Platte River
Recovery Implementation Program

2020 Interior Least Tern and Piping Plover Monitoring and Research Report, Central Platte River, Nebraska

Prepared for: Governance Committee
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PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

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PREFACE

This is a report of the Platte River Recovery Implementation Program's (Program or PRRIP) monitoring and research efforts for interior least terns (least tern) and piping plovers during 2020. The report was prepared to inform Program partners, licensing agencies, and the general public of our activities and to provide a summary of results to fulfill the requirements of the Program's state (Nebraska Master Permit #1208) and federal (TE183430-3) monitoring permits.

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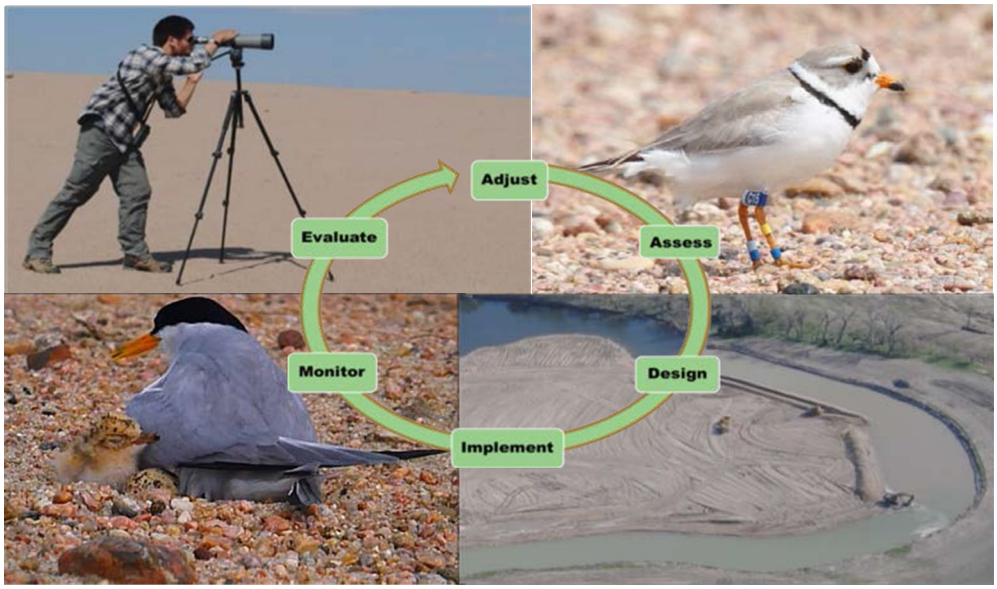
Adjust
Assess
Design
Implement
Monitor
Evaluate

INTRODUCTION

The Platte River Recovery Implementation Program (Program or PRRIP) was initiated in 2007 as a result of a cooperative agreement negotiating process that started in 1997 between the states of Colorado, Wyoming, and Nebraska; the U.S. Department of the Interior (DOI); water users; and conservation groups. The Program is led by a Governance Committee (GC) that is assisted by several standing advisory committees as well as an Executive Director (ED) and staff. The Program is intended to address issues related to the Endangered Species Act and loss of habitat in the central Platte River between Lexington and Chapman, Nebraska by managing certain land and water resources following principles of adaptive management to provide benefits for four "target species" including the endangered interior least tern (*Sternula antillarum*) and the threatened piping plover (*Charadrius melodus*).

The northern Great Plains population of piping plovers was listed as threatened on January 10, 1986. The least tern was listed as endangered on June 27, 1985; however, a recently completed five-year review recommends delisting interior least terns due to population recovery. Delisting of interior least terns is anticipated January 2021 according to a U.S. Fish and Wildlife Service (USFWS) Director's announcement.

The Program has three main elements:

- Increasing stream flows in the central Platte River during relevant time periods through re-timing and water conservation or supply projects. The First Increment objective is to re-time and improve flows in the central Platte River to reduce shortages to target flows by an average of 130,000 – 150,000 acre-feet per year at Grand Island.
- Enhancing, restoring, and protecting habitat lands for the target species. The First Increment objective is to protect, restore, and maintain 10,000 acres of habitat.
- Accommodating certain new water-related activities in the basin.

Past data and analyses are included in annual reports produced by West Incorporated (2001−2007) and Program EDO staff (2008−2020), and are available in the Program's online Public Library (https://platteriverprogram.org/program-library). Least tern and piping plover activity and reproductive success during 2020 are summarized in this report. Monitoring and research during 2020 were a collaborative effort between Program EDO staff, the Crane Trust, and Nebraska Public Power District (NPPD). The data summarized in this report were collected in accordance with the PRRIP 2017 Central Platte River Tern and Plover Monitoring and Research Protocol (2017). Implementation includes: 1) monitoring interior least tern (least tern) and piping plover (plover) use and productivity on midstream-river sandbars and off-channel sand and water (OCSW) nesting sites that include both created and rehabilitated sandpits; and 2) document habitat characteristics that are believed to influence nest site selection and nest and brood success along the central Platte River between Lexington and Chapman, Nebraska.

Together with the United States Geological Survey - Northern Prairie Wildlife Research Center (USGS-NPWRC), the Program has also banded least tern and piping plover adults and chicks on the central Platte with three objectives: 1) quantify dispersal of adults between units of nesting habitat on the Central Platte River among years; 2) quantify colonization rate of newly constructed or managed nesting habitat by local versus immigrant adults; and 3) quantify frequency and location of renesting attempts by adults with failed nests. Banding of least tern and piping plover

adults and chicks was conducted for seven consecutive years on the central Platte River (2009–2016). The 2020 season marked the fourth year of band resighting following discontinuation of banding efforts. The Program was recently informed that the USGS will no longer use the data collected via the Program's resighting efforts. Thus, band resighting efforts by the Program will be discontinued in 2021. Initial results pertaining specifically to the central Platte River were published in a USGS Report by Roche *et al*. in 2016. We anticipate a final report documenting results of those efforts (within the context of a Great Plains metapopulation analysis) will be available on the Program's online Public Library following publication by USGS in 2021.

STUDY AREA

Our study area encompassed the PRRIP's Associated Habitat Reach (AHR) segment of the central Platte River between Lexington and Chapman, Nebraska (~90 river miles, Figure 1) as well as OCSW sites within 3.5 miles of the river in this reach. River or on-channel habitat includes naturally-formed or constructed midstream sandbars used for nesting and open river channel used for foraging. OCSW habitat includes spoil piles of sparsely- or non-vegetated sand at sand and gravel mines and constructed nesting sites. Least terns typically nest on OCSW habitat or constructed on-channel islands and primarily forage on the river channel. Piping plovers typically nest on OCSW habitat or constructed on-channel islands. Adults forage on low elevation river sandbars or along the waterline of OCSW habitat. Juveniles forage along OCSW waterline until fledging when they are often observed foraging on the river channel.

2020 RIVER CONDITIONS

The number of low-elevation sandbars present within the PRRIP associated habitats region of the central Platte River is variable and dependent on seasonal and daily fluctuations in river flow. The size and distribution of non-vegetated, high- elevation sandbars characteristic of least tern and piping plover nesting sites within the region has been dependent upon construction and vegetation management efforts.

In 2020 daily flows were high during April and May, with the annual peak discharge occurring at the end of May. At the Kearney gage (USGS gage 06770200, USGS 2020) the annual peak discharge was 4,400 cubic feet per second (cfs) on May 25th (Figure 2). Discharge then dropped below 2,000 cfs for most of June and July. The majority of the river channel was inundated until mid-July when bare sand and foraging area on the river became available. After the first week of August, flows dropped to very low levels and there were large amounts of bare sand with very shallow water in most areas.

Cottonwood Ranch 4 May 2020

Cottonwood Ranch 31 August 2020

Shoemaker Island 10 May 2020

Shoemaker Island 2 September 2020

MANAGEMENT

Management actions designed to increase nesting habitat (bare sand) and productivity of least terns and piping plovers were taken at on- and off-channel sites during fall 2019 and spring 2020. Management activities were site specific and included: mechanical actions to create nesting habitat (dozers, scrapers, and backhoes), mechanical actions to improve nesting conditions and remove vegetative cover (disking, tree removal, mowing, and nest furniture distribution); chemical application to kill or prevent emergence of vegetation (spring or fall herbicide application); and predator control (fencing, trapping, predator deterrent lights, and limited turtle fencing).

SUMMARY OF HABITAT AVAILABILITY, 2007–2020

On-Channel Mechanical Habitat Creation and Maintenance

Constructed on-channel habitat availability has been variable and somewhat limited during the First Increment of the Program (Table 1). Approximately 24 acres of constructed habitat were present in the AHR in 2007 as the result of efforts by other conservation organizations. That habitat was subsequently lost over the course of several years due to erosion during natural high flow events. The Program began large-scale on-channel habitat construction efforts at the Elm Creek complex in the fall of 2012 and was also able to create on-channel habitat at the Cottonwood Ranch and Plum Creek complexes as part of sediment augmentation activities. Much of that habitat was lost during a natural high flow event in the fall of 2013. On-channel island construction began at the Shoemaker Island complex following the fall 2013 event. A

high flow event in June of 2014 eroded a portion of the habitat constructed in the fall of 2013, but the Program was able to construct a total of 28 acres of on- channel habitat during the fall of 2014 at the Elm Creek and Shoemaker Island complexes. However, all of it was lost due to erosion during the 2015 and 2016 high flow events. On- channel habitat construction by other conservation organizations has been very limited since 2007.

Off-Channel Mechanical Habitat Creation and Maintenance

Approximately 48 acres of managed off-channel nesting habitat were present in the AHR at the beginning of the First Increment (Table 1). The Program began acquiring and restoring off-channel sites in 2009. Total monitored off-channel habitat in the AHR increased to 209 acres during the period of 2009−2020 as the Program constructed and/or restored acres of habitat. Habitat availability increased compared to 2019 due to the flood events last year and the construction of new habitat from active mining. The Program plans to acquire or construct a minimum of 60 acres of off-channel habitat prior to the end of the First Increment Extension in 2032. Mining activities at Follmer Alda, Newark East, and the newly acquired OSG Lexington sandpit are still underway. We expect approximately 38 acres of new habitat to become available for the 2021 nesting season, with more acres being added to the nesting sites as mining there continues.

SANDPIT SITES:

Eleven of the sixteen off-channel sites monitored during 2020 were actively managed to increase least tern and piping plover reproduction. Program owned and/or managed sites are denoted with a superscript "P" (^{P}) and managed sites are identified by a superscript "M" (^{M}). Sites that were constructed specifically for tern and plover nesting are denoted by a superscript "C" (^{C}), and former sand and gravel mines (both formerly active and currently active) that were rehabilitated into or designated as possible nesting habitat are denoted by a superscript "G" (^{G}). Numbers correspond to map locations on Figure 3 and are included in Table 2.

^{MG}1 Lexington NPPD Pit – A pre-emergent herbicide was applied during spring 2020, the woven-wire predator fences with offset electric wires along the west side of the nesting areas were maintained, and predator trapping occurred during 2020. No sand and gravel mining occurred during 2020.

^{PMG}2 Dyer Pit – A contact herbicide was applied to kill existing vegetation primarily along the waterline during fall 2019. A pre-emergent herbicide was applied during spring 2020. Permanent 4-foot-high woven wire predator fences with offset electric wires across the south ends of each peninsula were maintained. Predator trapping also occurred during the 2020 nesting season. No sand and gravel mining occurred during 2020.

^{PMC}3 Cottonwood Ranch – A contact herbicide was applied to kill existing vegetation primarily along the waterline during fall 2019, a pre-emergent herbicide was applied, and predator trapping occurred during 2020. A permanent 4-foot-high woven wire predator fence with offset electric wires was maintained in 2020. No sand and gravel mining occurred.

^{MG}4 Blue Hole – A pre-emergent herbicide was applied during spring 2020, a permanent 4-foot-high fence was installed along the west edge of the peninsula, and predator trapping occurred during 2020. Predator deterrent lights and temporary turtle exclusion fences were installed on the south side of the nesting site during spring 2020 as part of a pilot study for additional predator management. Sand and gravel mining did not occur during 2020; however, the area west of the sandpit is a high traffic area for loading and unloading equipment.

^{MG}5 Johnson Pit – A pre-emergent herbicide was applied during spring 2020, the woven-wire predator fence with offset electric wires along the west side of the nesting area was maintained, and predator trapping occurred during 2020. No sand and gravel mining occurred during 2020.

^{G}6 Ed Broadfoot and Sons – Not managed. Sand and gravel mining occurred during 2020.

^{PMG}7 Broadfoot South-Kearney – A contact herbicide was applied to kill existing vegetation primarily along the waterline during fall 2019 and a pre-emergent herbicide was applied to the nesting area during spring 2020. A permanent 4-foot-high woven wire predator fence with offset electric wires was installed in 2020 across the east end of the main peninsula, and predator trapping occurred during 2020. Temporary turtle exclusion fences were also installed on the north and south shores of the central nesting area as part of a pilot year for additional predator management. Sand and gravel mining took place north of the main peninsula during 2020.

^{PMG}8 Broadfoot South-Kearney—Non-Access Islands – A 4-foot-high hog-panel fence with chicken wire was placed across the land-bridge extending to one of the non-access islands

located northwest of the main peninsula. Sand and gravel mining occurred directly east of the islands during 2020. The area where this is occurring is unvegetated, however, it is not suitable for nesting due to the active mining taking place. There were 7.3 acres of unmanaged, suboptimal habitat available on these islands for least tern or piping plover nesting and foraging this season. This can be seen in the figure. Most of these areas are partially or heavily vegetated, including large portions of the shorelines. Also due to the active mining, the area of this site varies year to year.

Non-Access Broadfoot South-Kearney islands in July

PMG 9 Newark West – A contact herbicide was applied to kill existing vegetation primarily along the waterline during fall 2019. A pre-emergent herbicide was applied during spring 2020, permanent 4-foot-high woven wire predator fences with offset electric wires across the ends of each peninsula were maintained, electric wires were installed along the perimeter on the outer property fence, and predator trapping occurred during 2020. Predator lights were installed on the nesting site during spring 2020 as part of a pilot year for additional predator management. No sand and gravel mining occurred during 2020.

PMG 10 Newark East – A contact herbicide was applied to kill existing vegetation primarily along the waterline during fall 2019. A pre-emergent herbicide was applied during spring 2020. The permanent 4-foot-high woven wire predator fence with offset electric wires across the end of the west peninsula was maintained and a temporary 4-foot-high electrified predator fence was installed across the east peninsula. Predator trapping occurred in 2020 as well as sand and gravel mining east of the nesting areas. Aside from additions due to mining, existing habitat was also improved in 2019 through mechanical management. Low areas were filled in and shoreline slopes were smoothed out to make them more gradual. There were 16.3 acres available for least tern and piping plover nesting and foraging in 2020, which was an increase of about 4.5 acres from 2019.

Newark East Sandpit in July

PMC 11 Leaman East – A contact herbicide was applied to kill existing vegetation along the waterline during fall 2020. A pre-emergent herbicide was applied to the nesting area during spring and predator trapping occurred during 2020. A permanent, 4-foot-high woven wire predator fence with offset electric wires was maintained in 2020. No sand and gravel mining occurred.

MG 12 Trust Wild Rose East – The nesting area was disked in the fall of 2019. No sand and gravel mining occurred.

PMG 13 Follmer-Alda Pit – A contact herbicide was applied to kill existing vegetation along the waterline during fall 2019. A pre-emergent herbicide was applied to the nesting area during spring 2020. Sand and gravel mining occurred east of the main peninsula during 2020. The east peninsula will have available habitat in 2021.

G 14 DeWeese-Alda – Not managed. Sand and gravel mining occurred during 2020.

G15 Hooker Brothers - GI South East – Not managed. Sand and gravel mining occurred during 2020.

G16 Hooker Brothers - GI East – Not managed. Sand and gravel mining occurred during 2020.

MONITORING

In 1997, the DOI and the States of Nebraska, Colorado, and Wyoming adopted the "Cooperative Agreement for Platte River Research and Other Efforts Relating to Endangered Species Habitats" (Cooperative Agreement). In 2001, the Cooperative Agreement coordinated a standardized protocol for monitoring reproductive success and reproductive habitat parameters of least terns and piping plovers in the central Platte River from Lexington to Chapman, Nebraska. The standardized protocol was implemented by CNPPID, CPNRD, NPPD, and USFWS-GI during 2001−2006. In 2007, the Program assumed responsibilities of the protocol. Program staff, contracted personnel, and cooperators have since implemented it. The protocol was revised prior to the 2010 nesting season and again prior to the 2017 nesting season (PRRIP 2017).

SEMI-MONTHLY RIVER AND SANDPIT SURVEYS:

METHODS

We conducted 5 semi-monthly surveys (1 and 15 May, 1 June, 15 July, and 1 August) of the central Platte River between Chapman and Lexington, Nebraska (river surveys); and 7 semi-monthly sandpit surveys (1 and 15 of May, June, and July; and 1 August). In addition, we surveyed all sandpits within Program Associated Habitats that met the Program's minimum habitat criteria (sandpit surveys) to document adults, breeding pairs, nests, chicks, and fledglings during 2020. We derived least tern and piping plover breeding pair estimates (BPE) according to the methods described by Baasch *et al*. (2015). Briefly, we derived least tern and piping plover breeding pair estimates by adding the number of active, or recently failed nests (within the species-defined renest interval) to the number of active, or recently failed or fledged broods (within the species-defined renest or post fledge interval, respectively) observed on a given date. We obtained least tern breeding pair estimates by assuming: 1) least tern nests did not hatch within 21 days of being initiated; 2) least terns did not re-nest within 5 days of losing a nest or brood; 3) least tern chicks fledged at 21 days of age (fledging age 2010−2020); 4) least tern chicks that survived to 15 days of age (fledging age 2007−2009) also fledged; and 5) least terns did not re-nest after fledging chicks. We determined piping plover breeding pair counts by assuming: 1) piping plover nests did not hatch within 28 days of being initiated; 2) piping plovers did not re-nest within 5 days of losing a nest or brood or fledging chicks; 3) piping plover chicks fledged at 28 days of age (fledging age 2010−2020); 4) piping plover chicks that survived to 15 days of age (fledging age 2007−2009) also fledged; and 5) piping plovers did not re-nest within 5 days of fledging a brood. We included summaries of the total number of adults, breeding pairs, nests, chicks, and fledglings observed during river surveys, sandpit surveys, and a combination of river and sandpit surveys (semi-monthly survey totals) to provide 7 snapshots of the numbers observed during the 2020 nesting seasons. All counts of adults, breeding pairs, nests, chicks, and fledglings reported during semi-monthly surveys represent minimums present as they rely on direct observation.

The Program typically reports breeding pairs at their peak, when numbers of breeding pairs observed during a single observation period within the entire Program AHR first peaked (Table

2). Thus, peak breeding pair estimates are associated with a specific peak date. A site peak is also reported in Table 2 which represents the highest number of estimated breeding pairs at a single site during a single observation period, regardless of the date when breeding pairs peaked over the entire AHR. Both AHR and site peak breeding pairs utilize the rules for calculated breeding pairs (BPE) as described above. To be comparable to other programs that use other sampling intervals and methods, in Table 16-18 the Program also reports maximum breeding pairs. These are calculated using the Program's BPE as described above, however, the renest and post-fledge intervals were set to 0 days, except the post-fledge interval for least terns, which do no renest after successfully fledging offspring. The maximum breeding pair estimate is less sensitive to variable sampling intervals and allows comparisons to areas or historical data where a 14-day monitoring interval was used. In Figures 10 and 11, the Program also reports mid-June nest and brood counts as a means of comparison to other programs or historical data that result from a single, once annual mid-June survey (Baasch *et al*. 2015). The Program's BPE was found to be the most appropriate estimator of breeding pairs based on our monitoring protocol and sampling effort (Baasch *et al*. 2015).

Semi-monthly River Surveys – Program staff conducted semi-monthly river surveys between the J2 Return and the Chapman Bridge on 30 April and 1 May; 13-15 May; 4-5 June; 15-16 July; and 4-5 August during 2020. The 15 May survey was conducted with kayaks. The J2 Return to Dyer section, as well as well as the Hwy 281- Burlington RR stretch were excluded from this survey due to time and weather constraints, a lack of available nesting habitat, and an absence of least tern and piping plover sightings on these stretches during previous years. For all other river surveys, we used an airboat to survey channels wider than 75 yards between Lexington and Chapman, NE that could be safely navigated. We documented all observations of least tern and piping plover adults, breeding pairs, nests, chicks, and fledglings located within this reach of river. River surveys for 15 June and 1 July were not conducted due to airboat maintenance, as well as a lack of dry unvegetated sandbars appropriate for nesting habitat on the river during June. The J2 Return to Dyer was not completed for the 1-August survey due to weather.

Semi-monthly Sandpit Surveys – We conducted 7 semi-monthly surveys from outside the nesting colony at 16 sandpit sites to count individual birds and document least tern and piping plover adults, breeding pairs, nests, chicks, and fledglings. Semi-monthly sandpit surveys were conducted outside the nesting areas on 30 April - 5 May; 11-19 May; 29 May – 1 June; 15 June; 30 June-2 July; 13-17 July; and 30 July – 3 August during 2020. Program staff and personnel from NPPD and the Crane Trust conducted semi-monthly sandpit surveys during 2020.

Semi-monthly Survey Totals – To obtain an estimate of numbers of least tern and piping plover adults, breeding pairs, nests, chicks, and fledglings within the Program AHR throughout the 2020 nesting season, we summed numbers detected during semi-monthly river and sandpit surveys nearest 1 and 15 May, June, and July and 1 August.

RESULTS

SEMI-MONTHLY SURVEYS 2020

Semi-monthly River Surveys 2020 – Each of the semi-monthly river surveys between Lexington and Chapman, Nebraska during 2020 required 2–3 days to conduct. As some scheduled semi-monthly river surveys were not completed, the dates for which the highest counts of each species were observed on the river may not coincide with semi-monthly surveys on sandpits (Table 3 vs. Table 4). We observed the most least tern adults (21) and piping plover adults (12) foraging on the river during the 15 July river survey 2020 (Table 3). We observed no least terns or piping plovers nesting on the river during the 2020 river surveys. All least tern and piping plover adults and fledglings observed during semi-monthly river surveys in 2020 were either known (banded) or were presumed (near areas with sandpits that fledged chicks) to be associated with nearby sandpit nesting sites.

Semi-monthly Sandpit Surveys 2020 – A total of 16 sites were monitored during each of the semi-monthly survey periods. Each of the 7 semi-monthly sandpit surveys from outside the nesting area required 1 day to conduct in 2020, though some sites were surveyed on different dates. Similar to past years, most least tern and piping plover breeding pairs, nests, and chicks were observed on sandpit sites where management activities occurred prior to the nesting season. However, we did observe 6 least tern nests on the unmanaged Hooker Brothers-GI South East site this season. Three of the nests hatched and a total of 3 fledglings were observed on this site. We observed the most adult least terns (115) and the most adult piping plovers (48) during the 15 June sandpit survey (Table 4). Forty-eight adult piping plovers were also observed on the 1 July survey. The most least tern (81) and piping plover (30) breeding pairs were observed during the 15 June survey. Thirty piping plover breeding pairs were also observed during the 1 July survey. Across all the sandpit sites, the most observed nests occurred on 15 June for least terns (81) and on 1 June for piping plovers (19). The 1 July survey was when the most least tern chicks (80) and piping plover chicks (39) were observed.

Semi-monthly Survey Totals 2020 – Semi-monthly survey totals include both sandpit and river survey counts of adults, breeding pairs, nests, chicks, and fledglings observed during the 7 semi-monthly sandpit and river surveys and represent an estimate of the overall numbers present within Program AHR during 7 time periods in the 2020 nesting season (Table 5). No breeding pairs, nests, or chicks were observed on the river during 2020, thus total AHR counts are based on semi-monthly sandpit surveys. A total of 16 sandpit sites and the river were surveyed each semi-monthly survey period.

SEMI-MONTHLY SURVEYS 2001-2020

Semi-monthly River Surveys, 2001–2020: The 15 June and 1 July surveys were not completed in 2020, likely making the numbers presented here an underestimate of the total present on the central Platte river for 2020, especially for piping plovers, for which the 1 July survey is typically when the largest number of birds are observed. Even with this constraint, more piping plovers were observed on the river this season than last (Figure 4). The total number of adult least terns observed was somewhat lower than the total observed in 2019, as might be expected with the reduced number of surveys completed. However, based on the lower total of least terns observed

on sandpits compared to 2019, this number likely still would have been lower even if all surveys had been completed.

Semi-monthly Sandpit Surveys, 2001–2020: The total number across all semi-monthly surveys of least tern adults observed on sandpits within the Program AHR in 2020 was similar to totals observed over the past three years (Figure 5). The total of piping plover counts on sandpit sites during 2020 semi-monthly surveys were lower than totals observed over the past 10 years, other than 2018, which had a similar total. We observed the most adult least terns (115) and adult piping plovers (48) during semi-monthly sandpit surveys that occurred during the 15 June.

Semi-monthly Sandpit-River Surveys Combined, 2001–2020: We observed lower numbers of least tern and piping plover adults within the Program AHR in 2020 compared to 2019 (Figure 6); however, these are combined river and sandpit numbers, and some river survey visits were not completed, making it difficult to interpret these numbers. Least tern and piping plovers were observed foraging on the river, but no nesting was observed on-channel. All observed least tern and piping plover nests were located on off-channel sandpits.

