Platte River Recovery Implementation Program

Piping Plover and Interior Least Tern Monitoring and Research on the Central Platte River, Nebraska, in 2024
FINAL REPORT

Prepared for:
Technical Advisory Committee
Governance Committee

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25 March 2025

Suggested Citation:

PRRIP. 2025. Platte River Recovery Implementation Program: Piping plover and interior least tern monitoring and research on the central Platte River, Nebraska, in 2024. 2024 Annual Report.

PREFACE

This report summarizes the Platte River Recovery Implementation Program's (Program or PRRIP) monitoring and research efforts for piping plovers and interior least terns during 2024. We prepared this report to inform Program partners, licensing agencies, and the public of our activities and to provide a summary of results to fulfill the requirements of the Program's state (Nebraska Master Permit #1421) and federal (TE183430-3.3) monitoring permits.

Annual monitoring reports produced by West Incorporated (2001-2007) and Program EDO staff (2008-2024) include previous data and analyses and are available on the Program's online Public Library (https://platteriverprogram.org/program-library). PRRIP's published data are also available for use by other programs to provide information on plover and tern productivity on the central Platte River that may be helpful for broader scale interpretation of species productivity and management decisions.

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TABLE OF ABBREVIATIONS

Abbreviation	Definition
ac	Acres
AHR	Associated Habitat Reach
AMP	Adaptive Management Plan
BPE	Breeding Pair Estimate
cfs	Cubic feet per second
CI	Confidence interval
CNPPID	Central Nebraska Public Power and Irrigation District
CPNRD	Central Platte Natural Resources District
Cooperative Agreement	Cooperative Agreement for Platte River Research and Other Efforts Relating to Endangered Species Habitats
DSR	Daily survival rate
EA	Environmental Account
EDO	Executive Director's Office
ESA	Endangered Species Act
ft	Feet or foot
GC	Governance Committee
ISAC	Independent Scientific Advisory Committee
J-2	Johnson Hydropower Return
LCL	Lower confidence limit
MCA	Moving complex approach
mi	Mile or miles
NPPD	Nebraska Public Power District
OCSW	Off-channel sand and water
PRRIP or Program	Platte River Recovery Implementation Program
sec	Second
TAC	Technical Advisory Committee
UCL	Upper confidence limit
USDA-APHIS-WS	United States Department of Agriculture and Animal and Plant Health Inspections Service Wildlife Services
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

EXECUTIVE SUMMARY

Improving productivity of piping plovers (*Charadrius melodus*; hereafter plovers) and interior least terns (*Sternula antillarum*; hereafter terns) on the central Platte River is a primary management objective of Platte River Recovery Implementation Program ("Program" or "PRRIP"). Long-term monitoring of plovers and terns by the Program has been key to understanding the status of both species along the central Platte River. During 2024, the Executive Director's Office (EDO) and Program partners surveyed the river and 18 adjacent off-channel sand and water (OCSW) sites for plovers and terns along PRRIP's Associated Habitat Reach (AHR) on the central Platte River between Lexington and Chapman, Nebraska. Biologists conducted surveys twice per month between 1 May and 1 August to count the number of adults and nests. Once at least one nest was found, biologists monitored the site twice per week to determine nest fate and if the nest was successful, count number of chicks, monitor chick fates, and quantify number of fledglings. In addition to these monitoring efforts, the EDO implemented additional remote camera monitoring, predator track surveys, and predator management actions at six Program-managed OCSW sites for the fourth consecutive year to better understand the role of predation on plover productivity and the efficacy of predator deterrents on nest and chick predation. Below, we summarize results from our 2024 plover and tern monitoring, and predator management and monitoring efforts.

Plover Monitoring

Plovers nested at 12 of 18 OCSW sites that provided a total of 246 ac of potential nesting habitat during 2024. We have observed a significant, positive relationship between the estimated number of plover breeding pairs and area of potential nesting habitat at OCSW sites since 2001. We estimated a peak of 47 plover breeding pairs (BPE) at our monitored sites across the AHR during 2024, which was the highest BPE to date. Thirty-five of 74 plover nests were successful, resulting in the lowest apparent nest success (0.47) observed during the contemporary 2010-2024 monitoring period. However, 74 total nests is the highest number of nests ever observed by the Program and 35 successful nests is a comparable number to past years (28 successful nests in 2020, 30 successful nests in 2021 and 2022, and 40 successful nests in 2023). Plover nests produced 120 chicks (<15 days old) and 63 fledglings (≥28 days old), which is the most fledglings ever observed on our sites. We observed a slightly lower fledge ratio in 2024 (1.34 chicks/BPE) compared to 2022 and 2023 (1.41 chicks/BPE in both years).

We observed a high amount of variability in plover reproductive effort and success among sites. Blue Hole, Newark West, Newark East, Leaman, and Trust Wildrose East were the most productive OCSW nesting sites for plovers in 2024 with fledge ratios ≥1. Newark West and Leaman are both sites that had low fledge ratios the last two years (0.00 chicks/BPE for both sites in 2022; 0.33 chicks/BPE and 0.00 chicks/BPE, respectively in 2023; site-specific peak date used to estimate BPE). This year, however, these two sites not only had fledge ratios ≥1, Newark West had the highest fledge ratio on any site in 2024 (3.67 chicks/BPE; site-specific peak date used to estimate BPE). The other seven OCSW sites at which we observed plover nesting had between zero and seven successful nests. Fledge ratios at these seven sites ranged between 0.0 chicks/BPE and 0.75 chicks/BPE (site-specific peak date used to estimate BPE).

We successfully assigned nest fates to 67 of the 74 plover nests observed during 2024. Twenty-two nests failed due to predation (0.30 of total nests), four failed due to abandonment (0.05), and six failed due to weather (0.08). Three nests failed due to unknown causes (0.04) and four nests had an unknown outcome (0.05). Of the 35 nests that were successful, 24 fledged (0.32 of total nests) and one failed due to predation (0.01). Ten broods failed due to unknown causes (0.14). Since initiating remote camera monitoring in 2020, the proportion of nests and broods that failed due to unknown causes has decreased from a maximum of 0.57 of nest fates in 2019 to 0.18 in 2024.

Results from our 2024 plover monitoring efforts indicate continued increases in plover use and nest productivity metrics on monitored sites across the central Platte River from recent lows observed during 2018 and 2019. More nests were observed this year than in any previous year. High nest numbers were at least partially due to renesting after losses to predation and weather events, resulting in low apparent nest success this year. Even with the low apparent nest success, OCSW sites produced more fledglings than prior years. Higher numbers of fledglings is likely attributable to successful nesting on sites in the eastern half of the reach that experienced fewer losses to predation and weather events.

Tern Monitoring

Terns nested at 12 of 18 OCSW sites during 2024 and there has been a positive relationship between the estimated number of tern breeding pairs and area of potential nesting habitat at OCSW sites since 2001. We estimated a peak of 141 tern breeding pairs at our monitored sites, the highest number since 2015 (also 141). Of 221 tern nests, 95 were successful for an apparent nest success of 0.43, the lowest observed during the contemporary 2010-2024 monitoring period. Tern nests produced 184 chicks (<15 days old) and 118 fledglings (≥28 days old). The fledge ratio (0.84 chicks/BPE) is the lowest observed since 2019 (0.75 chicks/BPE). However, the number of tern fledglings is comparable to the number of fledglings observed in 2023 (124 fledglings).

We observed a high amount of variability in tern reproductive effort and success among sites. Blue Hole, Non-Access Islands (NAI) Kearney Broadfoot South, Newark West, Leaman, and Follmer were the most productive OCSW nesting sites for terns in 2024 with fledge ratios ≥1. Newark West also had the highest fledge ratio for terns on any site in 2024 (1.36 chicks/BPE; site-specific peak date used to estimate BPE). NAI Kearney Broadfoot South, Leaman, and Follmer all either had no tern nesting or 0.00 chicks/BPE in 2023 and 2022 but ranged from 1.00 chicks/BPE to 1.08 chicks/BPE this year. The other seven OCSW sites at which we observed tern nesting had between zero and sixteen successful nests. Fledge ratios at these seven sites ranged between 0 chicks/BPE and 0.72 chicks/BPE (site-specific peak date used to estimate BPE).

We successfully assigned nest fates to 173 of the 221 tern nests observed during 2024. Thirty-nine nests failed due to predation (0.18 of total nests), 11 failed due to abandonment (0.05), and 28 failed due to weather (0.13). Thirty-two nests failed due to unknown causes (0.14) and 16 nests had an unknown outcome (0.07). Of the 95 nests that were successful, 75 fledged (0.34), two failed due to predation (0.01), and four failed due to weather (0.02). Ten broods failed due to unknown causes (0.05) and four broods had an unknown outcome (0.02).

Results from our 2024 tern monitoring efforts indicate continued increases in tern use on monitored sites across the central Platte River. The BPE and total number of nests were the highest observed. Similar to plovers, terns had a low apparent nest success this year, likely due to renesting after predation and weather events. The fledge ratio was lower than previous years, but the number of fledglings was similar to 2023, likely attributable to successful nesting on sites in the east that had fewer losses due to predation and weather events.

Predator Management and Monitoring

The Program employed basic predator management efforts at three OCSW sites (Dyer, Cottonwood Ranch, and Newark East), which included trapping and removal of mammalian predators; removal of trees within a ≥492 ft radius of the nesting area; installation of avian spikes on all potential non-removable perches; maintaining a ≥100 ft water moat surrounding nesting peninsulas; and installation of electrified predator exclusion fences across the entrances to each peninsula. At three other OCSW sites (Kearney Broadfoot South, Newark West, and Leaman), the Program used additional predator management efforts in the form of predator exclusion fencing with electrified wires surrounding nesting peninsulas and predator deterrent lights.

EDO biologists and technicians conducted a total of 102 shoreline track surveys across the six OCSW sites during 2024, ranging from 15 weekly surveys at Dyer to 19 weekly surveys at Newark West and Newark East, and recorded 225 total unique track registers (2.21 track registers/survey). Biologists deployed 29 shoreline cameras for a total of 3,241 camera days across the six sites. Shoreline cameras recorded 894 unique predator registers resulting in 0.276 unique registers/camera day across all six sites. We observed 0.251 registers/camera day at the three sites with basic predator management compared to 0.302 registers/camera day at sites with additional predator management.

Biologists deployed 25 site-level cameras for a total of 2,935 camera days across the six sites and recorded 292 unique predator registers resulting in 0.099 unique registers/camera day. We observed 0.112 site-level registers/camera day at the three sites with basic predator management compared to 0.083 site-level registers/camera day at sites with additional predator management.

Biologists deployed 46 nest-level cameras to monitor 147 nests (51 plover; 96 tern) for a total of 1,451 camera days across the six sites. Nest-level cameras documented 46 unique registers of predator species (e.g., within view of camera but did not predate the nest) resulting in 0.032 nest-level registers/camera day. Nest-level cameras documented 29 predation events resulting in 0.020 predation event registers/camera day across all six sites. Of those 29 predation events, 18 were at sites with basic predator management (Dyer, Cottonwood Ranch, and Newark East), and 11 were at sites with additional predator management (Kearney Broadfoot South and Newark West). There were no predation events on Leaman. We observed predation events more frequently on sites with basic predator management (0.022 predation events/total camera days at basic sites) than at those with additional predator management (0.017 predation events/total camera days at additional sites).

We also documented two predation events that occurred on nests with nest-level cameras that were assumed predated due to evidence at the nest and the timing of the nest losses, although the cameras on these nests malfunctioned. Over all nests being monitored with cameras, 55 plover and tern nests were predated, either entirely or partially. Plover nests were predated by great horned owl

(*Bubo virginianus*), striped skunk (*Mephitis mephitis*), and red-tailed hawk (*Buteo jamaicensis*). Tern nests were predated by great horned owl, Canada goose (*Branta canadensis*), striped skunk, American badger (*Taxidea taxus*), and coyote (*Canis latrans*).

Biologists placed nest cameras at 147 of 209 (70%) plover and tern nests at the six OCSW sites in 2024. Sixty-five of the 147 nests with cameras (44%) and 19 of the 62 nests without cameras (31%) were successful. For both plover and tern nests combined, we found a significant difference in daily survival rates (DSR) for nests with (DSR = 0.965; 95% confidence interval [CI]: 0.935, 0.980) or without cameras (DSR = 0.947; 95% CI: 0.904, 0.971). DSR was higher for plover and tern nests with cameras compared to those without. Biologists deployed cameras at 51 of 52 plover nests at the six OCSW sites and 20 of the 51 nests were successful. One plover nest at Cottonwood Ranch did not have a camera and failed due to predation. Therefore, a meaningful comparison of DSR for plover nests with and without cameras was not possible. Biologists deployed cameras at 96 of 157 tern nests at the six sites and we found no significant difference in DSR for tern nests with (DSR = 0.959; 95% CI: 0.925, 0.980) or without cameras (DSR = 0.947; 95% CI: 0.903, 0.975). Combined average DSR for plover and tern nests during 2010-2016 across all six sites prior to camera deployment was 0.968 (95% CI: 0.932, 1.00), which was higher than our DSR estimates for nests with and without cameras during 2024.

We used a combination of predator monitoring techniques to help reduce uncertainty of plover and tern nest fates, better understand predator communities at nesting sites, and evaluate the effectiveness of additional predator management efforts during 2024. Even with camera malfunctions, we were able to successfully fate almost 95% of the 147 nests with cameras this year compared to just over 80% of the 62 nests without cameras. Predation was the main cause of nest failure this year for both plovers and terns, but predator communities varied by site, which we are better able to understand because of the additional predator monitoring efforts. We used the information from these efforts about which predator species were depredating our nests at each site to adjust trapping techniques specific to that site's predators.

In this report, we summarize results from the Program's management and monitoring efforts for plovers and terns during 2024 on the central Platte River and at OCSW nesting sites adjacent to the river. We also detail findings from our predator management, monitoring, and research efforts at six OCSW sites during 2024. Overall, the Program is using long-term plover and tern monitoring data and research on predator impacts on nest and brood success to evaluate progress toward management objectives and support adaptive management decision-making related to plovers and terns.

INTRODUCTION

The northern Great Plains population of piping plovers (*Charadrius melodus*; hereafter plovers) was listed as threatened on 10 January 1986 (50 Federal Register 50726) by the United States Fish and Wildlife Service (USFWS) under the Endangered Species Act (ESA). The northern Great Plains plover remains listed as threatened due to concerns over the species' viability given impacts of predation and habitat loss on survival and productivity (USFWS 2020). The interior least tern (*Sternula antillarum*; hereafter tern) was listed as endangered under the ESA on 27 June 1985 (50 Federal Register 21784). The USFWS removed the tern from ESA protective status on 12 February 2021 (86 Federal Register 2564); however, the tern remains protected under the Migratory Bird Treaty Act and the Nebraska Non-Game and Endangered Species Conservation Act (Nebraska Rev. Statute §37-801-811).

The Platte River provides key habitat for plovers and terns with both species nesting on manufactured sand and gravel pits adjacent to the active river channel and on unvegetated sandbars in the river channel (Sidle and Kirsch 1993, Kirsch 1996, Farnsworth et al. 2017, Farrell et al. 2018, Jorgensen et al. 2021). The Platte River Recovery Implementation Program (PRRIP or Program) is responsible for implementing certain aspects of plover and tern recovery plans along the central Platte River (PRRIP 2021b) and manages land and water to attain specific management objectives. The management objective for plovers and terns as defined in the Program's First Increment Adaptive Management Plan (AMP; PRRIP 2021b) is to improve their productivity along the central Platte River through: (1) increasing the number of fledged chicks; and (2) reducing adult mortality. Increasing the number of fledged chicks may be done through increasing the number of breeding pairs and/or increasing fledge ratios, the latter of which is related to nest loss and chick mortality due to predation, weather, flooding, and inadequate forage. Reducing adult mortality may primarily be accomplished by reducing predation, although severe weather may affect adult survival. The Program uses the number of nesting pairs and number of chicks fledged per nest or breeding pair (i.e., fledge ratio) as indicators for monitoring the status of plovers and terns. Though not required for ESA compliance, in 2021 the Program's Governance Committee (GC) directed Executive Director's Office (EDO) staff to continue monitoring terns following the same protocol as it did prior to federal delisting (PRRIP 2021a).

The Program's monitoring efforts for plovers and terns (PRRIP 2017) include: (1) observing use and nest productivity on riverine in-channel sandbars and created or rehabilitated off-channel sand and water (OCSW) nesting sites along the central Platte River between Lexington and Chapman, Nebraska; (2) identifying and documenting factors that influence nest site selection and nest and brood success; and (3) monitoring potential predators to gather information on the predator community present on and around nesting sites. The Program's First Increment Extension Science Plan, written in 2022, identified two Extension "Big Questions" related specifically to plover productivity and the role of predation (PRRIP 2022a). The first, "how much of an effect does predation have on plover productivity," is being addressed using data on nest and brood predation to quantify the impact of predation, by identifying predator species, and by determining whether losses are incurred during incubation or brood rearing (PRRIP 2022a). The second, "how effective is Program management at mitigating losses of plover productivity due to predation," is being addressed through data collection on the efficacy of trapping, fencing, and/or predator deterrent lighting at reducing nest and brood failure due to predation (PRRIP 2022a).

In this report, we summarize results from the Program's management and monitoring efforts for plovers and terns during 2024 on the central Platte River and at OCSW nesting sites adjacent to the river. We also detail findings from our predator management, monitoring, and research efforts at six OCSW sites during 2024. The monitoring conducted during 2024 was a collaborative effort between Program EDO staff and the Nebraska Public Power District (NPPD). Overall, long-term plover and tern monitoring data and research on predator impacts on plovers are being used to evaluate progress toward management objectives and to support adaptive management decision-making related to plovers and terns.

STUDY AREA

Our study area encompassed the Program's Associated Habitat Reach (AHR) segment of the central Platte River between Lexington and Chapman, Nebraska (~90 river mi, Figure 1) and OCSW sites within 3.5 mi of the river in this reach (Figure 2). River or on-channel habitat includes naturally formed or constructed midstream sandbars used for nesting and the open river channel used for foraging. The number of low-elevation sandbars present within the PRRIP AHR of the central Platte River has been variable and dependent on seasonal and daily fluctuations in river flow. The size and distribution of non-vegetated, high-elevation sandbars characteristic of plover and tern nesting sites within the region has been dependent upon construction and vegetation management efforts.

OCSW habitat includes spoil piles of sparsely- or non-vegetated sand at sand and gravel mines and constructed nesting sites. Migratory plovers typically arrive in early May and nest on OCSW habitat or constructed on-channel islands. Adults forage on low elevation river sandbars or along the waterline of OCSW habitat, though they are more reliant on OCSW shorelines while nesting (Sherfy et al. 2012). Chicks forage along OCSW waterlines until fledging when they are often observed foraging on the river channel. Migratory terns typically arrive later in May and nest on OCSW habitat or constructed on-channel islands. Terns forage at both the sand and water site and on the river channel, though they rely more on the river channel for foraging (Sherfy et al. 2012). Fledged terns at OCSW habitat along the AHR have been observed beginning to learn to forage in the water surrounding the nesting area, then are later often observed on the river channel.

2024 RIVER CONDITIONS

Median daily river discharge at the Kearney gage (USGS gage 06770200, USGS 2024b) between 1 May and 1 September 2024 was similar to the median daily river discharge between 2001 and 2023 (Figure 3). Differences include higher flows early to mid-July and mid to late August, and lower flows mid-July through mid-August (Figure 3). The Environmental Account (EA) flow release to suppress germination of in-channel woody vegetation was started by the Program in late May with EA flows reaching the Kearney gage on 27 May (Figure 3). Contribution to total discharge made by the EA release helped sustain water levels over 1,500 cfs throughout most of June and are visible as dark blue shaded areas in Figure 3. The EA flow release was halted on 23 June with the last of EA water reaching the Kearney gage on 28 June (Figure 3). The pictures below provide examples of river conditions on 15 May, 15 June, and 15 July that demonstrate river flow before, during, and after the June flow release in relation to sandbar habitat and vegetation growth from west to east across the AHR.

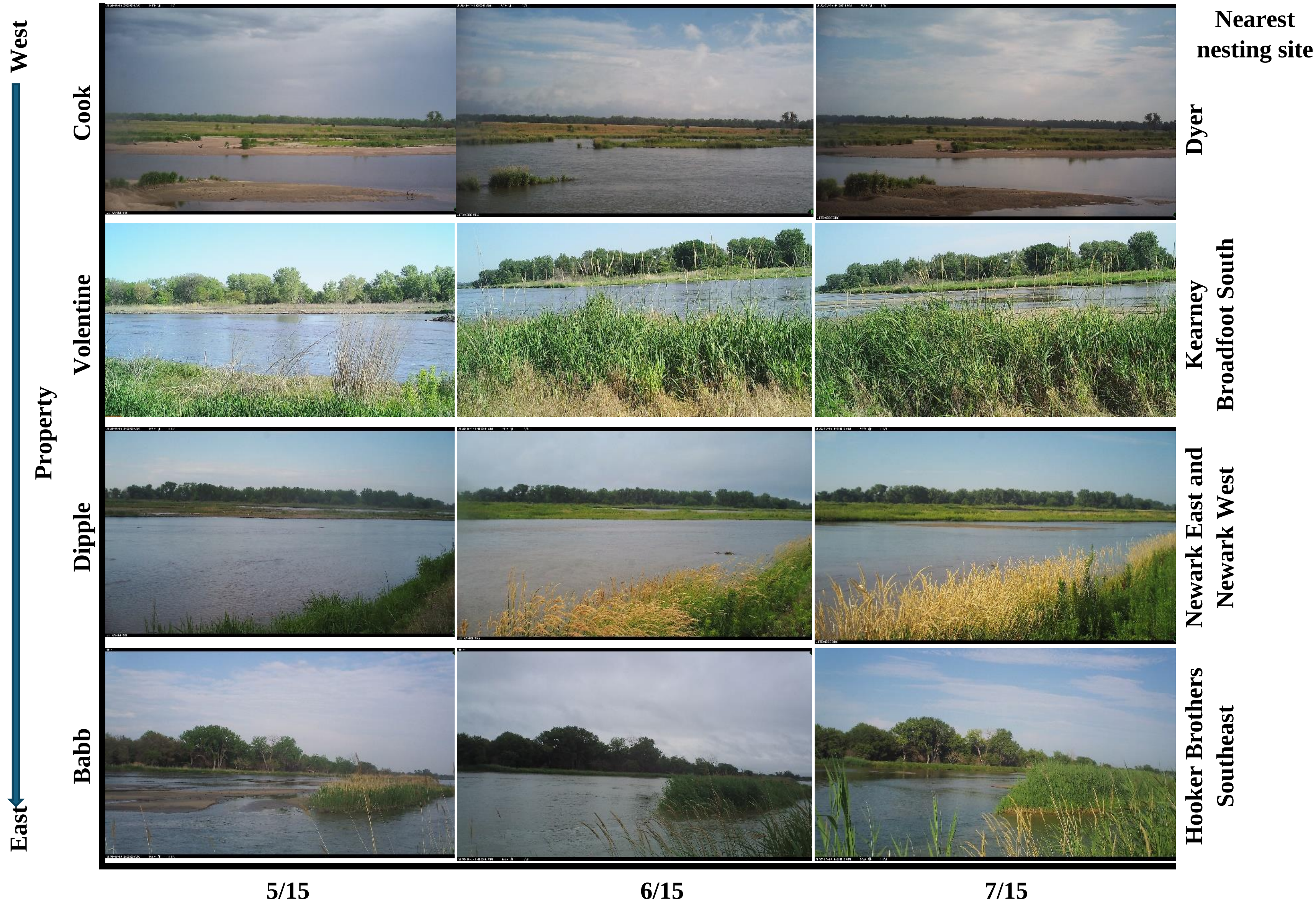
A combination of average snowpack in Wyoming during winter 2023-2024 and average rainfall across the Associated Habitat Reach (AHR) in 2024, resulted in consistent flows within the AHR. The peak discharge at the Kearney gage was 3,680 cfs on 7 July (Figure 3) due to a large rain event. The lowest flow recorded at the Kearney gage during the nesting season (1 May to 1 August) was 84.1 cfs on 1 August, the final day of the season (Figure 3).

MANAGEMENT

The Program undertook management actions designed to increase the amount of nesting habitat (bare sand), improve foraging habitat, and increase productivity of plovers and terns at on- and off-channel sites during fall 2023 and spring 2024. Management activities were site specific and included: disking, chemical application to kill or prevent emergence of vegetation (fall and/or spring herbicide application); and predator control (trapping, fencing, and/or predator deterrent lights).

OFF-CHANNEL MECHANICAL HABITAT CREATION AND MAINTENANCE (2007-2024)

Approximately 48 ac of managed off-channel nesting habitat were present in the AHR at the beginning of the Program's First Increment in 2009 (Figure 4). The Program began acquiring and restoring off-channel sites in 2009 and monitoring at these sites began in 2010. Total monitored off-channel habitat in the AHR increased to ~250 ac by 2021 as the Program constructed and restored potential nesting habitat (Figure 4). Area of potential nesting habitat across the AHR has remained mostly unchanged since 2021 except for small differences in water level and vegetation between each year (Figure 4). Across nine Program managed sites, bare sand habitat decreased by a total of 5.77 ac between 2023 and 2024 (see site specific details below). The largest loss in potential nesting habitat at Program sites between 2023 and 2024 occurred at the Newark East site where 1.87 ac of habitat was lost due to increased driving and mining activity on the far eastern side of the east peninsula. The OSG Lexington site experienced the largest gain in potential nesting habitat between 2023 and 2024 with an increase of 0.49 ac of bare sand. Across nine sites not owned or managed by the Program, bare sand habitat decreased by a total of 4.24 ac. Blue Hole experienced the largest increase in bare sand habitat (2.29 ac; see site specific details below). The Hooker Brothers Southeast site lost the greatest amount of potential nesting habitat with a loss of 3.92 ac between 2023 and 2024 due to encroachment of vegetation.



Vegetation monitoring pictures demonstrating changes in on-channel habitat availability through time across the AHR from west (top) to east (bottom) before (left column), during (middle column), and following (right column) June flow release. The Program property and nearest OCSW nesting site corresponding with the location of each photo series are provided on the left and right y-axis, respectively.

Off-Channel Sand and Water Sites

The Program and its partners actively managed 13 of the 18 off-channel sites that were monitored during 2024 with the goal of increasing plover and tern productivity (Figure 2). Management efforts at each of the 18 sites are summarized below. Site numbers correspond to map locations on Figure 2. Provided in parentheses after each site name are letters denoting management efforts and history of each site. Program owned or leased sites are denoted with a "P"; managed sites are identified with an "M"; sites constructed specifically for plover and tern nesting are denoted by a "C"; and sand and gravel mines (formerly and currently active) that were rehabilitated into or designated as possible nesting habitat are identified with a "G".

1. ***OSG Lexington (PMG)***–Program contractors applied a contact herbicide to kill existing vegetation along the waterline during fall 2023 and pre-emergent herbicide to the nesting area during spring 2024. Predator trapping occurred during the 2024 nesting season. We installed a permanent 4-ft-high woven wire predator exclusion fence in spring 2021 across the north entrance to the nesting area. The fence had offset electric wires to prevent terrestrial predators from climbing and an electrified top wire to prevent avian predators from perching. Additionally, we installed a temporary 4-ft-high woven wire predator fence with offset electric wires across the east entrance to the nesting area separating the nesting site from ongoing sand and gravel mining occurring east of the habitat in the spring of 2024. We installed a permanent 4-ft high woven wire fence in spring 2023 around the western and southwestern outer perimeter of the site as a predator deterrent and to limit human disturbance to the site. Potential nesting habitat increased by 0.49 ac between 2023 and 2024 due to water level and vegetation changes.

2. ***NPPD Lexington (MG)***–Program contractors applied a pre-emergent herbicide to the nesting area during spring 2024. Predator trapping occurred during the 2024 nesting season. Woven-wire predator exclusion fences with offset electric wires along the west side of the nesting areas were maintained during 2024. No sand and gravel mining occurred during 2024. Potential nesting habitat decreased by 1.09 ac between 2023 and 2024 due to water level and vegetation changes.

3. ***Dyer (PMG)***–Program contractors applied a contact herbicide to kill existing vegetation along the waterline during fall 2023 and pre-emergent herbicide to the nesting area during spring 2024. Predator trapping occurred during the 2024 nesting season. We maintained permanent 4-ft-high woven wire predator exclusion fences with offset electric wires and an electrified top wire across the south ends of each peninsula. No sand and gravel mining occurred during 2024. Potential nesting habitat decreased by 1.17 ac between 2023 and 2024 due to new washouts increasing steepness and reducing accessibility to shorelines in previously suitable habitat.

4. ***Cottonwood Ranch (PMC)***–Program contractors applied a contact herbicide to kill existing vegetation along the waterline during fall 2023 and pre-emergent herbicide to the nesting area during spring 2024. Predator trapping occurred during the 2024 nesting season. We maintained a permanent 4-ft-high woven wire predator exclusion fence with offset electric wires and top wire at the entrance to the nesting peninsula during 2024. No sand and gravel

mining occurred during 2024. Potential nesting habitat decreased by 1.71 ac between 2023 and 2024 due to new washouts increasing steepness and reducing accessibility to shorelines in previously suitable habitat.

5. ***T&F Lakeside (G)***–Not managed. Sand and gravel mining occurred during 2024. Potential nesting habitat did not change between 2023 and 2024.

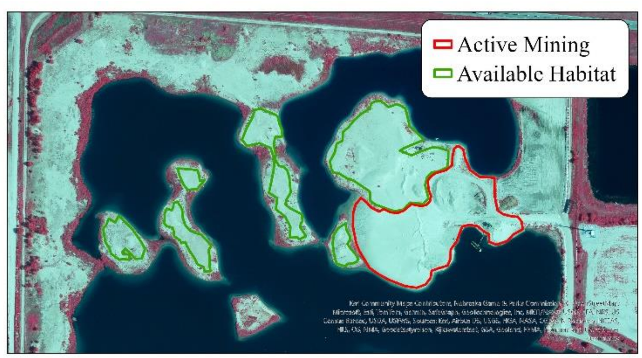
6. ***Blue Hole (MG)***–Program contractors applied a pre-emergent herbicide to the nesting area during spring 2024. Predator trapping occurred during the 2024 nesting season. There was no predator exclusion fence at the site. Sand and gravel mining did not occur during 2024; however, the area west of this OCSW site is a high traffic area for loading and unloading equipment. This site gained 2.29 ac between 2023 and 2024 due to the inclusion of bare sand on the northeast peninsula.

7. ***Johnson (MG)***–Program contractors applied a pre-emergent herbicide to the nesting area during spring 2024. No predator trapping occurred during 2024. NPPD maintained a non-electrified woven-wire predator exclusion fence along the west side of the nesting area. Sand and gravel mining did not occur during 2024. Potential nesting habitat decreased by 0.21 ac between 2023 and 2024 due to changes in water level.

8. ***Ed Broadfoot and Sons (G)***–Not managed. Sand and gravel mining occurred during 2024, and the site lost 2.39 ac of potential nesting habitat between 2023 and 2024 due to newly established mining zones.

9. ***Kearney Broadfoot South (PMG)***–Program contractors applied a contact herbicide to kill existing vegetation along the waterline during fall 2023 and pre-emergent herbicide to the nesting area during spring 2024. Predator trapping along the exterior shorelines of the site occurred during 2024. We maintained a permanent 4-ft-high woven wire fence with an electrified top wire (to prevent avian perching) along the interior shoreline of the entire nesting peninsula. The fence also spanned the east end of the peninsula, thereby limiting access from its only land entrance. Predator deterrent lights were installed on the site for the 2024 nesting season as a part of our additional predator management study. Sand and gravel mining during 2024 took place north of the main peninsula where nesting occurred. The site lost 0.89 ac between 2023 and 2024 due to washouts.

10. ***Non-Access Islands Kearney Broadfoot South (PMG)***–Predator trapping occurred during 2024. Due to active mining, the area of this site varies from year to year. There were 5.6 ac of unmanaged, suboptimal habitat available on these islands for plover or tern nesting and foraging during 2024. Available habitat consists of the interior, unvegetated portions of islands to the west and the unvegetated sandy tailing that remains as the eastern peninsula is mined. The shorelines of most of these islands are partially or



Habitat availability (green) and active mining (red) at Non-Access Islands Kearney Broadfoot South, July 2024.

heavily vegetated, thus do not contribute to the acres counted as habitat for this site. The far eastern portion of the actively mined peninsula is unvegetated; however, it is not suitable for nesting due to the activity in the area and changing terrain and is not counted toward total acreage either.

11. ***Newark West (PMG)***–Program contractors applied a contact herbicide to kill existing vegetation along the waterline during fall 2023 and pre-emergent herbicide to the nesting area during spring 2024. We maintained permanent 4-ft-high woven wire predator exclusion fences with offset electric wires and a top wire across the ends of each peninsula. In addition, the entire perimeter of the exterior of this site, outside of the surrounding water barrier, was enclosed with a permanent 4-ft-high woven wire fence with an offset electric wire. Predator trapping inside the perimeter fence, but outside the nesting peninsula, occurred during 2024. We installed predator deterrent lights on the nesting site during spring 2024 as part of our additional predator management. No sand and gravel mining occurred during 2024. Potential nesting habitat decreased by 0.67 ac between 2023 and 2024 due to a severe washout.

12. ***Newark East (PMG)***–Program contractors applied a contact herbicide to kill existing vegetation along the waterline during fall 2023 and pre-emergent herbicide to the nesting area during spring 2024. Predator trapping occurred during 2024. We maintained a permanent 4-ft-high woven wire predator fence with offset electric wires and electrified top wire across the west peninsula and a temporary 4-ft-high woven wire predator fence with offset electric wires across the east peninsula. Limited sand and gravel mining occurred east of the nesting areas, but the site lost 1.87 ac due to increased driving and mining activity on the far eastern side of the east peninsula.

13. ***Leaman (PMC)***–Program contractors applied a contact herbicide to kill existing vegetation along the waterline during fall 2023 and pre-emergent herbicide to the nesting area during spring 2024. Predator trapping occurred during 2024. The nesting peninsula was closed from its only land connection by a permanent 4-ft-high woven wire predator exclusion fence with an electrified top wire and offset electric wires. Additionally, there was a 4-ft-high woven wire fence that was not electrified separating the northern boundary of the site from the property to the north, but this fence did not completely enclose the site. We installed predator deterrent lights on the nesting site during spring 2024 as part of our additional predator management efforts. No sand and gravel mining occurred, but the site lost 0.05 ac of nesting habitat due to washouts.

14. ***Follmer (PMG)***–Program contractors applied a contact herbicide to kill existing vegetation along the waterline during fall 2023 and pre-emergent herbicide to the nesting area during spring 2024. Predator trapping occurred during 2024. Because there was no documented use by plovers or terns on this site until this year, a peninsula entry predator exclusion fence was not previously installed but will be installed prior to the 2025 nesting season. Sand and gravel mining occurred between the two existing managed peninsulas in 2024, and the area of potential nesting habitat increased by 0.10 ac.

15. ***Trust Wildrose East (MG)***–Program contractors disked the nesting area in the fall of 2023 and applied a pre-emergent herbicide to the nesting area during spring 2024. No sand and gravel mining occurred. Potential nesting habitat increased by 0.38 ac between 2023 and 2024 due to lower water level and vegetation changes.

16. ***DeWeese (G)***–Not managed. Sand and gravel mining occurred during 2024, and potential nesting habitat decreased by 0.03 ac. None of the 3.52 ac of potential nesting habitat at the site was located adjacent to a shoreline or water, and no birds have nested at this site.

17. ***Hooker Brothers Southeast (G)***–Not managed. Sand and gravel mining occurred during 2024, and the area of potential nesting habitat decreased by 3.92 ac between 2023 and 2024 due to water level and vegetation changes.

18. ***Hooker Brothers East (G)***–Not managed. Sand and gravel mining occurred during 2024. The area of potential nesting habitat increased by 0.73 ac between 2023 and 2024 due to dirt work done in 2024 and vegetation changes.

ON-CHANNEL MECHANICAL HABITAT CREATION AND MAINTENANCE (2007–2024)

Constructed on-channel habitat availability was variable and somewhat limited during the First Increment of the Program and no additional on-channel habitat has been added during the First Increment Extension (Figure 5). Approximately 24 ac of constructed on-channel habitat were present in the AHR in 2007 as the result of efforts by other conservation organizations (Figure 5). That habitat was subsequently lost over the course of several years due to erosion during high flow events. On-channel habitat construction by other conservation organizations has been very limited since 2007. The Program began large-scale on-channel habitat construction efforts at the Elm Creek complex in fall 2012 and created on-channel habitat at the Cottonwood Ranch and Plum Creek complexes as part of sediment augmentation activities to add 55 ac of habitat during the 2013 nesting season (Figure 5). Much of that habitat was lost during a high flow event in fall 2013. On-channel island construction began at the Shoemaker Island complex following the fall 2013 event. A high flow event in June 2014 eroded a portion of the habitat constructed in fall 2013, but the Program was able to construct a total of 28 ac of on-channel habitat during fall 2014 at the Elm Creek and Shoemaker Island complexes to increase on-channel habitat availability for the 2015 nesting season (Figure 5). However, most of it was lost due to erosion during 2015 and 2016 high flow events. The Program did not construct on-channel habitat after 2014 and there has been limited suitable on-channel habitat available for plover and tern nesting during 2017-2024.

On-channel maintenance on Program managed properties was mainly in the form of herbicide application at targeted sites prior to the 2024 nesting season. The in-channel sites were not sprayed with pre-emergent herbicide due to contractor unavailability. Program contractors applied contact herbicide to vegetation in fall 2023 to in-channel islands at the Cottonwood Ranch complex and to the moving complex approach (MCA) island in the Chapman complex. Program contractors disked the MCA island in the Chapman complex during spring 2023 to increase foraging habitat along the river, but no nesting habitat that met Program requirements was created or maintained.

Plover and Tern Monitoring

METHODS

MONITORING PROTOCOL REVISIONS OVER TIME

In 1997, the Department of the Interior 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 plovers and terns on the central Platte River from Lexington to Chapman, Nebraska. The standardized protocol was implemented by CNPPID, CPNRD, NPPD, and USFWS during 2001-2006 (https://platteriverprogram.org/program-library; Target Species: piping plover, interior least tern; Keywords: protocol implementation, [Year of Study]). In 2007, the Program assumed this responsibility and Program staff, contracted personnel, and cooperators have since implemented the monitoring protocol. The protocol was revised prior to the 2010 nesting season (PRRIP 2010) and again prior to the 2017 nesting season (PRRIP 2017). Data for 2024 were collected following the 2017 monitoring protocol.

Changes in monitoring protocols that affect the comparability of results over time have been noted where appropriate in tables and figures. Most changes occurred in 2010 and included:

- The definition of fledging age changed from 15 days for both species to fledging ages of 21 days for terns and 28 days for plovers.
- River surveys increased from three to seven surveys between May and August.
- Both inside and outside monitoring was implemented at all off-channel sites during 2010-2016.
- The Program began building and restoring OCSW sites to increase the amount of stable available habitat.
- The Program gained bi-weekly access to sites that had been previously restricted, and therefore were not included in reproductive calculations prior to 2010.

These changes, along with a gradual refinement of fating decisions to make them more consistent, have allowed us to improve our monitoring accuracy.

SEMI-MONTHLY OCSW AND RIVER SURVEYS

During 2024, biologists conducted seven semi-monthly (1 and 15 of May, June, and July; and 1 August) surveys of OCSW sites and the central Platte River spanning the AHR to count plover and tern adults, breeding pairs, nests, chicks, and fledglings.

Semi-Monthly OCSW Surveys

EDO and NPPD biologists conducted semi-monthly surveys at 18 Program-owned or partnered OCSW sites along the AHR during 2024 (Figure 2). EDO conducted surveys were usually conducted on the same date across multiple sites over the entire AHR or within a day. EDO biologists conducted semi-monthly surveys using spotting scopes and monitoring techniques from outside the nesting area on 29 April; 16-17 and 30-31 May; 13 and 27 June; 15 July; and 1 August 2024. NPPD biologists conducted surveys of the Blue Hole site on 6, 16, and 30 May; 14 June;

and 1, 15, and 31 July; the NPPD Lexington site on 6, 14, and 30 May; 14 June; and 1 and 15 July; and the Johnson site on 10 and 28 May; 12 and 29 June; and 15 July.

Semi-Monthly River Surveys

Three EDO biologists (one driver; two surveyors) used an airboat to conduct semi-monthly river surveys spanning the stretch of river between the J-2 Return, located east of Lexington, and the Chapman bridge, located west of Chapman, Nebraska. We included channels >200 ft wide that could safely be navigated in the survey. We conducted surveys on 30 April and 1 May; 15-16 May; 29-30 May; 11-12 June; 25-26 June; 16-17 July; and 30-31 July during 2024. Severe weather prevented the completion of the J-2 to Overton stretch on 15 May.

EDO staff conducted point count surveys at accessible locations (e.g., bridges; boat ramps) when segments of the river were unnavigable due to low flow. On the 16 May survey, biologists did not survey river segments between Minden and Gibbon due to low water levels at Rowe Sanctuary prior to the completion of the flow split on the Wyoming property. Biologists were also using a temporary boat ramp due to construction at Rowe Sanctuary, which made access difficult during low water levels. This stretch of river between the Minden and Gibbon bridges on Rowe Sanctuary's property is regularly used by both species for foraging as it is near some of the OCSW habitat, is wide and has fewer trees, and typically has large amounts of exposed sandbars and shallow water that is ideal for foraging. Though inaccessible by airboat, point counts were conducted at the temporary boat ramp.

EDO staff also conducted point count surveys at predefined locations, including Program properties, providing access to the river and bridges across the entire stretch of river between the J-2 Return and Alda bridge during the 1 August (conducted 30-31 July) survey affected by low river discharge. Between the Lexington to Alda stretch of the river, biologists conducted point count surveys at the Dyer property, Overton bridge, Cottonwood Ranch property, Elm Creek bridge, NPPD diversion dam, Bartels property, Odessa bridge, Kearney bridge, Kearney Broadfoot South OCSW site, north Wyoming property, Nebraska Game and Parks Fort Kearny Hike-Bike Trail bridges, Minden bridge, Gibbon bridge, Dippel property, Shelton bridge, Rowe Sanctuary, Wood River bridge, Binfield property, and Alda bridge. Normal airboat surveys were conducted between the Alda to Chapman stretch with the exception of the section between the Hwy 281 bridge and South Locust bridge which was not navigable. Point count surveys were conducted at those bridges.

SEMI-WEEKLY NEST AND CHICK MONITORING

In addition to semi-monthly surveys of the river and all 18 OCSW sites, EDO and NPPD biologists monitored any OCSW or river site with active nests or broods on a semi-weekly basis throughout the nesting season. Upon location of an active nest, biologists monitored from outside the nesting area to observe nests and/or chicks twice per week until the nest or brood failed, or the chicks fledged. Biologists recorded numbers of adults, nests, chicks, and fledglings during each survey.

Each survey outside of the nesting area consisted of ≥30 minutes of observation using binoculars and/or spotting scopes at a distance that did not cause disturbance to nesting birds (usually >165 ft., but occasionally closer as terrain dictated). Biologists made observations from multiple vantage points to allow observation of as much of the site as possible. Biologists often located nests and chicks by first observing adult birds. Biologists recorded date, observation start and stop times, and the number of plover and tern adults, nests, broods, chicks, and fledglings present during each semi-weekly site visit. When biologists observed chicks or fledglings, we estimated the date of hatching or fledging based on current and previous nest and chick observations. When the nest or brood failed, biologists attempted to determine the cause of failure and assign a nest/brood failure fate as abandoned, flooded, predated, weather, or unknown. Unknown causes of nest/brood failure were assigned when loss stage was known, but there was not enough evidence to assign a specific fate.

METRICS AND BREEDING PAIR ESTIMATION

For each semi-monthly river and OCSW site survey, we totaled the number of adults, breeding pairs, nests, chicks, and fledglings observed. These numbers provided seven snapshots of plover and tern relative abundance during the 2024 nesting season without accounting for detection probability. We used semi-weekly and semi-monthly survey data for OCSW sites with and without nests, respectively, to calculate the total number of plover and tern adults at all 18 OCSW sites based on the maximum count of adults observed at each site on any one survey. We calculated the total number of nests as the total unique nests observed across all sites and brood count as the total number of successful nests (≥1 chick hatched) across all sites. We calculated the total number of chicks (<15 days old) and fledglings (21 days old for terns; 28 days old for plovers) based on the maximum number of chicks and fledglings that were associated with each unique nest and summed across all nests.

We calculated plover and tern breeding pair estimates (BPE) for nesting observed on the river channel and at OCSW sites according to the methods described by 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). We calculated plover and tern BPE 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 determined plover breeding pair counts by assuming: (1) plover nests did not hatch within 28 days of being initiated; (2) plovers did not re-nest within 5 days of losing a nest or brood or fledging chicks; (3) plover chicks fledged at 28 days of age (defined fledging age for 2010-2024); (4) plover chicks that survived to 15 days of age (fledging age for 2007-2009) also fledged. We obtained tern breeding pair estimates by assuming: (1) tern nests did not hatch within 21 days of being initiated; (2) terns did not re-nest within five days of losing a nest or brood; (3) tern chicks fledged at 21 days of age (defined fledging age for 2010-2024); (4) tern chicks that survived to 15 days of age (fledging age for 2007-2009) also fledged; and (5) terns did not re-nest after fledging chicks.

The Program reports peak BPE when numbers of plover and tern breeding pairs observed during a single observation period within the entire Program AHR first peaked. Thus, peak breeding pair estimates are associated with a specific date. On- and off-channel BPE are calculated based upon the number of nests observed on the river channel or on OCSW sites, respectively. Thus on- and off-channel BPE represents the highest number of estimated breeding pairs across all on-channel river habitat during a single observation period, whereas off-channel BPE provides an estimate of the highest number of breeding pairs across all OCSW sites during a single observation period. We also calculated peaks in BPE for each OCSW site, 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.

SURVIVAL RATES

We separately estimated daily survival rates of plover and tern nests located on OCSW sites and on islands in the river channel that were monitored during 2024 by Program staff and personnel from NPPD. We defined nest success as any nest that hatched ≥1 chick. We considered the incubation period for terns and 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 (tern) or <28 days (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 plover nest was observed to be active and intact 12 days after it was initiated, and then was found to be empty (no eggs) four 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 two observation periods) and assigned a "failed" status to the nest as it likely did not hatch within 16 days of initiation. If, however, a plover nest with an unknown fate was last observed to be active 26 days after it was initiated, but then four days later (30 days after it was initiated) we observed an empty nest bowl with no sign of chicks of appropriate age in the area, we assigned the fate of the nest on day 28 (midpoint of the two 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. For this reason, the number of successful and failed nests included those with unknown fates and may differ from those presented in other sections of the report when unknown fates are presented.

We also separately estimated daily survival rates of plover and tern broods monitored during 2024. As the exact date of hatching was occasionally unknown, we considered the brooding period for tern and 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 (terns) or 28 days (plovers). Like 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 tern or plover chicks, respectively, and a successful status to the brood otherwise. Similar to nests, the number of successful and failed broods included those with unknown fates and may differ from those presented in other sections of the report when unknown fates are present.

We used mixed-effects nest fate logistic exposure models to estimate daily survival rates (DSRs) of plover nests and broods at OCSW sites (Shaffer 2004). We conducted separate analyses to estimate DSRs of tern nests and broods at OCSW sites. We developed three models for each of the four analyses. First, we estimated nest or brood survival as a constant (i.e., null model).

Second, we evaluated whether nest or brood survival was different for nests at Program and non-Program managed sites (i.e., ownership model). Third, we evaluated whether nest or brood survival was different across sites (i.e., site model). We included site as a random effect in each model to account for a potential lack of independence of nest fates at each site. We used the *glmer* function in package *lme4* (Bates et al. 2015) in Program R (R Core Team 2024) to fit models and estimate coefficients. When models did not converge due to insufficient data, we defaulted to a fixed effects model for estimates. For 2024, we defaulted to a fixed effects model for the DSR of plover broods at each site.

RESULTS

PIPING PLOVERS

2024 Seasonal Summary

During the 2024 plover nesting season, we observed: the highest peak estimated number of breeding pairs (47 pairs); the highest number of total nests (74 nests); a comparable number of successful nests (35 nests) to the past contemporary 2010-2024 monitoring period; the lowest apparent nest success (0.47) since 2008; and the highest number of fledglings (63 fledglings) (Tables 1 and 2). We observed similar fledge ratios in 2024 (1.34 chicks/BPE) to our fledge ratios in 2022 and 2023 (1.41 chicks/BPE in both years) (Table 2).

- Plovers nested at 12 of 18 OCSW sites with a high amount of variability in reproductive effort and success (Table 3). There was a total of 246 ac of potential nesting habitat available at the 18 OCSW sites in 2024.
- The peak AHR breeding pair estimate for plovers was 47 pairs (Table 2). Plover nests produced 120 chicks (<15 days old) and 63 fledglings (≥28 days old), resulting in a hatch ratio based on BPE of 2.55 chicks/BPE and a fledge ratio of 1.34 chicks/BPE (Table 2).
- Plovers established 74 nests, resulting in a hatch ratio based on nests of 1.62 chicks/nest and a fledge ratio of 0.85 chicks/nest (Table 2).
- Blue Hole, Newark West, Newark East, Leaman and Trust Wildrose East were the most productive OCSW nesting sites for plovers in 2024 with fledge ratios ≥1 chicks/BPE (site-specific peak date used to estimate BPE) (Table 3).
- The other seven OCSW sites at which we observed plover nesting had between zero and seven successful nests (Table 3). Fledge ratios at these seven sites ranged between 0.0 chicks/BPE and 0.75 chicks/BPE (site-specific peak date used to estimate BPE) (Table 3).
- The proportion of nests and broods that failed due to unknown causes remained low at 0.18 during 2024. Use of shoreline, nesting site, and nest cameras to monitor predators and nest fates has allowed us to significantly reduce the proportion of nest failures attributed to unknown causes, which peaked during the 2017-2019 period prior to current experimental design for remote camera monitoring.

