Directing Nest Site Selection of Least Terns and Piping Plovers

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Abstract.—Endangered Interior Least Terns (*Sterna antillarum athalassos*) and threatened Piping Plovers (*Charadrius melodus*) nest in Nebraska at gravel mines where they are vulnerable to disturbance and nest loss. Conflicts occur when their nesting and protected status delay mining activities. The possibility of shifting nesting from active to inactive mining areas by using a deterrent (mylar flagging), an attractant (gravel and driftwood spread on bare sand), and a control (untreated sand) was evaluated. Experimental plots (mean 0.36 ha) were established at 18 different gravel mines, twelve in 2000 and seven (one repeat) in 2001 along the Platte and Elkhorn rivers prior to nesting season. Of 117 tern nests, 73% were in attractant, 2% in deterrent, and 26% in control plots. Of 23 plover nests, 61% were in attractant, 9% in deterrent, and 30% in control. Colonies used plots containing less vegetation and more driftwood than unused plots. Within control plots, both tern and plover nests were surrounded by more large (>15 mm) gravel and less coarse sand than was available at random points. Within attractant plots, substrate at the nest did not differ from random points. In all plots, Least Tern nests were more likely to have driftwood by the nest than was available at random points. Hatching rates did not differ between attractant and control plots. To attract Least Terns and Piping Plovers, sand covered with 15% small gravel, 5-10% large gravel, <3% vegetation, and about ten pieces driftwood/1,000 m^2 was found to be effective. As deterrents, mylar streamers 7 m long, 30 mm wide, and 0.025 mm thick, attached to 1 m poles arranged in a 7 m grid were used. The combination of attractant and deterrent treatments provided a mechanism to protect nesting birds and avoid conflicts. *Received 28 June 2006, accepted 18 December 2006.*

Key words.—Conflict avoidance, Elkhorn River, gravel mines, Interior Least Terns, mylar flagging, Nebraska, nest site selection, Piping Plovers, Platte River.

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This paper is dedicated to the memory of John J. Dinan who loved birds and life but was taken by leukemia in August 2005.

In the Great Plains, endangered Interior Least Terns (*Sterna antillarum athalassos*) and threatened Piping Plovers (*Charadrius melodus*) nest on sandbars in major rivers and on sand spoil piles at sand and gravel mines located along the rivers (Sidle and Kirsch 1993). When these birds nest near mining or construction activities at gravel mines they are vulnerable to disturbance and destruction of nests or chicks (Lackey 1994). The U.S. Fish and Wildlife Service (1988, 1990) identified human disturbance as one of the important factors imperiling these birds. Additionally, their protected status can delay or alter work activities, causing hardship and economic loss (Held *et al.* 2005).

One way to avoid potential conflicts at gravel mines is to influence nest site selection so that birds shift nesting away from work activity areas to non-work areas. Few studies have attempted to manipulate nest site selection for terns and plovers by altering the suitability of the habitat (Saliva and Burger 1989). We evaluated mylar flagging (reflecting tape) as a deterrent (Bruggers *et al.* 1986) and gravel and driftwood scattered on the bare sand as an attractant (Kirsch 1992).

Mylar flagging of various types and configurations has been effective in deterring Canada Geese (*Branta canadensis*; Heinrich and Craven 1990), blackbirds, and various other species (Bruggers *et al.* 1986; Dolbeer *et al.* 1986) from agricultural crops, although some species did not respond. Mylar flagging was somewhat effective in repelling Snow Geese (*Chen caerulescens*, Mason and Clark