Least tern chick on shoreline

Numbers of adult least terns and piping plovers observed during semi-monthly surveys of the Program AHR declined briefly after 2007 but have since rebounded. Numbers of least terns and piping plovers observed are variable from year to year, but there has been an overall upward trend in counts (Figure 7). Counts observed during 2020 were similar or higher than numbers observed prior to Program implementation. Program analyses indicated least tern and piping plover breeding pair counts from 2001-2020 increased with habitat availability (Figure 8). An increase in breeding pairs for both species was observed when the program began adding habitat in 2009. For every acre of habitat added 0.37 more least tern breeding pairs (bp) were present in the AHR (95% CI: 0.21 - 0.53 bp; $p < 0.001$). For piping plovers, every acre of habitat added led to 0.17 more breeding pairs present in the AHR (95% CI: 0.12 - 0.22 bp; $p<0.001$).

NEST AND CHICK MONITORING

METHODS:

In addition to semi-monthly surveys, we monitored all sites with active nests or broods on a semi-weekly basis throughout the nesting season. There were 16 sandpits monitored in 2020 (Table 2 and Figure 9). We attempted to observe nests and chicks twice per week until the nest or brood failed, or the chicks fledged. We conducted surveys of adults, nests, chicks, and fledglings from outside the nesting area. Program staff, technicians, and Program partners monitored nesting sites during 2020.

Outside Monitoring – Outside surveys were performed for at least 30 minutes during each site visit using binoculars and/or spotting scopes, at a distance that did not cause disturbance to nesting birds (usually >165 ft., but closer or farther as terrain dictated). Observations were conducted from

multiple vantage points to allow observation of as much of the site as possible. Nests and chicks were often located by observing adult birds. We recorded date, observation start and stop times, and the number of least tern and piping plover adults, nests, broods, chicks, and fledglings present during each semi-weekly site visit. When chicks or fledglings were observed, we estimated the date of hatching or fledging based on current and previous nest and chick observations. We estimated numbers of least tern and piping plover breeding pairs as previously described in Baasch *et al*. (2015) and summarized above.

Survival – We calculated daily and incubation-period nest survival rates using the RMARK package in the RStudio program (R Core Team 2017). We included nests located at sandpit sites that were monitored during 2020 by Program staff, technicians, and personnel from NPPD and the Crane Trust to determine survival rates. In past years, when on-channel nesting was observed, these nests were also included. Nest success was defined as any nest that hatched ≥1 chick. We considered the incubation period for least terns and piping plovers to be 21 and 28 days, respectively, from when nests were determined to have been initiated. When the fate of a nest was unknown, we assigned a "failed" status to the nest if the date of determination (date first observed inactive) was <21 days (least tern) or <28 days (piping plover) after the date the nest was initiated and we failed to observe chicks of appropriate age near the nest bowl. For example, if a piping plover nest was observed to be active and intact 12 days after it was initiated, and then was found to be empty (no eggs) 4 days later (16 days after it was initiated) with no sign of chicks of appropriate age in the area, we fated the nest at 14 days (midpoint of the 2 observation periods) and assigned a "failed" status to the nest as it likely did not hatch within 16 days of initiation. If, however, a piping plover nest with an unknown fate was last observed to be active 25 days after it was initiated, but then 4 days later (29 days after it was initiated) we observed an empty nest bowl, no sign of chicks of appropriate age in the area, but with appropriate evidence (including pipping on the previous visit, chick poop, pipping fragments, etc.) we assigned the fate of the nest on day 27 (midpoint of the 2 observation periods) as "successful". Our assumption was that, on average, we discarded survived and failed intervals in the same proportion they occurred in the data.

We also used the package RMARK in RStudio to determine daily and brooding-period survival rates for broods of chicks. As the exact date of hatching was occasionally unknown, we considered the brooding period for least tern and piping plover chicks to be 21 and 28 days from the date we first observed nestlings, respectively. A successful brood was defined as any brood with ≥1 chick that was observed fledged or that survived 21 days (least terns) or 28 days (piping plovers). Similar to nest survival methods, when the fate of a brood was unknown, we assigned the fate of the brood at the midpoint of when a brood was last observed active and first documented as an "unknown" status. We assigned a failed status to a brood if the date of fate determination was <21 or <28 days after we first observed least tern or piping plover chicks, respectively, and a successful status to the brood otherwise.

We used GIS to determined distances to predator perch, nearest waterline and elevation of each nest above the waterline. We also determined the amount of nesting habitat available at each site using GIS.

RESULTS:

Mortality: We observed no research-related mortality during 2020. One least tern nest (1.0%) and two piping plover nests (4.1%) were determined abandoned. This is comparable to previous years. Predation was attributed as the cause of at least 5 least tern nests (4.8% of total tern nests) and 8 piping plover nests (16.3% of total plover nests), as well as 3 least tern broods (4.1% of total least tern broods) and 1 piping plover brood (3.6% of total piping plover broods) during 2020. Overall predation was lower than last year, and losses were spread out over time as well as over sites. In 2019, predation was concentrated over a few sites and large-scale losses of broods and chicks happened around the same time on those sites. No nests or broods from either species were recorded as being lost to weather or flooding during 2020. This was much lower than 2019, when 18 nests and broods were lost to significant flooding and cold rainy weather. In 2020, 22 least tern (21.0%) and 11 piping plover (22.4%) nest failures were attributed to unknown causes and these were fated as failed-unknown as there was not enough evidence to assign a specific fate, Sixteen least tern broods (21.6%) and nine piping plover broods (32.1%) were also assigned a failed-unknown fate. These losses were also lower than the 87 failed unknown losses observed in 2019. One least tern nest was declared to have an unknown outcome as there was not enough evidence to determine if it hatched before failing. Because systematic inside monitoring has not been performed since 2016, determining nest fates has not been as precise as previous years when grid searching was performed. Predator cameras deployed on nests during the 2020 nesting season did assist in determining the fate of three nests. Overall, total losses of chicks and broods were lower than the previous season.

Newly hatched least tern chick potentially predated by toad. Toad may have died due to choking on chick.

Least Terns: Least tern nests were observed and monitored at 10 of the 16 sandpits monitored during 2020 (Table 2, Figure 9). Adults observed in Table 6 represents the total across all the sites, of the largest count of adults observed at each site on any one survey. Nests are calculated as the total number of nests observed across all the sites over the nesting season. Chick and fledgling counts are the total of the highest number of chicks or fledglings in the appropriate age categories that are associated with each unique nest. The first observation of a least tern nest occurred on 30 May 2020 and the last nest was first observed on 21 July 2020. The first observation of a least tern chick occurred on 10 June 2020, and the last nest known to hatch occurred on 7 August 2020. In 2020, at least 1 egg from 70% (74/105) of least tern nests hatched resulting in 160 chicks and an overall nest-success rate of 1.52 chicks/nest and 1.90 chicks/breeding pair (160 chicks/84 breeding pairs) during 2020 (Table 6).

Average daily survival rate of least tern nests over all monitored sites during 2020 was 0.9843 (range =0.9289-1.0000; Table 6 and Table 7). A significant difference in average daily nest survival was observed between sites [$\chi 2(7, N=105) = 16.565$; $p = 0.02$; Table 7]. Average survival rate over the 21-day incubation period over all the monitored sites during 2020 was 0.7167 (range = 0.2125–1.0000; Table 6 and 7). We observed the first least tern fledgling on 7 July 2020 and the last known least tern chick to fledge did so on 28 August

2020. Apparent fledge success at all sites monitored was 1.02 fledglings/nest (107 fledglings/105 nests) or 1.27 fledglings/breeding pair (107 fledglings/84 breeding pairs) (Table 6) with all nests occurring on sandpit sites during 2020. Average daily survival rates for least tern broods across all sites during 2020 was 0.9835 (range = 0.9687–1.0000; Table 6 and Table 8). There was no significant difference in average daily brood survival between sites [$\chi 2(6, N=74) = 6.682$; $p = 0.35$; Table 8]. Average brooding-period survival rate across all sites was 0.7047 (range = 0.5131–1.0000; Table 6 and Table 8). Significant site differences are difficult to interpret given high variability across sites in initial reproductive investment. Significant differences can be attributed to the few sites (Cottonwood Ranch and TrustWildrose- East) that had very few nests, of which all were successful. For example, this season, Trust Wildrose East only had one least tern nest, which did fledge a chick, giving it a 1.0 (standard error = 0) for a survival.

We tested for an effect of ownership (i.e., Program or other) on nest and brood survival rates during 2020. Least tern incubation period survival was higher at Program owned and/or managed nesting areas than non-Program sites and averaged 0.7824 and 0.5515 respectively (Table 9). This difference was significant [$\chi 2(1, N=105) = 4.528$; $p = 0.03$]. Brooding period survival rates were similar at Program owned and/or managed nesting areas and non-Program sites and averaged 0.7112 and 0.6777 (Table 10), respectively. This difference was not significant [$\chi 2(1, N=74) = 0.054$; $p = 0.82$].

Piping Plovers: Piping plover nests were observed at 8 of 16 sandpits monitored during 2020 (Table 2; Figure 9). Adults observed in Table 11 represents the total across all the sites, of the largest count of adults observed at each site on any one survey. Nests are calculated as the total number of nests observed across all the sites over the nesting season. Chick and fledgling counts are the total of the highest number of chicks or fledglings in the appropriate age categories that are associated with each unique nest. The first observation of a piping plover nest was made on 5 May 2020 and the last nest was first observed on 2 July 2020. The first observation of a piping plover chick occurred on 30 May 2020 and the last successful nest was observed as hatched on 20 August 2020. At least one egg from 57% (28/49) of piping plover nests hatched, which resulted in 98 chicks and an overall hatch ratio of 2.00 chicks/nest or 3.06 chicks/breeding pair (98 chicks/32 breeding pairs) during 2020 (Table11).

Piping plover adult on nest.

Piping plover daily nest survival rate across all sites during 2020 was 0.9761 (range = 0.9519–1.0000; Table 11 and Table 12) with no significant differences observed between sites [$\chi 2(6, N=49) = 4.494$; $p=0.61$]. Average incubation-period survival rate was 0.5083 (range = 0.2511–1.0000; Table 11 and Table 12). We first observed a piping plover fledgling on 28 June 2020 and the last known piping plover chick to fledge did so on 14 August 2020. We observed an apparent nest-based fledging rate of 0.80 (39 fledglings/49 nests) and a pair-based fledging rate of 1.22 (39

fledglings/32 breeding pairs) at all sites monitored during 2020 (Table 11). Average daily survival rates for piping plover broods across all sites during 2020 was 0.9810 (range = 0.5000–1.000; Table 11 and Table 13). A significant difference was observed between sites [$\chi 2(4, N=28) = 13.780$; $p= 0.008$; Table 13]. Average brooding-period survival rate across all sites was 0.5848 (range = 0.0000–1.0000). Significant site differences are once again difficult to interpret given high variability across sites in initial reproductive investment. Those sites with more than one piping plover nest were all very similar in terms of daily brood survival rates. Alternatively, Cottonwood Ranch and Newark West each had only one piping plover nest in 2020, which each successfully fledged a chick (giving a perfect survival rate with no variability). Leaman East also had only a single plover nest in 2020, but did not successfully fledge, resulting in a daily brood survival rate of 0.50 (the lowest among all sites monitored in 2020) (Table 13).

We tested for an effect of ownership (i.e., Program or other) on nest and brood survival rates during 2020. Piping plover nest survival rates and incubation period survival rates were similar on Program sites to that of non-Program sites (Table 14). Daily nest survival rates were 0.9756 for the Program and 0.9775 for non-Program sites. Incubation period survival rates were 0.5015 and 0.5290 for Program and non-Program site, respectively. Although average non-Program survival rates were higher, this difference was not significant [$\chi 2(1, N=49) = 0.025$; $p=0.87$; Table 14]. The rates for Program versus non-Program daily brood survival were 0.9787 and 0.9868 and brooding period survival rates 0.0.5471 and 0.6893, respectively (Table 15). No significant difference in piping plover brood survival was observed between Program and non-Program sites [$\chi 2(1, N=28) = 0.409$; $p=0.52$].

Breeding Pair Counts:

Two piping plover adults that nested on Lexington sandpit.

Least tern breeding pair counts peaked at 84 pairs (Table 6, 16 and 18) on 19 June 2020. Piping plover breeding pair counts peaked at 32 pairs (Table 11, 16 and 18) on 12 June 2020. Similar to nest and adult counts, least tern breeding pair counts have increased steadily since 2001 (Figure 10). Piping plover breeding pair counts increased slightly from 2001−2007, declined during 2008 and 2009, and have since increased (Figure 11). With 2020 counts lower than those of 2019, we also observed a decrease in least tern and piping plover breeding pairs in 2020. However, tern and plover numbers are still higher than counts observed during the years prior to the Program implementation.

Species Response to Habitat Creation and Maintenance:

Water flowing over the Kearney diversion.

The total number of nests and breeding pairs has increased for both species during the First Increment of the Program (Figures 11-12 and Table 16). In 2020, 84 least tern and 32 piping plover breeding pairs were observed in the AHR (Figure 8 and Table 16). Though some nesting has occurred on riverine sandbars in the past, OCSW sites have provided the most consistently available nesting habitat for both species (Table 1). The limited amount of on-channel nesting observed at the beginning of the First Increment declined even further as on- channel habitat was lost during several high flow events. As a result, most of the nesting in the AHR during the First Increment of the Program has occurred on managed off- channel habitats (Table 17 vs. Table 18, Figures 13-14). The number of breeding pairs has generally increased over the course of the First Increment as the Program has constructed additional OCSW habitats (Figure 8). Overall, the Program has observed a positive species response to off-channel habitat construction and maintenance. There has been an upward trend in counts for breeding pairs, nest counts, and fledge counts (Table 18); this is likely in part due to the increasing habitat availability. However, there has been a downward trend in the proportion of successful chicks for both species (Figures 15 and 16). Lower fledge ratios in 2019 led to concern over productivity. Though least tern fledge ratios have held steady over the life of the Program, last year was the lowest they have been since before 2007 (Figure 17). Piping plover fledge ratios peaked in 2012, which was around the time the Program stopped adding new nesting sites, but they have seen a gradual decline since then. Fledge ratios in 2018 and 2019 were particularly low (Figure 17). Predation is being investigated as a possible contributor to low fledge ratios in 2018 and 2019. Though breeding pairs and nest counts were lower this year than in 2019 (Figures 10-12), fledge ratios increased in 2020 for both species (Figure 17). Those birds that did choose to nest within the AHR were more successful this year than last year.

RESEARCH

In addition to implementation of the Program's surveillance monitoring protocol, conservation monitoring and directed research was conducted during the First Increment to provide data to evaluate the Program's management objectives and priority hypotheses. Design and implementation of research activities was guided by the ED Office and the TAC, reviewed by the Program's Independent Scientific Advisory Committee (ISAC) and ultimately approved by the Program's Governance Committee (GC).

FORAGING HABITS STUDY

The first directed research project related to least terns and piping plovers on the central Platte River began in 2009 with the implementation of a Foraging Habits Study. A contract to conduct this study over two field seasons (2009−2010) was awarded to the USGS-NPWRC. The research was jointly funded by the Program and the USGS-NPWRC. In 2009-2010, 23 least terns and 16 piping plovers were radiomarked and monitored using fixed telemetry dataloggers. Terns were more often located outside their nesting site, whereas plovers were more likely to be logged within

their nesting site. Terns, the more mobile of the two species, relied more heavily on fish resources obtained in the nearby Platte River. Plovers were more reliant upon foraging along their nesting sandpit shorelines or interior substrates. Detailed results of the Foraging Habits Study were published by Sherfy et al. in 2012.

MIGRATION AND DISPERSAL STUDY

In 2011, the Program and the USGS entered into an agreement for the USGS to conduct a study to evaluate Habitat Colonization and Productivity of Least Terns and Piping Plovers Nesting on Central Platte River sandpits and sandbars. The research was jointly funded by the Program and the USGS-NPWRC. This study was designed to address three specific objectives contributing to the understanding of dispersal patterns and habitat use by least terns and piping plovers:

1. **Dispersal**
   Quantify dispersal of adults between units of nesting habitat on the central Platte River among years.
2. **Colonization**
   Quantify colonization rate of newly constructed or managed nesting habitat by local versus immigrant adults.
3. **Renesting**
   Quantify frequency and location of renesting attempts by adults with failed nests.

Adult and Chick Band Observations – As part of Program-funded research implemented by USGS field crews, 152 adult plus 685 least tern chicks and 85 adult plus 591 piping plover chicks were banded along the central Platte River between 2009 and 2016 (Table 19).

Checking band movement on a newly banded piping plover adult.

From 2010 to 2016, USGS personnel were responsible for conducting resighting of banded birds. In 2017, PRRIP personnel began implementing band resighting efforts and continued band resighting until 2020. Band resighting was conducted at most off-channel nesting sites, usually once, sometimes twice per week. Band resighting was performed by placing a small handheld video camera on a mini tripod that was positioned approximately 24 inches away from the nest, buried in the substrate, and facing away from the sun. This was done to minimize disturbance to the birds while maintaining video quality. Nest information recorded at each placement included: date, site, nest ID, nest marker ID, species, UTMs, river mile, number of eggs, and a photo of the nest with the nest marker was taken. Camera setup and data collection took 5 minutes or less. Once the setup was complete, the cameras were set to record for 30 minutes and the biologist left the nesting colony to ensure adults would return to their nests. Once 30 minutes had passed, the biologist retrieved the band resighting cameras. Cameras were removed earlier as needed, based on the birds' observed reaction to camera presence. The number of adults and band combinations were recorded and entered into an internal band resighting database. Screenshots of the adults were taken and saved with their nest ID for review purposes.

During the four years band resighting was conducted by Program staff, a total of 276 least tern adults were observed using the protocol described above; 181 of these were banded adults. For piping plovers, a total of 157 adults were observed and 87 of these were banded adults. The proportion of observed least tern adults with bands was 65.6% and the proportion of observed piping plover adults with bands was 55.4%. Only 0.6% of banded least tern adults and 17.2% of banded piping plover adults were not banded within the AHR. Band resighting in 2020 resulted in a total of 12 least terns and 10 piping plover bands being recorded (Tables 20-21). Of the banded birds observed in 2020, 12 (100%) least terns and 9 (90%) piping plovers were banded within the AHR.

After twelve years (2009-2020) of band resighting efforts on the central Platte River, we have compiled valuable information regarding site and habitat (sandpit or riverine) fidelity and philopatry, wintering ground locations for central Platte River piping plovers, survival and recruitment, re-nesting probabilities, as well as the impact of human activity and habitat disturbance. The Program has observed the tendency of adult least terns and piping plovers to return to nest at the site where they were banded or at nearby sites within the AHR on the central Platte River. We observed least tern and piping plover fledglings at non-natal sites within the AHR late in the nesting season on multiple occasions. Band resighting data were analyzed by USGS to produce a report summarizing least tern and piping plover demographics and movements in the central Platte River Valley (Roche *et al*. 2016). The report compiles data from 2009-2014 to report findings on reproductive success, dispersal, adult survival and recruitment, colonization, and renesting specific to least terns and piping plovers in our study area. They found that for both species, the age of the site played an important factor in use. The older the site, the higher the use by the birds. Least terns were more likely to use newly created habitat than piping plovers, but among their species young piping plovers were more likely to use newly created habitat than the more experienced adults. There was low natal nest site fidelity in least terns, but this may have been due to low observations and resighting difficulty with this species. Even adult site fidelity was highly variable between years for least terns. For piping plovers there was no natal site fidelity observed, though there were instances of plovers hatched in the area coming back to nest in the central Platte River Valley. For breeding adults, there was high site fidelity observed between years (87% of documented attempts). Dispersal for piping plovers was dependent on habitat availability and reproductive success; when these were high, site fidelity was high. Dispersal distance was affected by age, as typically juveniles dispersed farther. Renesting was not documented in any of the banded least terns. Piping plover renesting was observed for 17% of the 75 uniquely marked individuals and 14% of the 111 nests initiated by at least 1 banded adult. Most renesting attempts took place on the same site as the first failed nesting attempt.

Rose *et al*. (unpublished data), incorporating band resighting data from the central Platte into a regional analysis, looked at the three objectives in relation to the overall Great Plains piping plover population. Though some demographic characteristics are specific to certain sub-populations occupying different areas and habitats, connectivity has been found to be high between sub-populations of piping plovers in the Northern Great Plains with both immigration and emigration being observed between areas. Dispersal, both natal and adult, was found to be highly affected by habitat availability and reproductive success and was also driven by population density. As habitat availability increased, piping plovers were more likely to disperse, but over shorter distances. They tended to nest in areas with higher densities, as they used

conspecifics to determine habitat quality. The dispersal distance was affected not only by habitat availability, but also mate fidelity and age. Mate fidelity lowered distance of dispersal, and birds that were making their first breeding attempt dispersed higher distances. Renesting was affected by habitat availability and reproductive success, but also depended on how late losses were incurred during the nesting season, effort invested, stage of nest or chicks when they failed, cause of failure, and how long the adult had been breeding in the area. Overall rates of renesting were low, with 16% of reproductive failures renesting. Of these, 25% were renests after a failure in the incubation stage, and 1.2% were second attempts after a failure in the brood stage. Not only were the renesting rates lower, but the success rate was lower as well. Only 21% of renest attempts hatched, compared to 51% of first attempt nests. Of those that hatched only 5% fledged at least one chick, while 24% of first attempt nests fledged at least one chick. Renest propensity and success rate declined as the season progressed. Failure due to predation and failure in the brood stage both decreased the chance of renesting.

NESTING HABITAT SELECTION STUDY

Over the past eleven years we have collected habitat measures believed to influence nest site selection, nest placement and productivity. We used GIS and LiDAR to determine elevation of each nest above the waterline and to determine linear distances to potential predator perches and nearest waterline for all nests. Information provided by predator monitoring cameras in 2017 and 2018, indicated that permanent fence lines also serve as potential predator perches. In 2019, fencing was included as a potential perch in analyses, though it was not included in previous years. Electric wires were added to the top of permanent fences at all Program managed sites prior to the 2020 nesting season to prevent perching in the future. Fences with electric wires top wires were not included as possible predator perches in the 2020 analysis.

The EDO used resource selection functions and 15 years of data to assess the influence physical site attributes and inter- and intra-specific interactions have on nest site selection by least terns and piping plovers on off-channel nesting sites (Baasch *et al*. 2017). We found nest site selection by least terns and piping plovers was influenced by factors the Program can manage such as distance to predator perch and elevation above waterline as well as factors that cannot be managed. The relative probability of use for both species was maximized when distance to the nearest predator perch was ≥150 m and elevation above the waterline was ≥3 m. Probability of use for nesting by least terns increased as distance to water increased whereas the probability of use by piping plovers was maximized when distance to water was ~50 m. In addition, we found piping plovers avoided nesting near each other, whereas colonial least terns selected nest sites near those of conspecifics. Our results suggest that important features of constructed, off-channel nesting sites for both species should include no potential predator perches within 150 m of nesting habitat and nesting areas at least 3 m above the waterline. Efficient site designs for least terns would be circular, maximizing the area of nesting habitat away from the shoreline whereas an effective site design for piping plovers would be more linear, maximizing the area of nesting habitat near the waterline. An efficient site design for both species would be lobate, incorporating centralized nesting habitat for least terns and increased access to foraging areas for nesting and brood-rearing piping plovers.

Average off-channel least tern and piping plover nest elevations above water, distances to edge of water, and distances to predator perch by site during 2020 will be presented as an Addendum for review and approval pending receipt of validated 2020 LIDAR and accompanying analyses. Tables 22 and 23 serve as placeholders until such time as these data can be provided.

OFF-CHANNEL NEST AND BROOD SURVIVAL

The Program and its partners have invested substantial resources in creating and managing off-channel nesting habitat for least terns and piping plovers along the central Platte River. Among other things, management activities implemented at nesting sites to increase nest and brood survival included tree removal, predator trapping, construction of a water barrier surrounding the nesting area and installation of predator fences. We used 15 years of data at off-channel sites along the central Platte River to assess the influence of several biotic and abiotic factors on the survival of least tern and piping plover nests and broods (Farrell *et al*. 2018). We found productivity of least terns and piping plovers was reduced during both the nesting and brood rearing stage primarily by climactic factors rather than factors the Program can manage. At that point, we concluded that habitat management activities implemented at off-channel sites to date were sufficient for maintaining high levels of productivity for least terns and piping plovers along the central Platte River. Recent 2018-2019 reductions in tern and plover productivity have increased uncertainties around the impact of predation on tern and plover productivity at off-channel sites which led to the implementation of a pilot study testing additional predator management actions at a limited number of Program managed nesting sites as further described below.

INSIDE VERSUS OUTSIDE MONITORING

The Program implemented four years of season-long monitoring from within (inside) and outside the nesting colonies at off-channel least tern and piping plover nesting sites along the central Platte River to compare these monitoring techniques and their influence on productivity estimates (Farrell and Baasch in press). We found inside monitoring efforts resulted in higher detection of nests and early-development chicks. Excluding these from nest and chick survival analyses would result in estimates of nest and chick survival rates that are higher for outside monitoring crews. However, more chicks ≥15 days old were observed by outside monitoring crews. While fledgling counts between methods were similar for piping plovers, more least tern fledglings were observed from outside the nesting colony which, when combined with lower breeding pair counts, would result in higher productivity measures such as fledge ratios. The most appropriate method of survey appears to depend on the objectives of the study and availability of resources. If resources are limited, monitoring from outside the colony can result in reasonable estimates of abundance and productivity measures, provided a majority of the nesting area can be observed from outside the nesting colony and an appropriate estimate of the proportion of nests and breeding pairs that are not observed is available.

