), but is more erratic elsewhere, ranging from once in 20 to 25 years at Terral and Gainesville (upstream) to once every 1 to 7 years at Arthur City (downstream). During the last decade, however, scouring flows have occurred along the entire Oklahoma/Texas Red River border.

Rangewide, declining habitat conditions may already be limiting population expansion and may limit future expansion needed for species' recovery. Since settlement there has been a 90% reduction in the area of active channel along some segments of the Platte River in Nebraska (Sidle et al. 1989). Recent videography indicates that habitat availability may be limiting Least Tern populations on over 160 km of that river (Ziewitz et al. 1992). In the last 50 years, 90% of historic sandbar habitat and 75% of backwater areas have been lost along the Missouri River (Keenlyne 1993). Degrading habitat along the Mississippi River also has been noted (Smith and Stucky 1989).

FLEDGING SUCCESS

Fledging success of Least Terns monitored in Oklahoma from 1982 to 1992 (Table 3) has varied among years, among river systems, and among colonies within river systems. Salt flat areas have had lower (weighted) mean production (0.3 to 0.4 fledglings/pair) than rivers (0.7 to 0.9 fledglings/pair). Few sites have had consistently high production with the exception of one on the Arkansas River in Tulsa. Due to ideal habitat and control of human disturbance, a man-made island in Tulsa has had the highest local production in the state, averaging 1.7 fledglings/pair (SD = 0.28) during 1987-1992. Statewide, during 1982-1992, the (weighted) mean production was 0.5 to 0.7 fledglings/pair (Table 3), comparable to the national average and thought to be sufficient for population stability (U.S. Fish and Wildlife Service 1989).

Table 3. Estimated fledging success of Least Terns in Oklahoma, 1982 to 1992.

	YEAR	NO. PAIRS MONITORED	FLEDGLINGS/ PAIR	SOURCE
Arkansas River	92	125-166	0.5-0.7	Wood and Leslie (1992)
	91	129-153	0.6-1.1	U.S. Army Corps Eng. (1991)
	90	98-100	0.7	U.S. Army Corps Eng. (1990)
	88	73-76	0.5	L. Hill, J. Hoffman, F. Pianalto fieldnotes
	87	28	0.5	F. Pianalto fieldnotes
	86	36	0.9	Hoffman (1986)
Canadian River	92	34	1.6	Byre (1992)
	91	19	0.6	Byre (1991)
	87	52	1.6	Archibeque (1987)
Cimarron River	92	18	0.05	Boyd (1992)
	90	44	0.4	Boyd (1990)
Optima Lake	92	8	0	Boyd (1992)
	88	19	0	M. Eddings (pers. comm.)
	87	30	1.1	Boyd (1987)
	86	26	1.0	Boyd (1987)
Salt Plains NWR	92	56	0.3	Utych and Leslie (1993)
	91	41	0.4-0.5	Utych and Leslie (1992)
	90	120	0.5-0.7	Boyd (1990)
	89	110	0.4	Boyd (1990)
	84	48-67	0.3-0.4	Hill (1985)
	83	64-91	0.2-0.4	Hill (1985)
	82	54-79	0.1-0.3	Hill (1985)
Ltl. Salt Plains	92	37	0.05	Boyd (1992)
	90	55	0.3	Boyd (1990)
Big Salt Plains	92	56	0.2	Boyd (1992)
	90	63	0.4	Boyd (1990)
		WEIGHTED MEAN	0.5-0.7	

THREATS

Natural and man-made factors continue to threaten the Least Tern and its habitat. These threats tend to be imminent, widespread, and difficult to alleviate (Table 4).

Natural factors, such as severe weather and predation, occur locally over wide areas in some years, resulting in high loss of eggs and chicks. Floods, hail, and blowing sand from high winds have inundated, pelted, and buried nests and young; drought and heat have dried up food supplies, addled eggs, and caused chick death or heat exhaustion (Grover and Knopf 1982; Hill 1985; Boyd 1990). Potential predators most often mentioned by Oklahoma researchers include the Coyote *(Canis latrans)*, Raccoon *(Procyon lotor)*, American Kestrel *(Falco sparverius)*, Great Horned Owl *(Bubo virginianus)*, and Great Blue Heron *(Ardea herodias)*. Coyote predation and sheet water flooding continue to limit tern reproduction at Salt Plains Refuge (Grover and Knopf 1982; Hill 1985; Utych and Leslie 1992, 1993); however, electric fencing, elevated nest sites, and chick shelters are being tested to try to alleviate these problems.

