1988

Conservation of Least Terns and Piping Plovers Along The Missouri River and Its Major Western Tributaries in South Dakota

Monica Jean Schwalbach

CONSERVATION OF LEAST TERNS AND PIPING PLOVERS ALONG THE MISSOURI RIVER AND ITS MAJOR WESTERN TRIBUTARIES IN SOUTH DAKOTA

BY

MONICA J. SCHWALBACH

A thesis submitted
in partial fulfillment of the requirements for the degree
Master of Science
Major in Wildlife and Fisheries Sciences (Wildlife option)
South Dakota State University
1988

CONSERVATION OF LEAST TERNS AND PIPING PLOVERS ALONG THE MISSOURI RIVER AND ITS MAJOR WESTERN TRIBUTARIES IN SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor

Head, Wildlife and Fisheries Sciences

ACKNOWLEDGEMENTS

I wish to extend sincere thanks and appreciation to my advisor, Dr. Ken Higgins, and my colleague, George Vandel, for their advice, assistance, insight, support and friendship throughout this project. Special appreciation is extended to the following people for their invaluable cooperation and assistance: J. Dinan, D. Gates, L. Phillips, M. Snyder, and D. Unkenholz. Thanks also to those people from the Corps of Engineers Division office in Omaha, NE; Corps of Engineers District office in Pierre, SD; U.S. Fish & Wildlife Service field office in Pierre, SD; South Dakota Department of Game, Fish and Parks; and South Dakota State University; who provided knowledge, technical support, and volunteer services.

This study was conducted by the South Dakota Cooperative Fish and Wildlife Research Unit with the U.S. Fish and Wildlife Service, South Dakota State University, South Dakota Department of Game, Fish and Parks, and the Wildlife Management Institute cooperating. Funding was provided by the U.S. Army Corps of Engineers, Missouri River Division, and South Dakota Department of Game, Fish and Parks.

TABLE OF CONTENTS

TABLE OF CONTENTS continued

LIST OF TABLES

LIST OF TABLES continued

LIST OF FIGURES

LIST OF FIGURES continued

CONSERVATION OF LEAST TERNS AND PIPING PLOVERS ALONG THE MISSOURI RIVER AND ITS MAJOR WESTERN TRIBUTARIES IN SOUTH DAKOTA

Abstract

MONICA J. SCHWALBACH

Interior least terns (Sterna antillarum) and piping plovers (Charadrius melodus) are listed as endangered or threatened over all of their breeding range, including South Dakota (SD).

Investigations were made into the status, distribution, production, habitat characteristics, and factors limiting productivity of least terns and piping plovers in SD. The study area included the Missouri River from the North Dakota state line to Ponca State Park, Nebraska, and the lower 1/3 of the Grand, Moreau, Cheyenne, and White rivers.

Least tern numbers increased substantially (253; 367) between 1986 and 1987, but plover numbers increased only slightly (187; 197).

Terns and plovers utilized 83 sites during the two years. Most tern and plover colonies occurred on sandbars below Gavins Point and Fort Randall dams, but some sand and gravel beaches, points, or parking lots were used along Oahe Reservoir, and some sand and gravel beaches were used along the Cheyenne River. All tern and plover colony sites were

characteristically barren or with short (<10 cm), sparse (<10%) vegetative cover. Dominant plant species varied among habitat types.

One-year turnover rates of colony sites ranged from 0.57 to 0.78 for least terns, and from 0.55 to 1.00 for piping plovers. Tern and plover turnover rates were high, probably because of the ephemeral quality of nesting habitat, coupled with high amounts of recreational activity during the 1986 and 1987 nesting seasons.

In 1986, production was poor for both species due to high water levels on the Missouri River throughout the nesting season. Production improved in 1987, and generally was moderate to good for both species. However, tern and plover production was poor both years on the Fort Randall Dam to Springfield, SD, river reach.

Tern and plover distribution and production in SD is largely determined by the relation of nesting habitats to water levels. Fluctuations in water levels affect the amount of beach and sandbar habitat available for nesting, and can cause inundation of colony sites during the nesting season.

Recreational activity, including picnicking, sunbathing, swimming, and fishing, can also adversely affect tern and plover distribution and productivity.

INTRODUCTION

South Dakota has two species of water birds that are receiving special status and attention by state and Federal wildlife agencies: least terns (Sterna antillarum, previously referred to as S. a. athalassos, USFWS 1985b) and piping plovers (Charadrius melodus). Presently, both bird species are rare and in danger of extinction throughout North America, including South Dakota.

The primary factor resulting in the rarity of these species is loss of habitat due to human alterations of their natural environment (Houtcooper et al. 1985). In 1985 the U.S. Fish and Wildlife Service (USFWS) listed the interior population of least terns as endangered and piping plovers as endangered or threatened over all of their breeding range, under the Endangered Species Act of 1973, as amended (USFWS 1985a, 1985b). The Endangered Species Act requires Federal agencies to ensure that their actions do not jeopardize the continued existence of any federally listed endangered or threatened species or result in the destruction or adverse modification of their habitat. Pursuant to this, the U.S. Army Corps of Engineers (COE), Missouri River Division, has entered into informal Section 7 consultation on these two species with the USFWS in North Dakota (ND), South Dakota (SD), and Nebraska (NE)

(Col. Tucker, COE Missouri River Division, Omaha, NE, 1986 pers. comm.).

Due to habitat declines, the SD population of least terns is listed as state endangered and piping plovers as state threatened (Wentz 1979). The SD Department of Game, Fish and Parks (GFP) describes both species as critically rare, "in danger of extirpation", with least tern habitat restricted to portions of the Missouri River and its western tributaries and piping plover habitat limited to the Missouri River and some northeast saline wetlands (Houtcooper et al. 1985). Since no plovers or terns have been seen or recorded on the Bad, James, Vermillion, or Big Sioux rivers during surveys in recent years, these rivers were not included in surveys for this project.

Historical information on the abundance of these two species for SD is lacking. Few nongame inventories were conducted on the Missouri prior to inundation upon completion of the Pick Sloan Plan dams by the COE in the 1960's. Of the remaining free flowing SD Missouri River available for terns and plovers, all is subject to water releases which are negatively impacting these two species. Normal flows of spring flooding, sandbar scouring and midsummer sandbar exposure have been replaced by more stabilized flows resulting in vegetative encroachment of sandbars with remaining sandbars subject to inundation

during the critical nesting season (Dinsmore 1981, Ducey 1981).

In 1986 a cooperative research project was initiated by GFP and the SD Cooperative Fish and Wildlife Research Unit (SDCFWRU) at South Dakota State University to assess the status of least terns and piping plovers nesting along the Missouri River and its major western tributaries in SD.

OBJECTIVES

The primary purpose of this study was to aid in conservation and management of least terns and piping plovers in South Dakota. To accomplish this purpose, the specific objectives were to:

1) Determine population numbers and distribution of least terns and piping plovers along the SD portion of the Missouri River and its major western tributaries,

2) Characterize nesting habitats for least terns and piping plovers along the SD portion of the Missouri River,

3) Investigate possible effects of recreational activity, predation, environmental conditions, and seasonal water level changes as factors affecting nest success, recruitment, and distribution, and to

4) Propose a water management strategy for the Corps of Engineers which would enhance tern and plover reproduction and survival along the SD portion of the Missouri River.

APPLICATION OF THE RESEARCH RESULTS

This thesis summarizes information gained from field surveys, discusses habitat management implications, and provides recommendations for protection priorities, management guidelines, and further study. This information will help identify current population trends, a critical factor in determining the success or failure of conservation efforts to preserve these endangered and threatened species for the future.

The proposed COE water release strategy includes consideration of future habitat needs (sandbar and island scouring), management of existing habitat, and methods for inventory and protection of specific least tern and piping plover colonies. As such, it should serve as the basis for a COE-GFP-USFWS management plan for these species.

Human disturbance has been documented as a reason for declining least tern and piping plover populations (Haig 1986, Sidle 1986). The Missouri River and its western tributaries will likely experience an increasing demand for recreational activities, as more people with leisure time

become aware of the recreational opportunities available. If a sound information and education program can be implemented, both increased recreation and species protection could occur, to the mutual benefit of river recreationists and wildlife alike.

STUDY AREA

The study area included the Missouri River from the ND state line to Ponca State Park, NE, and the lower reaches of the Grand, Moreau, Cheyenne, and White rivers all of which are major western tributaries to the Missouri River in SD (Fig. 1). Six primary areas for ground surveys were identified during aerial surveys in 1986, and included (1) the Missouri River reach from Gavins Point Dam to Ponca State Park, NE, (2) the Missouri River reach from Fort Randall Dam to Springfield, SD, (3) Oahe Reservoir, the Missouri River impoundment above Oahe Dam, (4) the tailrace areas below Oahe and Big Bend dams, (5) the Cheyenne River reach from its confluence with the Belle Fourche River downstream to Foster Bay at the mouth of the Cheyenne River, and (6) approximately the lower third of the Grand, Moreau, and White rivers.

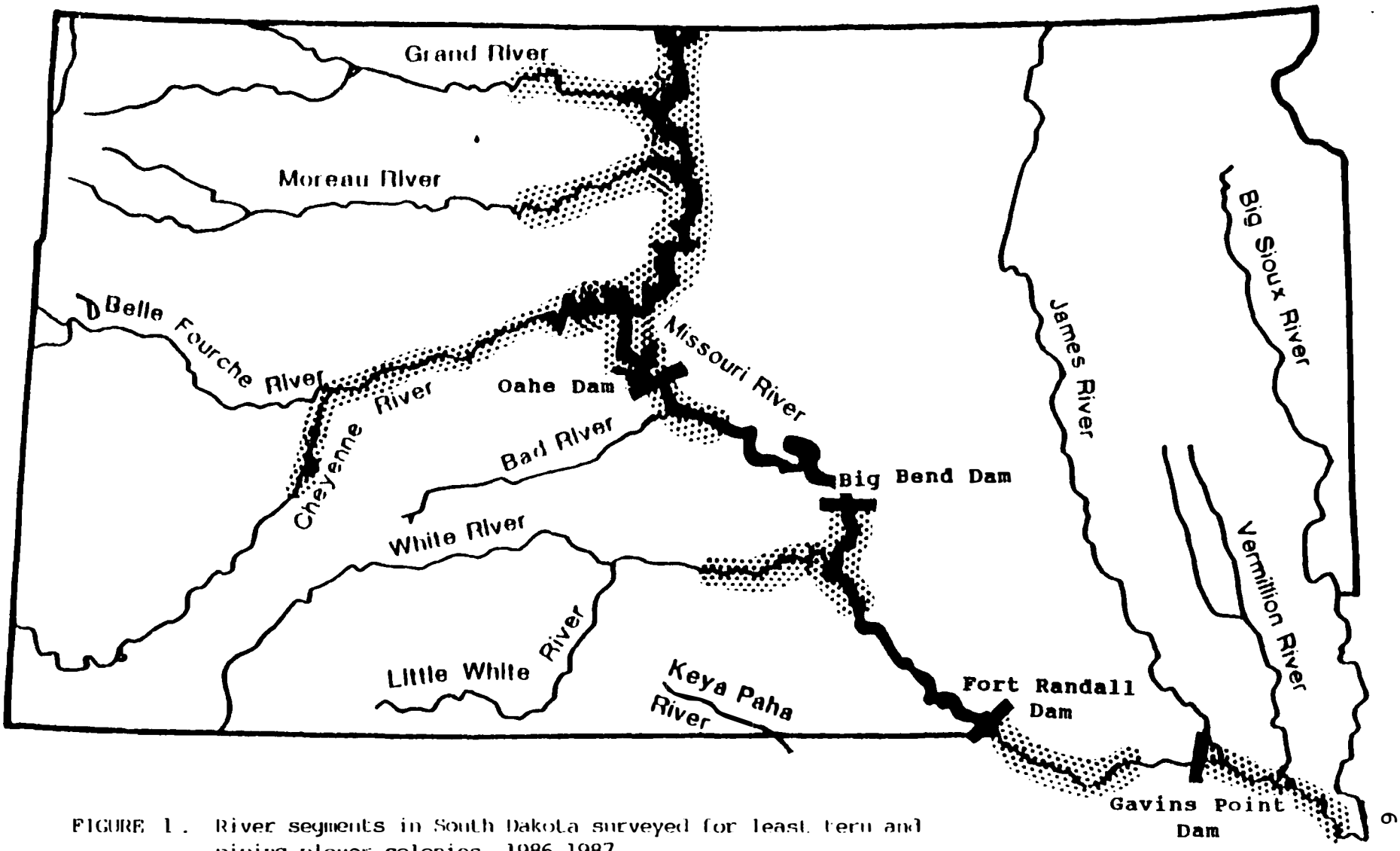

FIGURE 1. River segments in South Dakota surveyed for least tern and piping plover colonies, 1986-1987.

METHODS

Distribution

Aerial surveys of potential nesting habitat were conducted on 27-28 May and 2 July, 1986, and 12-13 July, 1987. Aerial surveys in 1987 were limited to the perimeter of Oahe Reservoir, since all other areas could be adequately surveyed by boat. Areas flown were habitats where nesting had been documented or where adult birds had been observed during previous May to August breeding seasons. Surveys were flown at low altitudes (75-100 m), with three observers in a fixed-wing aircraft. John Dinan (NE Game and Parks Commission, Lincoln, NE, pers. comm.) determined that least terns could be recognized during such flights, because they actively defend nesting areas and will flush at the approach of a low flying aircraft. Population distribution information gathered during aerial surveys was transcribed onto COE aerial mosaics, COE Missouri River recreational maps, USGS topographical maps, or county maps. Researchers then intensively searched these areas by boat to determine exact locations of least tern and piping plover colonies. Additional searches were made of other likely habitats for piping plovers, because they are usually harder to see than least terns unless they occur in sympatric colonies with least terns. Surveys along the Cheyenne, Grand, Moreau, and White rivers were conducted by canoe. Colony sites were

assigned a 5 digit number specifying the river (1=Missouri, 2=White, 3=Cheyenne, 4=Moreau, and 5=Grand), upstream project (1=Gavins Point Dam, 2=Fort Randall Dam, 3=Big Bend Dam, 4=Oahe Dam, 5=none, 6=other), and colony number within that river reach. Detail maps of each colony site were made during the initial visit and all nests were plotted on such maps. At the end of each field season, confirmed nesting locations were mapped and computerized for inclusion into the GFP Wildlife Division - Natural Heritage Database, Pierre, SD, and the Colonial Bird Register at Cornell University's Laboratory of Ornithology, Ithaca, New York.

Population Turnover Rates

Turnover rate provides an index (0.0 to 1.0) of colony site stability between years (Burger 1984). A low turnover rate indicates high colony stability. For example, a low turnover rate of 0.1 would indicate that most colonies are re-used in successive years, with very little pioneering by the species to new nesting sites and very few old colony sites being abandoned. Turnover rates can be measured between two or more successive years. A one-year turnover rate provides the index of colony site stability between two successive years. One-year turnover rates were measured between 1986 and 1987 for all river reaches in SD containing least tern and piping plover nesting colonies. Turnover was

computed by using the formula presented by Erwin et al. (1981):

$$T = 1/2\ (S_1/N_1 + S_2/N_2)$$

where: S_1 = the number of sites occupied only during the first year (but not in the second year), N_1 = the total number of sites occupied during the first year, S_2 = the number of sites occupied only during the second year (and not in the first year), and N_2 = the total number of sites occupied during the second year.

Population Status

All colonies found during the initial survey were visited a minimum of 3 times during each season, at approximately 18 day intervals from the first visit, in order to estimate population size and production. Usually these visits were as follows: one during the incubation stage, one during the hatching period, and one later when chicks were expected to fledge. First visits to colonies began in early June in 1986 and early May in 1987, and last visits were in mid August each year. The minimum number of site visits was increased to 5 (when possible) in 1987 to obtain a more precise estimate of production.

Each nesting season was divided into census periods wherein all colonies were visited sequentially (usually from north to south), and a total count was made of the adults of

each species. The population size of least terns and piping plovers for each season was determined as the maximum number of terns and plovers counted during any single census period.

Production

During the first and each subsequent visit to a nesting colony, information was recorded on nesting, production and disturbance. Upon arrival to the site, two researchers observed the nesting area from a distance to minimize bird disturbances. Each person counted the total number of adults for each species with the aid of binoculars and spotting scopes. Counts were compared and, if necessary, recounts were made until agreement on a total number was reached between individual counters. Unless all nests could be found by observation of adults from a boat, nesting areas were systematically searched, on foot, to find nests. Biological information collected at each site included number of adults, number of pairs, number of downy chicks, number of feathered chicks, number of fledglings, number of nests (active and inactive) and number of eggs per nest.

From the onset of laying, least terns lay a normal clutch of 3 eggs in 3 consecutive days (Ducey 1981). Incubation begins after the first egg is laid, and the incubation period lasts approximately 20-22 days (Sidle

1986). Piping plovers lay an egg every other day until a normal 4 egg clutch is complete. Incubation may begin during egg laying, and lasts for 25-31 days (Haig 1986). The flotation method of determining embryo developmental stage in tern eggs (Hays and LeCroy 1971) was calibrated to approximate the tern and plover incubation periods and was then used to estimate incubation stage for each clutch of both species (Fig. 2). This method of estimating incubation stage proved to be accurate in predicting hatching dates for terns and plovers to within 1-3 days. Knowledge of the incubation stage for each clutch enabled me to estimate nest initiation dates and predict hatching and fledging dates.