PREDATOR MANAGEMENT AND MONITORING

Prevention of predation by avian and terrestrial predators was identified as an important objective for increasing productivity of least terns and piping plovers. To do this, the Program implements several management actions to reduce the risk of predation for least terns and piping plovers at off-channel nesting sites. Off-channel nesting sites are peninsulas surrounded by water to provide a ≥100 feet wide barrier to terrestrial predators. Land connections to the nesting site are protected by installing permanent and temporary electrified fences at the entrance of each nesting area. Non-electrified fence-panel wings are positioned on the ends of the electrified fence and extend 1-2 meters into the water to deter terrestrial predators from swimming from the mainland to the nesting peninsula. All trees within ≥150 m radius of the nesting site are removed, avian spikes

are placed on all potential, non-removable perches and the Program actively traps and removes terrestrial predators around the periphery of the site.

TRAPPING DATA

The 2020 season marked the 9th year of terrestrial predator trapping and lethal removal on Program-owned off-channel nesting sites. These traps included live box traps, foothold traps, as well as snares. Trapping data demonstrated annual as well as spatial variability in predator presence at tern and plover off-channel nesting sites (Figure 18). Predators trapped included badger, bobcat, coyote, red-fox, opossum, raccoon, skunk, weasel, and woodchuck.

Despite these preventative measures, predation still occurs at off-channel nesting sites. In an effort to further decrease these pressures, additional predator management and monitoring strategies were implemented. These include predator monitoring with remote camera studies, predator deterrent lights, turtle exclusion fencing, turtle trapping, and track surveys.

PREDATOR CAMERA STUDIES

2017-2018 Panel Wing Cameras

During 2017 and 2018, predator panel wing cameras were installed at Dyer, Broadfoot South-Kearney, and Leaman East to determine whether the predator panel wing system (predator panel wings and moat combined) was effective at deterring mammalian predators from accessing off-channel nesting sites. A wide-angle camera system (capturing images of the gated entrance and attached panel wings from both outside and inside) allowed us to photograph potential predators as they approached and their response to the barrier system in place. The cameras allowed us to identify the potential mammalian predators that were approaching and those that were able to breach the panel wing system. The predator panel wing system appeared to be effective at deterring predators from entering the nesting site via the peninsula's land bridge. The number of approaches registered per 100 days of sampling effort at Broadfoot South-Kearney, Dyer, and Leaman in 2017 and 2018 were higher than the number of breaches where predators were registered inside the nesting site (Figure 19). This difference just fell shy of statistical significance according to a Wilcoxon signed rank test ($p = 0.0625$, $\alpha = 0.05$). Although some breaches occurred (9% of all registers), 91% of images registered by the panel wing camera system were of potential predators approaching the barrier from the outside. Based on total registers (approaches and breaches combined) for both years, the top three most abundant mammalian predators registered by this system for each site were as follows: raccoon at Leaman East; coyote, raccoon, and badger at Dyer; and raccoon, fox, and badger at Broadfoot South-Kearney.

Images captured by panel wing cameras.

2017-2018 Site-level Nesting Peninsula Cameras

Mammalian and avian predator presence and possible predation events at off-channel nesting sites were also studied at a site-level covering nesting peninsulas at Blue Hole, Broadfoot South-Kearney, Dyer, Leaman East, and Lexington during 2017 and 2018. This research was conducted by installing predator monitoring cameras along the edges of the peninsulas facing inward, to document predator presence. The cameras were programed to take 5-minute interval time-lapse and motion triggered photos. No actual predation events were documented with this study design, but a great deal of predator presence on the off-channel nesting sites was registered. There was a total of 251 (73%) avian and 95 (27%) mammalian predators registered on site cameras. The top four most abundant avian predators were great-horned owl, seagull, sub-adult bald eagle, and great blue heron (Figure 20). The top four most abundant mammalian predators were unknown terrestrial mammal, coyote, skunk, and raccoon (Figure 20).

2019-2020 Nest-level Cameras

Predation was hypothesized to have reduced least tern and piping plover productivity in recent years due to nesting sites being established for several years, allowing local predators to gain site knowledge and effectively predate least tern and piping plover eggs and chicks at higher rates than previously experienced along the central Platte River. To document predator presence at the nest level, remote cameras were installed at identified tern and plover nests. There were five primary research objectives for this study: 1) identify predators present at nests 2) identify the cause of nest/early brood failures, 3) quantify the impact of predator presence on least tern and piping plover productivity, 4) understand which predators pose the highest risks to tern and plover productivity, and 5) determine how the risk of predation varies by nest site location (within and across sites). The number of cameras at each site varied depending on the number of nests identified by outside monitoring protocols. The 2020 nesting season was the second year of predator identification research at the nest level for least terns and piping plovers at off-channel nesting sites. The sites included in this study in 2020 were Broadfoot South-Kearney, Leaman East, Newark East and Newark West. A total of 46 cameras were available and based on average number of nests observed at each site from 2016-2019, we estimated to have 16 cameras available for Broadfoot South-Kearney, 4 for Leaman, 15 for Newark East, and 11 for Newark West. Remote cameras were placed 7-10 feet from the nest to capture any predator activity near or directly at the nest while minimizing disturbance to nesting adults. The remote cameras were positioned on 3-foot-tall metal posts with avian spikes placed on top to prevent avian predator perching. Remote cameras were visited during each tern and plover monitoring survey for band resighting and other camera maintenance activities. A datasheet was used to document the install date, subsequent camera visitations, and predator evidence. Both avian and mammalian predatory species were documented by nest monitoring cameras (Figure 21). Nest cameras documented one predation event by a red fox consuming eggs at a nest in 2019. In 2020 there were three documented predation events by great horned owls consuming eggs at nests.

Great horned owl at nest.

In general, predation by either mammalian or avian predators have been determined to be significant factors limiting reproductive success and have become a focus of management practices for least terns and piping plovers (Catlin *et al*. 2011, Anteau *et al*. 2012, Saunders *et al*. 2017, Andes *et al*. 2019). One major component for successful management of endangered species is predator identity. Remote cameras are helpful at identifying potential nest predators (McQuillen and Brewer 2000, Keedwell and Sanders 2002, Sanders and Maloney 2002, Stake and Cimprich 2003, Richardson *et al*. 2009) and nest predation events (Cutler and Swann 1999). For these reasons, the Program continues to conduct predator research to help us better understand which predators are present at site and nest levels and if the Program needs to adjust current management techniques and/or implement additional management techniques to maintain/increase least tern and piping plover productivity. Over the past four years, the Program has gained information about which predator species are present at off-channel nesting sites (Figure 22) and will continue to use that information to make informed decisions about least tern and piping plover management.

2020 ADDITIONAL PREDATOR MANAGEMENT PILOT STUDIES

In 2020 the Program began a pilot year for the following additional predator management strategies. This season focused on identifying tern and plover interactions with and possible avoidance of the predator deterrent lights and turtle fence; as well as the overall feasibility of implementing these strategies. In the long term, we will attempt to determine the efficacy of these methods in decreasing predator activities on the sites, and whether this leads to an increase in tern and plover productivity. As this was a pilot year for most of these studies, more research and analysis of the data will need to be performed before results can be finalized. These data will help inform management actions moving forward into the future.

PREDATOR DETERRENT LIGHTS

Deterrent light sets were placed on Blue Hole and Newark West at a density of one light set per five acres of suitable nesting habitat. Sets consisted of both random pattern lights (Foxlights Solar Night Predator Deterrent, Foxlights International PTY LTD, Bexley North, Australia) and motion triggered lights (Luposwiten Solar Motion Sensor Lights, Luposwiten Direct, Shenzhen, Guangdong). Each was set on 8 ft tall posts with avian spikes installed on top of the lights to prevent them from being used as predator perches. The set of lights at Blue Hole consisted of 3 motion sensor lights and 3 random pattern lights (Figure 23). Newark West had 2 motion sensor lights and 2 random pattern lights (Figure 24). Of the 15 tern and plover nests monitored at Blue Hole in 2020, only 2 losses were attributed to predation, both at the western-most end of the site, furthest from the 3 sets of lights. Of the 10 tern and plover nests monitored at Newark West, no losses were attributed to predation. Based on outside observations of the birds' interactions with the lights, nesting location, and number of nests at each site, there did not appear to be any avoidance of the deterrent lights by least terns or piping plovers. We also did not interpret the single failed nest on the southern peninsula of Newark West to be indicative of avoidance or harm due to the lights, as it is typical to have very few nests on the southern peninsula on this site. As 2020 was a pilot study to determine the feasibility of this potential management action in reducing losses due to predation, the data obtained from 2020 will be integrated into a larger data set as the study continues to evaluate the benefits of predator deterrent lights in terms of improving tern and plover productivity.

TURTLE FENCE

Some of the managed least tern and piping plover off-channel nesting sites are also ideal nesting areas for spiny softshell turtles (*Apalone spinifera)* and smooth softshell turtles (*Apalone mutica*). In previous years, researchers observed high use of Program managed off-channel nesting sites by softshell turtles, as well as several predated turtle nests on at least four of the off-channel sites. It was hypothesized that turtle nests may be acting as an additional attractant to predators. Putting up an exclusion fence at the shoreline may serve to reduce the number of turtles that lay eggs on the site, lower predator attraction to those eggs, and serve as a physical barrier to predators that do manage to cross the water barrier.

Skunk predating softshell turtle nest on site.

In 2020, partial turtle exclusion fence was deployed on two sites. Each section of fence consisted of two types of fencing: a 4-ft-high wood slat snow fence with 2-inch slat spacing, and a 4-ft metal woven wire fence with 4x4 inch openings. The first site was Broadfoot South-Kearney, where the primary goal was to test bird interactions and possible aversion to the fence, but turtle interactions were also recorded. To test these interactions, fence segments of approximately 325 linear feet were placed on the north and south shores of an area that had typically high nesting and foraging in previous years. Each segment consisted of equal lengths of both wood slat fence and metal woven wire fence as illustrated in Figure 25. An electrified top wire was run along the top of the fence to deter avian predator perching. Interactions with the fence by both birds and turtles were recorded by outside observers, track monitoring, and cameras deployed on site.

Woven wire and wood slat fence deployed on north shore of Broadfoot South-Kearney. Top wire had not been installed yet.

Blue Hole was the second site for which turtle fencing was deployed. As this site is connected to the river and typically sees the most turtle activity, it was selected to focus on turtle interactions and the effectiveness of the fence in deterring turtle presence and nesting. Only one section of fence, consisting of both wood slat and woven wire fence, was deployed and it was placed on the southern shore, which is open to the river (Figure 23). This section was selected based on high turtle nesting in this area. Just as with Broadfoot South-Kearney, the fence also had an electrified top wire to prevent it from becoming an avian predator perch. There was one difference between sites in fence design. The Blue Hole section of fence also included two

Funnel trap constructed with wood slat fence on east end of Blue Hole turtle exclusion fence.

funnel traps that were placed on the east and west ends. Traps are described further in the turtle mark and recapture section below. Effectiveness at excluding turtles from the nesting site was monitored through captures at the funnel traps on the fence ends, visual turtle evidence (tracks and fence breaches), and registers of turtles on site cameras. Possible bird interactions and avoidance were also recorded by outside observers, track monitoring, and cameras deployed on site.

No avoidance by least terns and piping plovers was recorded at either site; and based on behavior, neither type of fence acted as a barrier for utilization of the shoreline by either terns or plovers. Both species nested, loafed, foraged near, and walked through each type of fence. Chicks of both species were also observed using the wood slat fencing as either shelter or shade. Nest locations and nest fates for both species at both sites can be seen in relation to fence placement in Figures 23 and 25. Nesting pattern and total nest numbers were similar to previous years. As 2020 was a pilot study to determine the feasibility of this potential management action in excluding turtles and reducing tern and plover losses due to predation, the data obtained from 2020 will be integrated into a larger data set as the study continues to evaluate the benefits of fencing in terms of improving tern and plover productivity.

TURTLE TRAPPING WITH MARK AND RECAPTURE

In 2020 we initiated a pilot mark and recapture study for softshell turtles to 1) test our ability to effectively capture softshell turtles, 2) estimate site-level softshell turtle population size, and 3) obtain information about softshell turtle utilization of tern and plover sites as nesting areas. Turtle trapping occurred from early May to mid-September. It was implemented at Dyer, Cottonwood Ranch OCSW, Blue Hole, and Broadfoot South-Kearney; all locations where softshells have been observed basking on nesting site shorelines. Dyer is cut off from the river and is approximately 850 ft from the river at the shortest distance (Figure 26). Cottonwood Ranch is also cut off from the river and is located approximately 1180 ft off the river (Figure 27). Blue Hole is connected to the river on its south shoreline (Figure 28). The shortest distance from the main river channel to the sandpit's shoreline is 260 ft. Broadfoot South-Kearney is located adjacent to the river and separated by a narrow berm (Figure 29). The approximate distance from interior shoreline to river is 460 ft.

Hoop net trap.

All traps were placed on the outer shore of the sandpit so that the bait in the traps would not attract predators onto the site. The additional funnel traps that were placed on the ends of the turtle exclusion fence at Blue Hole were not baited. Traps were placed in shallow water with the top of the traps placed above water so there was room for captured turtles to breath. The two funnel traps were attached to the east and west end of the turtle fence at Blue Hole. Wood slat fence was used

Adult softshell turtle being weighed.

to form a V-shape to funnel turtles that were following the fence into the traps. We used baited hoop nets, that were 3ft x 6ft with 2 -inch mesh. As terrain and habitat allowed, traps were spaced at a density of about one trap per 1400 ft of suitable nesting habitat shoreline. Four traps were deployed at Dyer, Cottonwood Ranch and Broadfoot South-Kearney. Blue Hole had four hoop nets and two additional funnel trap hoop nets. Broadfoot South-Kearney had an additional constraint on trap placement as active mining occurred on the northern shore of the site. Trap placement for each site can be viewed in Figures 26-29.

Trapping began in May at Dyer and Blue Hole, and these sites were trapped simultaneously on the same trap cycle. Cottonwood Ranch and Broadfoot South-Kearney were added in July and trapped simultaneously on the same trap cycle. Thus, traps were set at 2 of the 4 sites during each trapping cycle. Trapping cycles lasted 4 consecutive nights when traps were left open, checked twice daily, and rebaited every 1 to 2 days with fresh bait. Bait was placed in a Promar bait cage that allowed the scent to travel but prevented the bait from being depleted by captured turtles. Upon completion of a 4-night trapping cycle at the initial 2 sites, a trapping cycle began at the other 2 sites. To prevent habituation to traps, two weeks without trapping was maintained between trapping cycles at each site. Sample effort allocated at each site is included in Table 24.

All captured turtles were identified by species, weighed, measured, and sexed. If the turtle was identified as either a spiny or smooth softshell, they were tagged with a Monel tag and given a temporary mark with a non-toxic paint stick that was safe for animals. The tags were placed on the back of the carapace by punching a hole with tagging pliers and placing the marked Monel tag in place. Two sizes of tags were used to accommodate a range of turtle sizes. Immature turtles were not marked with a Monel tag. While being handled a damp cloth was placed over the turtle's heads to reduce stress and keep them calm. All turtles were released at the site of capture.

Metal Monel tag on a recaptured softshell turtle.

All softshell turtles captured were spiny softshell turtles. At Dyer there were 7 total captures of target species, and 0 recaptures of these individuals (Table 24). Blue Hole had 74 total captures and 16 recaptures. Cottonwood Ranch had 23 total captures and 13 recaptures. Total spiny softshell turtles captured at Broadfoot South-Kearney were 10, with just 1 recapture. Of the total capture and recapture events of spiny softshell turtles, 90 were females and 24 were males. Other species of turtle captured included common snapping turtles (*Chelydra serpentina*), painted turtles (*Chrysemys picta*), and red-eared sliders (*Trachemys scripta elegans*).

Captured common snapping turtle.

One bycatch did occur in the form of one great blue heron, which was released without injury at the trap location. There was only one incidence of trap related mortality. One male spiny softshell was found dead in the net. Other turtles in the

net at this time included 1 common snapping turtle, 4 painted turtles, and 1 other spiny softshell turtle. The softshell turtle had sustained injuries on its back-left leg, top of the carapace, and was missing part of the back-right leg and front left foot. The injuries and death of the softshell was attributed to being trapped together with the snapping turtle.

As a pilot study in 2020, we are currently evaluating the benefits of continuing this research to help us understand turtle populations, movement, our ability to manage their presence on our nesting sites in the future, and the benefits this management effort would provide in terms of tern and plover productivity.

TRACK SURVEYS

The final additional monitoring strategy that was implemented as a pilot study in 2020 was track surveys. As part of the pilot year, these surveys took place at each site that had additional predator management implemented (predator deterrent lights, turtle fencing, and turtle mark and recapture): Blue Hole, Broadfoot South-Kearney, Cottonwood Ranch, Dyer, and Newark West. They were conducted once a week along the entire shoreline of the managed sandpit and along the turtle exclusion fences. The purpose of these track surveys was to help record presence, movement, behavior, and density of predators and turtles. Researchers scanned for tracks or other signs within 15 ft of the waterline. Things surveyed for included scat, scrapes or digging, breaches of the fence, turtle nests and slides, and any other pertinent evidence. Each set of tracks was documented, a GPS point was taken, and a photograph was included as necessary. As an additional means of documenting predator presence on nesting sites, systematic track surveys will continue. Data obtained from track surveys will be combined with camera monitoring and predator trapping to survey the predator community and quantify impacts on tern and plover productivity.

Tracks documented on track surveys. Turtle tracks (left) and otter tracks (right).

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TABLES

Table 1. On- and off-channel nesting habitat in the Associated Habitat Reach by year, 2007−2020.

	On-Channel Habitat (ac)			Off-Channel Habitat (ac)		
Year	PRRIP	Others	Total	PRRIP	Others	Total
2007	0	24	24	0	48	48
2008	0	21	21	0	48	48
2009	0	15	15	0	48	48
2010	0	5	5	32	48	80
2011	0	5	5	60	48	108
2012	0	0	0	72	48	120
2013	55	0	55	72	48	120
2014	19	0	19	80	48	128
2015	47	0	47	90	48	138
2016	4	0	4	87	51	138
2017	0	0	0	99	61	160
2018	0	0	0	109	83	192
2019	0	0	0	94	84	178
2020	0	0	0	109	100	209
Average	**11.4**	**6.4**	**17.7**	**64.6**	**57.9**	**122.5**

Table 2. Site-specific numbers of adults, nests, chicks, and fledglings observed while monitoring sandpits for least tern and piping plover reproduction during 2020. Chick and fledgling counts represent numbers documented as being produced from each site. See the Management Section of this report for a detailed description of management actions taken at each site. Site numbers correspond with Figure 3.

Site #/Name	Management[A]	Surveys	Survey Time (hr)	Least Terns								Piping Plovers							
				AHR Peak Breeding Pairs[B]	Site Peak Breeding Pair[B]	Adult Counts[B]	Nests	Nests Hatched	Chicks 0-14 D	Chicks 15-21 D	Fledglings	AHR Peak Breeding Pairs[B]	Site Peak Breeding Pairs[B]	Adult Counts[B]	Nests	Nests Hatched	Chicks 0-14 D	Chicks 15-28 D	Fledglings
1 Lexington NPPD Pit	PFT	30	30	12	12	23	14	7	19	7	11	6	6	9	6	5	20	11	11
2 Dyer Pit	PFT	26	26	15	15	25	15	12	23	15	17	9	10	14	14	8	31	16	12
3 Cottonwood Ranch	PFTH	20	12	4	4	12	4	4	10	10	10	1	1	4	1	1	4	3	1
4 Blue Hole	PFT	32	45	3	6	12	8	3	5	5	6	3	4	9	7	3	10	8	7
5 Johnson Pit	PFT	10	5	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
6 Ed Broadfoot and Sons	N	16	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 Broadfoot South Kearney	PFTH	31	34	22	23	32	29	20	36	20	22	6	6	14	9	6	14	6	3
8 Broadfoot South-Kearney-N. Acc.	T	16	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9 Newark West	PFTH	21	11	8	8	13	8	6	17	11	11	1	2	6	2	1	4	2	2
10 Newark East	PFTH	28	15	15	16	20	16	15	35	20	20	4	6	8	6	3	11	6	3
11 Leaman East	PFTH	24	8	4	4	7	4	3	7	6	6	2	3	4	4	1	4	0	0
12 Trust Wild Rose East	N	16	8	1	1	2	1	1	2	0	1	0	0	0	0	0	0	0	0
13 Follmer-Alda Pit	PH	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 Deweese – Alda Pit	N	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 Hooker Brothers – GI South East	N	21	6	0	5	9	6	3	6	3	3	0	0	0	0	0	0	0	0
16 Hooker Brothers – GI East	N	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[A] Management actions applied to each site: fall 2019 herbicide (H), spring 2020 pre-emergent herbicide (P), predator fencing (F), predator trapping (T), or no management (N).

[B] AHR Peak Breeding Pair counts represent the estimated number of breeding pairs at each site on 19 June for least terns and 12 June for piping plovers, when numbers of breeding pairs observed within the entire Program Associated Habitat Reach first peaked. AHR Peak Breeding Pair counts do not necessarily represent the highest estimate of least tern or piping plover breeding pairs observed at any site throughout the year as some adults are known to have re-nested at different sites after losing their first nest or brood. Site Peak Breeding Pairs represents the highest number of estimated pairs at a site during the nesting season, regardless of AHR Peak Breeding Pair dates. Adults Counts represent the highest number adults observed during any single survey at a given site.

Table 3. Number of least tern and piping plover adults, breeding pairs (pair), nests, chicks, and fledglings observed during semi-monthly airboat and kayak surveys of the Platte River between Lexington and Chapman, Nebraska, in 2020.

	Interior Least Tern					Piping Plover				
Survey	**Adults**	**Pair[A]**	**Nests**	**Chicks**	**Fledglings**	**Adults**	**Pair[A]**	**Nests**	**Chicks**	**Fledglings**
1-May	0	0	0	0	0	8	0	0	0	0
15-May	6	0	0	0	0	11	0	0	0	0
1-Jun	14	0	0	0	0	5	0	0	0	0
15-Jun[B]	0	0	0	0	0	0	0	0	0	0
1-Jul[B]	0	0	0	0	0	0	0	0	0	0
15-Jul	21	0	0	0	3	12	0	0	0	0
1-Aug[C]	17	0	0	0	19	4	0	0	0	5

Table 4. Number of least tern and piping plover adults, breeding pairs (pair), nests, chicks, and fledglings documented from outside the nesting area during semi-monthly sandpit surveys in 2020.

	Interior Least Tern					Piping Plover				
Survey	**Adults**	**Pair[A]**	**Nests**	**Chicks**	**Fledglings**	**Adults**	**Pair[A]**	**Nests**	**Chicks**	**Fledglings**
1-May	0	0	0	0	0	36	8	4	0	0
15-May	2	4	0	0	0	19	15	8	0	0
1-Jun	85	53	43	0	0	44	25	19	5	0
15-Jun	115	81	81	0	0	48	30	16	15	0
1-Jul	101	78	17	80	0	48	30	10	39	7
15-Jul	72	67	8	25	38	27	18	5	28	5
1-Aug	10	57	3	3	5	3	3	0	5	6

Table 5. Number of least tern and piping plover adults, breeding pairs (pair), nests, chicks, and fledglings observed within Program Associated Habitats during semi-monthly surveys of sandpits and the river in 2020.

	Interior Least Terns					Piping Plovers				
Survey	**Adults**	**Pair[A]**	**Nests**	**Chicks**	**Fledglings**	**Adults**	**Pair[A]**	**Nests**	**Chicks**	**Fledglings**
1-May	0	0	0	0	0	44	8	4	0	0
15-May	8	4	0	0	0	30	15	8	0	0
1-Jun	99	53	43	0	0	49	25	19	5	0
15-Jun[B]	115	81	81	0	0	48	30	16	15	0
1-Jul[B]	101	78	17	80	0	48	30	10	39	7
15-Jul	93	67	8	25	41	39	18	5	28	5
1-Aug[C]	27	57	3	3	24	7	3	0	5	11

Annotations below apply to Tables 3-5.

[A] Pair represents the number of breeding pairs present on sandpits and river islands on 1 and 15 May, June, and July, and 1 August. Breeding pair counts were obtained using the Program's Breeding Pair Estimator (BPE). Quantities of nests may be different from breeding pairs because semi-monthly surveys occurred over several days and breeding pair counts were determined on the 1st or 15th of the month.

[B] River survey not completed due to airboat maintenance, as well as a lack of dry unvegetated sandbars on the river during June.

[C] J2 to Dyer stretch of river survey not completed due to weather.

Table 6. Summary of least tern reproductive success at sandpits and river-island sites on the central Platte River in Nebraska, 2007–2020. Site-specific details on numbers of adults, nest, chicks, and fledglings observed during 2020 are provided in Table 2. Site-specific details of daily, incubation- and brooding-period survival rates (RMark estimates) for 2020 are provided in Tables 7-8.

