

NESTING SUCCESS AND STATUS OF THE LEAST TERN BREEDING COLONY AT GIBSON LAKE IN SOUTHWESTERN INDIANA

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ABSTRACT. Federally-endangered interior least terns (*Sterna antillarum*) have nested at Gibson Lake in southwestern Indiana since 1986. In 2003 and 2004 we evaluated nesting success of least terns and identified factors influencing their productivity at Gibson Lake. In 2003 least terns nested only at secondary breeding sites, composed of deposited ash byproducts from coal combustion. Least terns produced eight fledglings from 39 total nests in 2003; we attributed most nest failures that year to flooding during heavy rains. In 2004 the terns returned to breed at their historical primary breeding site, a narrow gravel dike that bisects Gibson Lake (center dike). However, nesting success again was low in 2004 (13 fledglings produced from 84 total nests), although we attributed most nest failures in 2004 to predation on eggs and chicks by ring-billed gulls (*Larus delawarensis*). Our study implicated ring-billed gulls as the chief source of mortality on least tern eggs and chicks. The future success of the least tern breeding colony at Gibson Lake ultimately may depend on the establishment and sustained management of alternate breeding areas in the Gibson Lake vicinity.

Keywords: Indiana, *Larus delawarensis*, least tern, nest success, productivity, ring-billed gull, *Sterna antillarum*

Least terns are robin-sized waterbirds that nest colonially on sandy coastal beaches, river islands, and artificial structures such as sand pits, ash disposal areas, and gravel rooftops (Thompson et al. 1997). Gibson Lake in southwestern Indiana has been used as a nesting site by least terns (*Sterna antillarum*) since 1986 (Mills 1987; Castrale et al. 1999). Preferred nest sites of the least tern are largely free of vegetation, above high water levels, and protected from ground predators (Thompson et al. 1997).

Populations of least terns declined rapidly in the early 1900s, chiefly due to exploitation by overzealous feather and egg collectors. The interior population, which breeds in the central U.S. along major river systems, further declined in the mid-1900s because of river dam-

ming, channelization, pesticide use, and human development (Thompson et al. 1997; Kirsch & Sidle 1999). The interior population of the least tern was listed as federally-endangered in 1985 (Federal Register 1985) because of low population numbers and continued threats to breeding habitats (Kirsch & Sidle 1999). In addition, nest predators often limit productivity of least terns breeding in both natural and artificial sites (Kruse et al. 2001; DeVault et al. 2005).

The least tern colony at Gibson Lake is an important component of the interior population, and potentially could serve as a source of dispersing individuals for colonies along the Wabash and Mississippi rivers. In spring 2003 we initiated research aimed at evaluating the nesting productivity (hatching and fledg-

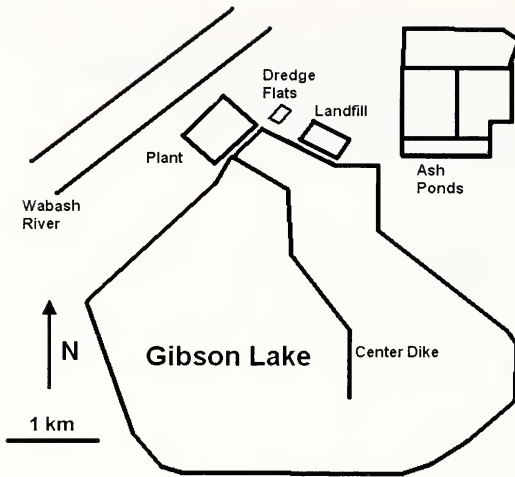


Figure 1.—Schematic of Gibson Lake and surrounding features of the Gibson Generating Station in Gibson County, Indiana. The center dike, dredge flats, landfill, and ash ponds are nesting areas for least terns. See the text for a description of the nesting areas.