Nest contents were checked on each visit, but the infrequent visits made determination of hatching success difficult because some eggs and chicks could not always be accounted for. Therefore no attempt was made to estimate average clutch sizes or individual clutch hatching success. Only estimates of fledging rates (# fledged/adult pair) were determined for each colony.

Fledging occurs at 18-21 days of age for terns and 21-35 days of age for plovers. Least terns will usually leave the natal colony site within 2 to 3 weeks after fledging (Thompson and Slack 1984). By combining knowledge of chick numbers by age groups and expected fledging dates, I was able to monitor the sites well enough to obtain numerical

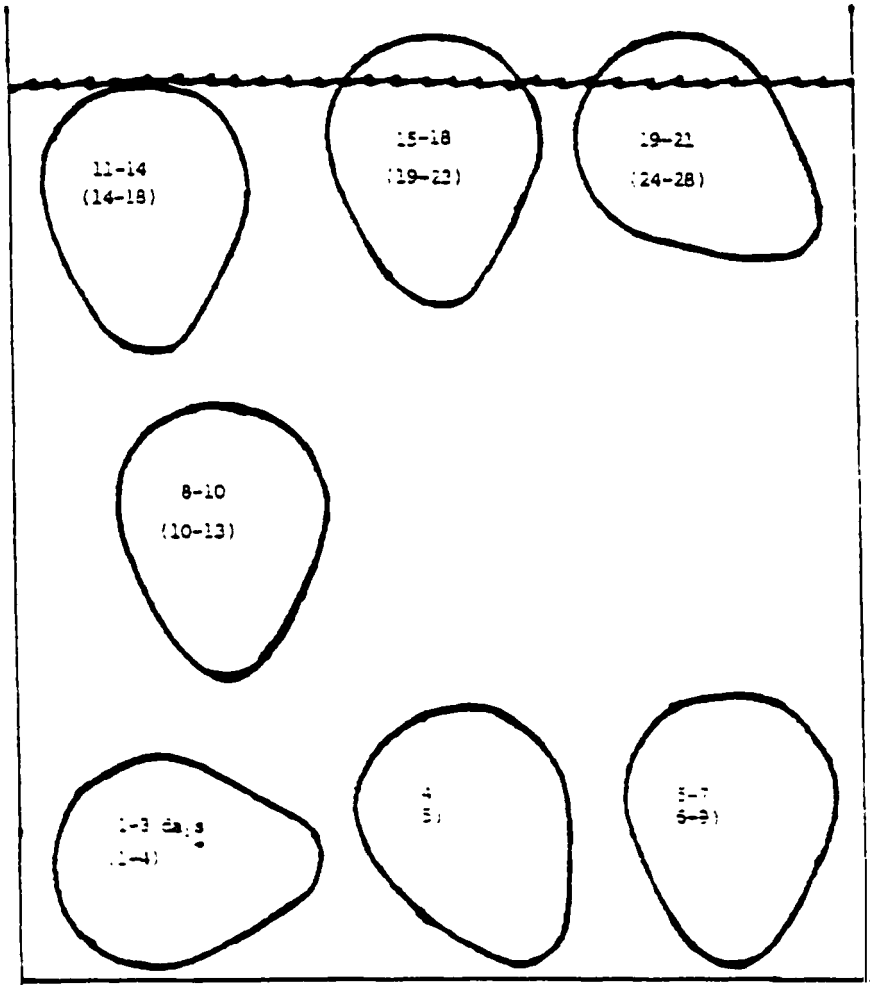

Figure 2. Flotation method for determining incubation stage of least tern and piping plover eggs (adapted from Hays and LeCroy 1971). Egg positions are shown with the number of days into incubation indicated for least terns and piping plovers (in parentheses).

estimates of fledglings during each nesting and brood rearing season. I assumed that fledglings were present at the natal colonies on the expected fledging dates, and that fledglings left their natal colony sites within 3 weeks after fledging.

Capture and Banding

Least tern and piping plover chicks were captured by hand in 1986 and were banded with USFWS aluminum leg bands on their right leg. In 1987 adults were captured at nest sites with drop trapas (Haig 1986), and chicks were captured by hand. Drop traps were placed at tern or plover nests for a period of no more than 5 minutes. If an adult did not return to the nest and resume incubation within that time period, the trap was removed and no further attempt was made to capture birds at that nest. Attempts were made to capture adults using mist nets, but this capture method proved unsuccessful and was abandoned. Birds captured in 1987 were fitted with either (1) a USFWS aluminum leg band (right leg for chicks, left leg for adults), (2) a USFWS leg band plus a pastel blue plastic leg flag (right leg), or (3) a USFWS leg band plus a leg flag plus a combination of 1 to 3 colored leg bands for individual identification (Fig. 3). Recapture records and salvage of bands will help to increase

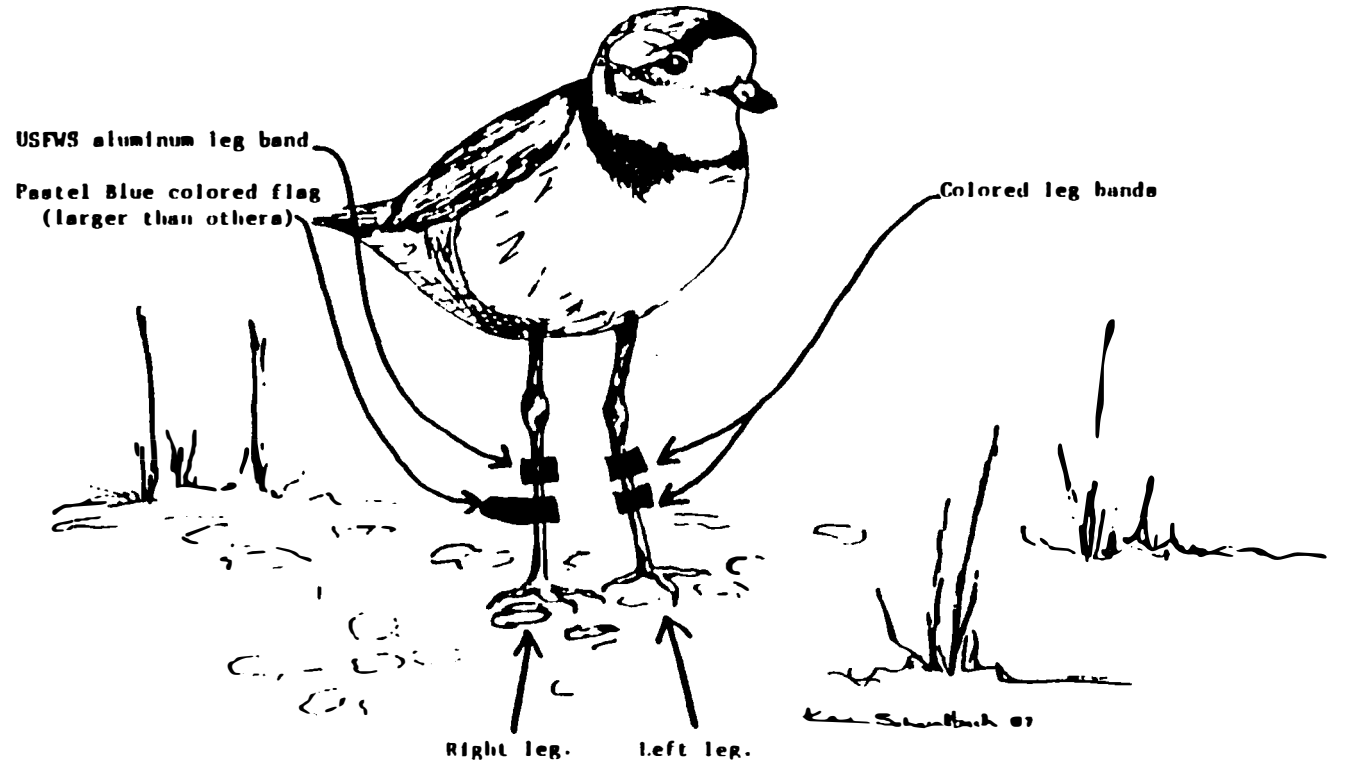

FIGURE 3. Placement of leg bands and colored leg flags on least terns and piping plovers. (Drawing by Karen Schwalbach)

our data base on overall distribution and life history of these species.

Characterization of nesting habitat

Concurrent with population censuses, measurements of habitat characteristics were conducted at each colony and nest site. Colony measurements included beach, point or sandbar size, ocular estimates of vegetative cover, and measurements along a vegetation transect. Vegetation transects were laid out across a representative portion of each colony site. Ten sampling quadrats (1 m^2) were selected along each transect by dividing the length of the transect by 10, placing the first quadrat at 0.5 times the calculated value, and then placing all other quadrats successively equidistant from the initial quadrat. Measurements within each quadrat included percent vegetative cover and mean height (cm) of all vegetation. Additionally, the most abundant plant species was identified in each quadrat. Nomenclature of plant species follows Flora of the Great Plains (Great Plains Flora Association 1986).

Characteristics measured at each nest site included: elevation above water (0.1 ft), distance to water's edge (m), distance to nearest neighboring conspecific nest (m), distance to nearest non-vegetative object (cm), height (cm) and type (organic debris, stick/log, cobble 5-10 cm, rock

>10 cm, shell or litter) of nearest object, distance to nearest plant (cm), height (cm) and type (grass, grass-like [sedge, rush, Typha], forb, shrub, tree) of nearest plant, and percent cover within 1 m^2 centering on the nest. Nest elevation above water was measured to the nearest 0.1 foot to conform with COE data on water levels and pool elevations. Elevation above water, distance to water's edge, and distances between nests were measured using a surveyor's level and rod.

Soil substrate samples were collected adjacent to each nest in 1986 by inserting a 10 cm diameter tin can 3 cm into the strata, sealing off the contents with a 20X30 cm plexiglass plate, and then transferring the substrate sample into a plastic container. Substrate samples were separated into particle size classes of coarse gravel, very fine gravel, coarse sand, very fine sand, coarse silt, and fines (all alluvium or substrate finer than coarse silt) (see Hamilton and Bergersen 1984, for a table describing particle size classification) using stacked sieves. Percentage by weight of each particle size class in each sample was calculated.

Measurements of habitat characteristic measurements were usually made during the first visit to a site. To avoid excessive exposure of eggs and chicks at colonies during inclement or hot weather, measurements were usually

made early or late in the day or in as brief a time as possible. In the latter case, data collection was done during two shorter visits whereby terns and plovers were censused, nests were located, and chicks banded during the first visit. During the second visit, measurements were made of the colony site and nest site characteristics. Due to heavy rains during the 5-6 June 1986 survey on the Gavins Point river reach, measurements were only conducted on a portion of all colony sites.

In addition to colony sites, habitat characteristics were measured at 20 potential sites in 1986 and 40 potential sites in 1987 where no terns or plovers nested. These potential sites were divided into three groups: (1) 20 sandbar sites [P1], located on the Gavins Point and Fort Randall reaches, which appeared by cursory examination to exhibit characteristics similar to colony sites on sandbars (low site profile, little or no vegetative cover, and average vegetation height of less than 1 m), (2) 20 beach or point sites [P1], located on Oahe Reservoir, which appeared by cursory examination to exhibit characteristics similar to colony sites on beaches or points (little or no vegetative cover, average vegetation height less than 1 m), and (3) 20 sandbar sites [P2], located on the Gavins Point and Fort Randall reaches, which were characterized by taller, more

dense vegetation than that at sandbar colony sites. No [P2] beach or point sites existed along Oahe Reservoir.

Potential site measurements included beach, point or sandbar size, ocular estimates of vegetative cover, and measurements along a vegetation transect, as described for colony sites. Elevations were measured and substrate samples were collected at 4 random locations on each site.

Water Discharges and Levels

Pool elevations (mean sea level) and discharge data (cubic feet per second) from each of the four Missouri River dams in SD were obtained from the COE. Mean nest elevations for each colony site and mean elevations for each potential site were calculated, corrected to a common date (approx. 10 June each year), and used for comparative purposes between river reaches and between years.

Statistical Analyses

Habitat characteristics at colony sites were compared with potential sites using stepwise discriminate analysis (STEPDISC) to predict which characteristics were important in site selection within habitat types (beach, point, sandbar). Comparisons of colony characteristics on different habitat types (beach, point, sandbar) were made using STEPDISC to determine the suitability of the different

habitat types. STEPDISC was also used in comparisons of substrate between site types (tern, plover, potential) and between habitat types (beach, point, sandbar).

Nest characteristics were compared using multivariate analysis of variance (MANOVA) to examine the effects of year, habitat, year by habitat interactions, species preference, and species by year interactions, on site selection. Statistical analyses were facilitated through Statistical Analysis System (SAS) computer programs at SDSU, and are described by SAS Institute Inc. (1982).

Disturbance Factors

During each visit to a nesting site, all evidence of disturbance was recorded, including flooding, recreational activity, predation, adverse environmental conditions and cattle use.

Signs and Posting

In 1987, an informational sign describing least terns and piping plovers and their need for protection was placed at Bolten Area boat ramp, River Mile (RM) 763.4, along the Missouri River (Fig. 4). Nine colonies in the vicinity of Bolten Area were posted with warning signs (Fig. 5) and monitored periodically during the May to August nesting season in a pilot study to determine the response of

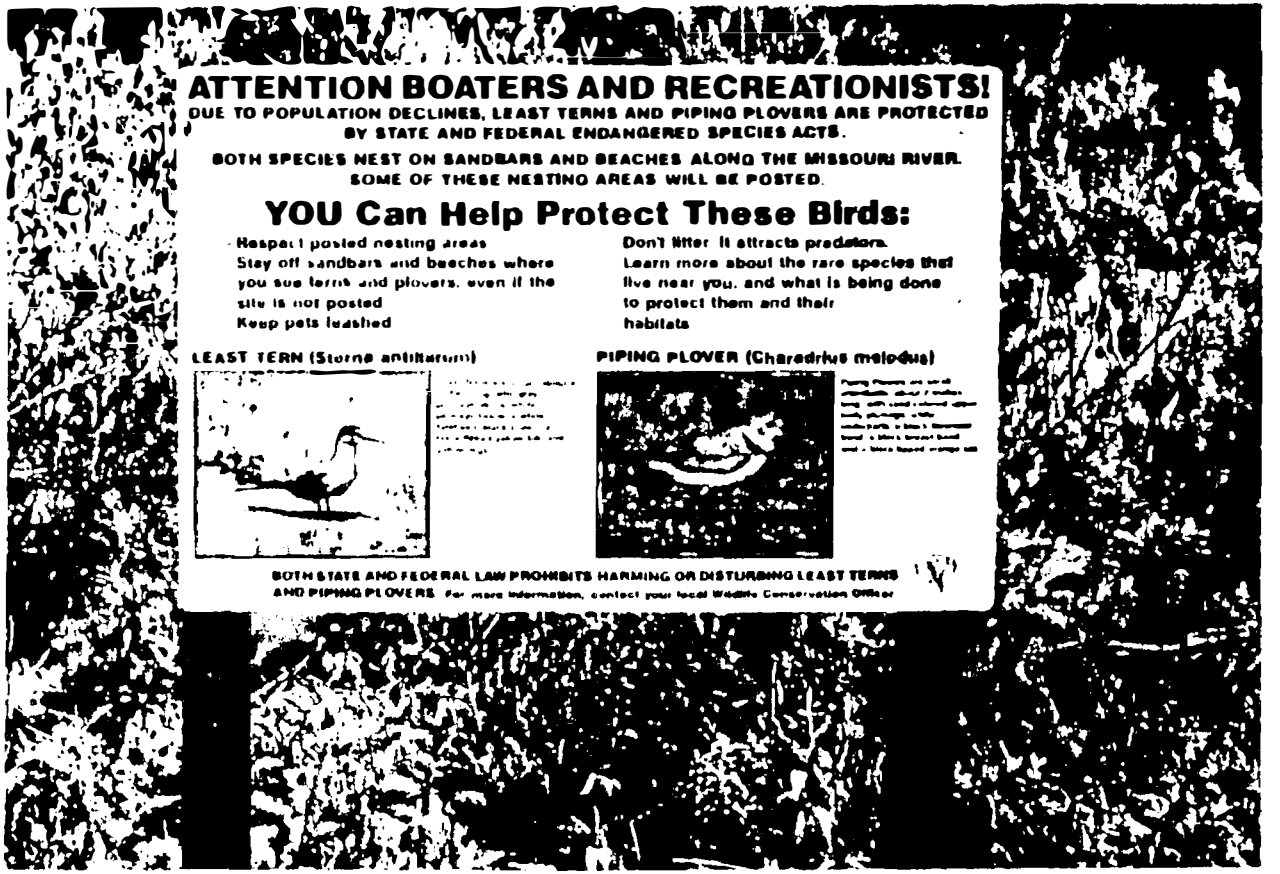

Figure 4. An informational sign describing least terns, piping plovers, and their need for protection was placed at the Bolten Area boat ramp along the Missouri River (RM 763.4) in 1987.