Semi-Monthly OCSW Surveys

Plover breeding pairs, nests, chicks, and fledglings were observed on OCSW sites rather than on-channel river locations in 2024 (Tables 4, 5, 6, and 7), which was similar to previous years. Based on the twice monthly OCSW surveys, the number of plover adults, chicks, and fledglings observed peaked at 66 adults on the 15 June survey, 40 chicks on the 15 June survey, and eight fledglings on the 15 July survey (Table 6). The number of plover nests counted was highest on the 1 June survey at 31 nests (Table 6). Since 2010, the number of adult plovers observed during twice monthly OCSW surveys generally was highest during the 1 June, 15 June, or 1 July surveys (Figure 6 and 7).

Semi-Monthly River Surveys

Based on the twice monthly river surveys, the number of adult plovers observed peaked on the 1 July survey at three birds (Table 7). No plover nests or chicks were observed during river surveys in 2024 (Table 7). A single plover fledgling was observed during the 15 July river survey. The number of adult plovers observed during river surveys has varied greatly across years and surveys (Figures 8 and 9). We assumed adult plovers and the single fledgling observed on the river were generally foraging from nearby OCSW sites due to the lack of nesting behavior witnessed on the river and the proximity of plover river locations to nearest OCSW sites. The 1 July survey corresponded to a mean daily discharge of 787 cfs at the Kearney gage (Figure 3). Most in-channel sandbars and potential nesting habitat were inundated during the periods of high flow during late May, June, and early July, and did not meet the Program's requirements towards in-channel nesting habitat (Figure 5; PRRIP 2015). Low or no suitable on-channel nesting habitat in the AHR during the First Increment and Extension of the Program (Figures 4 and 5) has resulted in most nesting occurring on managed off-channel sites (Table 4 vs. Table 5, Figure 10).

Nest Monitoring, Brood Monitoring, and Survival Rates

Biologists observed plover nesting at 12 of 18 OCSW sites during semi-monthly monitoring in 2024 (Table 3). Biologists then monitored nests and broods at the 12 OCSW sites on a semi-weekly basis and observed a total of 74 plover nests in 2024 (Table 2, Figure 11).

Breeding Pairs — Across OCSW sites, the number of estimated plover breeding pairs peaked at 47 pairs on 28 May. Biologists counted a maximum of 101 adults across all sites (Table 2). The peak BPE of 47 pairs represented the highest plover BPE observed by the Program (Table 2, Figure 12). Plover BPE in recent years has increased markedly compared to those observed during 2001-2009, due in part to construction, rehabilitation, and maintenance of OCSW sites (Figure 12). Annual peak OCSW plover BPE was positively correlated with the total area of potential nesting habitat available at OCSW sites during 2001-2024 (Figure 13). For every acre increase in potential nesting habitat at OCSW sites, there was an increase of 0.15 (95% confidence interval [CI] = 0.12, 0.19) plover breeding pairs (Figure 13).

Nests — Biologists observed and monitored a total of 74 plover nests during 2024 (Table 2, Figure 14). The number of plover nests has followed a generally increasing trend over time as the total area of potential nesting habitat at OCSW sites increased (Figure 12). Of the 12 OCSW sites that had plover nesting, Kearney Broadfoot South had the most at 13 nests (Table 3, Figure 11). Three of the 12 OCSW sites (NAI Kearney Broadfoot South, Trust Wildrose East, and Follmer) each had only one plover nest (Table 3, Figure 11). The first plover nest was observed on 29 April and the last nest was first observed on 8 July. Thirty-five of the 74 nests were successful, resulting in an apparent nest success of 0.47, which was the lowest apparent nest success during the 2010-2024 period and the lowest since 2008 (Tables 1 and 2; Figure 15).

The overall DSR of plover nests across all monitored OCSW sites was 0.973 (LCL: 0.958, UCL: 0.984) during 2024 (Tables 2 and 8). We found no significant difference in nest DSR between Program and non-Program sites (Table 9). The DSR of plover nests was 0.969 (LCL: 0.951, UCL: 0.984) at Program sites and 0.979 (LCL: 0.941, UCL: 0.996) at non-Program sites (Table 9). We found a significant difference in site-specific nest DSR, where Kearney Broadfoot South and NPPD Lexington had lower DSR than Blue Hole (reference site). Low confidence in the DSR estimate for a single nest at NAI Kearney Broadfoot South resulted in the inability to detect a significant difference between the lower DSR at NAI Kearney Broadfoot South and Blue Hole. The range of DSR across sites was 0.891 to 1 for the 12 OCSW sites with plover nests (Table 8).

The overall incubation period (28-day) survival rate of nests on all monitored sites was 0.463 (LCL: 0.299, UCL: 0.637; Tables 2 and 8). Incubation period survival was 0.408 (LCL: 0.244, UCL: 0.639) at Program sites and 0.551 (LCL: 0.184, UCL: 0.895) at non-Program sites (Table 9). Across monitored OCSW sites, incubation period survival ranged from 0.039 to 1 (Table 8).

<u>Broods</u> — Biologists observed 120 chicks from the 35 broods from successful nests (Table 2). The hatch ratio of 1.62 chicks/nest was the lowest observed since 2019 (Table 2). The first nest observed to hatch occurred on 28 May, while the last nest observed to hatch occurred on 25 July. Of the 120 chicks, biologists observed 70 chicks that survived ≥15 days (Table 2). Brood counts generally increased from 2010-2016 and have held relatively stable since then, averaging 32 broods from 2017-2024 (Figure 12).

Across the ten OCSW sites with plover broods, overall DSR for broods was 0.989 (LCL: 0.974, UCL: 0.998; Tables 2 and 10). We found no significant difference in DSR for broods on Program (DSR: 0.989; LCL: 0.969, UCL: 0.997) compared to non-Program (DSR: 0.985; LCL: 0.921, UCL: 0.996) sites (Table 11). Likewise, we found no significant difference in DSR across the ten OCSW sites with brood DSR ranging from 0.937 to 1 (Table 10).

The overall brooding period (28-day) survival rate was 0.725 (LCL: 0.471, UCL: 0.945; Tables 2 and 10). Brooding period survival was 0.739 (LCL: 0.417, UCL: 0.926) at Program sites and 0.654 (LCL: 0.100, UCL: 0.896) at non-Program sites (Table 11). Across monitored OCSW sites, brooding period survival ranged from 0.163 to 1 (Table 10).

<u>Fledges</u> — Of the 120 chicks from the 35 nests, 63 chicks made it to the 28-day fledging age resulting in a fledge ratio of 0.85 chicks/nest or 1.34 chicks/BPE (Table 2). Biologists first observed a plover fledgling on 24 June and the last known plover chick to fledge did so on 26 August. The proportion of successful chicks was 0.53 (Figure 15). When using nests as a unit of measure, the fledge ratio of 0.85 chicks/nest was lower than the past two years (0.95 chicks/nest in 2022 and 1.21 chicks/nest in 2023) (Table 2). When accounting for likely renesting using the Program's breeding pair estimator, we estimated a fledge ratio of 1.34 chicks/BPE which was just

below the fledge ratios observed in 2022 and 2023 (1.41 chicks/BPE in both years) (Table 2). The 3-year running average of plover fledge ratios has shown a steady increase since 2019 (Figure 16).

Nest and Brood Fates

We successfully assigned nest fates to 67 of the 74 plover nests observed during 2024 (Figure 17). Twenty-two nests failed due to predation (0.30 of total nests), four failed due to abandonment (0.05), and six failed due to weather (0.08) (Figure 17). Three nests failed due to unknown causes (0.04) and four nests had an unknown outcome (0.05) (Figure 17). Of the 35 nests that were successful, 24 fledged (0.32 of total nests) and one failed due to predation (0.01) (Figure 17). Ten broods failed due to unknown causes (0.14) (Figure 17). Due to increased effort of remote camera monitoring of plover nests, we have been able to reduce uncertainty regarding nest and brood fates on Program managed sites since 2020 (Figure 17). Additional predator monitoring in the form of site-level cameras and shoreline track surveys has allowed us to gather more fating evidence, which has also improved our ability to fate nests (see Predator Management and Monitoring section for more detail).

Incidental Take Summary and Mortality

In its 2006 Biological Opinion (USFWS 2006) and 2018 Supplemental Biological Opinion (USFWS 2018) on the Program, the USFWS developed an incidental take statement addressing incidental take for plovers and terns associated with operation of existing and new water-related activities, and habitat alteration or monitoring conducted in the Platte River basin covered by the Program. Such take includes killing, harming, and harassing which could include the loss of habitat, individuals (adults, eggs, and/or chicks), and recruitment. In this incidental take statement, the USFWS described five types of losses reasonably foreseeable to occur as a result of the implementation of the Program and established allowable take under each category. Quantification of allowable take is also identified in the individual section 10(a)(1)(A) federal permits issued to researchers. The Service acknowledged “Acts of God” or “Acts of Nature” as beyond operational control of Program participants, with that type of take not included as incidental take.

Since the Program’s initiation in 2007, incidental take has been minimal (Table 12). The Program observed one habitat restoration and land management-related plover chick mortality during 2014 due to electrocution in a predator deterrent fence (Cahis and Baasch 2015). The Program observed one research-related plover chick mortality during 2011 due to flushing the chick into the water where it was consumed by a fish (Baasch 2012) and one research-related plover chick mortality during 2013 due to a chick attempting to fly and landing into the water where it was consumed by a fish (Baasch 2014). In 2022, incidental take was observed at an inland lake as a single nest containing four plover eggs was inundated at Lake Minatare as the lake was filled in preparation for delivery of irrigation water (PRRIP 2023). Across the entire AHR encompassing both Program and non-Program sites, there was no documented research related mortality in 2024.

Between 2007 and 2016, a limited amount of nest and chick predation was observed and did not exceed the Service’s threshold at any Program owned or managed off-channel sand and water nesting site in any year (Table 12; USFWS 2018). Increased effort to monitor predator activities began in 2017, which has resulted in more documented predation than during the First Increment. However, losses of plover nests and chicks to predation have not exceeded the Service’s established threshold (i.e., the loss of 70% of nests or 80% of chicks to predation in three of five years for sites that average at least three plover nests; Table 12). The percentages provided in Table 12 for losses of nests due to predation are based on the total number of nests observed at each site during each year and percentages for losses of chicks are based on the total number of chicks observed at each site during each year.

Conclusions

Results from our 2024 plover monitoring efforts indicate continued increases in plover productivity metrics on monitored sites across the central Platte River from recent lows observed during 2018 and 2019. The estimated number of breeding pairs (47 pairs), the total number of nests observed (74 nests), and the number of plover fledglings (63 fledglings) were the highest observed during the 2001-2024 monitoring period. During the 2024 season, plover fledge ratios were 1.34 chicks/BPE and 0.85 chicks/nest at monitored sites. Fledge ratios are one of the indicators used by the Program to measure reproductive success of plovers over time and we have observed a positive trend in fledge ratios over the past several years after a low of 0.62 chicks/BPE and 0.49 chicks/nest in 2018. Renesting by plovers at sites with early nest losses due to predation and weather likely increased the total number of nests observed this year, but continued waves of predation made these efforts less productive. Together, these culminated in low overall apparent nest success (0.47) this year. In spite of low productivity at sites impacted by predation and weather (e.g. Kearney Broadfoot South, Dyer, and Cottonwood Ranch), other sites further east (Newark West, Newark East, and Leaman) had better nest success, bringing the total number of successful nests across the AHR to 35 nests, comparable to the average number of successful nests observed during the contemporary 2010-2024 monitoring period (31 nests). Successful nesting and brooding at these sites also made a large contribution to raising plover fledge ratios up to levels comparable to 2022 and 2023.

We have observed a significant, positive relationship between the estimated number of plover breeding pairs and area of potential nesting habitat at OCSW sites since 2001 (Figure 13). Plovers are territorial when establishing and defending nests, and this behavior requires sufficient spacing between nests (Haffner et al. 2009). Numbers of plover breeding pairs, nests, and broods increased markedly after the Program began constructing and managing more potential nesting habitat in 2010. As the area of potential nesting habitat at OCSW sites has increased and plateaued at ~250 ac from 2021-2024, we have seen annual variability in the estimated number of breeding pairs fluctuate between 36 and 47 pairs. Plovers exhibit strong fidelity to breeding sites (Ledee et al. 2010) and previous breeding success may influence faithfulness to sites (Friedrich et al. 2015; but see Wiens and Cuthbert 1988). Annual variability in breeding pairs at OCSW sites is likely related to a combination of the quantity of available habitat, density of plovers on each site as migratory birds arrive, and previous nest success.

The most productive plover OCSW nesting sites in 2024 were Blue Hole, Newark West, Newark East, Leaman, and Trust Wildrose East (Table 3). We observed no plover nesting on six OCSW sites (Table 3). Although Kearney Broadfoot South had the highest number of nests (13), only two nests hatched and the chicks and remaining egg of one of those successful nests were predated by a striped skunk (*Mephitis mephitis*). Newark East and Dyer had the next highest number of nests (12). Newark East hatched 8 of 12 nests and produced 26 fledglings. However, Dyer only hatched 3 of 12 nests and produced just three fledglings. Predation, weather, and abandonment all contributed to nest losses on Dyer. The first four plover nests initiated on Newark West were all predated by striped skunk (*Mephitis mephitis*), but the next three nests successfully hatched producing 11 fledglings, resulting in a site fledge ratio of 3.67, the highest across all sites. Both of the plover nests on Leaman and the single nest on Trust Wildrose East hatched and each site produced three fledglings. Although no fledglings were produced, NAI Kearney Broadfoot South and Follmer both had plover nesting for the first time this year.

The continued use of remote camera monitoring of shorelines, nesting sites, and nests on six Program-managed sites has allowed us to more accurately fate nests and, to a lesser extent broods. Camera monitoring began in 2020 and, as a result, the proportion of nests and broods that failed due to unknown causes has concurrently decreased from a maximum of 0.500 of nest fates in 2019 (Figure 17). In 2024, the proportion of nests that failed due to unknown causes was 0.18 (Figure 17). Video and images from cameras and information from track surveys helped us assign fates to 32 of the 35 plover nests that failed. Twenty-two nests (0.30 of total nests) failed due to predation, four nests (0.05) failed due to abandonment, and six nests (0.08) failed due to weather. We were not able to assign a fate to four plover nests (0.05) due to uncertainty about whether the nest failed before or after hatching. Of the 35 successful plover nests, 11 broods failed with the failure of ten of these broods attributed to unknown causes and one due to predation. The cause of brood losses remains one of the information gaps of our monitoring. Cameras have been effective at documenting predation on recently hatched chicks at the nest, but once chicks begin spending time away from the nest, then our cameras provide limited information on predation of broods. Overall, the data accumulated on plover nest and brood fates will be used to inform future management decisions to continue to improve adult survival and plover nest productivity along the AHR.

LEAST TERNS

2024 Seasonal Summary

Terns have positively responded to Program habitat creation, rehabilitation, and management along the AHR during 2001-2024 (Tables 13 and 14). During the 2024 plover nesting season, we observed: the highest peak estimated number of breeding pairs (141 pairs; the same number of breeding pairs as 2015, the previous high); the highest number of total nests (221 nests); the highest number of successful nests (95 nests) since 2015; the lowest apparent nest success (0.43) since 2006; and a slightly lower number of fledglings (118 fledglings) than the past two years (Tables 13 and 14). We observed the lowest fledge ratio (0.84 chicks/BPE) since 2019 (Table 14). As with previous years, we continued to observe a high amount of variability in reproductive effort and success across OCSW nesting sites (Table 15). We observed the following during the 2024 nesting season.

- Terns nested at 12 of 18 OCSW sites (Table 15). There was a total of 246 ac of potential nesting habitat available at the 18 OCSW sites in 2024.
- The peak AHR breeding pair estimate for terns was 141 pairs (Table 14). Tern nests produced 184 chicks (<15 days old) and 118 fledglings (≥21 days old), resulting in a hatch ratio of 1.30 chicks/BPE and fledge ratio of 0.84 chicks/BPE based on BPE (Table 14).

- Terns established 221 nests, resulting in a hatch ratio of 0.83 chicks/nest and a fledge ratio of 0.53 chicks/nest based on the number of nests (Table 14).
- Blue Hole, NAI Kearney Broadfoot South, Newark West, Leaman, and Follmer were the most productive OCSW nesting sites for terns in 2024 with fledge ratios ≥ 1 chicks/BPE (site-specific peak date used to estimate BPE) (Table 15).
- The other seven OCSW sites at which we observed tern nesting had between 0 and 16 successful nests (Table 15). Fledge ratios at these seven sites ranged between 0 chicks/BPE and 0.72 chicks/BPE (site-specific peak date used to estimate BPE).
- The proportion of tern nests and broods that failed due to unknown causes was 0.19. Losses of tern nests and broods to unknown causes remains lower than the loss of an average 0.35 of nests and broods to unknown causes documented from 2017-2019 prior to current implementation of shoreline, nesting site, and nest camera monitoring.

Semi-Monthly OCSW Surveys

Biologists observed tern breeding pairs, nests, and chicks on OCSW sites rather than on-channel river locations in 2024 (Tables 16, 17, 18, and 19). Based on the twice monthly OCSW surveys, the number of tern adults, chicks, and fledglings observed peaked at 254 adults on the 1 July survey, 73 chicks on the 15 July survey, and 15 fledglings on the 15 July and 1 August surveys (Table 18). The number of tern nests counted reached a maximum of 90 nests on the 1 July survey (Table 18). Since 2010, the number of adult terns observed during twice monthly OCSW surveys generally has been highest during the 15 June or 1 July surveys (Figure 18 and 19).

Semi-Monthly River Surveys

EDO staff observed no on-channel tern nesting during 2024 (Tables 17 and 19), which was similar to previous years. The last tern nest at an on-channel island site was documented by the Program in 2016 (Table 17). EDO staff counted a maximum of 56 adults and nine fledglings on the 15 July river survey and it was assumed these birds came to forage along the river from nearby OCSW sites because no nests or chicks were observed on-channel prior to that survey. This date of peak tern river use corresponded to a period of low Platte River discharge with a documented mean daily discharge of 316 cfs at the Kearney gage (Figure 3). Periods of peak tern foraging use of the river vary annually, but generally occur prior to nesting in late May or early June and again after chicks fledge in late July or early August (Figures 20 and 21). Migratory terns arrive to the central Platte River later than plovers with low tern foraging use of the river documented during early May river surveys since 2010 (Figure 21). Low or no suitable on-channel nesting habitat in the AHR during the First Increment and Extension of the Program (Figures 4 and 5) has resulted in most nesting occurring on managed off-channel sites (Table 16 vs. Table 17, Figure 22).

Nest Monitoring, Brood Monitoring, and Survival Rates

Biologists observed tern nesting at 12 of 18 OCSW sites during semi-monthly monitoring in 2024 (Table 15). Biologists then monitored nests and broods at the 12 OCSW sites on a semi-weekly basis and observed a total of 221 tern nests in 2024 (Table 14, Figure 23).

<u>Breeding Pairs</u> — The estimated number of tern breeding pairs peaked at 141 pairs on 2 July and biologists counted a maximum of 334 adults across all sites (Table 14). The BPE of 141 pairs tied

with 2015 for the highest tern BPE observed by the Program (Table 14, Figure 24). The numbers of tern nests, breeding pairs, and broods observed in 2024 showed a large increase this year compared to the relative stability in these metrics since the last peak in 2015 following the addition of OCSW habitat acres (Figure 24). As with plovers, we have observed a significant, positive relationship between annual tern BPE at OCSW sites with the total area of potential OCSW nesting habitat available during 2001-2024 (Figure 25). However, the amount of variability explained by the data was higher for plovers ($R^2 = 0.78$) than for terns ($R^2 = 0.63$), and the relationship between BPE and acres had a greater slope for terns. For every acre increase in potential nesting habitat at OCSW sites, there was an increase of 0.35 (95% CI = 0.23, 0.46) tern breeding pairs (Figure 25).

Nests — Biologists observed and monitored a total of 221 tern nests during 2024, the highest observed (Table 14, Figure 26). The OCSW sites with the most tern nests were Newark East (40 nets), Dyer (38 nests), and Newark West (32 nests) (Table 15). The remaining nine sites with nests had between 2 and 21 tern nests (Table 15). Biologists observed the first tern nest on 17 May and the last nest was first observed on 18 July. Ninety-five of the 221 nests were successful, the highest number of successful nests since 2015, for an apparent nest success of 0.43, which was the lowest apparent nest success since 2006 (Tables 13 and 14, Figure 27).

The overall DSR of tern nests across all monitored OCSW sites was 0.963 (LCL: 0.939, UCL: 0.975) during 2024 (Tables 14 and 20). We found no significant difference in nest DSR between Program and non-Program sites (Table 21). The DSR of tern nests was 0.957 (LCL: 0.938, UCL: 0.978) at Program sites and 0.979 (LCL: 0.915, UCL: 0.995) at non-Program sites (Table 21). We found a significant difference in site-specific nest DSR, where Dyer, Cottonwood Ranch, Kearney Broadfoot South, OSG Lexington, and NPPD Lexington had lower DSR than Blue Hole (reference site). The range of DSR across sites was 0.838 to 0.993 for the 12 OCSW sites with tern nests (Table 20).

The overall incubation period (21-day) survival rate of tern nests on all monitored sites was 0.454 (LCL: 0.267, UCL: 0.590; Tables 14 and 20). Incubation period survival was 0.397 (LCL: 0.261, UCL: 0.633) at Program sites and 0.645 (LCL: 0.155, UCL: 0.904) at non-Program sites (Table 21). Across monitored OCSW sites, incubation period survival ranged from 0.007 to 0.829 (Table 20).

Broods — Biologists counted 184 chicks from the 95 broods from successful nests (Table 14). The hatch ratio for terns was 1.30 chicks/BPE and 0.83 chicks/nest (Table 14). The first nest observed to hatch occurred on 10 June, whereas the last nest observed to hatch occurred on 30 July. Of the 184 chicks, biologists observed 127 chicks that survived ≥15 days (Table 14).

Across the 11 OCSW sites with tern broods, overall DSR for broods was 0.991 (LCL: 0.968, UCL: 0.999; Tables 14 and 22). We found no significant difference in DSR for broods on Program (DSR: 0.992; LCL: 0.969, UCL: 0.999) compared to non-Program (DSR: 0.985; LCL: 0.883, UCL: 0.998) sites (Table 23). We found a significant difference in brood DSR at sites, where Dyer had a lower DSR than Blue Hole (reference site). The range of DSR across sites was 0.778 to 1 (Table 22).

The overall brooding period (21-day) survival rate was 0.824 (LCL: 0.506, UCL: 0.971; Tables 14 and 22). Brooding period survival for terns was 0.846 (LCL: 0.518, UCL: 0.971) at Program sites and 0.726 (LCL: 0.073, UCL: 0.950) at non-Program sites (Table 23). Across monitored OCSW sites, brooding period survival for terns ranged from 0.005 to 1 (Table 22).

Fledges — Of the 184 chicks from the 95 nests, 118 chicks made it to the 21-day fledging age resulting in a fledge ratio of 0.84 chicks/BPE or 0.53 chicks/nest (Table 14). Biologists first observed a tern fledgling on 27 June and the last known tern chick to fledge did so on 19 August. The proportion of successful chicks was 0.64, which was slightly higher than the 0.60 observed in 2023, and within the range of recent annual variability in the metric (Figure 27). The fledge ratio of 0.53 chicks/nest represents the lowest observed during the contemporary 2010-2024 monitoring period, just below the 0.54 chicks/nest observed in 2019 (Table 14). Based on BPE, the 0.84 chicks/BPE from 2024 was the lowest since 2019, which was 0.76 chicks/BPE (Table 14, Figure 28).

Nest and Brood Fates

We successfully assigned nest fates to 173 of the 221 tern nests observed during 2024 (Figure 29). Thirty-nine nests failed due to predation (0.18 of total nests), 11 failed due to abandonment (0.05), and 28 failed due to weather (0.13) (Figure 29). Thirty-two nests failed due to unknown causes (0.14) and 16 nests had an unknown outcome (0.07) (Figure 29). Of the 95 nests that were successful, 75 fledged (0.34), two failed due to predation (0.01), and four failed due to weather (0.02) (Figure 29). Ten broods failed due to unknown causes (0.05) and four broods had an unknown outcome (0.02) (Figure 29).

Incidental Take Summary and Mortality

Incidental take of terns was minimal during the Program's First Increment and did not exceed the Service's threshold under any category of allowable take in any year (USBR 2018). With the removal of the tern from the federal list of threatened and endangered species on 12 February 2021, the Program's Governance Committee, including the USFWS, agreed that the provisions of the Incidental Take Statement specific to terns in the 2006 Biological Opinion (USFWS 2006) and 2018 Supplemental Biological Opinion (USFWS 2018) no longer apply (PRRIP 2021a). Across the entire AHR, spanning both Program and non-Program sites, there was no documented research related mortality during 2024.

Conclusions

Our 2024 monitoring efforts documented terns nesting in high numbers on OCSW sites along the central Platte River. We observed the highest estimated number of tern breeding pairs (141 pairs) since 2015 (also 141 pairs) and the highest number of total nests (221 nests) for the Program. However, the hatch ratio of 0.83 chicks/nest and the hatch ratio based on breeding pairs of 1.30 chicks/BPE was the lowest observed during the contemporary 2010-2024 monitoring period. Though renesting has been shown to be less common for terns than for plovers on the AHR (Roche et al. 2016), it is likely that some renesting was occurring for terns this year because of the wave of nest initiations that occurred following documented predation events at multiple sites in 2024.

The end product was a high number of nests (221 nests), low apparent nest success (0.43), but the highest number of successful tern nests (95 nests) since 2015.

Similarly, the 2024 tern fledge ratio (0.84 chicks/BPE) was the lowest since 2019. However, the number of tern fledglings (118 fledglings) was on par with the average number of fledglings produced annually from 2020-2023 (119 fledglings). Terns responded to losses with increased reproductive effort to make 2024 a successful year for fledgling production across the AHR.

As with plovers, there was a significant positive relationship between the estimated number of tern breeding pairs at OCSW sites and the area of potential nesting habitat at OCSW sites (Figure 25). Although the amount of variability explained by the data was higher for plovers (R^2 = 0.78) than for terns (R^2 = 0.63), the slope of the relationship between breeding pairs and OCSW habitat area was greater for terns than plovers. For every acre OCSW habitat increased, we observed an increase of 0.35 tern breeding pairs (95% CI: 0.23-0.46). This may be due to differences in nesting behavior as terns nest colonially whereas plovers are territorial. The Program has observed two peaks in tern use of OCSW habitat, one in 2015 and another in 2024. Numbers of tern breeding pairs, nests, and broods increased and eventually peaked in 2015 after the Program began constructing and managing more potential nesting habitat (Figure 24). From 2016-2023, we observed relative stability and a lack of immediate response by terns to increased habitat availability in terms of nest counts, breeding pairs, and brood counts (Figure 24). The large increase in nests, breeding pairs, and brood counts observed in 2024 follows a period of OCSW habitat restoration that has added approximately 110 acres since 2015 to provide a total of approximately 250 OCSW acres.

We continue to observe high variability in tern use and productivity across OCSW sites. The most productive tern OCSW nesting sites in 2024 were Blue Hole, NAI Kearney Broadfoot South, Newark West, Leaman, and Follmer (Table 15). We observed no tern nesting on six OCSW sites (Table 3). Although Newark East had the highest number of tern nests (40 nests), half failed due to weather or abandonment. Newark East still produced 21 fledglings, the second highest after Newark West, which produced 30 tern fledglings. Newark West had the highest site fledge ratio (1.36 chicks/BPE). Blue Hole and Leaman each produced 18 fledglings from 18 nests. NAI Kearney Broadfoot South and Follmer both had tern nesting for the first time this year and both produced fledglings, 2 and 13 respectively.

As with plovers, we have been able to reduce uncertainty regarding tern nest and, to a lesser extent, brood fates on Program managed sites since 2020 (Figure 29). The proportion of tern nests and broods that failed due to unknown causes was 0.19 (Figure 29), which was similar to the proportion of plover nests and broods that failed due to unknown causes (0.18; Figure 17). However, the proportion of only nests that failed due to unknown causes was higher for terns (0.14) than plovers (0.04), which was likely due to multiple related reasons. First, since the delisting of terns, we have preferentially allocated nest cameras to determine the fate of plover nests given their continued protection under the ESA. As a result, we do not have as much nest-specific information regarding fates of tern nests and must rely on shoreline and site cameras, track surveys, and evidence from the nesting site to determine tern nest fates. Second, having more tern nests on each site in close proximity to one another increases the likelihood of loss of multiple tern nests to the same predation or weather event. Without having imagery to document the cause of the loss, it is likely that multiple nests fail simultaneously due to unknown causes.

PREDATOR MANAGEMENT AND MONITORING

The Program implemented several long-term management strategies to reduce the risk of predation at 12 Program-managed OCSW sites during their construction and/or rehabilitation. We selected off-channel nesting sites with peninsulas surrounded by water to manage and provide a ≥100 ft water deterrent to terrestrial predators. We installed permanent and temporary electrified woven wire fences across the land entrance to each nesting area. We positioned non-electrified fence-panel wings on the ends of the electrified fence and extended them between three and seven ft in the water to deter terrestrial predators from swimming from the mainland to the nesting peninsula. To reduce the potential for avian predation, we removed all trees within a ≥492 ft radius of the nesting site and placed avian spikes on all potential perches that could not be removed. Finally, we trapped and removed terrestrial predators from around the periphery of the site on an annual basis from March through August (and into September on the Newark West and East sites until plovers and terns were no longer observed).

The Program again used additional predator monitoring in 2024 to reduce the number of nest and brood losses attributed to unknown causes and increase our understanding of the impacts of predation on plovers and terns. This was the fourth year of our predator monitoring study after a 2020 pilot study, which was enacted due to low plover fledge ratios observed during 2018 and 2019, a decrease in the proportion of successful plover chicks over time, and concerns about predation impacts on plovers. Predator monitoring efforts at six OCSW sites included track surveys along the shoreline and remote camera monitoring at the shoreline, on the nesting site, and at individual nests. We considered three of these six OCSW sites to use basic predator management techniques and the other three to employ additional predator management strategies.

For the 2024 season, the basic design and implementation remained the same as in 2021-2023 (PRRIP 2022b, PRRIP 2023, PRRIP 2024). We used basic predator management at the Cottonwood Ranch, Dyer, and Newark East sites. We deployed additional predator management efforts on three Program-managed sites (Kearney Broadfoot South, Newark West, and Leaman) that included additional predator exclusion fences surrounding entire nesting peninsulas and predator deterrent lights (see details below). The Program will continue implementing additional predator management strategies through 2025 to provide a multi-year data set that will be analyzed and used to inform future management decisions.

PREDATOR MANAGEMENT

METHODS

Terrestrial Mammal Trapping

The United States Department of Agriculture and Animal and Plant Health Inspections Service Wildlife Services (USDA-APHIS-WS) conducted terrestrial mammal trapping and lethal removal at ten Program-owned and NPPD off-channel nesting sites in 2024 (Table 24). Personnel from USDA-APHIS-WS deployed traps from late March through August at each site, with trapping continuing into early September at Newark West and Newark East until plovers and terns were no longer observed. Traps deployed included live cage traps, dog proof leg-hold traps, leg-hold/foot-hold traps (jaw traps), and body-hold snares (Table 24). Firearms were used when deemed necessary. Personnel from USDA-APHIS-WS recorded the date on which each trap was deployed, trap type, trap identification number, and OCSW site. Daily trapping logs were kept to record the date and time of trap checks, trap type, number of traps checked, number of empty closed traps, number of traps closed with caught animal, and number of traps set to be checked the next day. When a terrestrial mammal was captured, USDA-APHIS-WS personnel identified the species, the trap in which it was captured, time, and date, and then lethally removed the mammal from the site.

We calculated trapping effort at each site as the number of trap days, which was the total number of days each trap was open summed over all traps at each site. Because visits to traps were not conducted daily and because traps may have closed between visits, we determined the number of trap days when the trap closed between visits as one-half of the number of days since the trap was last checked. We did not include firearm usage in trapping effort. We used the total number of mammals captured in traps at the site divided by the total number of trap days to calculate the number of captures per unit effort (i.e., trap days). Animals removed through use of a firearm were counted toward total number of captures but were not included in the calculation of captures per trap day.

Predator Exclosure Fencing

In addition to our predator exclusion fences that were deployed across nesting peninsula entrances, in 2021, we installed and maintained additional predator exclusion fencing that surrounded our nesting areas on two OCSW sites: Kearney Broadfoot South and Newark West. On the interior shoreline of the nesting area at Kearney Broadfoot South, we installed an interior 4-ft woven wire predator fence with two electrified wires (Figure 30). The fence had 4-in x 4-in openings to allow plovers and terns to easily move through but prevent medium- and large-sized mammalian predators from accessing the site. We mounted one wire 3-in above the fence and along the tops of the fence posts to prevent avian predator perching and minimize mammals from climbing over the fence. We mounted the second wire at approximately the same height as the top of the woven wire fence but offset to the outside to prevent mammals from climbing over. We deployed an exterior 4-ft high woven wire predator exclusion fence at Newark West that surrounded the outside of the water moat along the property line (Figure 31). We mounted one electrified wire offset to the outside of the fence and approximately 3-ft above the ground. Because the fence was located outside the nesting and foraging areas, we used a fence that had 2-in x 4-in openings.

Predator Deterrent Lighting

We deployed predator deterrent lights at three Program monitored and managed sites. At Kearney Broadfoot South, we deployed 4 motion-activated lights (Luposwiten Solar Motion Sensor Lights, Luposwiten Direct, Shenzhen, Guangdong), four random pattern lights (Foxlights Solar Night Predator Deterrent, Foxlights International PTY LTD, Bexley North, Australia), and 28 blinking walking lights (RISOON Solar Strobe Lights, RISOON; Figure 30). We mounted the blinking walking lights to the interior predator exclusion fence and set each to flash at alternate times to give the illusion of movement along the fence. We deployed motion-activated and random pattern lights in pairs of two across the site at a density of approximately one set per four ac. We installed these lights on top of a 7-ft high post with avian spikes placed on top of the lights to prevent them from being used as predator perches. At Newark West, we deployed four motion-activated and four random pattern lights distributed across the two nesting peninsulas (Figure 31). Finally, we deployed three sets of motion activated and random pattern lights distributed across the Leaman site (Figure 32).

PREDATOR MONITORING

The Program monitored predator presence and predation events at six OCSW nesting sites during 2024: Dyer, Cottonwood Ranch, Kearney Broadfoot South, Newark West, Newark East, and Leaman. We documented predator presence using a combination of USDA-APHIS-WS trapping of terrestrial mammals outside of the nesting peninsulas, track surveys along peninsula shorelines, remote cameras set along peninsula shorelines and within nesting sites, and remote cameras placed to monitor individual nests. We documented predation events using the remote cameras.

METHODS

Terrestrial Mammal Trapping

We used daily trapping logs to provide information on potential terrestrial predator presence along external shorelines and along the outside of nesting peninsulas. We identified the species present at the site and the number of captures per species per trap day as an indicator of relative abundance.

Track Surveys

EDO biologists and technicians conducted track surveys along peninsula shorelines at the six nesting sites once per week from May through August (and into September on the Newark West and East sites until plovers and terns were no longer observed) to document avian and terrestrial predator presence and any predators that entered the nesting peninsula. We summarized track survey effort at each site by totaling the number of surveys completed during the nesting season. One or two observers began track surveys at the nesting peninsula entrance and walked the entirety of the shoreline while searching for evidence of predator species presence. Presence included tracks along the shoreline, digs (i.e., disturbed sand under a fence due to animal digging), fence turn backs (i.e., the animal walked to the fence and retreated), and scat. If observers found more than one sign of presence for any one species, then they recorded only one unique species register due to uncertainty as to the number of individuals of that species that were present. Observers attempted to identify the species responsible for animal digs when possible; otherwise, they attributed them to an unknown species. If other species' tracks were found during the same survey, observers did not count the animal dig as a unique register because it was likely caused by one of the identified species. Observers cleared tracks in the sand after each survey to prevent double counting upon the next weekly survey.

Remote Trail and Video Cameras

EDO biologists attached shoreline trail cameras (Bushnell; Overland Park, KS) to 3-ft tall metal posts placed every 1,200 linear ft along the shorelines of the six nesting sites. Biologists attached avian spikes to the top of each post to prevent avian predator perching. When the 1,200 linear feet spacing did not provide camera coverage of shorelines, then the distance between shoreline cameras was shortened to improve coverage. We quantified shoreline camera monitoring effort at each site as the number of days each shoreline camera was deployed (camera days) totaled over all cameras at each site. We programmed trail cameras to take motion-triggered photos followed by a 30-sec video. We identified animals registered on cameras to the species level but did not attempt to identify individuals. Because multiple cameras at a single site could have photographed the same individual several times, we limited our final dataset to include only unique potential predator registers captured by shoreline cameras. We defined a unique register as a photo/video of a single species separated by at least 24-hours from a previous register of the same species. We considered multiple photos of the same species taken by shoreline cameras at the same site within a 24-hour period to be a single unique register. We also considered a photo/video of multiple individuals of the same species to be a single unique register. We added the number of unique potential predator registers over the entire nesting season by site to calculate the total number of unique potential predator registers for each site. We divided the number of unique shoreline registers for each site by the total number of shoreline camera days to obtain a measure of registers per unit effort.

EDO biologists attached site-level trail cameras to 4-ft tall PVC pipes at each of the six nesting sites at a density of one camera every four ac near the edges of the peninsula facing inland to document potential predator presence on the nesting site. Biologists placed avian spikes on the top of each PVC pipe to prevent avian predator perching. Biologists programmed site-level cameras to take motion-triggered photos followed by a 30-sec video. We calculated and defined monitoring effort, number of camera days, and unique registers the same as for shoreline cameras. We divided the number of unique site-level registers for each site by the total number of site-level camera days to obtain a measure of registers per unit effort.

EDO biologists placed nest-level trail cameras and cellular video cameras (Arlo; Carlsbad, CA) at active plover and tern nests (i.e., adults were tending the nest until the nest was successful or failed) at the same six nesting sites to document potential predator presence and predation events occurring at the nest. Biologists placed nest-level cameras at a density of approximately one camera every two ac and only placed them at established nests (i.e., the nest contained ≥1 egg in the nest bowl). The number of cameras allocated per site was established before the nesting season with five to ten cameras deployed per site concurrently. Biologists preferentially placed cameras at plover nests before tern nests and not every nest was monitored by a camera to allow investigation of potential camera effects on nest survival and success. Biologists removed the camera once the nest was no longer active (i.e., successful or failed) and used the camera at another nest if needed.

Biologists placed trail cameras ~5 ft from plover nests and ~7 ft from tern nests to minimize disturbance to nesting adults. Biologists attached trail cameras to 2-ft tall metal posts with avian spikes placed on top to prevent avian predator perching. Biologists placed cellular video cameras closer to the nest (i.e., 1.5-2 ft) with the purpose of documenting detailed nesting information (i.e., adult nesting behavior, hatching, predation, and weather events) that trail cameras sometimes miss. Each nesting site was designated one cellular video camera. Biologists programmed nest-level cameras to take motion-triggered photos followed by a 30-sec video. We calculated nest-level camera monitoring effort and number of nest-level camera days using the same methods described above for shoreline and site-level cameras. We categorized photos/videos from each nest-level camera as a predator register (i.e., potential predator documented without predating the nest) or predation event (i.e., predator documented predating the nest). For predation events, we recorded the date, time, type of predation (ate egg[s], chick[s], or adult[s]), and predator behavior/activity. If we documented more than one predation event by the same predator species in 24-hr at the nesting site (at ≥1 nest[s]), we considered it as one unique predation event. However, we included all information from the predation event (e.g., total number of nests, eggs, or chicks eaten) when totaling numbers of plover and tern nests, eggs, and chicks predated during 2024. We added the number of unique nest-level registers to the number of unique nest-level predation events and divided by the total number of nest-level camera days for each site to obtain a measure of nest-level registers per unit effort. We also separately divided the number of unique nest-level predation events for each site by the total number of nest-level camera days to obtain a measure of predation events per unit effort.

We used mixed-effects nest fate logistic exposure models to calculate DSR of nests at the six OCSW sites to determine whether the presence of nest cameras affected nest survival rates. Using data from the six sites, we conducted an analysis using all plover and tern nests combined and developed three models. First, we evaluated whether survival was different for nests with and without cameras (i.e., camera model). Second, we evaluated whether survival was different for nests with and without cameras and across sites (i.e., camera + site model). Third, we evaluated whether survival was different for nests with and without cameras, across sites, and within sites (i.e., camera + site + camera*site model). We conducted two additional analyses using data only from plover nests and from tern nests to separately fit the camera model. We included site as a random effect in each model to account for a potential lack of independence of nest fates at each site. We used package *lme4* (Bates et al. 2015) in Program R (R Core Team 2024) to fit models and estimate coefficients. When models did not converge due to insufficient data, we defaulted to a fixed effects model for estimates. In 2024, we defaulted to a fixed effects model for the comparison of nests with and without cameras within each site. We also made an overall and site-by-site comparison between DSR of nests with and without cameras in 2024 to the combined average DSR of all plover and tern nests calculated using data from 2010-2016 prior to any camera usage at sites.

RESULTS

Trapping of Terrestrial Mammals

There has been a high amount of variability among years and across OCSW sites based on trapping of potential mammalian predators during 2012-2024 (Figure 33). This variability is due to differences in trapping effort across years and sites prior to 2021 and may be related to changes in predator communities over time. During 2024, personnel from USDA-APHIS-WS deployed 246 traps across ten sites with the number of traps per site ranging between 16 and 38 (Table 24). The first traps were set on 29 March and traps were all removed by 7 September 2024. Total number of trap days per site ranged from 986.5 days at Follmer to 5548.5 days at Newark West (mean = 2,958.2; standard error [SE] = 416.7) and totaled 29,581.5 days across all ten sites (Table 25).

Traps captured and removed 393 terrestrial animals encompassing six species and USDA-APHIS-WS personnel used a firearm to remove one raccoon (*Procyon lotor*) (Table 26). Overall trapping efficiency was 0.013 captures/trap day (Table 25). Across the ten sites, trapping efficiency ranged between 0.009 captures/trap day at Dyer and 0.024 captures/trap day at Follmer (mean = 0.015; SE = 0.002; Table 25). When comparing the trapping efficiencies of the six OCSW nesting sites where the Program used cameras to monitor predator presence and predation events (Figure 34), we observed mean trapping efficiencies of 0.011 captures/trap day at basic predator management sites (Dyer, Cottonwood Ranch, and Newark East) and 0.013 captures/trap day at additional predator management sites (Kearney Broadfoot South, Newark West, and Leaman). Raccoons were the most frequently captured terrestrial mammal at every site with a total of 366 raccoons captured over all sites (Tables 26 and 27; Figure 35). Other species captured in traps included American badger (*Taxidea taxus*), cottontail rabbit (*Sylvilagus spp.*), coyote (*Canis latrans*), Virginia opossum (*Didelphis virginiana*), and striped skunk (*Mephitis mephitis*) (Figure 35).

Shoreline Track Surveys

EDO biologists and technicians conducted a total of 102 shoreline track surveys across the six OCSW sites during 2024, ranging from 15 weekly surveys at Dyer to 19 weekly surveys at Newark West and Newark East, and recorded 225 total unique track registers (2.21 track registers/survey; Table 28). Number of unique track registers per survey ranged from 1.47 track registers/survey at Newark West to 3.60 track registers/survey at Dyer (mean = 2.26; SE = 0.33; Table 28). We observed more tracks per survey at sites with basic predator management (2.60 track registers/survey) than at those with additional predator management (1.83 track registers/survey); Table 28).

Tracks from avian species were most frequently observed at all sites (Figure 36). Across all sites, we observed 1.25 avian track registers/total survey effort, 0.52 reptilian track registers/total survey effort, and 0.43 mammalian track registers/total survey effort. Among avian species, we most frequently observed tracks from Canada geese (*Branta canadensis*) (0.93 track registers/total survey effort) when considering total survey effort at all six sites combined. On a site-by-site basis, we most frequently observed tracks from Canada geese (*Branta canadensis*) and great blue herons (*Ardea herodias*) at all six sites for avians (Figure 37a). Among reptiles, we most frequently observed turtles (Order Testudinata) over all sites (0.46 track registers/total survey effort) and at each site (Figure 37c). Among mammalian species, we most frequently observed tracks from white-tailed deer (*Odocoileus virginianus*) (0.11 track registers/total survey effort) when combining data from all sites. However, the frequency of occurrence and composition of the mammal predator community as observed by track surveys varied greatly by site (Figure 37b). We most frequently observed American badger (*Taxidea taxus*) tracks at Dyer, white-tailed deer tracks at Cottonwood Ranch and Newark East, and striped skunk (*Memphitis mephitis*) tracks at Kearney Broadfoot South (Figure 37b). Notably, no mammal tracks were observed during track surveys at Leaman.

Shoreline Camera Monitoring

EDO biologists deployed 29 shoreline cameras for a total of 3,241 camera days across the six sites during 2024 (Table 29). Number of shoreline cameras deployed per site ranged from three cameras totaling 348 camera days at Leaman to seven cameras totaling 714 camera days at Kearney Broadfoot South (Table 29). Shoreline cameras recorded 894 unique predator registers resulting in 0.276 unique registers/camera day across all six sites. We observed a low of 0.126 registers/camera day at Cottonwood Ranch and a high of 0.339 registers/camera day at Leaman (mean = 0.275 registers/camera day, SE = 0.031; Table 29). We observed 0.251 registers/camera day at sites with basic predator management compared to 0.302 registers/camera day at sites with additional predator management.

We documented avian species most frequently on shoreline cameras across all six sites (Figure 38a). We documented mammal and reptilian species less frequently than avian species on shoreline cameras (Figure 38). We observed mammals on shoreline cameras most frequently at Kearney Broadfoot South (0.042 registers/camera day; Figure 38b). We most frequently observed reptiles on shoreline cameras at Cottonwood Ranch (0.032 registers/camera day) (Figure 38c).

We documented nine different avian species on shoreline cameras with Canada geese (*Branta canadensis*) (0.157 registers/total camera days) and great blue herons (*Ardea herodias*) (0.039 registers/total camera days) observed most frequently across the six sites (Figure 39a). Among mammals, we documented 11 different species on shoreline cameras with the frequency of observation varying among the six sites (Figure 39b). We observed turtle species (Order Testudinata) on shoreline cameras on all sites except Newark West (Figure 39c).

Site-Level Camera Monitoring

EDO biologists deployed 25 site-level cameras for a total of 2,935 camera days across the six sites during 2024 (Table 30). Number of site-level cameras deployed per site ranged from three cameras totaling 348 camera days at Leaman to five cameras totaling 655 camera days at Newark East (Table 30). Site-level cameras recorded 292 unique predator registers resulting in 0.099 unique registers/camera day across all six sites. We observed a low of 0.044 registers/camera day at Kearney Broadfoot South and a high of 0.140 registers/camera day at Newark West (mean = 0.099 registers/camera day, SE = 0.018; Table 30). We observed 0.112 registers/camera day at sites with basic predator management compared to 0.083 registers/camera day at sites with additional predator management (Table 30).

We documented avian species most frequently on site-level cameras at all sites except Kearney Broadfoot South (Figure 38a). We documented mammal species most frequently on site-level cameras at Kearney Broadfoot South (0.027 registers/camera day) (Figure 38b) and observed no mammals at Leaman (Figure 38b). We observed no reptilian species on site-level cameras (Figure 38c).

Among the six avian species observed on site-level cameras, we observed Canada geese (*Branta canadensis*) (0.068 registers/total camera days) the most frequently across all six sites (Figure 40a). We observed five different mammals across five sites with high variability in the frequency of occurrence across sites (Figure 40b).

Nest-Level Camera Monitoring

EDO biologists deployed 46 nest-level cameras to monitor 147 nests for a total of 1,451 camera days across the six sites during 2024 (Table 31). The 147 nests were comprised of 51 plover and 96 tern nests. Nest-level cameras documented 46 unique registers of potential predator species (e.g., within view of camera but did not predate the nest) (Table 32) and 29 predation events resulting in 0.052 nest-level registers (including predation events)/camera day (Table 32). Among the six OCSW sites, we observed nest-level registers of avian species at all sites except Cottonwood Ranch, and mammalian species at all sites except Leaman (Figure 38 and 41). We observed nest-level registers of reptilian species at only Dyer and Kearney Broadfoot South (Figure 38 and 41). Avian species observed on nest-level cameras included Canada goose (*Branta* *canadensis*), great blue heron (*Ardea herodias*), great horned owl (*Bubo virginianus*), red-tailed hawk (*Buteo jamaicensis*), turkey vulture (*Cathartes aura*), and an unknown avian species (Figure 41a). Mammalian species observed on nest-level cameras included American badger (*Taxidea taxus*), coyote (*Canis latrans*), mouse spp. (*Peromyscus spp.*), Ord's kangaroo rat (*Dipodomys ordii*), and striped skunk (*Mephitis mephitis*) (Figure 41b). Among reptilian species, we observed soft-shelled turtle (*Apalone spp.*) and garter snake (*Thamnophis spp.*) on nest-level cameras (Figure 41c).

Nest-level cameras documented 29 unique predation events resulting in 0.020 predation event registers/camera day across all six sites (Table 31). Of those 29 predation events, 18 were at sites with basic predator management (Dyer, Cottonwood Ranch, and Newark East) and 11 were at sites with additional predator management (Kearney Broadfoot South and Newark West). There were no predation events on Leaman. We observed predation events more frequently on sites with basic predator management (0.022 predation events/total camera days) than at those with additional predator management (0.017 predation events/total camera days). We also documented two predation events that occurred on nests with nest-level cameras that were assumed predated due to evidence at the nest and the timing of the nest losses, although the cameras on these nests malfunctioned (Tables 32). Over all nests being monitored with cameras, 55 plover and tern nests were predated, either entirely or partially (Tables 32).