ing success) of the least tern colony at Gibson Lake. In a previous paper (DeVault et al. 2005), we reported on our efforts using remote cameras aimed at model nests and actual least tern nests to identify nest predators at the Gibson Lake tern colony. We demonstrated that ring-billed gulls (*Larus delawarensis*) were responsible for most egg and chick mortality. Here, we further explore the relationship between ring-billed gulls and least tern nesting success at Gibson Lake by relating gull abundance to predation on least tern eggs and chicks. We also report on the productivity of the least tern colony, focusing on the breeding seasons of 2003–2004. Castrale et al. (1999) updated the status of the Gibson Lake tern colony from its inception in 1986 through 1998.

STUDY AREA AND HISTORY OF THE LEAST TERN COLONY AT GIBSON LAKE

The Gibson Generating Station, owned and operated by Cinergy Corp., is a large, coal-fired power generating station located in Gibson County in southwestern Indiana, adjacent to the Wabash River (Fig. 1). A principal feature of the power plant is Gibson Lake, a shallow (depth averaging 4 m) 1180 ha impoundment that cools water during the generation of

electricity. Gibson Lake contains large populations of small fish, including threadfin shad (*Dorosoma petenense*), gizzard shad (*Dorosoma cepedianum*), and brook silverside (*Labidesthes sicculus*). A narrow (~10 m wide), 3.4 km long dike (center dike), composed of crushed limestone gravel with larger riprap along the edges, bisects the lake (Fig. 1).

The breeding colony at Gibson Lake is the eastern-most established colony known to exist for interior least terns (Kirsch & Sidle 1999). Least terns first began nesting at Gibson Lake in 1986 (Mills 1987), when a single pair was found nesting on the center dike (Fig. 2). Since that time, least terns have nested at Gibson Lake every year except 1988. The center dike has been the primary nesting site during most of the history of the Gibson Lake least tern colony, although three other areas (ash ponds, landfill, and dredge flats; Fig. 1) near Gibson Lake have been used as secondary nesting sites in recent years. The three secondary nesting habitats are composed of deposited ash byproducts from coal combustion, although they vary with respect to the specific type of ash present, topography, and potential for flooding during heavy rains. Least terns first began nesting on the landfill in 2003 and on the dredge flats in 2004. The ash ponds and surrounding roads have been used for nesting by least terns periodically since 1993.

The least tern colony at Gibson Lake has been managed since its inception through cooperative agreements between the Indiana Department of Natural Resources, the U.S. Fish and Wildlife Service, and Cinergy Corp. Several management activities have been implemented on the center dike to make it more attractive to nesting least terns, including the use of decoys to attract nesting individuals, the regular use of herbicide to prevent overgrowth of vegetation, and strict control of human access during the breeding season (Johnson & Castrale 1993).

Many predators of least tern eggs and chicks (Thompson et al. 1997), such as ring-billed gulls, herring gulls (*Larus argentatus*), great blue herons (*Ardea herodias*), black-crowned night-herons (*Nycticorax nycticorax*), American crows (*Corvus brachyrhynchos*), and various hawks and owls, occupy the Gibson Lake area. Mink (*Mustela vison*) and Norway rats (*Rattus norvegicus*) have

