Technical Nongame and Endangered Species Session

Attributes of Least Tern Colonies along the Arkansas River, Oklahoma

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Abstract: We investigated attributes of 5 colony sites of endangered least terns (*Sterna antillarum athalassos*) nesting on the Arkansas River from Tulsa to Muskogee, Oklahoma, in 1992 and 1993. We tested hypotheses that least terns selected areas to nest with the lowest amount and height of vegetation and nested near driftwood or similar debris. River flows prior to the nesting season in May 1993 scoured all sandbars, removing vegetation and increasing abundance of driftwood. Attributes of colony sites of nesting least terns varied substantially from one location to another. Distances from nests and random points to vegetation and driftwood varied among colony sites. Occurrence of driftwood at colony sites increased after floods in 1993, and least tern nests at 4 of 5 colony sites were significantly closer to driftwood than were random points inside a colony. Nests at all colony sites surveyed were situated on sandbars at maximal distances to the narrowest water barrier from shores of sandbars to the river bank. Our results suggest that river flows that elevate sandbars before the nesting season ultimately will enhance recovery of endangered least terns on the Arkansas River by reducing losses of nests to flooding, retarding establishment of vegetation, and increasing abundance of driftwood.

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Least terns in the interior United States typically nest on riverine sandbars with little or no vegetation from mid-May through early August. Loss of such nesting habitat and human disturbance (Carreker 1985, Sidle and Harrison 1990) were key factors that led to the federal listing of the interior population of least terns as endangered (U.S. Fish and Wildl. Serv. 1985). Alterations to hydrology and channelization of major rivers in the interior United States have resulted in vegetation encroachment (Williams 1978, Stinnett et al. 1987), which has reduced availability of nesting habitat of least terns (Sidle et al. 1989, Ziewitz et al. 1992). Irrigation and impoundment projects also have contributed to alteration of channel characteristics (Williams 1978, Tomelleri 1984, Stinnett et al. 1987).

Least terns nest on sparsely vegetated sandbars and islands in riverine and coastal areas (Grover and Knopf 1982, Thompson and Slack 1982, Faanes 1983, Gochfeld 1983, Carreker 1985, Hill 1985, Kotliar and Burger 1986, Kreil and Dryer 1987, Ducey 1988, Sidle et al. 1988, Smith and Renken 1991, Ziewitz et al. 1992, Kirsch 1996). Typically, least terns nest in areas with <20% vegetative cover (Thompson and Slack 1982, Gochfeld 1983), but they have been observed nesting in areas with >30% vegetative cover on the Missouri River (Dryer and Dryer 1985). Least terns in riverine and alkaline flat habitats often nest near driftwood or similar debris (Grover and Knopf 1982, Hill 1985, Ducey 1988, Smith and Renken 1991, Renken and Smith 1993, Schweitzer 1994, Winton 1997).

We investigated attributes of 5 nesting colonies of least terns on the Arkansas River in east-central Oklahoma in 1992 and 1993. We evaluated hypotheses that least terns selected areas with the lowest amount and height of vegetation and nested near driftwood or similar debris. Because least terns in the interior United States are federally listed as endangered and few data exist on their nesting activities on the Arkansas River, our study was designed to understand how to enhance availability of important nesting areas and recovery objectives (Sidle and Harrison 1990).

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Study Area

We studied colonies of least terns on the Arkansas River below Keystone Dam from Tulsa downriver to Muskogee, Oklahoma. The Arkansas River below Keystone Dam is a low-gradient river ranging from 200 to 900 m in width (Okla. Water Resour. Board 1990). Typically, the river's channel is wide with braided streams around expansive sandbars. Periodic high flows caused by releases from Keystone Reservoir through Keystone Dam (Wood 1994) inundate and scour sandbars and remove vegetation. Resultant barren sandbars presumably are most suitable for nesting least terns (Sidle and Harrison 1990).

Before 1993, scouring flows had not occurred on the Arkansas River below Keystone Dam since 1986 (Wood 1994). Consequently, vegetation occurred on high-elevation sandbars in 1992. Although both 1992 and 1993 had periods of high river flows, the magnitude of flows was greater in 1993 than in 1992. Maximum flow from May through August was 24,300 cfs in 1992 and 148,000 cfs in 1993 (Wood 1994).

Methods

As part of larger study of least terns on the Arkansas River (Wood 1994), we monitored 12 colonies in 1992 and 20 in 1993 from 15 May to 15 August. We selected 5 colony sites along the river reach that had the range of physical and biological attributes that were hypothesized to influence selection of nest sites by least terns. Colonies were monitored remotely with a variable-power spotting scope every 4–5 days during incubation and every 2–3 days after chicks hatched. Nest locations were recorded on hand-drawn maps during each nesting season. After least terns left colony sites in mid-August, we searched the sites and located all nests that were not destroyed by wind, rain, or other disturbances.

