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03. Population Demographics of the Loggerhead Shrike: Insights into the Species Decline from a Long-Term Study in the Midewin National Tallgrass Prairie

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Population Demographics of the Loggerhead Shrike: Insights into the Species Decline from a Long-Term Study in the Midewin National Tallgrass Prairie

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ABSTRACT   We monitored a breeding population of loggerhead shrikes (*Lanius ludovicianus*) in the Midewin National Tallgrass Prairie from 2005 to 2016. Demographic data were compiled annually, including information on population size, age structure, and reproductive success. We banded adult shrikes, with some additional effort focused on nestlings (2005–2007) and independent hatch-year birds (2014–2016). We measured return rate as the number of birds that were previously banded. Site reuse rates were quantified as the use of a breeding territory in multiple years. Site fidelity, the use of a site by the same male or female in consecutive years, and dispersal distance of banded birds from their natal or previous breeding territory were assessed in 2015 and 2016, after inception of a color-banding program in 2014. Population size ranged from 4 to 14 breeding pairs, with additional single nonbreeding birds noted in most years. The percentage of the population that successfully fledged at least one young each year ranged from 50 to 100%. First nests were more often unsuccessful than later nests. Site reuse was high, and appears related to nesting success in the preceding year, suggesting that shrikes use postbreeding information when selecting nest sites. The ratio of second-year (SY, first year breeder) to after-second-year (ASY) birds varied by year and among sex, with larger-than-expected numbers of SY female birds. Average natal dispersal distance within Midewin was 0.97 km, and average adult dispersal distance was 1.6 km. Female dispersal distance was slightly greater than that of males (2.1 km vs. 1.3 km). By the end of each breeding season, the majority of the known adult population was banded, but approximately only one-third of the banded population returns at the start of the subsequent breeding season. Population size and trend appear correlated with number of ASY birds, and immigration rates of unbanded birds include first-year breeders and those that have bred at least once before, likely from outside of Midewin.

KEY WORDS age ratio, dispersal, *Lanius ludovicianus*, leg banding, loggerhead shrike, nesting success, population size, population trend, site fidelity, site reuse

The loggerhead shrike (*Lanius ludovicianus*) is one of only two species of shrike that occur in the New World, and the only shrike endemic to North America. The species utilizes a variety of shrub and grassland habitats that vary from shrub–steppe in the western United States to unimproved pastureland associated with limestone plains in the eastern Canadian province of Ontario, to longleaf pine savanna in the SE Coastal Plain (Pruitt 2000). Shrikes breeding in northern portions of their range undertake short-distance migration to more southerly states and Mexico, wintering generally south of 47° latitude (Yosef 1996, Chabot et al. unpublished data). The wintering range is almost entirely encompassed within that of non-migrant conspecifics (Yosef 1996, Chabot et al. forthcoming).

The range of the loggerhead shrike before European colonization is unclear. It is believed that in the late 1800s, the species expanded into NE North America with the clearing of land for agriculture (Cadman 1985). By the mid-1900s, the shrike was considered to be common throughout the continent. However, by the 1950s, northeastern populations were noted to be in decline (Pruitt 2000). Since 1960, this trend has also been observed throughout North America, but with the greatest decline among migratory populations (Sauer et al. 2014). The species is now rare in much of its former range (Sauer et al. 2014), even where apparently suitable habitat still exists (Pruitt 2000). The U.S. Fish and Wildlife Service considers the loggerhead shrike to be a bird of conservation concern and it is listed as a focal species in the State Wildlife Action Plans for 28 eastern states (https://www1.usgs.gov/csas/swap/species_view.html?sciname=Lanius%20ludovicianus&taxonomyGroup=%22Birds%22), including Illinois.

Many reasons have been cited as potentially contributing to the decline of the loggerhead shrike, including loss of habitat on the breeding and wintering grounds, pesticides, mortality associated with roads, adverse weather conditions, and interspecific competition (Yosef 1996, Pruitt 2000). It is likely that a combination of factors is involved, possibly at

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different times throughout their annual life cycle. For example, adverse climatic trends on the breeding grounds may reduce nesting success, whereas road mortality may decrease the survival rate during migration. Further research is required to better understand the cause(s) of the decline and seasonal interactions among factors.