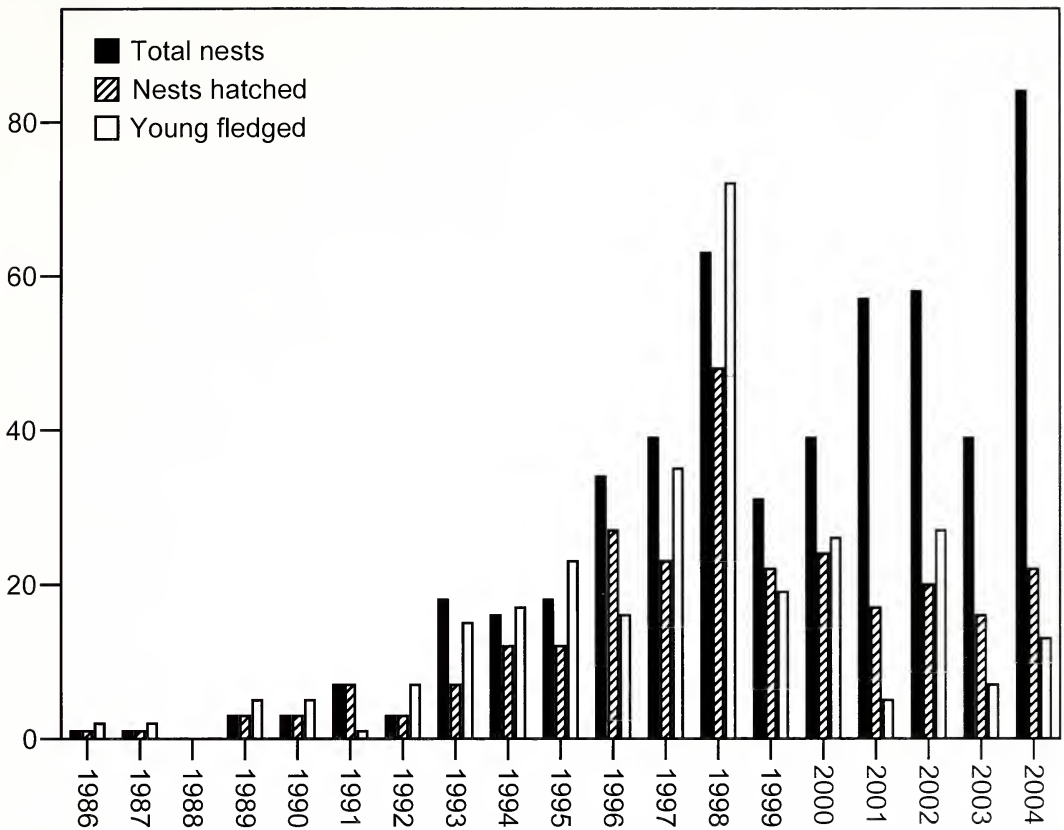


Figure 2.—Nesting productivity of least terns at Gibson Lake, Indiana, from 1986–2004. Hatched bars indicate the number of nests in which at least one egg hatched; open bars indicate the number of chicks that fledged from all successful nests.

been present on the center dike, and raccoons (*Procyon lotor*) and Virginia opossums (*Didelphis virginiana*) are common throughout the Gibson Lake area. A chain-link fence is located near the north end of the center dike to prevent medium-sized mammalian predators easy access to the colony. Also, there have been periodic efforts to control nest predation on the center dike, such as the use of strobe lights to reduce nocturnal predation by great horned owls (*Bubo virginianus*) and black-crowned night-herons, the construction of plywood chick shelters and open-top predator-exclusion fences around individual nests, and lethal control of mink, Norway rats, raccoons, and ring-billed gulls (Johnson & Castrale 1993; DeVault et al. 2005).

Throughout most of the 1990s the Gibson Lake least tern colony was one of the most productive colonies in the interior population (Castrale et al. 1999; Kirsch & Sidle 1999;

Fig. 2). As demonstrated in 1998 (72 fledglings from 63 total nests), the Gibson Lake colony has the potential to produce a substantial number of fledglings (Fig. 2). However, beginning in 1999, the nesting success (percentage of nests from which at least one chick fledged) of least terns at Gibson Lake dropped below 40%, and in 2001, nesting success dropped to only 5%. Although the number of nesting attempts by least terns at Gibson Lake increased from 31 in 1999 to 58 in 2002, nesting success averaged only 27% during that time period. In contrast, from 1995–1998, nesting success at the colony averaged 51%, with a high of 70% in 1998. The sharp decrease in productivity in recent years most likely can be attributed to increased predation on eggs and chicks (JSC unpubl. data). Although quantitative data are lacking, anecdotal observations have suggested that ring-billed gulls, in particular, have increased in number

at Gibson Lake during the years that least tern nesting success declined (JSC unpubl. data). We strongly suspect that ring-billed gulls are attracted to fish carrion that regularly accumulates around the center dike.