1994) and Brant (*Branta bernicula*, Summers and Hillman 1990) from farm fields, and Ring-billed (*Larus delawarensis*) and Herring (*Larus argentatus*) Gulls from loafing areas (Belant and Ickes 1997), but was ineffective in deterring Herring Gulls from nesting sites. Mylar flagging was also ineffective in repelling birds from blueberries (Tobin *et al.* 1988) and Great-tailed Grackles (*Quiscalus mexicanus*) from citrus groves, the latter apparently because of winds, breakage, and tangling in vegetation (Tipton *et al.* 1989). To our knowledge, mylar flagging has not been tested before on terns or plovers. It appears to be safe, without hazard to the birds, and affects only the immediate area where deployed. As with most repellents, effectiveness appears to vary by species and situation, method of use, level of need for the resource being protected, and whether suitable alternative resources are available nearby. In this study, mylar reflecting tape was evaluated as a tool to shift Least Tern and Piping Plover nesting sites, nest success was monitored to document any effects, and plot characteristics were measured to determine how well attraction plots matched control sites selected for nesting.

METHODS

Study Area

In Nebraska, sand and gravel are mined in the floodplain of the Platte, Loup, and Elkhorn rivers. A typical operation results in a constructed lake where materials are dredged, a gravel plant where materials are sorted and transported, and a spoil pile of unused sand. Least Terns and Piping Plovers nest on these spoil piles. Work activities on these spoil piles can include pumping a wet slurry of new sand, storing equipment, removing sand for sale, and housing development following completion of mining activities.

Eighteen different gravel mines were available and suitable for use in this study. In 2000, twelve gravel mines along the Lower Platte River (mouth of the Loup River to confluence with the Missouri River) were used. In 2001, six new gravel mines along the Central Platte (between Central City, NE and the mouth of the Loup River) and Elkhorn Rivers were used and the experiment was repeated at one gravel mine on the Lower Platte. Within each mine the most suitable nesting habitat was identified and divided into three similar plots of approximately equal area, shoreline, and distance to vegetation, so that plots would be as ecologically similar as possible. Other researchers have implicated width of beach, distance to water, distance to vegetation, amount of vegetation, presence of shells or pebbles in the sand substrate, elevation, slope, previous breeding history at a site, and human disturbance as factors influencing nest site selection by Least Tern and Piping Plovers (Thompson and Slack 1982; Gochfeld 1983; Kotliar and Burger 1986; Prindiville Gaines and Ryan 1988; Wiens and Cuthbert 1988; Burger and Gochfeld 1990; Flemming *et al.* 1992; Espie *et al.* 1996). Overall mean plot size was 3,565 m^2 (SE = 556 m^2, range 600-14,000 m^2). Two mines each year had sufficient space for only two plots.

Treatments

Each year, plots were assigned one of three treatments, deterrent (mylar flagging), attractant (gravel and driftwood), or control (untreated sand). In 2000, treatments were randomly assigned to plots at seven gravel mines and non-randomly in a way to avoid conflicts with mining activities at five mines (Table 1). In 2001, treatments were assigned to plots randomly at four gravel mines and non-randomly at three. At gravel mines with non-random treatments, we attempted to make plots of equal size and similar probability for nesting. Because non-random plots were assigned based on using the deterrent treatment in areas of planned work activities, treatments may be considered randomly assigned with respect to colony nest site selection. That is, at most mines the areas with planned work activities and those without appeared approximately equal in attractiveness for nesting, with the possible exception of Mines 7 and 3 (Table 1), each of which included a peninsula that appeared attractive to birds. At site 7, to minimize the probability of conflict with work planned on the peninsula, deterrent and control plots were assigned to the peninsula, divided length-wise, and the attractant plot was placed on the shore of the lake near the base of the peninsula. At Mine 3, the deterrent plot was placed along the shoreline to deter birds from in front of a dredge, and the attractant and control plots were randomly assigned to an adjacent semi-circle shaped peninsula.

In addition to the above 18 experimental sites, observations are reported from two "non-experimental" gravel mines in 2000 and three in 2001 but these were not included in statistical analyses. At these sites, a single treatment (deterrent or attractant) was used to shift birds away from areas where mining activities were planned. In 2000 and 2001, mylar flagging was erected over a nesting area of about 1,200 m^2 at a gravel mine where no suitable attractant plot could be created. In 2000 an attractant plot of about 5,600 m^2 was created at one mine but additional plots could not be established. In 2001, a mylar grid and three eye-spot balloons were deployed over an entire peninsula (approximately 5,000 m^2) except for a portion of the peninsula neck. At a fourth non-experimental site, a gravel mine operator erected a single line of mylar flagging in 2001, attempting to deter nesting from approximately 2,000 m^2 of sand.