Man-made factors, such as pollution, human disturbance, untimely flood releases, and habitat loss tend to be more pervasive than natural factors, resulting in potentially greater loss of individuals and habitat. Little data are available on the extent or effects

Table 4. Classification of threats to the Least Tern in Oklahoma.

THREAT	MAGNITUDE[1]	IMMEDIACY[2]
HABITAT LOSS/DEGRADATION		
Mainstem dam operations	Moderate to high	Imminent
Tributary dam operations	Moderate	Imminent
Channelization/maintenance dredging	High	Imminent
Irrigation/diversion	Moderate	Imminent
Bank stabilization	Moderate	Imminent
Bridge construction	Low	Imminent
Sand/gravel mining	Low	Imminent
Proposed mainstem reservoirs	Moderate to high	Non-imminent
Proposed tributary reservoirs	Moderate	Non-imminent
Chloride control		
Red River Basin	Low to moderate	Imminent
Arkansas River Basin	Moderate to high	Non-imminent
Pollution	Low to high	Imminent
PREDATION	Low to moderate	Imminent
SEVERE WEATHER	Low to moderate	Imminent
HUMAN DISTURBANCE	Low to high	Imminent

[1]High threat - pervasive; resulting in rapid population declines or habitat loss.
Moderate threat - moderately widespread; resulting in small, continual declines in populations or habitat.
Low threat - localized; may be short-term, self-correcting or the impacts are not fully known.
[2]Imminent threat - identifiable and actually occurring.
Non-imminent threat - could potentially occur.

of pollutants on Least Terns in Oklahoma. Pollutant levels of concern have been found in the Arkansas River near Tulsa (heavy metals and petroleum products), and at Salt Plains Refuge (copper and selenium) (Martin 1990, 1992). Further study is needed to determine if biological effects of present concentrations can be demonstrated.

Human disturbance has caused physical loss (smashed eggs and young) and can affect survival of eggs and young by altering Least Tern behavior. "Area closed" signs, colony monitoring, public education, and law enforcement have been used to successfully combat human disturbance of Least Tern colonies on the Arkansas River in Tulsa and on the Canadian River in Norman.

Under state and federal laws (Title 29 Oklahoma Statutes and 50 Code of Federal Regulations), persons may be arrested and fined for "take" of Least Terns; i.e., killing, harassing, or in any way disturbing the birds, their nests, or eggs. The maximum criminal penalty for an individual who knowingly commits such a crime is one year in jail and/or a $100,000 fine. In 1990, a pilot paid a $2,000 fine to avoid possible civil penalties for landing a helicopter in a Tulsa tern colony, and in 1992 a recreationist forfeited his all-terrain vehicle for driving through a clearly marked and posted Norman colony. Eight Least Tern mortalities (all chicks) occurred in the first case and none in the latter.

Under Section 7 of the Endangered Species Act, all federal agencies are required to consult with the Service to determine if actions they fund, carry out, or permit affect endangered species or their habitat. In Oklahoma, consultations on the Least Tern have considered bridges, pipelines, sand mining, channel fills, dam operations, oil and gas wells, and pesticide registrations. Impacts often are avoided simply by scheduling activity in or near the river bottom when terns are absent or by providing protective buffers. Consultation on the effects of dams, however, is complex. The Service presently is consulting with the Corps to minimize harmful effects of Arkansas River dam operations on terns (U.S. Fish and Wildlife Service 1989). During the prolonged wet summer of 1992, the Corps modified releases from Keystone Dam to prevent flooding of Least Tern nests and young. This consultation likely will serve as a model for future consultations on the Canadian and Red rivers.

The Service also has requested that the Corps consult on the Red River Basin chloride control project under construction. Runoff from the Red River is largely unsuitable for municipal, industrial, and agricultural uses because of excessive naturally-occurring sodium chloride concentration. The Corps has developed a plan to control chloride using ring dikes, weirs, low-flow collection dams, pipeline pumpage, and brine lakes. A reduction in chloride could cause a concomitant increase in turbidity and a decrease in production of small fish (Least Tern prey) because of the electrochemical properties of clays.