Use of nest-level cameras allowed us to accurately determine the fate of plover nests at the six OCSW sites (Table 33). We placed nest-level cameras at 51 of 52 plover nests observed at these sites and documented 20 successful nests, two successful nests with predation, 20 nests that failed due to predation, four nests that failed due to abandonment (one of which was abandoned after being partially predated; Table 32), four nests that failed due to weather, one nest that failed due to unknown causes, and two nests that had an unknown outcome (Table 33). The one plover nest without a camera was determined failed due to predation based on supporting evidence from other monitoring efforts (Table 33). Across the six sites during the plover incubation period, we observed 72 of 197 eggs hatch (Table 34). Seventy-eight eggs failed due to predation, eight failed due to abandonment, 19 failed due to weather, ten failed due to unknown causes, and ten had an unknown outcome (Table 34). During the brood-rearing period, five chicks failed due to predation and one chick failed due to unknown causes (Table 34).

We placed nest-level cameras at 96 of 157 tern nests observed at the six OCSW sites (Table 33). Forty-five nests with cameras and 19 nests without cameras were successful, six nests with cameras were successful though experienced some loss due to predation, 26 nests with cameras and 11 nests without cameras failed due to predation, ten nests with cameras and one nest without a camera failed due to abandonment, ten nests with cameras and 18 nests without cameras failed due to weather, five nests with cameras and eight nests without cameras failed due to unknown causes, and four nests without cameras had unknown outcomes (Table 33). Across the six sites during the tern incubation period, we observed 90 of 227 eggs hatch. Seventy-three eggs failed due to predation, 20 failed due to abandonment, 26 failed due to weather, 13 failed due to unknown causes, and five had an unknown outcome (Table 34). During the brood-rearing period, three chicks failed due to predation, seven failed due to weather, and six failed due to unknown causes (Table 34). All monitoring sources (i.e., outside/inside observers; nest, site, and shoreline camera data; and track surveys) were used to determine both plover and tern nest fates. However, individual plover/tern egg and chick fates were determined primarily using camera data with limited data available from outside monitoring.

Plover nests were predated by great horned owl (*Bubo virginianus*), striped skunk (*Mephitis mephitis*), and red-tailed hawk (*Buteo jamaicensis*) (Table 35, Figure 42). Predations occurred at both the egg and chick stages for plovers. Among the 23 plover nests monitored by cameras that were predated, the predation event occurred at an average on day 18.39 of incubation, which represents 65.7% of the 28-day incubation period for plovers (Table 35, Figure 42). Tern nests were predated by great horned owl, Canada goose (*Branta canadensis*), striped skunk (*Mephitis mephitis*), American badger (*Taxidea taxus*), and coyote (*Canis latrans*) (Table 35, Figure 42). Predations occurred at both the egg and chick stages for terns. Among the 32 tern nests monitored by cameras that were predated (including one nest which had two predation event occurrences; a great horned owl predated one egg and an American badger predated the remaining two eggs), the predation event occurred at an average on day 13.61 of incubation, which represents 64.8% of the 21-day incubation period for terns (Table 35, Figure 42).

Effect of Nest-level Cameras on Daily Survival Rates

EDO biologists placed nest cameras at 147 of 209 (70%) plover and tern nests at the six OCSW sites in 2024 (Table 33). Sixty-five of the 147 nests with cameras (44%) and 19 of 62 nests without cameras (31%) were successful (Table 33). For both plover and tern nests combined, we found nests with cameras (DSR = 0.965; 95% CI: 0.935, 0.980) had a significantly higher DSR than nests without cameras (DSR = 0.947; 95% CI: 0.904, 0.971; Figure 43). We also found differences in DSR both within and among the six sites that had nests with and without cameras that had both nest success and failure (Table 36, Figure 44). DSR at Cottonwood Ranch was significantly lower than DSR at Dyer (reference site), but DSR at Leaman, Newark East, and Newark West was significantly higher than DSR at Dyer. Newark West was the only site with a significant difference in DSR between camera and non-camera nests, where DSR was lower for camera nests compared to non-camera nests (Figure 44).

Biologists deployed cameras at 51 of 52 plover nests at the six OCSW sites (Table 33). One nest at Cottonwood Ranch did not have a camera and failed due to predation (Table 33). Therefore, a meaningful comparison of DSR for plover nests with and without cameras was not possible (Figure 45). Biologists deployed cameras at 96 of 157 tern nests at the six sites (Table 33). We found no significant difference in DSR for tern nests with (DSR = 0.959; 95% CI: 0.925, 0.980) or without cameras (DSR = 0.947; 95% CI: 0.903, 0.975; Figure 45). Combined average DSR for plover and tern nests during 2010-2016 across all six sites prior to camera deployment was 0.968 (95% CI: 0.932, 1.00), which was higher than our DSR estimates for nests with and without cameras during 2024. By site, DSR estimates for nests with and without cameras during 2024 were generally lower than median DSR during 2010-2016, with two exceptions (Figure 46). At Newark West non-camera nests had a DSR this year similar to the median from 2010-2016, but camera nests at this site had lower DSR. Leaman was the only site this year with DSR comparable to the median value from 2010-2016 (Figure 46), and it is the only site for which predation was not documented this year.

DISCUSSION

EDO biologists observed high use and reproductive investment in both plovers and terns during the 2024 monitoring period. The estimated number of breeding pairs (47 plover pairs and 141 tern pairs) and the total number of nests observed (74 plover nests and 221 tern nests) were the highest observed in the 2010-2024 contemporary monitoring period for both plovers and terns. However, both plovers and terns experienced their lowest apparent nest success (0.47 and 0.43, respectively) in the 2010-2024 contemporary monitoring period. Both species experienced high nest loss to predation and weather this year. Twenty-two plover nests and 39 tern nests failed due to predation and an additional six plover nests and 28 tern nests failed due to weather. Partial nest loss due to predation or weather was also observed on the six OCSW sites with camera monitoring.

Since implementing the predator monitoring study in 2021, we have observed changes in predators responsible for nest losses and changes in sites where losses were incurred. The three western sites with predator monitoring (Dyer, Cottonwood Ranch, and Kearney Broadfoot South), had an increase in nest losses this year. On Dyer, we observed via nest-level cameras 17 nests that were either partially or entirely predated by great horned owl (*Bubo virginianus*) or American badger (*Taxidea taxus*), including one nest that was partially predated by both predator species (1 of 3 eggs were predated by a great horned owl and the remaining two eggs were predated by an American badger the next day) in 2024. Although great horned owls and American badgers have predated nests on Dyer in the past, they never have predated this large quantity. Cottonwood Ranch only had one predation event captured via nest-level cameras in the past three years by a bullsnake (*Pituophis catenifer sayi*) in 2023. This year via nest-level cameras however, we observed six nests that were entirely or partially predated by striped skunk (*Mephitis mephitis*) and one nest by an American badger. At Kearney Broadfoot South, 15 nests were observed via nest-level cameras to be either entirely or partially predated by striped skunk and one nest by red-tailed hawk (*Buteo jamaicensis*). An additional five nests on Kearney Broadfoot South with nest-level cameras were assumed predated by striped skunk due to evidence at the nest and the timing of the nest losses, although the cameras on these nests malfunctioned. Neither predator species had been documented via nest-level cameras predating nests at Kearney Broadfoot South in the past, nor has this large quantity of nests been predated in one year. In 2021, great horned owls were observed via nest-level cameras to predate eight nests at Kearney Broadfoot South, and in 2023, a Canada goose (*Branta canadensis*) was observed stepping on a nest.

Beginning early in the season, repeated waves of predation caused the loss of multiple nests at multiple sites throughout the season. Half of the nests that were lost to predation at Dyer were lost in the first week of June and the other half the first week of July. All six nests that were predated by striped skunk on Cottonwood Ranch occurred on 1 June. Kearney Broadfoot South had six nests with observed predation between 26 and 28 May, an additional eight between 19 and 23 June, and five more 3 July. Plovers are more likely to renest if nest loss occurs early in the season, but less likely if the nest loss is due to predation (Swift et al. 2020), and renesting in terns has been shown to be less common than for plovers (Roche et al. 2016). At Dyer, Cottonwood Ranch, and Kearney Broadfoot South following early plover and tern nest losses, we documented a subsequent increase in total plover and tern nests, supporting likely renesting. However, because of the multiple rounds of losses, the benefits of renesting were limited during 2024.

High productivity on eastern sites with predator monitoring (Newark West, Newark East, and Leaman) made up for those losses on the western sites. A variety of predators have impacted nests at Newark West as observed via nest-level cameras in 2021-2023 including striped skunk, great horned owl, bullsnake, and American crow (*Corvus brachyrhynchos*). Similar predators predated a similar number of nests in 2024, six partial or entire nests. However, even though the first four plover nests were predated, the next three nests hatched and produced 11 fledglings. Terns also did well on Newark West this year with 30 fledglings produced, the highest quantity and highest fledge ratio across all monitored sites. Newark East had a similar low quantity of predated nests observed via nest-level cameras and similar predator species to past years. Twenty-six plover fledglings, the highest quantity of all monitored sites, and 21 tern fledglings were produced this year. Leaman, a site that has not been productive since 2020, also had high productivity this year producing 3 plover fledglings and 18 tern fledglings. Great horned owls predated seven nests on Leaman in 2021, but there were no nests loss to any predator species this year.

Follmer is an eastern monitored site that does not have additional predator monitoring. This site has been monitored since 2012 and has never had any documented use by either plovers or terns until this year. Although the nest did not produce any fledglings, we observed one plover nest on Follmer in 2024. However, 13 tern fledglings from 12 nests were produced on Follmer in 2024.

Even with the high nest losses throughout the 2024 monitoring season, both plovers and terns had high productivity. Sixty-three plover fledglings were produced across all monitored sites in 2024, the highest ever produced. Plovers also had a similar fledge ratio (1.34 chicks/BPE) to the past two years (1.41 chicks/BPE in 2022 and 2023). Terns produced 118 fledglings this year and although this number is slightly lower than the last two years (143 fledglings in 2022 and 124 fledglings in 2023), it is higher than any previous year except 2015 (146 fledglings).

PAST RESEARCH SYNTHESIS

Plover and tern monitoring and research conducted on the central Platte River since 2001 have been designed and implemented to provide information on an array of topics relevant to species management, including monitoring methods and protocol implementation; habitat use; reproductive success and survival; behavior; population demographics and dispersal; and predator monitoring and management. Reports produced by West Incorporated during 2001-2007 prior to Program implementation provided a general overview of plover and tern habitat use, nesting, and productivity (https://platteriverprogram.org/program-library; Target Species: piping plover or interior least tern; Keywords: least tern, piping plover, technical reports, protocol implementation). Upon Program implementation (2008-present), the surveillance monitoring protocol changed, and the resulting reports produced by EDO staff and partners contained more detailed information on implementation of the Program's surveillance monitoring protocol, conservation monitoring, and directed research. This directed research was used to address priority hypotheses developed in the Program's Adaptive Management Plan and evaluate progress toward the Program's First Increment and First Increment Extension management objectives. Design and implementation of research activities were guided by the EDO and the technical advisory committee (TAC), reviewed by the Program's Independent Scientific Advisory Committee (ISAC), and ultimately approved by the Program's Governance Committee (GC). Links to these studies and other research relevant to the Program's objectives and our understanding of plover and tern ecology are provided in the Appendix Table A1.

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ACKNOWLEDGEMENTS

Support for monitoring and research activities outlined in this report was provided by the Central Platte Natural Resources District, Nebraska Public Power District, and the Platte River Recovery Implementation Program. We extend a special thanks to non-governmental agencies and private landowners that allowed access to their properties and the many people who assisted in collecting data and provided technical guidance.

We would also like to acknowledge the privately-owned sand and gravel mining companies who allowed us access to their property to monitor and collect data on tern and plover activities. These companies included Broadfoot Sand and Gravel Corporation and Hooker Brothers Sand and Gravel.

TABLES

Table 1. Summary of piping plover reproductive effort and success at off-channel sand and water (OCSW) and river island sites on the central Platte River in Nebraska, 2001-2009. Data collected during 2001-2009 used different monitoring protocols than 2010-2024. Changes adopted in 2010 included an increase of fledge age from 15 days to 28 days and an increase in monitoring effort.

	Piping Plover								
Reproductive Parameter	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Max Adult Count	25	40	34	51	48	47	66	45	47
Peak Breeding Pair Estimate (BPE)	10	13	14	11	14	13	16	13	12
Total Nests Observed	10	15	15	13	20	15	20	18	14
Successful Nests (≥1 egg hatched)	8	13	13	9	15	11	15	8	9
Apparent Nest Success	0.80	0.87	0.87	0.69	0.75	0.73	0.75	0.44	0.64
Daily Nest Survival Rate	0.98	0.99	0.99	0.98	0.98	0.98	0.99	0.98	0.99
Incubation-period Survival Rate	0.53	0.75	0.85	0.63	0.64	0.65	0.71	0.58	0.67
Broods Observed	8	13	13	9	15	11	15	8	9
Chicks Observed (<15D)	28	28	43	34	46	37	45	26	30
Hatch Ratio (<15D Chicks/Nest)	2.80	1.87	2.87	2.62	2.30	2.47	2.25	1.44	2.14
Hatch Ratio (<15D Chicks/BPE)	2.80	2.15	3.07	3.09	3.29	2.85	2.81	2.00	2.50
Chicks (≥15D)	23	28	22	23	28	29	27	10	12
Fledglings (28D)	---[A]	---	---	---	---	---	---	---	---
Historic Fledge Ratio (≥15D Chicks/Nest)	2.30	1.87	1.47	1.77	1.40	1.93	1.35	0.56	0.86
Fledge Ratio (28D Chicks/Nest)	---	---	---	---	---	---	---	---	---
Historic Fledge Ratio (≥15D Chicks/BPE)	2.30	2.15	1.57	2.09	2.00	2.23	1.69	0.77	1.00
Fledge Ratio (28D Chicks/BPE)	---	---	---	---	---	---	---	---	---
Daily Brood Survival Rate	---	---	---	---	---	---	---	0.94	0.98
Brooding-period Survival Rate	---	---	---	---	---	---	---	0.42	0.79

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

Table 2. Summary of piping plover reproductive effort and success at off-channel sand and water (OCSW) and river island sites along the central Platte River in Nebraska, 2010-2024. Data collected during 2010-2024 used different monitoring protocols than 2001-2009. Changes adopted in 2010 included an increase of fledge age from 15 days to 28 days and an increase in monitoring effort.

	Piping Plover														
Reproductive Parameter	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Max Adult Count	96	71	73	94	108	99	108	77	74	88	71	67	74	82	101
Peak Breeding Pair Estimate (BPE)	20	28	30	27	30	40	43	40	37	45	31	36	37	41	47
Total Nests Observed	35	34	46	31	43	54	60	50	47	60	49	50	55	48	74
Successful Nests (≥1 egg hatched)	21	27	32	23	34	34	40	30	35	31	28	30	30	40	35
Apparent Nest Success	0.60	0.79	0.70	0.74	0.79	0.63	0.67	0.60	0.74	0.52	0.57	0.60	0.55	0.83	0.47
Daily Nest Survival Rate	0.98	0.99	0.99	0.99	0.99	0.98	0.99	0.98	0.99	0.98	0.98	0.98	0.97	0.99	0.97
Incubation-period Survival Rate	0.54	0.77	0.69	0.74	0.77	0.64	0.69	0.61	0.68	0.51	0.51	0.54	0.48	0.80	0.46
Broods Observed	21	27	32	23	34	34	40	30	35	31	28	30	30	40	35
Chicks Observed (<15D)	76	88	99	80	116	119	120	92	95	94	98	99	100	143	120
Hatch Ratio (<15D Chicks/Nest)	2.17	2.59	2.15	2.58	2.70	2.20	2.00	1.84	2.02	1.57	2.00	1.98	1.82	2.98	1.62
Hatch Ratio (<15D Chicks/BPE)	3.80	3.14	3.30	2.96	3.87	2.98	2.79	2.30	2.57	2.09	3.16	2.75	2.70	3.49	2.55
Chicks (≥15D)	50	61	68	43	67	73	70	53	32	42	52	45	65	65	70
Fledglings (28D)	41	46	59	28	55	52	55	47	23	30	39	35	52	58	63
Historic Fledge Ratio (≥15D Chicks/Nest)	1.43	1.79	1.48	1.39	1.56	1.35	1.17	1.06	0.68	0.70	1.06	0.90	1.18	1.35	0.95
Fledge Ratio (28D Chicks/Nest)	1.17	1.35	1.28	0.90	1.28	0.96	0.92	0.94	0.49	0.50	0.80	0.70	0.95	1.21	0.85
Historic Fledge Ratio (≥15D Chicks/BPE)	2.50	2.18	2.27	1.59	2.23	1.83	1.63	1.33	0.86	0.93	1.68	1.25	1.76	1.59	1.49
Fledge Ratio (28D Chicks/BPE)	2.05	1.64	1.97	1.04	1.83	1.30	1.28	1.18	0.62	0.67	1.26	0.97	1.41	1.41	1.34
Daily Brood Survival Rate	0.99	0.99	0.99	0.98	0.99	0.99	0.98	0.98	0.96	0.97	0.98	0.98	0.99	0.99	0.99
Brooding-period Survival Rate	0.70	0.73	0.78	0.62	0.69	0.68	0.55	0.63	0.29	0.44	0.58	0.51	0.79	0.69	0.73

Table 3. Site-specific numbers of adults, nests, chicks, and fledglings observed while monitoring off-channel sand and water (OCSW) nesting sites for piping plover reproduction during 2024. Numbers of estimated breeding pairs (BPE), apparent nest success, fledge ratios, and survey effort are provided for each site. Site numbers correspond with Figure 2.

	Piping Plover													
Site Name and No.	**Management[A]**	**No. Surveys**	**Hours of Observation**	**Peak BPE (AHR peak date[B])**	**Peak BPE (Site peak date[C])**	**Adult Counts**	**No. Nests**	**No. Nests Hatched**	**No. Chicks 0–14 days**	**No. Chicks 15–28 days**	**No. Fledglings**	**Apparent Nest Success**	**Fledge Ratio (AHR peak date[B])**	**Fledge Ratio (Site peak date[C])**
1. OSG Lexington	FHPT	32	51	7	8	14	8	7	19	9	6	0.88	0.86	0.75
2. NPPD Lexington	FPT	19	20	1	1	2	2	0	0	0	0	0.00	0.00	0.00
3. Dyer	FHPT	30	40	8	8	16	12	3	11	3	3	0.25	0.38	0.38
4. Cottonwood Ranch	FHPT	31	28	2	3	4	6	2	8	3	2	0.33	1.00	0.67
5. T&F Lakeside	N	8	4	---[D]	---	0	0	0	0	0	0	---	---	---
6. Blue Hole	PT	35	59	6	7	12	9	6	22	8	8	0.67	1.33	1.14
7. Johnson	FP	5	3	---	---	0	0	0	0	0	0	---	---	---
8. Ed Broadfoot and Sons	N	7	4	---	---	0	0	0	0	0	0	---	---	---
9. Kearney Broadfoot South	FHILPT	33	29	7	7	13	13	2	6	1	1	0.15	0.14	0.14
10. NAI Kearney Broadfoot South	T	24	13	1	1	6	1	0	0	0	0	0.00	0.00	0.00
11. Newark West	EFHLPT	37	24	2	3	6	7	3	12	11	11	0.43	5.50	3.67
12. Newark East	FHPT	39	32	10	10	18	12	8	29	27	26	0.67	2.60	2.60
13. Leaman	FHLPT	34	25	1	2	6	2	2	6	3	3	1.00	3.00	1.50
14. Follmer	HPT	28	25	1	1	2	1	1	3	2	0	1.00	0.00	0.00
15. Trust Wildrose East	DP	26	13	1	1	2	1	1	4	3	3	1.00	3.00	3.00
16. DeWeese	N	7	4	---	---	0	0	0	0	0	0	---	---	---
17. Hooker Brothers Southeast	N	20	10	---	---	0	0	0	0	0	0	---	---	---
18. Hooker Brothers East	N	7	4	---	---	0	0	0	0	0	0	---	---	---

[A] Management actions include: disking (D), exterior predator fencing (E), peninsula entry predator fencing (F), fall 2023 herbicide (H), interior predator fencing (I), predator deterrent lights (L), no management (N), spring 2024 pre-emergent herbicide (P), or predator trapping (T). See the Management Section of this report for a detailed description of management actions taken at each site.

[B] Peak estimated number of breeding pairs (BPE) at each site as calculated using the Program's BPE calculator on 28 May, when numbers of piping plover breeding pairs observed within the entire Program Associated Habitat Reach first peaked.

[C] Peak BPE (site peak date) represents the highest number of estimated pairs at a site during the nesting season, regardless of AHR Peak Breeding Pair dates.

[D] "---" denotes cannot be calculated.

Table 4. Peak estimated number of breeding pairs (BPE), number of nests and successful nests, and productivity by year for piping plovers at off-channel sand and water (OCSW) sites along the central Platte River in Nebraska, 2001-2024.

	Piping Plover				
Year	Off-Channel Peak BPE[A]	No. Nests	No. Successful Nests	No. Fledglings[B]	Fledglings Per Peak BPE[AB]
2001	10	10	8	22	2.20
2002	13	15	13	28	2.15
2003	14	15	13	22	1.57
2004	11	13	9	23	2.09
2005	14	20	15	28	2.00
2006	13	15	11	29	2.23
2007	14	16	13	20	1.43
2008	10	13	10	7	0.70
2009	10	12	8	11	1.10
2010	18	22	17	31	1.72
2011	28	34	27	46	1.64
2012	29	45	31	55	1.90
2013	27	31	23	28	1.04
2014	29	41	33	55	1.90
2015	35	47	33	51	1.46
2016	42	58	39	54	1.29
2017	40	50	30	47	1.18
2018	37	47	35	23	0.62
2019	45	60	31	30	0.67
2020	31	49	28	39	1.26
2021	36	50	30	35	0.97
2022	37	55	30	52	1.41
2023	41	47	40	58	1.41
2024	47	74	35	63	1.34
Mean	**26.29**	**34.96**	**23.42**	**35.71**	**1.47**

[A] BPE represents the peak off-channel. Peaks dates differ on- vs. off-channel. Due to this, the sum of these may not match the AHR peak.

[B] The dotted black line represents a change in protocol. Among other changes, in 2010 the Program began to use 28 days as the fledge age for piping plover chicks rather than the previous 15-day success interval.

Table 5. Peak estimated number of breeding pairs (BPE), number of nests and successful nests, and productivity by year for piping plovers at on-channel sites on the central Platte River in Nebraska, 2001-2024.

			Piping Plover		
Year	**On-Channel Peak BPE[A]**	**No. Nests**	**No. Successful Nests**	**No. Fledglings[B]**	**Fledglings Per Peak BPE[AB]**
2001	---[C]	0	0	0	---
2002	---	0	0	0	---
2003	---	0	0	0	---
2004	---	0	0	0	---
2005	---	0	0	0	---
2006	---	0	0	0	---
2007	4	4	2	7	1.75
2008	3	5	1	3	1.00
2009	2	2	1	1	0.50
2010	5	13	4	10	2.00
2011	---	0	0	0	---
2012	1	1	1	4	4.00
2013	---	0	0	0	---
2014	2	2	1	4	2.00
2015	6	7	1	1	0.17
2016	1	2	1	1	1.00
2017	---	0	0	0	---
2018	---	0	0	0	---
2019	---	0	0	0	---
2020	---	0	0	0	---
2021	---	0	0	0	---
2022	---	0	0	0	-
2023	1	1	0	0	0.00
2024	---	0	0	0	---
Mean	**2.78**	**1.54**	**0.50**	**1.29**	**1.38**

[A] BPE represents the peak on-channel. Peaks dates differ on- vs. off-channel. Due to this, the sum of these may not match the AHR peak.

[B] The dotted black line represents a change in protocol. Among other changes, in 2010 the Program began to use 28 days as the fledge age for piping plover chicks rather than the previous 15-day success interval.

[C] "---" denotes cannot be calculated.

Table 6. Number of piping plover adults, estimated number of piping plover breeding pairs (BPE), and numbers of piping plover nests, chicks, and fledglings documented from outside the nesting area (i.e., outside monitoring) during semi-monthly off-channel sand and water (OCSW) site surveys in 2024.

	Piping Plover				
Survey Date	**No. Adults**	**BPE[A]**	**No. Nests**	**No. Chicks**	**No. Fledglings**
1-May	62	5	4	0	0
15-May	64	32	30	0	0
1-Jun	63	39	31	15	0
15-Jun	66	39	19	40	0
1-Jul	57	33	17	31	7
15-Jul	29	15	4	22	8
1-Aug	9	9	0	18	1

[A] BPE represents the estimated number of breeding pairs present on OCSW sites on 1 and 15 May, 1 and 15 June, 1 and 15 July, and 1 August. Breeding pair counts were obtained using the Program's BPE calculator. Number 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.

Table 7. Number of piping plover adults, estimated number of piping plover breeding pairs (BPE), and numbers of piping plover nests, chicks, and fledglings observed during semi-monthly airboat surveys of the Platte River between Lexington and Chapman, Nebraska, in 2024.

	Piping Plover				
Survey Date	**No. Adults**	**BPE[A]**	**No. Nests**	**No. Chicks**	**No. Fledglings**
1-May	1	---[E]	0	0	0
15-May[B]	2	---	0	0	0
1-Jun	2	---	0	0	0
15-Jun	2	---	0	0	0
1-Jul	3	---	0	0	0
15-Jul[C]	1	---	0	0	1
1-Aug[D]	0	---	0	0	0

[A] BPE represents the estimated number of breeding pairs present on river islands on 1 and 15 May, 1 and 15 June, 1 and 15 July, and 1 August. Breeding pair counts were obtained using the Program's BPE calculator. Number 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] The Overton to J-2 Return section was not completed due to severe weather. Point counts were conducted in the Minden to Gibbon section due to low flows preventing access by airboat.

[C] Started slightly east of designated starting position for J-2 Return to Overton section due to low water levels.

[D] The Chapman to South Locust and Hwy 281 to Alda sections were completed as normal. Point counts were conducted for all other sections due to low flows preventing access by airboat.

[E] "---" denotes cannot be calculated.

Table 8. Daily and incubation-period survival rates and 95% lower (LCL) and upper confidence limits (LCL) for piping plover nests monitored on OCSW sites during 2024. Incubation-period nest survival rate = daily nest survival rate[28].

Site	Management[A]	No. Nests	No. Nests Failed	Exposure Days	Daily Nest Survival Rate	Daily Nest Survival Rate		Incubation Period Survival Rate	Incubation Period Survival Rate	
						LCL	UCL		LCL	UCL
OSG Lexington	FHPT	8	1	147	0.993	0.973	1	0.825	0.469	1
NPPD Lexington	FPT	2	2	21	0.891	0.749	0.992	0.039	0	0.795
Dyer	FHPT	12	9	218	0.957	0.922	0.991	0.294	0.103	0.768
Cottonwood Ranch	FHPT	6	4	75	0.945	0.887	0.987	0.204	0.035	0.687
Blue Hole	PT	9	3	195	0.984	0.959	0.990	0.645	0.313	0.750
Kearney Broadfoot South	FHILPT	13	11	206	0.944	0.911	0.980	0.197	0.073	0.572
NAI Kearney Broadfoot South	T	1	1	13	0.916	0.748	1	0.086	0	1
Newark West	EFHLPT	7	4	107	0.962	0.917	0.981	0.335	0.087	0.590
Newark East	FHPT	12	4	272	0.985	0.963	0.996	0.658	0.353	0.902
Leaman	FHLPT	2	0	48	1	1	1	1	0.995	1
Follmer	HPT	1	0	22	1	1	1	1	1	1
Trust Wildrose East	DP	1	0	26	1	1	1	1	1	1
All Sites		**74**	**39**	**1,350**	**0.973**	**0.958**	**0.984**	**0.463**	**0.299**	**0.637**

[A] Management actions applied to each site: disking (D), exterior predator fencing (E), peninsula entry predator fencing (F), fall 2023 herbicide (H), interior predator fencing (I), predator deterrent lights (L), spring 2024 pre-emergent herbicide (P), or predator trapping (T).

Table 9. Daily and incubation-period survival rates and 95% lower (LCL) and upper confidence limits (LCL) for piping plover nests monitored on Program and non-Program OCSW sites during 2024. Incubation-period nest survival rate = daily nest survival rate[28].

Ownership	No. Nests	No. Nests Failed	Exposure Days	Daily Nest Survival Rate	Daily Nest Survival Rate		Incubation Period Survival Rate	Incubation Period Survival Rate	
					LCL	UCL		LCL	UCL
Program[A]	62	34	1108	0.969	0.951	0.984	0.408	0.244	0.639
Non-Program[B]	12	5	242	0.979	0.941	0.996	0.551	0.184	0.895
All Sites	**74**	**39**	**1,350**	**0.973**	**0.958**	**0.984**	**0.463**	**0.299**	**0.637**

[A] Program sites: OSG Lexington, Dyer, Cottonwood Ranch, Kearney Broadfoot South, NAI Kearney Broadfoot South, Newark West, Newark East, Leaman, and Follmer.

[B] Non-Program sites: NPPD Lexington, Blue Hole, and Trust Wildrose East.

Table 10. Daily and brooding-period survival rates and 95% lower (LCL) and upper confidence limits (LCL) for observed piping plover broods (≥1 chicks) monitored on OCSW sites during 2024. Brooding-period survival rate = daily brood survival rate[28].

Site	Management[A]	No. Broods	No. Broods Failed	Exposure Days	Daily Brood Survival Rate	Daily Brood Survival Rate		Brooding Period Survival Rate	Brooding Period Survival Rate	
						LCL	UCL		LCL	UCL
OSG Lexington	FHPT	7	4	148	0.972	0.945	0.999	0.453	0.208	0.964
Dyer	FHPT	3	2	36	0.940	0.862	1.018	0.177	0.016	1.657
Cottonwood Ranch	FHPT	2	0	56	1	1	1	1	1	1
Blue Hole	PT	6	3	122	0.974	0.946	1.002	0.484	0.214	1.073
Kearney Broadfoot South	FHILPT	2	1	29	0.966	0.900	1.032	0.374	0.051	2.411
Newark West	EFHLPT	3	0	84	1	1	1	1	1	1
Newark East	FHPT	8	0	217	1	1	1	1	1	1
Leaman	FHLPT	2	0	52	1	1	1	1	1	1
Follmer	HPT	1	1	17	0.937	0.821	1	0.163	0.004	1
Trust Wildrose East	DP	1	0	23	1	1	1	1	1	1
All Sites		**35**	**11**	**784**	**0.989**	**0.974**	**0.998**	**0.725**	**0.471**	**0.945**

[A] Management actions applied to each site: disking (D), exterior predator fencing (E), peninsula entry predator fencing (F), fall 2023 herbicide (H), interior predator fencing (I), predator deterrent lights (L), spring 2024 pre-emergent herbicide (P), or predator trapping (T).

Table 11. Daily and brooding-period survival rates and 95% lower (LCL) and upper confidence limits (LCL) for piping plover broods (≥1 chicks) monitored on Program and non-Program OCSW sites during 2024. Brooding-period survival rate = daily brood survival rate[28].

Ownership	No. Broods	No. Broods Failed	Exposure Days	Daily Brood Survival Rate	Daily Brood Survival Rate		Brooding Period Survival Rate	Brooding Period Survival Rate	
					LCL	UCL		LCL	UCL
Program[A]	28	8	639	0.989	0.969	0.997	0.739	0.417	0.926
Non-Program[B]	7	3	145	0.985	0.921	0.996	0.654	0.100	0.896
All Sites	**35**	**11**	**784**	**0.989**	**0.974**	**0.998**	**0.725**	**0.471**	**0.945**

[A] Program sites: OSG Lexington, Dyer, Cottonwood Ranch, Kearney Broadfoot South, Newark West, Newark East, Leaman, and Follmer.

[B] Non-Program sites: Blue Hole and Trust Wildrose East.

Table 12. Piping plover incidental take at Program and non-Program sites during 2007-2024 under five take categories as specified by USFWS 2006 and USFWS 2018. Each cell in the table is shaded as white (no data available); green (below established limit for allowable take for a given year); or red (exceeded established limit for allowable take for a given year). Green shaded cells without values had no documented take.

Allowable Take[A]			First Increment Year													Extension Year				
			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Inundating Flow																				
Inland Lakes																		1[B]		
Habitat Restoration and Land Management									1[C]											
Research and Monitoring							1[D]		1[E]											
Percent of Nests and Chicks Observed at Site Lost Due to Predation[F]																				
Off-channel Sand and Water Nesting Sites	Nests	OSG Lexington																		
		NPPD Lexington					17%			20%							20%	29%		50%
		Dyer														21%		36%	11%	33%
		Cottonwood Ranch								50%									33%	33%
		Blue Hole	17%		20%					13%		38%	8%	25%		14%	43%	20%	14%	
		Johnson				33%							100%							
		Ed Broadfoot and Sons																		
		Kearney Broadfoot South									31%					11%	31%			85%
		NAI Kearney Broadfoot South																		
		Newark West									17%						25%	88%		57%
		Newark East														17%		14%	9%	
		Leaman														50%	100%			
		Trust Wildrose East										25%		50%						
		Follmer																		
		Hooker Brothers Southeast																		

		Table 12 continued	First Increment Year													Extension Year				
			2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Off-channel Sand and Water Nesting Sites	**Chicks**	OSG Lexington																		
		NPPD Lexington														20%				
		Dyer								33%									14%	
		Cottonwood Ranch																		
		Blue Hole												61%						
		Johnson																		
		Ed Broadfoot and Sons																		
		Kearney Broadfoot South									6%						16%			50%
		NAI Kearney Broadfoot South																		
		Newark West															27%	100%		
		Newark East																		7%
		Leaman																		
		Trust Wildrose East																		
		Follmer																		
		Hooker Brothers Southeast																		

[A] For Allowable Take information, see USFWS 2006, USFWS 2018, and USBR 2018.

[B] One plover nest containing four plover eggs was inundated at Lake Minatare on 6/5/2022 (PRRIP 2023).

[C] The Program observed one habitat restoration and land management plover chick mortality during 2014 due to electrocution in a predator deterrent fence (Cahis and Baasch 2015).

[D] The Program observed one research-related plover chick mortality during 2011 due to flushing the chick into the water where it was consumed by a fish (Baasch 2012).

[E] The Program observed one research-related plover chick mortality during 2013 due to a chick attempting to fly and landing into the water where it was consumed by a fish (Baasch 2014).

[F] As of 12/31/2016, a limited amount of predation was observed and did not exceed the Service's threshold at any Program owned or managed off-channel sand and water nesting site in any year (USBR 2018). Increased effort to monitor predator activities began in 2017, which has resulted in more documented predation than during the First Increment, but losses to predation have not exceeded the Service's established threshold (i.e., the loss of 70% of nests or 80% of chicks to predation in three of five years for sites that average at least three plover nests).

Table 13. Summary of least tern reproductive effort and success at off-channel sand and water (OCSW) and river island sites on the central Platte River in Nebraska, 2001-2009. Data collected during 2001-2009 used different monitoring protocols than 2010-2024. Changes adopted in 2010 included an increase of fledge age from 15 days to 21 days and an increase in monitoring effort.

	Least Tern								
Reproductive Parameter	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Max Adult Count	45	117	105	133	184	122	133	145	114
Peak Breeding Pair Estimate (BPE)	22	33	38	39	45	33	38	36	42
Total Nests Observed	27	39	49	48	56	49	49	55	54
Successful Nests (≥1 egg hatched)	20	27	31	33	38	19	22	29	29
Apparent Nest Success	0.74	0.69	0.63	0.69	0.68	0.39	0.45	0.53	0.54
Daily Nest Survival Rate	0.98	0.98	0.98	0.98	0.98	0.96	0.97	0.98	0.99[A]
Incubation-period Survival Rate	0.70	0.70	0.62	0.70	0.70	0.46	0.55	0.61	0.73[A]
Broods Observed	20	27	31	33	38	19	22	29	29
Chicks Observed (<15D)	46	65	62	72	73	38	49	59	68
Hatch Ratio (<15D Chicks/Nest)	1.70	1.67	1.27	1.50	1.30	0.78	1.00	1.07	1.26
Hatch Ratio (<15D Chicks/BPE)	2.09	1.97	1.63	1.85	1.62	1.15	1.29	1.64	1.62
Chicks (≥15D)	44	59	57	60	62	25	40	44	46
Fledglings (21D)	---[B]	---	---	---	---	---	---	---	---
Historic Fledge Ratio (≥15D Chicks/Nest)	1.63	1.51	1.16	1.25	1.11	0.51	0.82	0.80	0.85
Fledge Ratio (21D Chicks/Nest)	---	---	---	---	---	---	---	---	---
Historic Fledge Ratio (≥15D Chicks/BPE)	2.00	1.79	1.50	1.54	1.38	0.76	1.05	1.22	1.10
Fledge Ratio (21D Chicks/BPE)	---	---	---	---	---	---	---	---	---
Daily Brood Survival Rate	---	---	---	---	---	---	---	0.98	0.98[C]
Brooding-period Survival Rate	---	---	---	---	---	---	---	0.75	0.79[C]

[A] Does not include reproductive information from Mormon Island.

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

[C] Does not include reproductive information from Dinan Island.

Table 14. Summary of least tern reproductive effort and success at off-channel sand and water (OCSW) and river island sites on the central Platte River in Nebraska, 2010-2024. Data collected during 2010-2024 used different monitoring protocols than 2001-2009. Changes adopted in 2010 included an increase of fledge age from 15 days to 21 days and an increase in monitoring effort.

	Least Tern														
Reproductive Parameter	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Max Adult Count	170	150	137	197	260	262	200	159	174	169	158	166	188	157	334
Peak Breeding Pair Estimate (BPE)	53	62	66	65	94	141	88	78	88	93	83	83	85	90	141
Total Nests Observed	76	90	88	96	146	187	122	118	112	132	105	99	128	124	221
Successful Nests (≥1 egg hatched)	48	52	63	51	82	116	77	63	79	67	74	64	86	83	95
Apparent Nest Success	0.63	0.58	0.72	0.53	0.56	0.62	0.63	0.53	0.71	0.51	0.70	0.65	0.67	0.67	0.43
Daily Nest Survival Rate	0.98	0.97	0.99	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.96
Incubation-period Survival Rate	0.64	0.58	0.76	0.56	0.52	0.63	0.71	0.61	0.65	0.61	0.72	0.65	0.64	0.66	0.45
Broods Observed	48	52	63	51	82	116	77	63	79	67	74	64	86	83	95
Chicks Observed (<15D)	122	125	144	118	180	258	170	129	168	137	160	158	196	207	184
Hatch Ratio (<15D Chicks/Nest)	1.61	1.39	1.64	1.23	1.23	1.38	1.39	1.09	1.50	1.04	1.52	1.60	1.53	1.67	0.83
Hatch Ratio (<15D Chicks/BPE)	2.30	2.02	2.18	1.82	1.91	1.83	1.93	1.65	1.91	1.47	1.93	1.90	2.31	2.30	1.30
Chicks (≥15D)	76	101	95	70	104	158	91	78	113	74	97	100	141	126	127
Fledglings (21D)	75	96	84	64	91	146	80	76	117	71	107	102	143	124	118
Historic Fledge Ratio (≥15D Chicks/Nest)	1.00	1.12	1.08	0.73	0.71	0.84	0.75	0.66	1.01	0.56	0.92	1.01	1.10	1.02	0.57
Fledge Ratio (21D Chicks/Nest)	0.99	1.07	0.95	0.67	0.62	0.78	0.66	0.64	1.04	0.54	1.02	1.03	1.12	1.00	0.53
Historic Fledge Ratio (≥15D Chicks/BPE)	1.43	1.63	1.44	1.08	1.11	1.12	1.03	1.00	1.28	0.80	1.17	1.20	1.66	1.40	0.90
Fledge Ratio (21D Chicks/BPE)	1.42	1.55	1.27	0.98	0.97	1.04	0.91	0.97	1.33	0.76	1.29	1.23	1.68	1.38	0.84
Daily Brood Survival Rate	0.98	0.99	0.99	0.97	0.98	0.98	0.98	0.97	0.98	0.97	0.98	0.99	0.99	0.99	0.99
Brooding-period Survival Rate	0.72	0.89	0.81	0.59	0.69	0.68	0.61	0.56	0.69	0.57	0.70	0.77	0.84	0.85	0.82

Table 15. Site-specific numbers of adults, nests, chicks, and fledglings observed while monitoring off-channel sand and water (OCSW) nesting sites for least tern reproduction during 2024. Numbers of estimated breeding pairs (BPE), apparent nest success, fledge ratios, and survey effort are provided for each site. Site numbers correspond with Figure 2.

	Least Tern													
Site Name and No.	**Management[A]**	**No. Surveys**	**Hours of Observation**	**Peak BPE (AHR peak date[B])**	**Peak BPE (Site peak date[C])**	**Adult Counts**	**No. Nests**	**No. Nests Hatched**	**No. Chicks 0-14 days**	**No. Chicks 15-21 days**	**No. Fledglings**	**Apparent Nest Success**	**Fledge Ratio (AHR peak date[B])**	**Fledge Ratio (Site peak date[C])**
1. OSG Lexington	FHPT	32	51	17	17	39	21	4	8	5	5	0.19	0.29	0.29
2. NPPD Lexington	FPT	19	20	0	2	10	2	0	0	0	0	0.00	---[D]	0.00
3. Dyer	FHPT	30	40	21	22	46	38	8	17	2	0	0.21	0.00	0.00
4. Cottonwood Ranch	FHPT	31	28	8	8	22	13	2	3	2	2	0.15	0.25	0.25
5. T&F Lakeside	N	8	4	---	---	0	0	0	0	0	0	---	---	---
6. Blue Hole	PT	35	59	15	16	26	18	11	24	16	18	0.61	1.20	1.13
7. Johnson	FP	5	3	---	---	0	0	0	0	0	0	---	---	---
8. Ed Broadfoot and Sons	N	7	4	---	---	0	0	0	0	0	0	---	---	---
9. Kearney Broadfoot South	FHILPT	33	29	10	10	18	16	4	8	4	4	0.25	0.40	0.40
10. NAI Kearney Broadfoot South	T	24	13	1	2	4	2	1	2	2	2	0.50	2.00	1.00
11. Newark West	EFHLPT	37	24	18	22	40	32	18	35	30	30	0.56	1.67	1.36
12. Newark East	FHPT	39	32	17	29	55	40	16	27	21	21	0.40	1.24	0.72
13. Leaman	FHLPT	34	25	15	17	32	18	16	34	26	18	0.89	1.20	1.06
14. Follmer	HPT	28	25	11	12	20	12	9	16	13	13	0.75	1.18	1.08
15. Trust Wildrose East	DP	26	13	---	---	4	0	0	0	0	0	---	---	---
16. DeWeese	N	7	4	---	---	0	0	0	0	0	0	---	---	---
17. Hooker Brothers Southeast	N	20	10	8	8	18	9	6	10	6	5	0.67	0.63	0.63
18. Hooker Brothers East	N	7	4	---	---	0	0	0	0	0	0	---	---	---

[A] Management actions include: disking (D), exterior predator fencing (E), peninsula entry predator fencing (F), fall 2023 herbicide (H), interior predator fencing (I), predator deterrent lights (L), no management (N), spring 2024 pre-emergent herbicide (P), or predator trapping (T). See the Management Section of this report for a detailed description of management actions taken at each site.
[B] Peak estimated number of breeding pairs (BPE) at each site as calculated using the Program's BPE calculator on 2 July, when numbers of least tern breeding pairs observed within the entire Program Associated Habitat Reach first peaked.
[C] Peak BPE (site peak date) represents the highest number of estimated pairs at a site during the nesting season, regardless of AHR Peak Breeding Pair dates.
[D] "---" denotes cannot be calculated.

Table 16. Peak estimated number of breeding pairs (BPE), number of nests and successful nests, and productivity by year for least terns at off-channel sand and water (OCSW) sites along the central Platte River in Nebraska, 2001-2024. The mean for each metric during 2001-2024 is provided at the bottom of the table.

Least Tern					
Year	**Off-Channel Peak BPE[A]**	**No. Nests**	**No. Successful Nests**	**No. Fledglings[B]**	**Fledglings Per Peak BPE[AB]**
2001	22	27	20	44	2.00
2002	33	39	27	59	1.79
2003	38	49	31	57	1.50
2004	39	48	33	60	1.54
2005	45	56	38	62	1.38
2006	33	49	19	25	0.76
2007	30	36	20	38	1.27
2008	26	35	21	35	1.35
2009	38	46	24	42	1.11
2010	53	76	48	75	1.42
2011	62	90	52	96	1.55
2012	66	88	63	84	1.27
2013	65	96	51	64	0.98
2014	94	144	82	91	0.97
2015	133	173	113	146	1.10
2016	86	120	74	80	0.93
2017	78	118	63	76	0.97
2018	88	112	79	117	1.33
2019	93	132	67	71	0.76
2020	83	105	74	107	1.29
2021	83	99	64	102	1.23
2022	85	128	86	143	1.68
2023	90	124	83	124	1.38
2024	141	221	95	118	0.84
Mean	**66.83**	**92.13**	**55.29**	**79.83**	**1.27**

[A] BPE represents the peak recorded at off-channel sites. Peak BPE dates differ on-channel and off-channel and each may differ from the overall AHR peak BPE.

[B] The dotted black line represents a change in protocol between 2009 and 2010. Among other changes, in 2010 the Program began to use 21 days as the fledge age for least tern chicks rather than the previous 15-day success to fledge interval.

Table 17. Peak estimated number of breeding pairs (BPE), number of nests and successful nests, and productivity by year for least terns at on-channel island sites on the central Platte River in Nebraska, 2001-2024. The mean for each metric during 2001-2024 is provided at the bottom of the table.

Least Tern					
Year	On-Channel Peak BPE[A]	No. Nests	No. Successful Nests	No. Fledglings[B]	Fledglings Per Peak BPE[AB]
2001	---[C]	0	0	0	---
2002	---	0	0	0	---
2003	---	0	0	0	---
2004	---	0	0	0	---
2005	---	0	0	0	---
2006	---	0	0	0	---
2007	11	13	2	2	0.18
2008	10	20	8	9	0.90
2009	6	8	5	4	0.67
2010	---	0	0	0	---
2011	---	0	0	0	---
2012	---	0	0	0	---
2013	---	0	0	0	---
2014	2	2	0	0	0
2015	8	14	3	0	0
2016	2	2	0	0	0
2017	---	0	0	0	---
2018	---	0	0	0	---
2019	---	0	0	0	---
2020	---	0	0	0	---
2021	---	0	0	0	---
2022	---	0	0	0	---
2023	---	0	0	0	---
2024	---	0	0	0	---
Mean	**6.50**	**2.46**	**0.75**	**0.63**	**0.29**

[A] BPE represents the peak recorded at sites on the river channel. Peak BPE dates differ on-channel and off-channel and each may differ from the overall AHR peak BPE.

[B] The dotted black line represents a change in protocol between 2009 and 2010. Among other changes, in 2010 the Program began to use 21 days as the fledge age for least tern chicks rather than the previous 15-day success to fledge interval.

[C] "---" denotes cannot be calculated.

Table 18. Number of least tern adults, estimated number of least tern breeding pairs (BPE), and numbers of least tern nests, chicks, and fledglings documented from outside the nesting area (i.e., outside monitoring) during semi-monthly off-channel sand and water (OCSW) site surveys in 2024.

	Least Tern				
Survey Date	**No. Adults**	**BPE[A]**	**No. Nests**	**No. Chicks**	**No. Fledglings**
1-May	0	0	0	0	0
15-May	65	0	4	0	0
1-Jun	173	66	54	0	0
15-Jun	224	86	63	7	0
1-Jul	254	139	90	42	3
15-Jul	192	99	19	73	15
1-Aug	70	79	1	23	15

[A] BPE represents the estimated number of breeding pairs present on OCSW sites on 1 and 15 May, 1 and 15 June, 1 and 15 July, and 1 August. Breeding pair counts were obtained using the Program's BPE calculator. Number 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.

Table 19. Number of least tern adults, estimated number of least tern breeding pairs (BPE), and numbers of least tern nests, chicks, and fledglings observed during semi-monthly airboat surveys of the Platte River between Lexington and Chapman, Nebraska, in 2024.

	Least Tern				
Survey Date	**No. Adults**	**BPE[A]**	**No. Nests**	**No. Chicks**	**No. Fledglings**
1-May	0	---[D]	0	0	0
15 May [B]	15	---	0	0	0
1-Jun	32	---	0	0	0
15-Jun	34	---	0	0	0
1 July [C]	28	---	0	0	0
15 July [B]	56	---	0	0	9
1 August [B]	28	---	0	0	1

[A] BPE represents the estimated number of breeding pairs present on river islands on 1 and 15 May, 1 and 15 June, 1 and 15 July, and 1 August. Breeding pair counts were obtained using the Program's BPE calculator. Number 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] The Overton to J-2 Return section was not completed due to severe weather. Point counts were conducted in the Minden to Gibbon section due to low flows preventing access by airboat.

[C] Started slightly east of designated starting position for J-2 Return to Overton section due to low water levels.

[D] The Chapman to South Locust and Hwy 281 to Alda sections were completed as normal. Point counts were conducted for all other sections due to low flows preventing access by airboat.

[D] "---" denotes cannot be calculated.

Table 20. Daily and incubation-period survival rates and 95% lower (LCL) and upper confidence limits (LCL) for least tern nests monitored on OCSW sites during 2024. Incubation-period nest survival rate = daily nest survival rate[21].