The Midewin National Tallgrass Prairie supports a small, isolated population of loggerhead shrikes. As the species has either been extirpated or nearly so in most of northeastern North America (Sauer et al. 2014), the Midewin population is an important stronghold, supporting an apparently stable, albeit small, migratory breeding population. A study of the shrike population in Midewin has been underway since 2005, focused on assessing annual population demographics. Banding has been ongoing since 2005, with a color-banding program beginning in 2014. It is hoped that information gathered from this study will lead to a better understanding of the threats faced by migratory populations, and will assist in developing recovery strategies in areas where suitable habitat still exists.

MATERIALS AND METHODS

Surveys for shrikes are undertaken in suitable habitat throughout the Midewin National Tallgrass Prairie in early May, before leaf-out, when nests can easily be located, coinciding with the start of the breeding season in the area. An annual staff and volunteer loggerhead shrike survey has been conducted each year since 2005, with additional targeted follow-up survey work at historically occupied sites and other areas of potential habitat, which is comprised of active pasture and hayfields. Midewin is a tallgrass prairie reserve and U.S. National Grassland operated by the U.S. Forest Service. Established in 1996, it is the first national tallgrass prairie designated in the United States, and the only federal tallgrass prairie reserve east of the Mississippi River. It is located on the site of the former Joliet Army Ammunition Plant north of Wilmington, Illinois, with several other state and county protected areas nearby. At more than 19,000 acres (7,689 ha), Midewin forms the heart of a conservation macrosite totaling more than 40,000 acres (16,187 ha) found to the south of Chicago, Illinois.

Adult shrikes are trapped using a purpose-built single-cell walk-in live trap with top and side entrances. Traps are baited with a live domesticated house mouse (*Mus musculus*) that is protected in a hardware cloth cage. The trapping and banding protocol is approved by Queen's University's and the Canadian Wildlife Service's Animal Care Committees.

Adult shrikes were banded with federal-issue U.S. Geological Survey stainless steel bands from 2005 to 2013. Nestlings were also banded from 2005 to 2007. Nestling and hatch-year (HY) birds are always banded on the left leg, whereas adults are banded on the right, to distinguish age at which returning birds were banded. Nestling banding was discontinued because of the perceived high level of disturbance caused by the removal of young from the nest. Although individual birds reacted differently, and those in Midewin may have responded differently from those in other populations, the adult shrikes aggressively defended their nest with loud vocalizations and appeared distressed throughout the banding process, even when alternative methods such as leaving one young in the nest were attempted. Beginning in 2014, a color-banding program was initiated in which adult and HY birds that were independent of their parents were banded with a unique four-band combination, including a stainless steel band and three double-overlap plastic colored bands (Haggie Engraving). The band status of returning birds was determined by visual observation of individuals, with the aid of a birding spotting scope.

Upon capture, adults were sexed on the basis of the presence (female) or absence (male) of a brood patch and aged on the basis of the retention of juvenile (HY) plumage as second year (SY, first breeding season) or after second year (ASY, second or subsequent breeding season; Pyle 1997). Shrikes were released at their point of capture, with average handling time less than 15 minutes per bird. Banding was not conducted in inclement weather, or at temperatures lower than 10°C or higher than 30°C, as stated in the banding protocol.

Return rates are calculated as the number of banded birds that return to Midewin. To the best of our knowledge, no other targeted shrike banding was occurring within several hundred miles of our study site; it is probable that a returning banded bird originated from Midewin. All breeding pairs are monitored throughout the season to assess reproductive success, which is determined by the presence of fledged young. Sites with single birds are also monitored to determine if a territory is being maintained, or a mate found. Site reuse is based on the presence of a breeding pair, regardless of band status. As of 2015, true site fidelity, in which a bird returns to a natal site or previous breeding territory, is quantifiable, as banded birds carry a unique combination of bands. Similarly, as of 2015, we were able to measure natal and breeding dispersal distance. Dispersal distance is limited to the extent of habitat surveyed within Midewin—in other words, shrikes dispersing outside of Midewin are not included in our estimates of dispersal distance. However, it is worth noting that, on the basis of eBird records for the 10-year period before 2016, no shrike was reported within a 15-mile radius of Midewin. Thus, although we are not able to measure long-distance dispersal, we are likely capturing the majority of local dispersal events.