	Least Tern													
Reproductive Parameter	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Adults Observed	132	80	97	123	125	116	136	166	224	157	118	174	169	158
Peak Breeding Pairs	39	37	42	53	60	64	58	94	141	88	77	88	95	84
Total Nests Observed	53	64	60	76	90	88	95	146	188	119	118	113	132	105
Successful Nests (≥1 egg hatched)	22	27	37	43	52	63	51	82	116	74	63	79	67	74
Apparent Nest Success	0.42	0.42	0.62	0.57	0.58	0.72	0.54	0.56	0.62	0.62	0.53	0.67	0.51	0.70
Daily Nest Survival Rate	0.97	0.98	0.99	0.98	0.97	0.99	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98
Incubation-period Survival Rate	0.55	0.61	0.73	0.64	0.58	0.76	0.56	0.52	0.63	0.71	0.61	0.65	0.61	0.72
Chicks Observed (<15D)	50	54	71	105	124	144	118	180	258	170	129	168	137	160
Hatch Ratio (<15D Chicks/Total Nests)	0.94	0.84	1.18	1.38	1.38	1.64	1.24	1.23	1.37	1.43	1.09	1.49	2.04	1.52
Hatch Ratio (<15D Chicks/Breeding Pair)	1.28	1.46	1.69	1.98	2.07	2.25	2.03	1.91	1.83	1.93	1.68	1.91	1.44	1.90
Chicks (≥15D)	40	44	48	67	98	95	70	104	158	91	78	117	74	107
Fledglings (21D)	----[A]	-----	----	64	89	84	64	91	146	80	76	117	71	107
Historic Fledge Ratio (≥15D Chicks/Total Nests)	0.75	0.69	0.80	0.88	1.09	1.08	0.74	0.71	0.84	0.76	0.66	1.04	0.56	1.02
Fledge ratio (21D Chicks/Nest)	-----	-----	----	0.84	0.99	0.95	0.67	0.63	0.78	0.67	0.64	1.04	0.54	1.02
Historic Fledge Ratio (≥15D Chicks/Breeding Pair)	1.03	1.19	1.14	1.26	1.63	1.48	1.21	1.11	1.12	1.03	1.01	1.33	0.78	1.27
Fledge Ratio (21D Chicks/Breeding Pair)	-----	-----	----	1.21	1.48	1.31	1.10	0.62	1.04	0.91	0.99	1.33	0.75	1.27
Daily Brood Survival Rate [B]	-----	0.98	0.98	0.98	0.99	0.99	0.97	0.98	0.98	0.98	0.97	0.98	0.97	0.98
Brooding-period Survival Rate [B]	-----	0.75	0.79	0.72	0.89	0.81	0.59	0.69	0.68	0.61	0.56	0.69	0.57	0.70

[A] "-----" years for which indicated data were not collected.

[B] Brood survival rates reported in the table are not comparable across all years because estimates are reported as survival for a 15-day interval for least tern chicks during 2007–2009 and in 2010 the Program began to use 21 days as the fledge age for least tern chicks.

Table 7. Daily and incubation-period survival rates (RMark estimates) for least tern nests monitored on sandpit sites during 2020. Incubation-period nest survival rate = (daily nest survival rate)[21].

Site	# Nests	# Nests Lost	Exposure Days	Daily* Nest Survival Rate	Daily Nest Survival SE	Daily Nest Survival Rate 95% CI		Incubation Period Survival Rate	Incubation Period Survival Rate 95% CI	
						Lower	Upper		Lower	Upper
Lexington Sandpit	14	5	261.0	0.9810	0.0084	0.9552	0.9921	0.6687	0.3821	0.8462
Dyer Sandpit	15	3	258.0	0.9884	0.0066	0.9648	0.9963	0.7833	0.4709	0.9245
Cottonwood Ranch OCSW	4	0	80.0	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Blue Hole	8	5	68.0	0.9289	0.0307	0.8401	0.9701	0.2125	0.0258	0.5290
Broadfoot - Kearney South	29	9	515.0	0.9827	0.0057	0.967	0.9910	0.6928	0.4946	0.8264
Newark West	8	2	135.0	0.9853	0.0103	0.9431	0.9963	0.7326	0.2922	0.9255
Newark East	16	1	302.0	0.9967	0.0033	0.9769	0.9995	0.9328	0.6124	0.9903
Leaman East (Sandpit) OCSW	4	1	79.5	0.9875	0.0124	0.9166	0.9982	0.7679	0.1606	0.9637
Hooker Brothers - South East	6	3	109.0	0.9728	0.0155	0.9192	0.9912	0.5609	0.1703	0.8309
Trust Wildrose - East	1	0	21.0	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
All Sites	105	29	1828.5	0.9843	0.0029	0.9774	0.989	0.7167	0.6193	0.7934

*A significant difference in average daily nest survival was observed between sites [$\chi 2(7, N=105) = 16.565$; $p = 0.02$].

Table 8. Daily and brooding-period survival rates (RMark estimates) for observed least tern broods (1 or more chicks) monitored on sandpit sites during 2020. Brooding-period brood survival rate = (daily brood survival rate)^{21}.

Site	# Broods	# Broods Lost	Exposure Days	Daily Brood Survival Rate	Daily Brood Survival SE	Daily Brood Survival Rate 95% CI		Brooding Period Survival Rate	Brooding Period Survival Rate 95% CI	
						Lower	Upper		Lower	Upper
Lexington Sandpit	7	3	94.5	0.9687	0.0178	0.9075	0.9899	0.5131	0.1301	0.8077
Dyer Sandpit	12	3	190.5	0.9844	0.0090	0.9527	0.9950	0.7184	0.3613	0.8992
Cottonwood Ranch	4	0	75.0	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Blue Hole	3	0	59.0	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Broadfoot Kearney-South	20	6	310.5	0.9809	0.0077	0.9581	0.9914	0.6664	0.4066	0.8337
Newark West	6	1	88.5	0.9888	0.0112	0.9246	0.9984	0.7888	0.1927	0.9673
Newark East	15	4	226.5	0.9825	0.0087	0.9543	0.9934	0.6900	0.3742	0.8704
Leaman East (Sandpit)	3	1	33.5	0.9706	0.0290	0.8186	0.9959	0.5342	0.0150	0.9168
Hooker Brothers - South	3	1	46.5	0.9787	0.0211	0.8638	0.9970	0.6365	0.0462	0.9391
Trust Wildrose - East	1	0	16.0	1.0000	0.0000	1.0000	1.0000	1.0000	0.9997	1.0003
All Sites	74	19	1140.5	0.9835	0.0038	0.9742	0.9894	0.7047	0.5780	0.8001

Table 9. Daily and incubation-period survival rates (RMark estimates) for least tern nests monitored on Program and non-Program sites during 2020. Incubation-period nest survival rate = (daily nest survival rate)[21].

Site	# Nests	# Nests Lost	Exposure Days	Daily Nest Survival Rate	Daily Nest Survival SE	Daily Nest Survival Rate 95% CI		Incubation* Period Survival Rate	Brooding Period Survival Rate 95% CI	
						Lower	Upper		Lower	Upper
Non-Program	29	13	459.0	0.9721	0.0076	0.9525	0.9837	0.5515	0.3597	0.7083
Program	76	16	1369.5	0.9884	0.0029	0.9811	0.9929	0.7824	0.6702	0.8605
All Sites	105	29	1828.5	0.9843	0.0029	0.9774	0.9890	0.7167	0.6193	0.7934

Program sites: Dyer, Cottonwood Ranch OCSW, Broadfoot South-Kearney, Newark West, Newark East, & Leaman OCSW.
Non-Program sites: Lexington, Blue Hole, Trust Wild Rose East, & Hooker Brothers South-East.

***** Least tern incubation period survival was higher at Program owned and/or managed nesting areas than non-Program sites [$\chi 2(1, N=105) = 4.528$; $p = 0.03$].

Table 10. Daily and brooding-period survival rates (RMark estimates) for least tern broods (1 or more chicks) monitored on Program and non-Program sites during 2020. Brooding-period brood survival rate = (daily brood survival rate)[21].

Site	# Broods	# Broods Lost	Exposure Days	Daily Brood Survival Rate	Daily Brood Survival SE	Daily Brood Survival Rate 95% CI		Brooding Period Survival Rate	Brooding Period Survival Rate 95% CI	
						Lower	Upper		Lower	Upper
Non-Program	14	4	216.0	0.9816	0.0091	0.9521	0.9931	0.6777	0.3569	0.8646
Program	60	15	924.5	0.9839	0.0041	0.9735	0.9903	0.7112	0.5686	0.8144
All Sites	74	19	1140.5	0.9835	0.0038	0.9742	0.9894	0.7047	0.5780	0.8001

Program sites: Dyer, Cottonwood Ranch OCSW, Broadfoot South-Kearney, Newark West, Newark East, & Leaman OCSW.
Non-Program sites: Lexington, Blue Hole, Trust Wildrose East, & Hooker Brothers South-East.

Table 11. Summary of piping plover reproductive success at sandpit and river island sites along the central Platte River in Nebraska, 2007–2020. Site-specific details on numbers of adults, nest, chicks, and fledglings observed during 2020 are provided in Table 2. Site-specific details of daily, incubation- and brooding-period survival rates (RMark estimates) for 2020 are provided in Tables 12-13.

	Piping Plover													
Reproductive Parameter	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Maximum Adults Observed	52	23	31	46	55	60	68	69	74	64	65	74	88	71
Peak Breeding Pairs	19	13	12	20	27	30	27	30	39	43	40	37	45	32
Total Nests Observed	27	21	15	33	34	46	31	43	54	60	51	47	60	49
Successful Nests (≥1 egg hatched)	15	8	9	21	27	32	23	34	34	40	30	35	31	28
Apparent Nest Success	0.56	0.38	0.60	0.64	0.79	0.70	0.74	0.79	0.63	0.68	0.59	0.74	0.52	0.57
Daily Nest Survival Rate	0.99	0.98	0.99	0.98	0.99	0.99	0.99	0.99	0.98	0.99	0.98	0.99	0.98	0.98
Incubation-period Survival Rate	0.71	0.58	0.67	0.54	0.77	0.69	0.73	0.77	0.64	0.69	0.61	0.68	0.51	0.51
Chicks Observed (<15D)	44	26	27	76	87	99	80	116	119	120	92	95	94	98
Hatch Ratio (<15D Chicks/Nest)	1.63	1.24	1.80	2.30	2.56	2.15	2.58	2.70	2.2	2.00	1.80	2.02	1.57	2.00
Hatch Ratio (<15D Chicks/Breeding Pair)	2.32	1.24	2.25	3.80	3.22	3.30	2.96	3.87	3.05	2.79	2.30	2.57	2.09	3.06
Chicks (≥15D)	27	10	18	53	61	68	43	67	73	70	53	36	42	52
Fledglings (28D)	-----[A]	-----	-----	42	45	59	28	55	52	55	47	23	30	39
Historic Fledge Ratio (≥15D Chicks/Nest)	1.00	0.48	1.20	1.61	1.79	1.48	1.39	1.56	1.35	1.17	1.04	0.77	0.70	1.06
Fledge ratio (28D Chicks/Nest)	-----	-----	-----	1.27	1.32	1.28	0.90	1.28	0.96	0.92	0.92	0.49	0.50	0.80
Historic Fledge Ratio (≥15D Chicks/Breeding Pair)	1.42	0.77	1.50	2.65	2.26	2.27	1.59	2.23	1.87	1.63	1.33	0.97	0.93	1.63
Fledge Ratio (28D Chicks/Breeding Pair)	-----	-----	-----	2.01	1.67	1.97	1.04	1.83	1.33	1.28	1.18	0.62	0.67	1.22
Daily Brood Survival Rate[B]	-----	0.94	0.98	0.99	0.99	0.99	0.98	0.99	0.99	0.98	0.98	0.96	0.97	0.98
Brooding-period Survival Rate[B]	-----	0.42	0.79	0.70	0.73	0.78	0.62	0.69	0.68	0.55	0.63	0.29	0.44	0.58

[A] "-----" years for which indicated data were not collected.

[B] Brood survival rates reported in the table are not comparable across all years because estimates are reported as survival for a 15-day interval for piping plover chicks during 2007–2009 and in 2010 the Program began to use 28 days as the fledge age for piping plover chicks.

Table 12. Daily and incubation-period survival rates (RMark estimates) for piping plover nests monitored on sandpit sites during 2020. Incubation-period nest survival rate = (daily nest survival rate)[28].

Site	# Nests	# Nests Lost	Exposure Days	Daily Nests Survival Rate	Daily Nests Survival SE	Daily Nests Survival Rate 95% CI		Incubation Period Survival Rate	Incubation Period Survival Rate 95% CI	
						Lower	Upper		Lower	Upper
Lexington Sandpit	6	1	122.5	0.9919	0.0081	0.9446	0.9989	0.7956	0.2026	0.9685
Dyer Sandpit	14	6	268.0	0.9778	0.0089	0.9516	0.9900	0.5341	0.2491	0.7551
Cottonwood Ranch	1	0	8.0	1.0000	0.0000	1.0000	1.0000	1.0000	0.9993	1.0007
Blue Hole	7	4	97.5	0.9597	0.0197	0.8976	0.9848	0.3165	0.0485	0.6516
Broadfoot South-Kearney	9	3	139.5	0.9787	0.0122	0.9361	0.9931	0.5474	0.1572	0.8242
Newark West	2	1	32.0	0.9692	0.0303	0.8113	0.9957	0.4167	0.0029	0.8859
Newark East	6	3	141.0	0.9789	0.0120	0.9367	0.9932	0.5510	0.1605	0.8259
Leaman East (Sandpit)	4	3	61.0	0.9519	0.0272	0.8609	0.9844	0.2511	0.0151	0.6442
All Sites	49	21	869.5	0.9761	0.0051	0.9637	0.9844	0.5083	0.3546	0.6436

Table 13. Daily and brooding-period survival rates (RMark estimates) for observed piping plover broods (1 or more chicks) monitored on sandpit sites during 2020. Brooding-period survival rate = (daily brood survival rate)[28].

Site	# Broods	# Broods Lost	Exposure Days	Daily* Brood Survival Rate	Daily Brood Survival SE	Daily Brood Survival Rate 95% CI		Brooding Period Survival Rate	Brooding Period Survival Rate 95% CI	
						Lower	Upper		Lower	Upper
Lexington Sandpit	5	2	80.5	0.9755	0.0171	0.9071	0.9939	0.4986	0.0652	0.8415
Dyer Sandpit	8	2	192.0	0.9896	0.0073	0.9595	0.9974	0.7470	0.3145	0.9299
Cottonwood Ranch	1	0	26.0	1.0000	0.0000	1.0000	1.0000	1.0000	0.9997	1.0003
Blue Hole	3	0	70.0	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Broadfoot South-Kearney	6	4	77.5	0.9496	0.0246	0.8733	0.9810	0.2352	0.0225	0.5840
Newark West	1	0	25.0	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Newark East	3	1	49.5	0.9800	0.0198	0.8712	0.9972	0.5679	0.0210	0.9242
Leaman East (Sandpit)	1	1	1.5	0.5000	0.3536	0.0589	0.9411	0.0000	0.0000	0.1829
All Sites	28	10	522.0	0.9810	0.0059	0.9651	0.9898	0.5848	0.3697	0.7496

*A significant difference in average daily brood survival rate was observed between sites [$\chi 2(4, N=28) = 13.780$; $p= 0.008$].

Table 14. Daily and incubation-period survival rates (RMark estimates) for piping plover nests monitored on Program and non-Program sites during 2020. Incubation-period nest survival rate = (daily nest survival rate)[28].

Site	# Nests	# Nests Lost	Exposure Days	Daily Nest Survival Rate	Daily Nest Survival SE	Daily Nest Survival Rate 95% CI		Incubation Period Survival Rate	Incubation Period Survival Rate 95% CI	
						Lower	Upper		Lower	Upper
Non-Program	13	5	220.0	0.9775	0.0099	0.9471	0.9906	0.5290	0.2184	0.7679
Program	36	16	649.5	0.9756	0.0060	0.9606	0.9850	0.5015	0.3247	0.6556
All Sites	49	21	869.5	0.9761	0.0051	0.9637	0.9844	0.5083	0.3546	0.6436

Program sites: Dyer, Cottonwood Ranch OCSW, Broadfoot South-Kearney, Newark West, Newark East, & Leaman OCSW.
Non-Program sites: Lexington, & Blue Hole.

Table 15. Daily and brooding-period survival rates (RMark estimates) for piping plover broods (1 or more chicks) monitored on Program and non-Program sites during 2020. Brooding-period survival rate = (daily brood survival rate)[28].

Site	# Broods	# Broods Lost	Exposure Days	Daily Brood Survival Rate	Daily Brood Survival SE	Daily Brood Survival Rate 95% CI		Brooding Period Survival Rate	Brooding Period Survival Rate 95% CI	
						Lower	Upper		Lower	Upper
Non-Program	8	2	150.5	0.9868	0.0093	0.9488	0.9967	0.6893	0.2294	0.9115
Program	20	8	371.5	0.9787	0.0075	0.9580	0.9893	0.5471	0.3005	0.7401
All Sites	28	10	522.0	0.9810	0.0059	0.9651	0.9898	0.5848	0.3697	0.7496

Program sites: Dyer, Cottonwood Ranch OCSW, Broadfoot South-Kearney, Newark West, Newark East, & Leaman OCSW.
Non-Program sites: Lexington & Blue Hole

Table 16. Least tern and piping plover on- and off-channel total nesting incidence by year, 2007−2020.

	Least Tern							Piping Plover						
Year	Max[A] BP	Peak[B] BP	Nests	Succ. Nests	Fledges	Fledges per Max BP	Fledges per Peak BP	Max[A] BP	Peak[B] BP	Nests	Succ. Nests	Fledges	Fledges per Max BP	Fledges per Peak BP
2007	41	39	53	22	40	0.98	1.03	20	19	27	15	25	1.25	1.32
2008	36	37	64	27	44	1.22	1.19	14	13	21	8	10	0.71	0.77
2009	43	42	60	36	46	1.07	1.10	12	12	15	9	12	1.00	1.00
2010	51	53	80	44	64	1.25	1.21	20	20	33	22	46	2.30	2.30
2011	62	60	90	53	89	1.44	1.48	28	27	34	27	45	1.61	1.67
2012	66	64	88	63	84	1.27	1.31	29	30	46	32	59	2.03	1.97
2013	63	58	95	51	64	1.02	1.10	27	27	31	23	28	1.04	1.04
2014	86	94	146	82	91	1.06	0.97	28	30	43	25	59	2.11	1.97
2015	141	141	188	116	146	1.04	1.04	36	39	54	34	52	1.44	1.33
2016	88	88	119	74	80	0.91	0.91	40	43	60	40	55	1.38	1.28
2017	77	77	118	63	76	0.99	0.99	38	40	51	30	47	1.24	1.18
2018	88	88	113	79	117	1.33	1.33	37	37	47	35	23	0.62	0.62
2019	95	95	132	67	71	0.75	0.75	45	45	60	31	30	0.67	0.67
2020	81	84	105	74	107	1.32	1.27	29	32	49	28	39	1.34	1.22
Mean	72.71	72.86	103.64	60.79	79.93	1.12	1.12	28.79	29.57	40.79	25.64	37.86	1.34	1.31

[A] and [B] are both estimated numbers of breeding pairs present when the number of breeding pairs within the entire Program AHR during a single observation period first peaked as estimated using the Program's breeding pair estimator as described on pages 11-12 of this report.

[A]Max breeding pairs are estimated by setting renest intervals for both terns and plovers to 0 and post fledge renest intervals for plovers to 0 days (terns do not renest after fledging offspring). Numbers for total on- and off-channel Max BPs included in Table 16 are not the simple sum of values reported in Tables 17 and 18 below; as on- and off-channel Max BPs were sometimes maximized on different dates.

[B]Peak breeding pairs are estimated by setting renest intervals for both terns and plovers to 5 and post fledge renest intervals for plovers to 5 days (terns do not renest after fledging offspring).

Table 17. Least tern and piping plover on-channel total nesting incidence and productivity by year, 2007−2020.

	Least Tern							Piping Plover						
Year	Max[A] BP	Peak[B] BP	Nests	Succ. Nests	Fledges	Fledges per Max BP	Fledges per Peak BP	Max[A] BP	Peak[B] BP	Nests	Succ. Nests	Fledges	Fledges per Max BP	Fledges per Peak BP
2007	11	11	13	2	2	0.18	0.18	3	4	4	2	7	2.33	1.75
2008	10	10	20	7	9	0.90	0.90	3	3	5	1	3	1.00	1.00
2009	5	4	8	5	4	0.80	1.00	2	2	2	1	1	0.50	0.50
2010	0	0	0	0	0	---[C]	---	5	4	11	4	10	2.00	2.50
2011	0	0	0	0	0	---	---	0	0	0	0	0	---	---
2012	0	0	0	0	0	---	---	1	1	1	1	4	4.00	4.00
2013	0	0	0	0	0	---	---	0	0	0	0	0	---	---
2014	2	0	2	0	0	0.00	---	2	1	2	1	4	2.00	4.00
2015	8	8	14	3	0	0.00	0.00	4	5	7	1	1	0.25	0.20
2016	2	0	2	0	0	0.00	---	1	1	2	1	1	1.00	1.00
2017	0	0	0	0	0	---	---	0	0	0	0	0	---	---
2018	0	0	0	0	0	---	---	0	0	0	0	0	---	---
2019	0	0	0	0	0	---	---	0	0	0	0	0	---	---
2020	0	0	0	0	0	---	---	0	0	0	0	0	---	---
Mean	2.71	2.36	4.21	1.21	1.07	0.31	0.52	1.50	1.5	2.43	0.86	2.21	1.64	1.89

[A] and [B] are both estimated numbers of breeding pairs present when the number of breeding pairs within the entire Program AHR during a single observation period first peaked as estimated using the Program's breeding pair estimator as described on pages 11-12 of this report.

[A]Max breeding pairs are estimated by setting renest intervals for both terns and plovers to 0 and post fledge renest intervals for plovers to 0 days (terns do not renest after fledging offspring).

[B]Peak breeding pairs are estimated by setting renest intervals for both terns and plovers to 5 and post fledge renest intervals for plovers to 5 days (terns do not renest after fledging offspring).

[C] "---" fledge ratios cannot be calculated for years when there were no breeding pairs, and are not included in calculation of the mean.

Table 18. Least tern and piping plover off-channel total nesting incidence and productivity by year, 2007−2020.

	Least Tern							Piping Plover						
Year	Max[A] BP	Peak[B] BP	Nests	Succ. Nests	Fledges	Fledges per Max BP	Fledges per Peak BP	Max[A] BP	Peak[B] BP	Nests	Succ. Nests	Fledges	Fledges per Max BP	Fledges per Peak BP
2007	32	28	40	20	38	1.19	1.36	19	15	23	13	18	0.95	1.20
2008	27	27	44	20	35	1.30	1.30	11	10	16	7	7	0.64	0.70
2009	39	38	52	31	42	1.08	1.11	10	10	13	8	11	1.10	1.10
2010	51	53	80	44	64	1.25	1.21	18	16	22	18	36	2.00	2.25
2011	62	60	90	53	89	1.44	1.48	28	27	34	27	45	1.61	1.67
2012	66	64	88	63	84	1.27	1.31	28	29	45	31	55	1.96	1.90
2013	63	58	95	51	64	1.02	1.10	27	27	31	23	28	1.04	1.04
2014	86	94	143	82	91	1.06	0.97	27	29	41	24	55	2.04	1.90
2015	133	133	174	113	146	1.10	1.10	32	34	47	33	51	1.59	1.50
2016	86	88	117	74	80	0.93	0.91	39	42	58	39	54	1.38	1.29
2017	77	77	118	63	76	0.99	0.99	40	40	51	30	47	1.18	1.18
2018	88	88	113	79	117	1.33	1.33	37	37	47	35	23	0.62	0.62
2019	95	95	132	67	71	0.75	0.75	45	45	60	31	30	0.67	0.67
2020	81	84	105	74	107	1.32	1.27	29	32	49	28	39	1.34	1.22
Mean	71.43	70.50	99.36	59.57	78.86	1.14	1.16	27.86	28.07	38.36	24.79	35.64	1.29	1.30

[A] and [B] are both estimated numbers of breeding pairs present when the number of breeding pairs within the entire Program AHR during a single observation period first peaked as estimated using the Program's breeding pair estimator as described on pages 11-12 of this report.

[A]Max breeding pairs are estimated by setting renest intervals for both terns and plovers to 0 and post fledge renest intervals for plovers to 0 days (terns do not renest after fledging offspring).

[B]Peak breeding pairs are estimated by setting renest intervals for both terns and plovers to 5 and post fledge renest intervals for plovers to 5 days (terns do not renest after fledging offspring).

Table 19. Numbers of least tern and piping plover adults and chicks banded along the central Platte River, 2009−2016.

Year	Least Tern Adults	Least Tern Chicks	Piping Plover Adults	Piping Plover Chicks
2009	16	35	11	25
2010	7	74	13	64
2011	4	98	2	68
2012	9	103	15	86
2013	32	99	12	64
2014	28	114	11	106
2015	56	162	21	88
2016	39	107	28	90
Total	**152**	**685**	**85**	**591**

Table 20. Site-specific totals for 2020 least tern band resighting efforts.

Sites Monitored	Nests Monitored	Banded Adults	Unbanded Adults	Adults Observed	Proportion of Banded Adults
Broadfoot South-Kearney	17	4	9	13	30.8%
Blue Hole	0	0	0	0	0.0%
Dyer Sandpit	4	1	2	3	33.3%
Leaman	4	2	2	4	50.0%
Lexington Sandpit	0	0	0	0	0.0%
Newark East	7	1	2	3	33.3%
Newark West	7	4	2	6	66.7%
Over All Sites	**39**	**12**	**17**	**29**	**41.4%**

Table 21. Site-specific totals for 2020 piping plover band resighting efforts.

Sites Monitored	Nests Monitored	Banded Adults	Unbanded Adults	Adults Observed	Proportion of Banded Adults
Broadfoot South-Kearney	6	1	4	5	20.0%
Blue Hole	3	1	1	2	50.0%
Dyer Sandpit	5	3	4	7	42.9%
Leaman	1	1	0	1	100.0%
Lexington Sandpit	3	2	3	5	40.0%
Newark East	3	1	3	4	25.0%
Newark West	2	1	1	2	50.0%
Over All Sites	**23**	**10**	**16**	**26**	**38.5%**

Table 22. Average off-channel least tern nest elevations above water, distances to edge of water, and distances to predator perch by site during 2020. These covariates were found to influence nest site selection by least terns on off-channel sites along the central Platte River (Baasch *et al*. 2017).