Site	Management[A]	No. Nests	No. Nests Failed	Exposure Days	Daily Nest Survival Rate	Daily Nest Survival Rate		Incubation Period Survival Rate	Incubation Period Survival Rate	
						LCL	UCL		LCL	UCL
OSG Lexington	FHPT	21	14	291	0.949	0.921	0.966	0.229	0.100	0.380
NPPD Lexington Sandpit	FPT	2	2	14	0.838	0.694	0.955	0.007	0	0.275
Dyer	FHPT	38	29	459	0.933	0.905	0.949	0.143	0.060	0.234
Cottonwood Ranch	FHPT	13	11	95	0.875	0.869	0.947	0.024	0.019	0.217
Blue Hole	PT	18	4	296	0.986	0.981	0.993	0.679	0.586	0.829
Kearney Broadfoot South	FHILPT	16	12	143	0.913	0.847	0.967	0.077	0.009	0.392
NAI Kearney Broadfoot South	T	2	1	36	0.971	0.950	0.999	0.444	0.236	0.968
Newark West	EFHLPT	32	14	478	0.970	0.962	0.981	0.426	0.337	0.583
Newark East	FHPT	40	24	663	0.962	0.955	0.972	0.342	0.276	0.447
Leaman	FHLPT	18	2	300	0.993	0.978	1	0.829	0.534	0.999
Follmer	HPT	12	3	190	0.984	0.970	0.997	0.637	0.423	0.914
Hooker Brothers Southeast	N	9	3	136	0.977	0.958	0.993	0.522	0.300	0.822
All Sites		**221**	**119**	**3,101**	**0.963**	**0.939**	**0.975**	**0.454**	**0.267**	**0.590**

[A] Management actions applied to each site: exterior predator fencing (E), peninsula entry predator fencing (F), fall 2023 herbicide (H), interior predator fencing (I), predator deterrent lights (L), no management (N), spring 2024 pre-emergent herbicide (P), or predator trapping (T).

Table 21. Daily and incubation-period survival rates and 95% lower (LCL) and upper confidence limits (LCL) for least tern nests monitored on Program and non-Program OCSW sites during 2024. Incubation-period nest survival rate = daily nest survival rate[21].

Ownership	No. Nests	No. Nests Failed	Exposure Days	Daily Nest Survival Rate	Daily Nest Survival Rate		Incubation Period Survival Rate	Incubation Period Survival Rate	
					LCL	UCL		LCL	UCL
Program[A]	192	110	2,655	0.957	0.938	0.978	0.397	0.261	0.633
Non-Program[B]	29	9	446	0.979	0.915	0.995	0.645	0.155	0.904
All Sites	**221**	**119**	**3,101**	**0.963**	**0.939**	**0.975**	**0.454**	**0.267**	**0.590**

[A] Program sites: OSG Lexington, Dyer, Cottonwood Ranch, Kearney Broadfoot South, NAI Kearney Broadfoot South, Newark West, Newark East, Leaman, and Follmer.

[B] Non-Program sites: NPPD Lexington, Blue Hole, and Hooker Brothers Southeast.

Table 22. Daily and brooding-period survival rates and 95% lower (LCL) and upper confidence limits (LCL) for observed least tern broods (≥1 chicks) monitored on OCSW sites during 2024. Brooding-period survival rate = daily brood survival rate[21].

Site	Management[A]	No. Broods	No. Broods Failed	Exposure Days	Daily Brood Survival Rate	Daily Brood Survival Rate		Brooding Period Survival Rate	Brooding Period Survival Rate	
						LCL	UCL		LCL	UCL
OSG Lexington	FHPT	4	1	63	0.984	0.937	1	0.711	0.252	1
Dyer	FHPT	8	8	38	0.778	0.702	0.914	0.005	0.001	0.150
Cottonwood Ranch	FHPT	2	0	42	1	1	1	1	1	1
Blue Hole	PT	11	3	179	0.983	0.972	0.994	0.695	0.552	0.889
Kearney Broadfoot South	FHILPT	4	0	83	1	1	1	1	1	1
NAI Kearney Broadfoot South	N	1	0	20	1	1	1	1	1	1
Newark West	EFHLPT	18	1	330	0.997	0.991	1	0.938	0.825	1
Newark East	FHPT	16	2	255	0.992	0.980	1	0.848	0.660	1
Leaman	FHLPT	16	2	318	0.994	0.987	1	0.875	0.767	1
Follmer	HPT	9	1	164	0.994	0.988	1	0.879	0.773	1
Hooker Brothers Southeast	N	6	2	111	0.981	0.963	0.991	0.675	0.458	0.827
All Sites		**95**	**20**	**1,603**	**0.991**	**0.968**	**0.999**	**0.824**	**0.506**	**0.971**

[A] Management actions applied to each site: exterior predator fencing (E), peninsula entry predator fencing (F), fall 2023 herbicide (H), interior predator fencing (I), predator deterrent lights (L), no management (N), spring 2024 pre-emergent herbicide (P), or predator trapping (T).

Table 23. Daily and brooding-period survival rates and 95% lower (LCL) and upper confidence limits (LCL) for least tern broods (≥1 chicks) monitored on Program and non-Program OCSW sites during 2024. Brooding-period survival rate = daily brood survival rate[21].

Ownership	No. Broods	No. Broods Failed	Exposure Days	Daily Brood Survival Rate	Daily Brood Survival Rate		Brooding Period Survival Rate	Brooding Period Survival Rate	
					LCL	UCL		LCL	UCL
Program[A]	78	15	1,313	0.992	0.969	0.999	0.846	0.518	0.971
Non-Program[B]	17	5	290	0.985	0.883	0.998	0.726	0.073	0.950
All Sites	**95**	**20**	**1,603**	**0.991**	**0.968**	**0.999**	**0.824**	**0.506**	**0.971**

[A] Program sites: OSG Lexington, Dyer, Cottonwood Ranch, Kearney Broadfoot South, NAI Kearney Broadfoot South, Newark West, Newark East, Leaman, and Follmer.

[B] Non-Program sites: Blue Hole and Hooker Brothers Southeast.

Table 24. Number of traps by trap type deployed for terrestrial predator trapping at ten Program and Nebraska Public Power District owned piping plover and least tern off-channel sand and water (OCSW) nesting sites during late March through August (and into September on the Newark West and East sites until plovers and terns were no longer observed) 2024.

Site	Management[A]	Trap Type				
		No. Cage Traps	No. Dog Proof Traps	No. Leg Hold Traps	No. Snare Traps	Total No. Traps
OSG Lexington	FHPT	10	11			21
NPPD Lexington	FPT	8	14			22
Dyer	FHPT	14	15		2	31
Cottonwood Ranch	FHPT	12	16			28
Blue Hole	PT	8	12	5		25
Kearney Broadfoot South	FHILPT	10	12			22
Newark West	EFHLPT	14	14		10	38
Newark East	FHPT	9	14			23
Leaman	FHLPT	8	12			20
Follmer	HPT	3	13			16
Total		**96**	**133**	**5**	**12**	**246**

[A] Management actions applied to each site: exterior predator fencing (E), peninsula entry predator fencing (F), fall 2023 herbicide (H), interior predator fencing (I), predator deterrent lights (L), spring 2024 pre-emergent herbicide (P), and predator trapping (T).

Table 25. Summary of terrestrial predator trapping activities at ten Program and Nebraska Public Power District owned piping plover and least tern off-channel sand and water (OCSW) nesting sites during late March through August (and into September on the Newark West and East sites until plovers and terns were no longer observed) 2024. Provided for each site are the total number of trap days and corresponding total number of captures based on the total number of days each trap was deployed.

Site	Management[A]	No. Traps Deployed	Total No. Trap Days	Total No. Captures	Captures / Trap Day
OSG Lexington[B]	FHPT	21	2,360.5	32	0.014
NPPD Lexington	FPT	22	1,840	40	0.022
Dyer	FHPT	31	4,111	35	0.009
Cottonwood Ranch	FHPT	28	4,044	52	0.013
Blue Hole	PT	25	2,280.5	32	0.014
Kearney Broadfoot South	FHILPT	22	2,772	56	0.020
Newark West	EFHLPT	38	5,548.5	55	0.010
Newark East	FHPT	23	3,257.5	42	0.013
Leaman	FHLPT	20	2,381	25	0.010
Follmer	HPT	16	986.5	24	0.024
Total		**246**	**29,581.5**	**393**	**0.013**

[A] Management actions applied to each site: exterior predator fencing (E), peninsula entry predator fencing (F), fall 2023 herbicide (H), interior predator fencing (I), predator deterrent lights (L), spring 2024 pre-emergent herbicide (P), and predator trapping (T).

[B] Removed one raccoon at OSG Lexington with a firearm. This capture was included in total captures, but not included in calculation of captures/trap day.

Table 26. Summary of terrestrial predator trapping activities at ten Program and Nebraska Public Power District owned piping plover and least tern off-channel sand and water (OCSW) nesting sites during late March through August (and into September on the Newark West and East sites until plovers and terns were no longer observed) 2024. Provided for each site are the numbers of each species captured, total number of captures at the site, total number of trap days, and number of captures per trap day.

		Species Captured								
Site	**Manage-ment**[A]	**American Badger**	**Cottontail Rabbit**	**Coyote**	**Virginia Opossum**	**Raccoon**	**Striped Skunk**	**No. Captures**	**Trap Days**	**Captures/ Trap Day**
OSG Lexington[B]	FHPT					31	1	32	2,360.5	0.014
NPPD Lexington	FPT					39	1	40	1,840	0.022
Dyer	FHPT	2			2	31		35	4,111	0.009
Cottonwood Ranch	FHPT				1	49	2	52	4,044	0.013
Blue Hole	PT			4	1	27		32	2,280.5	0.014
Kearney Broadfoot South	FHILPT		1		2	51	2	56	2,772	0.020
Newark West	EFHLPT			1	3	50	1	55	5,548.5	0.010
Newark East	FHPT				1	40	1	42	3,257.5	0.013
Leaman	FHLPT				1	24		25	2,381	0.010
Follmer	HPT					24		24	986.5	0.024
Total		**2**	**1**	**5**	**11**	**366**	**8**	**393**	**29,581.5**	**0.013**

[A] Management actions applied to each site: exterior predator fencing (E), peninsula entry predator fencing (F), fall 2023 herbicide (H), interior predator fencing (I), predator deterrent lights (L), spring 2024 pre-emergent herbicide (P), and predator trapping (T).

[B] Removed one raccoon at OSG Lexington with a firearm. This capture was included in total captures, but not included in calculation of captures/trap days.

Table 27. Total number of terrestrial predators captured by species and trap type at ten Program and Nebraska Public Power District owned piping plover and least tern off-channel sand and water (OCSW) nesting sites during late March through August (and into September on the Newark West and East sites until plovers and terns were no longer observed) 2024.

	No. Captures by Trap Type					
Species	**Cage Trap**	**Dog Proof Trap**	**Firearm[A]**	**Leg Hold**	**Snare**	**Total No. Captures**
American Badger	1				1	2
Cottontail Rabbit	1					1
Coyote				4	1	5
Virginia Opossum	7	3			1	11
Raccoon	81	280	1		4	366
Striped Skunk	5	1			2	8
Total	**95**	**284**	**1**	**4**	**9**	**393**

[A] Removed one raccoon at OSG Lexington with a firearm. This capture was included in total captures, but not included in calculation of captures/trap days.

Table 28. Summary of weekly track surveys conducted at six piping plover and least tern off-channel sand and water (OCSW) nesting sites during May through August (and into September on the Newark West and East sites until plovers and terns were no longer observed) 2024. The six nesting sites were located along the Platte River between Overton and Wood River, Nebraska.

Nesting Site	Management[A]	Total No. Track Surveys	Total Unique Track Registers	Track Registers/ Survey
Dyer	FHPT	15	54	3.60
Cottonwood Ranch	FHPT	16	40	2.50
Kearney Broadfoot South	FHILMPT	16	41	2.56
Newark West	EFHLPT	19	28	1.47
Newark East	FHPT	19	36	1.89
Leaman	FHLPT	17	26	1.53
Total		**102**	**225**	**2.21**

[A] Management actions applied to each site: exterior predator fencing (E), peninsula entry predator fencing (F), fall 2023 herbicide (H), interior predator fencing (I), predator deterrent lights (L), spring 2024 pre-emergent herbicide (P), and predator trapping (T).

Table 29. Summary of registers of potential predator species captured by shoreline cameras deployed at six off-channel sand and water (OCSW) piping plover and least tern nesting sites during May through August (and into September on the Newark West and East sites until plovers and terns were no longer observed) 2024. The six nesting sites were located along the Platte River between Overton and Wood River, Nebraska.

Nesting Site	Management[A]	No. of Shoreline Cameras	Total No. Shoreline Camera Days[B]	Total No. Unique Predator Registers	Unique Registers/ Camera Day
Dyer	FHPT	6	569	159	0.279
Cottonwood Ranch	FHPT	4	462	58	0.126
Kearney Broadfoot South	FHILPT	7	714	202	0.283
Newark West	EFHLPT	4	522	158	0.303
Newark East	FHPT	5	626	199	0.318
Leaman	FHLPT	3	348	118	0.339
Total		**29**	**3,241**	**894**	**0.276**

[A] Management actions applied to each site: exterior predator fencing (E), peninsula entry predator fencing (F), fall 2023 herbicide (H), interior predator fencing (I), predator deterrent lights (L), spring 2024 pre-emergent herbicide (P), and predator trapping (T).

[B] Individual cameras were not functioning for a total of 17 days at Dyer, 22 days at Cottonwood Ranch, 62 days at Kearney Broadfoot South, 14 days at Newark West, and 93 days at Newark East. Total number of shoreline camera days excludes days when cameras malfunctioned.

Table 30. Summary of registers of potential predator species captured by site-level cameras deployed at six off-channel sand and water (OCSW) piping plover and least tern nesting sites during May through August (and into September on the Newark West and East sites until plovers and terns were no longer observed) 2024. The six nesting sites were located along the Platte River between Overton and Wood River, Nebraska.

Nesting Site	Management[A]	No. Site-level Cameras	Total No. Site-level Camera Days	Total No. Unique Predator Registers	Unique Registers / Camera Day
Dyer	FHPT	5	510	71	0.139
Cottonwood Ranch	FHPT	4	464	25	0.054
Kearney Broadfoot South	FHILPT	5	565	25	0.044
Newark West	EFHLPT	3	393	55	0.140
Newark East	FHPT	5	655	87	0.133
Leaman	FHLPT	3	348	29	0.083
Total		**25**	**2,935**	**292**	**0.099**

[A] Management actions applied to each site: exterior predator fencing (E), peninsula entry predator fencing (F), fall 2023 herbicide (H), interior predator fencing (I), predator deterrent lights (L), spring 2024 pre-emergent herbicide (P), and predator trapping (T).

Table 31. Summary of nest-level camera monitoring effort and registers of predation events captured by cameras deployed at piping plover and least tern nests at six off-channel sand and water (OCSW) nesting sites during May through August 2024. The six nesting sites were located along the Platte River between Overton and Wood River, Nebraska.

Nesting Site	Management[A]	No. of Nest Cameras Allocated to Site	Max No. of Nest Cameras Used Concurrently	No. of Nests Monitored	Total No. Nest Camera Days	Total Unique Predation Events	Unique Predation Events/ Camera Day
Dyer	FHPT	10	10	31	316	13	0.041
Cottonwood Ranch	FHPT	8	8	15	169	2	0.012
Kearney Broadfoot South	FHILPT	8	8	28	233	6	0.026
Newark West	EFHLPT	7	7	27	204	5	0.025
Newark East	FHPT	8	8	31	336	3	0.009
Leaman	FHLPT	5	5	15	193	0	0.000
Total		**46**	**46**	**147**	**1,451**	**29**	**0.020**

[A] Management actions applied to each site: exterior predator fencing (E), peninsula entry predator fencing (F), fall 2023 herbicide (H), interior predator fencing (I), predator deterrent lights (L), spring 2024 pre-emergent herbicide (P), or predator trapping (T).

Table 32. Summary of numbers of unique predator registers and predation events at piping plover and least tern nests monitored by cameras during May through August 2024. Nest-level cameras were deployed at six off-channel sand and water (OCSW) nesting sites. The six nesting sites were located along the Platte River between Overton and Wood River, Nebraska.

Site	Date	Nest ID	Target Species Nest	Predator Type	Predator Species	Unique Predator Register[A]	Unique Predation Event[B]	Unique Predation Event Not Captured on Camera[C]	No. of Individual Predated Nests[D]	Unique Events[E]
Dyer	5/11/2024	O-DS-01-24	Plover	Avian	Canada Goose	1				1
Dyer	5/24/2024	O-DS-08-24	Tern	Avian	Great Horned Owl		1		1	1
Dyer	6/3/2024	O-DS-05-24[F], O-DS-11-24	Plover, Plover	Avian	Great Horned Owl		1		2	1
Dyer	6/4/2024	O-DS-07-24	Tern	Avian	Great Horned Owl		1		1	1
Dyer	6/5/2024	O-DS-10-24	Plover	Avian	UNK Avian	1				1
Dyer	6/6/2024	O-DS-10-24, O-DS-17-24	Plover, Tern	Avian	Canada Goose	1				1
Dyer	6/7/2024	O-DS-09-24[G], O-DS-10-24	Tern, Plover	Avian	Great Horned Owl		1		1	1
Dyer	6/7/2024	O-DS-17-24	Tern	Avian	Canada Goose	1				1
Dyer	6/8/2024	O-DS-09-24[G]	Tern	Mammalian	American Badger		1		1	1
Dyer	6/10/2024	O-DS-15-24	Tern	Mammalian	American Badger		1		1	1
Dyer	6/11/2024	O-DS-20-24	Tern	Avian	Great Horned Owl		1		1	1
Dyer	6/12/2024	O-DS-17-24	Tern	Avian	Canada Goose	1				1
Dyer	6/13/2024	O-DS-17-24	Tern	Avian	Canada Goose	1				1
Dyer	6/24/2024	O-DS-21-24	Plover	Avian	Great Horned Owl		1		1	1
Dyer	6/24/2024	O-DS-27-24	Tern	Avian	Canada Goose	1				1
Dyer	6/25/2024	O-DS-30-24	Plover	Reptilian	Soft-shelled Turtle	1				1
Dyer	6/25/2024	O-DS-42-24	Plover	Avian	Canada Goose	1				1
Dyer	6/26/2024	O-DS-27-24	Tern	Avian	Canada Goose	1				1

Table 32 continued

Site	Date	Nest ID	Target Species Nest	Predator Type	Predator Species	Unique Predator Register[A]	Unique Predation Event[B]	Unique Predation Event Not Captured on Camera[C]	No. of Individual Predated Nests[D]	Unique Events[E]
Dyer	6/27/2024	O-DS-28-24	Tern	Mammalian	American Badger	1				1
Dyer	6/27/2024	O-DS-28-24	Tern	Avian	Canada Goose	1				1
Dyer	6/28/2024	O-DS-27-24	Tern	Avian	Canada Goose	1				1
Dyer	6/30/2024	O-DS-27-24	Tern	Avian	Canada Goose	1				1
Dyer	6/30/2024	O-DS-45-24	Plover	Avian	Great Horned Owl		1		1	1
Dyer	7/1/2024	O-DS-25-24	Tern	Avian	Great Horned Owl	1				1
Dyer	7/2/2024	O-DS-26-24, O-DS-31-24	Tern, Tern	Mammalian	American Badger		1		2	1
Dyer	7/2/2024	O-DS-28-24	Tern	Avian	Canada Goose	1				1
Dyer	7/3/2024	O-DS-28-24	Tern	Avian	Great Horned Owl	1				1
Dyer	7/3/2024	O-DS-28-24[H], O-DS-34-24	Tern, Tern	Mammalian	American Badger		1		2	1
Dyer	7/3/2024	O-DS-38-24	Tern	Avian	Canada Goose	1				1
Dyer	7/4/2024	O-DS-24-24[I], O-DS-46-24	Tern, Tern	Mammalian	American Badger		1		2	1
Dyer	7/5/2024	O-DS-23-24[J]	Tern	Mammalian	American Badger		1		1	1
Dyer	7/5/2024	O-DS-25-24	Tern	Avian	Canada Goose	1				1
Dyer	7/6/2024	O-DS-38-24	Tern	Avian	Canada Goose	1				1
Cottonwood Ranch	6/1/2024	O-CWR-01-24, O-CWR-02-24, O-CWR-03-24, O-CWR-04-24, O-CWR-05-24, O-CWR-06-24	Tern, Tern, Tern, Tern, Plover, Tern	Mammalian	Striped Skunk		1		6	1
Cottonwood Ranch	6/11/2024	O-CWR-09-24	Tern	Mammalian	Ord's Kangaroo Rat	1				1

Table 32 continued Site	Date	Nest ID	Target Species Nest	Predator Type	Predator Species	Unique Predator Register[A]	Unique Predation Event[B]	Unique Predation Event Not Captured on Camera[C]	No. of Individual Predated Nests[D]	Unique Events[E]
Cottonwood Ranch	7/4/2024	O-CWR-15-24	Tern	Mammalian	American Badger		1		1	1
Kearney Broadfoot South	5/9/2024	O-BFS-03-24	Plover	Reptilian	Garter Snake	1				1
Kearney Broadfoot South	5/26/2024	O-BFS-04-24, O-BFS-05-24	Plover, Plover	Mammalian	Striped Skunk		1		2	1
Kearney Broadfoot South	5/27/2024	O-BFS-01-24	Plover	Mammalian	Striped Skunk			1	1	1
Kearney Broadfoot South	5/28/2024	O-BFS-02-24, O-BFS-03-24, O-BFS-06-24	Plover, Plover, Plover	Mammalian	Striped Skunk			1	3	1
Kearney Broadfoot South	6/19/2024	O-BFS-10-24, O-BFS-11-24, O-BFS-15-24	Tern, Plover, Plover	Mammalian	Striped Skunk		1		3	1
Kearney Broadfoot South	6/23/2024	O-BFS-09-24, O-BFS-12-24[K], O-BFS-17-24, O-BFS-19-24, O-BFS-20-24	Plover, Tern, Plover, Tern, Tern	Mammalian	Striped Skunk		1		5	1
Kearney Broadfoot South	7/3/2024	O-BFS-21-24, O-BFS-22-24, O-BFS-24-24, O-BFS-26-24[L], O-BFS-27-24	Tern, Tern, Tern, Plover, Tern	Mammalian	Striped Skunk		1		5	1
Kearney Broadfoot South	7/11/2024	O-BFS-28-24	Plover	Avian	Great Horned Owl	1				1
Kearney Broadfoot South	7/21/2024	O-BFS-29-24	Tern	Mammalian	Striped Skunk		1		1	1
Kearney Broadfoot South	7/26/2024	O-BFS-28-24	Plover	Avian	Red-tailed Hawk		1		1	1

Table 32 continued

Site	Date	Nest ID	Target Species Nest	Predator Type	Predator Species	Unique Predator Register[A]	Unique Predation Event[B]	Unique Predation Event Not Captured on Camera[C]	No. of Individual Predated Nests[D]	Unique Events[E]
Newark West	5/13/2024	O-NW-02-24	Plover	Mammalian	Striped Skunk		1		1	1
Newark West	5/15/2024	O-NW-01-24	Plover	Mammalian	Striped Skunk		1		1	1
Newark West	6/1/2024	O-NW-18-24	Plover	Mammalian	Striped Skunk		1		1	1
Newark West	6/8/2024	O-NW-03-24, O-NW-09-24, O-NW-10-24	Tern, Plover, Tern	Mammalian	Striped Skunk		1		3	1
Newark West	6/29/2024	O-NW-16-24	Tern	Avian	Canada Goose	1				1
Newark West	7/6/2024	O-NW-14-24[M]	Tern	Avian	Great Horned Owl		1		1	1
Newark West	7/6/2024	O-NW-15-24	Tern	Avian	Canada Goose	1				1
Newark West	7/19/2024	O-NW-35-24	Tern	Avian	Canada Goose	1				1
Newark West	7/25/2024	O-NW-32-24, O-NW-35-24	Plover, Tern	Avian	Canada Goose	1				1
Newark West	8/1/2024	O-NW-35-24	Tern	Avian	Turkey Vulture	1				1
Newark West	8/2/2024	O-NW-35-24	Tern	Avian	Canada Goose	1				1
Newark East	4/30/2024	O-NE-01-24	Plover	Mammalian	Mouse spp.	1				1
Newark East	6/15/2024	O-NE-37-24	Tern	Avian	Canada Goose	1				1
Newark East	6/16/2024	O-NE-37-24[N]	Tern	Avian	Canada Goose		1		1	1
Newark East	6/22/2024	O-NE-37-24	Tern	Avian	Canada Goose	1				1
Newark East	7/4/2024	O-NE-40-24	Tern	Avian	Canada Goose	1				1
Newark East	7/6/2024	O-NE-45-24	Plover	Mammalian	American Badger	1				1
Newark East	7/7/2024	O-NE-45-24	Plover	Avian	Great Horned Owl	1				1
Newark East	7/10/2024	O-NE-40-24	Tern	Avian	Canada Goose	1				1
Newark East	7/11/2024	O-NE-40-24	Tern	Avian	Canada Goose	1				1
Newark East	7/13/2024	O-NE-48-24	Tern	Avian	Canada Goose	1				1
Newark East	7/19/2024	O-NE-50-24	Tern	Mammalian	Coyote		1		1	1
Newark East	7/20/2024	O-NE-44-24[O]	Plover	Avian	Great Horned Owl		1		1	1

Table 32 continued

Site	Date	Nest ID	Target Species Nest	Predator Type	Predator Species	Unique Predator Register[A]	Unique Predation Event[B]	Unique Predation Event Not Captured on Camera[C]	No. of Individual Predated Nests[D]	Unique Events[E]
Leaman	6/3/2024	O-LES-02-24	Tern	Avian	Great Horned Owl	1				1
Leaman	7/10/2024	O-LES-14-24, O-LES-19-24	Tern, Tern	Avian	Canada Goose	1				1
Leaman	7/13/2024	O-LES-17-24	Tern	Avian	Canada Goose	1				1
Leaman	7/14/2024	O-LES-17-24	Tern	Avian	Canada Goose	1				1
Leaman	7/24/2024	O-LES-21-24	Tern	Avian	Canada Goose	1				1
Leaman	7/25/2024	O-LES-21-24	Tern	Avian	Canada Goose	1				1
Leaman	7/28/2024	O-LES-21-24	Tern	Avian	Great Blue Heron	1				1
Leaman	7/28/2024	O-LES-21-24	Tern	Avian	Canada Goose	1				1
TOTAL						**46**	**29**	**2**	**55**	**77**

[A] Predator species registered on the nest camera because they approached the nest and left without predating the nest (i.e., did not consume the eggs and/or chicks in the nest bowl).

[B] Predator predated the nest (i.e., consumed the eggs and/or chicks in the nest bowl) on camera.

[C] Predation event not documented due to camera malfunction, but nest was determined predated by using information from all predator monitoring methods.

[D] Number of individual nests that were predated, either entirely or partially. This accounts for predation that occurred at multiple nests by the same predator species, within 24 hrs. at one nesting site.

[E] Running count of unique events on nests monitored by cameras.

[F] O-DS-05-24: 3 out of 4 eggs were predated and the remaining egg was abandoned.

[G] O-DS-09-24: 1 out of 3 eggs were predated by a great horned owl on 6/7/2024 and the remaining 2 eggs were predated by an American badger on 6/8/2024. The nest was not included in the No. of Individual Predated Nests for the 6/7 predation event because it was accounted for on 6/8.

[H] O-DS-28-24: 1 egg hatched and the remaining egg was predated.

[I] O-DS-24-24: 2 eggs hatched and the remaining egg was predated.

[J] O-DS-23-24: 2 eggs hatched and the remaining egg was predated.

[K] O-BFS-12-24: 2 out of 3 eggs were entirely predated and the striped skunk ate the eggshell of the remaining egg but not the chick inside. The chick was mature enough to survive and eventually fledged.

[L] O-BFS-26-24: 3 out of 4 eggs hatched. All 3 chicks and the remaining egg were predated.

[M] O-NW-14-24: 2 out of 3 eggs hatched. Both chicks and the remaining egg were predated.

[N] O-NE-37-24: 1 out of 2 eggs were predated and the remaining egg hatched.

[O] O-NE-44-24: 2 out of 3 eggs hatched and both chicks were predated. The remaining egg hatched and eventually fledged.

Table 33. Nest fate comparisons for piping plover and least tern nests that were and were not monitored by remote cameras during 2024 at six off-channel sand and water sites. All monitoring sources (i.e., outside/inside observers; nest, site, and shoreline camera data; and track surveys) were used to determine nest fates. The six nesting sites were located along the Platte River between Overton and Wood River, Nebraska.

Site	No. Nests		No. Successful Nests		No. Successful Nests w/Predation[A]		No. Nests Failed-Predation		No. Nests Failed-Abandoned		No. Nests Failed-Weather		No. Nests Failed-Unknown		Unknown Outcome	
	Camera	No Camera	Camera	No Camera	Camera	No Camera	Camera	No Camera	Camera	No Camera	Camera	No Camera	Camera	No Camera	Camera	No Camera
Piping Plover																
Dyer	12		3				4		2[B]		1				2	
Cottonwood Ranch	5	1	2				1	1	1		1					
Kearney Broadfoot South	13		2		1		11									
Newark West	7		3				4									
Newark East	12		8		1				1		2		1			
Leaman	2		2													
Total Plover	**51**	**1**	**20**	**0**	**2**	**0**	**20**	**1**	**4**	**0**	**4**	**0**	**1**	**0**	**2**	**0**
Least Tern																
Dyer	19	19	8		3		9	7	1			2	1	6		4
Cottonwood Ranch	10	3	2				6	2	1		1	1				
Kearney Broadfoot South	15	1	4		1		8	1	2				1			
Newark West	20	12	9	9	1		2		4		4	3	1			
Newark East	19	21	10	6	1		1	1	2	1	5	12	1	1		
Leaman	13	5	12	4									1	1		
Total Tern	**96**	**61**	**45**	**19**	**6**	**0**	**26**	**11**	**10**	**1**	**10**	**18**	**5**	**8**	**0**	**4**
Overall Totals	**147**	**62**	**65**	**19**	**8**	**0**	**46**	**12**	**14**	**1**	**14**	**18**	**6**	**8**	**2**	**4**

[A] Predation occurred at successful nests while eggs and chicks were present in the nest bowl.

[B] O-DS-05-24: 3 out of 4 eggs were predated and the remaining egg was abandoned.

Table 34. Nest, egg, and chick fates for piping plover and least tern nests that were monitored by remote cameras during 2024 at six off-channel sand and water sites. All monitoring sources (i.e., outside/inside observers; nest, site, and shoreline camera data; and track surveys) were used to determine nest fates. Individual egg and chick fates were determined primarily using camera data with limited data available from outside monitoring. The six nesting sites were located along the Platte River between Overton and Wood River, Nebraska.

	Nests			Eggs							Chicks				
Nesting Site	**No. Monitored**	**No. Successful**	**Total No. Camera Days**	**No. Laid**	**No. Hatch**	**No. Failed-Predated**	**No. Failed-Abandoned**	**No. Failed-Weather**	**No. Failed-Unknown**	**No. Unknown Outcome**	**No. Left Nest**	**No. Mortality-Predated**	**No. Mortality-Weather**	**No. Mortality-Failed Unknown**	**No. Unknown Outcome**
Piping Plover															
Dyer	12	3	151	48	11	19	4	5	1	8	11				
Cottonwood Ranch	5	2	66	16	8	4	1	3			7			1	
Kearney Broadfoot South	13	2	142	50	6	39			4	1	3	3			
Newark West	7	3	84	29	12	16			1		12				
Newark East	12	8	183	46	29		1	11	4	1	27	2			
Leaman	2	2	39	8	6		2				6				
Total Plover	**51**	**20**	**665**	**197**	**72**	**78**	**8**	**19**	**10**	**10**	**66**	**5**	**0**	**1**	**0**
Least Tern															
Dyer	19	8	165	52	17	29	2	1	3		9	1	7		
Cottonwood Ranch	10	2	103	26	3	16	4	2		1	3				
Kearney Broadfoot South	15	4	91	32	8	20	2		2		7			1	
Newark West	20	9	120	45	18	5	5	12	2	3	14	2		2	
Newark East	19	10	153	40	18	3	6	11	2		16			2	
Leaman	13	12	154	32	26		1		4	1	26			1[A]	
Total Tern	**96**	**45**	**786**	**227**	**90**	**73**	**20**	**26**	**13**	**5**	**75**	**3**	**7**	**6**	**0**
Overall Total	**147**	**65**	**1,451**	**424**	**162**	**151**	**28**	**45**	**23**	**15**	**141**	**8**	**7**	**7**	**0**

[A] One chick at Leaman hatched and left the nest successfully, but then was found dead about five feet away from the nest when the nest camera was picked up.

Table 35. Summary of predation events on piping plover and least tern nests that were monitored by remote cameras during 2024 at six off-channel sand and water sites. Provided for each predated nest are the: predator species, nest status when predation occurred, development stage of the nest when predation occurred, number of predated eggs or chicks, and estimated day of incubation when the predation occurred. Percent incubation completed was calculated based on an assumed 28-day incubation period for piping plovers and 21-day incubation period for least terns.

Nesting Site	Species	Nest ID	Predator Species	Nest Status When Predated	Developmental Stage when Predation Occurred	No. of Predated Eggs	No. of Predated Chicks	Incubation Day when Predation Occurred	Percent Incubation Completed
Dyer	Plover	O-DS-05-24	Great Horned Owl	Active	Eggs	3		26	93%
Dyer	Tern	O-DS-07-24	Great Horned Owl	Active	Eggs	3		17	81%
Dyer	Tern	O-DS-08-24	Great Horned Owl	Active	Eggs	2		3	14%
Dyer	Tern	O-DS-09-24[A]	Great Horned Owl	Active	Eggs	1		18	86%
Dyer	Tern	O-DS-09-24[A]	American Badger	Active	Eggs	2		19	90%
Dyer	Plover	O-DS-10-24	Great Horned Owl	Active	Eggs	4		17	61%
Dyer	Plover	O-DS-11-24	Great Horned Owl	Active	Eggs	4		17	61%
Dyer	Tern	O-DS-15-24	American Badger	Active	Eggs	3		14	67%
Dyer	Tern	O-DS-20-24	Great Horned Owl	Active	Eggs	3		11	52%
Dyer	Plover	O-DS-21-24	Great Horned Owl	Active	Eggs	4		24	86%
Dyer	Tern	O-DS-23-24	American Badger	Active	Eggs	1		24	100%
Dyer	Tern	O-DS-24-24	American Badger	Active	Eggs	1		24	100%
Dyer	Tern	O-DS-26-24	American Badger	Active	Eggs	3		23	100%
Dyer	Tern	O-DS-28-24	American Badger	Successful	Eggs/Chicks	1	1	21	100%
Dyer	Tern	O-DS-31-24	American Badger	Active	Eggs	3		24	100%
Dyer	Tern	O-DS-34-24	American Badger	Active	Eggs	3		16	76%
Dyer	Plover	O-DS-45-24	Great Horned Owl	Active	Eggs	4		11	39%
Dyer	Tern	O-DS-46-24	American Badger	Active	Eggs	3		13	62%
Cottonwood Ranch	Tern	O-CWR-01-24	Striped Skunk	Active	Eggs	3		8	38%
Cottonwood Ranch	Tern	O-CWR-02-24	Striped Skunk	Active	Eggs	3		8	38%
Cottonwood Ranch	Tern	O-CWR-03-24	Striped Skunk	Active	Eggs	3		9	43%

Table 35 continued **Nest ID** **Predator Species**

Nesting Site	Species			Nest Status When Predated	Developmental Stage when Predation Occurred	No. of Predated Eggs	No. of Predated Chicks	Incubation Day when Predation Occurred	Percent Incubation Completed
Cottonwood Ranch	Tern	O-CWR-04-24	Striped Skunk	Active	Eggs	3		9	43%
Cottonwood Ranch	Plover	O-CWR-05-24	Striped Skunk	Active	Eggs	4		9	32%
Cottonwood Ranch	Tern	O-CWR-06-24	Striped Skunk	Active	Eggs	2		6	29%
Cottonwood Ranch	Tern	O-CWR-15-24	American Badger	Active	Eggs	2		13	62%
Kearney Broadfoot South	Plover	O-BFS-01-24[B]	Striped Skunk	Active	Eggs	2		26	93%
Kearney Broadfoot South	Plover	O-BFS-02-24[B]	Striped Skunk	Active	Eggs	4		27	96%
Kearney Broadfoot South	Plover	O-BFS-03-24[B]	Striped Skunk	Active	Eggs	2		27	96%
Kearney Broadfoot South	Plover	O-BFS-04-24	Striped Skunk	Active	Eggs	4		19	68%
Kearney Broadfoot South	Plover	O-BFS-05-24	Striped Skunk	Active	Eggs	4		19	68%
Kearney Broadfoot South	Plover	O-BFS-06-24[B]	Striped Skunk	Active	Eggs	4		14	50%
Kearney Broadfoot South	Plover	O-BFS-09-24	Striped Skunk	Active	Eggs	2		16	57%
Kearney Broadfoot South	Tern	O-BFS-10-24	Striped Skunk	Active	Eggs	3		18	86%
Kearney Broadfoot South	Plover	O-BFS-11-24	Striped Skunk	Active	Eggs	4		12	43%
Kearney Broadfoot South	Tern	O-BFS-12-24	Striped Skunk	Active	Eggs	2		14	67%
Kearney Broadfoot South	Plover	O-BFS-15-24	Striped Skunk	Active	Eggs	4		16	57%
Kearney Broadfoot South	Plover	O-BFS-17-26	Striped Skunk	Active	Eggs	4		16	57%
Kearney Broadfoot South	Tern	O-BFS-19-24	Striped Skunk	Active	Eggs	2		7	33%
Kearney Broadfoot South	Tern	O-BFS-20-24	Striped Skunk	Active	Eggs	2		7	33%
Kearney Broadfoot South	Tern	O-BFS-21-24[B]	Striped Skunk	Active	Eggs	2		10	48%
Kearney Broadfoot South	Tern	O-BFS-22-24	Striped Skunk	Active	Eggs	3		10	48%
Kearney Broadfoot South	Tern	O-BFS-24-24	Striped Skunk	Active	Eggs	1		7	33%
Kearney Broadfoot South	Plover	O-BFS-26-24	Striped Skunk	Successful	Eggs/Chicks	1	3	30	100%
Kearney Broadfoot South	Tern	O-BFS-27-24	Striped Skunk	Active	Eggs	2		3	14%
Kearney Broadfoot South	Plover	O-BFS-28-24	Red-tailed Hawk	Active	Eggs	4		19	68%
Kearney Broadfoot South	Tern	O-BFS-29-24	Striped Skunk	Active	Eggs	3		21	100%

Table 35 continued Nesting Site	Species	Nest ID	Predator Species	Nest Status When Predated	Developmental Stage when Predation Occurred	No. of Predated Eggs	No. of Predated Chicks	Incubation Day when Predation Occurred	Percent Incubation Completed
Newark West	Plover	O-NW-01-24	Striped Skunk	Active	Eggs	4		15	54%
Newark West	Plover	O-NW-02-24	Striped Skunk	Active	Eggs	4		13	46%
Newark West	Tern	O-NW-03-24	Striped Skunk	Active	Eggs	2		19	90%
Newark West	Plover	O-NW-09-24	Striped Skunk	Active	Eggs	4		14	50%
Newark West	Tern	O-NW-10-24	Striped Skunk	Active	Eggs	2		11	52%
Newark West	Tern	O-NW-14-24	Great Horned Owl	Successful	Eggs/Chicks	1	2	23	100%
Newark West	Plover	O-NW-18-24	Striped Skunk	Active	Eggs	4		9	32%
Newark East	Tern	O-NE-37-24	Canada Goose	Active	Eggs	1		7	33%
Newark East	Plover	O-NE-44-24	Great Horned Owl	Successful	Chicks	0	2	27	96%
Newark East	Tern	O-NE-50-24	Coyote	Active	Eggs	2		12	57%
Average Incubation Completed for Piping Plovers								**18.39**	**65.7%**
Average Incubation Completed for Least Terns								**13.61**	**64.8%**

[A] O-DS-09-24: included twice in the table because 1 out of 3 eggs were predated by a great horned owl on 6/7/2024 and the remaining 2 eggs were predated by an American badger on 6/8/2024.

[B] Includes data from indicated nests where plover nest/eggs were predated but the individual predator or predation event was not captured on camera because the camera malfunctioned.

Table 36. Covariate coefficient estimates, associated standard errors, and P-values for a model examining effects of nest cameras and site on daily survival rates of piping plover and least tern nests at six off-channel sand and water sites adjacent to the Platte River.

Covariate	Estimate	Standard Error	P-value
[a]Intercept (Site = Dyer)	2.248	0.238	<0.0001
Camera = yes	0.829	0.328	0.012
Site = Cottonwood Ranch	-1.639	0.669	0.014
Site = Kearney Broadfoot South	0.457	1.034	0.658
Site = Newark West	2.035	0.623	0.001
Site = Newark East	0.849	0.351	0.016
Site = Leaman	2.146	1.028	0.037
Camera(yes)*Site(Cottonwood Ranch)	1.084	0.771	0.160
Camera(yes)*Site(Kearney Broadfoot South)	-0.941	1.081	0.384
Camera(yes)*Site(Newark West)	-2.005	0.712	0.005
Camera(yes)*Site(Newark East)	-0.183	0.502	0.716
Camera(yes)*Site(Leaman)	0.353	1.453	0.808

[a] Intercept term includes Site = Dyer

FIGURES

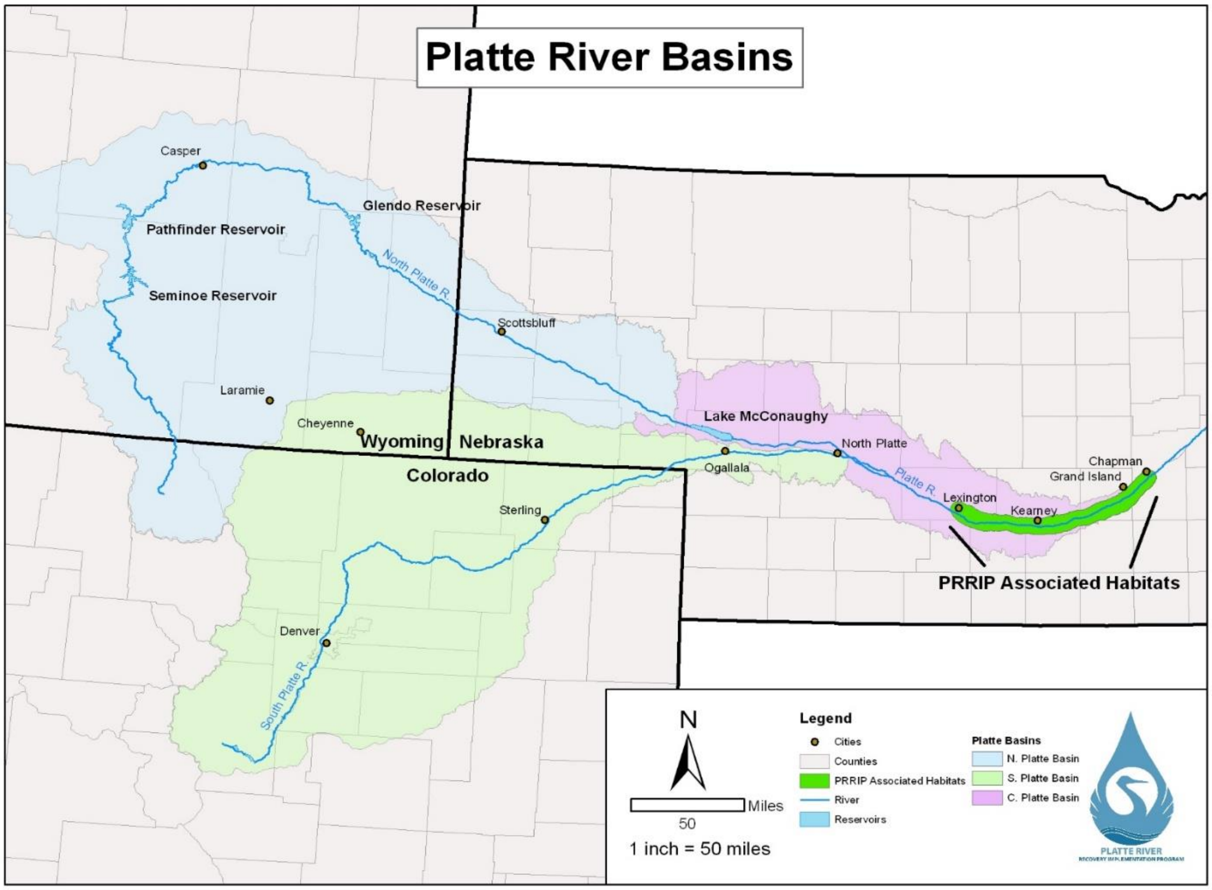


Figure 1. Platte River Basins extending from Colorado and Wyoming through Nebraska. The study area for our piping plover and least tern monitoring and research efforts was the PRRIP Associated Habitat Reach of the central Platte River located between Lexington and Chapman, Nebraska (in dark green).

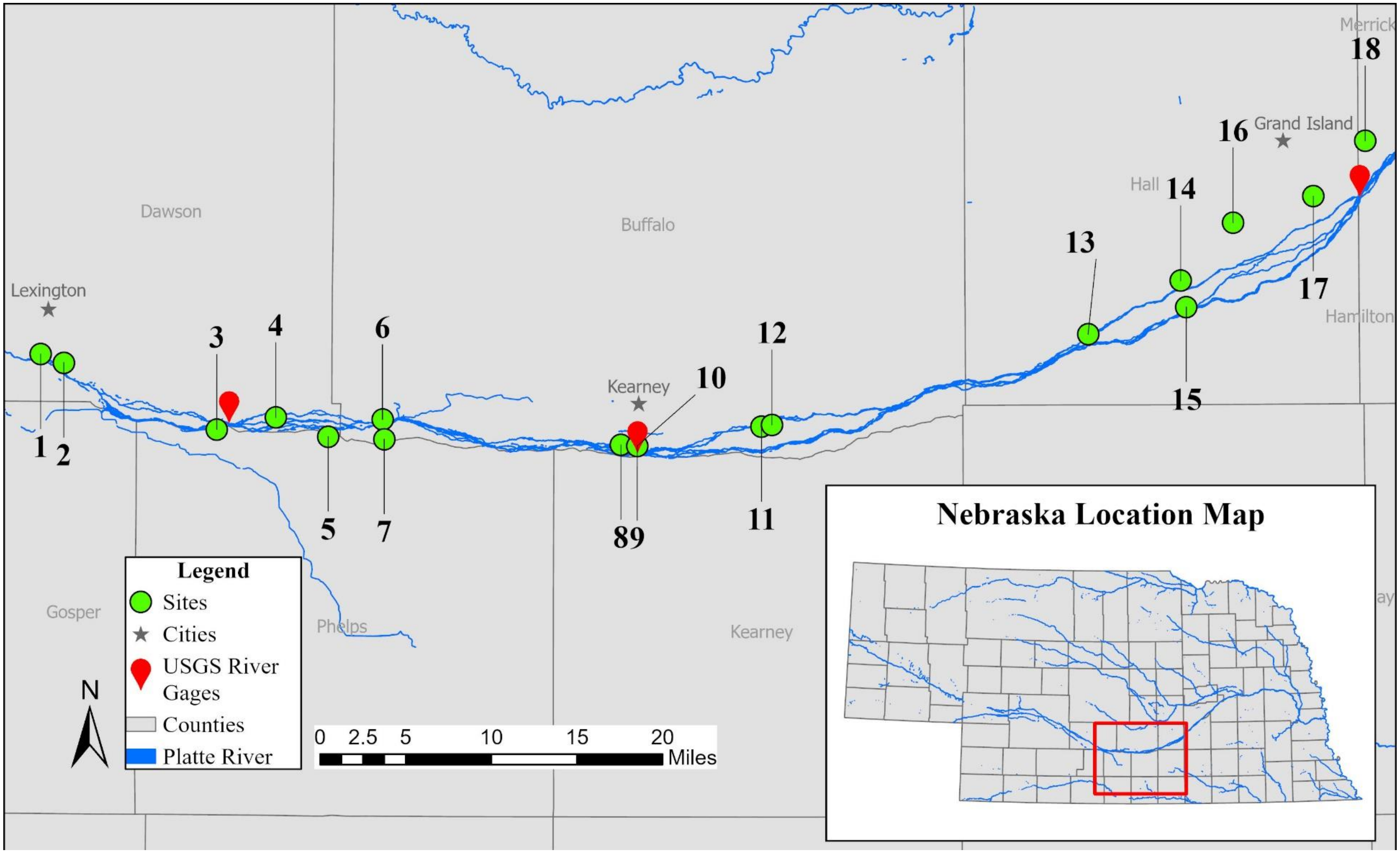


Figure 2. Distribution of the 18 off-channel sand and water (OCSW) sites (green circles) and Platte River channels (blue) monitored for piping plover and least tern nesting and foraging activities during 2024 in our study area between Lexington and Chapman, Nebraska. Locations of the three USGS river gage stations along the central Platte River are depicted in red. Sites are: (1) OSG Lexington; (2) NPPD Lexington; (3) Dyer; (4) Cottonwood Ranch; (5) T&F Lakeside; (6) Blue Hole; (7) Johnson; (8) Ed Broadfoot and Sons; (9) Kearney Broadfoot South; (10) Non-Access Islands Kearney Broadfoot South; (11) Newark West; (12) Newark East; (13) Leaman; (14) Follmer; (15) Trust Wildrose East; (16) DeWeese; (17) Hooker Brothers Southeast; and (18) Hooker Brothers East.