RESULTS

The size of the population of breeding shrikes in Midewin has ranged from a low of 4 pairs (2012) to a high
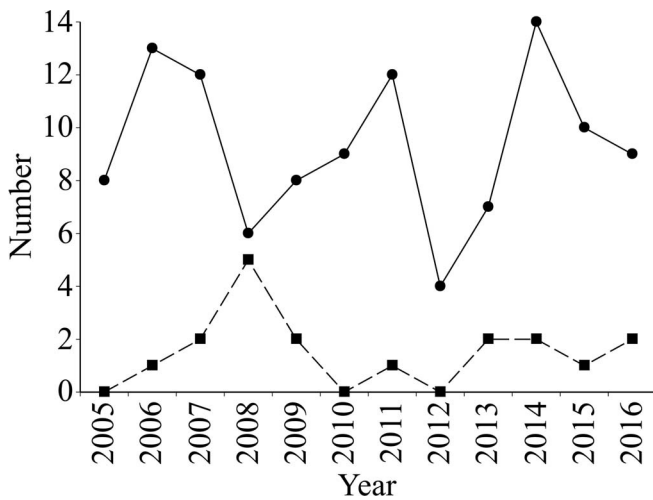
Figure 1. Population size and trend for loggerhead shrikes in Midewin National Tallgrass Prairie. The dashed lines with squares represents single birds. The solid line with circles indicates pairs.

of 14 (2014) pairs (Figure 1). Single, unpaired birds are usually observed, ranging from 1 to 5 per year (Fig. 1). Total adult population size has varied from 8 to 30 individuals (Figure 1).

Reproductive success by pair has varied from 100% (2005, 2010) to a low of 50% (2014; Figure 2). Detail on individual nesting attempts was recorded from 2014 to 2016. Fifty-seven to 80% of nesting attempts resulted in at least one fledged young (Figure 2). However, as few as one-third of first nesting attempts in this period were successful (Figure 3), with as many as three total nests attempted by an individual breeding pair. Overall reproductive output was high—between 2014 and 2016, 50 nests were initiated by 33 pairs (Figure 3). Of these, 44% were successful (Figure 3).

A total of 31 breeding territories was monitored over the course of this study. Nest trees are often the same as those used in the previous year, or located near the previous nest site, but annual territory boundaries may vary. Reuse rates of breeding territories are high, with a median of 3 years of use over the study period (Figure 4). Approximately one-third of territories were used for 1 or 2 years, one-third for 3 or 4 years, and the remaining used up to 14 consecutive years (Figure 4). Site reuse appears related to reproductive success in the preceding year (Table 1). Sixty-nine percent of territories in which young fledged were reused in the following year, compared with only 48% reuse of territories where reproduction was not successful. Historically active sites are often used after a period of disuse. Forty-one of the territories located in total had not been active the year before, but 66% of these had been used previously. Of the remaining 14 territories not used historically, 7 (50%) were located adjacent to an active breeding territory.
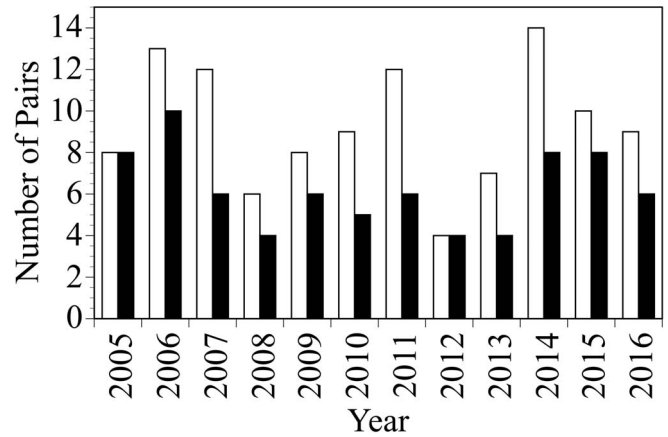

Figure 2. Number of loggerhead shrike pairs that successfully fledged at least one young in Midewin National Tallgrass Prairie over the course of the study. The open bars represent total number of pairs breeding each year. The solid black bars represent the number of pairs that successfully fledged young in that year.