	Least Terns		
Site Name	**Average Elevation[A] Above Water (in)**	**Average Distance to[B] Edge of Water (yds)**	**Average Distance to[B] Predator Perch (yds)**
Lexington NPPD	116	43	124
Dyer	85	37	285
Blue Hole	73	36	181
Broadfoot South-Kearney	78	32	57
Cottonwood Ranch	229	53	197
Newark West	87	37	181
Newark East	104	34	126
Leaman East	74	56	171
Hooker Brothers South-East	---[C]	36	199

[A] Nest and water elevations were obtained from lidar flown in October or November. Water elevation is calculated by averaging available hydro flattened imagery at each of the sites from 2011-2019. Average nest elevation values are calculated using lidar data from 2019 as the imagery from 2020 is not yet available.
[B] Distance to the edge of water and distance to nearest predator perch are calculated using imagery flown in July 2020.
[C] Value not available as nesting site is outside of the lidar flight transect.

Table 23. Average off-channel piping plover nest elevations above water, distances to edge of water, and distances to predator perch by site during 2020. These covariates were found to influence nest site selection by piping plovers on off-channel sites along the central Platte River (Baasch *et al*. 2017).

	Piping Plovers		
Site Name	**Average Elevation[A] Above Water (in)**	**Average Distance to[B] Edge of Water (yds)**	**Average Distance to[B] Predator Perch (yds)**
Lexington NPPD	132	43	110
Dyer	84	45	289
Cottonwood Ranch Sandpit	233	54	201
Blue Hole	61	39	167
Broadfoot South-Kearney	77	36	57
Newark West	99	40	189
Newark East	46	27	159
Leaman East	74	33	189

[A] Nest and water elevations were obtained from lidar flown in October or November. Water elevation is calculated by averaging available hydro flattened imagery at each of the sites from 2011-2019. Average nest elevation values are calculated using lidar data from 2019 as the imagery from 2020 is not yet available.
[B] Distance to the edge of water and distance to nearest predator perch are calculated using imagery flown in July 2020.

Table 24. Trap effort and spiny softshell turtle captures and recaptures by site.

Sites	Traps	Nights	Trap Nights	Total Captures	Recaptures
Dyer	4	25	100	7	0
Blue Hole	6	21	126	74	16
Cottonwood Ranch OCSW	4	16	64	23	13
Broadfoot South-Kearney	4	16	64	10	1
Total	**18**	**78**	**354**	**114**	**30**

FIGURES

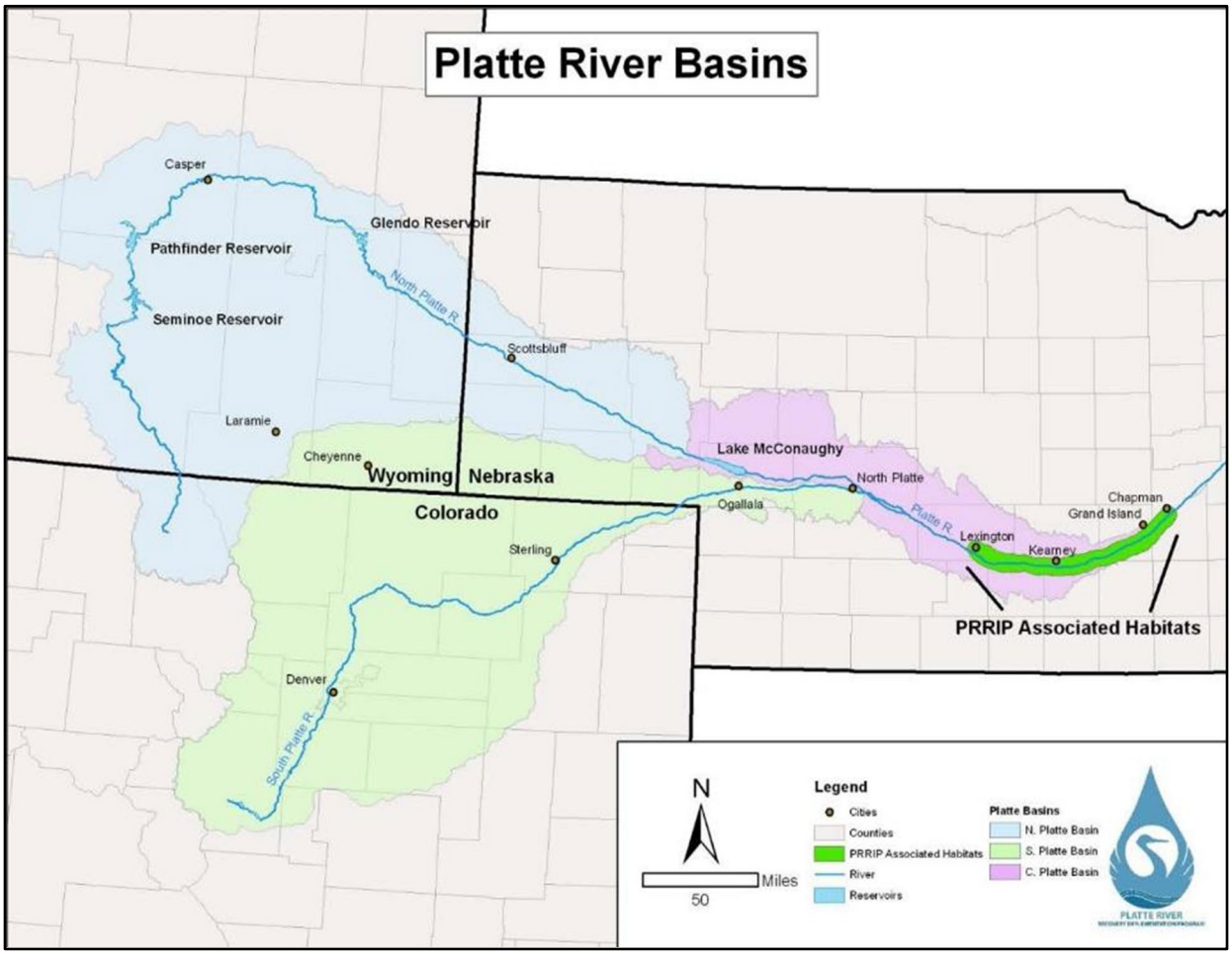


Figure 1. Platte River Basins extending from Colorado and Wyoming through Nebraska. The study area for our least tern and piping plover monitoring and research efforts was the PRRIP Associated Habitat Reach of the Platte River located between Lexington and Chapman, Nebraska (in dark green).

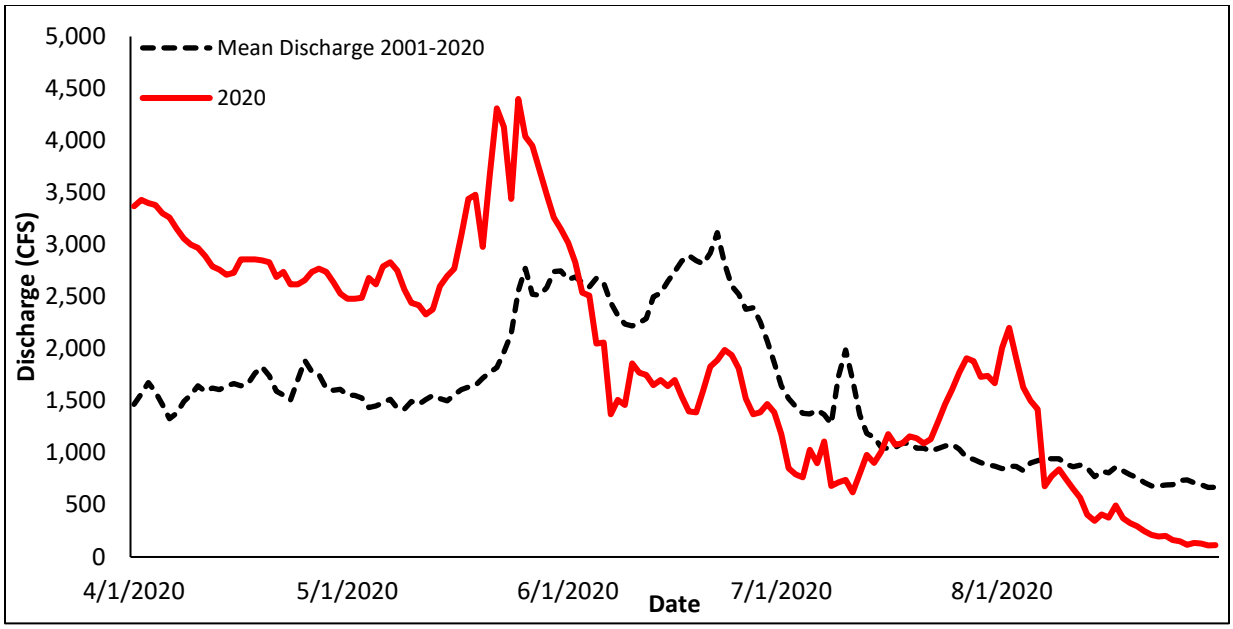


Figure 2. Mean daily discharge (ft^3/second; cfs) at Kearney, Nebraska (USGS gage 06770200) in 2020 (red line). Mean daily discharge from 2001–2020 at Kearney (USGS gage 06770200) (black dashed line) (USGS 2020). See Figure 3 for the location of gage stations within our study area.

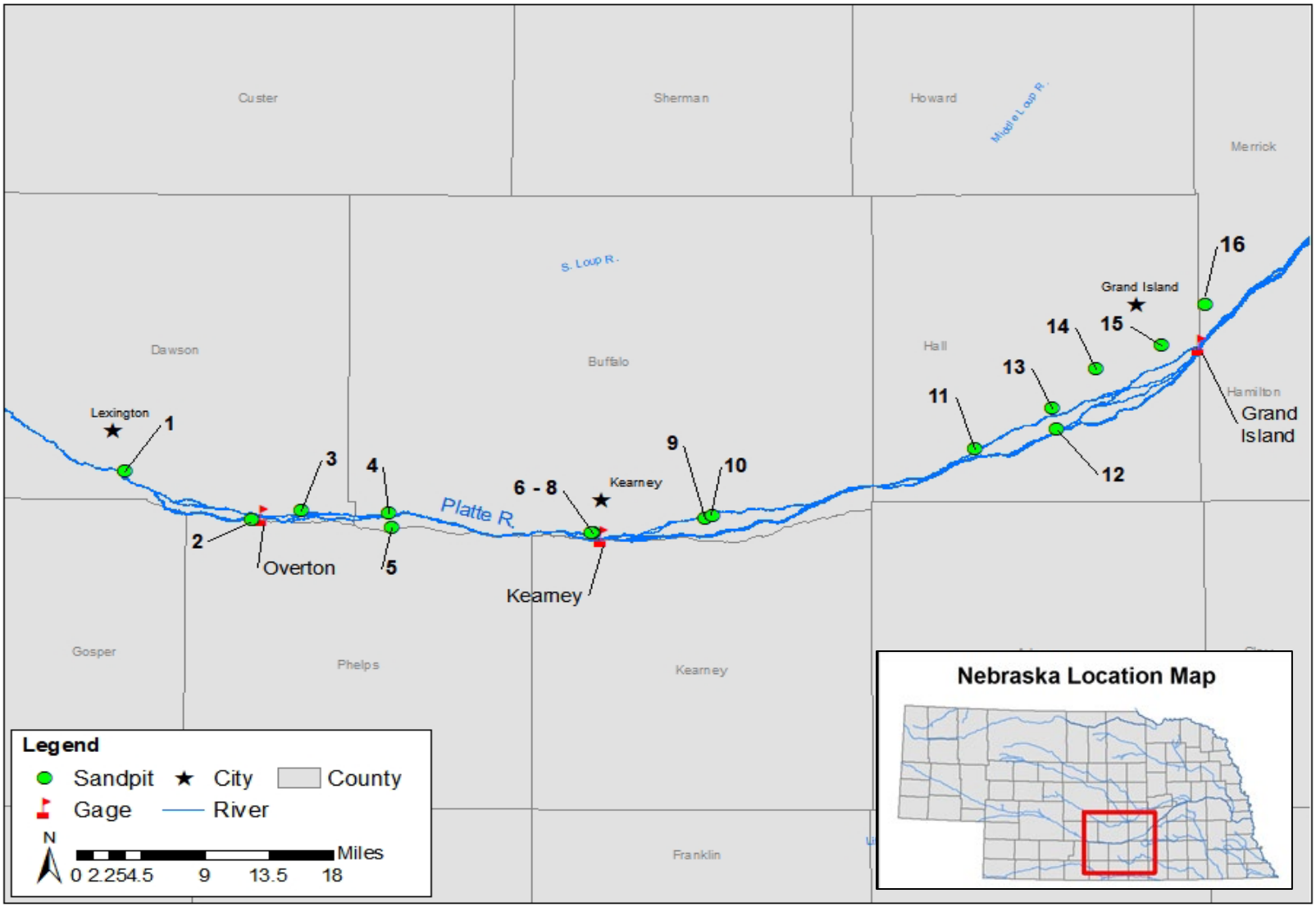


Figure 3. Study area including sandpits (green) and river channels (blue) monitored for least tern and piping plover nesting and foraging activities during 2020. River gauge locations are in red. Names of numbered sites are included in Table 2.

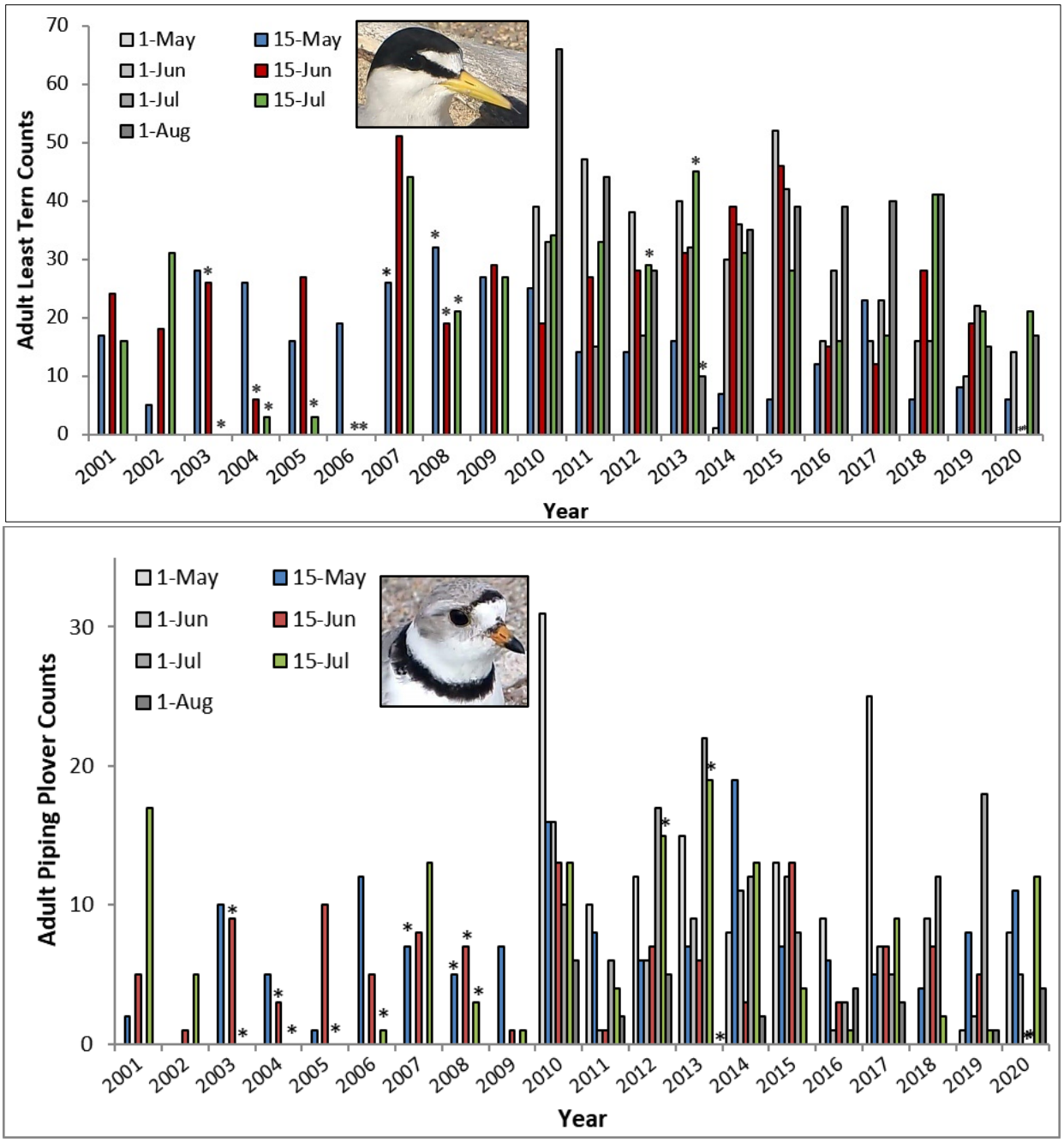


Figure 4. Numbers of least tern (top) and piping plover (bottom) adults observed during semi-monthly surveys of the Platte River between Lexington and Chapman, Nebraska, 2001-2020. *Sample periods for which at least one section of the river was not completed due to a lack of flow in the channel, high flow, or other restrictions.

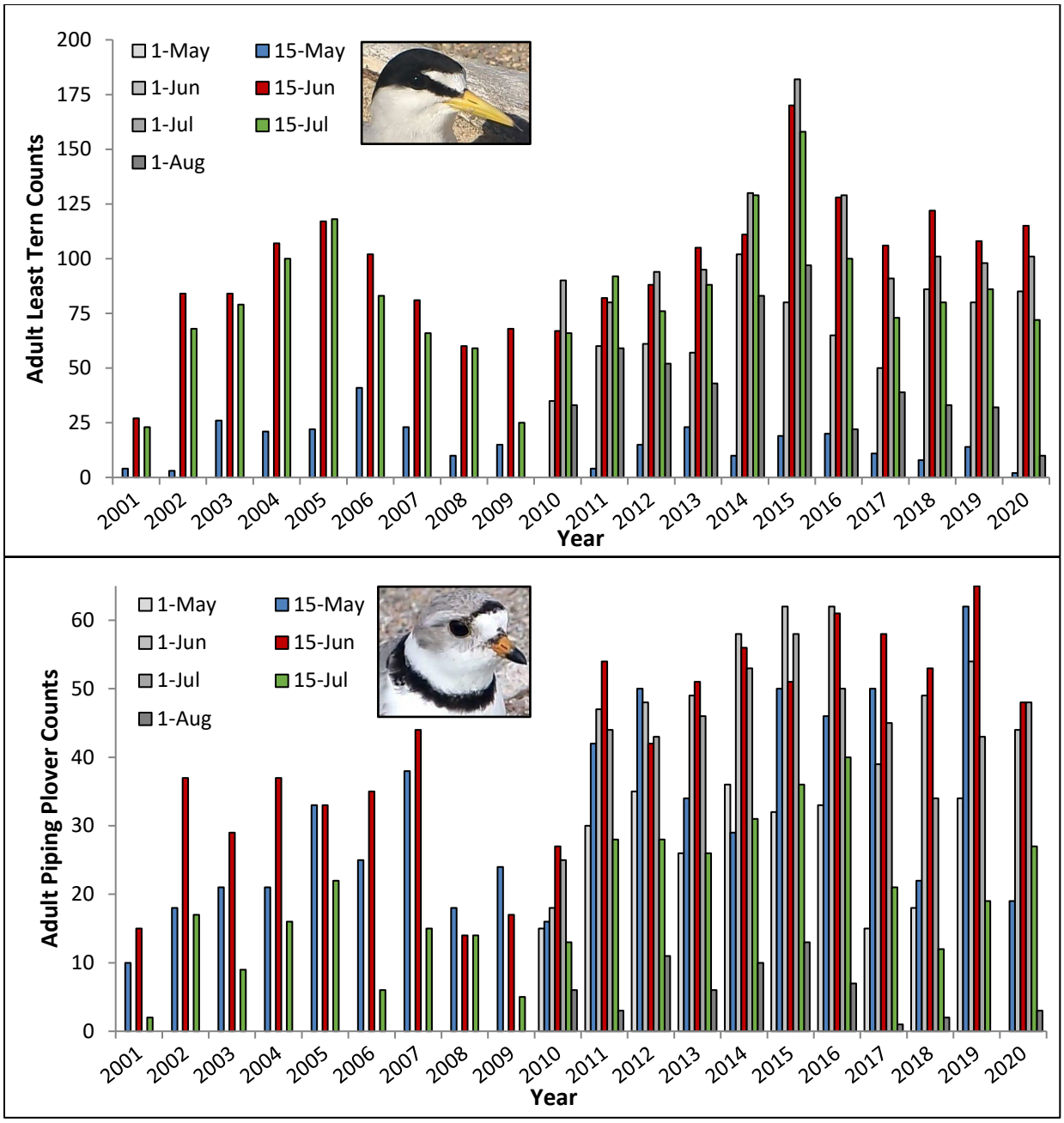
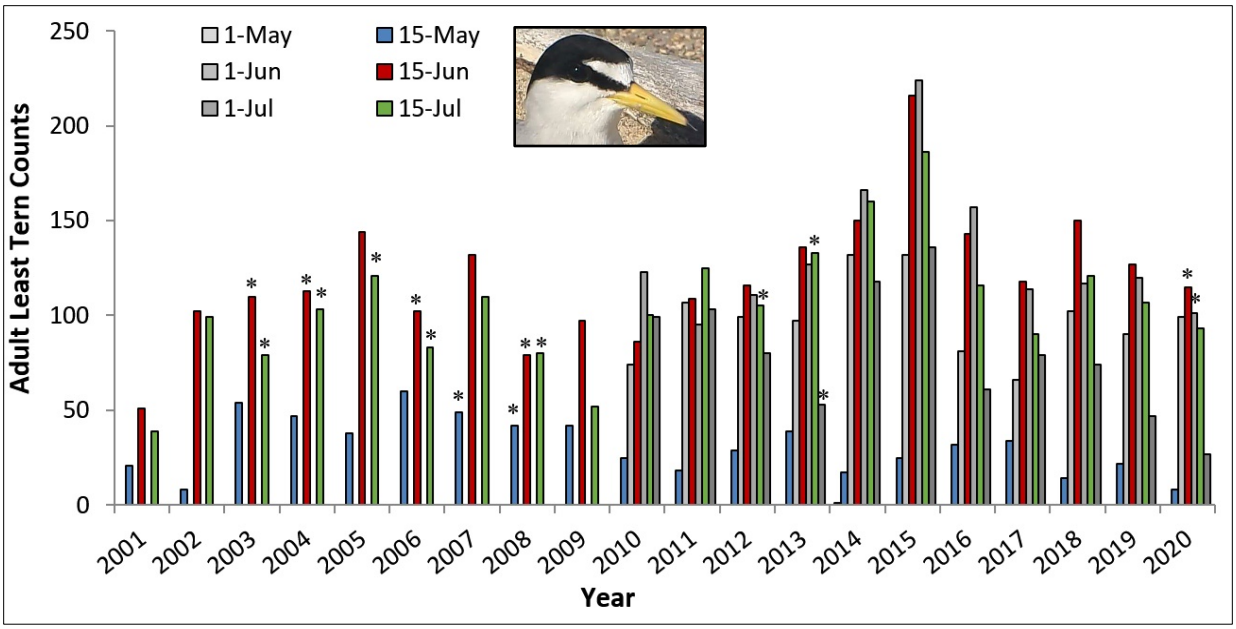


Figure 5. Numbers of least tern (top) and piping plover (bottom) adults observed during semi-monthly surveys of sandpits along the Platte River between Lexington and Chapman, Nebraska, 2001–2020.



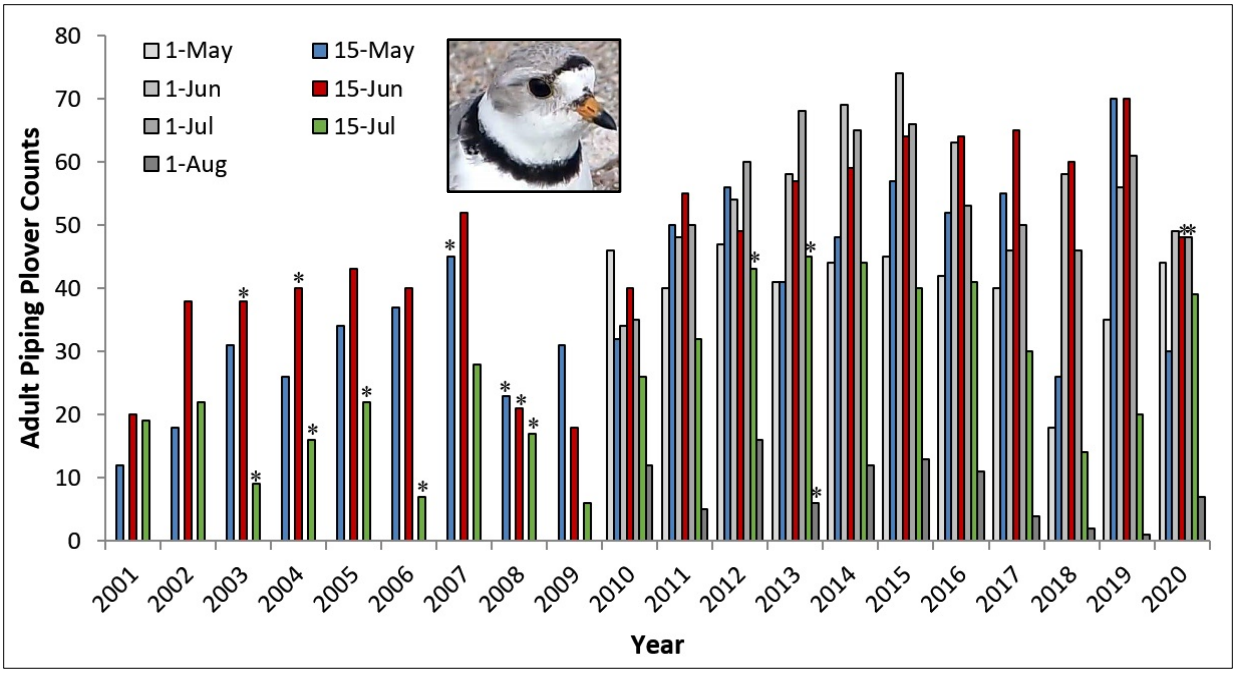


Figure 6. Numbers of adult least tern (top) and piping plover (bottom) adults observed during semi-monthly surveys of sandpits and central Platte River channels, combined, between Chapman and Lexington, Nebraska, 2001–2020.