Figure 5. Nine colony sites in the vicinity of Bolten Area boat ramp along the Missouri River were posted with warning signs urging recreationists to stay away.

recreationists to endangered species nesting habitat protection and the effectiveness of posting for site protection.

RESULTS

Population Distribution

In the two years of this study least terns occupied 78 different colony sites and piping plovers occupied 59 different colony sites (Table 1). Combined, the two species utilized 83 different sites between the two years, including 24 sympatric sites in 1986 and 41 sympatric sites in 1987.

Of the 83 colony sites, 43 were found along the Gavins Point reach, 13 along the Fort Randall reach, 14 along Oahe Reservoir, and 13 along the Cheyenne River (Fig. 6). Only least terns nested along the Cheyenne River. No least terns or piping plovers were observed on the Grand, Moreau or White rivers in either year of this study, although 4 least terns and 1 piping plover were sighted at the mouth of the White River in July 1987.

Population Status

The number of adult piping plovers increased only slightly between 1986 and 1987 (187 ; 197) but there was a substantial increase in the number of least terns between the years (253 ; 367). In both years, most least terns

Table 1. Colony sites used by nesting least terns and piping plovers along the Missouri and Cheyenne rivers, South Dakota, 1986-1987.

		Least terns		Piping Plovers	
		1986	1987	1986	1987
Missouri River:					
Site	RM[a]				
11025	807.5		x		x
11001	804.0	x	x	x	x
11002	803.2	x	x	x	x
11003	801.6	x	x	x	x
11004	801.0	x		x	
11013	801.0s	x		x	
11005	800.9	x	x	x	x
11041	800.9s		x		x
11042	799.8		x		x
11006	798.0			x	
11043	796.9		x		x
11026	796.4	x	x	x	x
11044	796.3		x		x
11048	796.2		x		x
11045	796.0		x		x
11027	791.5		x		x
11047	791.0		x		x
11046	790.5		x		x
	789.5	x		x	
	783.4	x		x	
11038	783.0		x		x
11010	782.6	x		x	
11011	781.3	x		x	
11039	780.3		x		x
11012	778.5	x	x	x	x
	776.8	x		x	
11014	773.8	x			
11040	773.0		x		x
11028	771.0	x	x	x	x
11009	770.0	x	x	x	x
11029	768.5		x		x
11030	767.1		x	x	x
11008	766.0	x	x	x	x
	764.8	x		x	
	762.5	x		x	
11031	761.6		x		x

Table 1 (cont'd). Colony sites used by nesting least terns and piping plovers along the Missouri and Cheyenne rivers, 1986-1987.

		Least terns		Piping Plovers	
		1986	1987	1986	1987
Missouri River (cont'd):					
Site	RM[a]				
11032	759.0		x		x
11033	758.9s		x		x
11034	758.9	x	x	x	x
11035	757.0	x	x	x	x
11036	756.9		x		x
11007	755.3	x		x	
11037	753.6		x		x
12016	876.1		x		x
12003	873.0	x		x	
12004	866.5		x		x
12011	852.0		x		
12012	840.6		x		x
12013	840.5		x		x
12017	840.5s		x		x
12018	840.3		x		
12001	839.0	x		x	
12014	834.0				x
12015	833.0		x		x
12008	832.8	x	x		x
12019	832.0				x
16015	1158.5		x		
16001	1155.0			x	
16002	1155.0e			x	
16009	1127.0	x	x		
16016	1123.0		x		
16020	1119.2		x		
16025	1109.5		x		
16007	1108.5	x	x	x	x
16006	1108.0	x			
16003	1105.7	x			
16004	1104.2	x			
16014	1104.0		x		x
16013	1090.0		x		x
16005	1072.8			x	

Table 1 (cont'd). Colony sites used by nesting least terns and piping plovers along the Missouri and Cheyenne rivers, 1986-1987.

		Least terns		Piping Plovers	
		1986	1987	1986	1987
Cheyenne River:					
Site	RM[a]				
35002	62.5	x	x		
35014	61.7		x		
35007	61.0		x		
35005	60.5	x			
35006	56.2	x	x		
35003	54.5	x			
35008	51.8		x		
35004	50.0	x			
35001	46.3	x	x		
35012	45.2		x		
35013	27.7		x		
35009	16.5		x		
35010	8.7		x		

[a] River Mile. River mile designations for sites on the Missouri River were determined from Corps of Engineers aerial mosaic photographs or recreational maps, except in the case of sites between rm 841.0 and rm 831.0 (Niobrara, NE, to Springfield, SD) which were estimated from U.S.G.S. topographic maps. River mile designations for sites on the Cheyenne River were estimated from county maps, with river miles representing the miles upstream from the Highway 73 bridge, Ziebach County, SD. Where more than one site occurs at a common river mile designation, the side of the river where the site is located, when facing downstream, is indicated (e=east, w=west, n=north, s=south). Maps indicating exact locations of these sites are on file with the South Dakota Natural Heritage Database, GFP, Pierre, SD.

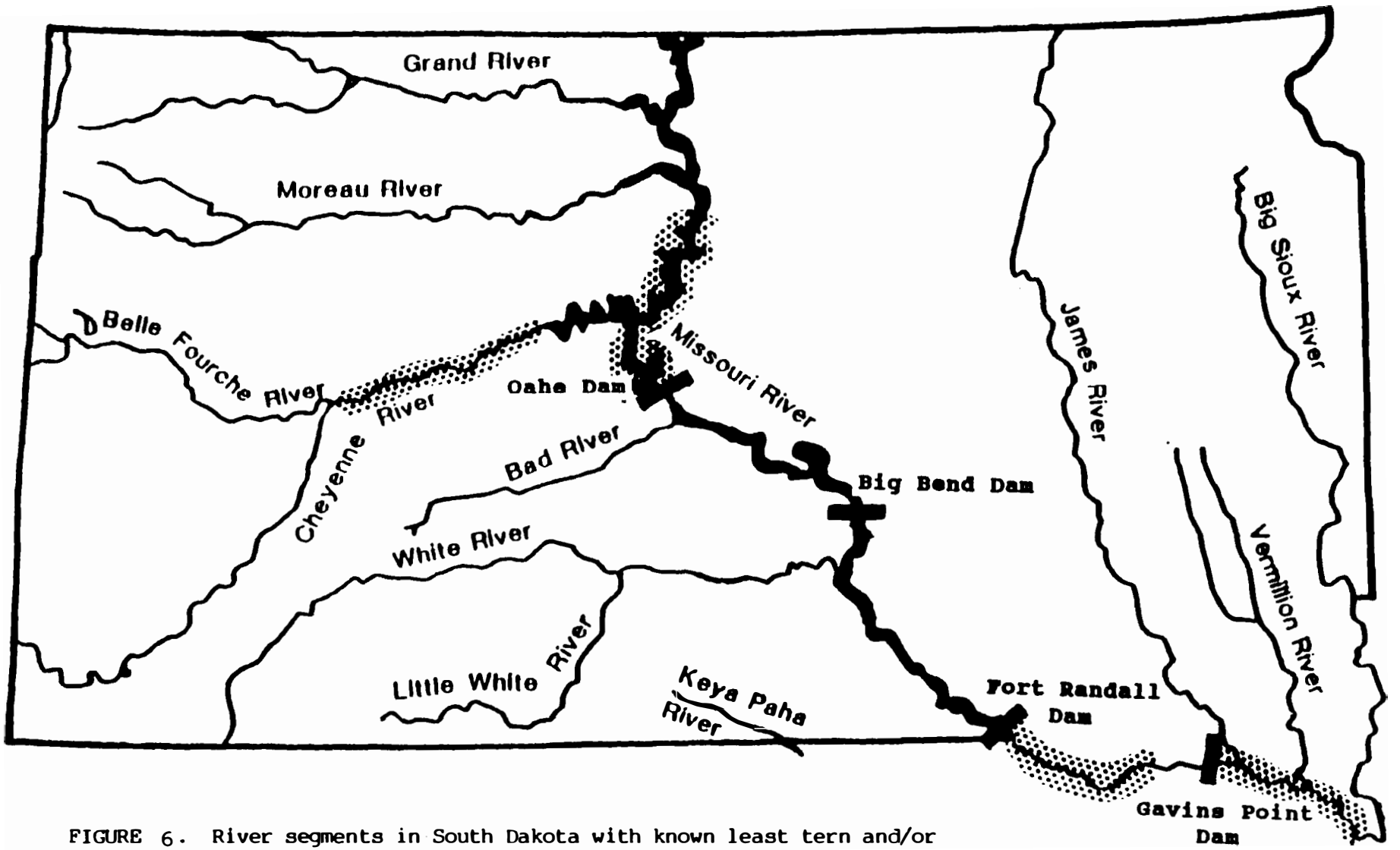

FIGURE 6. River segments in South Dakota with known least tern and/or piping plover colonies.

(80%) and piping plovers (98%) nested on sandbar sites below Fort Randall and Gavins Point dams. The average number of adult terns per colony was greater on sandbar sites below Gavins Point (8 adults/colony) and Fort Randall (8/colony) dams than on beach sites along Oahe Reservoir (3/colony) or the Cheyenne River (5/colony) (Table 2, Appendix Tables 1-8). The average number of adult plovers per colony was also greater on sandbar sites below Gavins Point (7/colony) and Fort Randall (4/colony) dams than on beach sites along Oahe Reservoir (2/colony).

Only 16 of the 83 colony sites were used in both years by least terns, 13 were used in both years by piping plovers, and 11 were used in both years by both species (Table 1). Ten of the least tern colony sites, 12 of the piping plover colony sites, and all of the sympatric sites occupied in both years were sandbars on the Gavins Point Dam to Ponca, NE, river reach.

Twenty 1986 colonies were not used in 1987, and 43 new colonies sites were used in 1987. One-year turnover rates were high, and ranged from 0.57 on the Gavins Point reach to 0.78 on the Fort Randall reach for least terns, and from 0.55 on the Gavins Point reach to 1.00 on the Fort Randall river reach for piping plovers (Table 2).

Distance between conspecific nests at colony sites varied between years and habitats (Table 3), with the

Table 2. Numbers and turnover rates of least tern and piping plover colonies along the Missouri and Cheyenne rivers, South Dakota, 1986-1987.

	# of colonies	mean # adults/ colony	Number of colonies used in 86	Number of colonies not used in 86	Number of colonies not used in 87	T[a]
LEAST TERNS:						
Missouri River:						
Gavins Point						
1986	22	8				
1987	31	8	22	20	11	0.57
Fort Randall						
1986	3	8				
1987	9	7	3	8	2	0.78
Oahe Reservoir						
1986	5	3				
1987	8	3	5	6	3	0.68
Cheyenne River:						
1986	6	5				
1987	10	5	6	7	3	0.60
PIPING PLOVERS:						
Missouri River:						
Gavins Point						
1986	23	8				
1987	31	6	23	19	11	0.55
Fort Randall						
1986	2	6				
1987	9	2	2	9	2	1.00
Oahe Reservoir						
1986	4	2				
1987	3	2	4	2	3	0.71

[a] Turnover rate, see Methods for explanation.

TABLE 3. Distance (m) between conspecific nests at least tern and piping plover colony sites along the Missouri and Cheyenne rivers, South Dakota, 1986-1987.

	N	Distance mean	(SE)
LEAST TERNS:			
Missouri River:			
Gavins Point			
1986	38	35.59	(6.01)
1987	104	26.76	(2.24)
Fort Randall			
1986	22	19.04	(4.04)
1987	49	20.84	(2.37)
Oahe Reservoir			
1986	12	9.40	(1.23)
1987	7	3.64	(0.27)
Cheyenne River:			
Least Terns			
1986	10	20.00	(5.31)
1987	20	—[a]	—
PIPING PLOVERS:			
Missouri River:			
Gavins Point			
1986	15	41.09	(5.00)
1987	67	58.58	(5.28)
Fort Randall			
1986	6	30.49	(10.40)
1987	16	73.01	(18.09)
Oahe Reservoir			
1986	2	14.48	(3.81)
1987	0		

[a] Not measured in 1987.

effects of habitat ($P > 0.0056$) and year by species ($P > 0.0010$) detected as important in describing these variations. In general, plovers nested in looser colonies than terns did in all habitat types.

Nest Initiations

Dates of nest initiation were determined or estimated for 85 of 173 (49%) tern nests in 1986, 167 of 189 (88%) tern nests in 1987, 16 of 88 (18%) plover nests in 1986, and 98 of 109 (90%) plover nests in 1987. Least tern nest initiation dates ranged from 4 May to 3 August and 16 May to 27 July in 1986 and 1987, respectively (Fig. 7). Piping plover nest initiation dates ranged from 26 May to 9 July and 1 May to 11 July in 1986 and 1987, respectively (Fig. 8). The median nest initiation dates were 7 July 1986 and 23 June 1987 for least terns, and 20 June 1986 and 1 June 1987 for piping plovers. Nesting occurred earlier in 1987 than 1986 for both species.

Production

Fledging success was better in 1987 than in 1986 for both least terns (110 vs. 44) and piping plovers (106 vs. 8). Massey and Atwood (1981) described the criteria of fledging success for least terns in California where 1.0-1.5 fledglings/nesting pair is considered good success, 0.5-

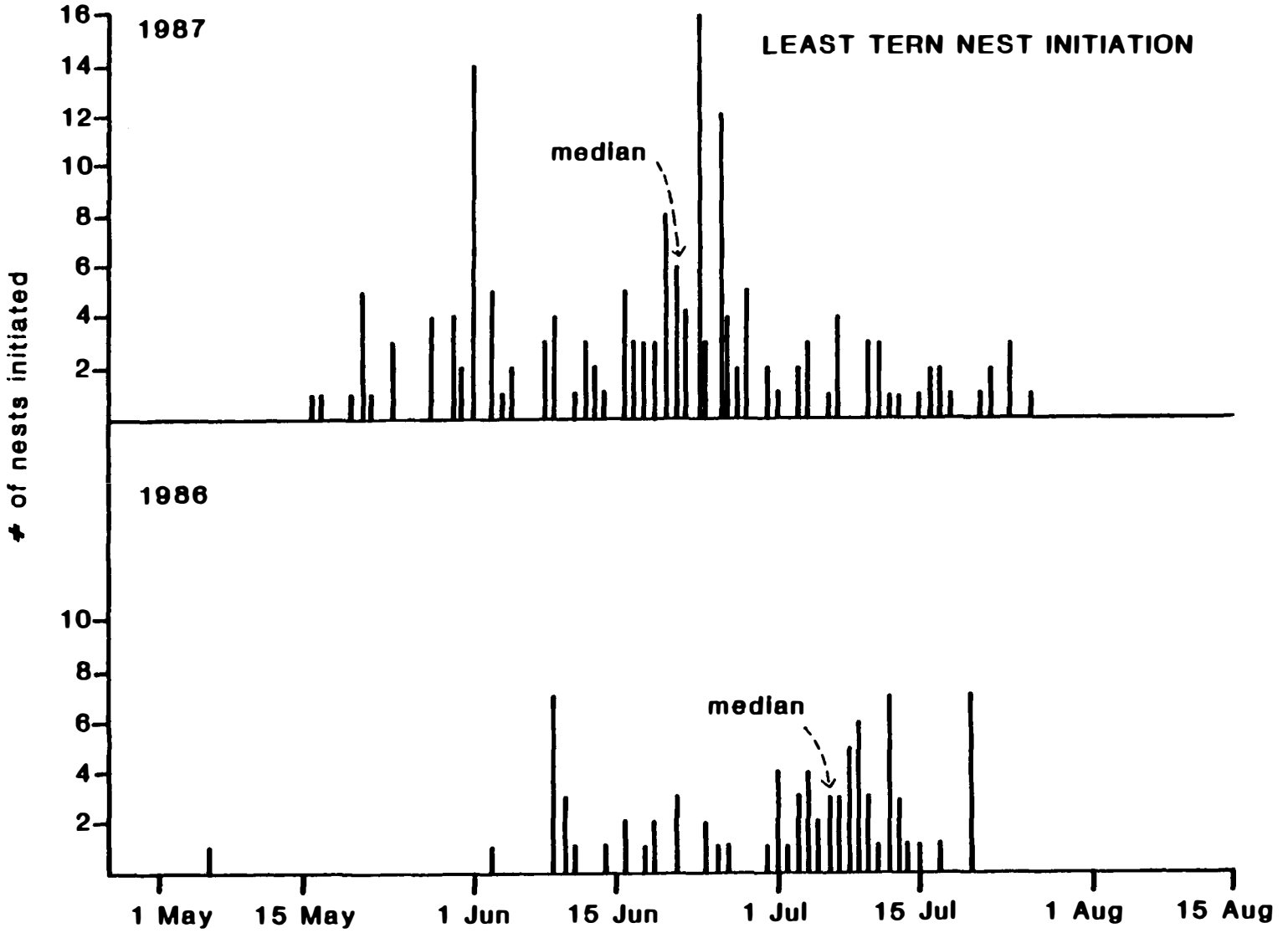

Figure 7. Chronology of least tern nest initiation in South Dakota, 1986-1987.

