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Breeding habitat of the least tern is made up primarily of coastal beaches and inland river sandbars. Populations of the interior (*Sterna antillarum athalassos*) and east coast (*S. a. antillarum*) subspecies are now declining (Marshall et al. 1975, Duffy 1977, Jernigan et al. 1978) and the western subspecies (*S. a. browni*) is endangered (Wilbur 1974). Although coastal populations have received considerable attention (Wolk 1974, Atwood et al. 1977, Blodgett 1978), little research has been conducted on the interior race (Hardy 1957, Downing 1975).

The piping plover inhabits river sandbars and sand beaches and, like the least tern, breeding populations are declining (Arbib 1975, 1978, Niemi et al. 1977). Of the two races, little is known about the interior population (*Charadrius melodus circumcinatus*) (Pickwell 1925, Renaud 1974, Niemi and Davis 1979).

In Nebraska, the Platte River has historically supported breeding populations of least tern and piping plover (Bent 1929), and both species are found where sandbars are present (Downing 1975). Changes in adjacent land use including increased use of center pivot irrigation systems, and in the water regime of the Platte River, have resulted in reduced availability and quality of sandbar breeding habitat. This is primarily the result of reduced water levels and the subsequent encroachment of woody vegetation within the river channels (Currier 1982). Williams' (1978) study of Platte River channel shrinkage described changes that have occurred in peak discharges, annual flow, channel width, and bed elevations between 1865-1978. Current annual flows are about 69% reduced from pristine times (Krapu et al. 1982).

The objectives of this study were to: 1) determine the distribution and abundance of least tern and piping plover using the Platte River in central Nebraska, 2) quantify selected parameters associated with their nesting habitat, 3) evaluate the impact of changing land use on tern and plover nesting habitat, and 4) suggest management alternatives for least tern and piping plover breeding habitat.

STUDY AREA AND METHODS

The primary study area encompassed reaches of the Platte River between Grand Island, Hall County, and Lexington, Dawson County, a distance of about 150 km (Fig. 1).

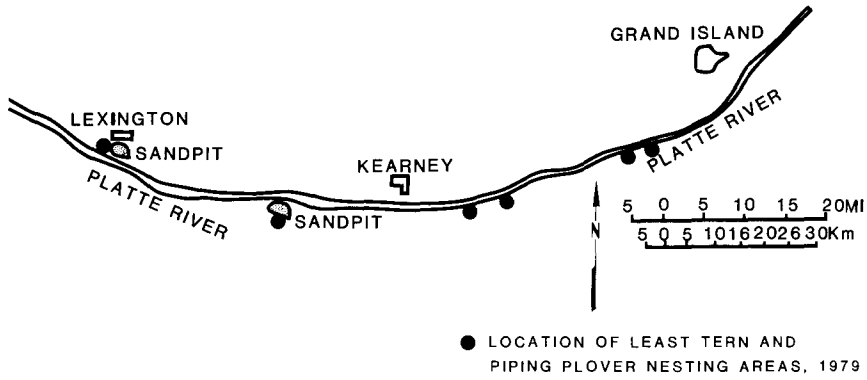

Fig. 1 The Platte River from Lexington to Grand Island, Nebraska, showing colony locations.

Although several channels are present, only the main channel provided habitat suitable for breeding least tern and piping plover. The channels are characterized by numerous islands and sandbars that divert the water flow into many smaller channels. Vegetation associated with the sandbars and adjacent areas is characterized in Currier (1982).

Based on a preliminary 1978 study, and after reviewing aerial photographs (scale = 1:5,000), reaches of river with apparently suitable sandbar habitat were identified for later field study. During 1979, sandbars within about 84 km of river channels were surveyed for tern and plover nests. Nest searches were initiated on 19 May and continued through 26 June.

Each nest was marked with colored surveying tape attached to a metal stake. The location of each nest was marked on reduced 7.5′ U.S. Geological Survey topographic maps.

The following observations or measurements were made at each nest site: length of sandbar (if ≥200 m, then estimated), sandbar width, height of nest above water line, distance of nest to nearest river channel, river channel width, maximum channel depth, distance from nest to nearest vegetation and vegetation type(s), depth to water-saturated soil below nest, length, width, and depth of nest, distance to nearest conspecific nest, percent woody and herbaceous vegetation on sandbar, and percent bare ground, distance from nest to nearest river bank, and type of on-shore vegetation.