METHODS

Nesting productivity.—During the breeding seasons of 2003 and 2004 we visited all potential least tern nesting sites approximately every two days to search for new nests and to check the status of extant nests. Because the substrate was extremely unstable at the dredge flats, we were unable to reach those nests on foot; instead, we observed least terns nesting at the dredge flats with a spotting scope from ~50 m. At all other sites, we approached the colony on foot and recorded the position of each nest with a mobile Global Positioning System unit. During visits to nesting areas we checked all extant least tern nests for evidence of predation or abandonment. When they were 1–3 days old, we banded each least tern chick we encountered with one plastic and one aluminum leg band.

Gull surveys.—Surveys of ring-billed gulls were conducted from 20 May through 28 August in 2003 and from 15 April through 19 August in 2004 (see also DeVault et al. 2005). We conducted approximately three surveys during each week, although we postponed surveys during inclement weather. During each survey, we slowly drove around Gibson Lake and throughout the remainder of the Gibson Generating Station property (including the length of the center dike) and recorded the number of ring-billed gulls observed. After least terns began nesting on the center dike in 2004, automobiles were prohibited on the dike and we instead conducted gull surveys on foot when checking the status of nests. We conducted most (> 90%) gull surveys before 0900 h.

Statistical analyses.—For the 2004 nesting season, we used linear regression to explore the relationship between the number of ring-billed gulls roosting on the center dike and predation pressure on least tern eggs and chicks at the center dike. The number of ring-billed gulls roosting on the center dike during each consecutive one-week period of the breeding season was estimated by calculating the mean number surveyed on the center dike during the one-week period (we normally con-

ducted three surveys per week). We calculated predation pressure during each one-week period as the number of predation events on nests at the center dike recorded during each week divided by the total number of least tern nests available to predators on the center dike during that week. Analyses were performed with SPSS version 10.0 (SPSS 1999).

RESULTS

Bird surveys.—We observed a steady increase in the number of ring-billed gulls occupying the center dike during the 2003 breeding season. The number of gulls ranged from 25 individuals to over 250 near the end of the breeding season (DeVault et al. 2005). In 2004 there were fewer than 20 ring-billed gulls on the center dike from 10 May through 20 June. The relatively low number of ring-billed gulls on the center dike at the beginning of the breeding season in 2004 can be attributed to lethal removal (by shooting) of gulls in April, before least terns began nesting (DeVault et al. 2005). However, during the period 20 June to 1 August, the number of ring-billed gulls occupying the center dike rose steadily, mirroring counts from 2003 (DeVault et al. 2005).

Nesting productivity.—For the first time since 1989, least terns did not nest on the center dike at Gibson Lake in 2003. Least terns nested at the ash ponds and the landfill from 6 June through 24 July. At the ash ponds, at least one egg in 12 of 19 total nests survived to hatching, and eight chicks survived to fledging. The unsuccessful nests were lost to predation and abandonment at the ash ponds. At the landfill, at least one egg in 4 of 20 total nests survived to hatching, but no chicks survived to fledging. All nests that failed to produce chicks at the landfill were washed away during heavy rains. Least terns did not nest at the dredge flats in 2003.

In 2004, least terns constructed 84 nests from 30 May through 15 July. Seventy-two nests were constructed on the center dike and twelve were constructed at the dredge flats. There was very little exposed substrate at the ash ponds in 2004, which precluded nesting by least terns. No least tern nests were found at the landfill in 2004.