A number of planned large projects may undergo Section 7 consultation in the future:

1. Dredging of Great Salt Plains Lake — spoil deposition on the salt flats at Salt Plains Refuge.

2. Arkansas River Basin chloride reduction — inundation of nesting habitat and reduction of food resources at Salt Plains Refuge and Little Salt Plains.

3. Proposed new reservoirs — dozens deferred or inactive, but which could be reactivated any time.

RECOVERY NEEDS

Once a species is listed under the Endangered Species Act, the primary goal is to return the species to a point at which protection under the Act is no longer required. The recovery plan for the Interior Least Tern (U.S. Fish and Wildlife Service 1990) identifies goals for recovery and tasks for completion. According to the plan, to be considered for removal from the endangered species list, the interior population of the Least Tern must reach 7,000 breeding adults and remain stable or increasing for 10 years. Additionally, essential habitat must be protected and managed. Essential habitat is nesting and foraging habitat necessary for continued existence and growth of the population to meet recovery objectives.

The target population for Oklahoma represents nearly 25% of the overall recovery goal. The Oklahoma recovery objectives specify 1650 breeding adults maintained in the following distribution: Arkansas River 250, Salt Plains Refuge 300, Cimarron River basin 400, Canadian River 300, Beaver/North Canadian River 100, and Red River system 300. The greatest number of adults (not necessarily all breeding) observed at these areas in a given year was 315-402 on the Arkansas River (1992), 240 at Salt Plains Refuge (1990), 345-435 in the Cimarron River basin (1989), 328-356 on the Canadian River (1992), 60 on the Beaver/North Canadian River (1987), and 308-321 in the Red River system (1991).

The extent of population mixing among rivers and between rivers and coastline is unknown. Band returns indicate some mixing (Boyd 1993, Boyd and Thompson 1985, Lingle 1993, Schwalbach et al. 1993). Boat and ground surveys on the Missouri and Platte rivers occasionally show increases in the number of adults between years that cannot be explained fully by recruitment of young produced on those rivers in previous years; these trends have led to speculation that Least Terns from the Mississippi River may sometimes emigrate to tributary rivers (R. Renkin, pers.

comm.). Boat surveys indicate that tern numbers on the Mississippi fluctuate widely some years, depending on sandbar availability (Rumancik 1991). Deteriorating coastal conditions also may push birds to the interior (J. Sidle, pers. comm.).

Population trends will be difficult to interpret without periodic, standardized total counts across the entire range of the Interior Least Tern. Such an effort recently was completed for the Piping Plover *(Charadrius melodus)*. With or without such an effort for the Least Tern, birders can aid recovery by reporting sightings to the Service, volunteering to monitor colonies, and educating landowners and river recreationists about the plight of the tern.

Recovery efforts in Oklahoma should focus on continued censusing and monitoring of primary habitat, consultation on federal actions (especially dam operations), and experimental management to stabilize or increase habitat and populations. Additional work is needed to identify and prioritize essential habitat so that management efforts are geared to the most important areas. Because essential habitat will largely be privately owned, protection will require acquisition or agreements with landowners. Protection and management have been initiated by The Nature Conservancy on portions of the Arkansas (11 km) and Canadian (32 km) rivers in Tulsa and Norman.

CONCLUSIONS

The recovery potential for the Least Tern in Oklahoma appears to be low to moderate. Current populations may be close to target numbers and average production may appear sufficient to maintain those numbers, but threats tend to be far-ranging and difficult to control. In particular, continued habitat loss and degradation may threaten long-term species survival and recovery. Costly and intensive river management is needed. Techniques such as island construction, vegetation control, predator exclusion, and chick shelter enhancement are still experimental and have uncertain probabilities of success.

Unfortunately, the Least Tern is not the only species in trouble on Oklahoma's sand-bottom rivers. A suite of listed species and candidates for listing depend upon this ecosystem. The endangered Whooping Crane *(Grus canadensis)* and the threatened Piping Plover migrate through the state and need this habitat for resting and refueling. The Snowy Plover *(C. alexandrinus)*, a candidate for listing as threatened or endangered, nests in association with the Least Tern in western Oklahoma. Three candidate fishes, the Arkansas Darter *(Etheostoma cragini)*, Arkansas River Speckled Chub *(Hybopsis aestivalis tetranemus)*, and Arkansas River Shiner *(Notropis girardi)* inhabit shallow channels with sandy substrates in Oklahoma. To be most cost effective, river management should focus on restoring a functioning ecosystem for the Least Tern and associated species.

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