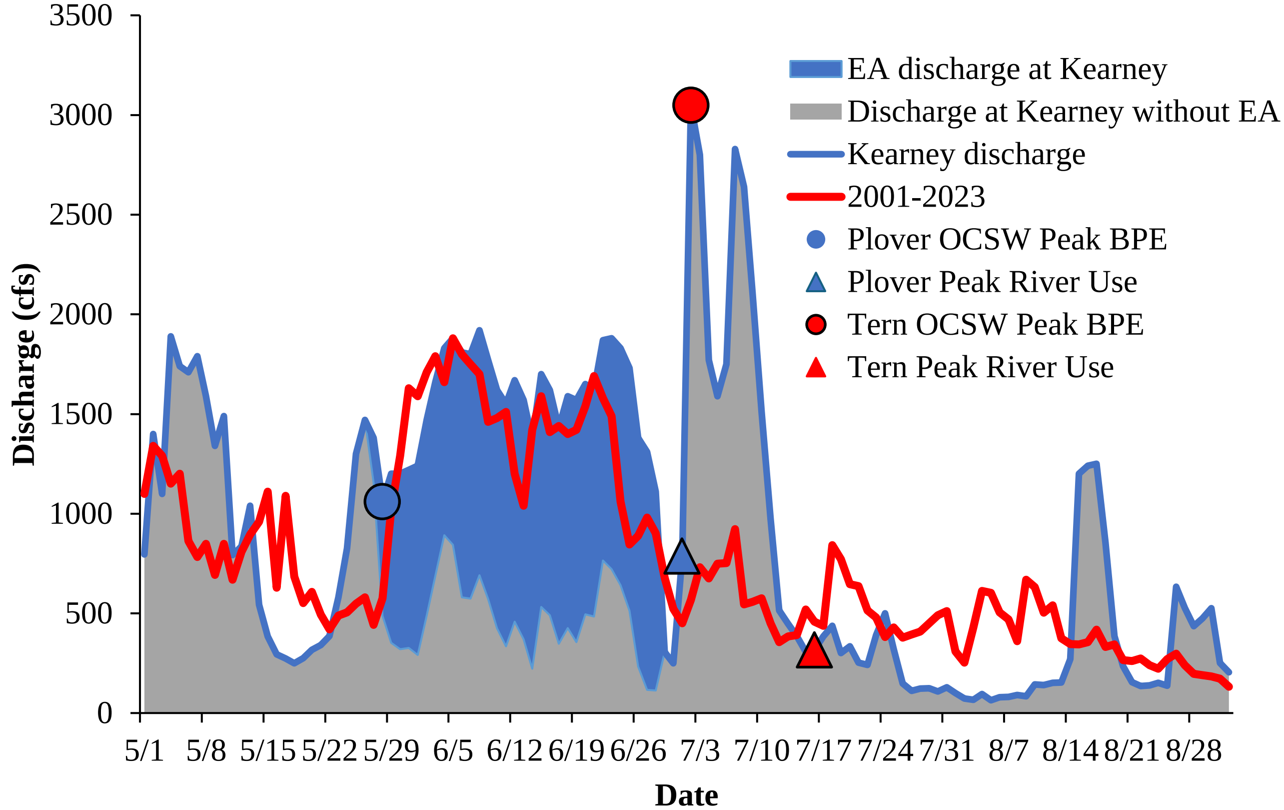


Figure 3. Daily discharge (cubic feet per second; cfs) at Kearney, Nebraska (USGS gage 06770200; USGS 2024b) between 1 May and 1 September, 2024 (blue line). See Figure 2 for location of gage stations within our study area. Also depicted in the figure are the: median daily discharge during 2001-2023 at Kearney (red line); 2024 mean daily discharge without the inclusion of the Environmental Account (EA) release (gray shaded area); and 2024 EA release mean daily discharge during 27 May to 28 June at Kearney (dark blue shaded area). Dates on which estimated breeding pairs/nest (BPE) and river use for piping plovers and least terns peaked are denoted with circles and triangles. Plover BPE peaked at OCSW sites across the Associated Habitat Reach (AHR) on 28 May (blue circle); tern BPE peaked at OCSW sites across the AHR on 2 July (red circle); and adult counts observed on river surveys peaked for plovers on 1 July (blue triangle) and terns on 15 July (red triangle).

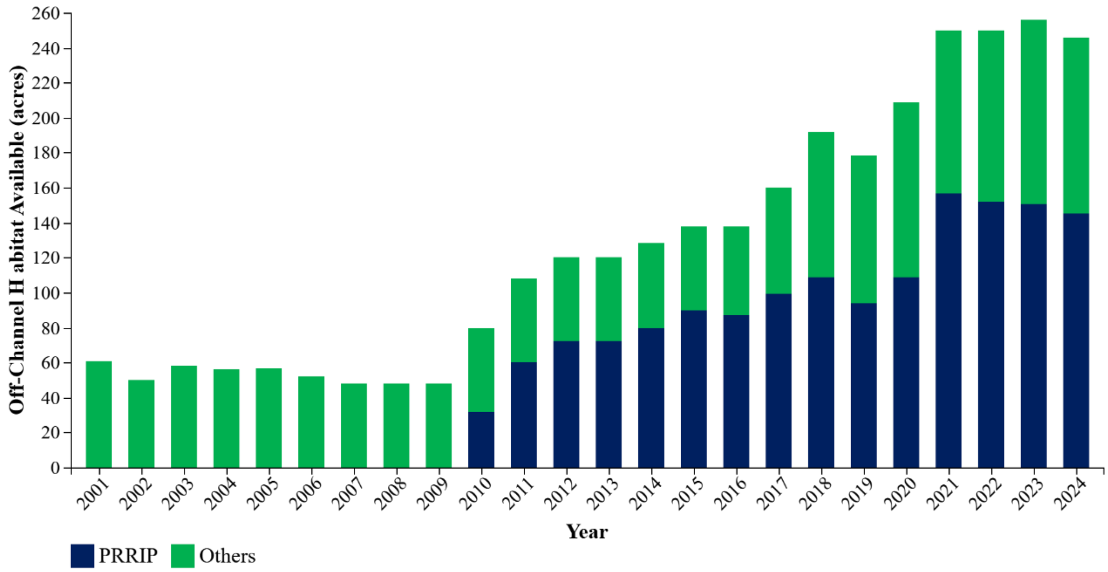


Figure 4. Availability of OCSW piping plover and least tern nesting habitat along the Associated Habitat Reach (AHR) between Lexington and Chapman, Nebraska, adjacent to the Platte River during 2001-2024. OCSW habitat is separated into sites owned and/or managed by the Program (PRRIP, indigo shaded bars) and by other organizations (Others, green shaded bars). The OCSW nesting habitat fits the accepted Program habitat requirements for piping plovers and least terns (PRRIP 2015). Due to access restrictions that limited monitoring at some sites, available OCSW habitat during 2001-2009 only included sites that were used in the reproductive and survival calculations each year.

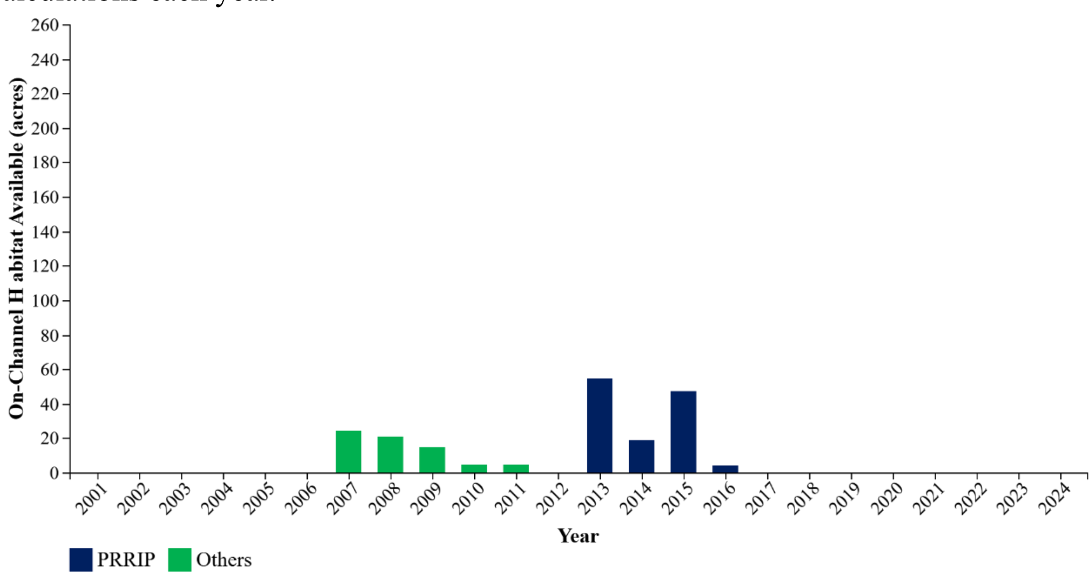


Figure 5. Monitored on-channel piping plover and least tern nesting habitat on the Platte River along the Associated Habitat Reach (AHR) between Lexington and Chapman, Nebraska, during 2001-2024 that was created, rehabilitated, and managed by the Program (PRRIP, indigo shaded bars) and other organizations (Others, green shaded bars). The on-channel nesting habitat fits the accepted Program habitat requirements (PRRIP 2015). On-channel habitat available during 2001-2006 only included sites that were used in reproductive and survival calculations each year; however, no nesting was observed during this period.

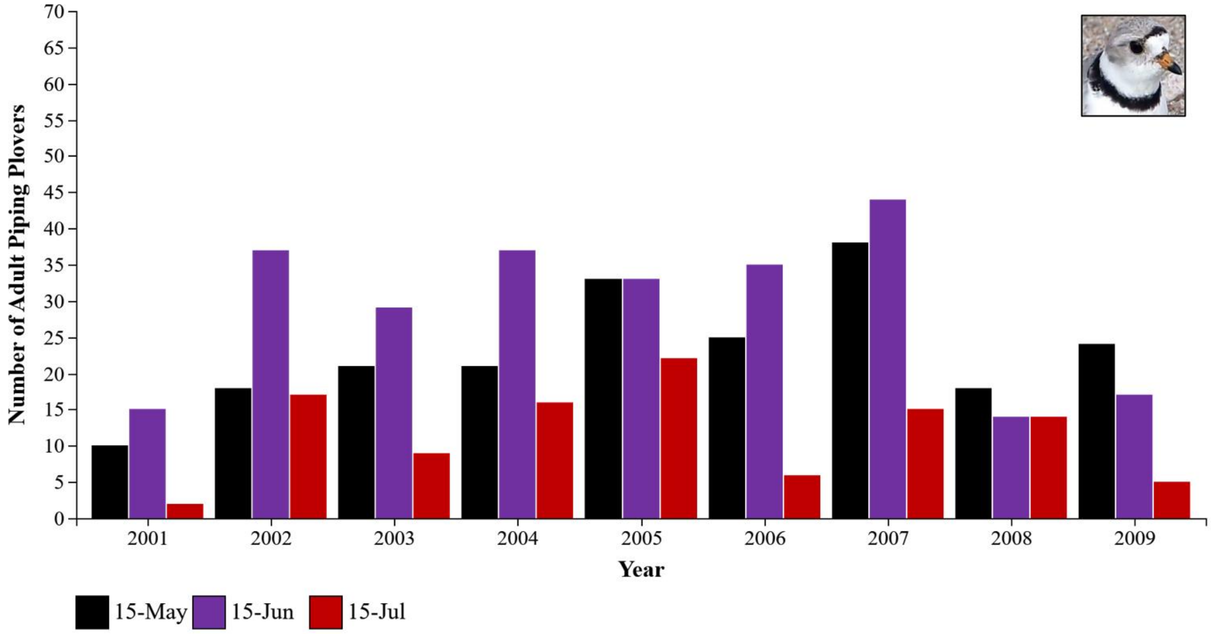
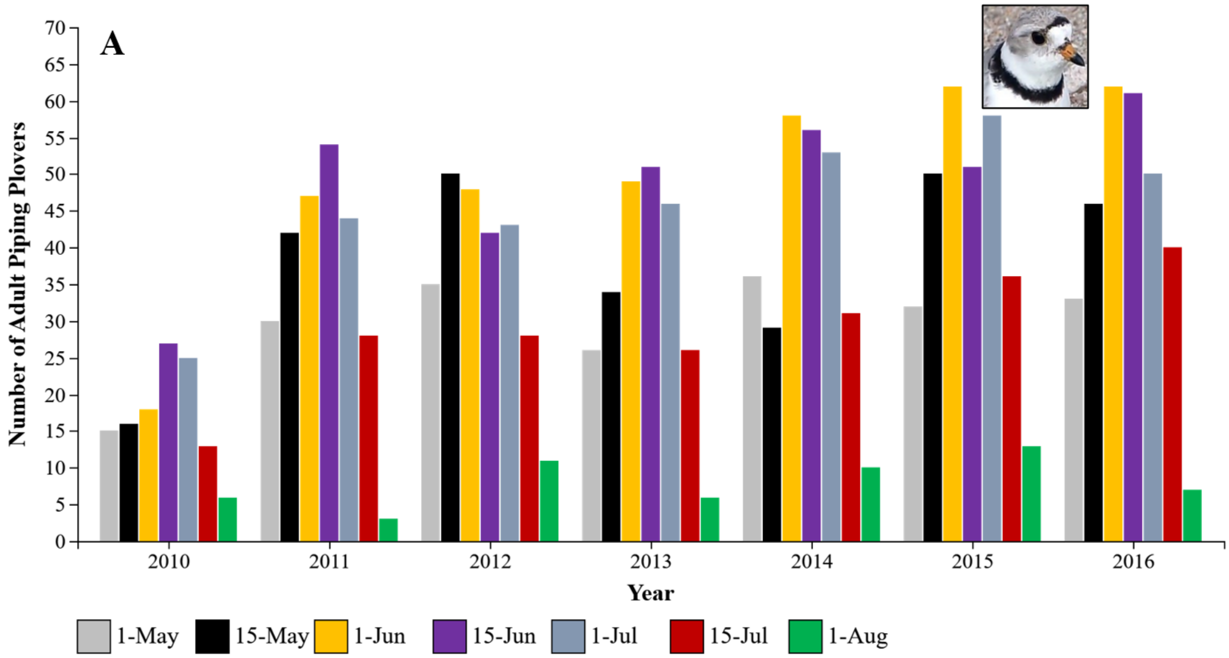


Figure 6. Number of adult piping plovers observed during three semi-monthly surveys of OCSW sites along the Platte River between Lexington and Chapman, Nebraska, 2001-2009. Numbers of adults include observations of both non-breeding and breeding piping plovers.



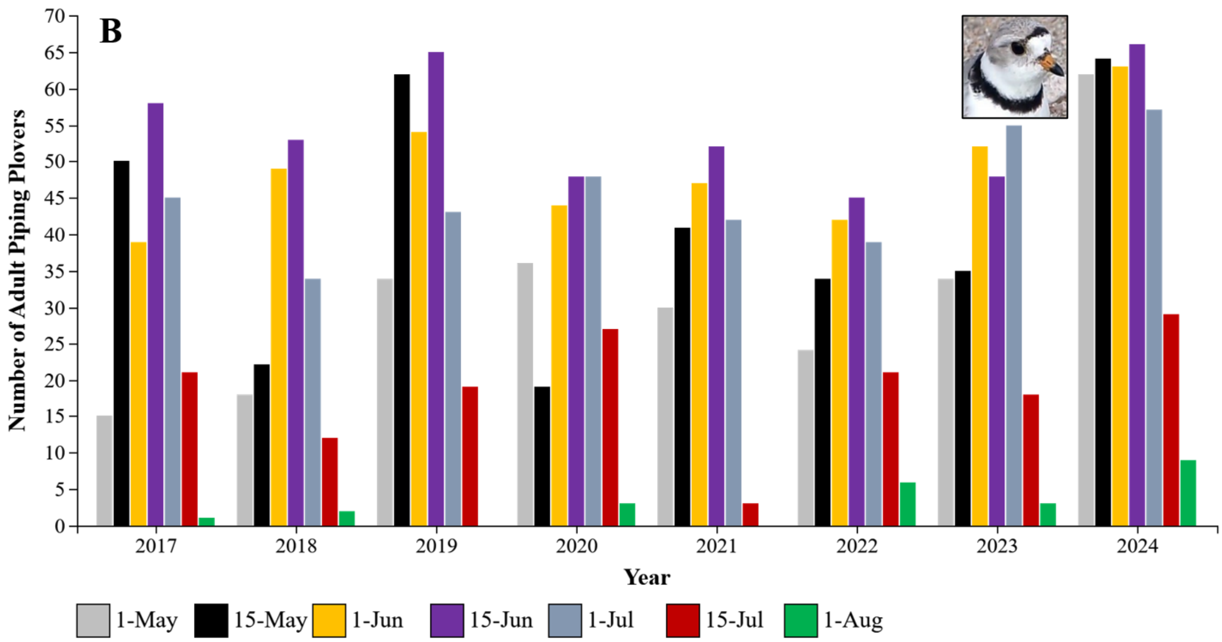


Figure 7. Number of adult piping plovers observed during semi-monthly surveys of OCSW sites along the Platte River between Lexington and Chapman, Nebraska, 2010-2024, during the periods of (A) 2010-2016, and (B) 2017-2024. Numbers of adults include observations of both non-breeding and breeding piping plovers.

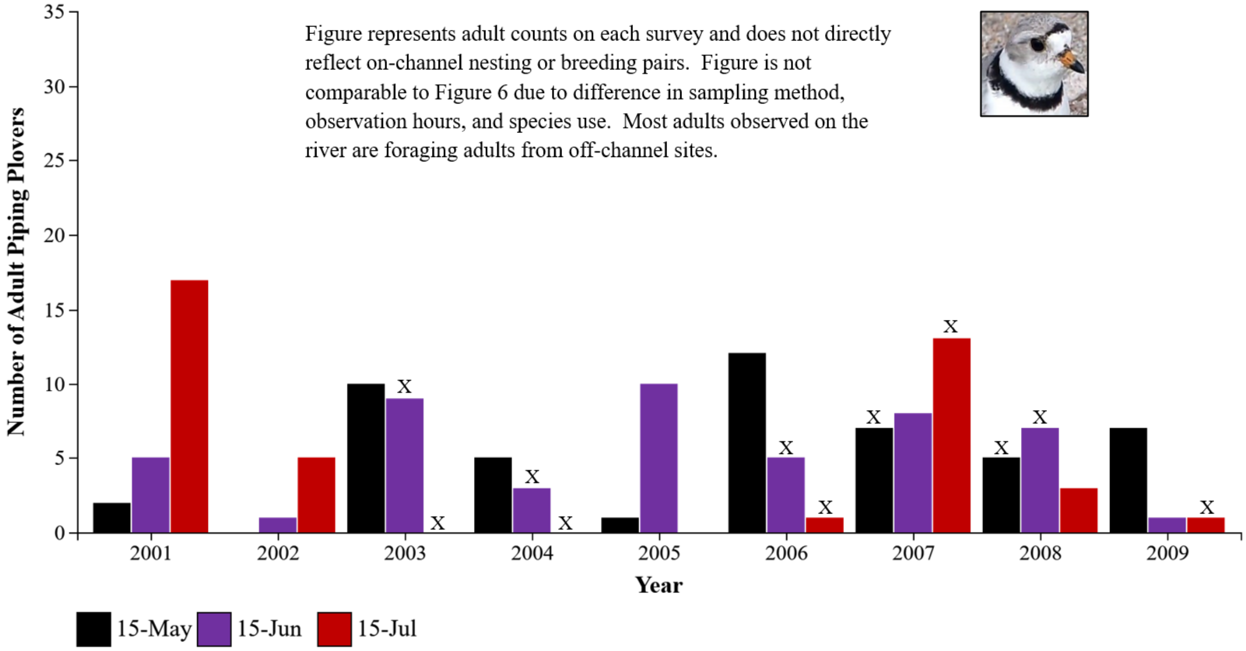


Figure 8. Number of adult piping plovers observed during three semi-monthly surveys of the Platte River between Lexington and Chapman, Nebraska, 2001-2009. Numbers of adults include observations of both non-breeding and breeding piping plovers. Sampling periods for which at least one section of the river was not completed due to lack of flow or high flow in the channel, or other restrictions, are denoted with an "X". These surveys include: 15 May 2007, 2008; 15 June 2003, 2004, 2006, 2008; and 15 July 2003, 2004, 2006, 2007, 2008.

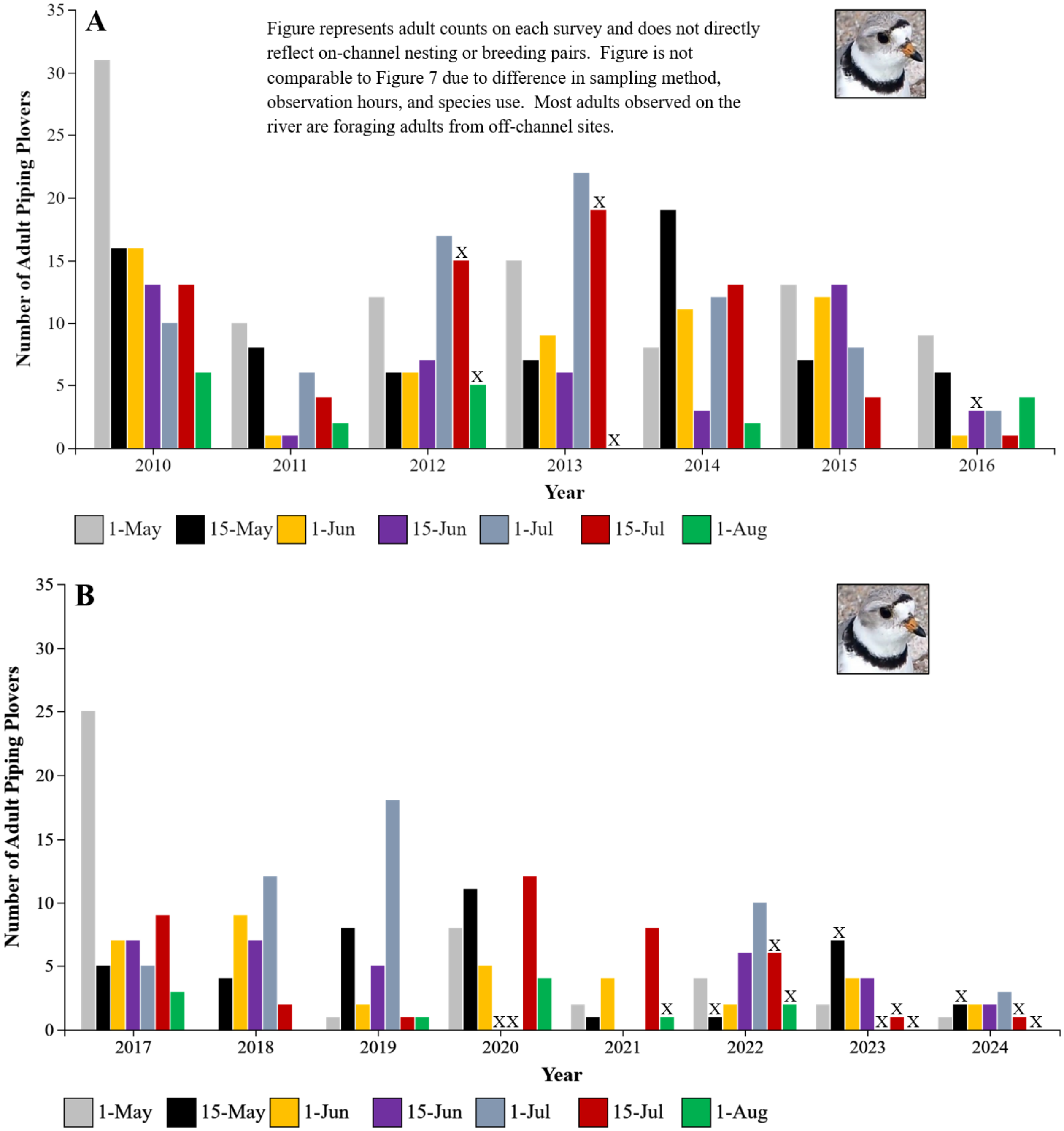


Figure 9. Number of adult piping plovers observed during semi-monthly surveys of the Platte River between Lexington and Chapman, Nebraska, 2010-2024, during the periods of (A) 2010-2016, and (B) 2017-2024. Sampling periods for which at least one section of the river was not completed due to lack of flow or high flow in the channel, or other restrictions, are denoted with an “X”. These survey dates include: 15 May 2022, 2023, 2024; 15 June 2016, 2020; 1 July 2020, 2023; 15 July 2012, 2013, 2022, 2023, 2024; and 1 August 2012, 2013, 2021, 2022, 2023, 2024.

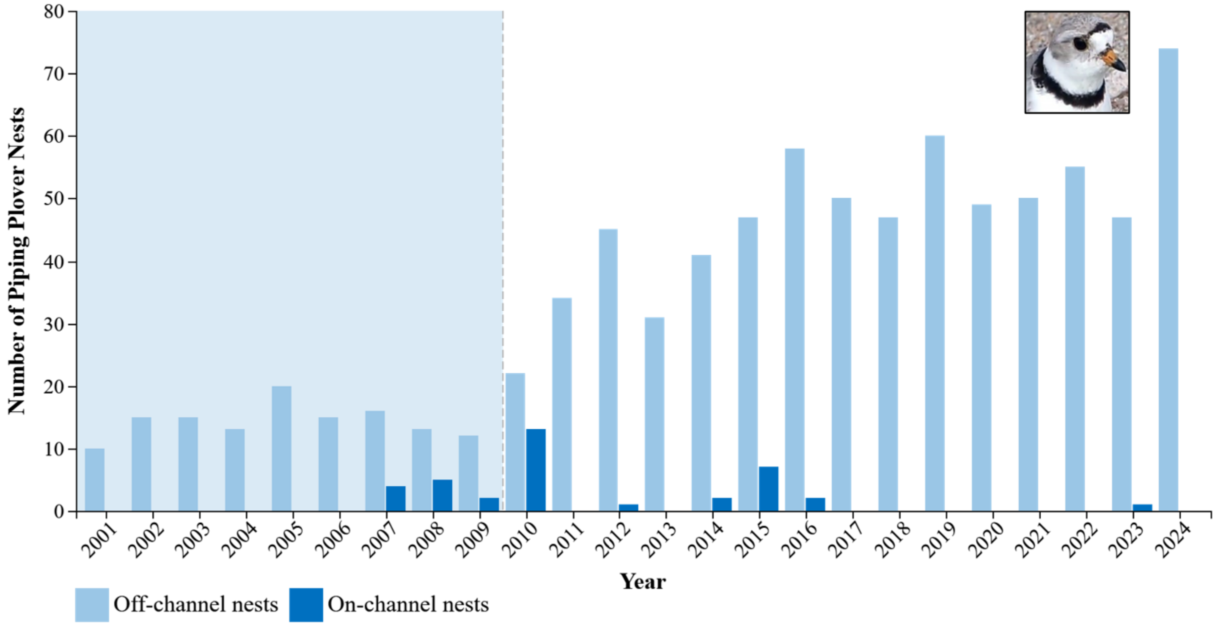


Figure 10. Comparison of numbers of piping plover nests found during off-channel (light blue bars) and on-channel (dark blue bars) surveys within the Program Associated Habitat Reach along the Platte River between Lexington and Chapman, Nebraska, 2001-2024. The dashed line represents changes in protocol between 2009-2010, including an increase in monitoring effort. The shaded area represents years in which nest totals are not comparable to recent totals.

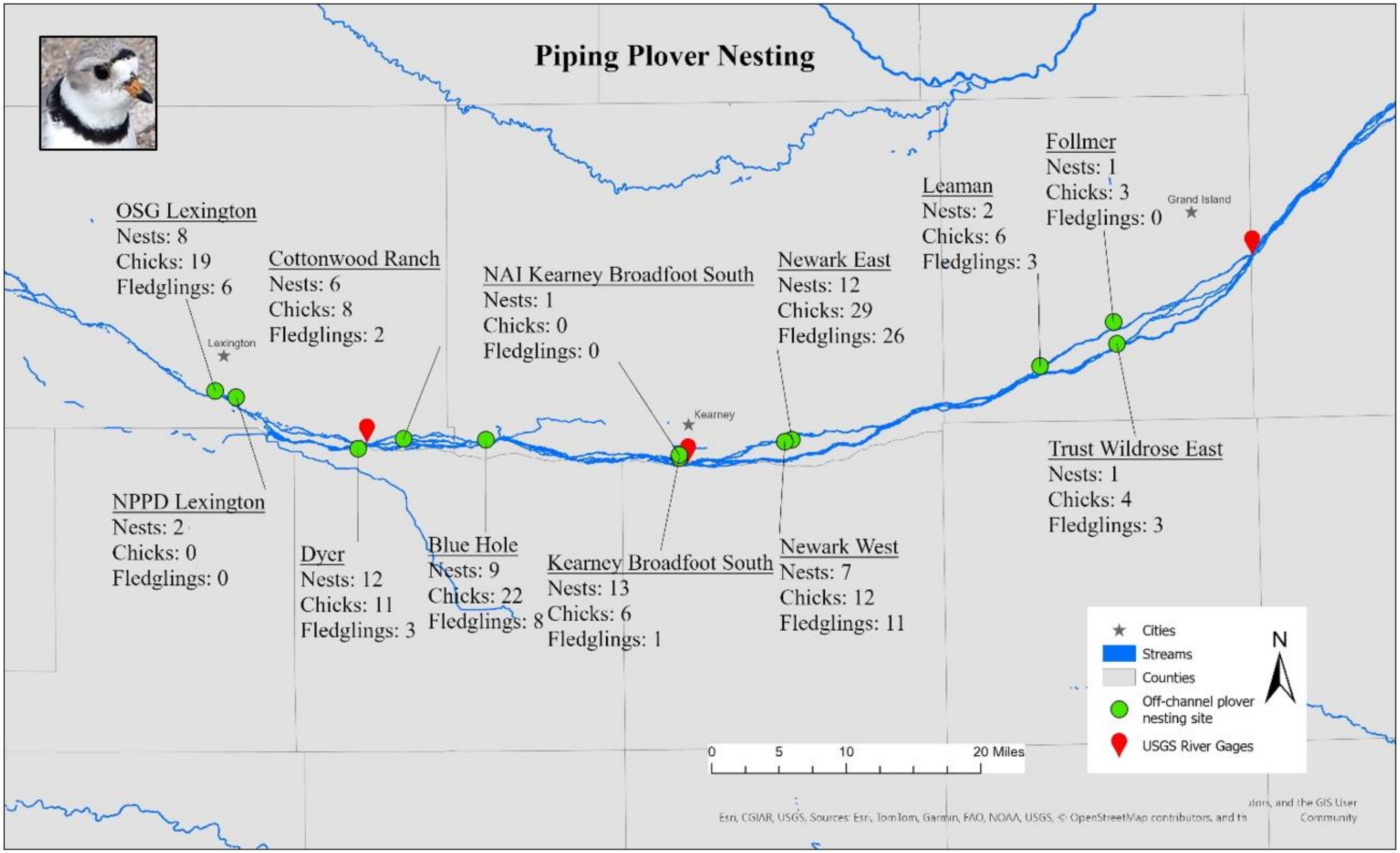


Figure 11. Distribution and numbers of piping plover nests, chicks, and fledglings observed within Program associated habitats during 2024 surveys along the Platte River between Lexington and Chapman, Nebraska. Piping plover nests and chicks were observed and monitored at 12 of 18 off-channel sites during 2024. The locations of the Overton (USGS gage 06768000, USGS 2024a), Kearney (USGS gage 06770200, USGS 2024b) and Grand Island (USGS gage 0670500, USGS 2024c) river gages are marked with a red pin.

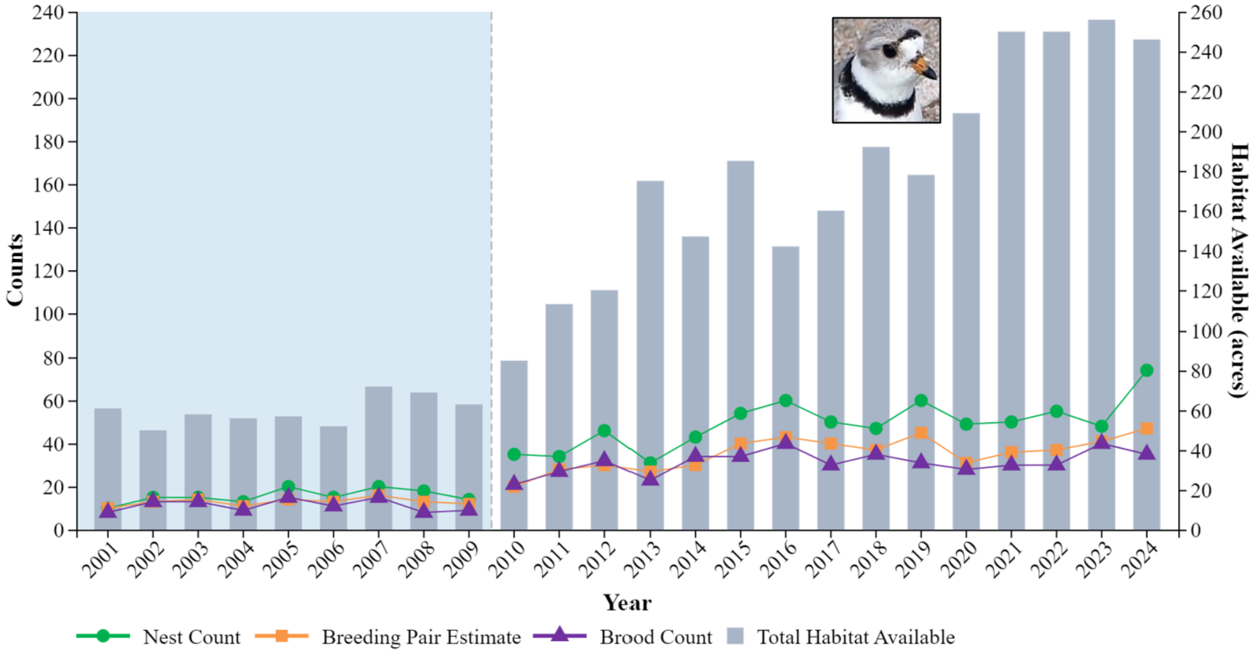


Figure 12. Annual variation in the total numbers of piping plover nests (green line), breeding pair estimates (orange line), brood counts (purple line), and total on- and off-channel habitat available (acres; blue bars) observed within the Program Associated Habitat Reach along the Platte River between Lexington and Chapman, Nebraska, during 2001-2024. The dotted line represents changes in protocol that occurred between 2009 and 2010, including an increase in monitoring effort. Data from 2001-2009 (shaded area) may not be comparable to data from 2010-2024. Due to access restrictions that limited monitoring at some sites, available habitat from 2001-2009 only included sites that were used in the reproductive and survival calculations each year.

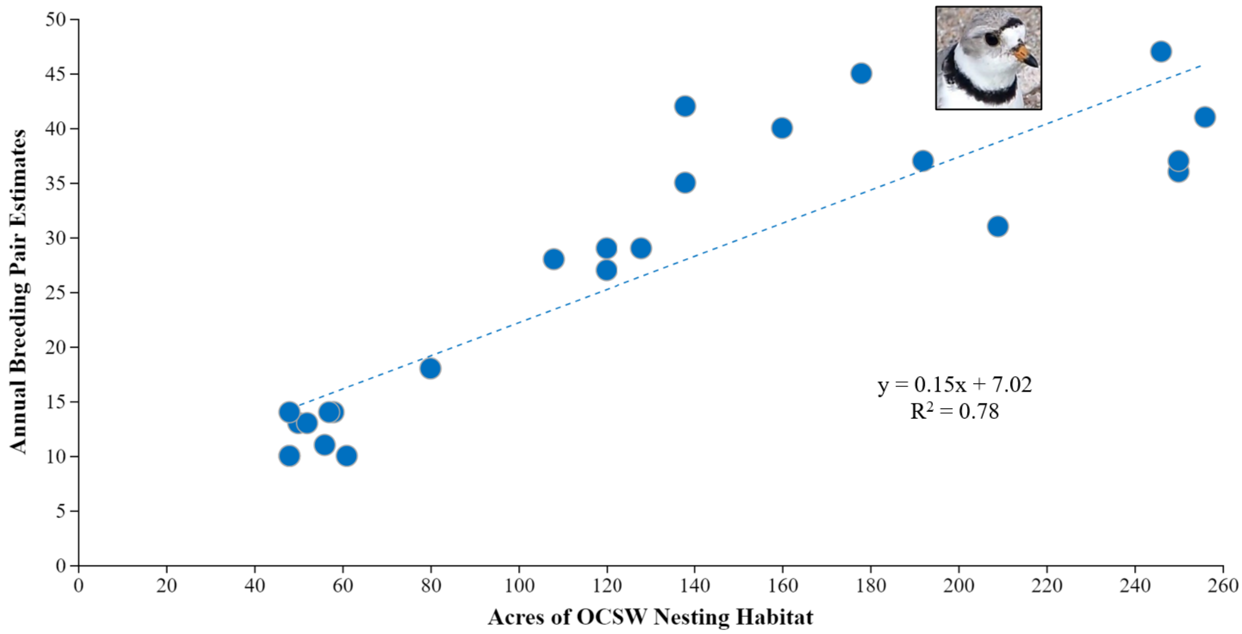


Figure 13. Relationship between the annual estimated number of OCSW piping plover breeding pairs and availability (acres) of monitored off-channel habitat (OCSW sites) within the Program Associated Habitat Reach between Lexington and Chapman, Nebraska, during 2001-2024. For every acre of OCSW habitat increase, an increase of 0.15 piping plover breeding pairs occurred (95% CI: 0.12-0.19 breeding pairs) at OCSW sites in the AHR and the results were statistically significant ($P < 0.001$). The linear line of best fit with corresponding equation and R^2 value are depicted. Due to access restrictions that limited monitoring at some sites, available habitat from 2001-2009 only included sites that were used in the reproductive and survival calculations each year.

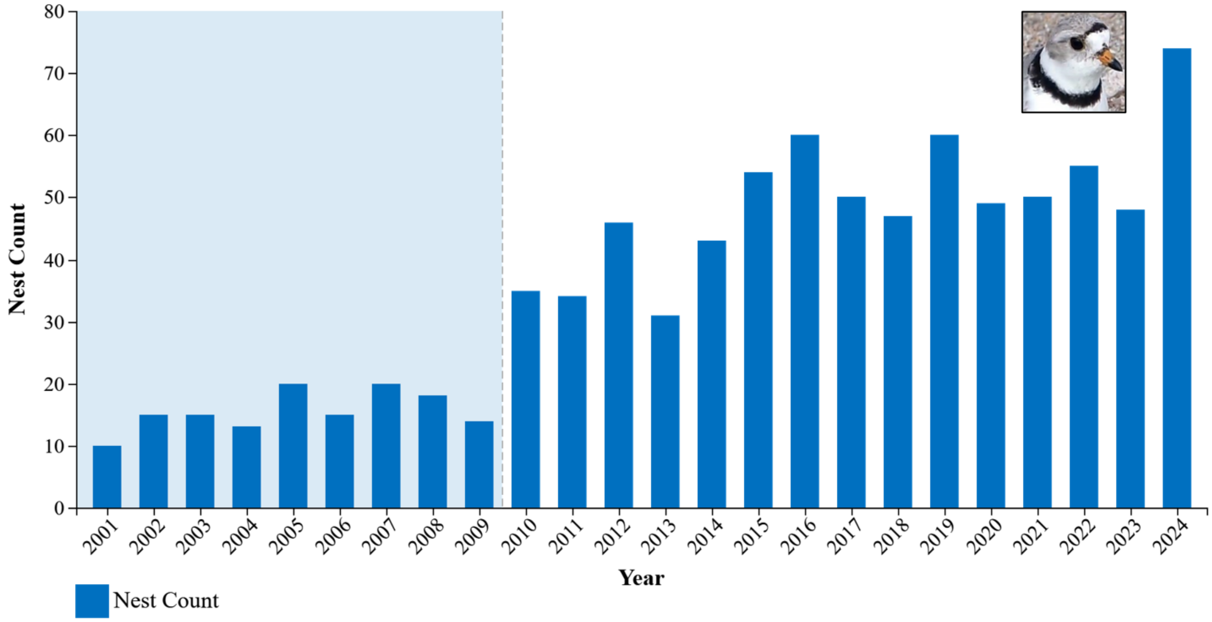


Figure 14. Total number of piping plover nests (nest count) observed during on- and off-channel surveys within the Program Associated Habitat Reach along the Platte River between Lexington and Chapman, Nebraska, 2001-2024. The dashed line represents changes in protocol between 2009 and 2010, including an increase in monitoring effort. The shaded area represents years in which nest totals are not comparable to recent totals.

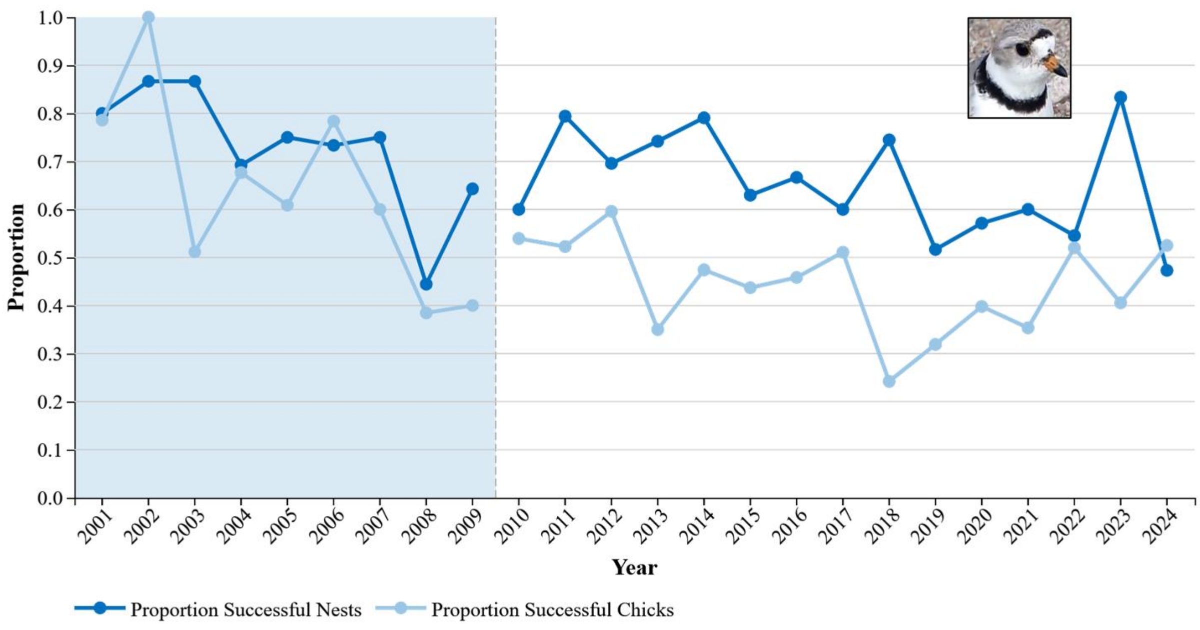


Figure 15. Proportion of successful nests (apparent nest success) and proportion of successful chicks (chicks fledged) for piping plover nests monitored during 2001-2024 within the Program Associated Habitat Reach along the Platte River between Lexington and Chapman, Nebraska. The dotted line represents changes in protocol between 2009 and 2010, including adjusting the fledge age from a 15-day success benchmark to 28 days for plovers. The shaded area represents years in which nest totals are not comparable to recent totals.

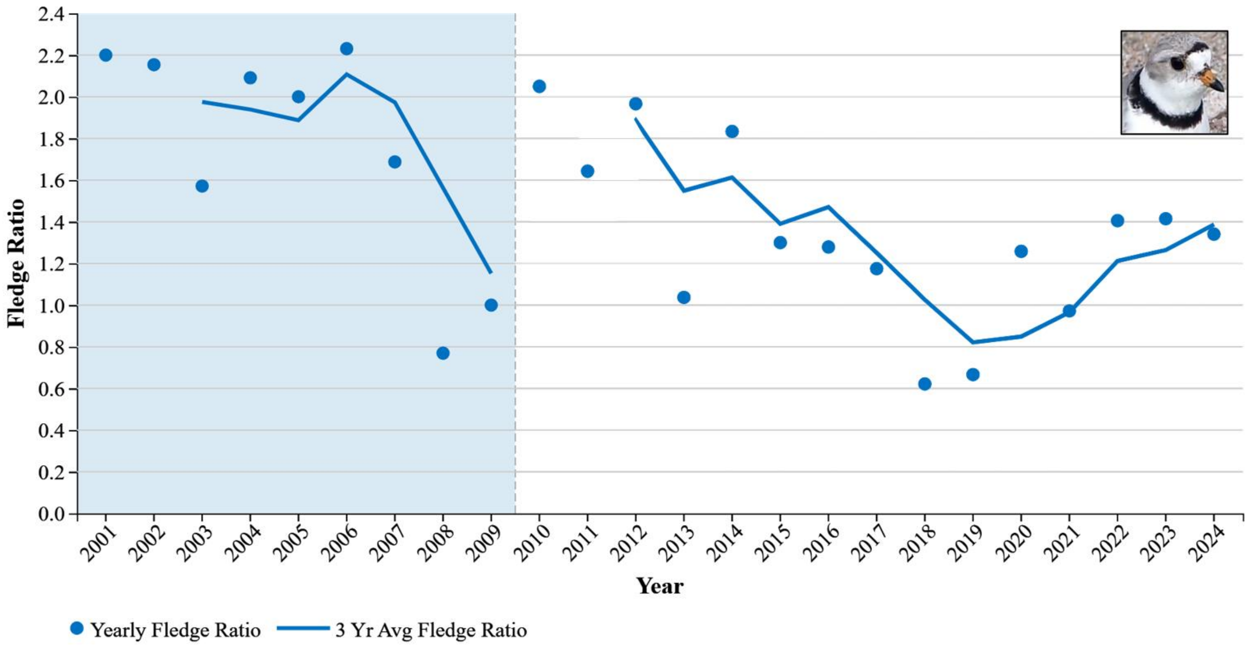


Figure 16. Piping plover fledge ratios (chicks fledged/estimated breeding pair [BPE]) on annual (point) and three-year running average (lines) bases during 2001-2009 and 2010-2024 within the Program Associated Habitat Reach along the Platte River between Lexington and Chapman, Nebraska. The dotted line represents changes in protocol between 2009 and 2010, including the fledge age being increased from 15-days to 28-days for piping plover chicks. The shaded area represents years in which fledge ratios are not comparable to recent fledge ratios.

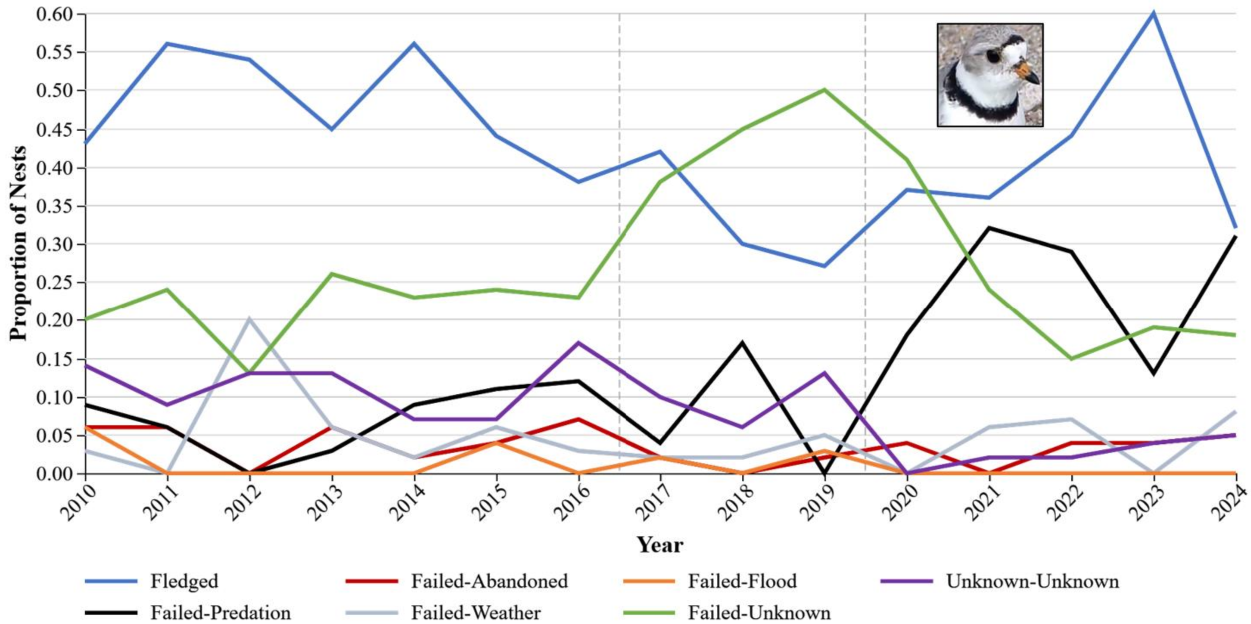


Figure 17. Proportion of piping plover nest successes with fledglings and nest failures (incurred during incubation or before fledgling) by year during 2010-2024 across the Program Associated Habitat Reach along the Platte River between Lexington and Chapman, Nebraska. Each nest success or failure represents a unique reproductive attempt. Assigned causes of nest failures include: abandonment, flooding, predation, weather, and failed due to unknown causes. The dotted line represents changes in monitoring protocol that occurred between 2016 and 2017, and 2019 and 2020. During 2010-2016, monitoring protocols included twice weekly inside and outside surveys at all sites with nesting and twice monthly river surveys. During 2017-2019, monitoring included twice weekly outside surveys at all sites with nesting, use of incidental evidence to fate nests, and twice monthly river surveys. During 2020-2024, monitoring included twice weekly outside surveys at all sites with nesting; camera monitoring at a sample of nests, nest sites, and shorelines to fate nests; use of incidental evidence to fate nests; additional predator management; and twice monthly river surveys.