On the center dike, at least one egg in 16 of the 72 nests constructed in 2004 survived to hatching. Four chicks fledged from two

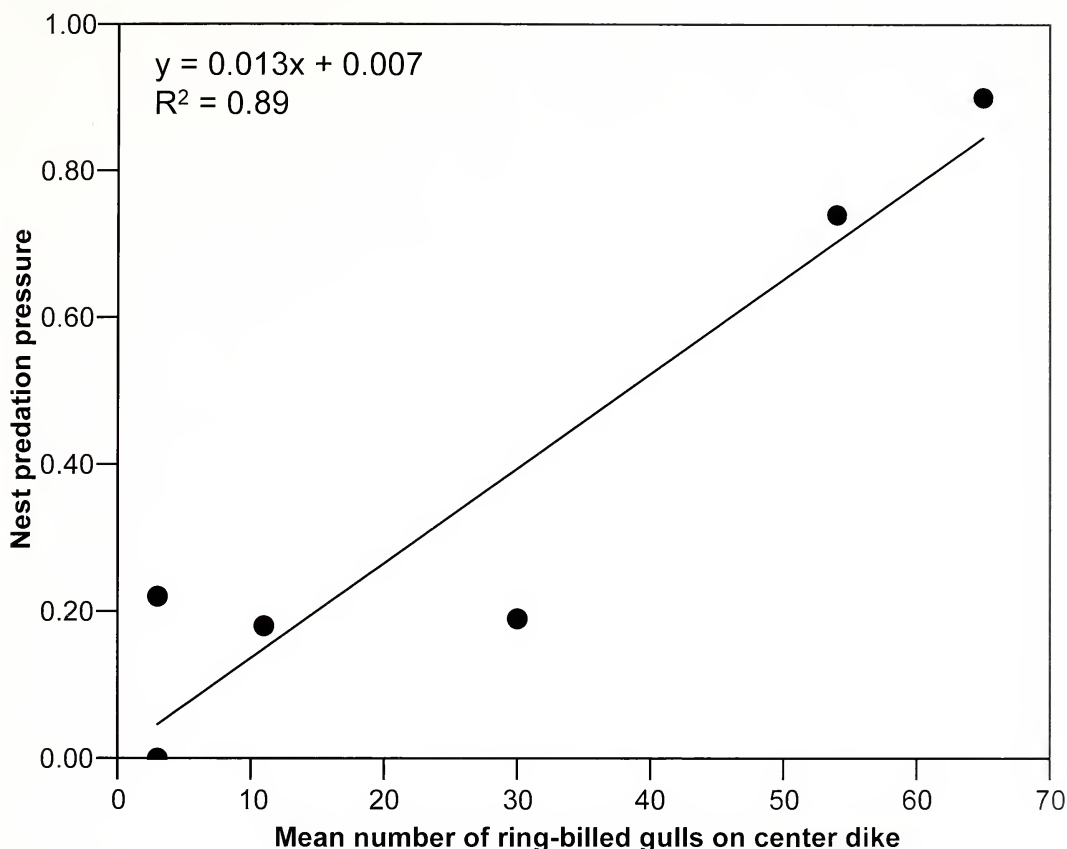


Figure 3.—Predation pressure on least tern nests on the center dike of Gibson Lake, Indiana, plotted as a function of the mean number of ring-billed gulls surveyed on the center dike. Points represent seven consecutive one-week periods from 1 June 2004 through 19 July 2004. Nest predation pressure was calculated as the number of predation events recorded during the one-week period on the center dike divided by the number of least tern nests available to predators on the center dike at some time during the week. Note that two data points occupy the point at the bottom of the graph (0 nest predation pressure; 3 ring-billed gulls).

successful nests on the center dike. Least tern hatching success on the center dike was much higher during the first 10 days of the nesting season. During the period 30 May through 10 June, 14 of the 23 nests (61%) on the center dike in which eggs were laid survived to hatching; however, only 2 of 49 nests (4%) in which eggs were laid after 10 June survived to hatching. No eggs laid after 20 June successfully hatched. Nest failure at the center dike was attributed primarily to nest predation, and nest predation pressure was strongly correlated with the number of ring-billed gulls on the center dike (Fig. 3). On the dredge flats, nine chicks fledged from four successful nests. All eight nest failures at the dredge flats were due to flooding.