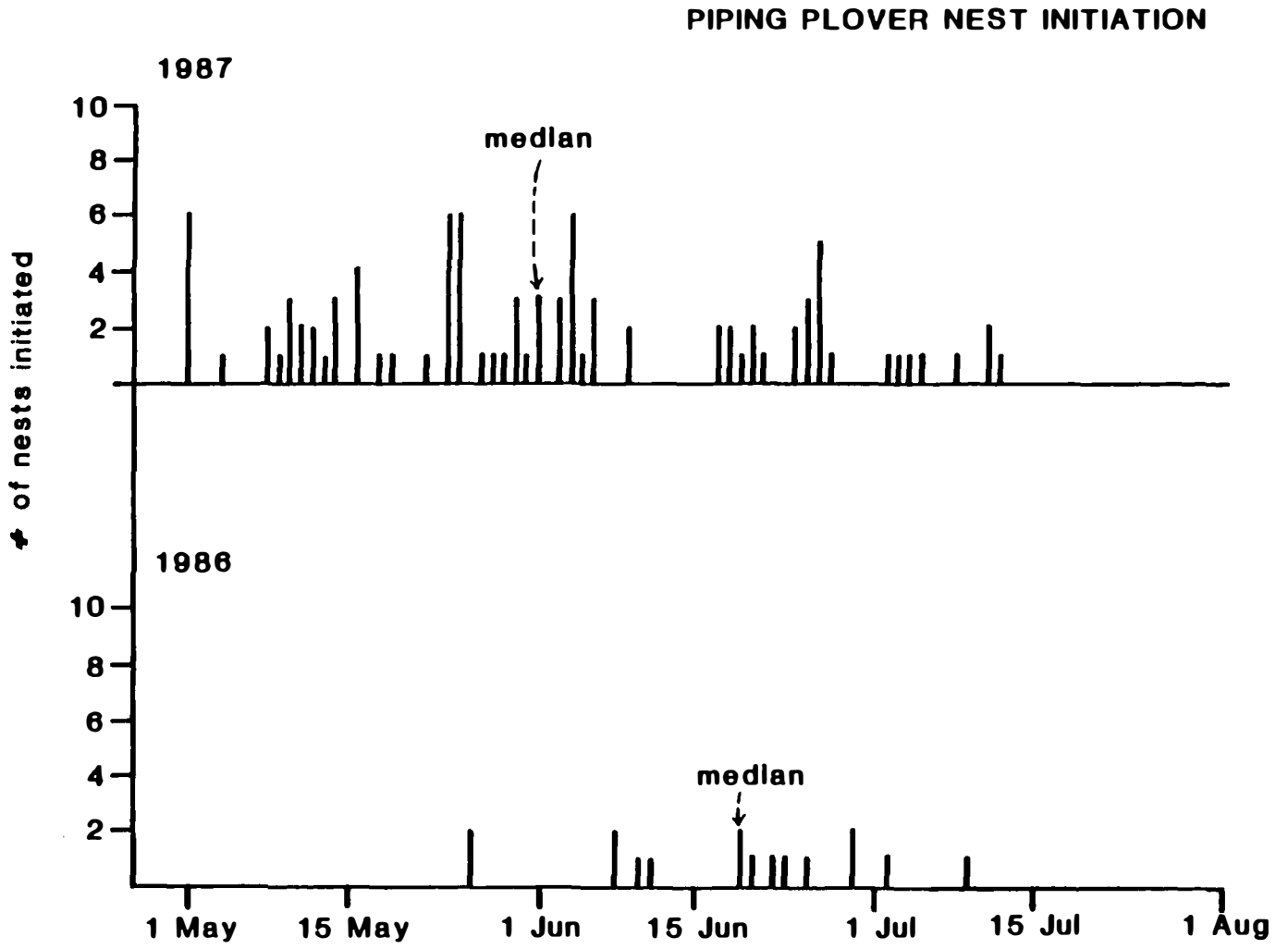

Figure 8. Chronology of piping plover nest initiation in South Dakota, 1986-1987.

1.0/pair is moderate, and 0-0.5/pair is poor. Assuming these criteria are applicable to the interior population of least terns in SD, fledging success ranged from poor on the Gavins Point (0.16/pair) and Fort Randall (0.48/pair) river reaches to good on the Cheyenne River (1.16/pair) in 1986, and from poor on the Fort Randall reach (0.67/pair) to good on Oahe Reservoir (1.62) in 1987 (Table 4). Similarly, piping plover success was poor on all reaches (0.05-0.18/pair) in 1986, but in 1987 it ranged from poor on the Fort Randall reach (0.13/pair) to good on the Gavins Point reach (1.13/pair) and Oahe Reservoir (2.50/pair). Fledging success was poor for terns and plovers during both years on the Fort Randall river reach which accommodates approximately 15% of the annual least tern population and 7% of the annual piping plover population in SD. Production summaries for individual sites on each river reach are provided in Appendix Tables 1-8.

Banding Summary

During 1986 and 1987, 121 least tern chicks and 56 piping plover chicks were banded with either a USFWS aluminum leg band, a USFWS leg band plus an international colored leg flag, or a combination of USFWS leg band plus leg flag plus individually color coded leg bands (Table 5). Additionally, 10 least tern adults and 16 piping plover

Table 4. Least tern and piping plover production along the Missouri and Cheyenne rivers, South Dakota, 1986-1987.

	1986			1987		
	Adults	Fledged	fl/pr[a]	Adults	Fledged	fl/pr
LEAST TERNS:						
Missouri River:						
Gavins Point	181	14	0.16	232	80	0.67
Fort Randall	25	6	0.48	60	13	0.43
Oahe Reservoir	16	6	0.75	21	17	1.62
Cheyenne River:	31	18	1.16	54	13	0.48
Totals:	253	44		367	110	
PIPING PLOVERS:						
Missouri River:						
Gavins Point	172	4	0.05	177	100	1.13
Fort Randall	11	1	0.18	16	1	0.13
Oahe Reservoir	4	3	0.09	4	5	2.50
Totals:	187	8		197	106	

[a] The number of young fledged per pair (or fledging rate) was determined by the equation, fl/pr = Fledged/Adults x 0.5, which assumes that the number of pairs present was equal to half the number of adults observed.

Table 5. Number of least terns and piping plovers banded in South Dakota, 1986-1987, with either (1) a U.S. Fish and Wildlife Service leg band only, (2) a USFWS leg band and colored leg flag, or (3) a USFWS leg band, colored leg flag, and colored leg band(s).

	USFWS only	USFWS & Flag	USFWS & Flag & Colors
Least Terns:			
1986 Juveniles	23	0	0
Adults	0	0	0
1987 Juveniles	63	16	19
Adults	0	0	10
Piping plovers:			
1986 Juveniles	5	0	0
Adults	0	0	0
1987 Juveniles	14	22	15
Adults	0	0	16

adults were marked in 1987. To date I have received only 1 band return. A banded least tern chick (from colony #11004) was retrieved from the stomach of a catfish caught along the Gavins Point river reach in August 1986.

Colony Site Characteristics

Colony sites along the Gavins Point and Fort Randall reaches were typically sandbars. However, one pair of plovers nested on a swimming beach below Gavins Point Dam in 1986, and two sites along the Gavins Point reach were low profile beaches attached to small vegetated islands. Oahe Reservoir colony sites were usually sand and gravel beaches or points, although three sites in 1986 were parking lots where plovers nested, and two sites in 1987 were sand and gravel islands. Nesting areas along the Cheyenne River were sand and gravel beaches.

Colony sites below Gavins Point Dam and along Oahe Reservoir were larger in 1987, as a result of lower water levels (Table 6). In contrast, colony sites on the Fort Randall river reach were generally smaller in 1987. While more habitat was exposed on the Fort Randall reach in 1987, due to lower water levels, the sites initially selected were small with a very low profile. Many of these sites were inundated early in the season and were subsequently abandoned by the birds following inundation.

Table 6. Average size (ha) of least tern and piping plover colony sites along three reaches of the Missouri River, South Dakota, 1986-1987.

	Year	Number of sites	Mean Size (SE)
Gavins Point	1986	12	3.06 (0.88)
	1987	31	3.29 (0.91)
Fort Randall	1986	3	4.40 (3.09)
	1987	11	1.90 (0.49)
Oahe Reservoir	1986	8	0.20 (0.05)
	1987	8	0.90 (0.18)

Eastern cottonwood (Populus deltoides), sandbar willow (Salix exigua) and slender flatsedge (Cyperus rivularis) were the most common plant species occurring on sandbar colony sites, while cocklebur (Xanthium strumarium) and common sunflower (Helianthus annuus) were the most common species on beach or point colony sites (Table 7). Eastern cottonwood, sandbar willow and slender flatsedge are facultative wetland plants (usually found in wetlands), but cocklebur and common sunflower are facultative species which occur in wetlands and nonwetlands (Reed 1986). Eight other plant species were common on sandbar colony sites, and 8 other plant species were common on beach and point colony sites (Table 7).

Height of vegetation and percent vegetative cover on sandbar colony sites were greater in 1986 than 1987 (Table 8). Since water releases from Gavins Point and Fort Randall dams averaged 3,000-5,000 cfs greater in 1986, less habitat was exposed and that which was exposed had more established vegetation than sites used in 1987. In contrast, vegetation height and percent cover on colony sites along Oahe Reservoir were greater in 1987. A near record water elevation on Oahe Reservoir in 1986 inhibited vegetative growth until later in the nesting season, whereas earlier reductions in water levels in 1987 allowed vegetation to sprout sooner.

Table 7. Common plant species found on least tern and piping plover sandbar colony sites and beach or point colony sites (Great Plains Flora Association 1986).

Sandbar colony sites:	
Populus deltoides	Eastern cottonwood
Salix exigua	Sandbar willow
Cyperus rivularis	Slender flatsedge
Echinochloa muricata	Wild millet
Juncus torreyi	Torrey's rush
Echinochloa crusgalli	Barnyard grass
Scirpus validus	Softstem bulrush
Cyperus odoratus	Fragrant flatsedge
Chenopodium glaucum	Oak-leaved goosefoot
Salix lutea	Yellow willow
Typha spp.	Cattails
Beach or point colony sites:	
Xanthium strumarium	Cocklebur
Helianthus annuus	Common sunflower
Polanisia dodecandra	Clammy-weed
Agropyron smithii	Western wheatgrass
Sporobolus cryptandrus	Sand dropseed
Populus deltoides	Eastern cottonwood
Salix lutea	Yellow willow
Rumex crispus	Curly dock
Bouteloua curtipendula	Sideoats grama
Opuntia sp.	Prickly pear

TABLE 8. Average vegetation height and percent cover at least tern and piping plover colonies and potential nesting sites along three reaches of the Missouri River, South Dakota, 1986-1987.

		Nesting sites N	mean (SE)	P1 sites[a] N	mean (SE)	P2 sites[b] N	mean (SE)
Gavins Point							
1986	ht (cm)	12	20.5 (2.4)	3	15.3 (7.4)	6	74.3 (19.7)
	% cover		3.0 (0.9)		1.6 (0.7)		46.1 (11.5)
1987	ht	31	7.0 (1.1)	6	8.0 (1.9)	5	66.6 (11.5)
	% cover		2.1 (0.4)		1.6 (0.2)		49.9 (13.2)
Fort Randall							
1986	ht	3	6.8 (3.9)	4	15.8 (12.4)	3	93.3 (34.7)
	% cover		1.2 (0.8)		3.6 (3.0)		51.4 (22.2)
1987	ht	11	5.9 (1.4)	7	8.7 (3.3)	5	96.0 (5.9)
	% cover		1.6 (0.4)		3.0 (1.1)		42.6 (6.5)
Oahe Reservoir							
1986	ht	9	2.7 (1.8)	2	3.5 (2.4)	—[c]	
	% cover		1.0 (0.9)		0.9 (0.8)	—	
1987	ht	8	8.7 (5.0)	18	11.2 (1.8)	—	
	% cover		2.4 (1.4)		3.6 (0.8)	—	

[a] Sandbars, beaches, or points which appeared by cursory examination to exhibit similar habitat characteristics as active nesting habitats.
[b] Sandbars, beaches, or points which appeared by cursory examination to exhibit similar habitat characteristics as active nesting habitats, except for obviously greater height and percent vegetation.
[c] No P2 sites were sampled on Oahe Reservoir since none were present in either year.

The maximum average vegetation height on any colony site was 32 cm, however the average vegetation height on 66% of the colony sites was between 0 and 9 cm (Fig. 9). Vegetative cover at all of the colony sites was less than 10%. These data show that terns and plovers only colonize sites with sparse, short vegetation.

Vegetation height (Wilks' Lambda = 0.5414) and mean nest elevation (Wilks' Lambda = 0.3800) were significant between year variables on Gavins Point sandbars ($P < 0.01$), with vegetation height smaller and nest elevations greater in 1987 than in 1986.

Mean nest elevation (Wilks' Lambda = 0.9423) and percent vegetative cover (Wilks' Lambda = 0.7595) were significant between year variables on Fort Randall sandbars; nest elevation was lower and percent cover was smaller on colony sites in 1987 than in 1986. The differences between 1987 and 1986 in colony attributes on these two river reaches was expected and predictable: water levels below Gavins Point were managed both years to provide stable flows and differences in habitat on that reach were visually apparent in the field. Meanwhile, water levels fluctuated considerably on the Fort Randall reach (ca. 17,000 to 35,000 cfs in 1986; 12,000 to 31,000 cfs in 1987) and differences in the habitat between years on that reach were not obvious in the field. No site characteristics on Oahe Reservoir

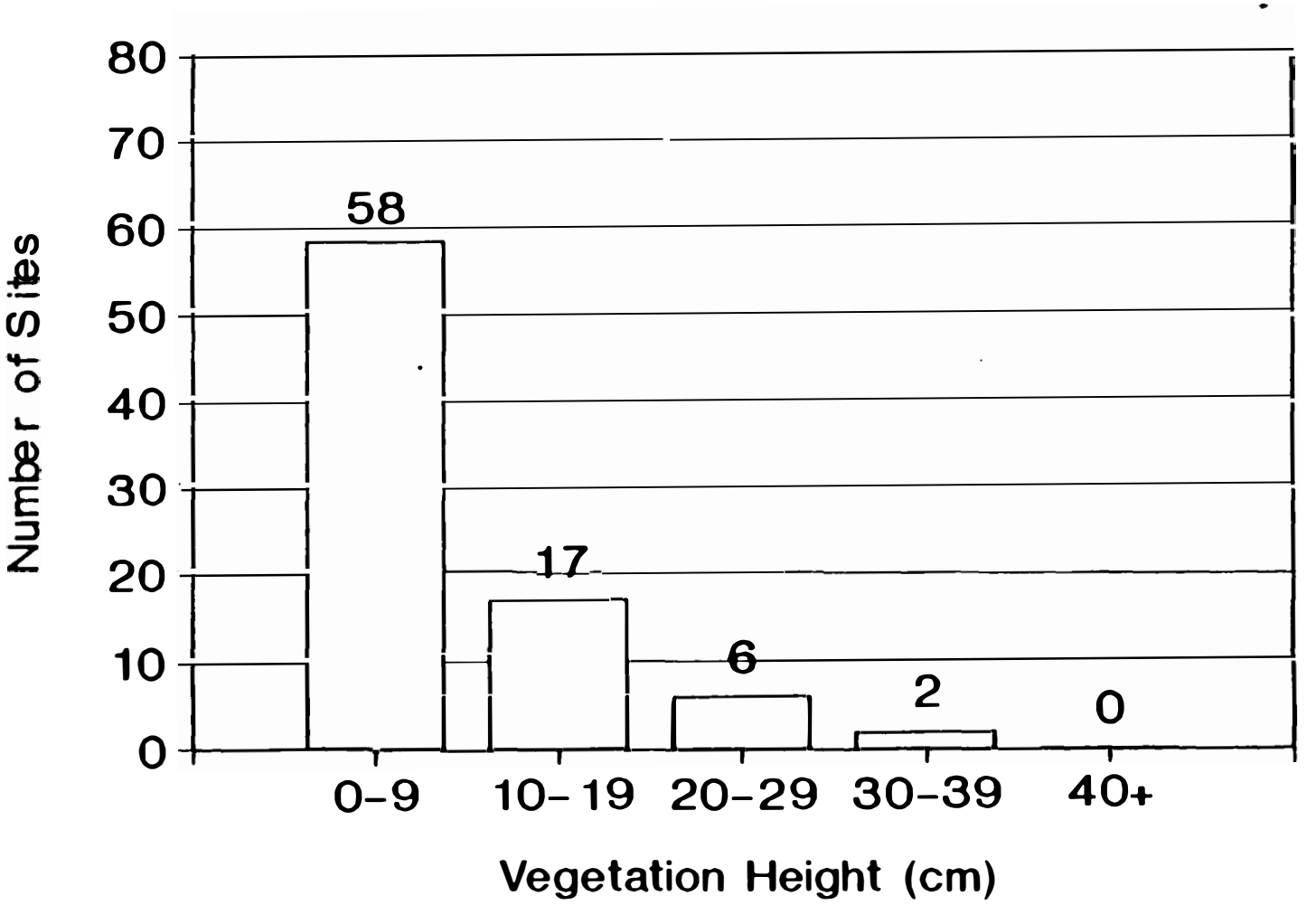

Figure 9. Mean vegetation height at least tern and piping plover colony sites along the Missouri River, South Dakota, 1986-1987.

colonies were significant predictors of between year variability.