* Sample periods for which at least one section of the river was not completed due to a lack of flow in the channel, high flow, or other restrictions.

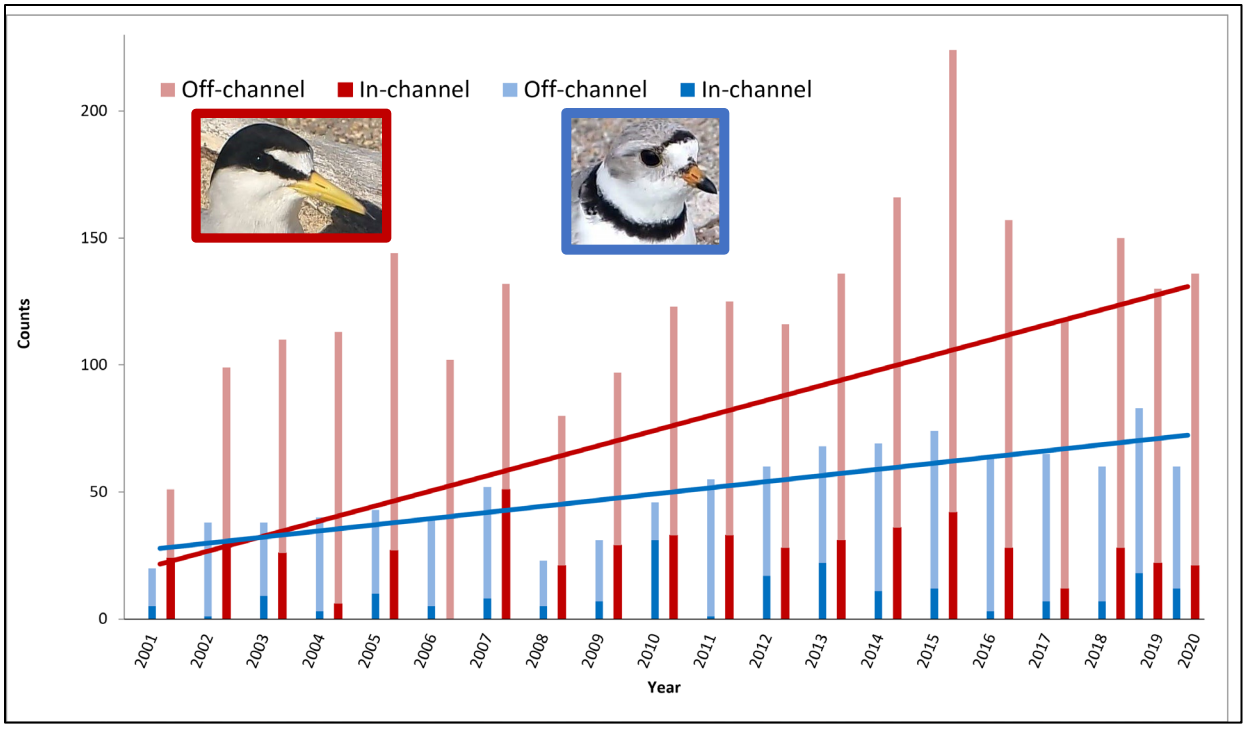


Figure 7. Trends (lines) in peak counts of least tern (red bars) and piping plover (blue bars) adults observed during semi-monthly surveys of sandpits (light blue and light red bars) and the central Platte River (dark blue and dark red bars) between Lexington and Chapman, Nebraska, 2001-2020.

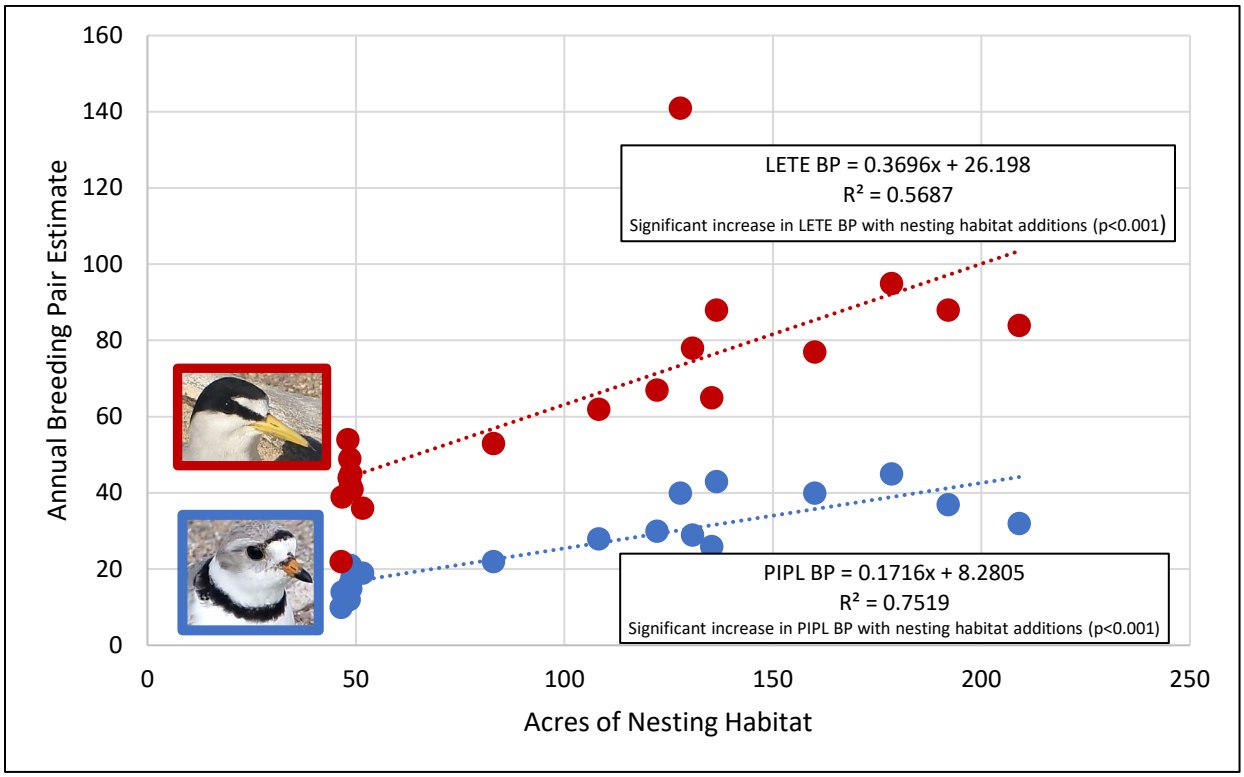


Figure 8. Relationship between numbers of least tern (red) and piping plover (blue) breeding pairs and availability of off-channel habitat within the Program Associated Habitat Reach, 2001-2020.

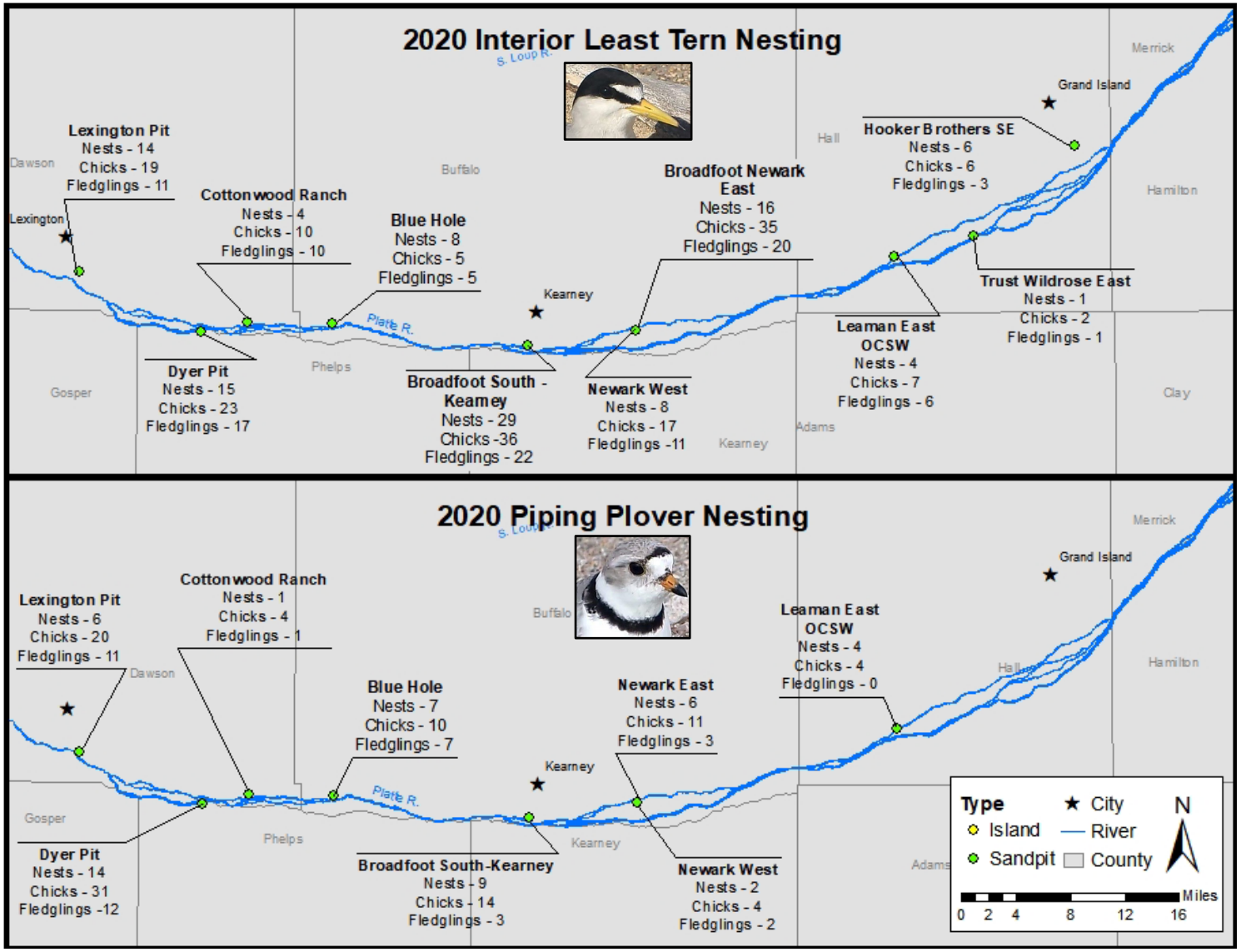


Figure 9. Distribution and numbers of least tern and piping plover nests, chicks, and fledglings observed within Program associated habitats during 2020 surveys of sandpits. Least tern nests and/or chicks were observed and monitored at 10 of the 16 sandpits and piping plover nests and chicks were observed and monitored at 8 of the 16 sandpits monitored during 2020.

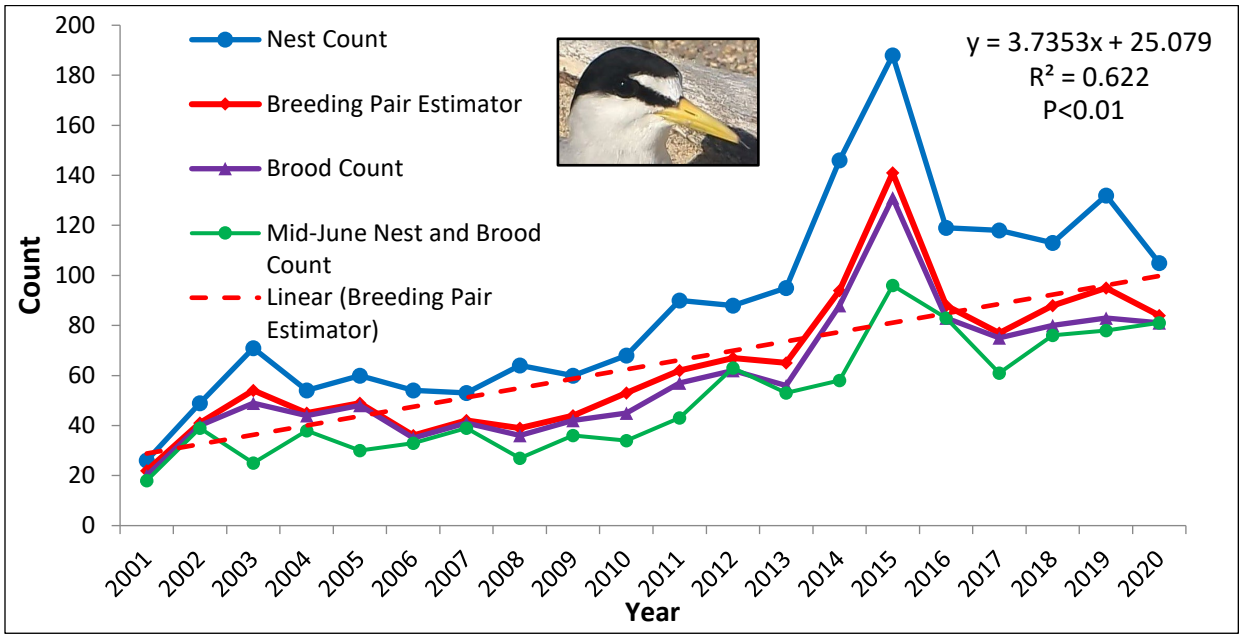


Figure 10. Annual total numbers of least tern nests, breeding pairs (and linear trend), broods, and the mid-June nest and brood counts observed within the Program Associated Habitat Reach, 2001-2020.

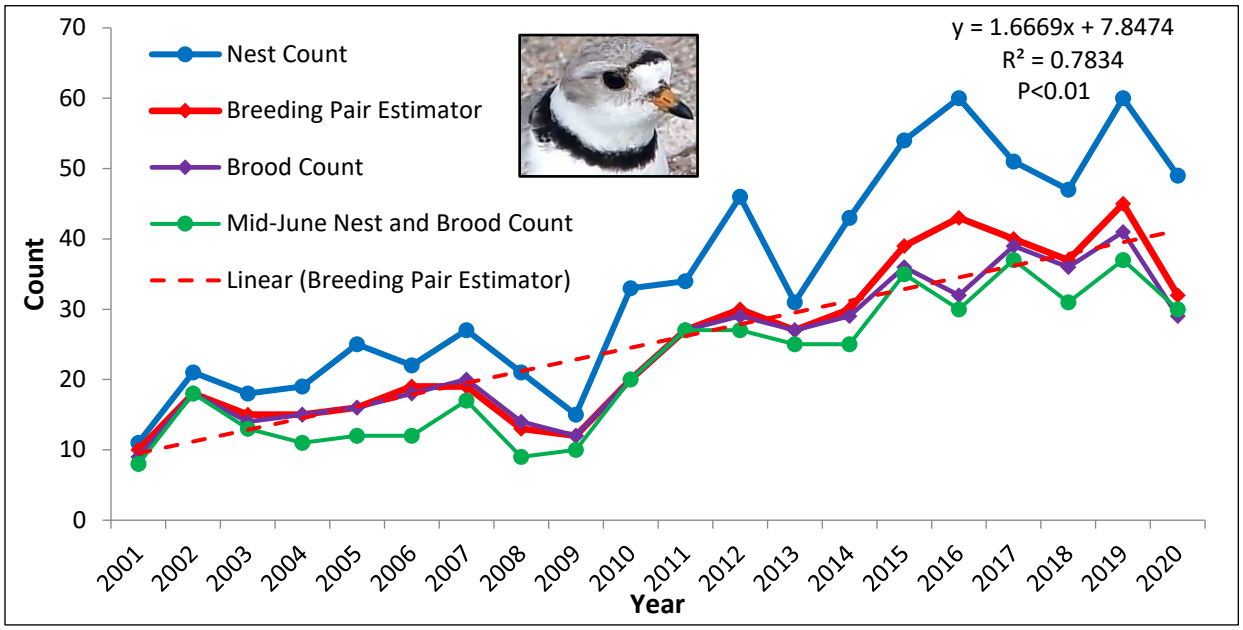


Figure 11. Annual total numbers of piping plover nests, breeding pairs (and linear trend), broods, and the mid-June nest and brood counts observed within the Program Associated Habitat Reach, 2001-2020.

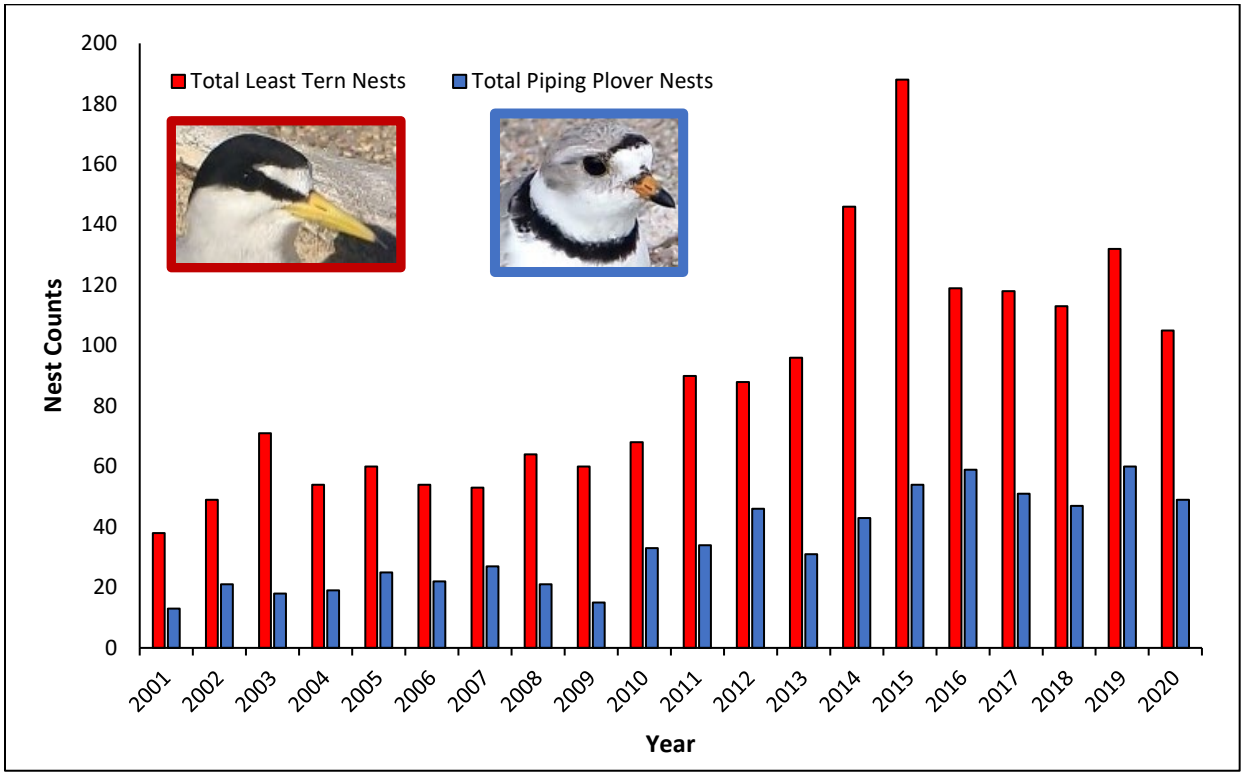


Figure 12. Comparison of total least tern (red bars) and piping plover (blue bars) nests within the Program Associated Habitat Reach, 2001-2020.

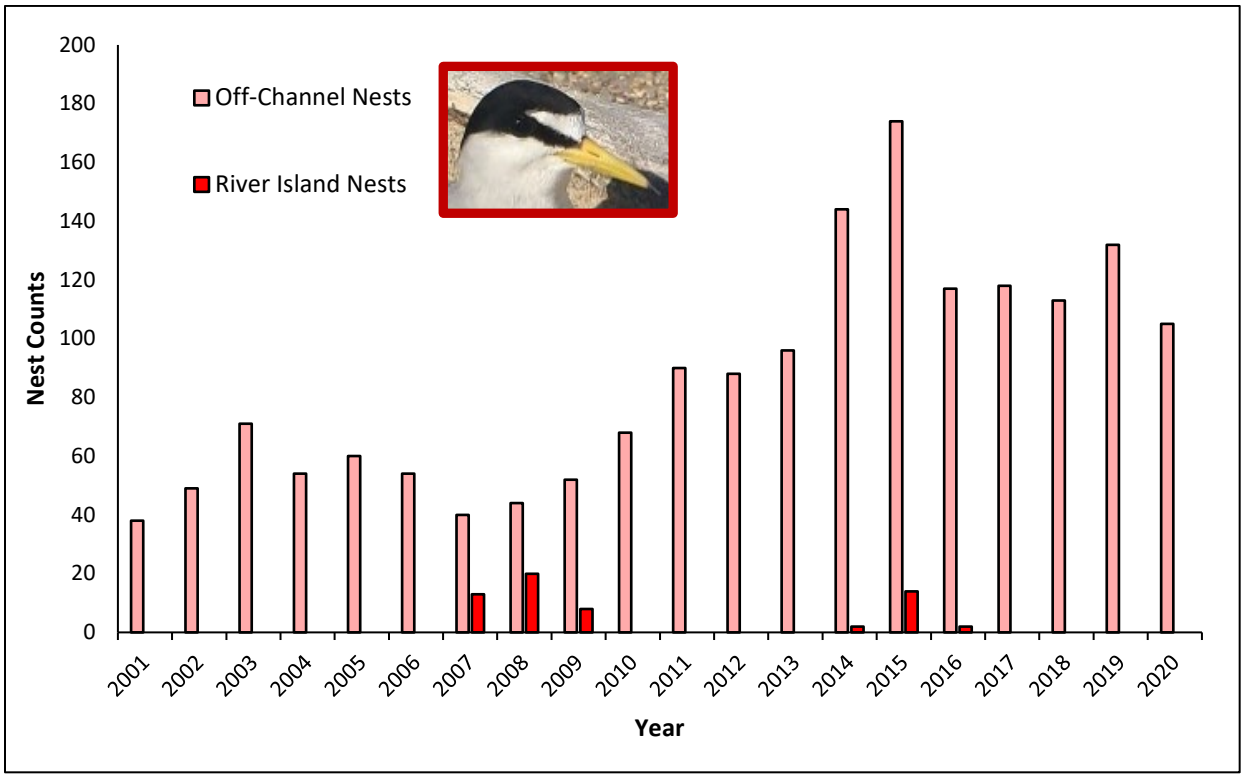


Figure 13. Comparison of least tern off-channel (light red bars) and on-channel (dark red bars) nests within the Program Associated Habitat Reach, 2001-2020.

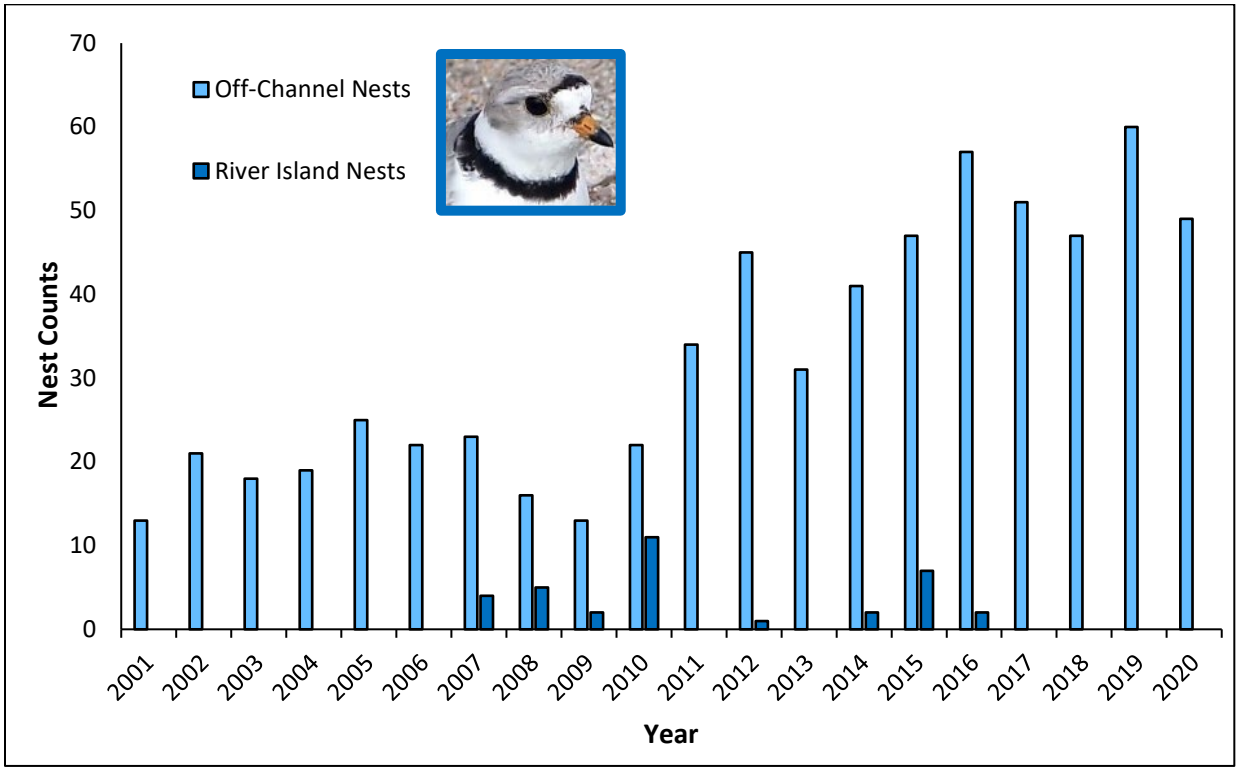


Figure 14. Comparison of piping plover off-channel (light blue bars) and on-channel (dark blue bars) nests within the Program Associated Habitat Reach, 2001-2020.