Nest elevations were plotted with a transit, and inter-nest distances were individually measured. Square meter quadrats (Phillips 1959) were centered over each nest to quantify percent cover and vegetative composition. Changes in daily river flows were monitored at U.S. Geological Survey gauging stations at Overton and Grand Island, Nebraska.

Each nest was visited 5-7 times during the study period. During each visit, nest contents (eggs or nest materials) were noted. Supplemental nesting phenology and population data were collected on nearby sandpits adjacent to the river.

RESULTS AND DISCUSSION

Phenology, Distribution and Population

Least tern and piping plover were first observed in the study area on 11 May. Arrival dates range from 24 April to 25 May at Lexington, Nebraska, for least tern (Wycoff 1960) and 7 April to 4 May for piping plover (Bent 1929, Tout 1947). Courtship activities began shortly after arrival and nest initiation occurred during 15 May - 21 June for both species.

Four nesting groups were located on the river and two at adjacent sandpits (Fig. 1). The number of nesting pairs at each site is listed in Table 1. One site supported 16 piping plover and 14 least tern nests.

Table 1. Nesting sites and minimum breeding populations along the Platte River during June 1979.

	Number of breeding pairs	
Sites	Least tern	Piping plover
1	0	8
2	0	8
3	14	16
4	3	8
Total	17	40

Least terns typically nest in groups of fewer than 50 pairs and a colony of 30 pairs is probably large for *S. a. athalassos*. Little information exists on piping plover group size, but 16 pairs may represent a substantial number (Wilcox 1959). The use of sandpits and dredge spoil sites by terns is well known (Downing 1975, Jernigan et al. 1978), and both sandpit sites in this study have histories of past use (C. R. Frith, pers. comm.)

Reproduction

The first nest initiation by piping plover and least tern was observed 15 and 21 May, respectively. Young plovers first hatched on 8 June, and terns on 14 June. The incubation period for piping plovers was estimated at 24 days. Wilcox (1959) reported that the mean incubation period among piping plovers on Long Island, New York, was 28 days. Incubation period in the least tern was 19 days which is similar to that reported by Hagar (1937) for Massachusetts, and 17 or 18 days reported by Moser (1940) at Omaha, Nebraska. Mean clutch size among 25 piping plover and 11 tern nests was 4.0 and 2.9. Two young least terns were

successfully hatched from one nest on 14 June, and 13 piping plovers hatched from five nests ($\bar{x}$ = 2.6) during 8-19 June.

All nests, both hatched and active, were submerged by rising water on 21 June. Hardy (1957) suggested that the beginning of nesting by least terns on river systems was directly related to the cessation of spring floods. Prairie streams are frequently subjected to flash floods during the summer months. In 1979, normal late spring fluctuations in river stage were greatly altered because of a heavy, late snowmelt in the Rocky Mountains coupled with very heavy rainfall in western and central Nebraska during 10-20 June.

We monitored river stages throughout the nesting period. Low flow was from 6-9 June, peak discharge was 28-30 June (Fig. 2). Only two nests were lost to rising water prior to 16 June, but by 21 June only one area was not flooded.

The river remained high through mid-July. During this period, we attempted to locate additional plover nests on the Platte River. Portions of the Loup River system, 50 km north of the study area in Howard County, Nebraska were also searched and 10 least tern nests were found. The complete inundation of sandbar habitats combined with the stage at which the first nests were lost, obviously discouraged renesting on both river systems.