Five leg bands from least tern chicks were recovered (all on the center dike): one was found in a regurgitated pellet (presumably from a ring-billed gull), and three chicks were found dead from unknown causes at nests. Additionally, one band was found lying on the ground at a nest.

DISCUSSION

One of the most convincing results of our research was that ring-billed gulls serve as the primary predators of least tern eggs and chicks on the center dike of Gibson Lake. Data from remote cameras indicated that other species, such as American kestrels (*Falco sparverius*), snakes, and Canada geese (*Branta canadensis*), occasionally prey upon or oth-

erwise damage least tern eggs and chicks, but ring-billed gulls almost certainly were responsible for most least tern egg and chick mortality at Gibson Lake in 2004 (DeVault et al. 2005).

Our data indicated that the number of ring-billed gulls present on the center dike was strongly correlated with the probability of nest predation on the dike. There were few instances of predation on least tern eggs during the first 10 days of the breeding season in 2004, when ring-billed gulls were scarce. However, ring-billed gulls gathered at Gibson Lake, and particularly at the center dike, over the course of the breeding season; and by late June in 2004, the population of ring-billed gulls on the center dike had grown to a size that apparently precluded successful nesting by least terns (Fig. 3; see also DeVault et al. 2005). Thus, a reduction of ring-billed gulls on the center dike likely would increase the productivity of least terns at Gibson Lake, but only if the number of ring-billed gulls occupying the center dike could be maintained at a minimum (< 20 individuals) during the entire breeding season.

Although predation by ring-billed gulls on least tern eggs and chicks was the primary source of mortality on the center dike, we recorded relatively few predation events at the three secondary nesting areas. In 2003, breeding least terns were moderately successful at the ash ponds (eight fledglings from 19 nests); and although no fledglings were produced at the landfill, the primary source of mortality at that site was flooding, not predation. Similarly, in 2004, nine chicks fledged from four successful nests at the dredge flats; and all mortality at that site also was caused by flooding. Although it is difficult to control mortality from flooding, it may be possible to deter least terns from nesting in areas where they have a low probability of producing fledglings (i.e., the landfill) using a suite of fear-provoking stimuli (Conover 2002).

The least tern colony at Gibson Lake has continued to grow in terms of the number of nests constructed (Fig. 2), but the colony undoubtedly will serve only as a population sink (Pulliam 1988) or reproductive trap (Gates & Gysel 1978; Battin 2004) unless a higher percentage of nests begin to produce fledglings. It now appears evident that least terns breeding on the center dike will continue to suffer

from substantial nest predation unless numbers of ring-billed gulls can be controlled. Unfortunately, the logistic difficulties and ethical issues associated with lethal removal of large numbers of gulls lessen the ability to successfully manage the center dike as a nesting area for least terns at Gibson Lake. Also, nest disturbance techniques (e.g., Ickes et al. 1998) are not viable because ring-billed gulls do not breed at Gibson Lake (most present are juvenile loafers). Thus, the ultimate solution for effective conservation of least terns in the Gibson Lake vicinity likely will involve the establishment and sustained management of alternate nesting habitats.

Extensive efforts are underway to increase the available nesting habitat for least terns on sites adjacent to Gibson Lake. Two properties, the Cane Ridge Wildlife Area (owned and managed by the U.S. Fish and Wildlife Service) and Tern Bar Slough (owned and managed by the Indiana Department of Natural Resources) are being developed to provide new nesting habitats for least terns. At the Cane Ridge Wildlife Area, a 24 ha impounded least tern nesting unit containing a 1.2 ha nesting island, was constructed recently. This nesting unit will be operated and managed specifically for nesting least terns, and managers will attempt to attract least terns to the nesting unit with decoys and vocalizations (Johnson & Castrale 1993). Tern Bar Slough is approximately 340 ha, and plans are being developed to include least tern nesting islands during the restoration of that property.