Not all birds could be aged in hand as SY or ASY, in which case they were aged simply as After Hatch Year (Figure 5). For years in which at least 75% of the population was aged as SY or ASY (2007, 2009–2015, Figure 5), the percentage of SY birds within the known-age population averaged 38% (range 26–50%). The proportion of SY birds
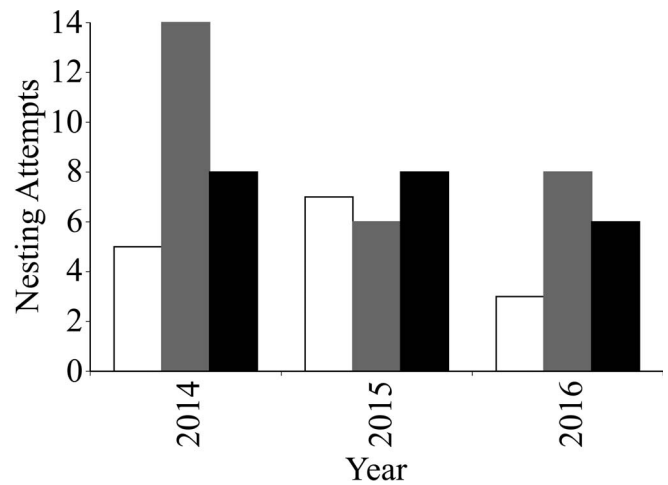

Figure 3. Summary of total reproductive effort of loggerhead shrikes in Midewin National Tallgrass Prairie from 2014 to 2016. The open bars represent number of first nesting attempts in which young were successfully fledged. The gray bars represent the total number of failed nesting attempts (no young fledged). The black bars represent the total number of successful nesting attempts (at least one young fledged).
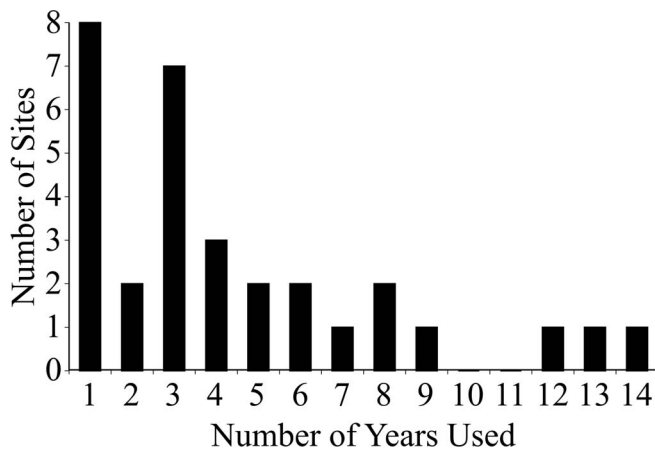
Figure 4. Number of years of use for breeding territory used by loggerhead shrikes in Midewin National Tallgrass Prairie.

varied considerably between sexes and among years (Figure 6). With the exception of 2015, a greater number of SY female, rather than male, birds was observed (Figure 6).

Banding effort has remained relatively constant over the study period. Banding during incubation is targeted at males only, as females alone incubate eggs and it is possible that the time off the nest for banding may be detrimental to hatch success. Thus, banding effort is not equal between the sexes. Additionally, single birds often do not hold territories and this cohort often remains unbanded. For these reasons in
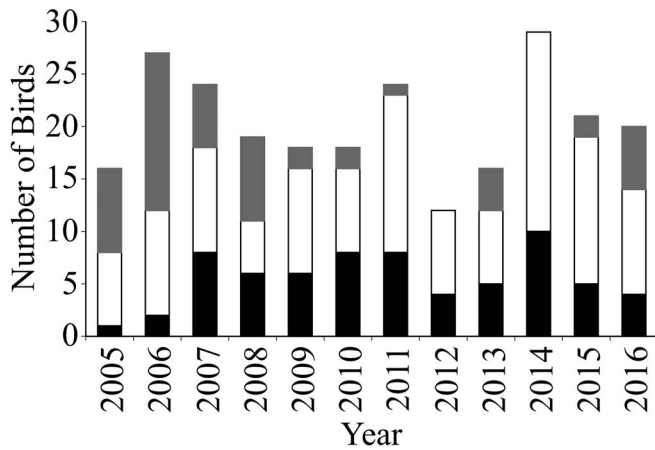

Figure 5. Population age structure for loggerhead shrikes in Midewin National Tallgrass Prairie. The number of second-year (SY) birds are represented by the open portion of the bar. The number of after-second-year (ASY) birds are represented by the black portion of the bar. Birds that could only be aged as after hatch year are represented by dark gray.