Variables important in separating sandbar colony sites and potential [P1] sandbar sites were elevation (Wilks' Lambda = 0.9066) and size (Wilks' Lambda = 0.8023), with both values generally greater on colony sites than on potential sites. Percent vegetation (Wilks' Lambda = 0.8643) was important in distinguishing between beach and point colony sites and potential [P1] beach and point sites; beach and point colony sites had less vegetative cover than P1 beach and point sites.

As was expected in comparing sandbar colony sites with potential [P2] sandbar sites, percent vegetative cover was a significant predictor of variability ($P < 0.001$, Wilk's Lambda = 0.2020).

Nest Site Characteristics

Stepwise discriminate analysis indicated that particle composition of substrate was similar at tern nest sites, plover nest sites, and potential sites within habitat types (Table 9). However, very fine sand (Wilk's Lambda = 0.3071), fines (Wilk's Lambda = 0.2610), and fine sand (Wilks' Lambda = 0.2328) were important ($P > 0.01$) in distinquishing substrate characteristics at colony sites between habitat types. Very fine sand (Wilks' Lambda =

TABLE 9. Average percentages of 6 particle size classes in substrate samples collected at tern nests, plover nests, and potential habitat sites along the Missouri and Cheyenne rivers, South Dakota.

	Tern nests		Plover nests		Potential	
	N	mean (SE)	N	mean (SE)	N	mean (SE)
Missouri River:						
Gavins Point						
VFG[a]	37	0.6 (0.4)	14	0.1 (0.1)	80	0.6 (0.4)
CS		3.1 (1.1)		2.2 (0.6)		1.7 (0.6)
FS		14.9 (2.0)		23.7 (3.7)		9.4 (1.3)
VFS		80.2 (2.8)		73.2 (4.2)		87.0 (2.0)
CSi		0.9 (0.2)		0.5 (0.2)		1.5 (0.2)
FI		0.4 (0.1)		0.3 (0.1)		0.5 (0.1)
Fort Randall						
VFG	22	0.3 (0.1)	6	0.1 (0.1)	76	2.4 (1.2)
CS		1.1 (0.6)		1.8 (1.8)		2.1 (0.7)
FS		10.4 (4.9)		4.8 (3.4)		7.1 (1.6)
VFS		85.7 (5.2)		92.3 (5.2)		86.9 (2.8)
CSi		0.7 (0.1)		0.8 (0.2)		1.1 (0.2)
FI		0.3 (0.0)		0.3 (0.1)		0.4 (0.1)
Oahe Reservoir						
VFG	11	8.6 (1.4)	5	30.7 (9.2)	104	19.3 (1.8)
CS		26.6 (7.9)		25.0 (10.0)		32.3 (1.7)
FS		54.5 (7.8)		40.1 (16.5)		30.7 (1.6)
VFS		10.1 (2.7)		8.7 (3.5)		17.1 (1.6)
CSi		0.1 (0.1)		0.3 (0.2)		0.6 (0.1)
FI		0.1 (0.0)		0.2 (0.1)		0.1 (0.0)
Cheyenne River:						
VFG	12	13.8 (5.2)	—[b]		4	0.0 (0.0)
CS		7.0 (2.3)	—			0.9 (0.9)
FS		34.0 (6.1)	—			11.1 (10.3)
VFS		44.4 (8.2)	—			84.9 (10.6)
CSi		2.5 (1.3)	—			2.2 (1.1)
FI		1.3 (0.6)	—			1.0 (0.2)

[a] VFG=very fine gravel, CS=coarse sand, FS=fine sand, VFS=very fine sand, CSi=coarse silt, FI=fines (all particles smaller than coarse silt).

[b] No piping plovers nested on the Cheyenne River.

0.1185), fines (Wilk's Lambda = 0.1078), and fine sand (Wilk's Lambda = 0.1022) were also important in distinguishing substrate characteristics at potential sites between habitat types. Substrate at sandbar sites was composed primarily of very fine sand particles, whereas substrate at beach or point sites was composed primarily of fine sand.

Mean nest elevations on the dates of nest initiation were greater for both species in 1987 than 1986 (Table 10) The use of higher nest sites by these birds in 1987 when more strata was exposed at lower elevations than in 1986, suggests a selection for higher nest sites when such sites are available. Nest to water distances were also greater in 1987 than 1986 (Table 10), suggesting that birds select nest sites away from the water's edge, as well as being relatively high above the water level.

Mean nest elevations were plotted for 3 sites which were used by terns and plovers in both years: site #11001 below Gavins Point, site #12008 below Fort Randall, and site #16007 on Oahe Reservoir (Figs. 10-12). Mean nest elevations at all 3 sites were higher, relative to the water level, in 1987 than in 1986. At all sites nesting by both species was initiated earlier in 1987, as habitat was exposed earlier in that year. On the Gavins Point and Oahe sites (Figs. 10 and 12) the nesting period ended earlier in

Table 10. Average nest to water distances (m) and nest elevations (ft) of least tern and piping plover nests along three reaches of the Missouri River, South Dakota, 1986-1987.

	N	Distance mean (SE)	N	Elevation mean (SE)
LEAST TERNS:				
Gavins Point				
1986	39	20.14 (2.21)	29	0.63 (0.06)
1987	113	27.15 (1.57)	90	1.52 (0.09)
Fort Randall				
1986	22	6.19 (0.61)	11	0.78 (0.17)
1987	51	18.11 (1.34)	44	0.97 (0.07)
Oahe Reservoir				
1986	15	4.92 (0.58)	4	1.25 (0.32)
1987	9	10.54 (1.22)	9	2.41 (0.43)
PIPING PLOVERS:				
Gavins Point				
1986	16	20.36 (3.58)	12	0.64 (0.10)
1987	74	35.84 (1.96)	47	1.43 (0.09)
Fort Randall				
1986	6	5.84 (1.59)	1	1.46 (0.0)
1987	19	17.97 (3.32)	10	0.92 (0.13)
Oahe Reservoir				
1986	5	24.43 (6.41)	4	10.69 (3.46)
1987	1	13.78 (0.0)	1	0.86 (0.0)

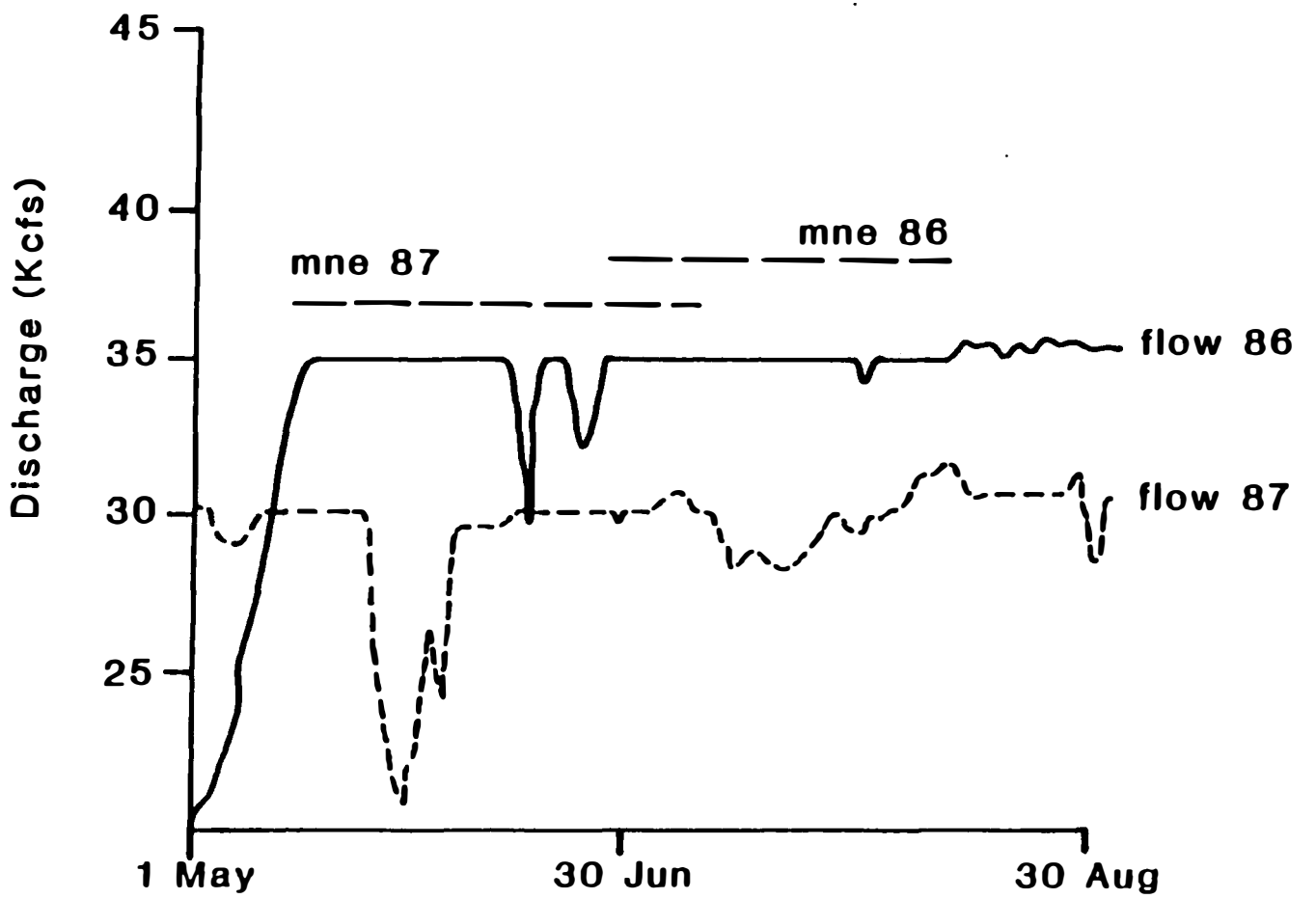

FIGURE 10. Mean nest elevation in relation to water releases at colony site #11001, below Gavins Point Dam, in 1986 and 1987. Mean nest elevation lines (mne) depict the length and dates that nests were active at the site, as well as relative elevation above water level.

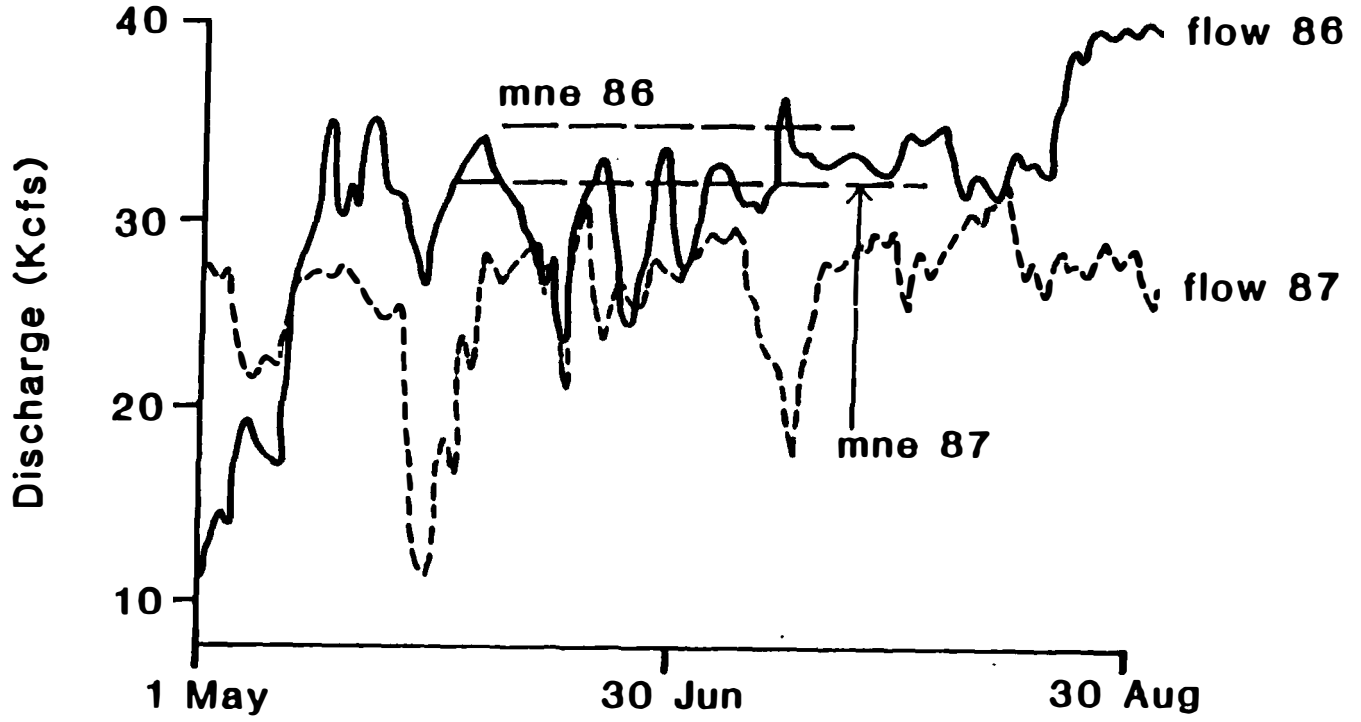

FIGURE 11. Mean nest elevation in relation to water releases at colony site #12008, below Fort Randall Dam, in 1986 and 1987. Mean nest elevation lines (mne) depict the length and dates that nests were active at the site, as well as relative elevation above water level.

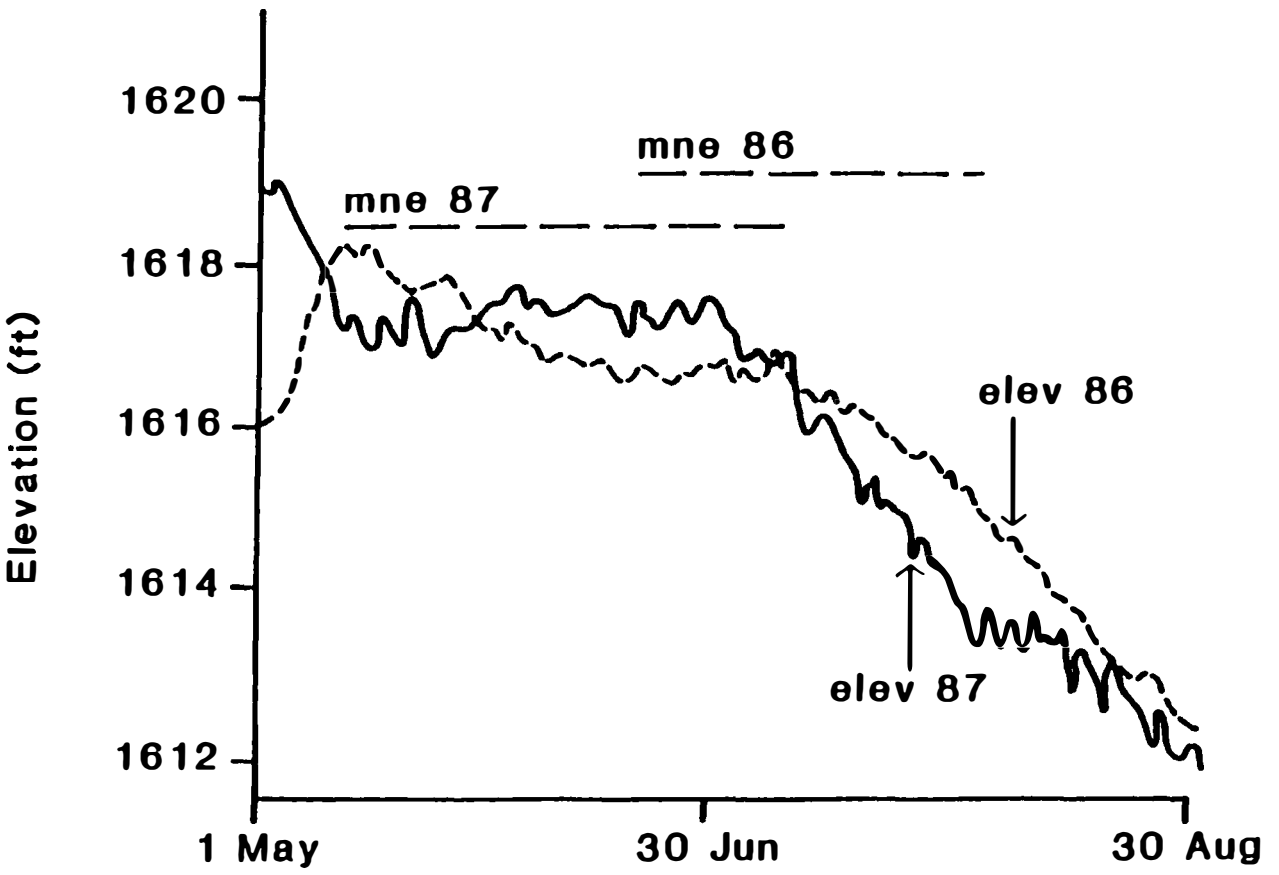

FIGURE 12. Mean nest elevation in relation to water elevations at colony site #16007, on Oahe Reservoir, in 1986 and1987. Mean nest elevation (mne) lines depict the length and dates that nests were active at the site, as well as relative elevation above the water level.