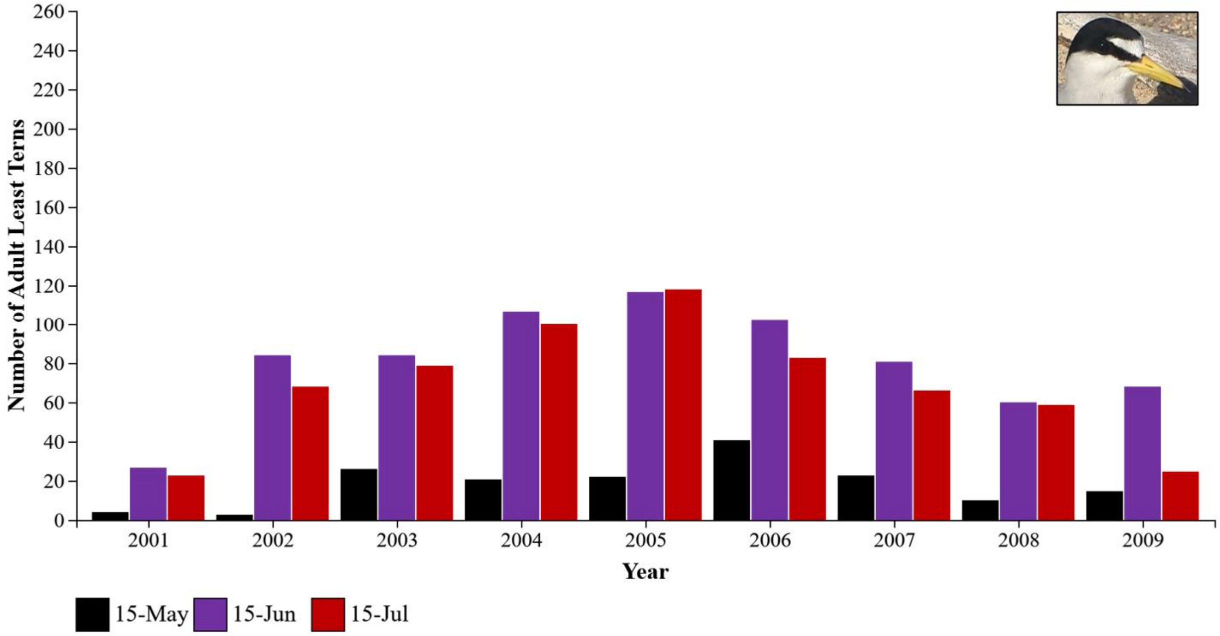


Figure 18. Number of adult least terns observed during three semi-monthly surveys of OCSW sites along the Platte River between Lexington and Chapman, Nebraska, 2001-2009. Numbers of adults include observations of both non-breeding and breeding least terns.

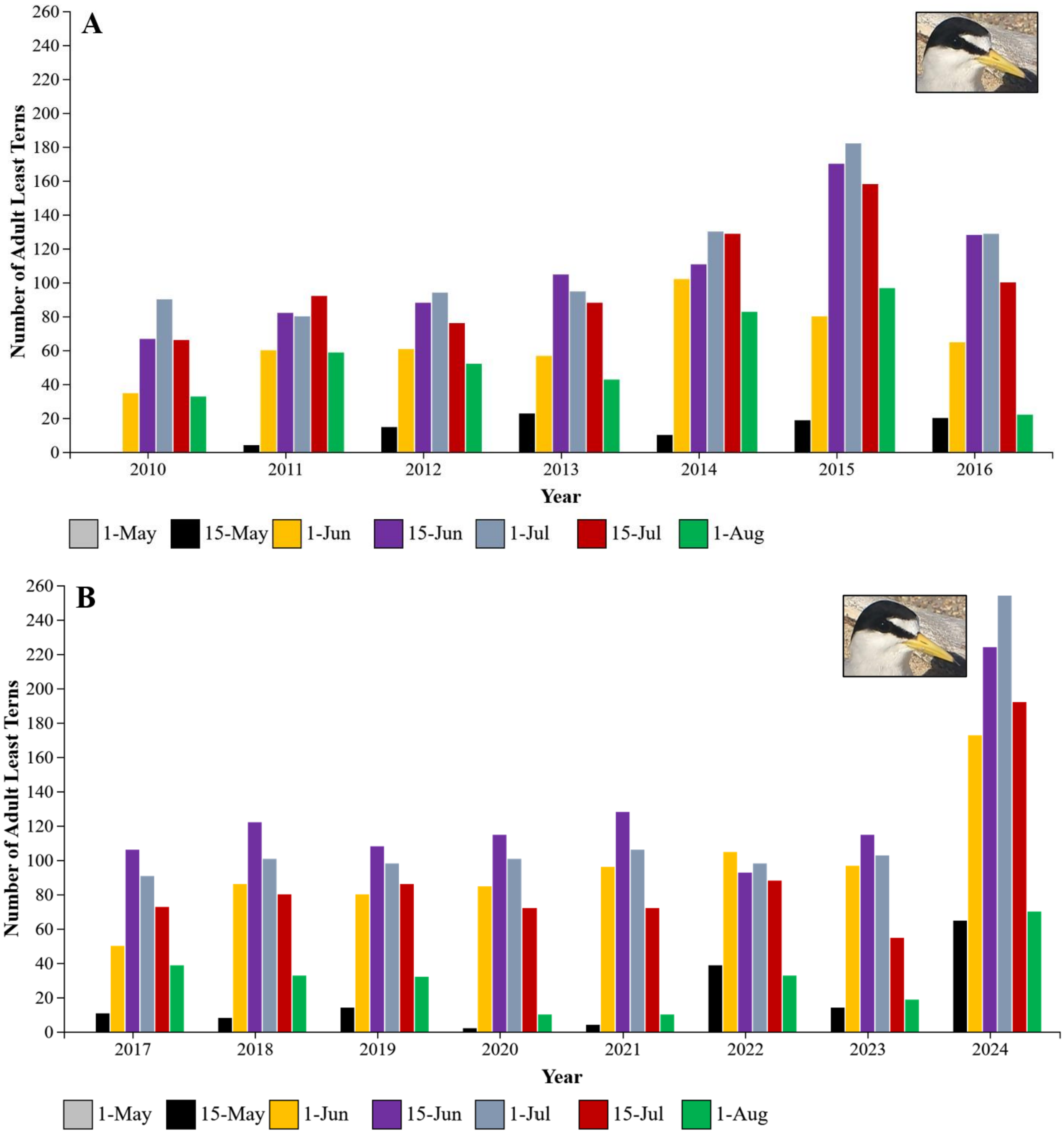


Figure 19. Number of adult least terns observed during seven semi-monthly surveys of OCSW sites along the Platte River between Lexington and Chapman, Nebraska, 2010-2024, for the periods of (A) 2010-2016, and (B) 2017-2024. Numbers of adults include observations of both non-breeding and breeding least terns.

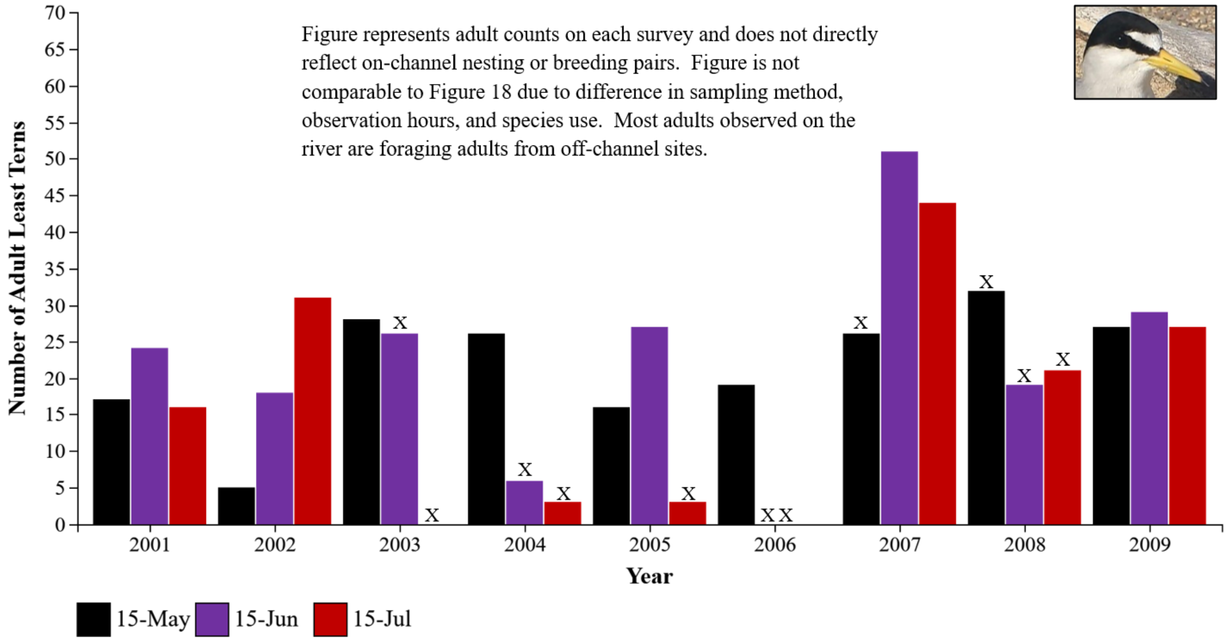


Figure 20. Number of adult least terns observed during three semi-monthly surveys of the Platte River between Lexington and Chapman, Nebraska, 2001-2009. Numbers of adults include observations of both non-breeding and breeding least terns. Sampling periods for which at least one section of the river was not completed due to lack of flow in the channel, or other restrictions, are denoted with an "X". These surveys include 15 May 2007, 2008; 15 June 2003, 2004, 2006, 2008; and 15 July 2003, 2004, 2005, 2006, 2008.

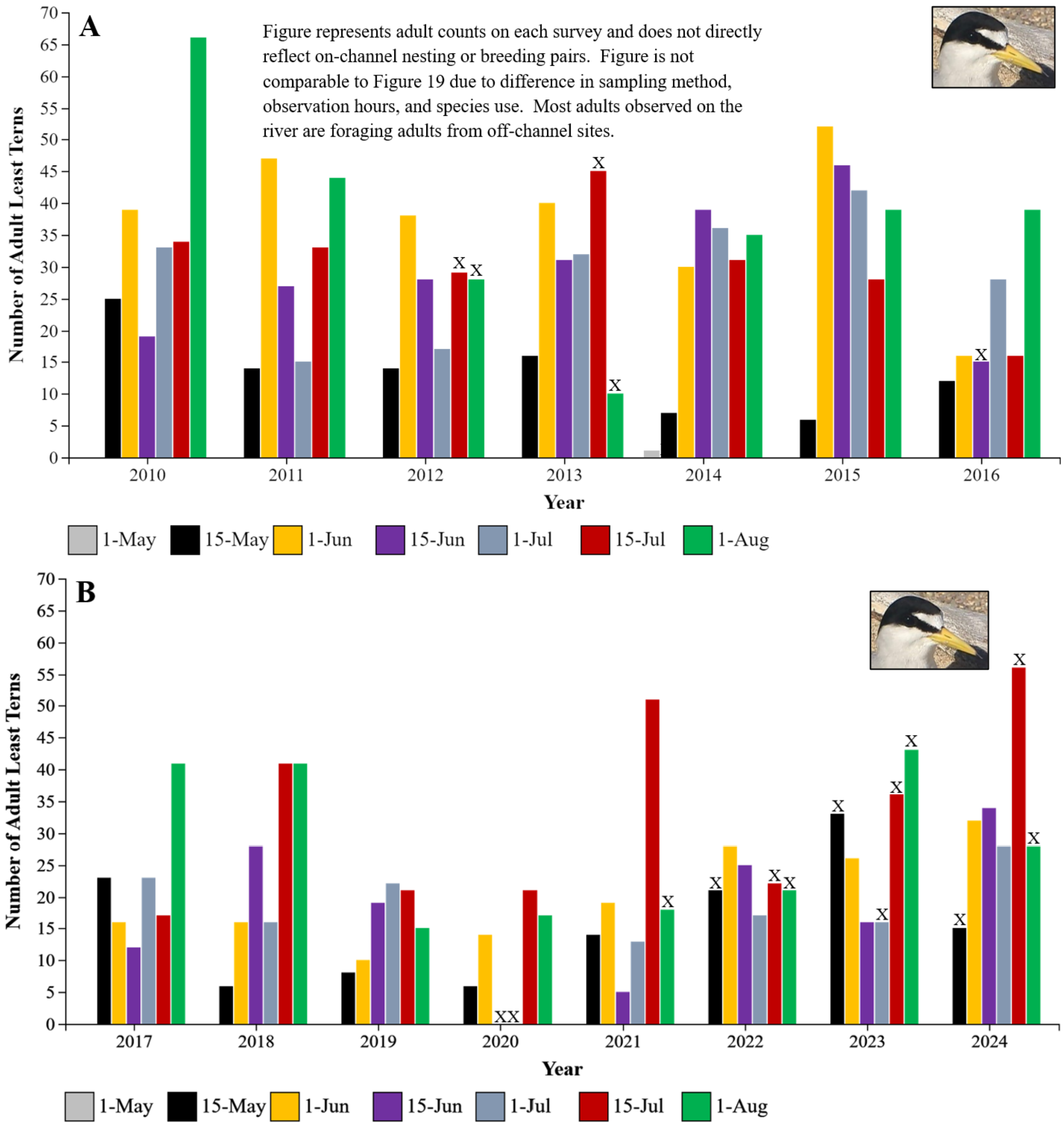


Figure 21. Number of adult least terns observed during seven semi-monthly surveys of the Platte River between Lexington and Chapman, Nebraska, 2010-2024, during the periods of (A) 2010-2016, and (B) 2017-2024. Sampling periods for which at least one section of the river was not completed due to lack of flow or high flow in the channel, or other restrictions, are denoted with an "X". These survey dates include: 15 May 2022, 2023, 2024; 15 June 2016, 2020; 1 July 2020, 2023; 15 July 2012, 2013, 2022, 2023, 2024; and 1 August 2012, 2013, 2021, 2022, 2023, 2024.

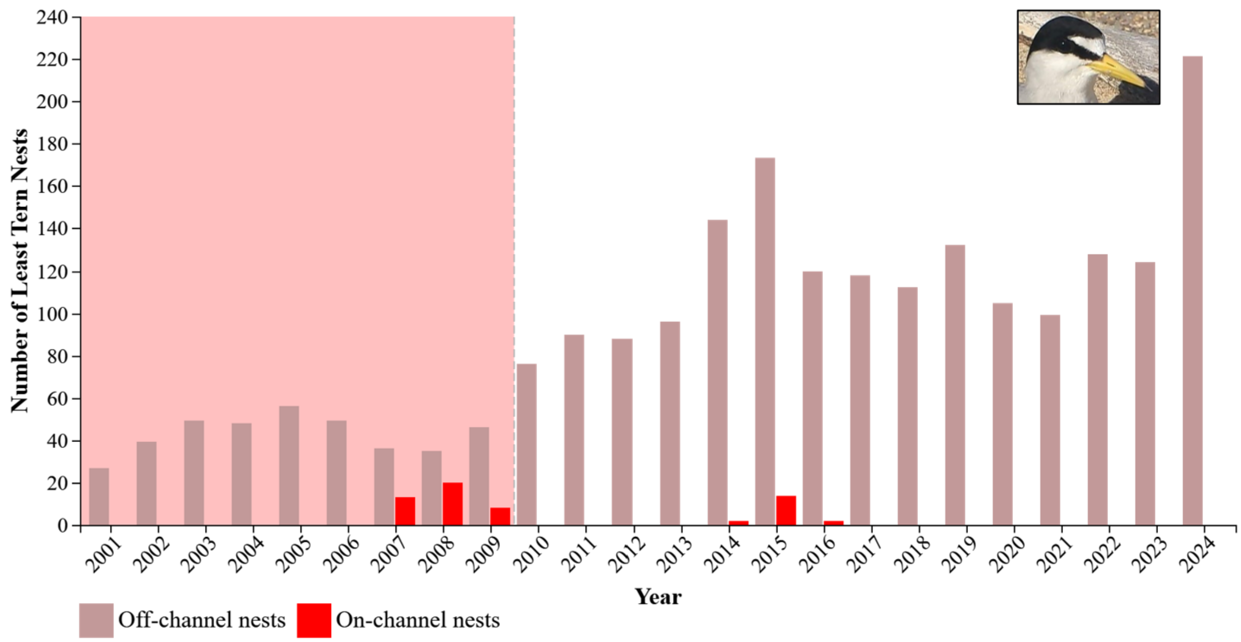


Figure 22. Comparison of numbers of least tern nests found during off-channel (light red bars) and on-channel (dark red bars) surveys within the Program Associated Habitat Reach along the Platte River between Lexington and Chapman, Nebraska, 2001-2024. The dashed line represents changes in protocol between 2009 and 2010, including an increase in monitoring effort. The shaded area represents years in which nest totals are not comparable to recent totals.

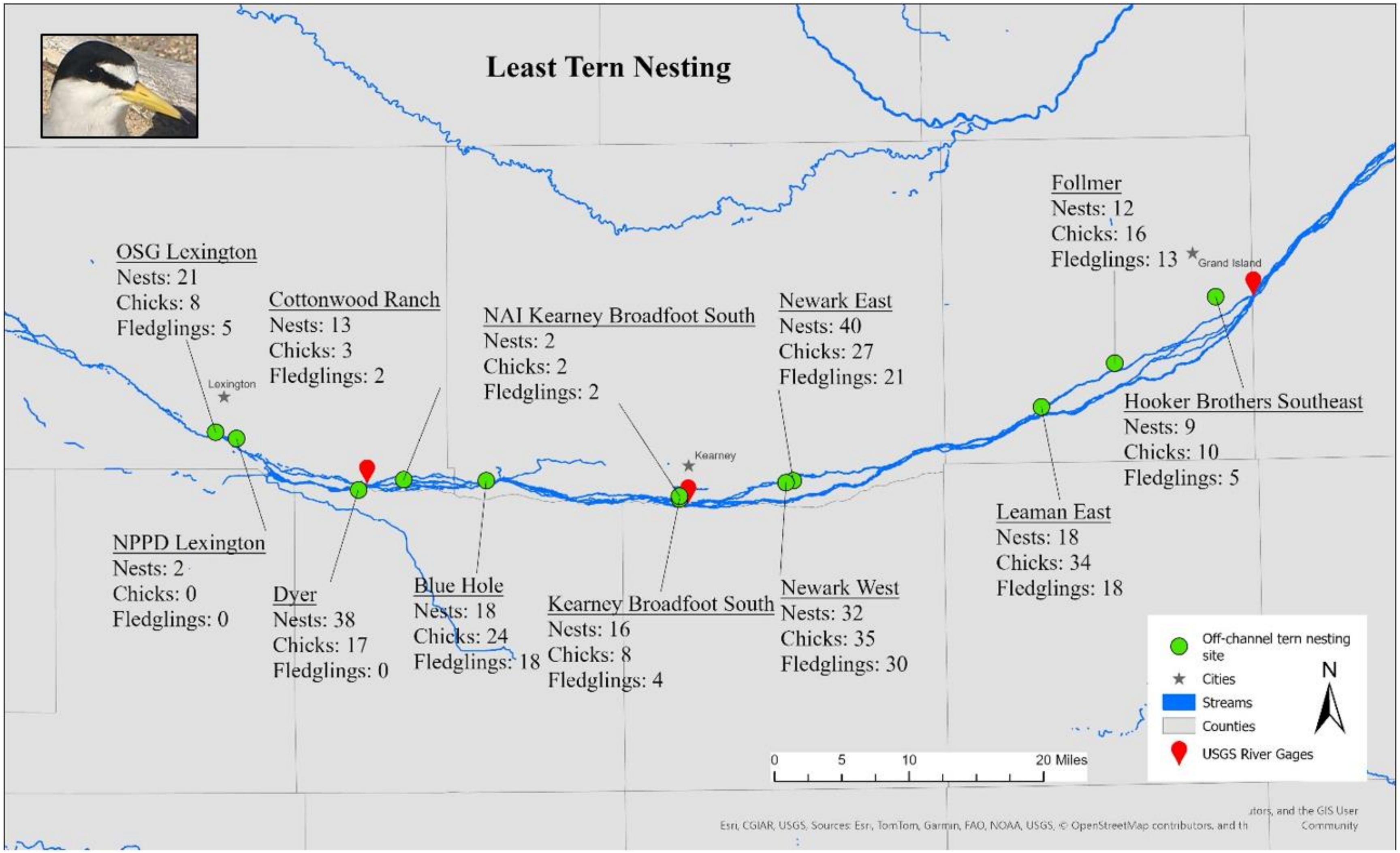


Figure 23. Distribution and numbers of least tern nests, chicks, and fledglings observed within Program associated habitats during 2024 surveys along the Platte River between Lexington and Chapman, Nebraska. Least tern nests and chicks were observed and monitored at 12 of 18 off-channel sites during 2024. The locations of the Overton (USGS gage 06768000, USGS 2024a), Kearney (USGS gage 06770200, USGS 2024b) and Grand Island (USGS gage 0670500, USGS 2024c) river gages are marked with a red pin.

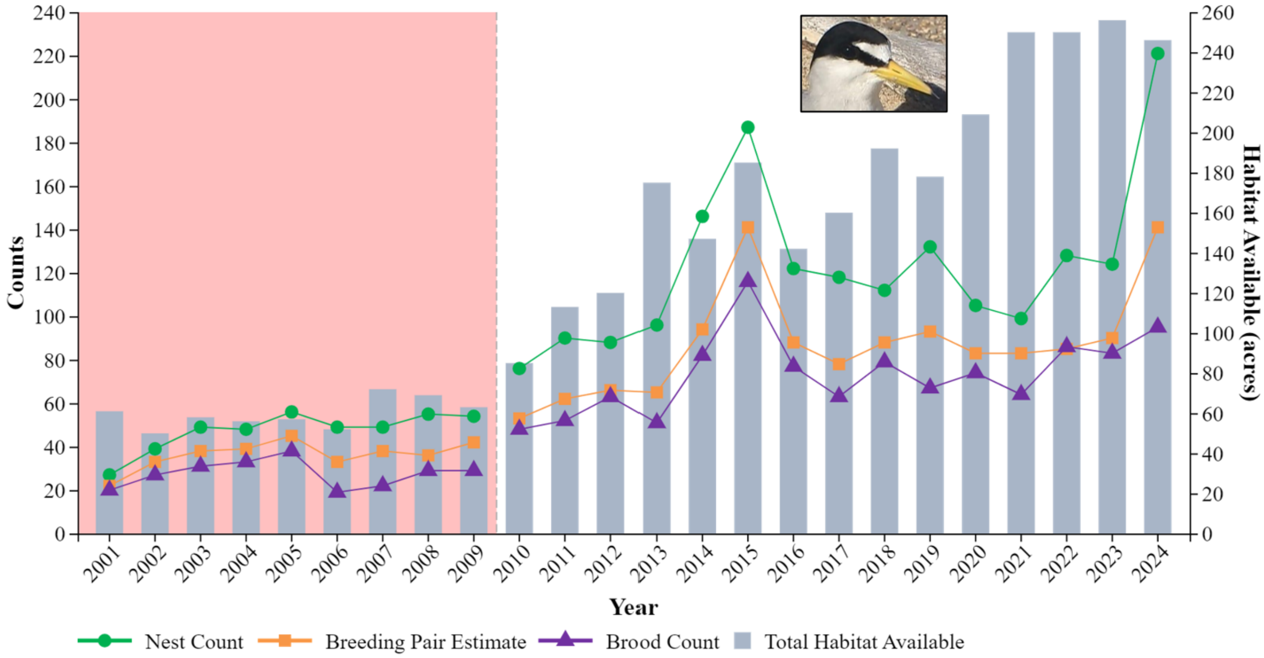


Figure 24. Annual variation in the total numbers of least tern nests (green line), breeding pair estimates (orange line), brood counts (purple line), and total on- and off-channel habitat available (acres; blue bars) observed within the Program Associated Habitat Reach along the Platte River between Lexington and Chapman, Nebraska, during 2001-2024. The dotted line represents changes in protocol that occurred between 2009 and 2010, including an increase in monitoring effort. Data from 2001-2009 (shaded area) may not be comparable to data from 2010-2024. Due to access restrictions that limited monitoring at some sites, available habitat from 2001-2009 only included sites that were used in the reproductive and survival calculations each year.

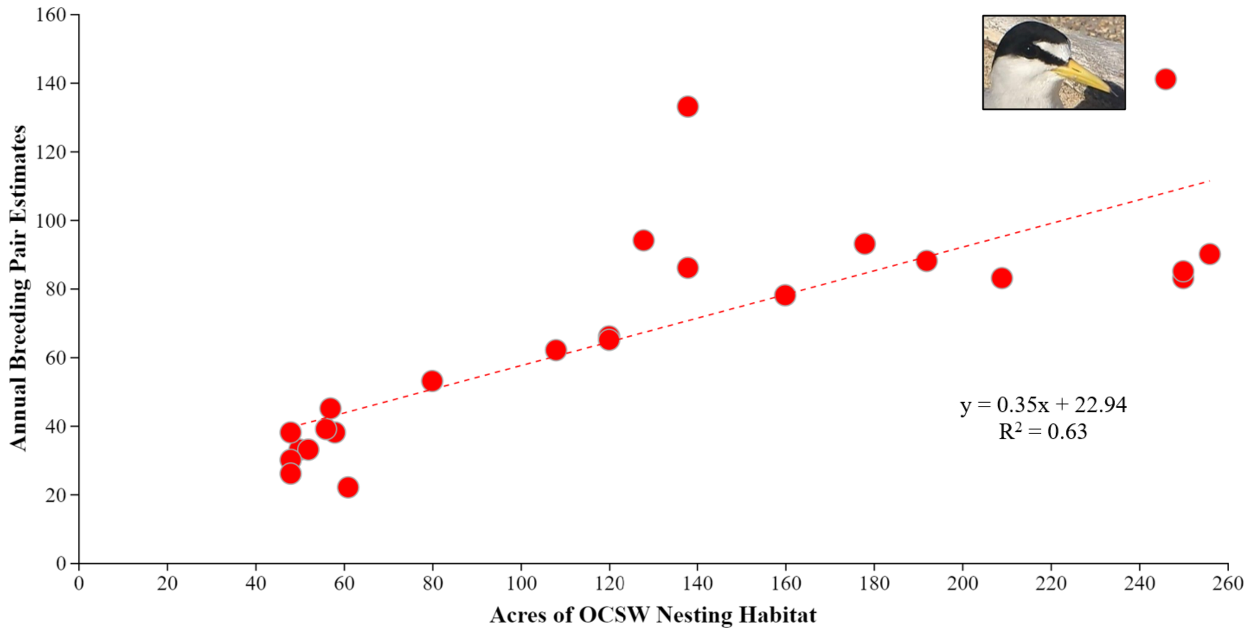


Figure 25. Relationship between the annual estimated number of OCSW least tern breeding pairs and availability (acres) of monitored off-channel habitat (OCSW sites) within the Program Associated Habitat Reach between Lexington and Chapman, Nebraska, during 2001-2024. For every acre of OCSW habitat increase, an increase of 0.35 least tern breeding pairs occurred (95% CI: 0.23-0.46 breeding pairs) at OCSW sites in the AHR and the results were statistically significant ($P < 0.001$). The linear line of best fit with corresponding equation and R^2 values are depicted. Due to access restrictions that limited monitoring at some sites, available habitat from 2001-2009 only included sites that were used in the reproductive and survival calculations each year.

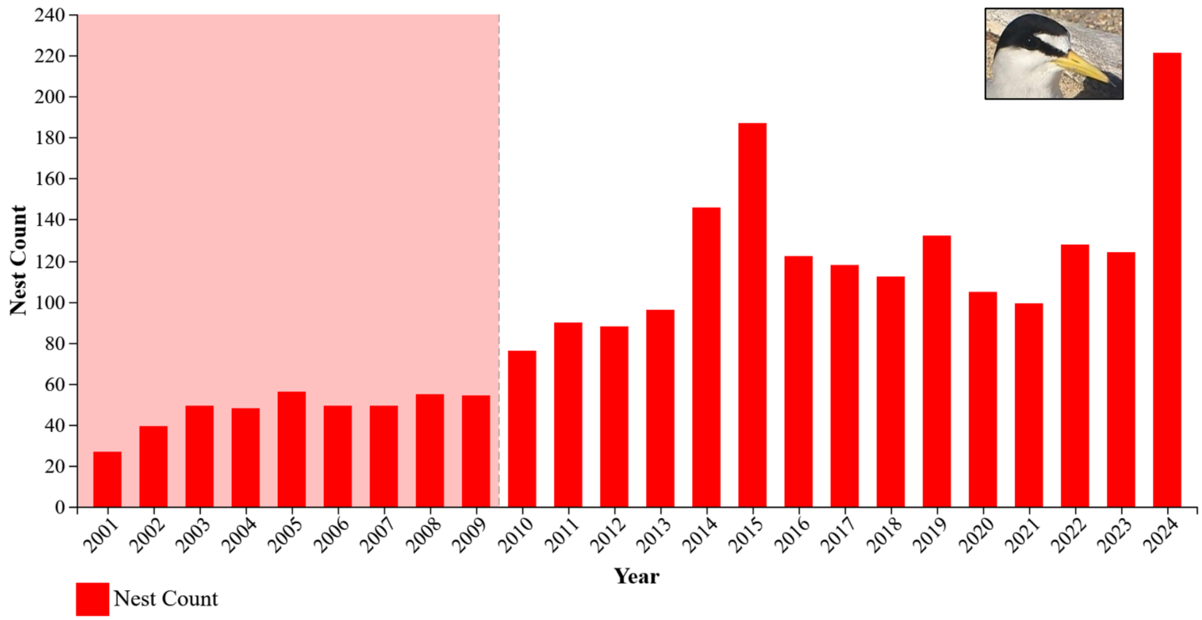


Figure 26. Total number of least tern nests (nest count) observed during on- and off-channel surveys within the Program Associated Habitat Reach along the Platte River between Lexington and Chapman, Nebraska, 2001-2024. The dashed line represents changes in protocol between 2009 and 2010, including an increase in monitoring effort. The shaded area represents years in which nest totals are not comparable to recent totals.

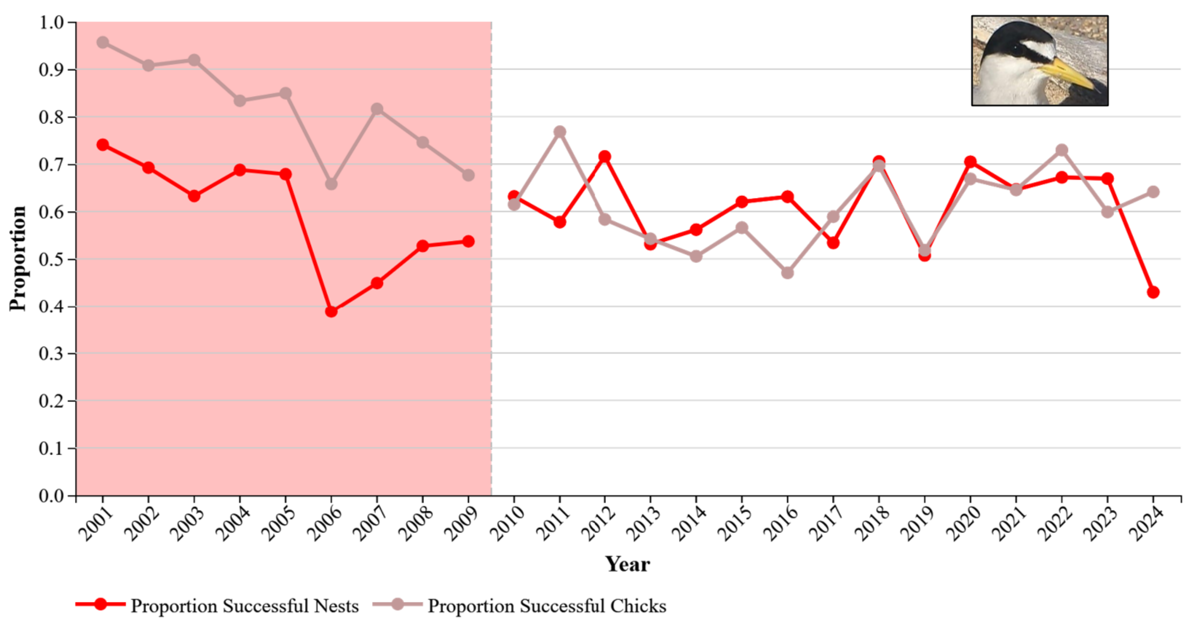


Figure 27. Proportion of successful nests (apparent nest success) and proportion of successful chicks (chicks fledged) for least tern nests monitored during 2001-2024 within the Program Associated Habitat Reach along the Platte River between Lexington and Chapman, Nebraska. The dotted line represents changes in protocol between 2009 and 2010, including adjusting the fledge age from a 15-day success benchmark to 21 days for least terns. The shaded area represents years in which nest totals are not comparable to recent totals.

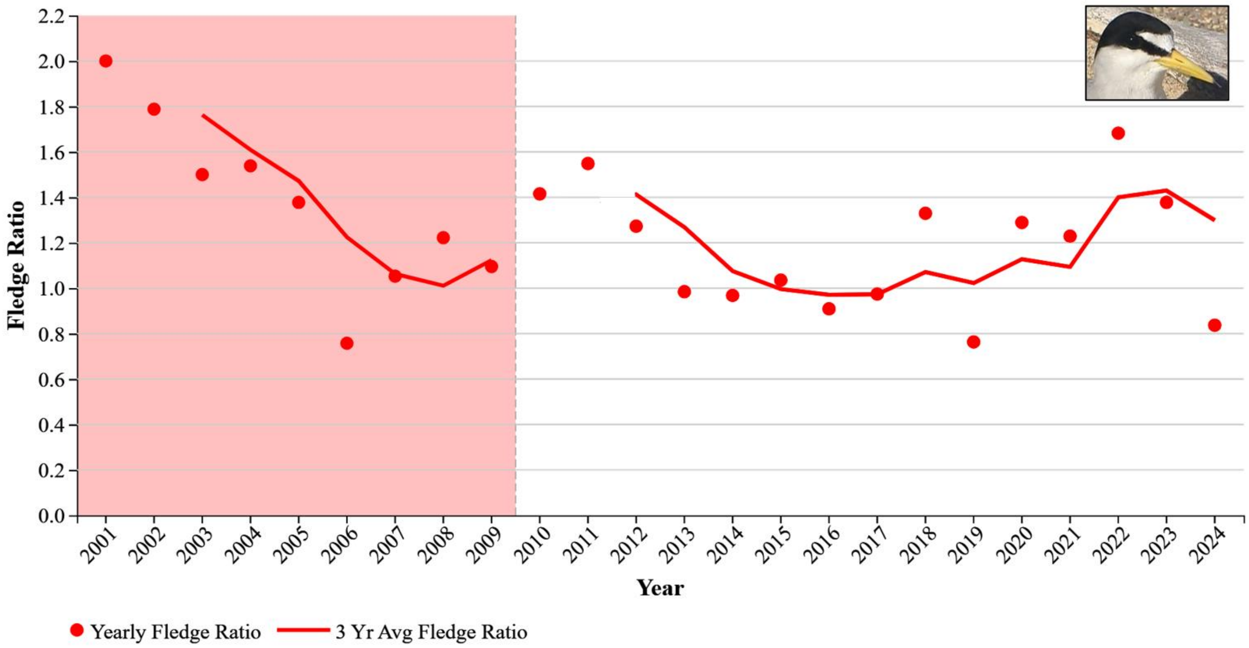


Figure 28. Least tern fledge ratios (chicks fledged/estimated breeding pair [BPE]) on annual (point) and three-year running average (lines) bases during 2001-2009 and 2010-2024 within the Program Associated Habitat Reach along the Platte River between Lexington and Chapman, Nebraska. The dotted line represents changes in protocols between 2009 and 2010, including the fledge age being increased from 15-days to 21-days for least tern chicks. The shaded area represents years in which fledge ratios are not comparable to recent fledge ratios.

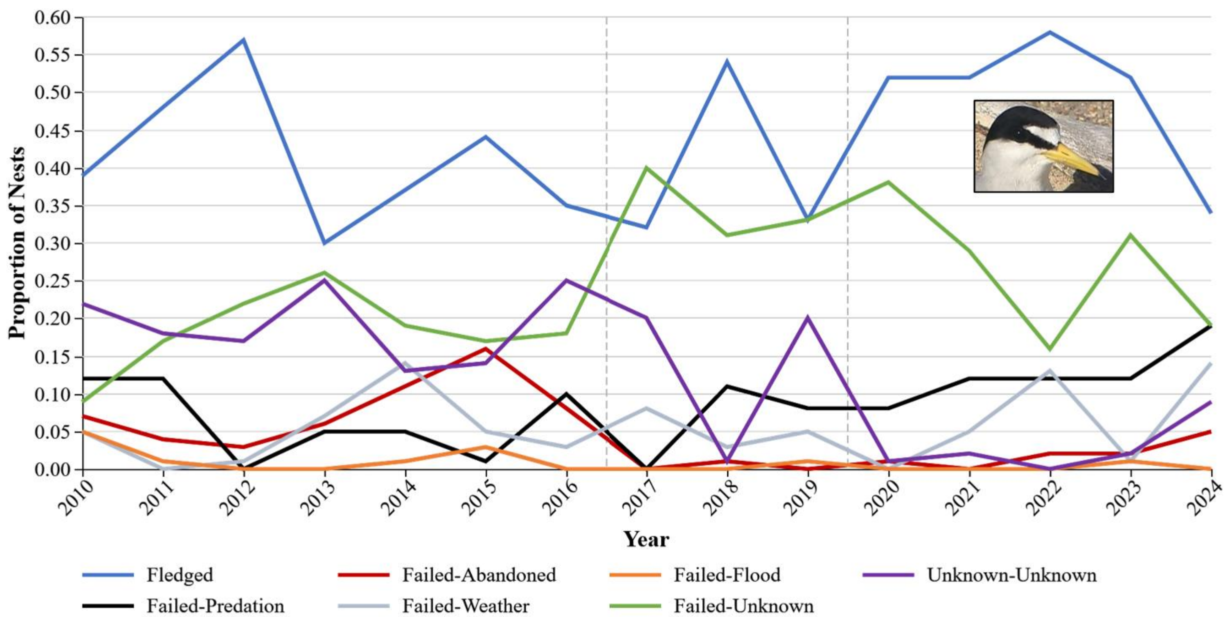


Figure 29. Proportion of least tern nest successes with fledglings and nest failures (incurred during incubation or before fledgling) by year during 2010-2024 across the Program Associated Habitat Reach along the Platte River between Lexington and Chapman, Nebraska. Each nest success or failure represents a unique reproductive attempt. Assigned causes of nest failures include: abandonment, flooding, predation, weather, and failed due to unknown causes. The dotted line represents changes in monitoring protocol that occurred between 2016 and 2017, and 2019 and 2020. During 2010-2016, monitoring protocols included twice weekly inside and outside surveys at all sites with nesting and twice monthly river surveys. During 2017-2019, monitoring included twice weekly outside surveys at all sites with nesting, use of incidental evidence to fate nests, and twice monthly river surveys. During 2020-2024, monitoring included twice weekly outside surveys at all sites with nesting; camera monitoring at a sample of nests, nest sites, and shorelines to fate nests; use of incidental evidence to fate nests; additional predator management; and twice monthly river surveys.

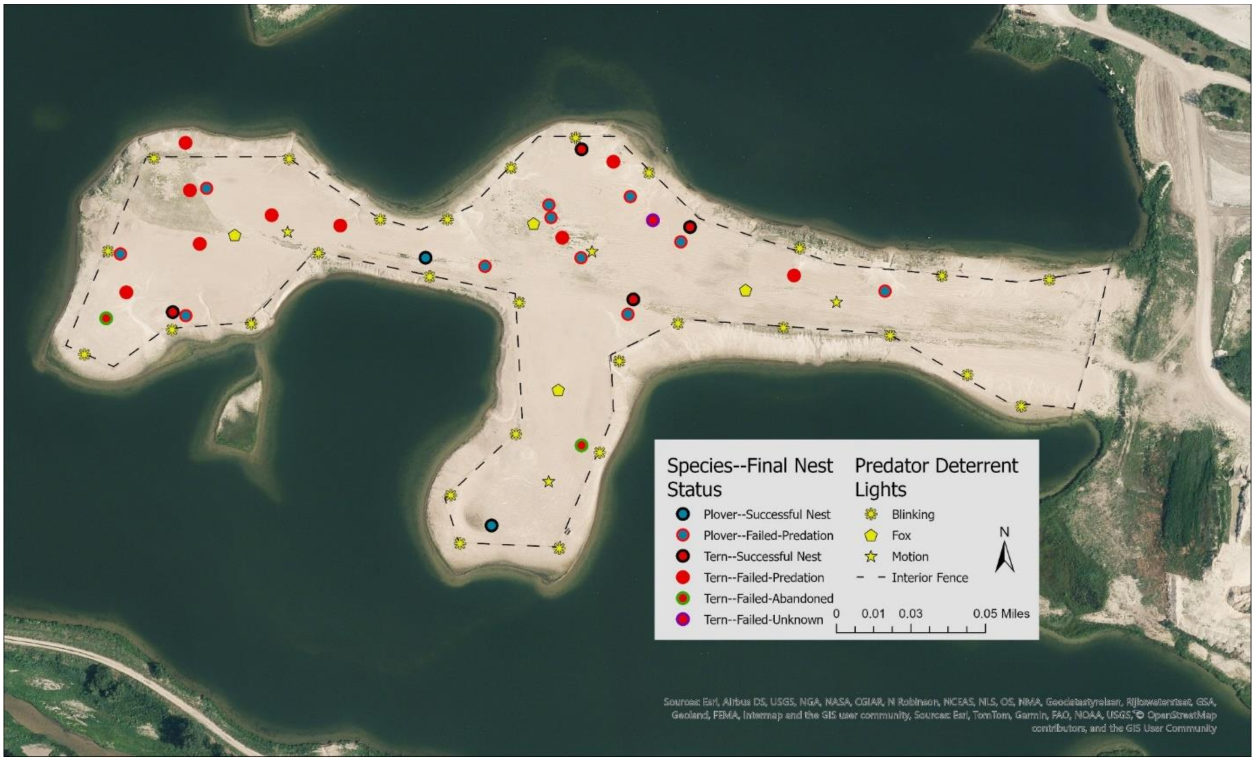


Figure 30. Piping plover (Plover, blue inner circle) and least tern (Tern, red inner circle) nest locations and corresponding final nest status at the Kearney Broadfoot South off-channel sand and water site during May through August 2024. Also depicted are predator management efforts including: blinking walking lights (yellow asterisks) mounted to the fenceline to give the illusion of movement; random pattern lights (yellow pentagons) and motion activated lights (yellow stars) deployed in sets and evenly distributed; and an interior predator exclusion fence (black dashed line) placed along the shoreline. The final nest status denotes whether the nest was successful and at least one chick hatched, or the nest failed during the incubation stage. Final nest status for successful nests is denoted by a blue circle with a black outer ring for plovers and a red circle with a black outer ring for terns. Nests that failed due to predation are denoted with a red outer ring; nests that failed due to abandonment are denoted with a green outer ring; nests that failed due to unknown causes are denoted with a purple outer ring.

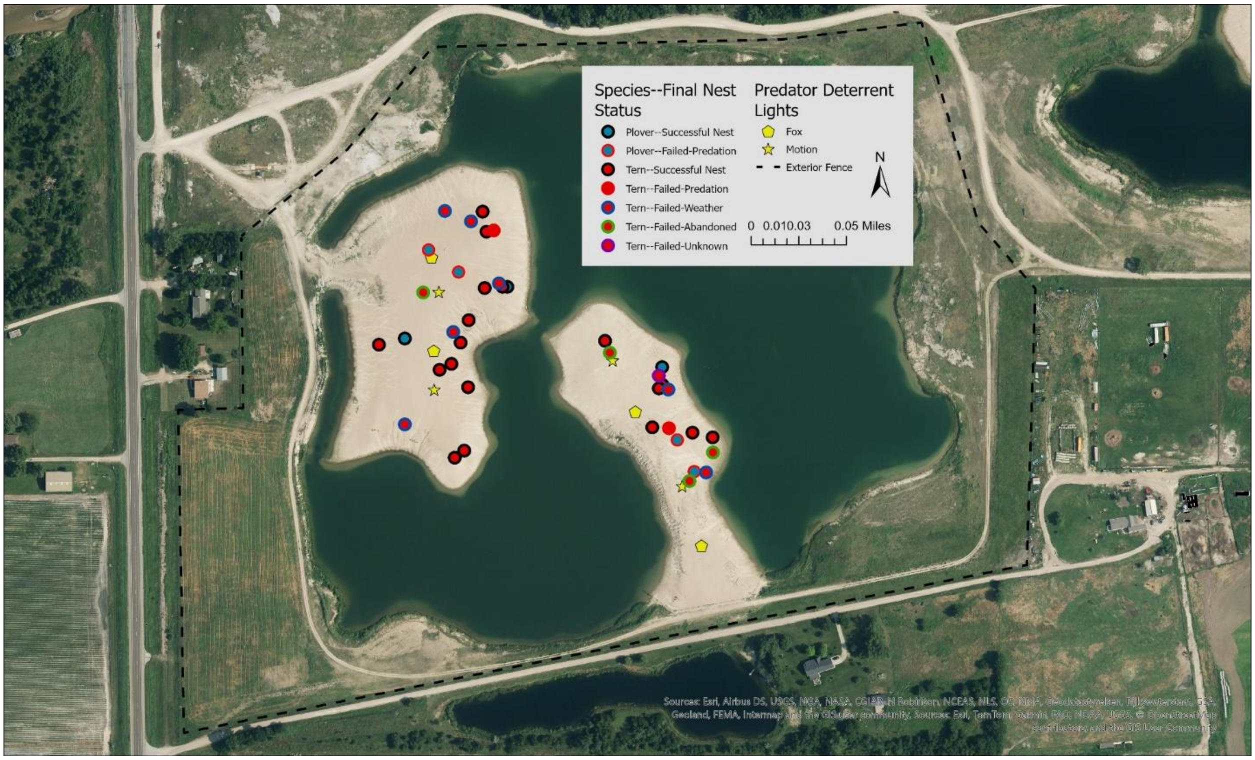


Figure 31. Piping plover (Plover, blue inner circle) and least tern (Tern, red inner circle) nest locations and corresponding final nest status at the Newark West off-channel sand and water site during May through August 2024. Also depicted are predator management efforts including: random pattern lights (yellow pentagons) and motion activated lights (yellow stars) deployed in sets and evenly distributed; and an exterior fence (black dashed line) placed around the site. The final nest status denotes whether the nest was successful and at least one chick hatched, or the nest failed during the incubation stage. Final nest status for successful nests is denoted by a blue circle with a black outer ring for plovers and a red circle with a black outer ring for terns. Nests that failed due to predation are denoted with a red outer ring; nests that failed due to weather are denoted with a blue outer ring; nests that failed due to abandonment are denoted with a green outer ring; nests that failed due to unknown causes are denoted with a purple outer ring.

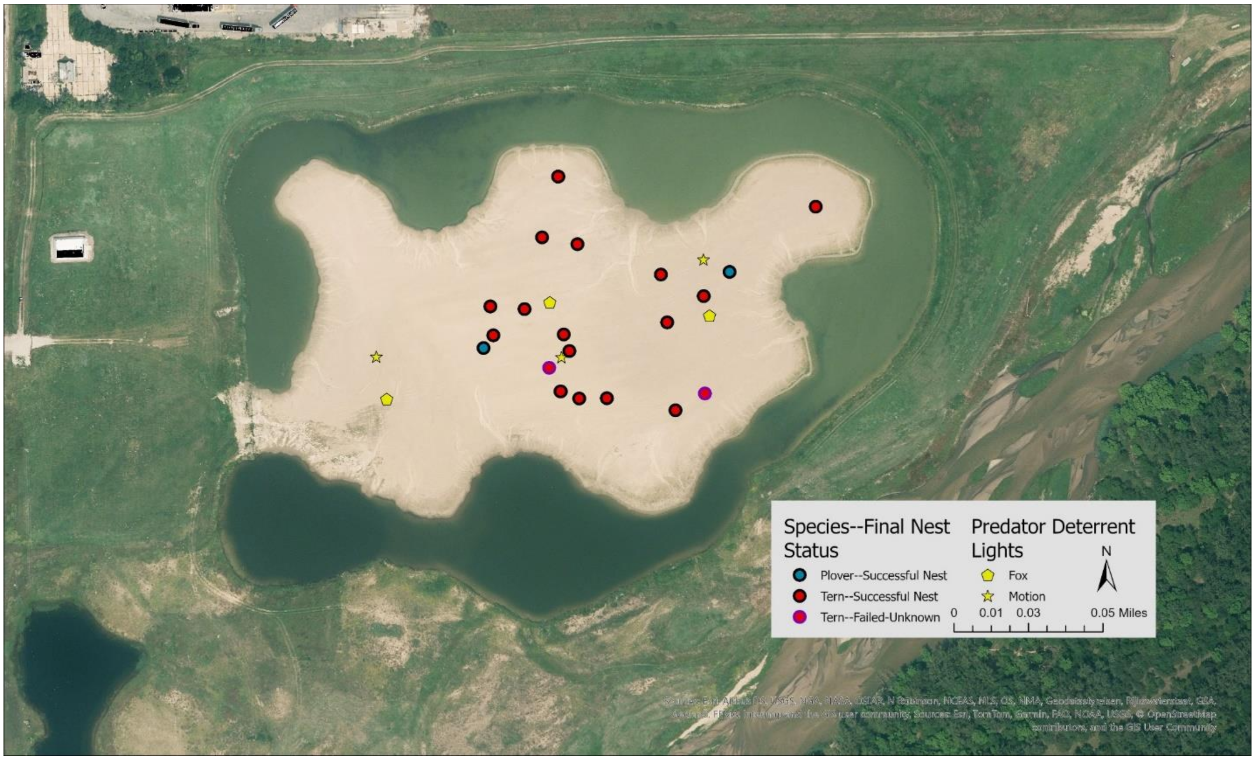


Figure 32. Piping plover (Plover, blue inner circle) and least tern (Tern, red inner circle) nest locations and corresponding final nest status at the Leaman off-channel sand and water site during May through August 2024. Also depicted are predator management efforts including: random pattern lights (yellow pentagons) and motion activated lights (yellow stars) deployed in sets and evenly distributed. The final nest status denotes whether the nest was successful and at least one chick hatched, or the nest failed during the incubation stage. Final nest status for successful nests is denoted by a blue circle with a black outer ring for plovers and a red circle with a black outer ring for terns. Nests that failed due to unknown causes are denoted with a purple outer ring.