Table 1. Breeding territory reuse in comparison with reproductive success in the preceding year.

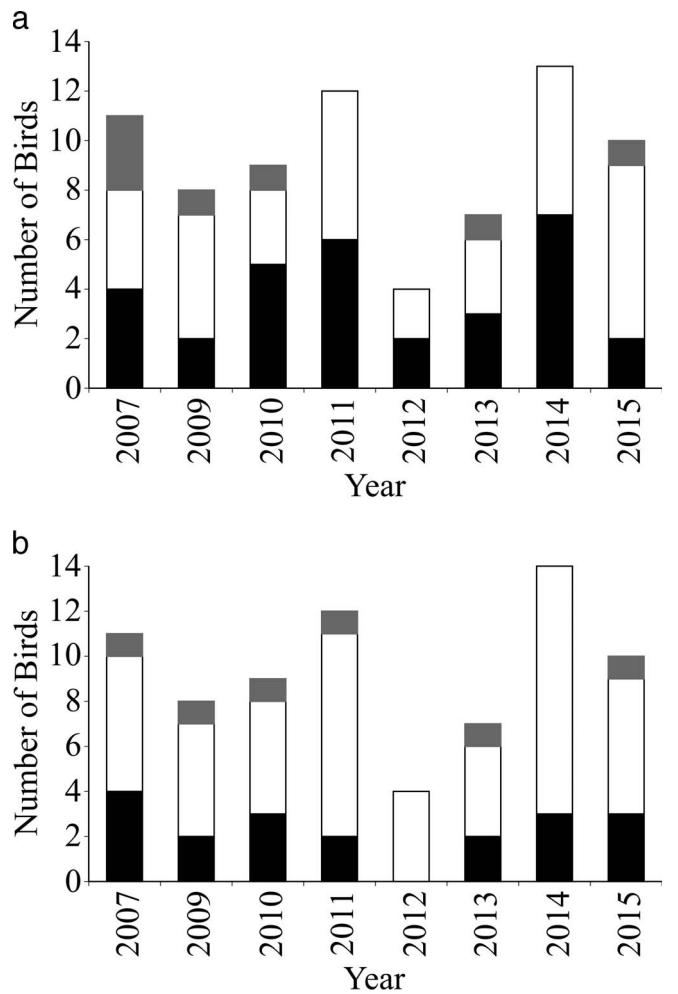| Breeding Territory	Rate
Successful	72 (70%)
Reused in subsequent year	50 (69%)
Not reused in subsequent year	22 (31%)
Unsuccessful	31 (30%)
Reused in subsequent year	15 (48%)
Not reused in subsequent year	16 (52%)

Figure 6. Population age structure for female (a) and male (b) loggerhead shrikes in Midewin National Tallgrass Prairie for years in which at least 75% of the population could be aged as second year (SY) or after second year (ASY). The number of SY birds is represented by the open portion of the bar. The number of ASY birds is represented by the black portion of the bar. Birds that could only be aged as after hatch year are represented by dark gray.
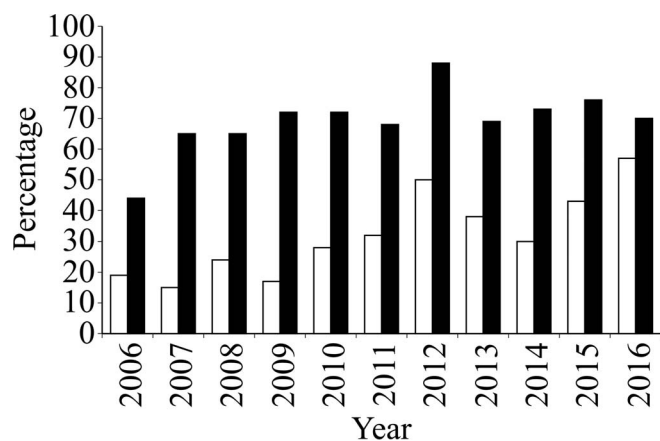
Figure 7. Proportion of the population banded at the end of the breeding season and return rate of banded loggerhead shrikes at the start of the breeding season in Midewin National Tallgrass Prairie. The open bars represent the proportion of birds that were banded that returned in a subsequent breeding season. The solid black bars represent the proportion of adult birds that were banded at the end of the breeding season.

particular, the proportion of the total population banded at the end of the breeding season has varied (Figure 7).