1987, while nesting continued well into July on the Fort Randall site (Fig. 11). Partial inundation occurred several times during both years at that site, resulting in nest losses and renesting. These 3 examples represent the general scenario for most nesting sites on the Gavins Point, Fort Randall, and Oahe river reaches, respectively. Where water levels were maintained with low, stable summer discharges (i.e. 30,000 cfs below Gavins Point in 1987, Fig. 10) least terns and piping plovers nested at relatively higher elevations with reduced danger from wave action, and thus their potential for higher productivity was enhanced.

Least terns and piping plovers most commonly nested near Eastern cottonwood (58%), sandbar willow (12%), and slender flatsedge (10%) on sandbar colony sites. Similarly, least terns and piping plovers most commonly nested near cocklebur (17%) and common sunflower (17%) on beach or point colony sites. These results indicate that terns and plovers in SD do not select particular plant species at nest sites, but rather nest near plant species in relation to their relative abundance.

Analyses of vegetative characteristics revealed significant effects of year by habitat, for distance to vegetation ($P > 0.0057$) and vegetation height ($P > 0.0001$), and a significant effect of year by species, for vegetation height ($P > 0.0388$). Least tern nests were usually located

further from vegetation than piping plover nests, and vegetation height near tern nests was less than that at plover nests (Table 11). Vegetation height at 195 of 282 (69%) least tern nests and 76 of 120 (63%) piping plover nests was less than 10 cm (Fig. 13). Habitat ($P > 0.0012$), year ($P > 0.0501$), and species effects were evident for percent vegetative cover at tern and plover nests. Percent cover at 266 of 283 (94%) least tern nests and 107 of 120 (89%) piping plover nests was less than 5% (Fig. 14). Percent cover generally was greatest at sandbar nest sites in 1986.

The distance from tern and plover nests to the nearest object was significant with respect to the effects of year by habitat ($P > 0.0008$) and year by species ($P > 0.0126$). Height of objects nearest tern and plover nests was significantly greater in 1986 than in 1987 for all habitat types ($P > 0.0060$). On sandbar nesting sites, terns and plovers nested closer to sticks or logs rather than cobbles, rocks, or litter (Table 12). Meanwhile, on Oahe Reservoir nesting sites, terns nested closer to cobbles while plovers continued to nest close to sticks or logs. Terns nesting on the Cheyenne River usually nested closer to cobbles than sticks, logs, or rocks.

TABLE 11. Average distance to vegetation, vegetation height, and percent vegetative cover at least tern and piping plover nests along the Missouri and Cheyenne rivers, South Dakota, 1986-1987.

	N	Distance (cm) mean (SE)	Height (cm) mean (SE)	% Cover mean (SE)
LEAST TERNS:				
Missouri River:				
Gavins Point				
1986	39	78.2 (28.4)	15.9 (2.2)	2.1 (0.9)
1987	121	73.9 (15.9)	5.6 (0.7)	1.1 (0.2)
Fort Randall				
1986	22	26.5 (12.8)	12.4 (2.0)	1.9 (0.3)
1987	43	61.8 (22.5)	4.9 (0.7)	1.5 (0.3)
Oahe Reservoir				
1986	15	457.3 (119.1)	8.2 (1.0)	0.0 (0.0)
1987	10	83.6 (12.7)	30.7 (21.8)	0.0 (0.0)
Cheyenne River:				
Least Terns				
1986	12	648.6 (127.0)	7.6 (1.0)	0.0 (0.0)
1987	20	510.7 (105.2)	8.9 (1.1)	0.0 (0.0)
PIPING PLOVERS:				
Missouri River:				
Gavins Point				
1986	17	10.1 (1.7)	21.2 (3.8)	3.2 (1.5)
1987	74	77.6 (20.3)	7.4 (1.2)	1.1 (0.2)
Fort Randall				
1986	6	8.7 (4.3)	27.7 (4.4)	4.2 (1.0)
1987	17	13.2 (3.0)	7.2 (1.6)	2.5 (0.5)
Oahe Reservoir				
1986	5	271.4 (185.1)	21.6 (10.7)	0.4 (0.2)
1987	1	694.0 (0.0)	15.0 (0.0)	0.0 (0.0)

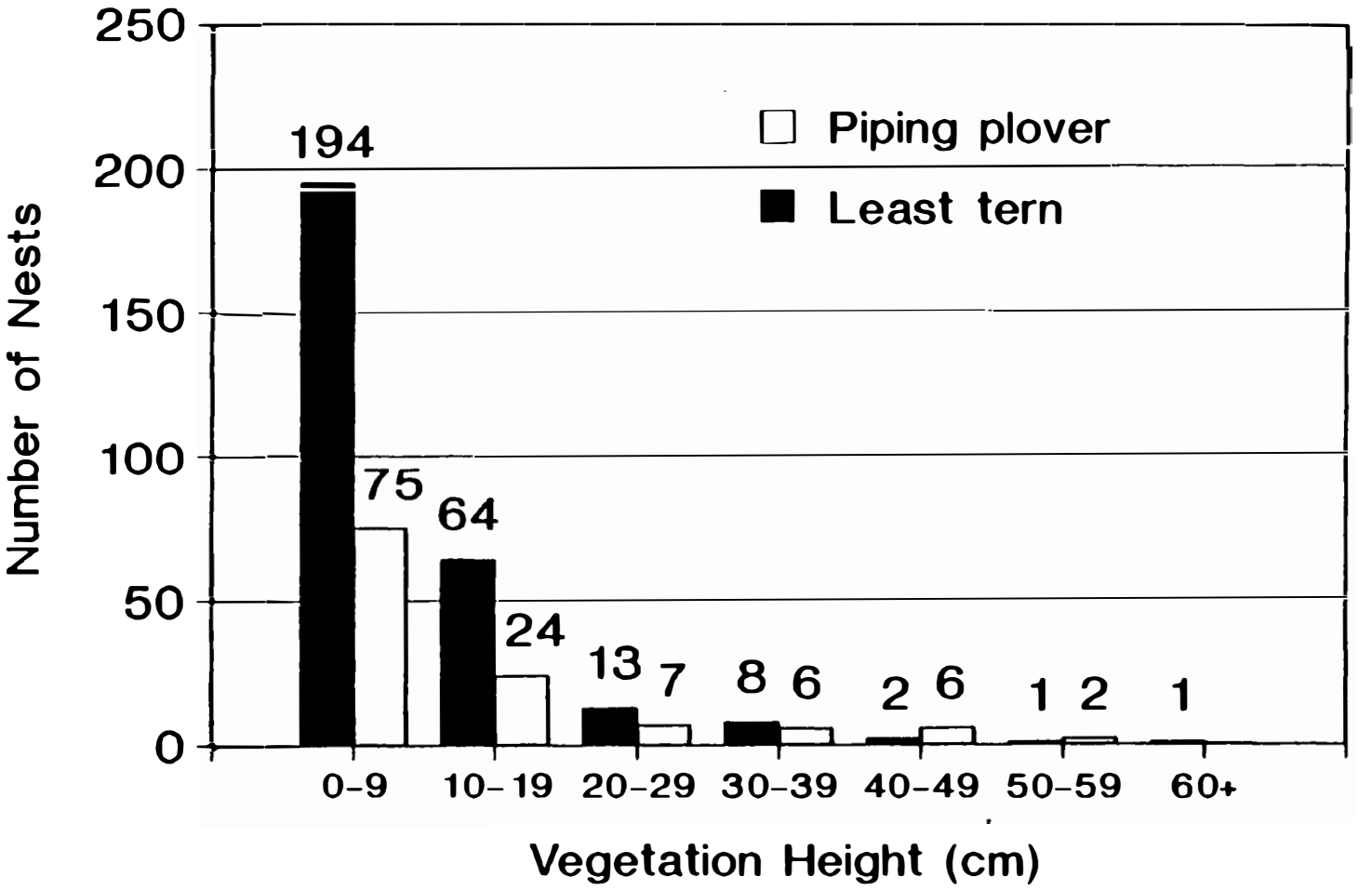

Figure 13. Mean vegetation height at least tern and piping plover nest sites, 1986-1987.

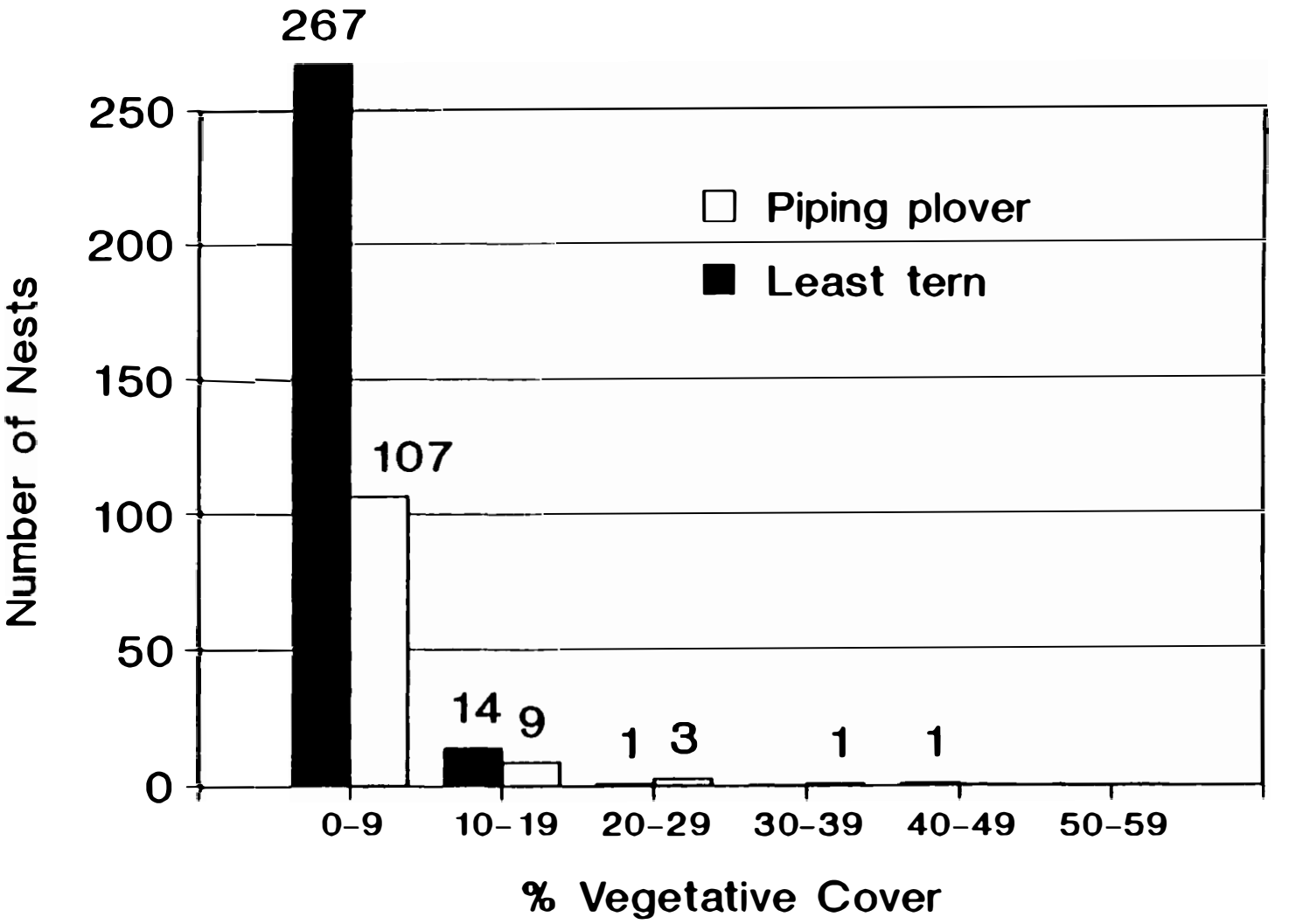

Figure 14. Percent vegetative cover within 1 m^2 of least tern and piping plover nests, centering on the nest cup, 1986-1987.

TABLE 12. Distance to object, object height, and object type[a] at least tern and piping plover nests along the Missouri and Cheyenne rivers, South Dakota, 1986-1987.

	N	Distance (cm) mean (SE)	Height (cm) mean (SE)	% Occurrence 1	2	3	4	5[a]
LEAST TERNS:								
Missouri River:								
Gavins Point								
1986	38	36.8 (9.6)	5.1 (2.5)	0	94	3	0	3
1987	121	34.9 (10.8)	1.7 (0.1)	19	80	1	0	0
Fort Randall								
1986	22	7.9 (2.1)	14.9 (7.3)	11	89	0	0	0
1987	43	15.3 (3.1)	1.7 (0.2)	23	77	0	0	0
Oahe Reservoir								
1986	15	30.5 (7.2)	27.7 (11.5)	18	9	73	0	0
1987	10	27.3 (5.9)	2.6 (1.1)	0	33	67	0	0
Cheyenne River:								
Least Terns								
1986	12	31.6 (8.1)	18.4 (10.9)	0	30	50	20	0
1987	20	66.5 (38.9)	2.2 (0.2)	0	20	45	35	0
PIPING PLOVERS:								
Missouri River:								
Gavins Point								
1986	17	42.6 (16.3)	14.9 (7.8)	7	86	0	0	7
1987	74	63.0 (14.2)	3.0 (1.3)	25	71	4	0	0
Fort Randall								
1986	6	5.0 (2.0)	66.6 (20.5)	0	100	0	0	0
1987	17	10.6 (3.1)	2.5 (1.0)	24	76	0	0	0
Oahe Reservoir								
1986	5	26.0 (7.0)	21.0 (19.5)	0	100	0	0	0
1987	1	9.0 (0.0)	1.0 (0.0)	0	100	0	0	0

[a] Object types: 1=organic debris, 2=stick/log, 3=cobble (5-10cm), 4=rock (>10cm), 5=other (litter, shells, etc.).

Disturbance Factors

All point, beach, and sandbar colony sites in 1986 were affected to some degree by high water levels. Although beach sites were least affected by high water levels, wave action posed a serious threat to productivity. Evidence of wave action or flooding (Fig. 15) was documented at 24 colony sites in 1986, with 53 tern nests and 32 plover nests destroyed or abandoned due to 'washing', which may be a result of rain action, wave action, flooding or a combination of these. All colony sites below Fort Randall and Gavins Point dams had signs of water disturbance at some time during the summer. In addition, nest scrape dampness was evident at most sandbar nest sites and may have added to the low production in 1986.

Parking lot colony sites were not influenced by high water levels during the 1986 nesting season. There were no parking lot colony sites in 1987.

Two points where terns nested along Oahe Reservoir (sites #16003 and 16004, Appendix Table 3) were destroyed due to wave action in mid to late June 1986. No birds remained at those sites by the second visit; washing and strata movement was evident at both. One site along the Fort Randall river reach (Site #12003, Appendix Table 2) was inundated and abandoned due to water releases below Fort Randall Dam during the week of 15 June 1986.

Figure 15. High water releases from Fort Randall Dam in June, 1986, flooded this piping plover nest at colony site #12003.

Evidence of nest disturbance or loss due to flooding or wave action was documented at 15 colonies in 1987: 4 colonies (13%) below Gavins Point Dam and 11 (100%) below Fort Randall Dam. Of the sandbar colony sites below Fort Randall, 6 were abandoned because of high water and nest inundation (site numbers 12011, 12012, 12013, 12017, 12018, 12019, Appendix Table 6). None of the sites on the Gavins Point reach were abandoned because of high water impacts. No detrimental effects due to wave action or flooding were observed on Oahe Reservoir sites in 1987.

Recreational activities occurring at tern and plover nesting areas consisted of hiking, picnicking, camping, sunbathing, swimming and fishing. Considerably greater recreational activity occurred along the Missouri River in 1987 than in 1986, due mainly to warmer, sunnier weather (George Vandel, GFP, Pierre, SD, pers. comm.). Litter, campfire pits, volleyball courts, and other miscellaneous evidence of recreational activity was noted on 38 colony sites (76%) along the Missouri River in 1987 as compared to 12 colony sites (38%) in 1986. At least 1 colony was abandoned as a direct result of excessive human activity (#11027, Appendix Table 5). Twenty-six of 31 (84%) colonies on the Gavins Point reach experienced human disturbance, while 9 of 11 (82%) colonies along the Fort Randall reach and 3 of 9 (33%) colonies on Oahe Reservoir experienced

notable human disturbance in 1987. Despite the posting effort, evidence of recreational activity was documented at 6 of 9 (67%) posted sites.

Egg loss due to predation was noted at 5 colonies in 1986, and zero colonies in 1987. Three dead least tern chicks or their remains were found in 1986 in comparison to 8 dead chicks and 3 dead adults in 1987. One dead piping plover chick was found in 1986, while no evidence of plover mortality was found in 1987. Except for 3 tern chicks which died of exposure during a rainstorm on 24 June 1987, I was not able to assign definitive causes of this mortality. However, evidence or sightings of potential predators of terns, plovers, and their eggs or chicks, were documented on or near several nesting areas and included: coyote (Canis latrans), domestic dog (Canis familiaris), raccoon (Procyon lotor), opossum (Didelphis marsupialis), mink (Mustela vison), prairie rattlesnake (Crotalus viridus), northern harrier (Circus cyaneus), red-tailed hawk (Buteo jamaicensis), common crow (Corvus brachyrhynchos), great blue heron (Ardea herodias), and ring-billed gull (Larus delawarensis).