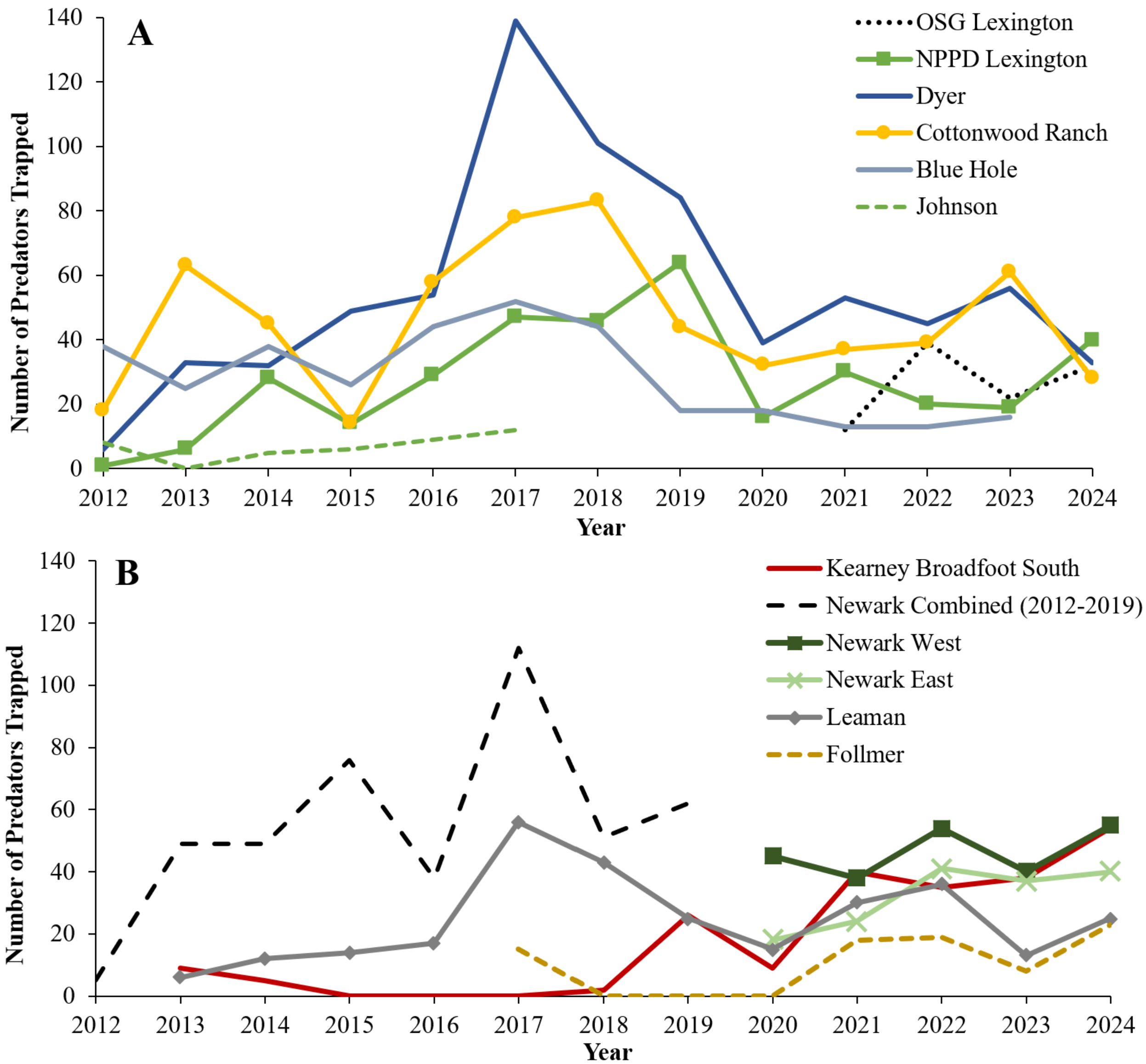


Figure 33. Annual variability in the total number of terrestrial predators trapped at Program-managed OCSW piping plover and least tern nesting sites and Nebraska Public Power District nesting sites during 2012-2024 between (A) Lexington and Kearney, and (B) Kearney and Alda, Nebraska. Predator trapping occurred during March through August of most years and trapping efforts increased substantially in 2017 at off-channel sites. Trapping did not occur at Kearney Broadfoot South during 2012. Captures only occurred at Follmer in 2017 and during 2021-2024 despite annual trapping efforts during 2017-2024. Predators trapped at Newark West and Newark East were previously reported as a total for both sites and are labeled here as Newarks Combined (2012-2019) until 2020 when Newark East was reported separately from Newark West.

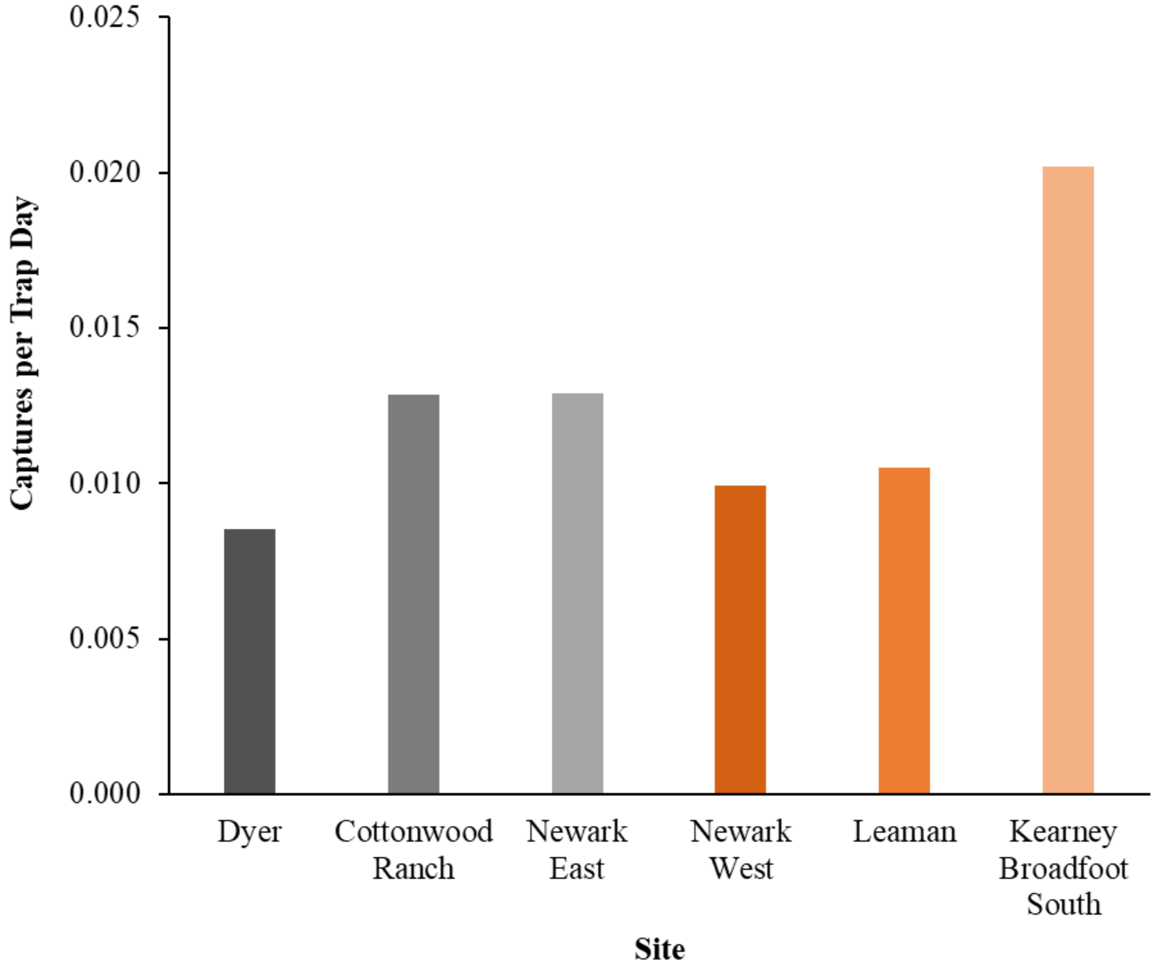


Figure 34. Captures of potential terrestrial predator species per trap day at six OCSW piping plover and least tern nesting sites adjacent to the central Platte River, Nebraska, during March through early September 2024. Captures per trap day was calculated by dividing the total number of potential terrestrial predator species captured in traps by the total number of trap days at each site. The total number of trap days at each site was calculated based on the number of traps deployed at each site and the number of days each trap was active for trapping. Sites had basic predator management (gray bars) or additional predator management (orange bars). Sites with basic predator management were Dyer, Cottonwood Ranch, and Newark East. Sites with additional predator management were Newark West, Leaman, and Kearney Broadfoot South.

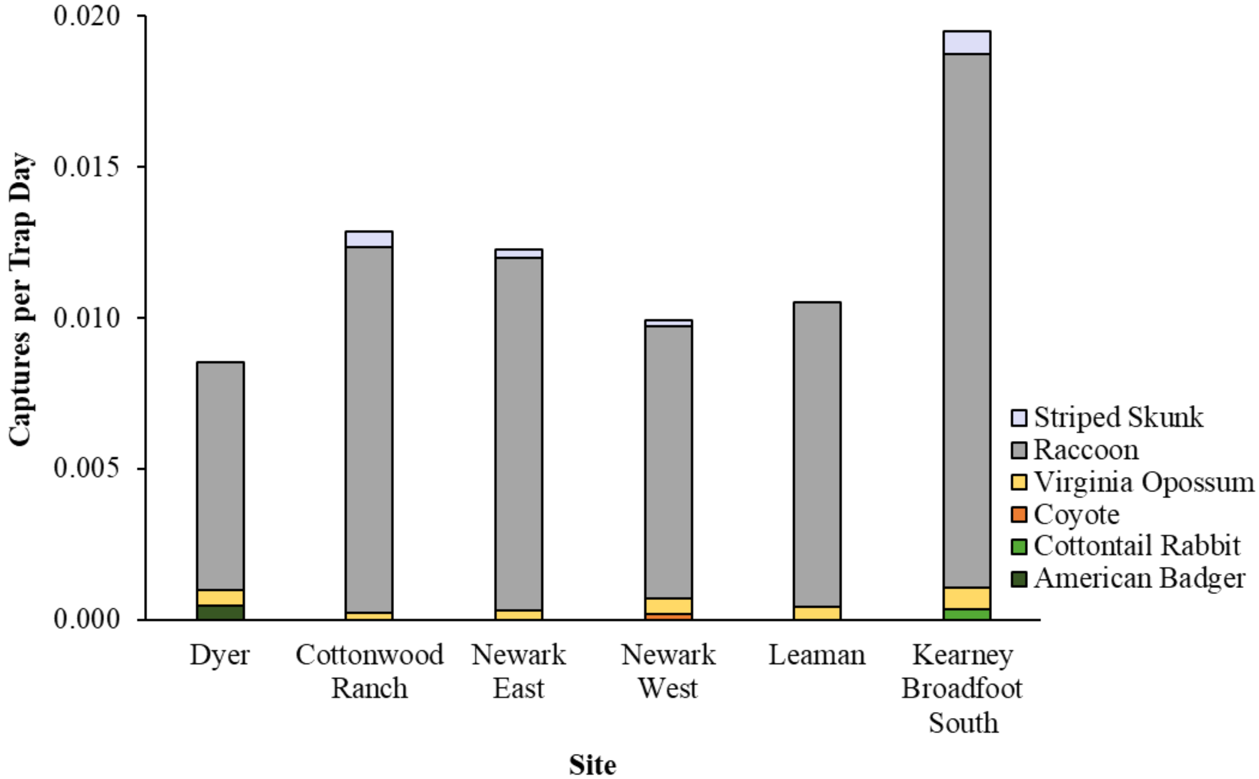


Figure 35. Captures of potential mammalian predator species per trap day by species at six OCSW piping plover and least tern nesting sites adjacent to the central Platte River, Nebraska, during March through early September 2024. Captures per trap day for each species was calculated by dividing the total number of each species captured in traps at each site by the total number of trap days at each site. The total number of trap days at each site was calculated based on the number of traps deployed at each site and the number of days each trap was active for trapping. Sites had basic predator management (Dyer; Cottonwood Ranch; Newark East) or additional predator management (Newark West, Leaman, Kearney Broadfoot South).

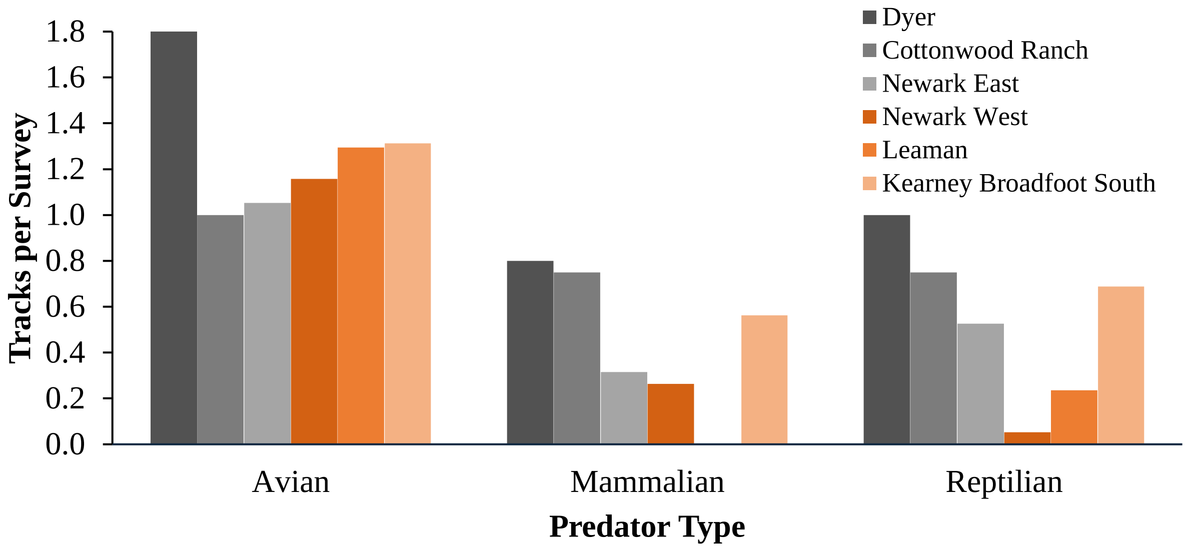


Figure 36. Potential avian, mammalian, and reptilian predators registered per track survey at six off-channel sand and water piping plover and least tern nesting sites adjacent to the central Platte River, Nebraska. Sites had basic predator management (gray bars) or additional predator management (orange bars). Tracks of potential predator species were identified using weekly track surveys at each site. Number of tracks per survey was calculated using the number of unique potential predator tracks at a site divided by the number of total weekly track surveys for that site. Sites with basic predator management were Dyer, Cottonwood Ranch, and Newark East. Sites with additional predator management were Newark West, Leaman, and Kearney Broadfoot South.

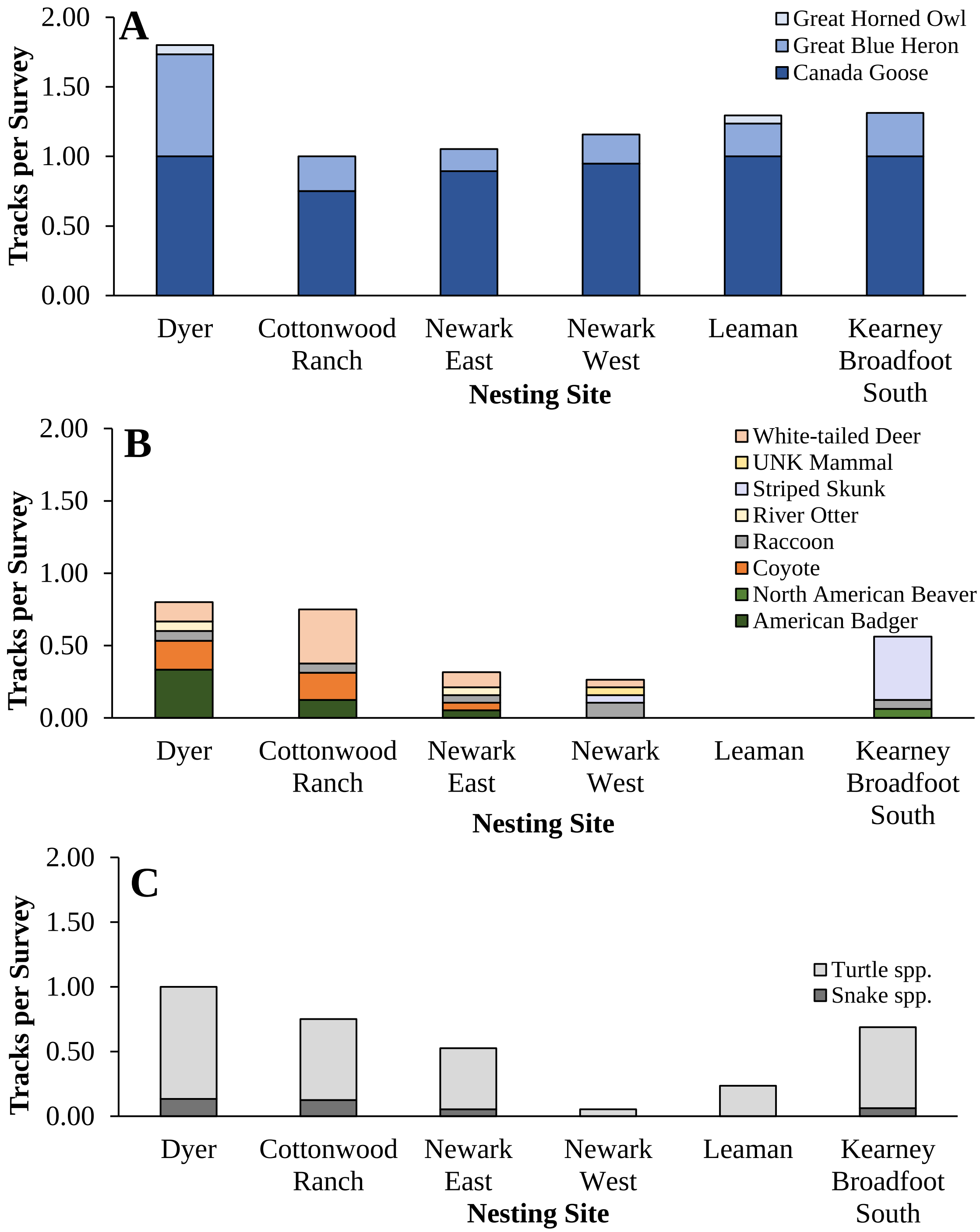


Figure 37. Potential (A) avian, (B) mammalian, and (C) reptilian predator species registered per track survey at six off-channel sand and water piping plover and least tern nesting sites adjacent to the central Platte River, Nebraska. Tracks of potential predator species were identified using weekly track surveys at each site. Number of tracks per species per survey was calculated using the number of unique potential predator tracks by species at a site divided by the number of total weekly track surveys for that site. Sites with basic predator management were Dyer, Cottonwood Ranch, and Newark East. Sites with additional predator management were Newark West, Leaman, and Kearney Broadfoot South. UNK = unknown; spp. = not identified to species.

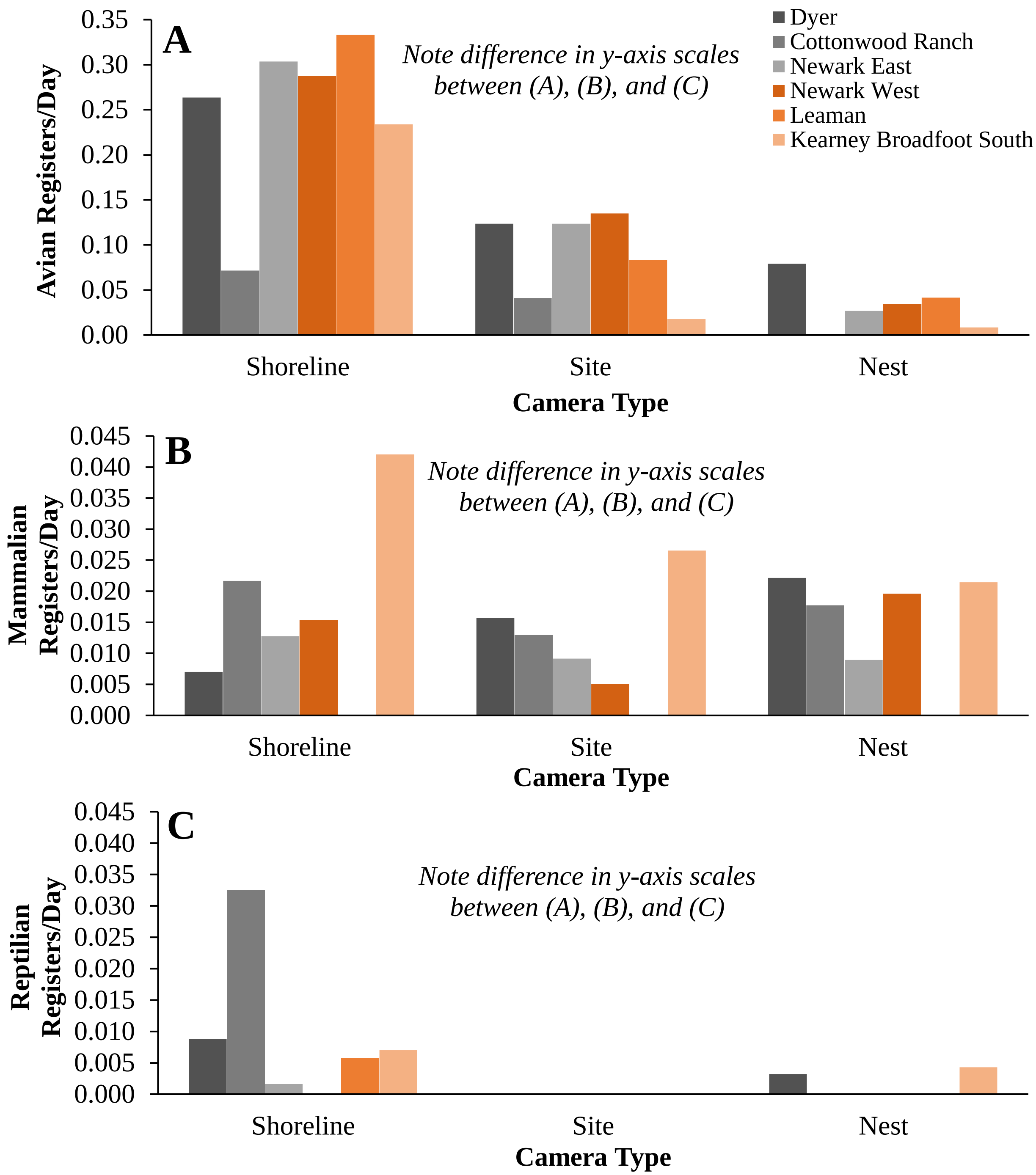


Figure 38. Registers of potential (A) avian, (B) mammalian, (C) reptilian predators captured by shoreline, site, and nest monitoring cameras per day at six off-channel sand and water piping plover and least tern nesting sites adjacent to the central Platte River, Nebraska. Sites had basic (gray bars) or additional predator management (orange bars). ***Note the differences in scale of the y-axis among (A), (B), and (C).*** The number of unique potential predator registers observed at a site via the indicated monitoring method was divided by the total number of camera days dedicated to the indicated monitoring effort at that site. Nest-level registers include predation events. Number of predation events/camera day is in Table 31.

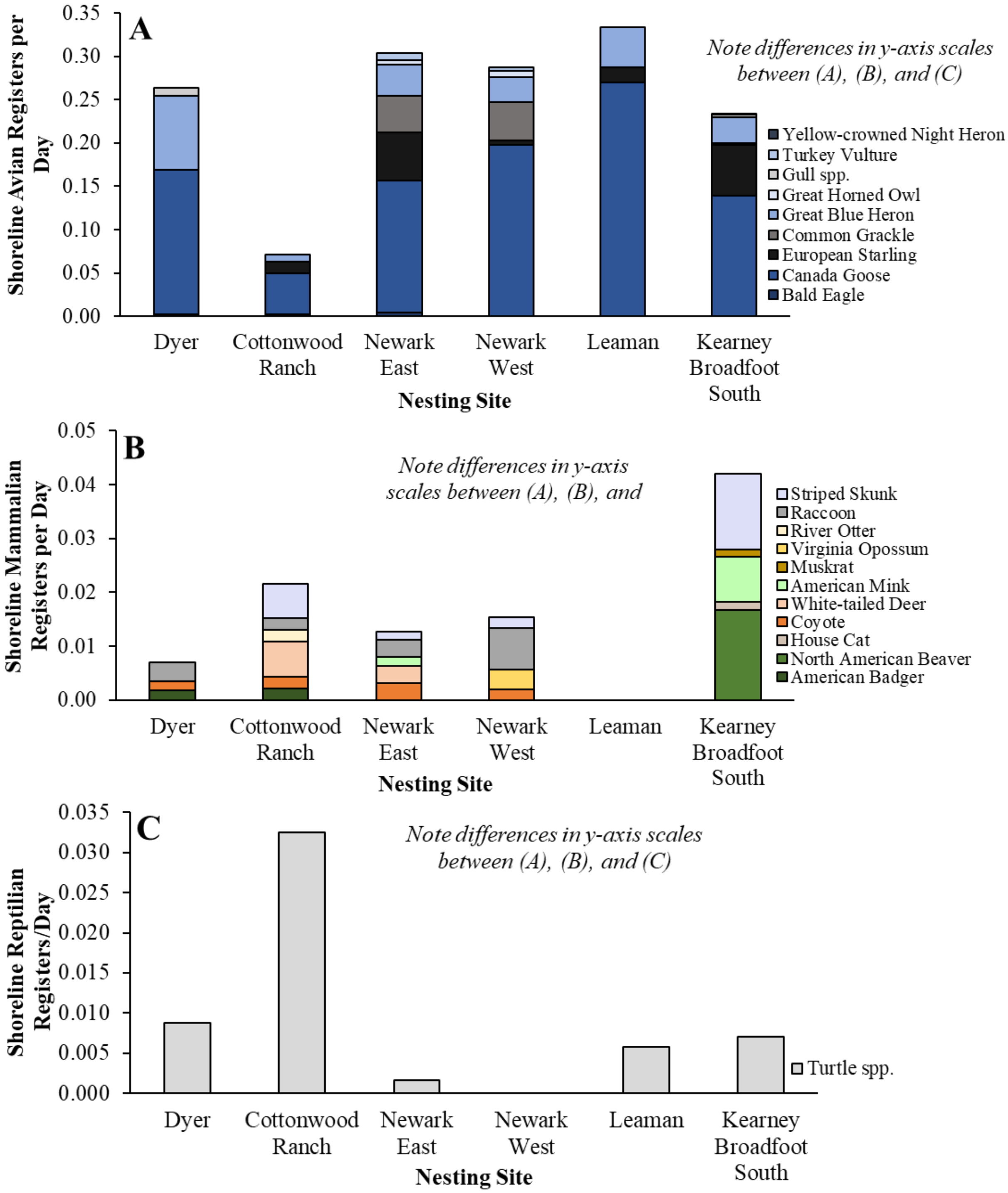


Figure 39. Potential (A) avian, (B) mammalian, (C) reptilian predator species registered by shoreline cameras at six off-channel sand and water piping plover and least tern nesting sites adjacent to the central Platte River, Nebraska. ***Note the differences in scale of the y-axis among (A), (B), and (C).*** The number of unique potential predator registers observed at a site using shoreline cameras was divided by the total number of camera days dedicated to the shoreline camera monitoring effort at that site. Sites with basic predator management were Dyer, Cottonwood Ranch, and Newark East. Sites with additional predator management were Newark West, Leaman, and Kearney Broadfoot South. spp. = not identified to species.

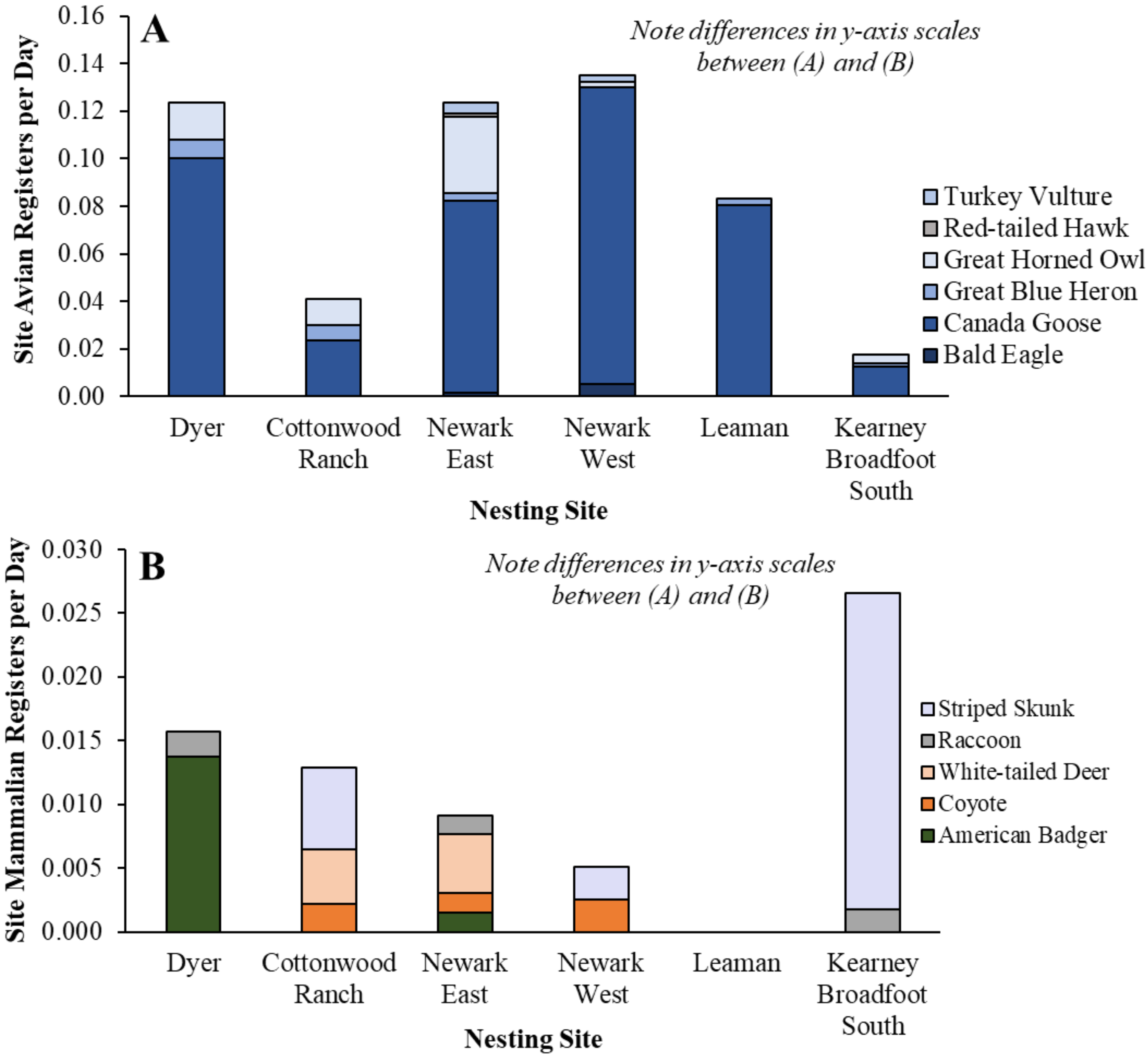


Figure 40. Potential (A) avian and (B) mammalian predator species registered by site-level cameras at six off-channel sand and water piping plover and least tern nesting sites adjacent to the central Platte River, Nebraska. ***Note the differences in scale of the y-axis between (A) and (B).*** No reptilian predator species were recorded on site-level cameras at the six sites. The number of unique potential predator registers observed at a site using site-level cameras was divided by the total number of camera days dedicated to the site-level camera monitoring effort at that site. Sites with basic predator management were Dyer, Cottonwood Ranch, and Newark East. Sites with additional predator management were Newark West, Leaman, and Kearney Broadfoot South.

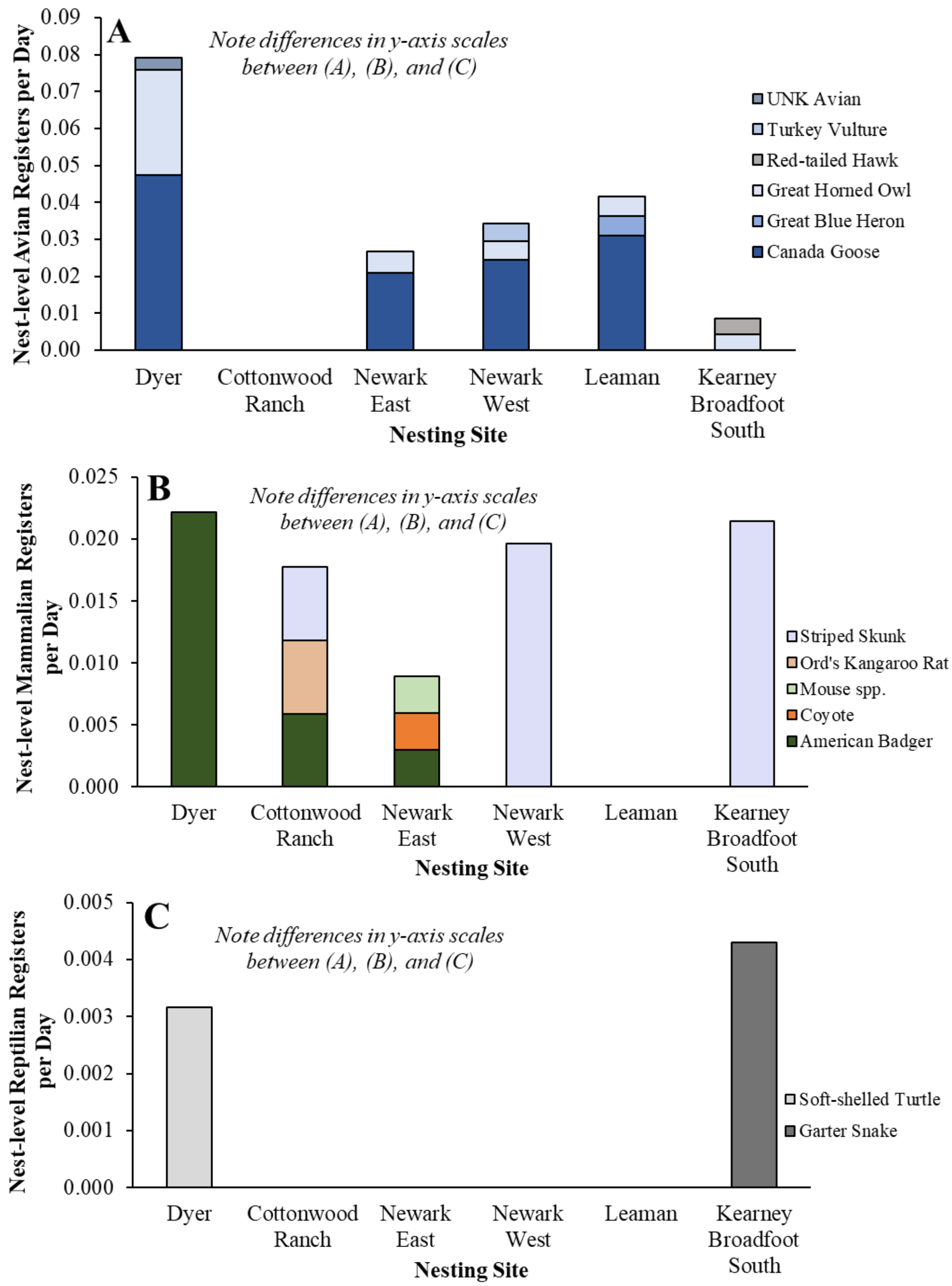


Figure 41. Potential (A) avian, (B) mammalian, and (C) reptilian predator species registered by nest-level cameras at six off-channel sand and water piping plover and least tern nesting sites adjacent to the central Platte River, Nebraska. ***Note the differences in scale of the y-axis between (A), (B), and (C).*** The number of unique potential predator registers observed at a site using nest-level cameras was divided by the total number of camera days dedicated to the nest-level camera monitoring effort at that site. Nest-level registers include predation events. Number of predation events per camera day is provided in Table 31. Sites with basic predator management were Dyer, Cottonwood Ranch, and Newark East. Sites with additional predator management were Newark West, Leaman, and Kearney Broadfoot South. UNK = unknown; spp. = not identified to species.

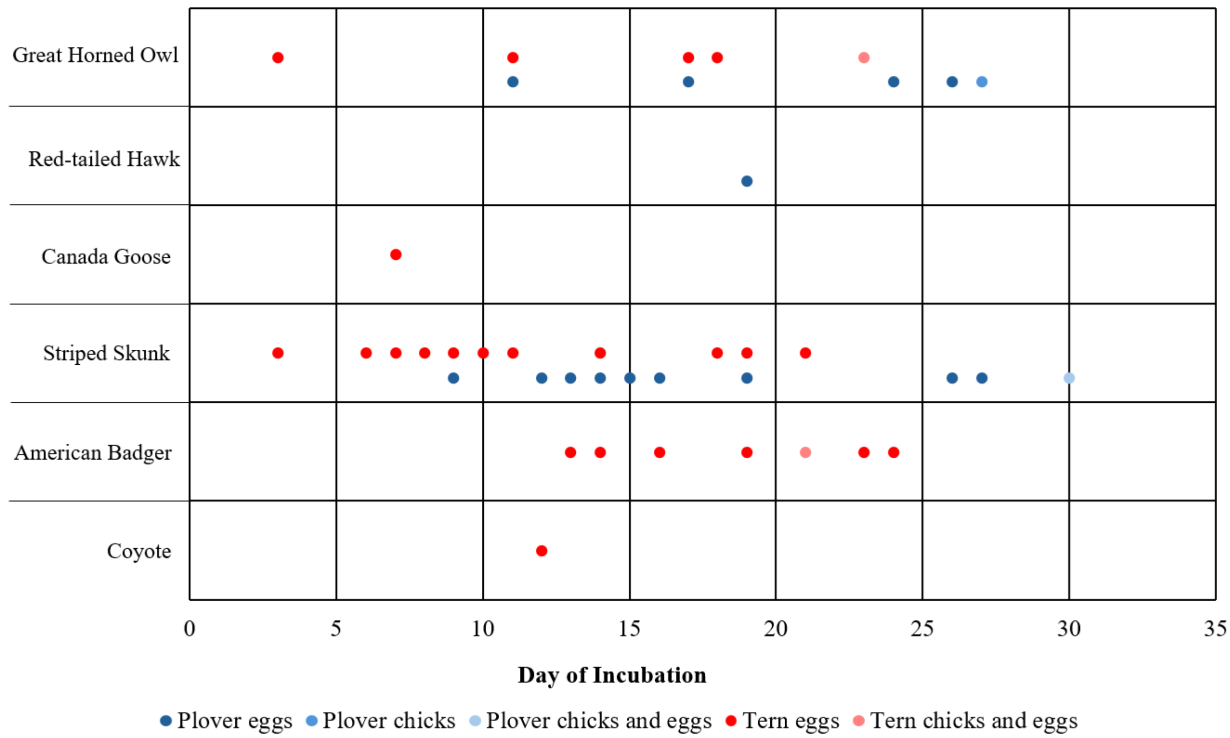


Figure 42. Incubation timeline indicating the day predation occurred on a total of 23 piping plover nests (blue circles) and 32 least tern nests (red circles) by a great horned owl, red-tailed hawk, Canada goose, striped skunk, American badger, and coyote during 2024. Losses of multiple nests at the same day of incubation by the same predator species are represented by a single point. One of the least tern nests had two predation event occurrences (a great horned owl predated 1 egg and a badger predated the remaining two eggs). Nests were located at Dyer (17 nests), Cottonwood Ranch (7 nests), Kearney Broadfoot South (21 nests), Newark West (7 nests), and Newark East (3 nests). Data from all nest monitoring sources (i.e., outside/inside observers; nest, site, and shoreline camera data; and track surveys) were used to determine nest fates. Shades of blue/red differentiate which developmental stage the nest was at when predation occurred.

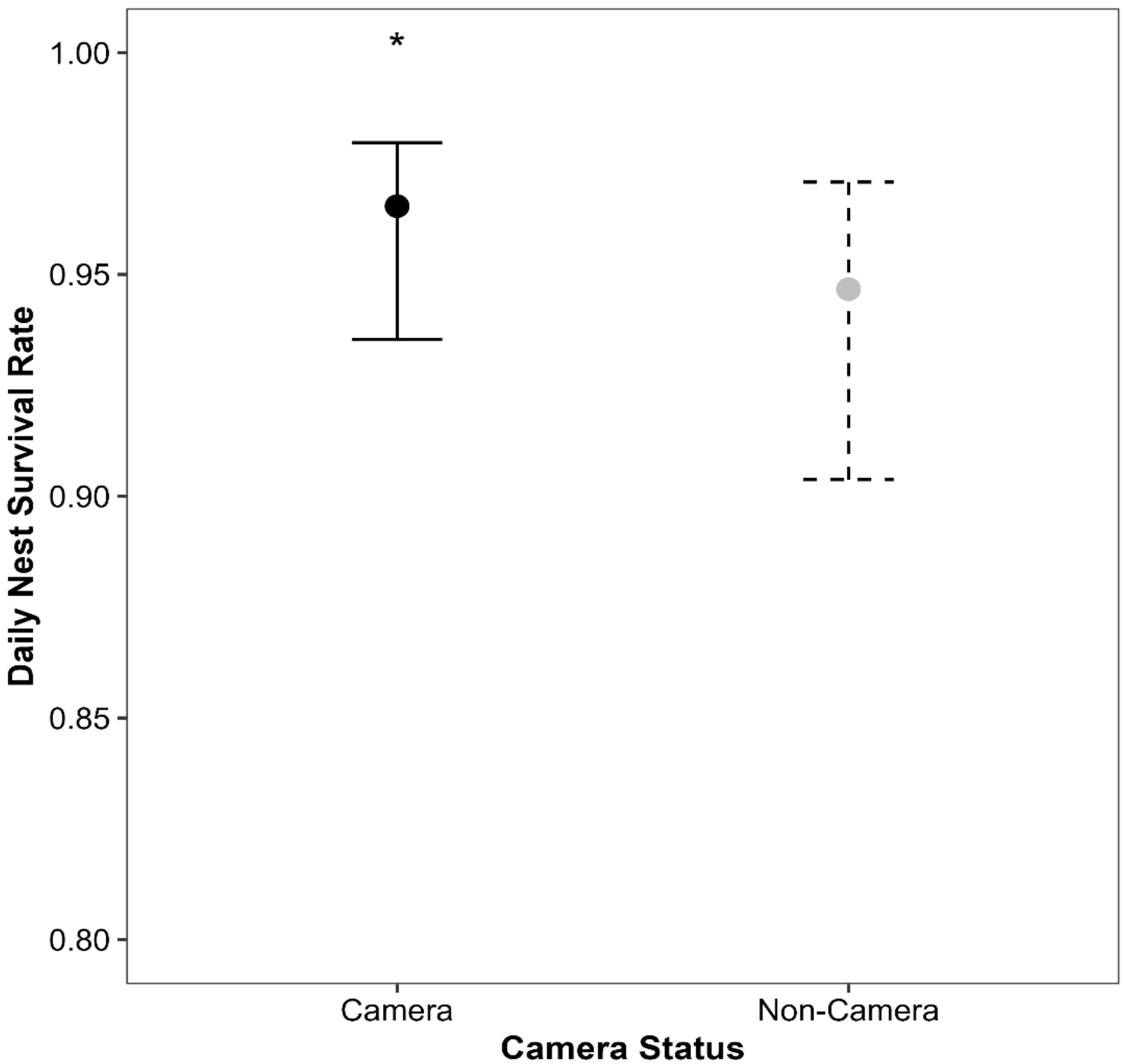


Figure 43. Estimated average daily survival rates (DSRs) of plover and tern nests with a nest camera present (Camera, black circle) or without a nest camera present (Non-Camera, gray circle) at six off-channel nesting sites during 2024. The 95% confidence intervals are depicted around each estimate (solid line for camera, dashed line for non-camera). Nests with cameras had a significantly higher DSR than nests without cameras during 2024 ($p = 0.029$*).

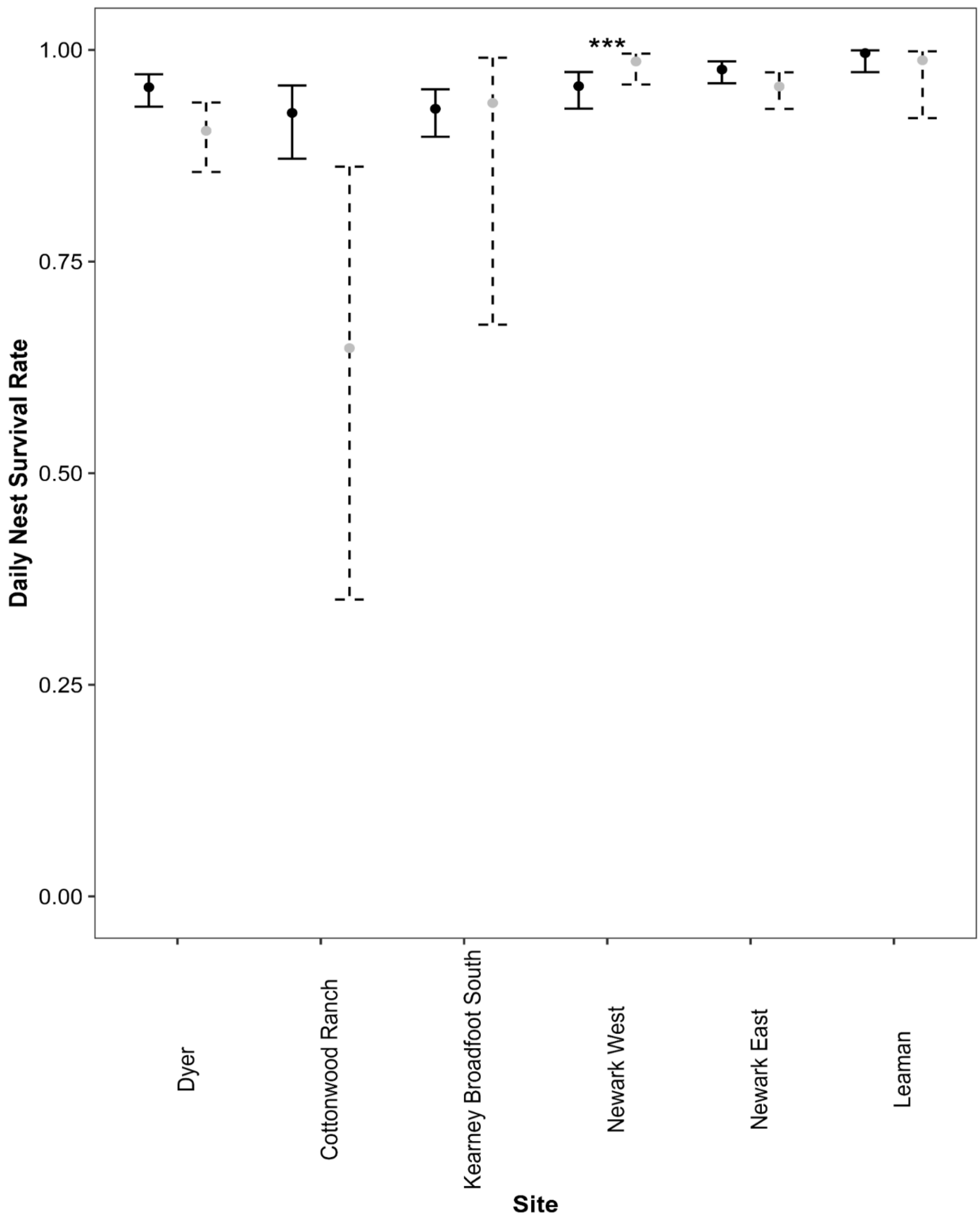


Figure 44. Average daily survival rates of plover and tern nests by site with (black circles) and without (gray circles) a nest camera present during 2024. EDO biologists deployed nest-level cameras at six off-channel nesting sites during 2024. The 95% confidence intervals are depicted around each estimate (solid line for camera, dashed line for non-camera). There was no significant difference in daily nest survival rates at nests with and without cameras for plovers and terns at any site during 2024, except Newark West ($p = 0.001$***).