We measured distances to vegetation and driftwood from nests and random points and average height of vegetation inside and outside colonies after least terns left the area in late August. Vegetative characteristics at the end of the nesting season did not represent conditions when least terns initiated nesting, but phenology and extent of growth during summer did not differ among colony sites. Frequencies of occurrence of vegetation and driftwood were enumerated by randomly placing 75–200 0.1-m^2 circular plots inside nesting areas and an equal number of plots outside nesting areas. In 1992, we conducted a pilot study in 3 colonies and measured height of vegetation and distance to the nearest vegetation from nest scrapes and an equal number of random points in 4 quadrants, oriented on the cardinal directions, around each nest and an associated random point. We formalized this approach in 1993 by adding 1) measurements to the nearest driftwood in each plot quadrant and 2) random points outside of colony areas.

We surveyed distances from nests to the narrowest and widest water barriers between shores of sandbars and the river bank at 3 colony sites in 1992 and 5 colony sites in 1993. Surveys were performed with a 100-m tape, a Colman Ranging 1200 range finder, and a Burger transit and stadia rod.

We examined differences among mean distances from vegetation and driftwood and height of vegetation to nests and random points by rank transforming data and performing analyses of variance (Conover and Iman 1981); ranked *t*-tests were used to compare paired means (Steel and Torrie 1980). All tests were done with SAS (SAS Inst. 1990), and statistical significance was set at $P < 0.05$.

Results

The number of least tern nests in the 5 colonies ranged from 3 to 28 nests in 1992 and 9 to 32 nests in 1993. Obvious changes in characteristics of sandbars occurred as a result of scouring flows (>140,000 cfs) of the Arkansas River in spring

1993. Frequency of occurrence of vegetation at colony sites decreased noticeably from 1992 to 1993 (Fig. 1a). In contrast, frequency of occurrence of driftwood was greater at all colony sites after high flows in 1993 than in 1992 (Fig. 1b).

Vegetation on all sandbars was generally a mix of young willow (*Salix* spp.), cottonwood (*Populus* spp.), and salt cedar (*Tamarix* spp.) with herbaceous species such as composites and sea purslane (*Sesuvium verrucosum*). Over all 5 colony sites, mean distances from least terns nests to the nearest vegetation were shorter (P <0.001) in 1992 ($\bar{x}$ = 1.32 m ± 0.16 SE, N = 80) than in 1993 ($\bar{x}$ = 4.78 m ± 0.29, N = 268), indicating greater abundance of vegetation in 1992. Similarly, height of vegetation closest to least tern nests was higher (P < 0.001) in 1992 ($\bar{x}$ = 15.9 cm ± 1.37 SE) than in 1993 ($\bar{x}$ = 11.0 ± 0.50 SE), indicating the presence of more established vegetation in 1992.

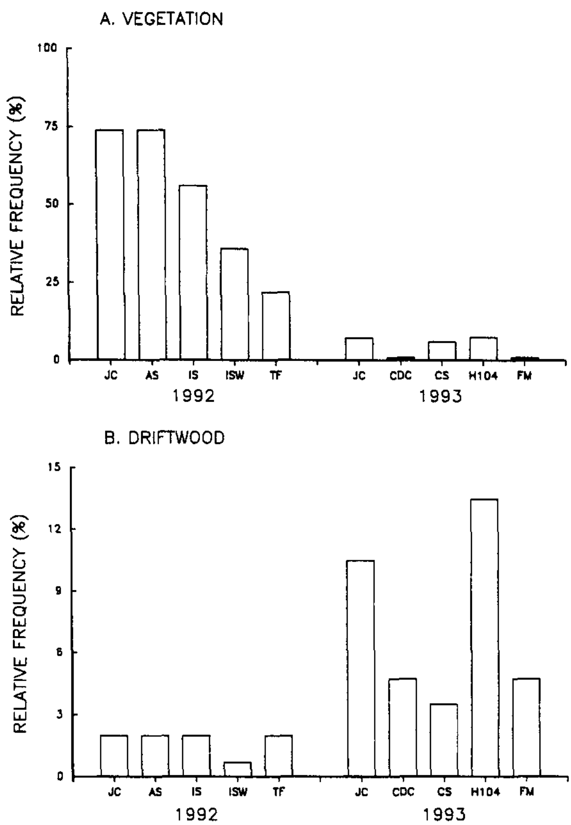

Figure 1. Frequency of occurrence of vegetation and driftwood in 75–200 0.1-m^2 plots at 5 colony sites of least terns on the Arkansas River from Tulsa to Muskogee, Oklahoma, prior to (summer 1992) and after (summer 1993) scouring floods. Colony abbreviations: JC, Joe Creek; AS, Anchor Stone; IS, Indian Springs; ISW, Indian Springs West; TF, Taft; CDC, Cedar Creek; CS, Coweta; H104, Highway 104; FM, Fern Mountain.