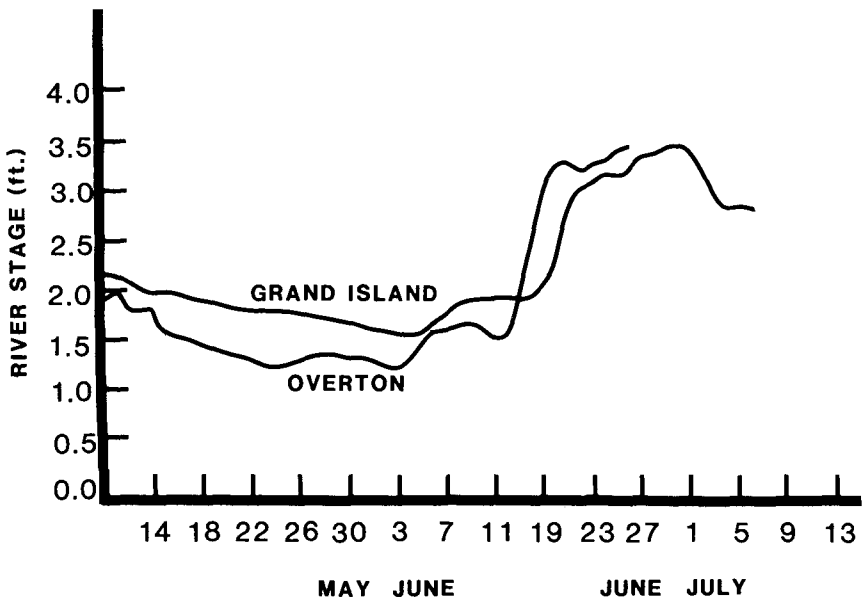

Fig. 2 Flow stages of the Platte River at Overton and Grand Island, Nebraska, May-July 1979.

Nest Colony Characteristics

Terns placed 17 nests at two locations, and 40 plover nests were located at four locations. The high percentage of bare ground (Table 2) in the vicinity of nest sites is comparable with that found in other regions (Jernigan et al. 1978, Niemi and Davis 1979). Ducey (1981) reported that 5-10% of the area of sandbars used by nesting least terns and piping plovers on the lower Platte River had been invaded by cottonwood saplings.

Normal vegetational succession created some problems interpreting the impact of vegetative growth on nest site selection. When early arrivals began selecting nest sites the sandbars were virtually bare. By mid-June, nesting cover had changed from the date of nest initiation. Thus, later nesting birds were required to choose and evaluate habitat that was much different from that found earlier.

Table 2. Mean values for physical characteristics of sandbars used for nesting and some nest characteristics. Number of samples in parentheses.

	Least tern	Piping plover
Sandbar characteristics		
Distance to nearest riverbank (m)	104 (5)	161.9 (28)
Sandbar length (m)	259 (5)	285.9 (28)
Width at nest (m)	58.9 (17)	55.4 (39)
% woody vegetation	9.6 (5)	7.3 (28)
% herbaceous vegetation	18.4 (5)	18.1 (28)
% bare ground	72.05 (5)	74.6 (28)
Nest characteristics		
Height above river stage (cm)	33.0 (9)	19.6 (14)
Depth to moisture (cm)	2.6 (17)	1.0 (39)
Distance to nearest river channel (m)	18.9 (17)	16.4 (39)
Depth of nearest river channel (cm)	30.8 (17)	26.0 (39)
Width of nearest river channel (m)	19.5 (17)	14.1 (39)
Diameter (cm)	1.2 (23)	1.1 (41)
Depth (cm)	0.3 (23)	0.2 (41)

Nest Characteristics

Nest height above river stage (Table 2) differed markedly between terns and plovers. The nonparametric Wilcoxon two-sample test for unpaired, ranked data (Sokal and Rohlf 1969) indicated that this difference in nest height was significant ($P = 0.1$). The greater mean depth to moisture also suggested that terns preferred higher and drier habitat. On one sandbar in the Middle Loup River, the mean height of 10 nests was 68.0 cm. Ducey (1981) reported that piping plovers occupied nest sites on the lower Platte River that were closer in elevation to the water level of the river.

Vegetation Characteristics

Three characteristics were chosen to evaluate vegetation surrounding the nest site, i.e., frequency of occurrence by class, percent plant cover by class (Table 3), and density of woody vegetation by species (Table 4). Values for these parameters suggest that piping plovers tolerate sites with more vegetation surrounding them than do terns. I tested whether the distribution of total woody stems within quadrats was the same for both species. Repeating the Wilcoxon two-sample test procedure resulted in rejection of equality ($P = 0.001$). The woody stem densities averaged greater for least terns primarily because one quadrat had extremely high stem densities (Table 4). This pair may have been forced to nest in marginal habitat because of competition for more favorable sites. Excluding changes in vegetative cover that occurred after nest initiation, both plovers and terns appeared to select nest sites that were barren of vegetation.

Table 3. Vegetative characteristics of habitat surrounding least tern and piping plover nests expressed as percent cover by class ($\bar{x}$ total percent/total quadrats) and frequency of occurrence by class (number quadrats containing a character/total number of quadrats).