Eggs and young birds can be sensitive to unfavorable environmental conditions. Excessive heat, cold, or rain may cause weakening and death of tern and plover chicks and mortality of eggs. For example, impacts of a heavy

rainstorm were observed on 24 June 1987, at site #11032, when a thunderstorm occurred during a visit to that colony. Nine tern nests and 5 plover nests had been found and marked just prior to the rainstorm. The site was monitored from a nearby riverbank during the rainstorm, which lasted approximately 80 minutes. When the rain subsided, the nests were re-examined. Of the 9 tern nests, 1 was completely washed away and 2 were covered with sand and had broken eggs. Three least tern chicks were found dead, and 1 tern chick was found washed over with sand but still alive. One plover nest was completely washed away, while 1 other was covered with sand, although the top of an egg was still visible. The impacts of flooding or wave action on tern and plover production and survival are likely similar to those which may occur during a rain event, with drowned chicks, damaged or destroyed eggs and nests, stressed adults, and ultimately reduced reproductive output. One important difference between flooding and rain events is that flooding may affect all nesting sites within a given river reach, whereas rain events often cause only localized disturbance.

The presence of cattle was documented at 1 Cheyenne River colony site in 1986, 3 Cheyenne River colony sites in 1987, and 1 Oahe Reservoir colony site in 1987. Although no direct nest loss by cattle was documented, heavy use of

beaches by loafing and watering cattle could cause nest site abandonment.

DISCUSSION

The distribution and production of least terns and piping plovers along the mainstem Missouri River in South Dakota is largely determined by the relation of nesting habitats to water levels. Fluctuations in water levels, reflective of mainstem dam discharges, inflow, hydropower, and downstream water needs, affect the amount of beach and sandbar habitat available for nesting (Dryer and Dryer 1985). Untimely increases in discharge of water from Fort Randall and Gavins Point dams causes inundation of colony sites downstream. Vegetative encroachment of sandbars caused by reduced sandbar scouring (by water or ice) due to long-term alterations of instream flows (U.S. Geological Survey 1983) further limits habitat availability. Recreational activity at colony sites is also a factor affecting tern and plover distribution and productivity. Predation is a limiting factor but the degree of its impact remains uncertain.

Near record level inflows into the Missouri River through most of the 1986 production season resulted in limited availability of suitable habitat for nesting. If suitable habitat is not available because of high water

levels during the nest initiation period, least terns and piping plovers are more likely to select marginal nesting habitat (Massey and Atwood 1979, J. Dinan pers. comm.). The high number of abandoned nests, numerous renesting attempts, and low fledging success in 1986 was reflective of high water effects on nesting area suitability and, hence, low productivity. Many sandbars below Gavins Point Dam in 1986 and below Fort Randall in 1986 and 1987 were low profile (less than 18 inches above surface water) and, therefore, were subject to wave action or small changes in water levels. Beach and point colony sites on Oahe Reservoir were small and subject to high wave action. In 1987 more habitat was exposed on Oahe Reservoir, below Fort Randall, and below Gavins Point than in 1986, due to decreased system storage and reduced water releases during the nesting season. This increase in habitat availability was accompanied by an increase in the number of sites used by nesting terns and plovers, and by a substantial numerical increase in the population of least terns.

Plover and tern colony turnover rates were high, probably because of the ephemeral quality of nesting habitat, coupled with high recreational activity on many sites during the nesting seasons. McNicholl (1975) reported that least terns may shift colony sites frequently due to habitat instability. Comparing turnover rates between

habitats (Table 2), Gavins Point sandbar sites were moderately stable (57% of the tern sites and 55% of the plover sites were either new or abandoned) while Fort Randall sandbar sites were highly unstable (0.78 for terns and 1.00 for plovers), and beach sites were intermediate between the sandbar sites. Turnover rates for least terns in other areas were much lower: 16-30% in New Jersey (Burger 1984), 9% in Massachusetts (Erwin 1977), and 13-29% in Missouri (Smith 1987, John Smith, Missouri Department of Conservation, Columbia, MO, pers. comm.). The relative instability of colonies in SD may be related to smaller habitat size compared to nesting habitats in other locations, and undesirable conditions at the colony sites.

Although least terns and piping plovers may use the same colony sites for several consecutive years (Carreker 1985, Dinsmore 1981), there is an interaction between habitat suitability, site fidelity, reproductive success, and social attraction of the species during nesting, all of which determine whether a site will be abandoned or occupied (Burger 1984, Kotlair and Burger 1986). While site fidelity is high, human disturbance, vegetative encroachment, or other factors may render a site unsuitable. Thus site abandonment is merely a response to undesirable environmental conditions. Flooding, vegetative encroachment and recreational activity are all factors which affect site

selection by terns and plovers in SD. If colony site stability can be improved through measures which enhance habitat conditions, specific colonies may be managed to maximize production.

On the SD mainstem Missouri River, water management regimes were critical to tern and plover reproductive success. In 1987, a low water year with relatively good nesting success, nesting was initiated and concluded earlier than in 1986, a high water year with poor nesting success. There are several important reasons for promoting early nesting in terns and plovers. Early nesters are usually comprised of older, more successful breeding adults (Massey and Atwood 1981). These birds have the greatest potential for promulgating the species. Production from later nesting attempts tends to be less (Smith 1987) due to reduced clutch sizes and greater recreational use at sites during warmer seasons. In addition, should localized catastrophes (e.g. rainstorms) occur, the ability for the affected individuals to renest later would result in a smaller impact on the reproductive success of the population as a whole.

Production was much better in 1987 for both species with 110 terns and 106 plovers fledged, compared to 44 terns and 8 plovers in 1986. However, the impacts of fluctuating water levels were evident on sandbar colony sites below Fort Randall dam in both years. If flows there could remain low

and stable during the nesting and brood rearing season, as they were below Gavins Point in 1987, production should be higher for both species.

Counts of juvenile least terns at colonies as a direct measure of annual production have often been used as the method to estimate survival from hatching to fledging. Thompson and Slack (1984) and Massey and Atwood (1981) reported that the majority of juvenile terns depart colonies within three weeks after fledging. Therefore, when more intensive colony monitoring is not possible, multiple fledgling counts timed with the breeding chronology at the colony sites should provide the most reliable estimates of survival to fledging. Observer familiarity with nesting chronology at colony sites is important in determining the timing of these counts.

Recreational use of the Missouri River was high during May through August, with the greatest use occurring in July and August in both years. This overlaps the usual tern and plover breeding season. Many of the sandbars and beaches suitable for plover and tern nesting were also the most desirable for sunbathing, swimming, picnicking, and other recreational activities, most of which conflict in time, space, or both. This problem was particularly acute below Fort Randall and Gavins Point dams, where there were too few sandbars suitable for both birds and people

(recreationists). Recreational activity on the Cheyenne River was minimal. Human disturbance has been documented as a significant factor affecting least tern and piping plover productivity in many locations (Burger 1984, Debinski 1985, Dryer and Dryer 1985, Flemming 1984, Haig 1986). The specific impacts of human disturbance on site tenacity and production on Missouri River nesting colonies should be addressed in more detail in the future.

Least terns feed opportunistically on forage fish. The distance they must fly from nesting sites to foraging areas may be an important component of habitat suitability (Carreker 1985, Massey and Atwood 1979), and a limiting factor in tern distribution the Missouri River and its western tributaries. Piping plovers feed mostly on insects (Whyte 1985). Food availability may also limit plover distribution, restricting their breeding range in SD to areas along the Missouri River. Little is known about the forage requirements of terns and plovers in South Dakota. Although food availability does not appear to be a limiting factor, research on this topic is necessary to realize the potential impacts of limited resources in relation to water flow management.

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

The following conclusions and recommendations for protection, management, and continued study of interior least terns and piping plovers in SD are based on the 1986 and 1987 tern and plover surveys, previous surveys, published and unpublished literature, and professional judgement. Due to the highly different water conditions between 1986 and 1987 on the Missouri River, conclusive statements about some of my objectives could not be made. These conclusions should therefore be considered tentative until further information is obtained which can be compared to the different water and habitat conditions between 1986 and 1987.

Conclusions

The key to protecting least terns and piping plovers is to determine the location and stability of colony sites and to protect, maintain, or restore this existing habitat accordingly. Since water level fluctuations affect habitat availability, habitat quality and species distribution, surveys are necessary to identify new nesting areas, confirm use of old nesting areas, monitor productivity and protect nesting sites. Until the populations of terns and plovers recover to the extent appropriate for delisting as

threatened or endangered, these surveys will need to be continued on an annual basis.

The greatest concentrations of nesting least terns and piping plovers occurred on the Gavins Point river reach, where approximately 65% of the least terns and 90% of the piping plovers nested during 1986 and 1987. Fewer least terns and piping plovers nested on the Fort Randall river reach, where the number of sites available for nesting was less. Oahe Reservoir habitats supported the least numbers of nesting terns and plovers, and colonies there were small compared to those on sandbars. While future management and research efforts should focus on terns and plovers nesting along the Gavins Point reach because of the larger concentration of birds there, the importance of the other river reaches should not be overlooked.

Along Oahe Reservoir, tern and plover production improved substantially from 1986 to 1987 because pool elevations were reduced earlier in 1987. The 1987 water levels below Gavins Point Dam were more conducive to least tern and piping plover production than the 1986 water levels. Least tern and piping plover production there improved dramatically from 1986 to 1987, due to an average summer discharge which was 5,000 cfs (ca. 1.0 feet) less in 1987, and to water levels which were maintained at a fairly constant stage (approximately 30,000 cfs) through the

nesting season. In contrast, least tern and piping plover production was poor and water levels were not conducive to production along the Fort Randall reach, both in 1986 and 1987. There, sporadic fluctuations during both nesting seasons caused inundation of nests, considerable renesting, and site abandonment.

Average numbers of adult least terns and piping plovers per colony were greater on sandbar sites than on beaches or points, indicating that beaches or points are less desirable as colony sites. Substrate at beaches and points was typically comprised of a greater percentage of fine sand and less very fine sand or fines than substrate at sandbar sites. Since substrates at nests were no different than those at potential sites within site types (beach, point, sandbar), other habitat characteristics are probably more important than substrate in nest site selection by terns and plovers. Colony site size was 3 times larger on sandbars than on Oahe Reservoir beaches or points. Site size may be an important factor in colony site selection by terns and plovers in SD.

Colony sites were characterically barren or with short (<10 cm), sparse (<10%) vegetation. Vegetation at tern and plover nests was generally less than 10 cm, and vegetative coverage was less than 5%. Clearly, vegetative structure is important in colony and nest site selection. Plant species

varied among site types, with sandbars dominated by Eastern cottonwood (Populus deltoides), sandbar willow (Salix exigua), and slender flatsedge (Cyperus rivularis), while beaches and points were dominated by cocklebur (Xanthium strumarium) and common sunflower (Helianthus annuus). Terns and plovers nested near plant species in relative proportion to plant abundance on the colony sites.

Recreational activity is an important factor affecting the productivity of least terns and piping plovers along the Missouri River in SD.

Compared with the potential impacts of water levels and recreational activity, predation and weather are not presently considered the most important factors limiting the production of least terns and piping plovers along the mainstem Missouri River but their importance may increase in rank during any one year.

Recommendations

1. I recommend the continuance of annual monitoring for at least the next 5 years. Although no least terns or piping plovers were found nesting along the tailrace areas downstream of Oahe or Big Bend dams, nesting could occur there if pool elevations are reduced and habitat conditions improve. Therefore, it is desirable to continue surveys along these areas at least semi-annually. Since no least

terns or piping plovers were found along the Grand, Moreau, or White rivers, annual surveys on those rivers are probably not warranted more frequently than once every 3 to 5 years.

2. Turnover rates of least tern and piping plover colonies were lowest on the Gavins Point reach, which indicated that nesting sites there were the most stable between the two years. A reduction in turnover rates may be achieved by improving the conditions of nesting habitats (e.g. reduced water levels during the nesting season, protection from human disturbance, etc.). When stable colony sites are established, management efforts can focus on intensive protection, maintenance, or restoration of specific colonies.

3. Water discharge plans at all SD mainstem dams should include provisions for tern and plover production until all agency goals for their protection and a sustainable level of tern and plover production are met. River stages should be maintained at low, constant levels throughout the mid May to August nesting and brood-rearing season. Daily and weekly fluctuations during the critical nesting period should be avoided. Stages can be adjusted later during the season (if necessary) by coordinating water level management with field surveys of nest elevations and adjusting flow rates as water

conditions dictate. To reduce possible impacts of wave action on nests, a minimum of 0.5 foot elevation should be maintained as a buffer zone between the lowest active nests and water levels.

The release schedule recommended to the COE by the Nebraska Game and Parks Commission (1985) provides an example of how releases can be managed under years of different water conditions. However, since riverbed degradation below the mainstem dams continually causes a reduction in the relative water elevations and correspondingly alters the water level changes produced by differing releases, specific discharge recommendations would be of limited value. Much could be gained by evaluating the amount and quality of habitat available at different discharge rates, and summer releases could more appropriately be determined with the use of this information. By combining information on system and tributary inflows, flood control requirements, and field surveys of conditions at the nesting sites, water levels could possibly be managed with greater flexibility, and thereby accommodate other river consumer needs in conjunction with endangered species production.

High discharge rates from tributaries may affect water levels along the Missouri River and necessitate reductions in water releases from the mainstem dams. Should downstream

flooding during the nesting season necessitate reductions in water releases from the mainstem dams, water levels will have to be managed to discourage terns and plovers from nesting on the newly exposed habitat. If not, a return to target water levels would inundate the new nests. River stage modeling can be combined with data on downstream tributary inflows and tern and plover nesting information to determine appropriate release times and amounts. Observations made during the 1986 and 1987 nesting seasons indicate that terns and plovers will select nest sites at higher elevations if such sites are available on suitable nesting habitat. Also, terns and plovers will spend several days preparing nest cups before egg-laying. Therefore, short-term reductions in water releases should not be of great concern. However, if it is necessary to reduce releases for more than 3 to 4 days, periodic increases of flows to target levels would serve to discourage nesting attempts at lower elevations.

4. Plans for enhancement of tern and plover production and populations by providing alternate or improved nesting habitat should be made. Habitat enhancement plans should include consideration of (1) nesting area size, abundance and distribution, and (2) nest elevations above water levels. Vegetation height at colony sites should be

maintained at less than 30 cm, and percent vegetative cover should remain at less than 10%. During normal and low flow years maximization of site size and elevation above water could occur with the water management strategy outlined above (Recommendation #3). Nesting habitat with favorable site conditions (short, sparse vegetation; large site size; high profile) in normal and low flow years may then serve as nesting refuges during high water years.

5. An information and education (I&E) program should be coordinated between state and federal agencies with a responsibility toward protection of least terns and piping plovers along the Missouri River. A system of colony site protection should be developed, implemented, and maintained until population goals (Haig 1987, Sidle 1987) are reached and assured. Posters describing each species, the reason for protection, and individual personal and agency responsibilities, should be placed at strategic places at all public boat ramps located within 5 miles of each nesting colony. Warning signs should be placed at colony sites known or suspected to be used frequently by recreationists. Patrols by authorized enforcement personnel should be performed periodically at each known colony. Additional enforcement attention may be necessary during holidays and weekends at sites known to attract recreationists.

Consideration should also be made of providing alternative public use areas for recreationists as part of the I&E program and management agreements.

6. Future studies should be designed to build on baseline data gathered in this study in order to gain a better understanding of tern and plover populations with the purpose of refining management plans for protection of these endangered and threatened species in SD.

Specific suggestions for further studies include:

1) Evaluations of methods to remove vegetation (e.g. discing, burning, herbicide applications) from sites that are currently unsuitable for nesting.
2) Evaluations of methods to reduce vegetative encroachment on colony sites, including scouring vegetation off sandbar colony sites with water by periodically inundating them during the non-production season.
3) Determination of the quality and quantity of habitat available at different river stages.
4) Determination of the temporal changes in the quality and quantity of nesting habitat.
5) Determination of the long term effects of Missouri River aggradation and degradation on tern and plover nesting habitat.

6) Evaluation of how alternative nesting areas benefit species abundance and production.

7) Assessment of food availability as a potential factor limiting tern and plover distribution and production.

8) Assessment of site protection as a strategy to improve tern and plover site tenacity and production.

9) Development of a model for determining accurate water elevations at given locations at specific discharge rates for the entire mainstem Missouri River.

LITERATURE CITED

Burger, J. 1984. Colony stability in least terns. Condor 86:61-67.

Carreker, R.G. 1985. Habitat Suitability Index Models: Least Tern. Biol. Rep. 82 (10.103). U.S. Fish and Wildlife Service, Washington, D.C. 29pp.

Debinski, D. 1985. The effect of human disturbance on piping plover nest incubation at Waugoschance Point in 1985. Univ. Michigan Biological Station, Naturalist Ecologist Program.

Dinsmore, J.J. 1981. Piping plovers: a synthesis of the literature and an annotated bibliography. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. Unpubl. Rep. 28pp.

Dryer, M.P. and P.J. Dryer. 1985. Investigations into the population, breeding sites, habitat characteristics, threats and productivity of the least tern in North Dakota. U.S. Fish and Wildlife Service, Habitat Resources Field Office, Bismark, North Dakota. Resource Info. Paper No. 1. 17pp.