The mylar tape ("Birdscare Flash Tape," Sutton Agricultural Enterprises, Salinas, California) was metallic red and silver on opposite sides, 30 mm wide and 0.025 mm thick. Initially, a 25-mm wide mylar ("BirdBaffler Reflective Tape") with silver on both sides was used, but this variety frayed and broke under windy conditions and was replaced by the 30-mm tape half way through the first season.

One end of each 7-m mylar streamer was attached to a 1-m fiberglass pole, and the other end allowed to wave freely. The poles were arrayed in a 7-m grid covering the entire plot. The streamer produced bright flashes from reflected sunlight and a loud rippling noise caused by blowing wind. The loose end of the streamer could

Table 1. Number of Least Tern and Piping Plover nests initiated in study plots at gravel mines, Platte and Elkhorn Rivers, Nebraska, 2000-2001.

Gravel mine[a]	Mean plot size (m^2)	Species	No. nests initiated				
			Attractant	Deterrent	Control	Outside plots	Total
1[b]	2,500	Tern	14	0	0	2	16
		Plover	1	0	0	0	1
2	2,541	Tern	22	0	0	5	27
		Plover	3	0	0	0	3
3[b]	11,395	Tern	8	0	7	18	33
		Plover	2	0	0	1	3
4	7,166	Tern	0	0	0	1	1
		Plover	0	0	0	2	2
5	5,060	Tern	10	0	7	3	20
		Plover	1	0	1	4	6
6	4,233	Tern	0	0	0	4	4
		Plover	1	1	1	0	3
7[b]	3,133	Tern	1	1	11	7	20
		Plover	0	1	3	0	4
8	2,216	Tern	0	0	0	0	0
		Plover	1	0	0	0	1
9	3,395	Tern	0	0	0	0	0
		Plover	0	0	0	1	1
10[b]	2,254	Tern	1	0	—	0	1
		Plover	0	0	—	0	0
11[b]	3,501	Tern	0	—	0	0	0
		Plover	2	—	0	0	2
12	1,576	Tern	16	0	3	0	19
		Plover	0	0	1	0	1
12[b]	2,280	Tern	11	0	1	0	12
		Plover	1	0	1	0	2
13	2,361	Tern	0	0	0	0	0
		Plover	1	0	0	0	1
14	600	Tern	0	—	0	0	0
		Plover	0	—	0	0	0
15[b]	1,803	Tern	0	1	0	5	6
		Plover	0	0	0	1	1
16	2,600	Tern	2	0	1	6	9
		Plover	1	0	0	0	1
17	1,622	Tern	0	0	0	0	0
		Plover	0	0	0	0	0
18[b]	3741	Tern	—	0	0	0	0
		Plover	—	0	0	0	0
Totals	3,565	Tern	85	2	30	51	168
		Plover	14	2	7	9	32

[a]Gravel mines 1-11 were used in 2000, 13-18 in 2001, and 12 was used both years.
[b]Non-random site where one or more plots were not randomly assigned so that birds could be deterred from a planned work area.

potentially touch ground-nesting birds, providing a further deterrent. Scattered vegetation sometimes interfered with movement of streamers and caused them to snag, fray, and break. The 25-mm mylar lasted two to three weeks, whereas the 30-mm held up for four to six weeks under windy conditions. The streamers were replaced as needed throughout the nesting season.

To create the attractant plot a front-end loader was used to spread a thin layer of road gravel (5-20 mm diameter) over the sand in strips. Volunteers from the "Adopt a Colony" program then raked the gravel across the plot and scattered approximately 30 pieces of driftwood (10-100 mm thick, 20-100 cm long) throughout the gravel field, resulting in about ten pieces of driftwood/1,000 m^2.