In 1992, our evaluation of attributes at 3 of the 5 colony sites indicated that mean distances from nests to vegetation and height of vegetation closest to nests differed (P <0.004) among colony sites (Wood 1994). Distances from nests to vegetation in 1992 were greater than those from random points in all colony sites, but they were significant (P <0.05) at only 1 colony.

In 1993, our expanded evaluation included all 5 colonies, and we measured distances from nests to driftwood and compared random points inside and outside the colonies (Table 1). As in 1992, there were significant (P <0.001) differences among the 5 colonies in all 3 measurements. For example, mean distances from nests to the nearest vegetation ranged from 2.35 m ± 0.16 SE at the Highway 104 colony to 12.08 m ± 0.87 SE at the Cedar Creek colony (Table 1). Least terns selected nest sites at greater distances from vegetation than random points in only 1 of the 5 colonies but closer to driftwood than random points in 4 of the 5 colonies (Table 1).

Mean distances from nests to the narrowest water barriers between shores of sandbars and the river bank were significantly greater than to the widest water barrier

Table 1. Mean distances (m) from 80 least tern nests[a] and random points, inside and outside colonies, to vegetation and driftwood and height (cm) of vegetation closest to nests at 5 colonies on the Arkansas River, Oklahoma, 1993.

			Random points				
	Nests		Inside		Outside		
Character Colony	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	P^b
Distance to vegetation							
Joe Creek	2.77	0.22	2.34	0.20	2.99	0.33	0.243
Cedar Creek	12.08	0.87	11.95	1.40	9.53	1.01	0.011
Coweta	2.85	0.29	2.02	0.22	2.41	0.29	0.088
Hwy. 104	2.35	0.16	2.61	0.33	4.49	0.53	<0.001
Fern Mtn.	6.72	0.67	7.46	0.67	6.85	0.84	0.289
P^c	<0.001		<0.001		<0.001		
Distance to driftwood							
Joe Creek	1.58	0.16	1.26	0.11	1.68	0.14	0.069
Cedar Creek	3.16	0.54	4.69	0.43	3.04	0.43	<0.001
Coweta	1.03	0.25	3.95	0.39	2.85	0.28	<0.001
Hwy. 104	1.10	0.19	1.21	0.17	3.08	0.36	<0.001
Fern Mtn.	2.18	0.28	3.67	0.29	3.21	0.32	<0.001
P^c	<0.001		<0.001		<0.001		
Height of vegetation							
Joe Creek	12.52	0.67	12.64	1.02	11.51	0.72	0.377
Cedar Creek	7.78	0.82	8.25	0.85	12.72	1.34	0.003
Coweta	10.07	0.92	11.89	1.09	11.68	0.84	0.367
Hwy. 104	9.65	1.03	11.46	0.99	11.98	0.98	0.842
Fern Mtn.	12.38	1.69	8.52	1.16	8.54	1.47	0.012
P^c	<0.001		<0.001		<0.001		

a. Numbers of nests for each colony in 1993 provided in Table 2.

b. Intracolony analysis of variance of ranked data (Conover and Iman 1981).

c. Intercolony analysis of variance of ranked data (Conover and Iman 1981).

Table 2. Mean distance (m) from nests (N) to the narrowest and widest water barriers from the shores of sandbars to the river bank at 5 least tern colonies on the Arkansas River, 1992–1993.

			Distance to narrowest water barrier		Distance to widest water barrier		
Year	Colony	N	$\bar{x}$	SE	$\bar{x}$	SE	P[a]
1992	Anchor Stone	6	184.2	5.42	40.3	5.16	<0.001
	Joe Creek	8	104.3	3.72	35.4	5.18	<0.001
	Taft	10	31.7	4.61	38.5	6.00	0.457
1993	Joe Creek	28	70.3	2.61	57.3	4.78	<0.021
	Cedar Creek	9	142.4	6.39	30.5	5.68	<0.001
	Coweta	8	103.7	3.82	35.8	6.70	<0.001
	Hwy. 104	21	102.4	3.81	33.0	3.34	<0.001
	Fern Mtn.	14	162.3	13.00	48.7	8.83	<0.001

a. Intracolony ranked t-tests.

at all but 1 of the 7 colonies measured in 1992 and 1993 (Table 2). Least tern nests generally were arranged in a linear pattern along sandbars farthest from the narrowest water barriers.