In total, 40 nestling shrikes were banded from 2005 to 2007, and 100 adult and 12 independent HY shrikes were banded from 2005 to 2016 (Table 2). The percentage of the total known population that carries bands at the end of the breeding season is usually greater than 60% (Figure 7). Conversely, the percentage of the population that is banded at the start of the season has seldom exceeded 40%, and has more often been closer to only one-third of the total known population (Figure 7). As nestling and independent HY birds were always banded on the left leg, and adults were banded on the right, we can quantify return rate by age of banding. Sixty-two shrikes (62%) banded as adults have been documented as return breeders since 2006. However, without recapture of banded birds, for which we had

extremely limited success, we are unable to quantify individual return rates before the inception of the color-banding program in 2014. Thus, it is likely that we counted the return of some individuals in more than 1 year (i.e., double counted) and the total number of returning individual birds is lower than 62%.

In 2015 and 2016, individual birds could be followed between breeding seasons because of the use of unique color-band combinations. Forty-seven percent of adult birds in 2014 and 50% of adults in 2015 returned to breed in Midewin. Thirty-three percent of females and 44% of males banded in 2014 returned (Table 2). None of the adult birds banded in 2015 has been relocated (Table 2). The use of unique color-band combinations permits assessment of whether survey effort has missed any shrike, which does appear to have occurred, but on a limited basis. One female and one male shrike banded in 2014 but not seen in 2015 were relocated, each at a different territory, in 2016.

One independent HY bird from 2014 and another from 2015 were found to return to Midewin as breeders, both of which were female (Table 2). However, as we could not sex nonbreeding birds in hand, we are unable to determine what percentage of the birds banded as HY birds were male vs. female, so we cannot ascertain if a bias in mortality by sex is occurring. Natal dispersal distance averaged 3.9 km (range 0.8 to 8.8 km). If the longer distance (8.8 km) is excluded, average juvenile dispersal distance is 0.97 km.

The use of color bands allows breeding dispersal distance and site fidelity, vs. site reuse, to be calculated. Adult female ($n = 4$) dispersal distance averaged 2.1 km (range 0 to 3.2 km). Adult male ($n = 7$) dispersal distances averaged 1.6 km (range 0 to 3.6 km). Overall, average breeding dispersal distance is 1.6 km. Site fidelity is low—only two males and one female were faithful to their previous breeding territory. One male remained faithful to the site at which he was banded in both 2015 and 2016, whereas the other moved to a different site the year after that in which he was banded, and then remained faithful to that site in 2016. A female banded in 2014 and relocated in 2015 moved to a new site, to which she remained faithful in 2016.

Table 2. Banding effort and return rates for adult, nestling, and independent hatch-year (HY) loggerhead shrikes in Midewin National Tallgrass Prairie.

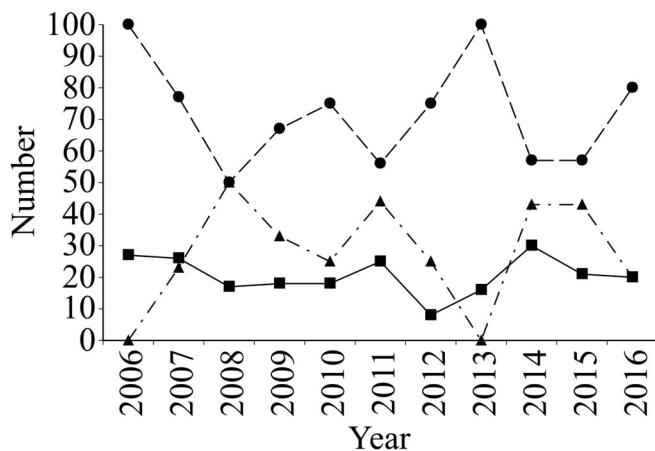|	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Adults banded	9	7	13	7	10	8	9	3	5	16	7	6
Banded adults returned	n/a	5	4	4	3	5	8	4	6	6	9	8
Nestlings banded	7	18	15	—	—	—	—	—	—	—	—	—
Banded nestlings returned	n/a	0	1	0	0	0	0	0	0	0	0	0
HY birds banded	—	—	—	—	—	—	—	—	—	6	5	1
Banded HY birds returned	—	—	—	—	—	—	—	—	—	0	1	2