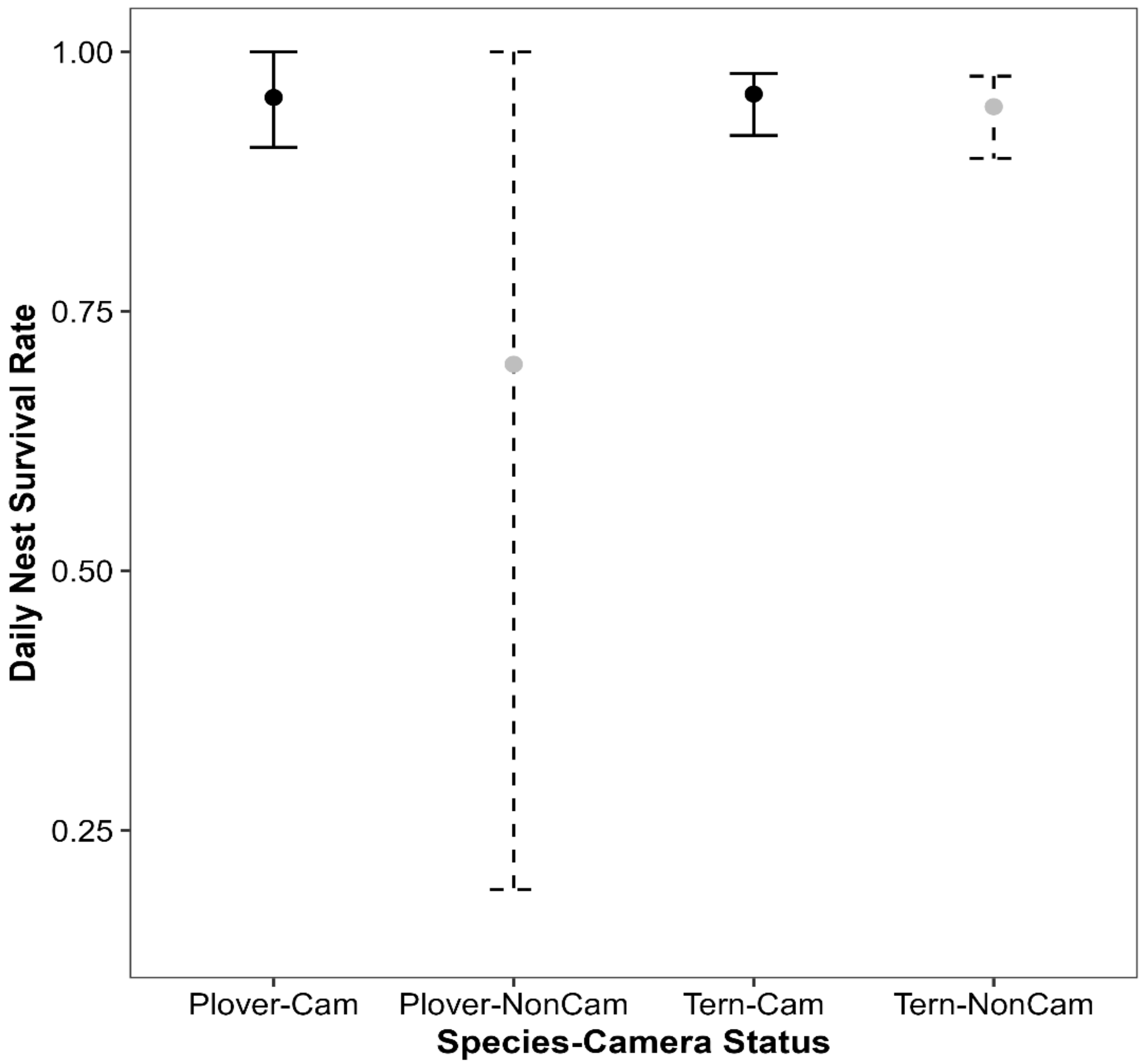


Figure 45. Average daily survival rates of plover nests with a nest camera present (Plover-Cam, black circle), plover nests without a nest camera present (Plover-NonCam, gray circle), tern nests with a nest camera present (Tern-Cam, black circle), and tern nests without a nest camera present (Tern-NonCam, gray circle) at six off-channel nesting sites during 2024. The 95% confidence intervals are depicted around each estimate (solid line for camera, dashed line for non-camera). Only one plover nest did not have a camera, thus we were unable to statistically evaluate differences between nests with and without cameras. There was no significant difference in daily nest survival rates at nests with and without cameras for terns during 2024.

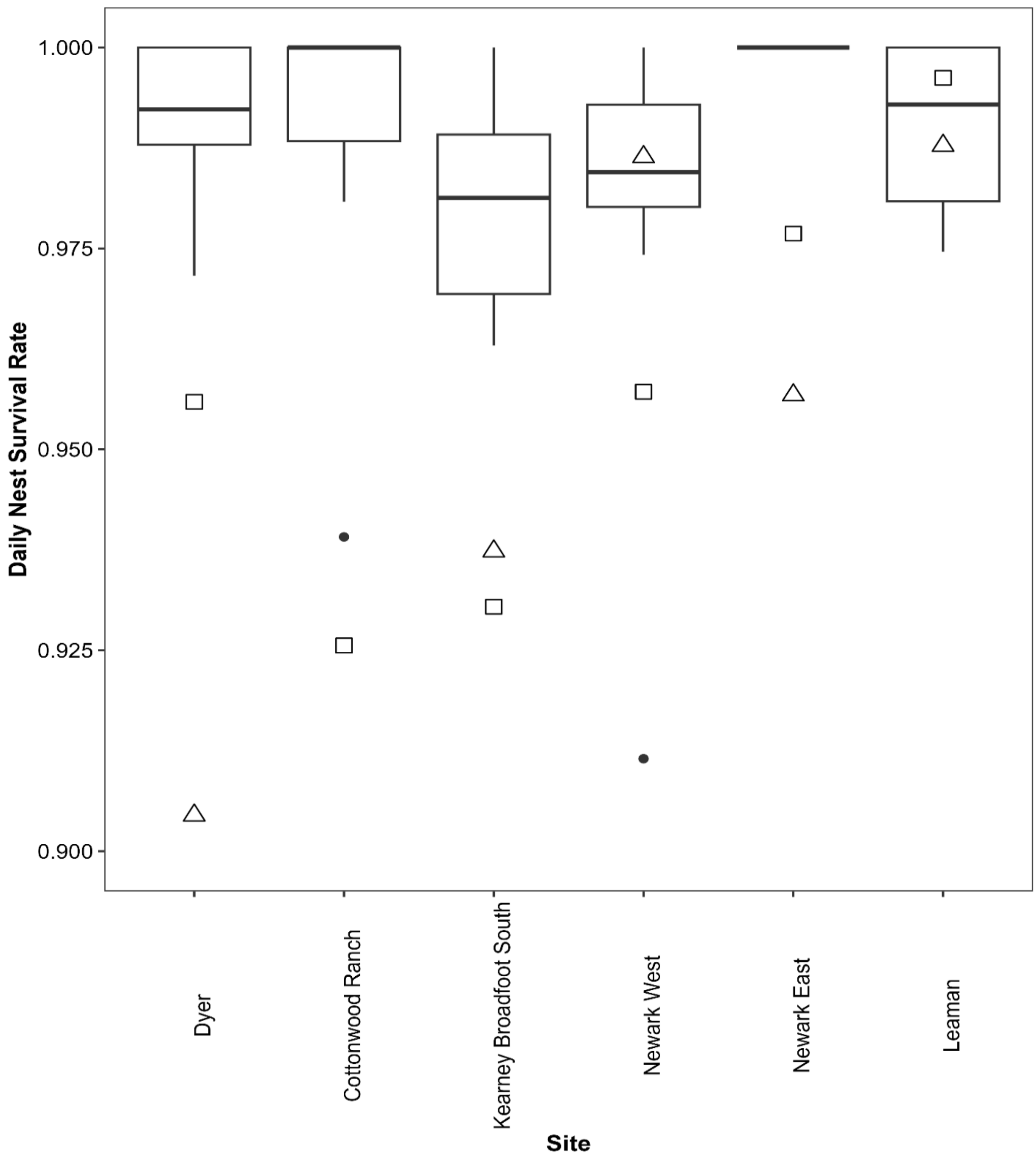


Figure 46. Combined 2024 plover and tern average daily nest survival rates (DSRs) of nests with a nest camera present (hollow squares) and without a nest camera present (hollow triangle) at six off-channel nesting sites compared to the distribution (boxplots) of plover and tern average daily nest survival rates prior to nesting site camera usage with outliers represented as filled circles (2010-2016). Points excluded from the figure include the DSR = 0.648 for nests without cameras at Cottonwood Ranch in 2024 and a Cottonwood Ranch 2010-2016 outlier (DSR = 0). The sample size for Newark East during 2010-2016 was one plover nest and one tern nest that were both successful, resulting in a DSR equal to 1.

APPENDIX

Table A1. Research relevant to the Program's objectives and to our understanding of piping plover ecology.

Publication Year	Study Topic	Citation	Document Title	Study Years	Summary	Primary Findings
2024	Tern and Plover Conservation Partnership annual reports	Tern and Plover Conservation Partnership https://ternandplover.unl.edu/additional-information/annual-reports/	Interior least tern and piping plover annual report for the lower Platte River, Nebraska	2008-2024	Annual reports for terns and plovers on the lower Platte River, Nebraska	These reports provide a synthesis of the respective annual monitoring and research efforts for piping plovers and least terns along the lower Platte River, Nebraska and the reproductive data collected.
2024	Grackle predation of a plover nest	Arneson JR, Peloquin DA, Prestby TG, and Saunders SP. 2024. Waterbirds 47(1):1-6. https://doi.org/10.1675/063.047.0111	Common grackle (*Quiscalus quiscula*) predation of a Great Lakes piping plover (*Charadrius melodus*) nest and its conservation implications	June 2023	A common grackle was observed consuming eggs from a protected Great Lakes plover nest, the first photographic documentation of grackle predation of a plover nest.	After documenting a common grackle consuming eggs from an enclosed (protected) Great Lakes plover nest, common grackles have been added to the suite of egg predators for plovers. This has critical implications for plovers, particularly in the Great Lakes region. Piping plovers are listed as federally endangered in this region and common grackles are relatively abundant. Current nest protection efforts rely on exclosures with openings that enable access by grackles. Authors recommend identifying plover nesting locations across the Great Lakes region that are frequently used by common grackles and subsequent alteration of exclosure use and/or habitat or predator management at locations where grackles are particularly problematic.
2024	Plover nest site selection	Dorsey SS. 2024. Masters Thesis, Virginia Tech. https://hdl.handle.net/1091/117400	Factors affecting piping plover (*Charadrius melodus*) nest site selection following landscape and predator community changes	2010-2020	Authors assessed changes in vegetation succession, plover nesting habitat selection, and suitable habitat availability from 2010 until 8 years after Hurricane Sandy.	Plovers exhibited a preference for nest sites with increased predator visibility compared to random selection, indicating a strategic selection process. Topographical variation caused greater visual obstruction at nest sites than vegetation.

2024	Plover monitoring program and costs	Ellis KS, Anteau MJ, MacDonald GJ, Ring MM, Sherfy MH, Swift RJ, and Toy DL. 2024. Ecological Solutions and Evidence 5:e12308. https://doi.org/10.1002/2688-8319.12308	Assessing trade-offs in developing a landscape-scale nest monitoring programme for a threatened shorebird	2000-2019	Authors assessed the effectiveness of multiple plover monitoring program scenarios and their associated costs.	Authors found that precision increased and bias decreased around plover nest survival estimates with greater survey coverage and nest visit frequency. However, there are monitoring programs where survey costs outweigh the statistical benefits.
2024	Consequences of off-river nesting	Forsberg EM. 2024. School of Natural Resources: Dissertations, Theses, and Student Research 377. https://digitalcommons.unl.edu/natresdiss/377	Demographic consequences of off-river nesting for piping plover (*Charadrius melodus*) and interior least tern (*Sternula antillarium athalassos*) in the Lower Platte River System, Nebraska	2008-2023	The author assessed consequences of off-river nesting at sandbars and off-river sites. Nest initiation and hatch date, extreme temperature, conspecific and heterospecific nesting proximity, and nest exclosure usage were also investigated.	No evidence was found for demographic consequences between off-river sites and sandbars. Demographic consequences among off-river site types varied. Vital rates were affected by seasonal date, nest age, proximity to tern nests, nest exclosures, and temperature factors.
2024	Spatiotemporal and weather effects	Guild R, Wang X, Hirtle S, and Mader S. 2024. Ecology and Evolution 14:e11581. https://doi.org/10.1002/ece3.11581	Spatiotemporal and weather effects of the reproductive success of piping plovers on Prince Edward Island, Canada	2011-2023	Authors employed a spatiotemporal modeling approach to investigate how location, nest timing, and weather conditions influence reproductive success rates of plovers in Prince Edward Island, Canada.	Modeled results did not support a negative impact of extreme high temperatures and strong precipitation events on reproductive outcomes of plovers. Spatiotemporal variability in apparent hatch success over the study period was identified in models along with worse hatch outcomes across popular beachgoing regions and for delayed nesting attempts.

2024	Effects of marking schemes on plovers	Wails CN, Catlin DH, Robinson SG, Bellman HA, Oliver KW, VanDerwater HL, Dorsey SS, DeRose-Wilson A, Karpanty SM, and Fraser JD. 2024. Journal of Ornithology. https://doi.org/10.1007/s10336-024-02211-x	Comparing the effects of marking techniques on the survival of Piping Plover chicks	2013-2023	Authors studied the effects of color bands and uniquely engraved flags on piping plover injury and survival rates.	Injuries associated with the two marking schemes were detected in some years. Authors compared survival of chicks between the two different marking schemes and found that pre-fledged survival of plovers with uniquely coded flags was similar to those that received color bands. The relatively high injury rate in some years, however, remains a concern.
2023	Platte River Recovery Implementation Program tern and plover monitoring reports	Available on Program Online Library: https://platteriverprogram.org/program-library. Keywords: least tern, piping plover, technical reports	Annual piping plover and least tern synthesis reports	2001-2023	Annual reports for terns and plovers on the central Platte River, Nebraska	These reports provide a synthesis of the respective annual monitoring and research efforts for piping plovers and least terns along the Program's Associated Habitat Reach on the central Platte River, and the reproductive data collected.
2023	Camera monitoring of nests	Call MN, Wilke AL, Poulton Z, Boettcher R, Karpanty SM, Kwon E, Lipford A, Gardner ED, Anderson L, Fraser JD, Catlin DH, Wails CN. 2023. Waterbirds 45:312-327. https://doi.org/10.1675/063.045.0310	Comparing in-person versus camera monitoring of shorebird reproductive success	2019	Tested effectiveness of in-person compared to camera-based monitoring to quantify productivity of plover nests in Virginia.	Cameras validated in-person monitoring conclusions, highlighted threats that surveys missed, and characterized the predator community. They also provided insight into the effectiveness of mammalian predator removal. However, cameras produced large quantities of data, and they failed to capture causes of mortality for mobile chicks. Cameras also did not consistently document chicks where monitoring in-person confirmed successful broods.

2023	Species distribution modeling of plover breeding density	Ellis KS, Anteau MJ, MacDonald GJ, Swift RJ, Ring MM, Toy DL, Sherfy MH, Post van der Burg M. 2023. Scientific Reports 13:6087. https://doi.org/10.1038/s41598-023-32886-w	Data integration reveals dynamic and systematic patterns of breeding habitat use by a threatened shorebird	2000-2019	Authors developed a spatiotemporal model of piping plover breeding habitat use in Montana, North Dakota, and South Dakota using a 20-year eBird dataset and nest monitoring data to examine effects of dynamic and long-tern environmental processes on breeding density.	Plover breeding habitat use and density were related to dynamic covariates including percentage of surface water within 90 m, vegetation coverage within 30 m, and percentage of crop and hay pasture surrounding the location. Habitat use was also related to a static layer that quantified distance to permanent lakes as a decreasing exponential function. The authors found that use of the eBird dataset provided more complete spatial coverage than nest monitoring data alone, but eBird data was related to surrounding road density due to site accessibility. The authors developed a predictive species distribution map for breeding plovers across portions of Montana, North Dakota, and South Dakota to inform conservation efforts.
2023	Use of predator exclosures at plover nests	Peters SH, Engley L, Rezansoff A, Prescott DRC, Jones PF. 2023. Conservation Science and Practice 5(4):e12909. https://doi.org/10.1111/csp2.12909	The effectiveness and cost efficiency of different predator exclosure designs to increase piping plover (*Charadrius melodus*) nest success and fledging rate in Alberta, Canada.	1998-2010	The authors compared daily nest survival, nest productivity, and cost using three types of nest exclosures (large, medium, small) and no exclosures.	The authors used data from 1998–2010 from 820 plover nests in Alberta, Canada. During 1998–2001 when large, medium, and small nest exclosures were used, there was no significant difference in daily nest survival rate between nests with and without an exclosure. During 2002–2010 when only small exclosures were used, nests with exclosures had significantly higher daily nest survival rates than those without exclosures. Nests with small exclosures hatched more chicks and produced more fledglings than those without exclosures. When considering only successful nests, there was no difference in number of fledglings between nests with and without exclosures, indicating no added benefit of exclosures beyond protecting the nest. The authors found that cost per chick was lowest using small exclosures that were cylindrical and measured 40-cm x 60-cm.

2023	Relationship between a suite of predators and plover chick survival	Robinson SG, Black KM, Catlin DH, Wails CN, Karpanty SM, Bellman H, Oliver KW, Ritter SJ, and Fraser JD. 2023. The Journal of Wildlife Management 88:e22538. https://doi.org/10.1002/jwmg.22538	Red fox trap success is correlated with piping plover chick survival	2015-2018	Authors used camera detections in a survival model to assess potential relationships between predator species detection and plover chick survival.	Authors found that plover chick survival was negatively related with red fox detection but not with raccoon or domestic cat detection. Although there was no direct evidence of red foxes taking plover chicks, there was a correlation between fox trap success and plover chick survival which suggests that foxes affect plover reproductive output.
2023	Use of predator exclosures at plover nests	Stantial ML, Cohen JB, Darrah AJ, Masio B. 2023. Ornithological Applications 2023:duad047, https://doi.org/10.1093/ornithapp/duad047	Predator exclosures increase nest success but reduce adult survival and increase dispersal distance of piping plovers, indicating exclosures should be used with caution.	2011-2018	Authors evaluated the impact of predator exclosures around plover nests on plover demography using a seven-year dataset from the New Jersey plover population.	Predator exclosures around plover nests increased nest success by 62% over a 34-day period. Exclosed nests were 4.7 times more likely to be abandoned, likely due to adult mortality. Abandoned nests were associated with lower adult survival. The authors found that after the male of a breeding pair had died and the nest was abandoned, the surviving female dispersed 10 times farther than birds whose first nest attempts were lost to other causes (e.g., flooding). This emigration effectively resulted in the loss of a local breeding pair. The authors used an online population projection model (PiperEx) to demonstrate exclosures were not expected to improve plover population growth rates in New Jersey and encouraged managers to consider whether exclosures are worth protecting eggs from predators with the trade-offs of reduced adult survival and increased emigration rates.

2023	Population viability analysis of northern Great Plains piping plover population	Swift RJ, Anteau MJ, Ellis KS, MacDonald GJ, Ring MM, Sherfy MH, Toy DL. 2023. Frontiers in Bird Science 2:1157682. https://doi.org/10.3389/fbirs.2023.1157682	Estimating population viability of the northern Great Plains piping plover population considering updated population structure, climate change, and intensive management	2006-2022	Authors updated a population viability model constructed by McGowan et al. (2014) using new data on plover vital rates and connectivity, potential management actions, and stochastic climate variability to predict the extinction probability of the northern Great Plains piping plover population over 50 years.	Using new information on metapopulation dispersal rates and connectivity, the authors predicted the risk of plover extinction to be between 0.088 and 0.373 over 50 years based on a 2006 population estimate. This represented an increase over the 0.033 probability of extinction predicted by the McGowan et al. (2014) model. However, in only one of eight scenarios did the median of the estimated plover population from 1,000 simulations decrease relative to the 2006 estimate. Reduction in adult survival due to a simulated effect of nest caging increased extinction probability to 0.267–0.373 and decreased the median of the estimated population size over time. In contrast, simulated increases in fecundity due to nest caging reduced extinction probability to 0.088–0.103 only if there was no negative effect on adult survival. Increasing variance around fecundity estimates to represent climate stochasticity had little effect on predicted population viability.
2023	Breeding habitat selection	Swift RJ, Anteau MJ, Ellis KS, Ring MM, Sherfy MH, and Toy DL. 2023. Ecosphere 14(5): e4524. https://doi.org/10.1002/ecs2.4524	Conspecific density and habitat quality affect breeding habitat selection: support for the social attraction hypothesis	2014-2019	Authors tested five hypotheses of plover habitat selection.	Authors found that adult plovers moved to new breeding locations as often as staying at the same breeding location. They also found that adult plovers use social cues for settlement decisions. Habitats were selected not because of the amount of habitat but rather the higher presumed quality with intermediate conspecific densities.
2023	Report to provide scientific information to inform future recovery planning	U.S. Fish and Wildlife Service. 2023. U.S. Fish and Wildlife Service Missouri River Recovery Office. 20 June 2023.	Biological Report for the northern Great Plains piping plover population (*Charadrius melodus circumcinctus*).	NA	Literature review and summary of updated information regarding northern Great Plains plover life history, breeding, habitat use, dispersal, and connectivity.	This USFWS literature review provided a summary of plover life history; current status of the northern Great Plains population in relation to habitat use and environmental conditions for breeding and brood rearing; and factors influencing species viability and future conditions needed to maintain sufficient resiliency, redundancy, and representation on the breeding range for a projected 50-year period.

2022	Population dynamics	Swift RJ, Anteau MJ, Ellis KS, Ring MM, Sherfy MH, Toy DL, Koons DN. 2022. https://doi.org/10.1002/ecs2.4190	Implications of habitat-driven survival and dispersal on recruitment in a spatially structured piping plover population	2014-2017	The authors estimated hatch-year survival to adulthood and natal dispersal rates between Missouri River and Alkali Wetlands breeding groups. They examined the role of habitat availability in natal dispersal and recruitment.	Hatch-year survival to adulthood was slightly higher for individuals hatched on the Missouri than on the Alkali Wetlands but declined over time. Those hatched on the Alkali Wetlands were more likely to disperse to breed on the Missouri than vice versa. The Missouri River showed higher natal fidelity, thus higher recruitment; but declining breeding group abundance was responsible for a declining trend in the number of recruits to the Missouri over time. Unbalanced, high natal dispersal rates withing the Northern Great Plains indicate high connectivity among regions driven by fluctuating availability of habitat.
2021	Effectiveness of predator management	Anteau MJ, Swift RJ, Sherfy MH, Koons DN, Ellis KS, Shaffer TL, Toy DL, Ring MM. 2021. Journal of Wildlife Management 86:e22139. https://doi.org/10.1002/jwmg.22139	Experimental evaluation of predator exclosures on nest, chick, and adult survival of piping plovers	2014-2016	Authors evaluated the survival of nests, chicks and adults at wetlands across the Northern Great Plain with and without nest exclosures.	Exclosed nests at treatment wetlands had greater cumulative survival than unexclosed nests at treatment or control wetlands. Survival to fledging was highest for chicks hatched from exclosed nests, and similar between chicks hatched from unexclosed nests at treatment and control wetlands. Adults associated with exclosed nests and unexclosed nests at treatment wetlands had greater survival than those associated with unexclosed nests at control wetlands. The positive influence of exclosures on nest survival was not offset by a reduction in chick or adult survival, indicating that exclosures are a viable tool for piping plover conservation.
2021	Piping plover survival and migratory connectivity	Ellis KS, Anteau MJ, Cuthbert FJ, Gratto-Trevor CL, Jorgensen JG, Newstead DJ, Powell LA, Ring MM, Sherfy MH, Swift RJ, Toy DL, Koons DN. 2021. Biological Conservation 264: 1-11. https://doi.org/10.1016/j.biocon.2021.109371	Impacts of extreme environmental disturbances on piping plover survival are partially moderated by migratory connectivity	2012-2019	This study evaluates survival at nonbreeding areas due to extreme environmental disturbances and estimates the connectivity between breeding vs. non-breeding areas using data from piping plover individuals from 2002-2019.	Hurricanes and algal blooms are negatively associated with nonbreeding season survival, though no negative association was detected for oil spills in this study. There was low migratory connectivity observed across nonbreeding areas for individuals from separate breeding areas. Survival among breeding states averaged 0.91, with the highest average belonging to the Great Lakes population. Mortality for the non-breeding season was consistently higher. The non-breeding states had an estimated survival of 0.81. A small degree of temporal synchrony in survival was found for the Northern and Southern Great Plains among the breeding states, and between Texas and the Eastern Gulf for the non-breeding states.

2021	Habitat availability	Jorgensen JG, Brenner SJ, Greenwalt LR, Vrtiska, MP. 2021. Ecosphere 12(4): e03474. https://doi.org/10.1002/ecs2.3471	Decline of novel ecosystems used by endangered species: the case of piping plovers, least terns, and aggregate mines	1993-2020	Authors evaluated how the number, size, and spatial distribution of different site types hosting different numbers of nesting plovers and terns along the Platte, Loup, and Elkhorn Rivers have changed over time and how current trends in the number of different site types will affect future habitat and bird abundance.	Overall area and total number of sites declined between 1993-2020. Traditional mines are being replaced by modern mines, which host lower numbers of nests of both species. Traditional mines are projected to decline in the future, reducing overall nesting habitat. Piping plovers and least terns are expected to continue to nest within the study area, but numbers are expected to be smaller compared to what has been observed in the past.
2021	Predator monitoring via remote cameras	Keldsen KJ. 2021. Masters Thesis, University of Nebraska at Kearney. ProQuest Dissertations Publishing 28645869.	Efficacy of predator exclusion methods and ID of nest predators for interior least terns and piping plovers at off-channel nesting sites along the central Platte River, Nebraska, USA	2017-2019	The author investigated the avian and mammalian predator presence and mode of access at off-channel nesting sites along the central Platte River. Effectiveness of a panel wing system were investigated as were predator communities.	The author found that predator approaches to the panel wing system were much higher than breaches and that the panel wing system was effective 90.6% of the time. When looking at predator communities, mammalian registers on camera traps were less abundant than avian registers at off-channel nesting sites. Great horned owl was the most frequent avian species registered and coyote the most frequent mammalian species. Developed landcover was positively correlated with presence of raccoons and skunks and tall vegetation was negatively correlated with presence of raccoons and skunks.

2021	Habitat selection	Robinson S, Bellman H, Walker K, Catlin D, Karpanty K, Ritter S, Fraser J. 2021. Ecosphere 12(12):e03870. https://doi.org/10.1002/ecs2.3870	Adult piping plover habitat selection varies by behavior	2016-2018	Plovers were monitored on Fire Island and Westhampton Island, New York, during 2016-2018 to record locations of adult birds. Authors used resource selection functions to determine whether breeding status or instantaneous behavior class best explained relationships with landscape characteristics.	Plovers displaying parental behavior (incubating, brooding, and accompanying chicks) selected locations closer to bay intertidal habitats and with proportionally more dry sand in the surrounding landscape. Non-parental plovers avoided areas with more dry sand and did not select for or against bay intertidal habitats. Birds exhibiting both types of behaviors avoided development and higher elevation areas throughout the landscape, but non-parental plovers avoided them more than parental plovers.
2021	Plover chick habitat selection	Robinson SG, Walker KM, Bellman HA, Gibson D, Catlin DH, Karpanty SM, Ritter SJ, Fraser JD. 2021. Journal of Wildlife Management 87: e22325. https://doi.org/10.1002/jwmg.22325	Piping plover chick ecology following landscape-level disturbance	2013-2019	Piping plovers on Fire and West Hampton Island, New York, were studied from 2013-2019 following hurricane Sandy which created abundant nesting habitat on these barrier islands in 2012. The study examined the effects of landscape features on habitat selection, behavior, and survival of plover broods.	Plover broods selected flatter sites with less dense vegetation than available at random. Chick foraging rates were highest in moist substrates and were lower in areas of higher nesting plover density. Chick survival was greater for broods that hatched earlier in the season and increased as chicks aged. Natural landscape disturbance was important for creating non-vegetated, open sand habitat for both nesting and foraging.

2021	Foraging movements and colony attendance	Sherfy MH, Ring MM, Stucker JH, Anteau MJ, Shaffer TL, Sovada MA. 2021. Waterbirds 44(1): 38-54. https://doi.org/10.1675.063.044.0104	Foraging movements and colony attendance of least terns (*Sternula antillarum*) on the central Platte River, Nebraska, USA	2009-2010	Documented least tern foraging movements and colony attendance during the breeding season on the central Platte River through the use of VHF transmitters and a network of datalogging receivers.	During daylight hours, terns typically remained within 8 km of nesting areas, but up to 17.5 km away at night. Moving distances were longer post-fledging. Colony attendance was higher during incubation and lower post fledge. Frequency and success of foraging were lowest on sandpit sites, intermediate on riverine sites, and highest at the Kearney Diversion Dam.
2021	Population dynamics	Swift RJ, Anteau MJ, Ellis KS, Ring MM, Sherfy MH, Toy DL. 2021. Movement Ecology 9:59. https://doi.org/10.1186/s40462-021-00293-3	Dispersal distance is driven by habitat availability and reproductive success in northern Great Plains piping plovers	2014-2019	Authors examined sources of variation for natal dispersal and interannual breeding for piping plovers in the northern Great Plains between 2014-2016.	Natal dispersal was, on average, longer than adult breeding movements. Individuals moved shorter distances when hatched, previously nested, or settled on river habitats. Hatch-year individuals moved shorter distances when there was more habitat available on their natal site than the year prior. Adults also moved shorter distances when more habitat was available at the settling site and when in closer proximity to other nesting areas.
2020	Population model for nest exclosure use	Darrah AJ, Cohen JB, Castelli PM. 2020. Wildlife Society Bulletin 1-13. https://doi.org/10.1002/wsb.1115	A decision support tool to guide the use of nest exclosures for piping plover conservation	2013-2018	Authors developed a decision support tool (PiperEx) that uses site-specific nest-fate data to inform a stochastic population project model to predict plover population growth rate at the site level with and without exclosure use.	Authors found that the probability of making the correct decision on whether to use exclosures or not increased with sample size. They used real data pooled across years and were able to predict the best decision for a particular year up to 100% of the time for a given area. If data for PiperEx is collected annually, the data from the previous 5 or 6 years can be used for decision making at the start of the season.

2020	Shorebird productivity monitoring protocols	Farrell PD, Baasch, DM. 2020. Waterbirds 43(2): 123-133. https://doi.org/10.1675/063.043.0201	Reducing effort when monitoring shorebird productivity	2013-2016	This study is a comparison of the accuracy of two monitoring protocols; one from inside nesting colonies, and one from outside the nesting colonies.	Both inside and outside monitoring result in reasonable estimates of abundance and productivity for both least terns and piping plovers. Outside monitoring of least terns resulted in higher fledge counts and lower breeding pair estimates, increasing reported fledge ratios. No consistent over or underestimates were found upon implementation of outside monitoring of piping plovers due to annual variability. Outside monitoring reduces effort, cost, and potential disturbance.
2020	Nest cameras	Hunt KL, Gibson D, Friedrich MJ, Huber CJ, Fraser JD, Karpanty SM, Catlin DH. 2020. Ibis 162:1–12. https://doi.org/10.1111/ibi.12726	Using nest captures and video cameras to estimate survival and abundance of breeding piping plovers *Charadrius melodus*	2005-2017	Authors used video cameras at plover nests to resight previously banded individuals.	Individual plovers were captured on nests and marked and recaptured from 2005 to 2014. From 2015 to 2017, individuals were resighted using video cameras deployed at nests. The number of marked and unmarked breeding individuals were counted and authors estimated apparent survival. Estimates of the abundance of breeding individuals and population growth each year were derived showing that camera data can be used to produce demographic parameters and abundance estimates for an avian species.
2020	Population dynamics of piping plovers	Swift RJ, Anteau M, Ellis K, Ring M, Sherfy M, Toy D, Koons D. 2020. U.S. Geological Survey Open-File Report 2020–1152, 211 p.	Spatial variation in population dynamics of northern Great Plains piping plovers	2014-2019	The purpose of this study was to determine movement and connectivity within and among the various populations of piping plovers in the Great Plains and factors that affect their success and survival. This study looked at survival, dispersal, renesting, and reproductive success of the birds.	River and alkali wetlands seem to be higher quality habitat for plovers than reservoirs, but river habitat had higher survival, reproductive output, and fidelity probabilities than alkali wetlands. Dispersal, both natal and adult, was highly affected by habitat availability and reproductive success, as well as by population density. Renesting propensity and renest success were low. The data indicates that there is high connectivity between the U.S. Alkali Wetlands and the norther river units of the Missouri River.

2020	Renesting in piping plovers	Swift RJ, Anteau MJ, Ring MM, Toy DL, Sherfy MH. 2020. The Condor: Ornithological Applications 122:1–18. https://doi.org/10.1093/condor/duz066	Low renesting propensity and reproductive success make renesting unproductive for the threatened piping plover (*Charadrius melodus*)	2014-2016	Authors studied renesting propensity, renesting intervals, and renest reproductive success in the northern Great Plains.	First nests had higher reproductive success and daily nest survival than renests. For reproductive attempts that failed in the nest stage, the apparent renesting rate for individuals was 25%. The apparent renesting rate dropped to 1.2% for reproductive attempts when broods were lost. Nests failing due to predation, reproductive failure occurring later in the breeding season, or individuals that had previously renested that year also decreased renesting propensity. Plovers nesting on reservoirs were less likely to renest than those nesting in other habitats.
2020	Heterospecific breeding association	Swift RJ, Anteau MJ, Roche EA, Sherfy MH Toy DL, Ring MM. 2020. Oikos 129: 1504-1520. https://doi.org/10.1111/oik.07256	Asymmetric benefits of heterospecific breeding association vary with habitat, conspecific abundance and breeding strategy	2007-2016	Authors tested how piping plover and interior least tern associations during breeding influence nest and chick survival.	Authors studied nest and chick survival for piping plovers and interior least terns on Lake Sakakawea, Garrison River Reach, and the Gavins Point Reach between 2007-2016. Plover nest and chick survival improved with the presence and abundance of terns, but terns only benefited from plover presence for certain study areas and breeding stages. Associations between these two species are mutualistic, but asymmetric, moderated by habitat, abundance on conspecifics, and breeding stage. Nesting requirements of both species should be considered when managing habitat for target species.
2019	Missouri River Recovery Program annual reports	Missouri River Recovery Program https://www.nwo.usace.army.mil/mrrp/Library/	MRRP ESA adaptive management compliance report	2001-2019	Annual reports for terns and plovers on the Missouri River	These reports provide a synthesis of the respective annual monitoring and research efforts for piping plovers and least terns along the Missouri River and the reproductive data collected.
2019	Nest fate classification	Andres AK, Shaffer TL, Sherfy MJ, Hofer CM, Dovichin CM, Ellis-Felege SN. 2019. Ibis 161:286-300. https://doi.org/10.1111/ibi.12629	Accuracy of nest fate classification and predator identification from evidence at nests of least terns and piping plovers	2013-2015	Authors evaluated nest fate misclassification rate and studied factors resulting in misclassification of least tern and piping plover nests.	Video cameras were used to evaluate nest fate misclassification rate. Ordinal logistic regressions were used to examine whether monitoring interval, clutch age, or temporal factors influenced a correct, partially misclassified, or misclassified nest fate classification. As clutch age and monitoring interval increased, researchers were less likely to correctly classify nest fates. Least tern nests were less likely to be correctly fated than piping plover nests. Also, causes of failure disagreed for 53.5% of nests when using field evidence vs video.

2018	Piping plover and least tern nest and brood survival	Farrell PD, Baasch DM, Farnsworth JM, Smith CS. 2018. Avian Conservation and Ecology 13(1): 1. https://doi.org/10.5751/ACE-01133-130101	Interior least tern and piping plover nest and brood survival at managed, off-channel sites along the central Platte River, Nebraska, USA 2001–2015	2001-2015	This study assessed the influence of several biotic and abiotic variables on the survival of least tern and piping plover nests and broods to inform Program management.	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.
2018	Population dynamics	Saunders SP, Cuthberg FJ, Zipkin EF. 2018. Journal of Applied Ecology 55:1380–1392. https://doi.org/10.1111/1365-2664.13080	Evaluating population viability and efficacy of conservation management using integrated population models	1993-2016	Authors developed a coupled integrated population model and Bayesian population viability analysis to assess impact of demographic rates on past population dynamics and predict population viability 10 years into the future for the Great Lakes piping plover population.	The authors' Bayesian population viability analysis indicates that the Great Lakes piping plover population does not face a high and immediate risk of quasi-extinction under current conditions. All possible environmental influences on population viability could not be accounted for. However, their model indirectly captures some of the inherent variation in plover population responses to these factors through the inclusion of environmental stochasticity.

2017	Nest-site selection by piping plovers and least terns	Baasch DM, Farrell PD, Farnsworth JM, Smith CS. 2017. Journal of Field Ornithology 88(3): 236-249. https://doi.org/10.1111/jofo.12206	Nest-site selection by interior least terns and piping plovers at managed, off-channel sites along the Central Platte River in Nebraska, USA	2001-2015	This study investigated habitat measurements that may influence nest site selection, nest placement, and productivity in an effort to gather information needed to design OCSW sites in a way to encourage tern and plover nesting and improve productivity.	Plovers preferred not to nest near each other, their probability of use for nesting was maximized when distance to was ~50 m, and an effective site design for them would be linear to maximize area of nesting habitat near the water. Least terns are colonial nesters, their nesting probability increased as distance to water was maximized, and an efficient design for them would be circular to maximize the area for nesting habitat away from the shoreline. Both species' probability of use was maximized when nearest predator perches were ≥150 m and elevation above water was ≥3 m. 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.
2016	Meta-population viability and habitat change	Catlin DH, Zeigler SL, Bomberger Brown M, Dinan LR, Fraser JD, Hunt KL, Jorgensen JG. 2016. Movement Ecology 2016 4:6 https://doi.org/10.1186/s40462-016-0072-y	Metapopulation viability of an endangered shorebird depends on dispersal and human-created habitats: piping plovers (*Charadrius melodus*) and prairie rivers	2008-2013	Authors studied effect of high flow events on plover metapopulation dynamics on lower Platte and Missouri Rivers	High flow events were associated with increased emigration, decreased immigration, and decreased survival in the subpopulation that experienced high flows. However, following the event, immigration into that subpopulation increased. Dispersal rates among subpopulations were negatively correlated with distance. Under the current disturbance interval and associated dispersal and survival rates, the metapopulation had a low probability of extinction but persistence depended on relatively stable, human-created habitats, not the dynamic, natural habitat.
2016	Population dynamics	Roche EA, Shaffer TL, Dovichin CM, Sherfy MH, Anteau MJ, Wilternuth MT. 2016. Condor 118:558–570. https://doi.org/10.1650/CONDOR-15-195.1	Synchrony of piping plover breeding populations in the U.S. Northern Great Plains	1993-2011	Authors assessed population synchrony, population stability, and factors influencing these metrics for plovers on the Northern Great Plains	Authors found that the abundance of breeding plover populations nesting in riverine and reservoir habitats were the most synchronous, while populations nesting in alkaline lake habitats exhibited the greatest stability. Changes in local breeding population abundances were not explained by a single factor across habitat types which suggests that dispersal across those habitats may have an overall stabilizing effect on the persistence of the Great Plains piping plover metapopulation.

2016	Demographics and movements	Roche EA, Sherfy MH, Ring MM, Shaffer TL, Anteau MJ, and Stucker JH, 2016. U.S. Geological Survey Open-File Report 2016–1061, 27 p.	Demographics and movements of least terns and piping plovers in the central Platte River valley, Nebraska.	2009-2014	Authors summarized data from banding and resighting piping plovers and least terns along the central Platte River to evaluate reproductive success, colonization, adult survival and recruitment, dispersal, and renesting.	There was no relationship between site age and plover chick and nest survival, but this was most likely due to the low sample size. Least tern nest and chick survival was correlated with the age of the site. Least tern nest survival at older sites was associated with higher nest survival and lower chick survival. Site age correlated with increased use for both species. Between species, least terns were more likely to use sites with newly available habitat than plovers, and within a species, young and inexperienced plovers were more likely to use newly created habitat compared to older adults. No natal site fidelity was observed in plovers, but instances of birds returning to the same general area were recorded. Adult plovers did have high breeding site fidelity year to year. Dispersal for piping plovers was dependent on habitat availability and reproductive success; when these were high, site fidelity was high. Dispersal distance for plovers was affected by age, as typically juveniles dispersed farther. Low natal site fidelity was observed in terns and breeding adult dispersal year to year was highly variable. No renesting was observed by terns, and there were few instances of renesting for plovers. Of these few attempts, about half were after losses that occurred in the brood stage. Most plover renesting attempts were on the same site as the first failure and had a high success rate. Renesting initiation after initial loss had high variability, 7.5 days ± 7.3.
2015	Breeding population estimators	Baasch DM, Hefley TJ, Cahis SD. 2015. Ecology and Evolution 5(18): 4197-4209. https://doi.org/10.1002/ece3.1680	A comparison of breeding population estimators using nest and brood monitoring data	2001-2014	This study details the method developed by the Program to estimate the number of breeding pairs using counts of nests and broods where multiple surveys were made throughout a single breeding season; it also compares the results of this method with other commonly used estimation methods.	When using data from multiple nest and brood surveys, this method results in reasonably precise estimates of the number of breeding pairs. Each method has its own biases, and either over- or underestimates based on data and frequency collected.

2015	Double brooding in plovers	Hunt KL, Dinan LR, Friedrich MJ, Bomberger Brown M, Jorgensen JG, Catlin DH, Fraser JD. 2015. Waterbirds 38:321–434. https://digitalcommons.unl.edu/natrespapers/641?utm_source=digitalcommons.unl.edu%2Fnatrespapers%2F641&utm_medium=PDF&utm_campaign=PDFCoverPages	Density dependent double brooding in piping plovers (*Charadrius melodus*) in the northern Great Plains, USA	2005-2013	Authors studied instances of plovers raising two broods per season on the Missouri River and lower Platte River.	Across the 9-year duration of the study on the Missouri River, there were 25 confirmed instances of double brooding. Double brooding was not observed locally on the lower Platte River. However, in 2013, two female plovers successfully hatched eggs and fledged chicks from nests on the lower Platte River and later were observed nesting for the second time on the Missouri River. Early nest initiation, male biased sex ratio, age of breeding adults, and decreased nest density are all factors predicted to increase the frequency of double brooding. Density appears to be an important factor that accounts for some of the difference in the proportion of double brooding on the Missouri River compared to the lower Platte River.
2014	Population viability analysis models	McGowan CP, Catlin DH, Shaffer TL, Gratto-Trevor CL, Aron C. 2014. Biological Conservation 177:220-220. https://doi.org/10.1016/j.biocon.2014.06.018	Establishing endangered species recovery criteria using predictive simulation modeling	NA	Authors used a population viability analysis model to simulate extinction probability of piping plovers in the Great Plains.	Authors simulated extinction probabilities of plovers in the Great Plains and estimated the relationship between extinction probability and various demographic parameters. They found that binomial regression models with mean population growth rate and the natural log of initial abundance were the best predictors of extinction probability 50 years into the future.
2012	Predator exclosures at nests	Beaulieu G. 2012. Masters Thesis, Dalhousie University, Halifax, Nova Scotia. https://dalspace.library.dal.ca/items/8aebb513-7295-43d8-a535-7707a837dd12	The implications of predator management for an endangered shorebird; do nest exclosures affect the behaviour of piping plovers and their predators?	2010-2011	The author examined the effects of nest exclosures on incubating plovers and their predators using behavioral observations, video observations, and an artificial nest experiment.	Plover behavior did not differ between exclosed and unexclosed nests, although different predator types seemed to have an effect on plover attentiveness. Predators visited and spent more time in the vicinity of exclosed nests than unexclosed nests.

2012	Foraging ecology	Sherfy MH, Anteau MJ, Shaffer TL, Sovada MA, Stucker JH. 2012. U.S. Geological Survey Open-File Report 2012–1059, 50 p.	Foraging ecology of least terns and piping plovers nesting on central Platte River sandpits and sandbars	2009-2010	This study looked at movement acquired via telemetry, behavior data, foraging habitat data, and productivity results in order to evaluate the use of foraging habitats by least terns and piping plovers.	When foraging, terns were more likely to be located outside their nesting area, while plovers were more likely to be within the nesting area. Terns rely more heavily on the nearby central Platte River and are more mobile. Plovers forage more often along sandpit shorelines while in the nesting or brooding stages.
2011	Predator trapping	Catlin DH, Felio JH, Fraser JD. 2011. Journal of Wildlife Management 75:458-462. https://doi.org/10.1002/jwmg.56	Effect of great-horned owl trapping on chick survival in piping plovers	2008-2009	Authors examined the effect of removing great-horned owls on plover hatchling survival on Missouri River sandbars.	In 2008, daily survival of plover chicks increased with owl removal, but the effect decreased with increasing age of the chick. In 2009, results were similar but not significant. Chick survival was higher in 2008 than in 2009, regardless of owl capture. Therefore, even if owl capture consistently were effective at increasing survival, the overall survival resulting from trapping may vary annually.
2011	Population viability analysis models	McGowan CP, Runge MC, Larson MA. 2011. Biological Conservation 144:1400-1408. https://doi.org/10.1016/j.biocon.2011.01.005	Incorporating parametric uncertainty into population viability analysis models	NA	Authors developed a method for adding uncertainty in parameter estimates into population models and used data from the Northern Great Plains piping population to demonstrate its utility.	Authors compared abundance projections and extinction probabilities from simulations that excluded and included parametric uncertainty. Final abundance was very low for all sets of simulations, but estimated extinction risk was much greater for the simulation that incorporated parametric uncertainty in the replication loop.
2010	Predator exclosures at nests	Barber C, Nowak, A, Tulk K, Thomas L. 2010. Avian Conservation and Ecology 5:6. http://www.ace-eco.org/vol5/iss2/art6/	Predator exclosures enhance reproductive success but increase adult mortality of piping plovers (*Charadrius melodus*)	1984-2006	Authors examined reproductive success and adult mortality for plover nests with and without predator exclosures at Prince Edward Island National Park, Canada.	Nests with exclosures had higher reproductive success than nests without exclosures. Significantly fewer exclosed nests were depredated than nonexclosed nests, but significantly more exclosed nests were abandoned by adults than nonexclosed nests and exclosed nests had significantly greater adult mortality.

2009	Population dynamics	Catlin DH. 2009. Ph.D. Dissertation, Virginia Polytechnic Institute, Blacksburg, Virginia. http://hdl.handle.net/10919/27442	Population dynamics of piping plovers (*Charadrius melodus*) on the Missouri River	2004-2007	Six-hundred and twenty-three nests on 16 sandbar complexes were monitored to evaluate plover habitat selection, nest success, and adult and juvenile survival.	Plovers selected for engineered sandbars and against natural and natural/modified habitats and engineered habitats had a significantly higher daily survival rate than natural or natural/modified habitats. After the 2006 breeding season when water discharge was higher, nesting densities were higher, reproductive success was lower due to predation, and adults and juveniles emigrated from the study area at a higher rate. Decreased productivity over time and associated predicted negative population growth suggest that the amount of engineered habitat created was inadequate to sustain population growth, and/or that relatively high water discharge and nesting densities coupled with low reproductive rates and high emigration rates could lead to rapid declines in the plover population.
2003	Nest predator exclosures	Murphy RK, Michaud IMG, Prescott DRC, Ivan JS, Anderson BJ, French-Pombier ML. 2003. Waterbirds 26:150–155. https://doi.org/10.1675/1524-4695(2003)026[0150:POAPPA]2.0.CO;2	Predation on adult piping plovers at predator exclosure cages	1993-2002	Authors compared adult plover mortality at nests surrounded by predator exclosures to those without exclosures.	Predator exclosures were placed at 1,355 plover nests on alkali lake beaches in Alberta, Saskatchewan, North Dakota, and Montana from 1993-2002. At the 420 plover nests not covered by cages, no losses of adult plovers were detected. However, 68 (5%) of the nests with cages had nesting plovers killed near them, apparently by raptors. Predation was greatest at small diameter cages with wire mesh tops at sites with low or moderate tree cover within two km. Predation decreased in areas with low tree cover when large diameter cages with soft netting tops were used. Of the 393 nests with small cages in relatively treeless areas, no predation was documented.
2002	Species recovery	Lutey JM. 2002. Final Report Prepared for U.S. Fish and Wildlife Service	Species recovery objectives for four target species in the central and lower Platte River (whooping crane, interior least tern, piping plover, pallid sturgeon)	NA	Author provided a literature review and a summary of recovery objectives for four threatened or endangered species along the Platte River	To be summarized later

2002	Nest Fates	Williams GE, Wood PA. 2002. Auk 119:1126–1132. https://doi.org/10.1093/auk/119.4.1126	Are traditional methods of determining nest predators and nest fates reliable? An experiment with wood thrushes (*Hylocichla mustelina*)	1998-2000	Authors used miniature infrared video cameras to monitor wood thrush nests to determine if evidence at nests can be used to predict predator identities and nest fates prior to reviewing footage.	Authors predicted predator class (avian, mammalian, or snake) on depredated nests before reviewing video footage and were incorrect 57% of the time. However, when predicting fate (fledged or failed), 23 of 27 nests were classified correctly. Therefore, they concluded that traditional methods of monitoring nests appeared to be effective for classifying success or failure of nests but ineffective at classifying nest predators.
2000	Population viability	Plissner JH, Haig SM. 2000. Biological Conservation 92:163–173.https://doi.org/10.1016/S0006-3207(99)00050-6	Viability of piping plover *Charadrius melodus* metapopulations	NA	Authors used a metapopulation viability analysis to examine viability and recovery objectives for plovers for the Atlantic Coast, Great Plains, and Great Lakes populations.	Baseline models indicated that Atlantic Coast plover populations, under current management practices, are at little risk of near extinction. However, Great Plains and Great Lakes populations require 36% higher mean fecundity for a significant probability of persisting for the next 100 years. Spatially-structured metapopulations exhibited lower viability than single-population models.
1993	Population dynamics	Ryan MR, Root BG, Mayer PM. 1993. Conservation Biology 7:581–585. https://doi.org/10.1046/j.1523-1739.1993.07030581.x	Status of piping plovers in the Great Plains of North America: a demographic simulation model	NA	Authors developed a stochastic population growth model using empirical demographic data for plovers in the northern Great Plains.	When using a stochastic population growth model using empirical demographic data, the plover population of the Great Plains of North America is declining by more than 7% annually. If left unchecked, this will result in extirpation in about 80 years. Annual population increases of 1% and 2% required 1.16 and 1.19 chicks per pair, respectively, which would allow the population to reach the level (2550 pairs) needed for delisting in 53 and 30 years respectively.