Discussion

Scouring flows of the Arkansas River in spring 1993 had a positive effect on sandbar attributes relative to nesting preferences of least terns (Sidle and Harrison 1990). Those flows reduced vegetative cover, increased abundance of driftwood and debris, and elevated sandbars by about 2 m in some cases (Wood 1994). The number of colonies on the Arkansas River from Tulsa to Muskogee increased from 12 in 1992 to 20 in 1993, and nest losses from flooding decreased from 18.2% in 1992 to 3.5% in 1993 (Wood 1994). Nesting least terns often used the highest sandbar elevations within available habitat on the Missouri River (Smith and Renken 1991). Losses of least tern eggs and chicks to flooding can occur where terns have to nest on low sandbars close to water (Schulenberg and Ptacek 1984, Carreker 1985, Ziewitz et al. 1992, Schwalbach et al. 1993, Wood 1994).

Attributes of colonies of nesting least terns on the Arkansas River varied substantially from one location to another, particularly with regard to distances from nest scrapes to vegetation and driftwood. Those differences no doubt reflected variable past flooding histories at each colony site, as influenced by their location above or below tributaries of the Arkansas River. Site fidelity and group adherence of least terns from past breeding experiences may have perpetuated reuse of colony sites, even as they become less desirable due to, for example, vegetation encroachment (McNicholl 1975, Carreker 1985, Kirsch 1996). Differences among colony sites on the Arkansas River indicate, however, that a relatively wide range of vegetative characteristics is acceptable to nesting least terns. Furthermore, productivity of colonies, as indexed by the maximum number of <7-day-old chicks that we observed at a colony site (Wood 1994), was not correlated ($P > 0.05$) with abundance of vegetation and driftwood or height of vegetation. Least terns may select sandbars based on features related to the amount of time that sandbars have been free from inundation (Smith and Renken 1991). In 1993 when flows of the Arkansas River remained high into late spring, least terns delayed initiation of nests until >14 days after sandbars emerged.

Generally, least terns nesting along the Arkansas River avoided sandbars with excessive vegetation and placed their nests to maximize distances to vegetation. Least terns nesting on Long Island, New York, tended to nest on beaches with 10% vegetative cover and avoided areas of 5% and 25% vegetation (Gochfeld 1983). Nests that were closer to vegetation than random points at 1 colony site (Highway 104) on the Arkansas River in 1993 (Table 1) suggested that some vegetation was tolerable to nesting least terns.

In 1992, driftwood on sandbars at the 5 colonies was scarce, but 5 (21%) of 24 nests were <20 cm from driftwood in that year. In 1993, least tern nests at 4 of the 5 colony sites were significantly closer to driftwood than were random points in the colonies (Table 1). Similar observations have been made on alkaline flats at Salt Plains National Wildlife Refuge, Oklahoma (Grover and Knopf 1982, Hill 1985, Schweitzer 1994, Winton 1997), and elsewhere (Ducey 1988, Smith and Renken 1991, Renken and Smith 1993).

Location of colony sites on sandbars at maximal distances to the narrowest water barrier suggested that risk of predation or human disturbance influenced selection of nest sites along the Arkansas River. As mean distance from nests to the widest water barrier increased, the maximum number of 7-day-old chicks observed decreased ($r = -0.603$, $P < 0.01$), suggesting that protection, presumably from terrestrial predators, was provided by the juxtaposition of a colony site and a wide water barrier. By this reasoning, our index of colony production should have decreased when colonies were closest to the narrowest water barrier, but we could not demonstrate such a relationship statistically ($P > 0.10$). Kirsch (1996) found that least terns on the lower Platte River, Nebraska, tended to nest on large mid-stream sandbars that were located where river channels were relatively wide. Such barriers may discourage mammalian predators from reaching sandbars (Swickard 1974, Faanes 1983).

Management Implications

Management activities that seek to minimize establishment of vegetation at breeding colonies of least terns should be encouraged (Sidle and Harrison 1990). Manual removal of vegetation may be warranted on stable sandbars that do not receive scouring flows, but such activities would not simulate natural deposition of driftwood or sand that can elevate sandbars during flooding events (Wood 1994) and may encourage invasion of undesirable plants (E. M. Kirsch, pers. commun.). Scouring flows at about 7-year intervals, such as those that occurred on the Arkansas River in 1986 and 1993, appear to be best for rejuvenating nesting habitat of least terns along highly regulated rivers in the south-central Great Plains (Wood 1994).

The juxtaposition of least tern nests and driftwood, particularly in 1993 after scouring flows of the Arkansas River, suggested that supplementing colonies with driftwood and similar debris (Winton 1997) may enhance nesting habitat. Additional research needs to be done to evaluate natural distributions of driftwood relative to selection of nest sites by least terns. However, based on our observations, driftwood should be placed at the highest elevations of a sandbar (to minimize flooding losses) and farthest from the narrowest water barriers between shores of sandbars and the river bank. On the other hand, some predators (e.g., coyotes *[Canis latrans]*) may cue in on such debris (Koenen et al. 1996*a*), increasing nest and chick losses, which may require additional protective measures (Koenen et al. 1996*b*). Any modifications to least tern colonies should be monitored closely to document their efficacy.

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