	Least tern (n = 17)		Piping plover (n = 37)	
Characteristic	% cover	Frequency	% cover	Frequency
Bare ground	89.1	-	79.4	-
Grass	3.4	0.47	4.4	0.62
Sedge/rush	0.6	0.41	1.2	0.32
Forb	4.1	0.47	9.4	0.73
Shrub	2.3	0.29	5.4	0.55

Substrate Characteristics

Although substrate characteristics were not quantified, piping plovers appeared to select sand of larger grain size for nesting than that chosen by terns. For example, at nesting area 3 the sandbar with the highest combined nest density consisted of two parts: a raised area in the center of the sandbar made up of fine sand, and a surrounding plain of coarser particles. Only least terns nested on the raised area, while piping plovers nested within 1 m of the plain. Most research has shown that least terns nest on substrates of large particle size (Massey 1971, Fisk 1978, Jernigan et al. 1978), but Platte River least terns may be an exception.

MANAGEMENT IMPLICATIONS

The least tern population along the Central Platte River appears to be in danger of further decline. Unless steps are taken to alleviate the continued reduction of open sandbar habitat, this population may be eliminated. Changing

Table 4. Density of woody vegetation by species for quadrats with woody vegetation, and for all quadrats (number stems species A/total number quadrats).

	Least tern		Piping plover	
	Woody vegetation (n = 5)	All quadrats (n = 17)	Woody vegetation (n = 21)	All quadrats (n = 37)
Cottonwood (*Populus deltoides*)	2.2	0.64	2.38	1.35
Plate-leaf willow (*Salix nigra*)	2.2	0.64	2.19	1.24
Interior willow (*S. interior*)	3.0	0.88	0.52	0.29
All woody vegetation	7.4	2.17	5.09	2.89

habitat conditions occurring along the Platte River are not isolated examples and management suggestions may be applicable to other interior populations.

My data suggest that clear visibility such as found along wide stretches of river is an essential habitat component. Williams (1978) demonstrated that reduced peak and annual flow in the Platte River encouraged woody vegetation encroachment on riverbanks and sandbars and reduced overall channel width. Clearing existing colonies of encroaching vegetation has been used successfully by Atwood et al. (1977) in California. Vegetation clearing during the non-nesting season coupled with increased water flows during spring floods can greatly reduce encroachment and sprouting of young vegetation. If encroachment of woody vegetation continues along the Platte River, this alternative must be examined more vigorously.

Most nesting least terns foraged in river channels within 100 m of the nest sites. A continuous water flow that serves as a mammalian predator barrier and supplies a stable source of food items is probably essential. Increased irrigation for crop prodution in upstream reaches of the Platte River has confounded the problem of vegetation encroachment. Continuous flows during the nesting season are also important in reducing human disturbance. During 1978, numerous instances were observed of all-terrain vehicles travelling up channels containing low water. Ducey (1981) attributed abandonment of three least tern nests on the lower Platte River to disturbance that included wading in the river, hiking on sandbars, and limited vehicular disturbance. However, piping plovers at the same location successfully reared young despite these disturbances.

Sufficient height of spring peak flows is required to provide deposition of adequate sandbar sediment (Firth 1974). The appearance of tall, flat sandbars on the neighboring Loup River system (which is not used extensively for irrigation water withdrawal) suggested that excessive water withdrawals and subsequent reduced annual flows in the Platte River have impeded the deposition of sediments on potential sandbars. Swickard (1972) has shown that creation of new nesting habitat by manual deposition of clean sand at existing colonies is beneficial. If the progressive deterioration of sandbar habitat continues because of inadequate flows during critical periods, this alternative may have to be considered.

Least terns demonstrate an ability to partially cope with some of these problems. They will renest after flooding (Wycoff 1960) and may tolerate some vegetation around the nest at coastal locations (Jackson 1976). Terns also nest at alternative sites (Fisk 1978) and are somewhat tolerant of human disturbance (Blodgett 1978). Their behavior and longevity may allow a population to rebound if conditions are improved (Tomkins 1959).

Piping plovers are not as restrictive in their habitat requirements as least terns. Vegetation encroachment is apparently tolerated to a greater extent; they will nest on lower sandbars, and will nest singly. The greater adaptability of plovers is reflected in their wider distribution in the Platte River Valley and by their larger population. However, plovers are similar enough to terns in habitat use that they can be affected by the same problems. Until more information is gathered on the habitat requirements of other inland populations, and until habitat management can be initiated, little can be done to prevent further decline

in quality and quantity of habitat, and population decline of least terns and piping plovers.

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