Substrate Analysis

The substrate within study plots and immediately surrounding nests was measured using a 1 m^2 sampling frame (Daubenmire 1959). At nests, the sampling frame was centered on the nest and data were recorded shortly after nest outcome was completed. To measure substrate within plots, two transects were randomly selected, perpendicular to each other, in each treatment plot during July and August. Starting from a random point along transects, six (year one) or eight (year two) sampling frames were placed 20 m (paces) apart, with the near edge of the frame centered on the transect where the 20th pace fell. In all sampling frames, the percent cover of four substrate categories (fine sand <1 mm, coarse sand 1-4.9 mm, small gravel 5-15 mm, and large gravel >15 mm diameter), the horizontal vegetation cover, and the presence of driftwood or similar objects within the frame were recorded.

To test for selection at the scale of the plot, sampling frame data from 21 used (at least 1 nest initiated) and 21 unused (no nests) experimental plots were compared. Gravel mines that did not attract any birds were excluded from this analysis because selection against the site may have been at a scale larger than the plot. To test for selection at the scale of the nest, measurements at nests were compared to random points within used attractant and control plots; deterrent plots had too few nests to make nest-scale comparisons.

Statistical Analyses

At the one experimental mine used in both years (Mine 12), it was assumed that the nesting response to plots was not independent between years, so results were averaged for this mine across years for analyses. The distribution of nests among treatments was evaluated using a Chi-square test. The presence of driftwood among plots and between nests and random points was compared using a Z test for proportions. The proportion of each type of substrate among treatment plots and between nests and random points was compared using least squares means and the least significant difference (LSD) multiple comparison procedure, computed using PROC GLM and PROC MIXED in SAS (SAS Institute 1999). Hatching success was calculated using the Mayfield method (Mayfield 1961, 1975) and daily survival rates were compared using a Z test for proportions. Successful nests were defined as nests that hatched at least one chick.

RESULTS

Of 120 nests initiated in study plots in 2000, 83 (69%) were in attractant, 34 (28%) in control, and three (3%) in deterrent plots. In 2001, 20 nests were initiated in study plots with 16 (80%) in attractant, 3 (15%) in control, and one (5%) in deterrent plots. Distribution of nests among treatments did not differ between years (χ^2_2 = 1.27, n.s.) so years were combined for subsequent analyses.

Both Least Terns ($\chi^2_2 = 91.4$, $P < 0.001$) and Piping Plovers ($\chi^2_2 = 9.46$, $P < 0.003$) avoided deterrent plots and selected attractant or control plots (Table 1). Attractant plots consistently had numerically more birds than did control, except for Mine 7 where the control plot was located on a peninsula but the attractant was not. Of the 16 mines that had both deterrent and alternative nesting plots available, 13 (81%) had no nests in the mylar-protected area so mining activities could proceed without disturbing birds, and the remainder had only one or two nests in deterrent plots.

One non-experimental mine (deterrent only), observed in 2000 and 2001, had one tern nest initiated each year within the mylar grid area and two to eight additional tern nests in marginal habitat outside the mylar. The non-experimental peninsula mine, which had a mylar grid and eye-spot balloons installed in 2001, had two nests (one tern, one plover) initiated in the treatment area in 2001 compared to 22 in 2000 before treatment. At this mine, an additional eleven nests in 2001 were initiated near the neck of the peninsula where no mylar was erected. Construction activities were delayed until August to protect the two vulnerable nests on the peninsula. The single line of mylar flags erected by a gravel operator generally deterred nesting from the immediate reach of the mylar but the mylar was not maintained to replace broken or snagged portions and was ineffective in deterring birds from the area.