Figure 8. Population size (total adults, including breeding and nonbreeding birds) in comparison with reproductive success in the year prior for loggerhead shrikes in Midewin National Tallgrass Prairie. The solid lines with squares represent the total adult population in Midewin. The dashed line with circles represents the percentage of breeding pairs that were successful in fledging young the year before. The dashed line with triangles represents the percentage of breeding pairs that were not successful in fledging young the year before.
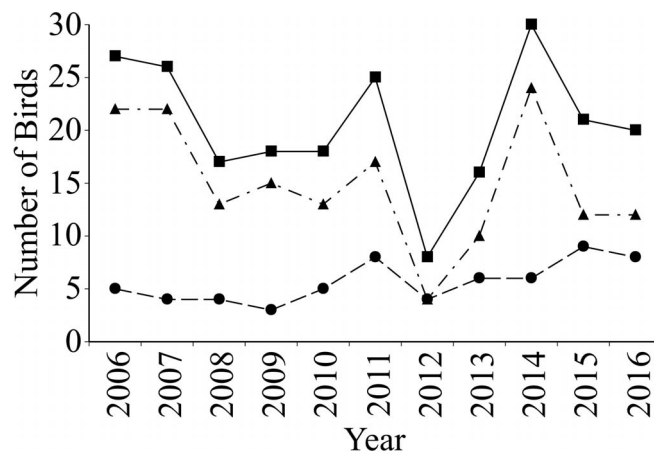

Figure 9. Population size (total adults, including breeding and nonbreeding birds) in comparison with immigration, as determined on the basis of band status, for loggerhead shrikes in Midewin National Tallgrass Prairie. The solid lines with squares represent the total adult population in Midewin. The dashed line with circles represents the number of birds that were banded in a previous year and returned to Midewin in a subsequent season. The dashed line with triangles represents the number of birds that were unbanded at the start of the breeding season.

Population size and trend were assessed in comparison with reproductive success, age structure, and return of banded birds vs. immigrants (unbanded birds) into Midewin. Sample sizes preclude statistical analysis, but graphic depiction of the data provides some insight into the factors driving population size and trend. Neither population size nor trend appears to relate to reproductive success rate in the prior year (Figure 8). Population size appears to be somewhat affected by the proportion of ASY birds in the population (Figure 9), and to male ASY birds in particular (Figure 10).

DISCUSSION

Site Reuse and Fidelity

A pattern of high site reuse but low site fidelity is apparent for loggerhead shrikes in the Midewin National Tallgrass Prairie. Historically, the loggerhead shrike has been reported to have high site fidelity (Atkinson 1901, Bent 1950, Porter et al. 1975, Kridelbaugh 1983). However, most of the earlier evidence for site fidelity in the species resulted from observations of the reuse of nests or nest sites by unmarked birds, with observers assuming that if a site was occupied in two consecutive years, the adults previously occupying the site had returned. Haas and Sloane (1989) reported rates of site reuse vs. fidelity similar to our results, and concluded that there was a need to reevaluate site

fidelity in loggerhead shrikes, in particular in light of the decline of the species. The insight and distinction is important for a species that has exhibited such a precipitous decline—when evaluating the cause of decline, low site fidelity and return rates should not necessarily be taken as evidence of high winter mortality.