Ducey, J.E. 1981. Interior Least Tern (Sterna antillarum athalassos). U.S. Fish and Wildlife Service, Pierre, South Dakota. Unpubl. Rep. 56pp.

Erwin, R.M. 1977. Population and colony site dynamics in selected Massachusetts waterbirds. Proc. Colonial Waterbird Group 1:19-25.

Erwin, R.M., J. Galli, and J. Burger. 1981. Colony site dynamics and habitat use in Atlantic Coast seabirds. Auk 98:550-561.

Flemming, S.P. 1984. The status and responses of piping plover (Charadrius melodus ORD) to recreational activity in Nova Scotia. B.S. Honours Thesis. Acadia Univ.

Great Plains Flora Association. 1986. Flora of the Great Plains. Univ. Press of Kansas, Lawrence, Kansas. 1392pp.

Haig, S.M. 1986. Draft recovery plan for the Great Lakes/ Northern Great Plains populations of the piping plover Charadrius melodus. Univ. North Dakota, Grand Forks, North Dakota. 108pp.

Hamilton, K., and E.P. Bergersen. 1984. Methods to estimate aquatic habitat variables. Colorado Coop. Fishery Research Unit, Colorado State Univ., Fort Collins, Colorado. Tech. Rep.

Hays, H. and M. LeCroy. 1971. Field criteria for determining incubation stage in eggs of the common tern. Wilson Bull. 83:425-429.

Houtcooper, W.C., D.J. Ode, J.A. Pearson, and G.M. Vandel III. 1985. Rare animals and plants of South Dakota. Prairie Nat. 17:143-165.

Kotliar, N.B. and J. Burger. 1986. Colony site selection and abandonment by least terns Sterna antillarum in New Jersey, U.S.A. Biol. Cons. 37:1-21.

Massey, B.W. and J.L. Atwood. 1979. Application of ecological information to habitat management for the California least tern. Progress Report 1, U.S. Fish and Wildlife Service, Laguna Niguel, California.

_____ and _____. 1981. Second wave nesting of the

California least tern: age composition and reproductive success. Auk 98:596-605.

McNicholl, M.K. 1975. Larid site tenacity and group adherence in relation to habitat. Auk 92:89-104.

Nebraska Game and Parks Commission. 1985. Missouri river least tern and piping plover habitat management proposal presented to the Army Corps of Engineers. Nebraska Game and Parks Commission, Lincoln, Nebraska. Unpubl. Rep. 4pp.

Reed, P.B., Jr. 1986. National wetland plant list-Regional indicator compilation. U.S. Fish and Wildlife Service, WELUT-86/w 17.01. St. Petersburg, Florida.

SAS Institute Inc. 1982. SAS User's Guide: Statistics, 1982 Edition. SAS Institute, Inc. Cary, North Carolina. 584pp.

Sidle, J.G. 1986. Draft recovery plan for the interior population of the least tern Sterna antillarum. Endangered Species Division, U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 35pp.

Smith, J.W. 1987. Improving the status of endangered species in Missouri (least tern investigations). Missouri Department of Conservation, Columbia, Missouri. Endangered Species Project No. SE-01-12. 39pp.

Thompson, B.C. and R.D. Slack. 1984. Post-fledging departure from colonies by juvenile least terns in Texas: implications for estimating production. Wilson Bull. 96:309-313.

U.S. Fish and Wildlife Service. 1985a. Endangered and threatened wildlife and plants; determination of endangered and threatened status for the piping plover. U.S. Government Printing Office, Washington, D.C. 50 CFR Part 17:50726-50734.

U.S. Fish and Wildlife Service. 1985b. Endangered and threatened wildlife and plants; interior population of the least tern determined to be endangered. U.S. Government Printing Office, Washington, D.C. 50 CFR Part 17:21784-21792.

U.S. Geological Survey. 1983. Hydrologic and geomorphic

studies of the Platte River Basin. U.S. Geological Survey Professional Paper 1277.

Wentz, W.A. 1979. Endangered and threatened species in South Dakota. South Dakota State Univ., Brookings, South Dakota. ESS 17A. 10pp.

Whyte, A.J. 1985. Breeding Ecology of the Piping Plover (Charadrius melodus) in Central Saskatchewan. M.S. Thesis. Univ. Saskatchewan, Saskatoon, Canada. 125pp.

APPENDIX

APPENDIX TABLE 1. Least tern and piping plover production on the Missouri River between Gavins Point Dam, South Dakota, and Ponca, Nebraska, 1986.

Site ID	RM	Census Adults[a]	Census Adults[b]	Active Pairs[c]	Active Nests	Eggs	Chicks	Fledged
Least Terns:								
11001	804.0	11	8	5	13	31	3	2
11002	803.2	8	6	4	5	24	0	0
11003	801.6	11	6	5	9	25	0	0
11004	801.0	7	0	4	1	3	2	2
11013	801.0	7	0	3	0	4	1	1
11005	800.9	18	18	9	5	13	2	2
11006	798.0	2	2	1	0	0	0	0
	796.4	11	11	5	0	0	0	0
	789.5	3	3	1	1	1	0	0
	783.4	12	0	6	6	8	0	0
11010	782.6	10	10	5	11	30	2	0
11011	781.3	13	13	11	16	36	2	2
11012	778.5	20	20	8	21	50	19	3
	776.8	6	6	3	0	0	0	0
11014	773.8	0	0	0	0	0	1	0
	770.5	20	4	10	11	23	0	0
11009	770.0	22	22	11	26	60	4	1
11008	766.0	22	22	11	14	32	8	1
	764.8	10	0	5	5	9	0	0
	762.5	18	0	9	9	16	0	0
	758.5	10	10	5	6	14	0	0
	757.0	5	0	6	6	9	0	0
11007	755.3	20	20	10	8	26	2	0
Totals:			181	137	173	414	47	14

a These values represent the maximum number of adults observed at the sites during the season. See footnote b.

b These values indicate the number of adult birds present during the census period which had the highest population number for the season. The total of census adults is used in calculating fledging success ratios (Table 3).

c The number of pairs utilizing a nesting site was estimated by considering # of active nests present during each visit, # of defensive adults, and other factors of activity at the site.

d These values indicate the total number of different active nests on all visits combined. Since sites were visited only periodically, some nests were likely not accounted for.

APPENDIX TABLE 1 (cont'd). Least tern and piping plover production on the Missouri River between Gavins Point Dam, South Dakota, and Ponca, Nebraska, 1986.

Site ID	RM	Census Adults[a]	Census Adults[b]	Active Pairs[c]	Active Nests	Eggs	Chicks	Fledged
Piping Plovers:								
11001	804.0	9	9	7	17	69	6	0
11002	803.2	4	4	2	2	13	0	0
11003	801.6	14	8	7	2	7	0	0
11004	801.0	5	0	2	2	11	2	1
11013	801.0	4	0	2	1	4	0	0
11005	800.9	13	13	6	3	8	4	2
11006	798.0	3	2	1	1	3	0	0
	796.4	13	13	6	3	6	0	0
	789.5	5	5	2	1	1	0	0
	783.4	8	0	4	3	5	0	0
11010	782.6	10	10	5	7	27	0	0
11011	781.3	8	8	4	5	24	3	0
11012	778.5	14	14	7	11	32	0	0
	776.8	8	8	4	1	3	0	0
11014	773.8	0	0	0	0	0	0	0
	770.5	10	10	5	5	13	0	0
11009	770.0	12	12	7	7	29	3	1
	767.0	2	2	1	1	4	0	0
11008	766.0	14	14	7	7	26	0	0
	764.8	3	0	2	2	5	0	0
	762.5	2	0	0	0	2	0	0
	758.5	6	6	3	1	1	0	0
	757.0	4	4	2	2	4	0	0
11007	755.3	30	30	15	4	13	1	0
Totals:			172	101	88	310	19	4

APPENDIX TABLE 2. Least tern and piping plover production on the Missouri River between Fort Randall Dam and Springfield, South Dakota, 1986.

Site ID	RM	Census Adults[a]	Adults[b]	Pairs[c]	Active Nests	Eggs	Chicks	Fledged
Least Terns:								
12001	839.0	14	14	10	12	45	6	6
12003	873.0	11	11	5	4	8	0	0
12008	832.8	11	0	7	7	15	5	0
Totals:			25	22	23	68	11	6
Piping Plovers:								
12001	839.0	14	8	7	4	12	6	1
12003	873.0	3	3	1	1	4	0	0
12008	832.8	0	0	0	0	0	0	0
Totals:			11	8	5	16	6	1

APPENDIX TABLE 3. Least tern and piping plover production on the Missouri River along Oahe Reservoir, South Dakota, 1986.

Site ID	RM	Census Adults[a]	Active Adults[b]	Pairs[c]	Nests	Eggs	Chicks	Fledged
Least Terns:								
16003	1105.7	2	2	1	1	1	0	0
16004	1104.2	2	2	1	1	1	0	0
16006	1108.0	6	6	3	1	3	2	0
16007	1108.5	15	4	9	11	19	6	6
16009	1127.0	2	2	1	1	3	0	0
Totals:			16	15	15	26	8	6
Piping Plovers:								
16001	1155.0	2	0	1	1	3	0	0
16002	1155.0	2	0	1	1	2	0	0
16005	1072.8	2	2	1	1	3	3	3
16007	1108.5	2	2	1	2	4	0	0
Totals:			4	4	5	12	3	3

APPENDIX TABLE 4. Least tern and piping plover production on the Cheyenne River, South Dakota, 1986.

Site ID	RM	Census Adults[a]	Census Adults[b]	Pairs[c]	Active Nests	Eggs	Chicks	Fledged
Least Terns:								
35001	43.5	4	4	1	1	4	4	4
35002	59.5	7	6	3	3	8	4	2
35003	51.8	7	6	3	6	15	3	2
35004	47.0	4	4	2	1	1	1	0
35005	57.5	8	0	4	1	3	3	3
35006	53.6	10	0	5	2	4	2	1
other		11	11	6	-	-	6	6
Totals:			31	24	14	35	23	18

APPENDIX TABLE 5. Least tern and piping plover production on the Missouri River between Gavins Point Dam, South Dakota, and Ponca, Nebraska, 1987.

Site ID	RM	Census Adults[a]	Census Adults[b]	Pairs[c]	Active Nests	Eggs	Chicks	Fledged
Least Terns:								
11025	807.5	4	4	2	1	3	0	0
11001	804.0	16	2	9	9	25	0	0
11002	803.2	4	4	2	1	3	3	0
11003	801.6	10	10	7	13	30	7	7
11005	800.9	8	8	4	7	18	2	0
11041	800.9s	2	2	1	1	2	0	0
11042	799.8	6	4	3	3	9	5	5
11043	796.9	11	0	4	4	12	5	5
11026	796.4	9	8	5	5	10	1	0
11044	796.3	8	8	4	5	12	0	0
11048	796.2	2	0	1	1	3	0	0
11045	796.0	18	18	10	8	16	8	4
11027	791.5	10	10	6	9	24	6	0
11047	791.0	4	0	2	4	10	0	0
11046	790.5	24	0	10	9	14	11	11
11038	783.0	2	2	1	1	3	0	0
11039	780.3	18	12	12	12	25	5	2
11012	778.5	20	20	8	11	29	5	1
11040	773.0	11	9	4	8	15	5	3
11028	771.0	14	9	7	7	18	5	0
11009	770.0	10	10	5	6	8	6	6
11029	768.5	22	22	18	18	51	27	0
11030	767.1	8	2	4	4	8	3	1
11008	766.0	10	10	5	9	19	6	6
11031	761.6	16	12	8	8	19	11	4
11032	759.0	20	20	10	11	20	15	13
11033	758.9s	3	2	1	1	2	2	2
11034	758.9	6	4	3	3	6	2	2
11035	757.0	6	2	1	1	3	3	1
11036	756.9	4	4	2	2	5	4	4
11037	753.6	14	14	7	7	19	6	3
Totals:			232	164	189	441	153	80

APPENDIX TABLE 5 (cont'd). Least tern and piping plover production on the Missouri River between Gavins Point Dam, South Dakota, and Ponca, Nebraska, 1987.

Site ID	RM	Census Adults[a]	Census Adults[b]	Active Pairs[c]	Active Nests	Eggs	Chicks	Fledged
Piping Plovers:								
11025	807.5	4	3	2	4	14	6	6
11001	804.0	16	3	11	11	39	3	1
11002	803.2	8	2	6	7	27	4	3
11003	801.6	14	6	5	7	28	14	14
11005	800.9	10	10	5	5	17	8	7
11041	800.9s	2	2	1	1	4	3	3
11042	799.8	4	3	2	2	6	4	3
11043	796.9	2	2	1	2	7	4	4
11026	796.4	10	10	5	3	12	3	0
11044	796.3	10	10	1	1	4	2	2
11048	796.2	2	0	1	1	3	3	2
11045	796.0	16	16	5	4	14	4	3
11027	791.5	5	4	2	4	13	0	0
11047	791.0	3	0	1	1	4	0	0
11046	790.5	2	0	2	2	8	5	5
11038	783.0	2	2	1	1	3	0	0
11039	780.3	6	6	3	5	18	3	3
11012	778.5	8	8	4	5	17	4	4
11040	773.0	9	9	4	4	14	4	4
11028	771.0	6	6	3	4	15	0	0
11009	770.0	8	8	4	7	21	6	6
11029	768.5	14	14	7	5	17	3	0
11030	767.1	8	4	4	4	14	7	1
11008	766.0	6	6	3	3	12	4	4
11031	761.6	6	6	3	2	7	4	3
11032	759.0	16	16	6	7	24	18	18
11033	758.9s	6	6	3	1	4	3	3
11034	758.9	6	6	3	3	10	6	1
11035	757.0	2	2	1	0	0	0	0
11036	756.9	2	1	1	0	0	0	0
11037	753.6	6	6	3	3	12	0	0
Totals:			177	103	109	388	125	100

APPENDIX TABLE 6. Least tern and piping plover production on the Missouri River between Fort Randall Dam and Springfield, South Dakota, 1987.

Site ID	RM	Census Adults[a]	Census Adults[b]	Pairs[c]	Active Nests	Eggs	Chicks	Fledged
Least Terns:								
12016	876.1	12	8	6	8	15	4	4
12004	866.5	22	22	11	19	43	9	2
12011	852.0	2	2	1	1	1	0	0
12012	840.6	8	0	4	4	7	0	0
12013	840.5	20	0	13	13	30	0	0
12017	840.5s	4	0	2	1	2	0	0
12018	840.3	2	0	1	2	2	0	0
12014	834.0	1	0	0	0	0	0	0
12015	833.0	16	14	7	9	18	5	5
12008	832.8	16	14	8	11	23	11	2
12019	832.0	3	0	0	0	0	0	0
Totals:			60	53	68	141	29	13
Piping Plovers:								
12016	876.1	2	1	1	0	0	0	0
12004	866.5	4	4	2	2	7	0	0
12011	852.0	1	0	0	0	0	0	0
12012	840.6	8	0	4	4	16	0	0
12013	840.5	10	0	6	6	21	0	0
12017	840.5s	2	0	1	1	4	0	0
12014	834.0	3	3	1	1	2	0	0
12015	833.0	4	4	2	3	8	0	0
12008	832.8	4	4	2	2	4	3	1
12019	832.0	2	0	1	1	3	0	0
Totals:			16	20	20	65	3	1

APPENDIX TABLE 7. Least tern and piping plover production on the Missouri River, along Oahe Reservoir, South Dakota, 1987.

Site ID	RM	Adults[a]	Census Adults[b]	Pairs[c]	Active Nests	Eggs	Chicks	Fledged
Least Terns:								
16013	1090.0	2	2	1	1	3	2	1
16014	1104.0	5	5	2	1	3	0	0
16007	1108.5	6	6	4	4	8	3	3
16025	1109.5	2	2	1	1	3	3	3
16020	1119.2	2	2	1	1	2	2	2
16016	1123.0	10	0	5	5	10	2	2
16009	1127.0	6	2	3	2	6	3	3
16015	1158.5	2	2	1	1	3	3	3
Totals:			21	18	16	38	18	17
Piping Plovers:								
16013	1090.0	2	2	1	1	4	4	2
16014	1104.0	2	2	1	1	3	3	3
16017	1108.5	2	0	1	1	3	3	0
Totals:			4	3	3	10	10	5

APPENDIX TABLE 8. Least tern and piping plover production on the Cheyenne River, South Dakota, 1987.

Site ID	RM	Census Adults[a]	Census Adults[b]	Pairs[c]	Active Nests	Eggs	Chicks	Fledged
Least Terns:								
35002	62.5	5	5	3	3	6	1	1
35014	61.7	4	0	2	1	2	1	1
35007	61.0	5	5	2	3	6	3	3
35006	56.2	8	7	5	6	15	2	2
35008	51.8	12	12	6	7	17	0	0
35001	46.3	2	2	1	0	0	0	0
35012	45.2	4	3	2	2	4	2	2
35013	27.7	2	2	1	1	2	2	2
35009	16.5	6	6	3	3	6	1	0
35010	8.7	12	12	5	5	15	7	2
Totals:			54	30	31	73	19	13