Mylar appeared not to affect nesting success of the few birds that nested within a mylar grid. Of eight nests (three plover, five tern) initiated in mylar (including non-experimental sites) four hatched, three failed, and one had an unknown outcome. Of the three failures, one each was attributed to predation, abandonment, and cause unknown. After the eggs hatched, the parents moved the chicks out of the mylar area. Both tern and plover broods were infrequently observed within the mylar grids. For all gravel mine nests combined, 44 hatched, 43 failed, and 22 had unknown outcomes, so results from the nests in mylar areas are roughly similar.

No substrate differed between control and deterrent plots, where the substrate was not manipulated (absolute t-value, $t_{20} \leq 1.19$, n.s.). Compared to control and deterrent plots, attractant plots had more small ($t_{20} \geq 5.65$, $P < 0.0001$) and large ($t_{20} \geq 2.70$, $P < 0.01$) gravel and more driftwood ($Z \geq 2.02$, $P < 0.04$), but less coarse sand ($t_{20} \geq 3.76$, $P < 0.001$) (Table 2). Coarse sand, the primary pre-treatment substrate, was partially covered by the added materials.

No sand or gravel substrate differed between plots used for nesting and those not used (absolute t-value, $t_{20} \leq 1.17$, n.s.), but used plots had less vegetation cover (1.6% vs. 6.4%; $t_{22} = 2.06$, $P = 0.05$). Plots used by either Least Terns ($Z = 2.75$, $P = 0.005$) or Piping Plovers ($Z = 2.66$, $P = 0.005$) had more driftwood than unused plots (8.5% of samples in plots used by least terns contained driftwood vs. 0.9% in unused plots, and 9.5% vs. 2.4% for plovers).

Substrate composition at nests in attractant and control plots did not differ from random points within attractant plots (Table 3) indicating that the substrate in attractant plots was similar to that at nests. Within control plots, however, Least Tern nests had more large gravel ($t_{192} = 2.12$, $P = 0.04$), more fine sand ($t_{145} = 2.11$, $P = 0.04$), and less coarse sand ($t_{132} = -2.59$, $P = 0.01$) than was found at random points. The substrate at Piping Plover nests in control plots showed a similar pattern but the sample size was smaller and the difference in large gravel was not significant (Table 3).

Least Tern nests were more likely to have driftwood present than random points ($Z = 4.46$, $P = 0.0005$). Although Piping Plovers selected plots with more driftwood available than unused plots, they were not more likely ($Z = 0.29$, n.s.) to have driftwood at the nest than was found at random points within used plots. Of 158 Least Tern nests found during the course of all field activities in 2000 and 2001, 44 (29%) had driftwood within the 1 m^2 sampling frame compared to two (8%) of 26 plover nests.

For both years combined, no difference was found between attractant and control plots in daily nest survival rates (DSR) for Least Terns ($Z = 1.16$, n.s.) or Piping Plovers ($Z = 1.00$, n.s.). Least Terns nests had a DSR of 0.9901 (VAR 0.0000195, N = 503 exposure days) in control plots and 0.9827 (VAR 0.0000114, N = 1500 exposure days) in attractant plots. These results include 6 Least Tern nests placed in an attractant plot at a non-experimental site. Piping Plover nests had a DSR of 0.9577 (VAR 0.0004290, N = 94.5 exposure days) in control plots and 0.9779 (VAR 0.0000957, N = 226 exposure days) in attractant plots. Sample sizes were too low to calculate DSRs in deterrent plots.

No substrate measurement differed between successful and unsuccessful nests (absolute t-value, $t_{144} \leq 1.73$, n.s.). The presence of driftwood did not affect hatch rates for Least Terns (77% hatch success with driftwood, 66% without, $\chi^2_2 = 1.59$, n.s.).

DISCUSSION

A major issue in management of threatened and endangered species is how to provide adequate protection for the species and yet avoid conflicts with human activities, particularly those that have economic impacts. The combination of deterrent and attractant treatments used in this study, with coopera-

Table 2. Means and standard errors (SE) of percent sand, gravel, and vegetation cover at random points within nest site selection experiment plots at gravel mines along the Platte and Elkhorn rivers, Nebraska, 2000 and 2001. Values for driftwood are percent of samples that contained a piece of driftwood or similar object. Values with the same letter within a row are not significantly different.