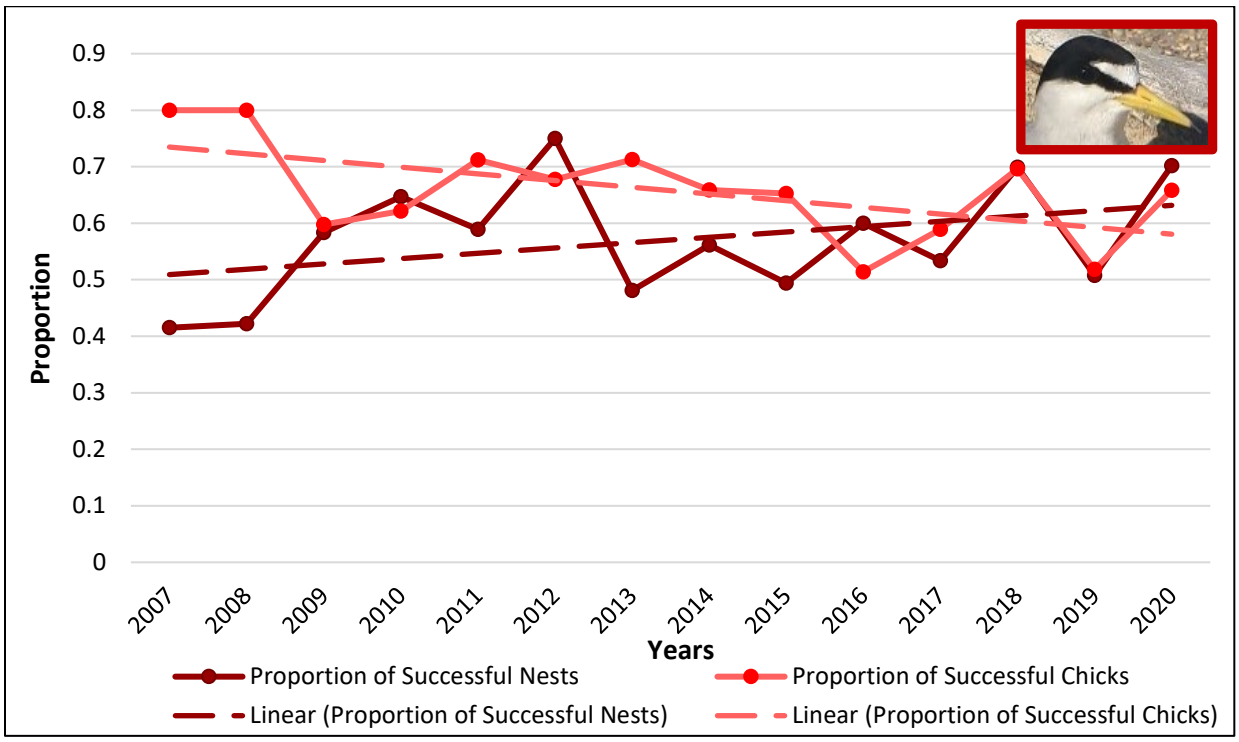


Figure 15. Proportion of successful nests and chicks (and linear trendline for each) for least terns from 2007-2020.

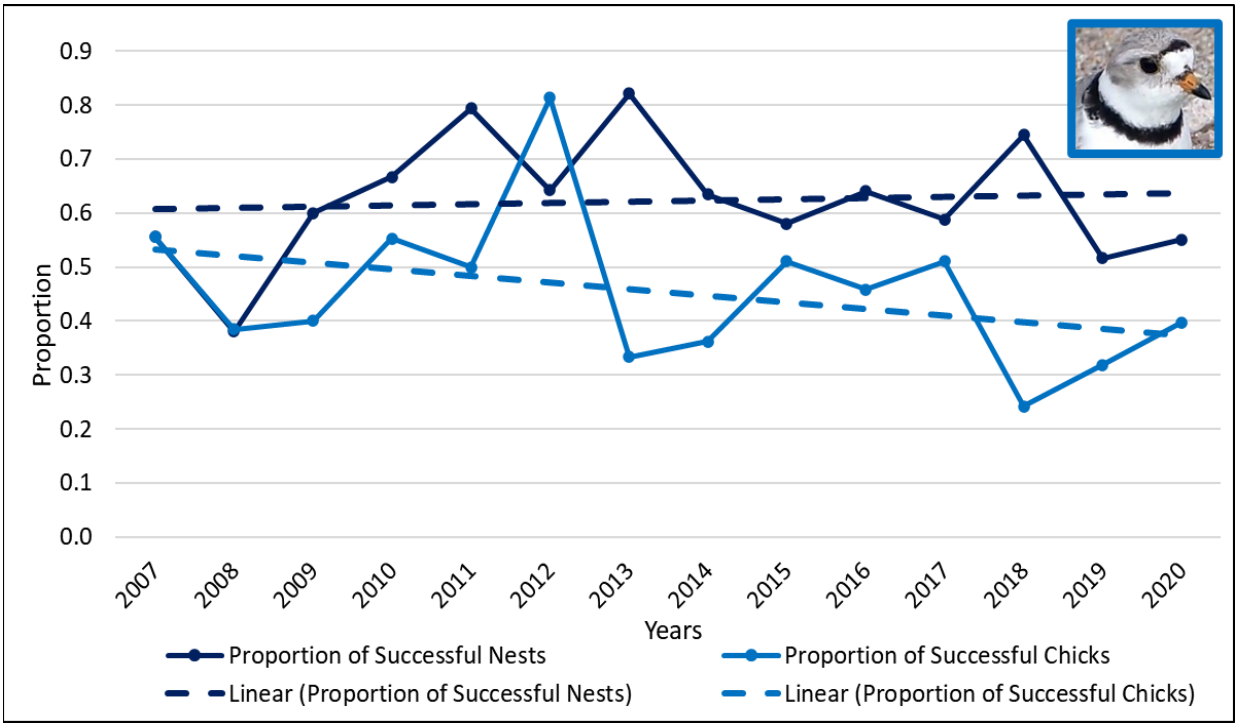


Figure 16. Proportion of successful nests and chicks (and linear trendline for each) for piping plovers from 2007-2020.

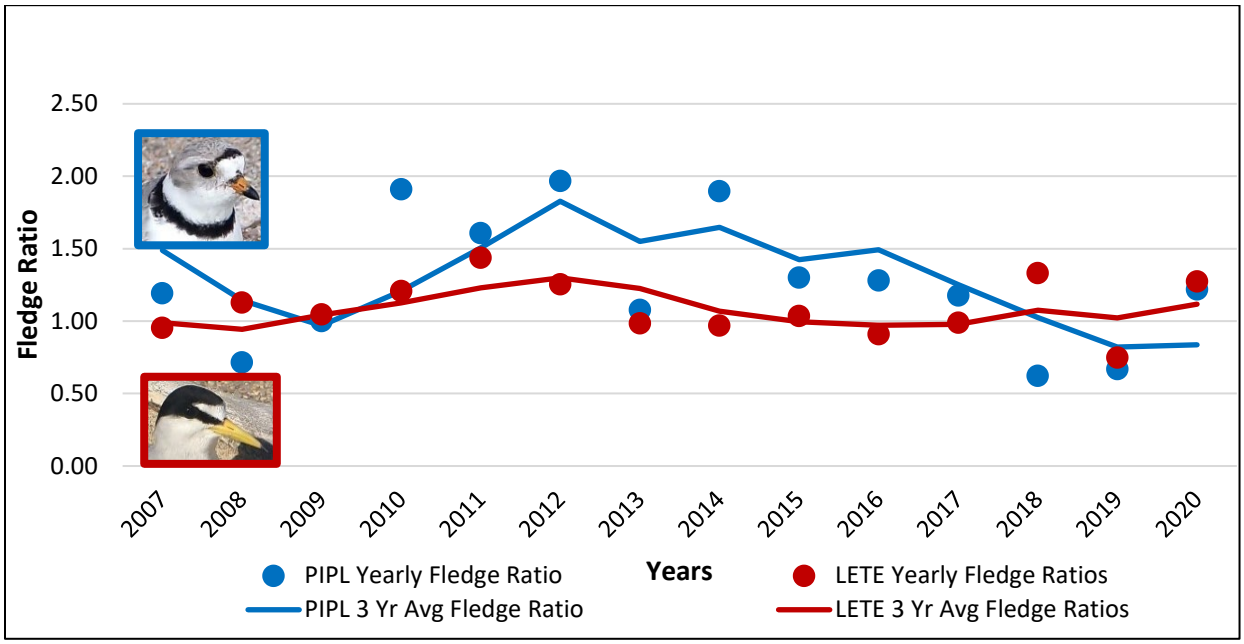


Figure 17. Annual fledge ratios (points) and 3-year running average fledge ratios (lines) for least terns (blue) and piping plovers (red) from 2007-2020.

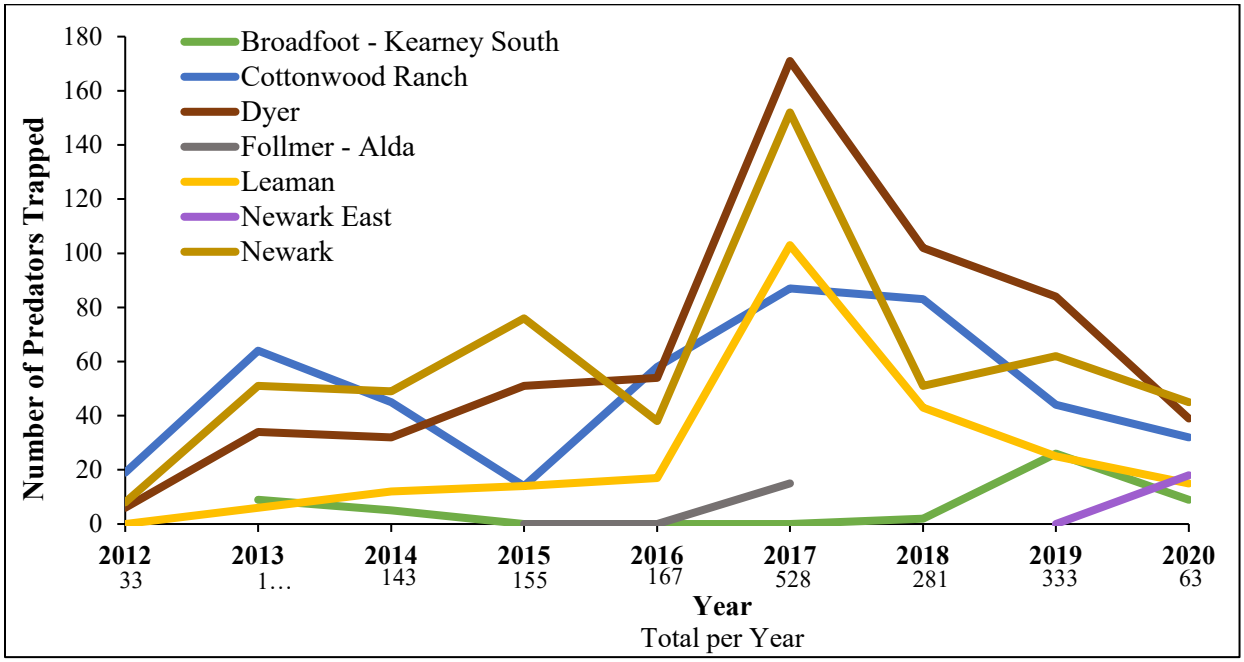


Figure 18. Numbers of predators trapped at Program-managed off-channel nesting sites 2012–2020. Predators trapped include badger, bobcat, coyote, red-fox, opossum, raccoon, skunk, weasel, and woodchuck. Predator trapping efforts at off-channel sites increased substantially in 2017. Trapping did not occur at Broadfoot South-Kearney during 2012 or at Follmer-Alda during 2012−2014 or 2018-2020. Predators trapped at Newark West and Newark East were previously reported as a total for both sites and are labeled here as Newark until 2020 when Newark East was reported separately from Newark West.

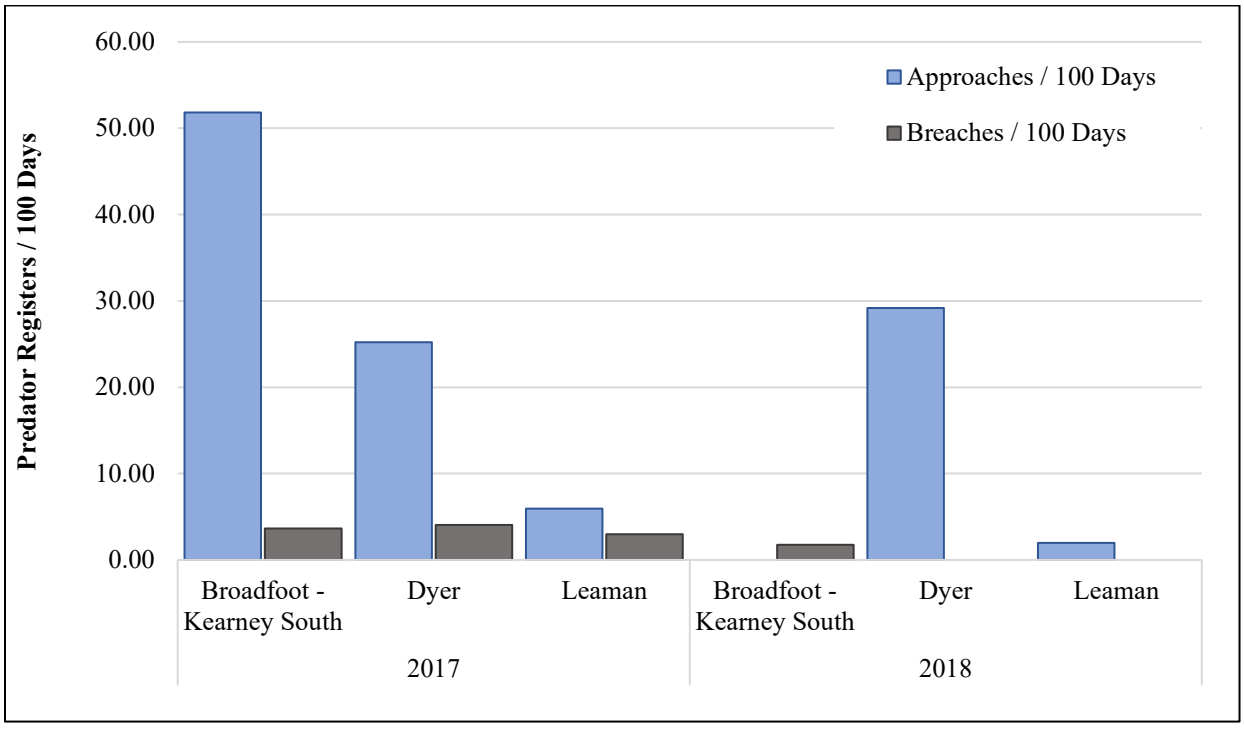


Figure 19. Registers of potential predator approaches and breaches per 100 days of panel wing camera effort at the off-channel nesting sites indicated during 2017 and 2018.

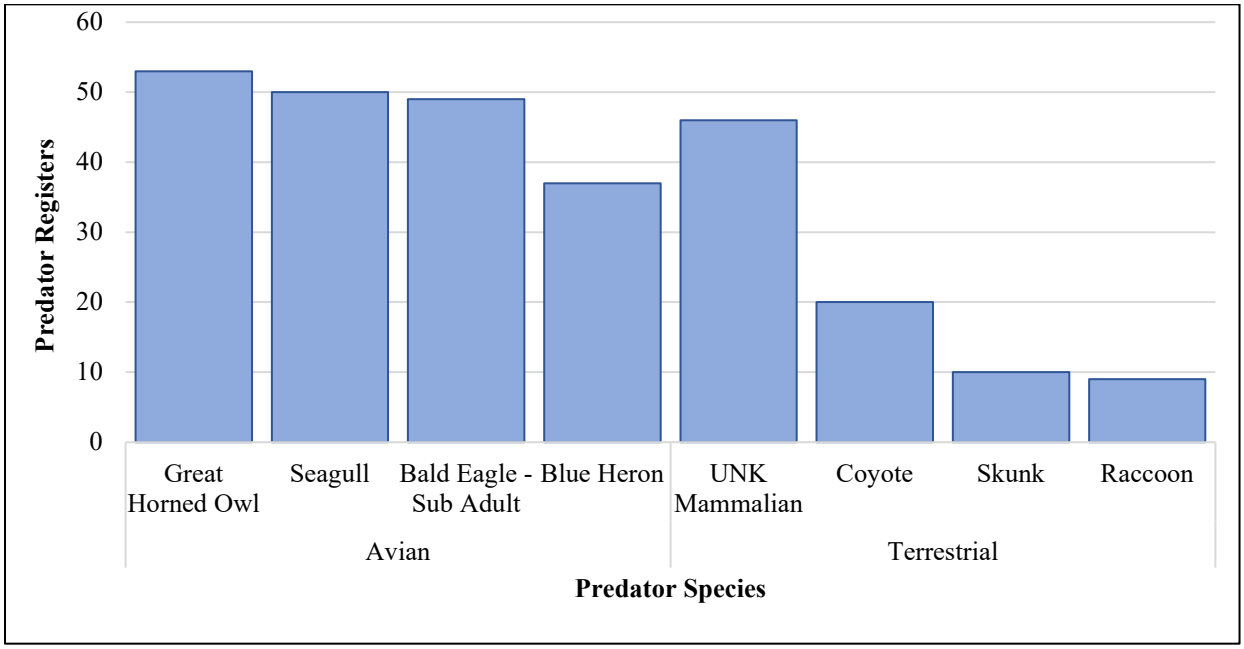


Figure 20. Top 4 most frequently registered avian and mammalian predators on site-level cameras at off-channel nesting sites; Blue Hole, Broadfoot South-Kearney, Dyer, Leaman East, and Lexington, during 2017 and 2018.

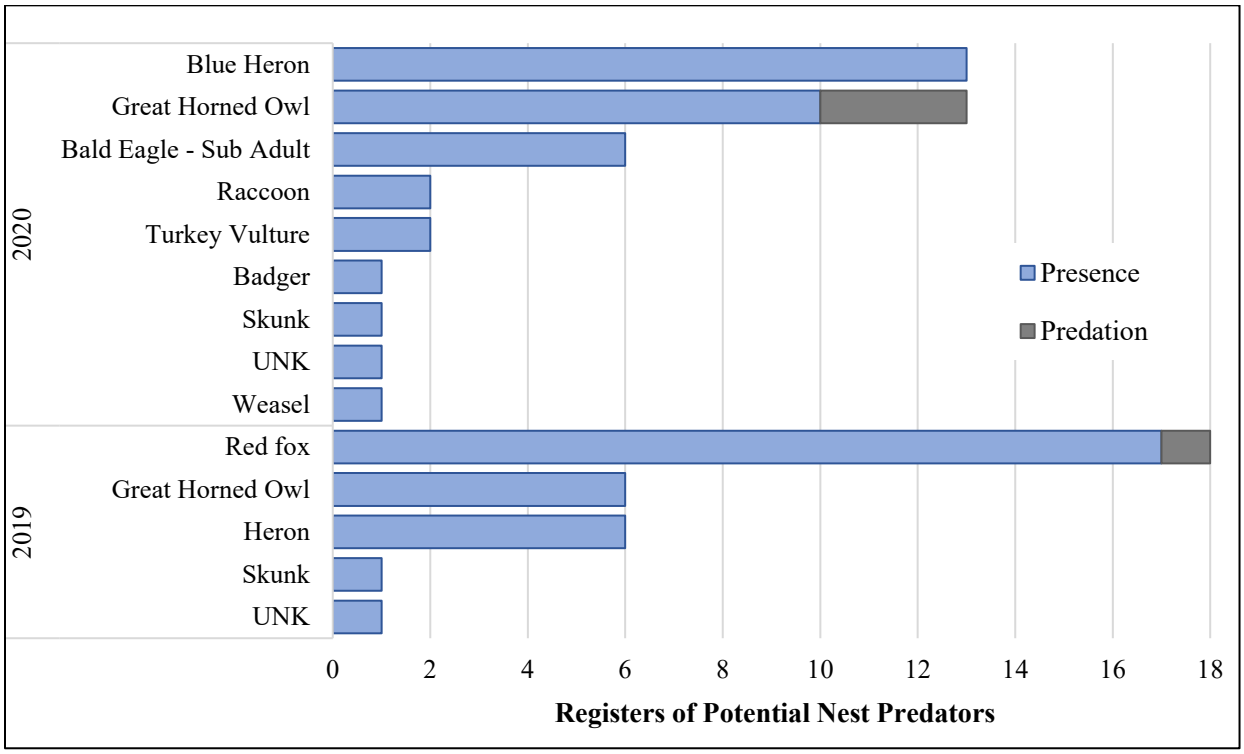


Figure 21. Registers of potential nest predator presence (blue) and predation events (grey) at least tern and piping plover nests at off-channel nesting sites; Broadfoot South–Kearney, Leaman East, Newark East and Newark West, during 2019 and 2020.

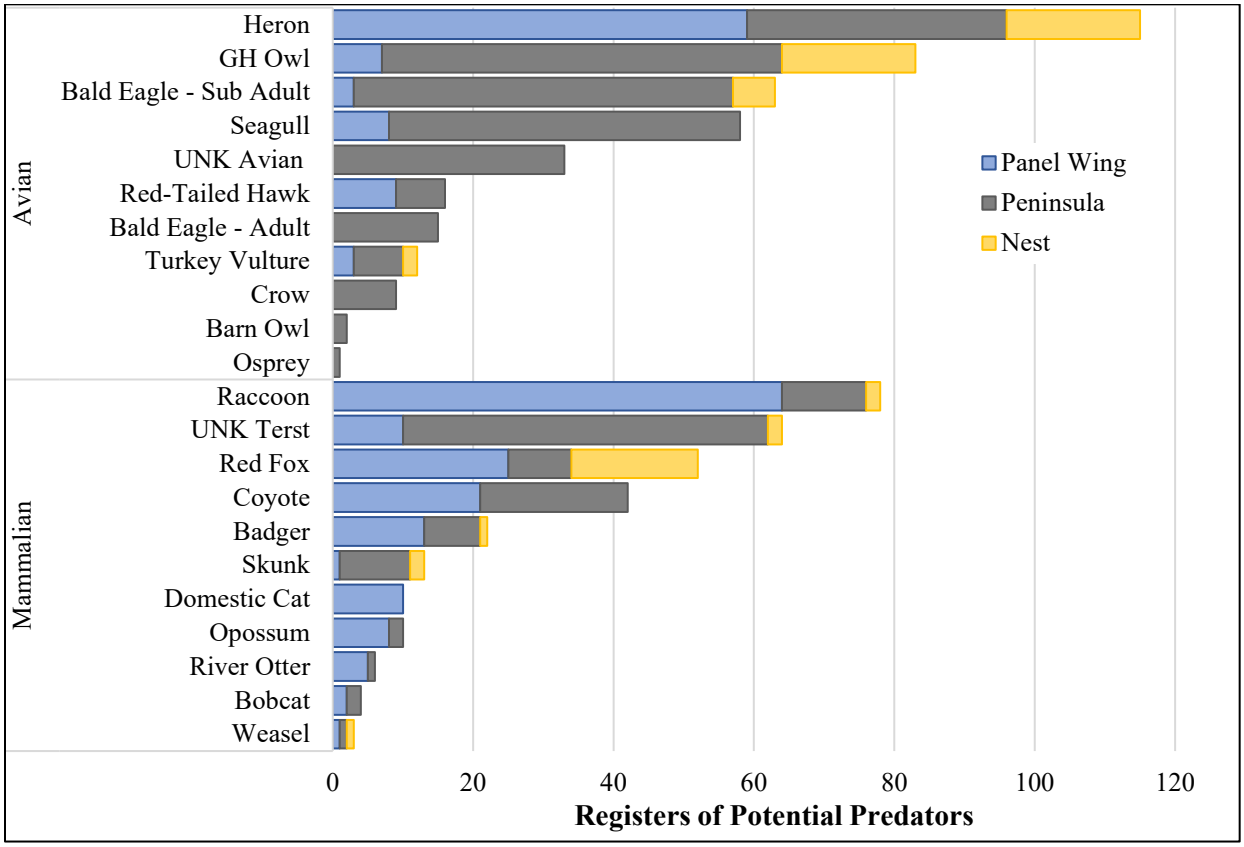


Figure 22. Total camera registers of potential predators at the panel wings (blue), on the nesting peninsulas (grey), and at tern and plover nests (yellow) at off-channel nesting sites; Blue Hole, Broadfoot South-Kearney, Dyer, Leaman East, Lexington, Newark East and Newark West, during 2017-2020.