Least terns began nesting at the Cane Ridge Wildlife Area during the breeding season of 2005 and appear to be producing fledglings at a high rate. Thus far, ring-billed gulls have not been present in significant numbers at Cane Ridge. We anticipate that ring-billed gulls will not roost commonly at Cane Ridge or Tern Bar Slough, and thus will not be a major source of mortality to least tern eggs and chicks at those locations. Ring-billed gulls were observed only rarely at sites other than the center dike during our bird censuses in 2003 and 2004. Furthermore, during experiments with remote cameras at the ash ponds and landfill, we recorded no instances of predation on model nests or actual least tern nests by ring-billed gulls (DeVault et al. 2005). We expect that the center dike will continue to be the preferred roosting site for ring-billed gulls

in the Gibson Lake vicinity because of its isolation to land and because of the reliable food source present there in the form of fish carrion (DeVault et al. 2005). However, if ring-billed gulls prove to be a major source of mortality to least tern eggs and chicks at the Cane Ridge Wildlife Area or Tern Bar Slough, other management techniques should be evaluated, such as the removal of gulls by trapping and the use of fear-provoking stimuli to repel gulls from least tern nesting areas.

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LITERATURE CITED

- Battin, J. 2004. When good animals love bad habitats: Ecological traps and the conservation of animal populations. *Conservation Biology* 18: 1482–1491.
- Castrale, J.S., C.E. Mills & T. Hayes. 1999. Growth of the least tern population at Gibson Lake, Indiana. *Indiana Audubon Quarterly* 77: 150–158.
- Conover, M.R. 2002. *Resolving Human-Wildlife Conflicts: The Science of Wildlife Damage Management*. CRC Press, Boca Raton, Florida. 418 pp.
- DeVault, T.L., M.B. Douglas, J.S. Castrale, C.E. Mills, T. Hayes & O.E. Rhodes, Jr. 2005. Identification of nest predators at a least tern colony in southwestern Indiana. *Waterbirds* 28(4):445–449.
- Federal Register. 1985. Endangered and threatened wildlife and plants; interior population of the least tern determined to be endangered. *Federal Register* 50:21784–21792.
- Gates, J.E. & L.W. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. *Ecology* 59:871–883.
- Ickes, S.K., J.L. Belant & R.A. Dolbeer. 1998. Nest disturbance techniques to control nesting by gulls. *Wildlife Society Bulletin* 26:269–273.
- Johnson, R.R. & J.S. Castrale. 1993. Management of breeding interior least terns in Indiana. *Proceedings of the Indiana Academy of Science* 102:59–65.
- Kirsch, E.M. & J.G. Sidle. 1999. Status of the interior population of least tern. *Journal of Wildlife Management* 63:470–483.
- Kruse, C.D., K.F. Higgins & B.A. Vander Lee. 2001. Influence of predation on piping plover, *Charadrius melodus*, and least tern, *Sterna antillarum*, productivity along the Missouri River in South Dakota. *Canadian Field-Naturalist* 115: 480–486.
- Mills, C.E. 1987. Indiana's first least tern nesting record. *Indiana Audubon Quarterly* 65:42–44.
- Pulliam, H.R. 1988. Sources, sinks, and population regulation. *American Naturalist* 132:652–661.
- SPSS. 1999. *SPSS Base 10.0 Applications Guide*. SPSS Inc., Chicago, Illinois. 426 pp.
- Thompson, B.C., J.A. Jackson, J. Burger, L.A. Hill, E.M. Kirsch & J.L. Atwood. 1997. Least tern. *In* *The Birds of North America*, No. 290 (A. Poole & F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, D.C. 32 pp.

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