	Attractant	Deterrent	Control
Vegetation	2.2 (1.5) A	5.1 (1.8) A	4.4 (1.8) A
Substrate			
Fine Sand (<1 mm)	14.7 (3.0) A	18.8 (3.5) A	13.1 (3.5) A
Coarse Sand (1-4.9 mm)	57.2 (4.0) A	80.0 (4.6) B	84.8 (4.6) B
Small Gravel (5-15 mm)	20.0 (2.2) A	0.5 (2.5) B	1.2 (2.5) B
Large Gravel (>15 mm)	8.0 (1.7) A	0.8 (2.0) B	0.9 (2.0) B
Driftwood	8.9 A	0.9 B	2.7 B

Table 3. Substrate composition and vegetation cover at Least Tern (LT) or Piping Plover (PP) nests (representing what the birds selected) and at random points within used plots (representing what was available to them in the area around their nest) at gravel mines along the Platte and Elkhorn rivers, Nebraska, 2000 and 2001. A used plot is defined as a plot with at least one nest initiated in it. Values with the same letter within a row are not significantly different (P > 0.05).

		Attractant plots		Control plots	
		Nests	Random	Nests	Random
Fine Sand	LT	16.8 A	13.4 AB	16.1 A	8.5 B
	PP	18.7 A	17.2 A	19.8 A	12.5 B
Coarse Sand	LT	56.5 A	53.5 A	64.9 A	85.4 B
	PP	43.2 A	54.7 A	43.3 A	79.2 B
Small Gravel	LT	18.9 A	23.3 A	9.0 AB	3.0 B
	PP	28.4 A	20.4 A	29.6 A	17.6 A
Large Gravel	LT	7.9 A	10.0 A	9.5 A	3.0 B
	PP	10.0 A	6.2 A	11.6 A	1.6 A
Vegetation	LT	2.2 A	3.1 A	1.5 A	2.0 A
	PP	4.6 A	1.7 A	3.2 A	3.0 A

tion of the mine operators, successfully prevented most conflicts, reducing disturbance to the birds and saving the mining companies lost revenue. For example, in 2003, use of mylar resulted in savings of up to $150,000 U.S. in potential lost revenue, based on industry estimates by type, size, and timing of conflict (Held *et al.* 2005) and savings of >$500,000 U.S. were reported in both 2004 and 2005 (R. Held, pers. comm.).

The results and additional observations at non-experimental mines indicate that shifting nesting locations within a mine is probably easier than moving them completely off of a mine, and that providing both deterrent and attractant areas will probably be more successful than providing just one of the treatments alone. In situations where nesting is not deterred completely, the substantial reduction in nesting may allow some work activities to proceed, depending in part on the nest location in relation to activities planned. Further, in situations where the birds must be deterred from an entire mine and no attractant or untreated alternatives are available, the mylar treatment alone appears to offer substantial reduction in the numbers of nesting birds. The failed attempt by a mining operator to deter birds using a strip of mylar, rather than a grid, and without maintaining it, indicates that the technique must be applied appropriately to be effective. Because these birds are imperiled and because even one nest may alter work plans, we recommend the technique be applied by individuals familiar with both the biology and behavior of these birds and the proper installation and maintenance of the deterrent and attractant techniques.

One potential trade-off to consider when using gravel as an attractant is that gravel is difficult to remove should plans for the site change (R. Held, pers. comm.). For example, housing developments sometimes follow when gravel mining operations are completed, and sites that remain attractive to nesting birds could result in conflicts with housing development or with recreational use of housing lots prior to development. Driftwood, however, can be easily removed, so in situations where future uses might result in conflicts with nesting birds, using only driftwood as an attractant may be preferred.