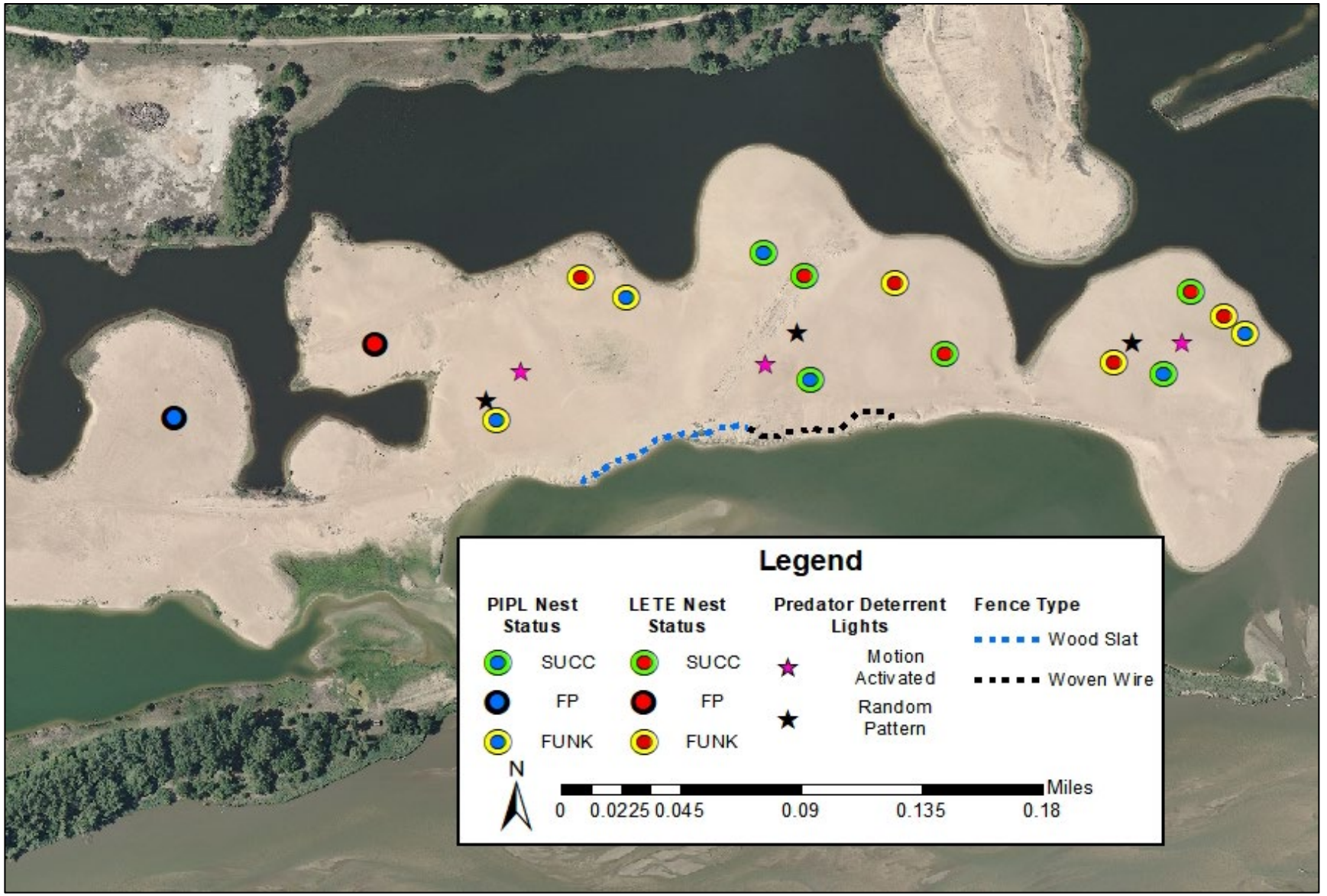


Figure 23. Least tern (red inner dot) and piping plover (blue inner dot) nest locations, as well as location of wood slat fence (blue dashed line) and woven wire fence (black dashed line) locations on Bluehole. Final nest statuses are denoted by the colored outer rings. Successful (SUCC) nests have a green outer ring, predated (FP) nests black, and failed unknown (FUNK) nests are yellow. Also pictured are the motion activated lights (pink stars) and random pattern lights (black stars).

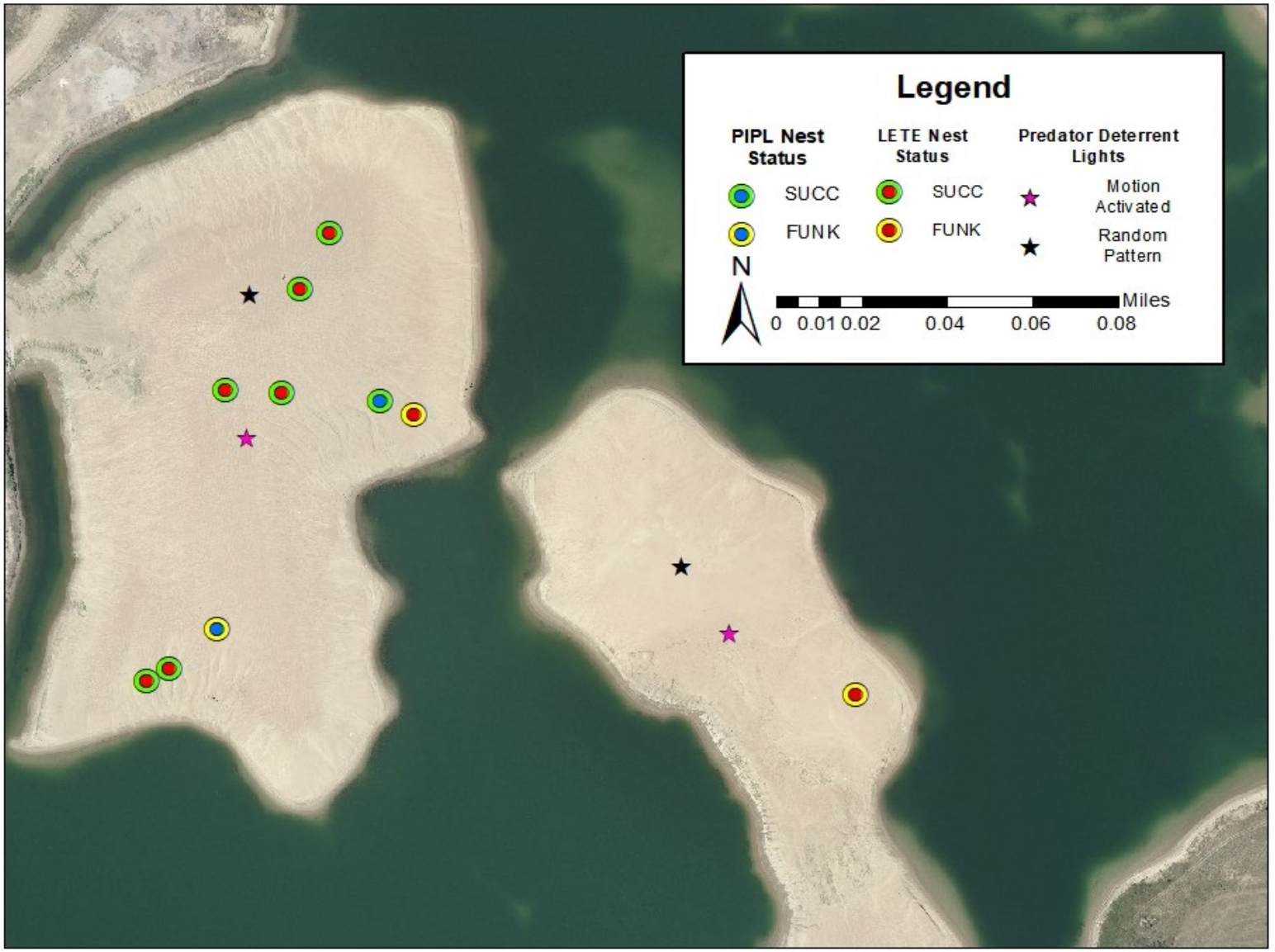


Figure 24. Locations of predator deterrent lights on Newark West. Motion activated lights (pink stars) and random pattern lights (black stars). Least tern nests (red dots) and piping plover nests (blue dots) are pictured in relation to the lights. Final nest statuses are denoted by the colored outer rings. Successful (SUCC) nests have a green outer ring and failed unknown (FUNK) nests are yellow. There were no predated (FP) nests at this site in 2020.

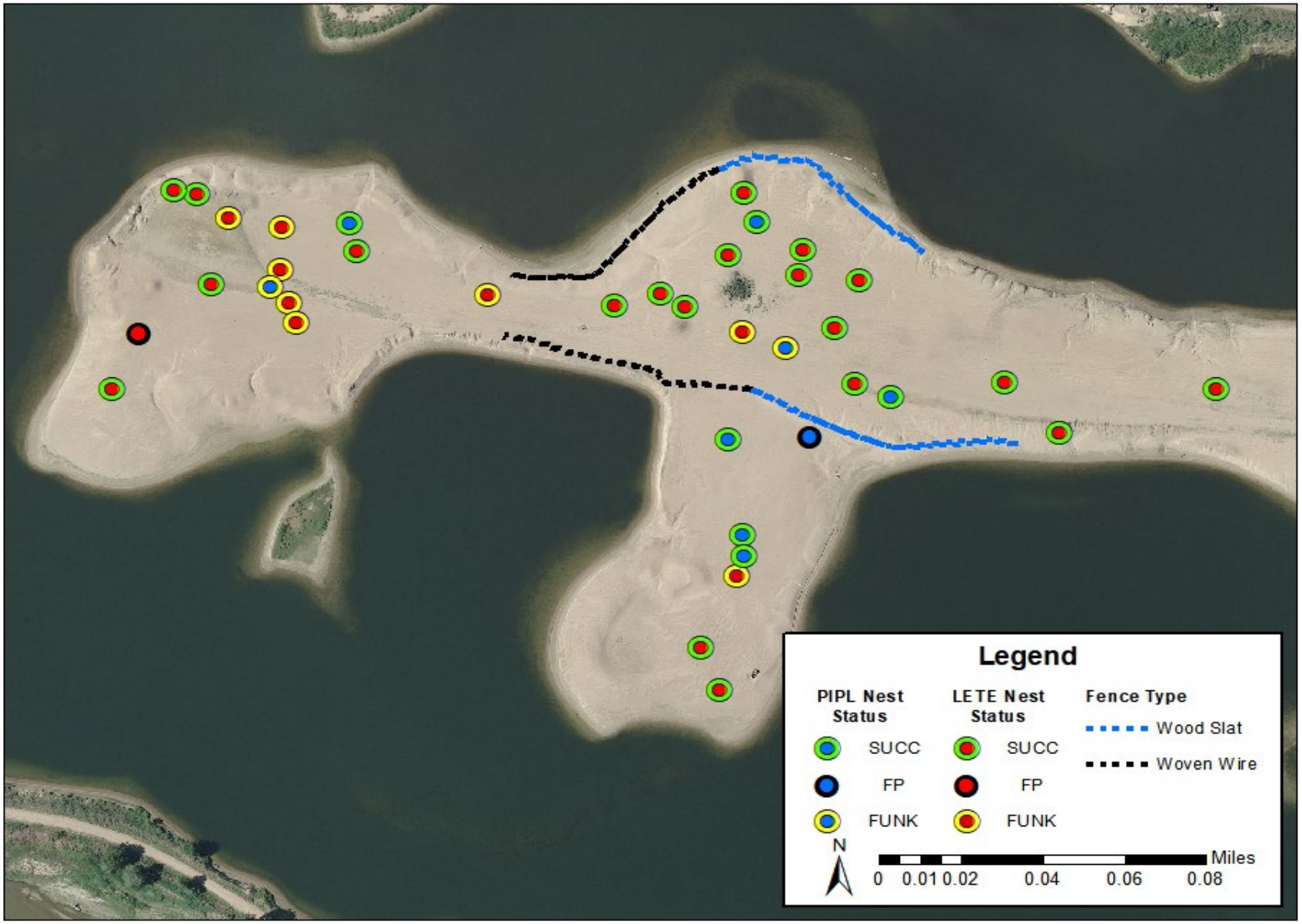


Figure 25. Least tern (red inner dot) and piping plover (blue inner dot) nest locations, as well as location of wood slat fence (blue dashed line) and woven wire fence (black dashed line) locations on Broadfoot South-Kearney. Final nest statuses are denoted by the colored outer rings. Successful (SUCC) nests have a green outer ring, predated (FP) nests black, and failed unknown (FUNK) nests are yellow.

Figure 26. Turtle trap locations (green circle) at Dyer. Standard UTM GPS Locations 14N: D1 (453545, 4503144), D2 (453250, 4503238), D3 (452945, 4503229), D4 (453054, 4502960). Nearby habitat includes sand and gravel pits, palustrine wetland, and a sandy bottom braided river (central Platte River).

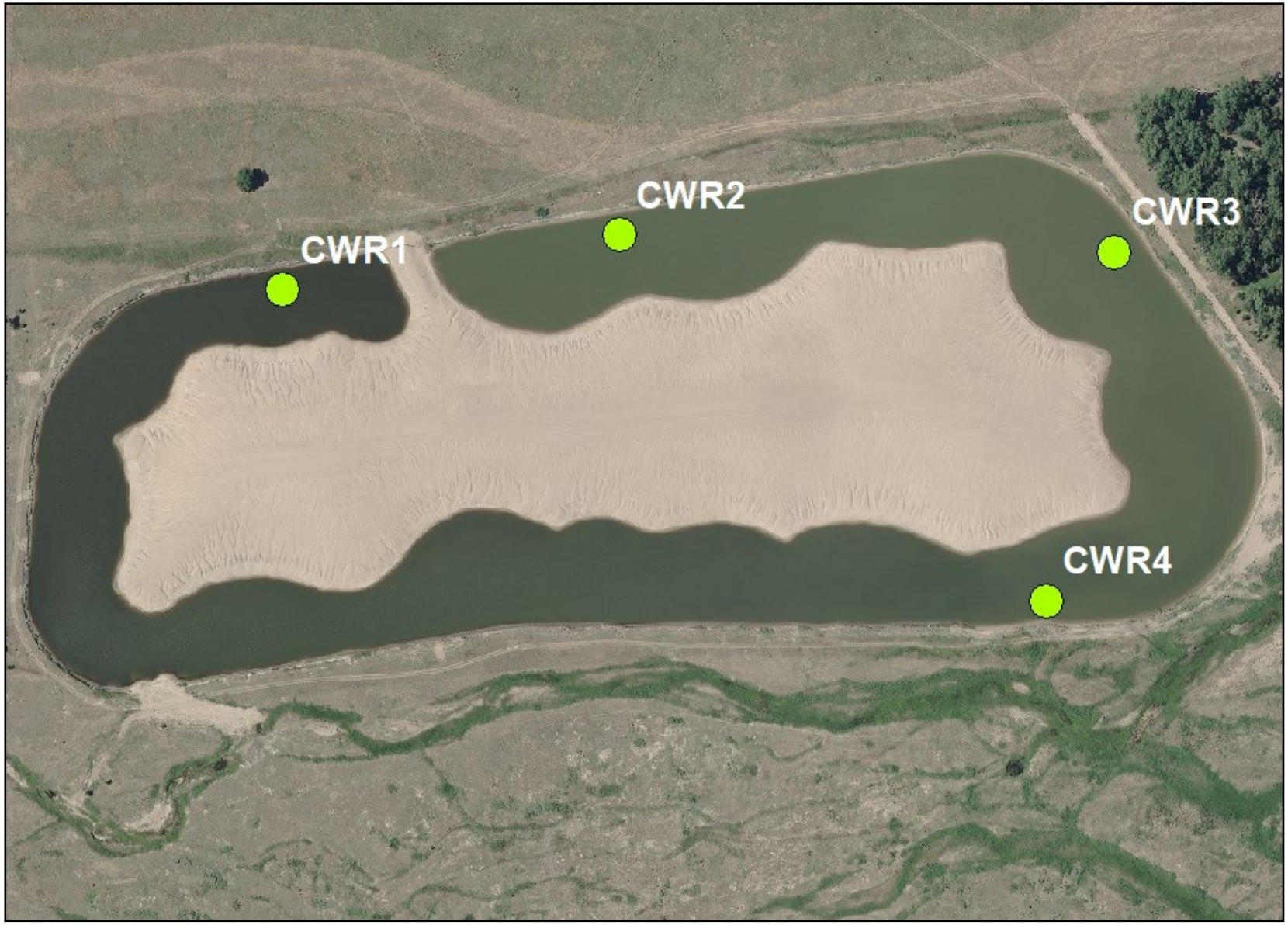


Figure 27. Turtle trap locations (green circle) at Cottonwood Ranch. Standard UTM GPS Locations 14N: CWR1 (458538, 4504303), CWR2 (458707, 4504327), CWR3 (458944, 4504350), CWR4 (459052, 4504159). Nearby habitat includes a sand and gravel pit, wetlands, sloughs, upland woodland, river shrubland, and a sandy bottom braided river (central Platte River).

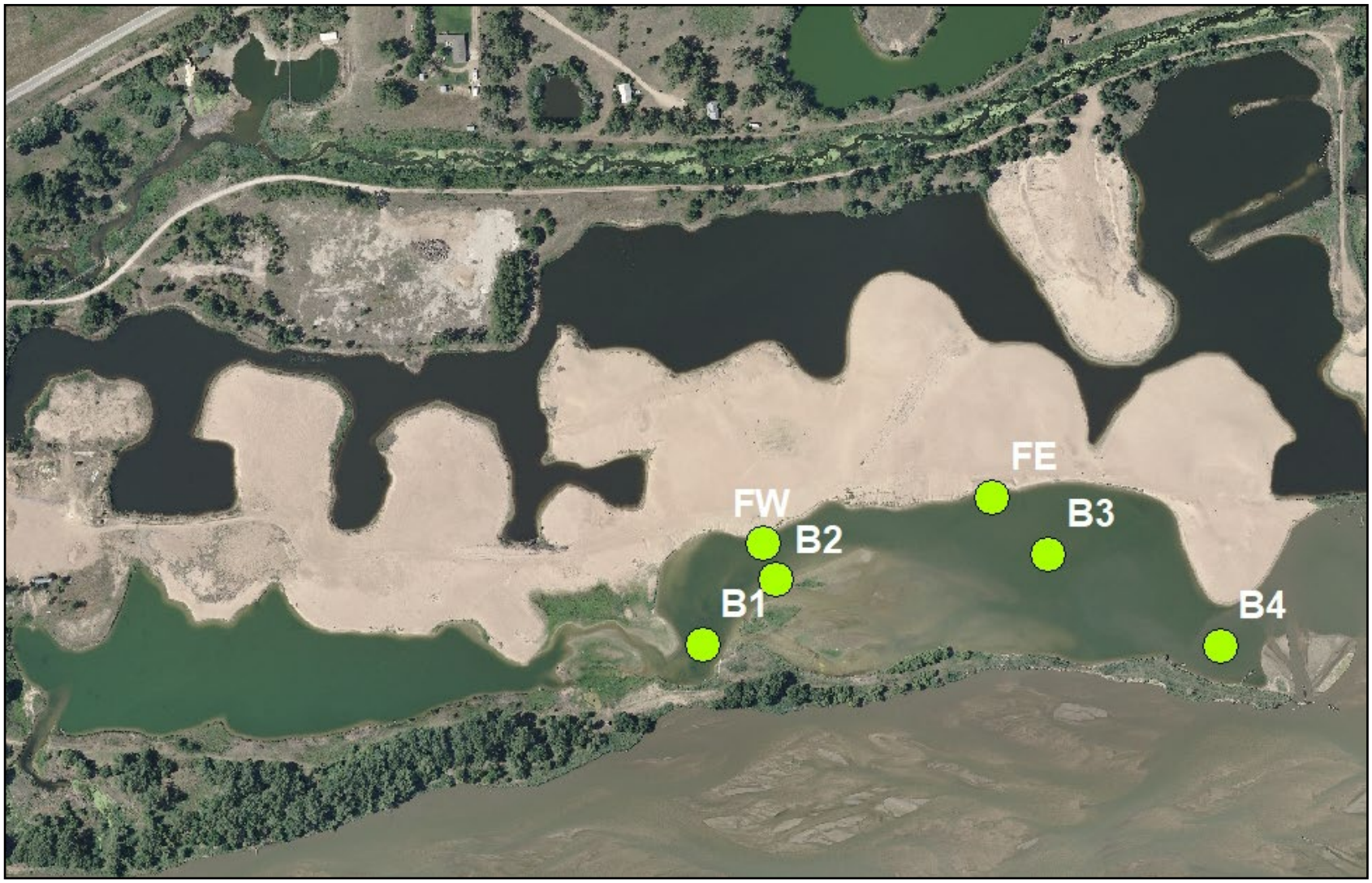


Figure 28. Turtle trap locations (green circle) at Bluehole. Standard UTM GPS Locations 14N: B1 (468557, 4503855), B2 (468608, 4503913), B3 (468820, 4503931), B4 (468963, 4503858), FE (468777, 4503968), FW(468617, 4503942). FE and FW denote funnel trap placement at the ends of turtle fencing. Nearby habitat includes a sand and gravel pit, ponds, riparian and upland woodland, bare ground/sparsely vegetated, rural development, and a nearby sandy bottom braided river (central Platte River).

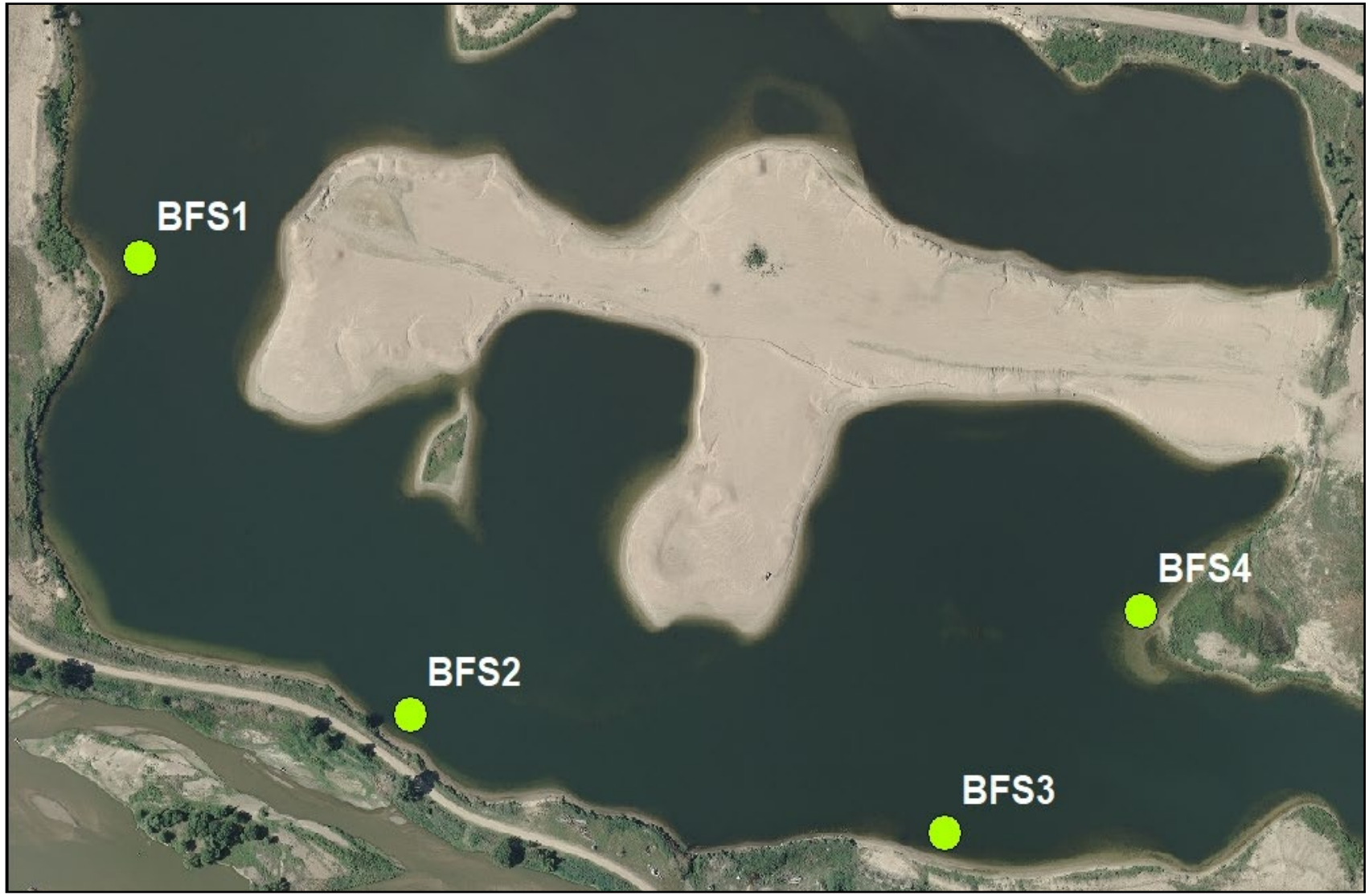


Figure 29. Turtle trap locations (green circle) at Broadfoot South-Kearney. Standard UTM GPS Locations 14N: BFS1 (491294, 4501605), BFS2 (491505, 4501307), BFS3 (491792, 4501263), BFS4 (491928, 4501430). Nearby habitat includes a sand and gravel pit, development, bare ground/unvegetated, riparian woodland, and a nearby sandy bottom braided river (central Platte River).