Our observations suggest that nesting on a peninsula may be more attractive to the birds than a linear shoreline. At Mine 7, a peninsula was divided between deterrent and control plots, while the attractant was placed along the shoreline. The bulk of the nests were placed in the control plot and a few in the mylar, indicating that site layout may be a primary nest site selection factor, while substrate may be secondary. At Mine 3, the deterrent was placed along a shoreline while the attractant and control plots were on a peninsula, and no nests were initiated in the deterrent plot while nests were split between attractant and control on the peninsula.

Earlier reports indicate that mylar strips appear to frighten birds by movement and associated reflected light and sound (Bruggers *et al.* 1986; Dolbeer *et al.* 1986; Heinrich and Craven 1990). In our study, in several instances where nests were initiated within the mylar grid, the nearest mylar flag had been snagged on vegetation and could not blow freely. Additionally, a few of the nests initiated outside of experimental plots were close to the mylar grid but out of reach of the outermost flagging. These observations suggest that the risk of being physically touched by a blowing streamer may be a greater factor in deterring nesting Least Terns and Piping Plovers than the sound or reflected light.

Lack of vegetation and the presence of driftwood appear to be factors influencing nest site selection at the scale of the plot (roughly analogous to colony site selection within a gravel mine). Gochfeld (1983) and Kotliar and Burger (1986) found that sparse vegetation was an important factor in Least Tern colony site selection. Espie *et al.* (1996) found that beaches with plover nesting had significantly more gravel substrate than non-nest beaches, and Prindiville Gaines and Ryan (1988) found that gravel was more abundant in plover territories compared to unoccupied sites. In our study, the presence of gravel did not appear to influence whether a plot would be occupied, but was a significant factor in the placement of nests within control plots.

At the scale of the nest, there appears to be a mix of substrates that the birds prefer. In attractant plots, substrate was used in proportion to its availability, whereas in control plots, the terns used spots where large gravel was available and piping plovers, although with smaller numbers and not statistically significant, showed a similar biological pattern. The fact that substrate composition at nests did not differ between attractant and control plots, despite differences between these plot types, indicates that our attractant treatment matched the substrate that the birds typically select.

Our results indicating that driftwood is attractive, especially to Least Terns, is similar to findings reported earlier that 21 of 149 (14%) Piping Plover nests and 95 of 132 (72%) Least Tern nests in Nebraska had driftwood or a similar object near the nest (J. Ducey 1983; unpublished data). Conway *et al.* (2003) found that 65% of Least Tern nests in Texas were within 15 cm of driftwood and/or rocks, though nests were not associated with objects more frequently than random sites. Possible reasons for placing nests near gravel or driftwood could include the potential for greater concealment from predators and protection from weather. For example, gravel might help prevent fine sand from blowing as much, and driftwood might create a lee from the wind. Both gravel and driftwood could help stabilize the sand when heavy rains wash over the nesting area.

Such debris, however, may not translate into increased nest success. Winton and Leslie (2003) found that predation was highest on least tern nests ≤5 cm from driftwood or hay. In studies of snowy plovers (*C. alexandrinus*), Page *et al.* (1985) found lower hatch success from nests placed next to objects compared to those placed in the open, and lower success on sand and gravel substrate than on more uniform alkali substrate. Further study is needed to better clarify the role of nest substrate and driftwood or similar objects near nests in relation to factors such as weather effects and various types of predators that might be present.

Our results indicate that a combination of a deterrent and an attractant were effective in shifting nest locations of Least Terns and Piping Plovers away from areas where construction activities such as equipment access, pumping, or sand removal were planned and where recreationists on motorized off road vehicles frequented. Birds were attracted to sites that had ground cover of <5% vegetation, 5-10% large gravel, 10-20% small gravel, and about ten pieces of driftwood/1,000 m^2. They were deterred by a 7 m grid of 30 mm wide, 0.025 mm thick mylar flagging mounted on 1 m posts, maintained throughout the period of nest site selection (April-July in Nebraska) to retain effectiveness. The combination of deterrent and attractant appears to be an effective approach for shifting nest site selection away from sites where conflicts with other uses may occur.

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