Site reuse in Midewin appears to be related to nesting success, specifically, sites where reproduction is successful and young fledge are more often reused. Etterson (2003) suggested that social factors were partly responsible for the spatial distribution of shrikes as breeding territories were shown to be spaced more closely together than expected if nest site choice were random. The apparent correlation between site use and reproductive success observed in Midewin suggests that conspecific attraction or "public information" is also a determinant of territory establishment. Specifically, shrikes may be using postbreeding information, such as the presence of successfully fledged young, as a proxy measure for territory quality, although the pattern of site reuse could also be explained if the quality of the habitat at reused sites was higher than those not reused. However, Chabot et al. (2001) documented a similar pattern of high rate of reuse of historically active sites, but found that the amount of suitable habitat within the surrounding landscape, rather than nest site or territory attributes, was the most likely explanatory factor. Given that this is not likely to differ for sites within Midewin, we suggest that social cues
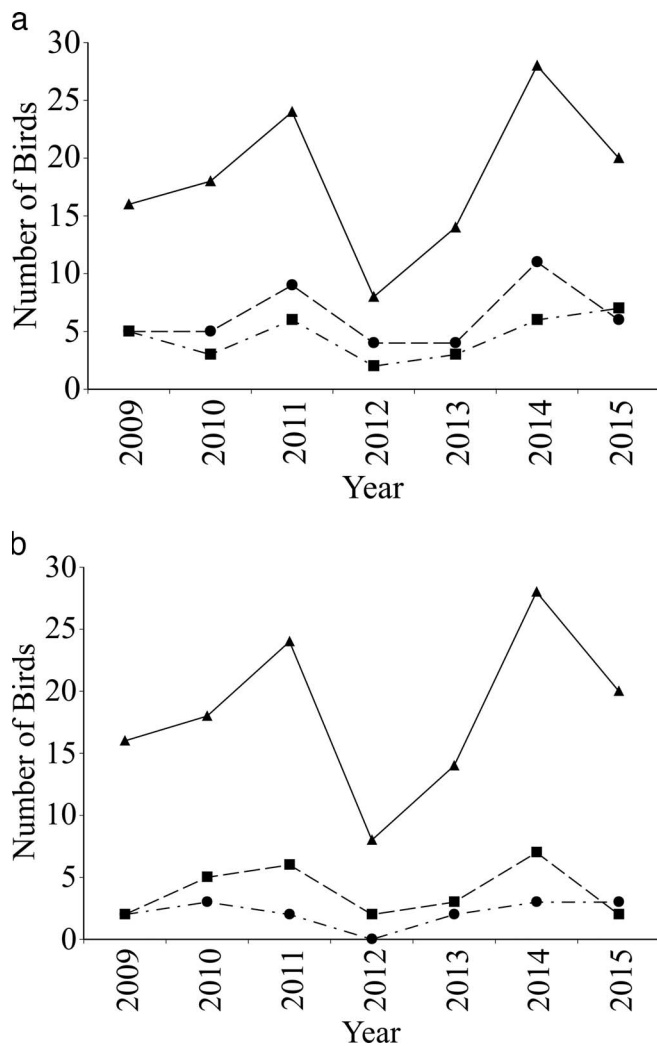
Figure 10. Population size (total adults, including breeding and nonbreeding birds) in comparison with age structure of male (a) and female (b) loggerhead shrikes in Midewin National Tallgrass Prairie.

are indeed the more likely explanation for higher reuse rates of sites where reproduction was successful.

Adult Return Rates

Shrikes in Midewin become "trap shy" and our recapture rate of previously banded birds was near zero. Therefore, without the use of unique color-band combinations, we were only able to assess individual return rates for 2 of our 12-year study. Nonetheless, the results provided by comparison of banded vs. unbanded breeders does provide valuable information. However, as estimates of return rates depend upon many factors, including search effort and area, the detectability of the species, the ease in which a returning bird can be identified by reading a marker, and the

permanence of the marker, caution should be taken in interpreting results.

The return rate of adult shrikes to Midewin (61%) is similar to, but somewhat higher than that noted elsewhere, although, as previously noted, our return rate may be elevated because of double counting among years. Across the species range, return rates have varied considerably: 27% in 2000, 28% in 2001, 13% in 2002, 11% in 2003 in Ontario (Okines and McCracken 2003), 14% in North Dakota (Haas and Sloane 1989), 16% in Manitoba (Collister and DeSmet 1997), 32% in Alberta (Collister and DeSmet 1997), 41% in Indiana (Burton and Whitehead 1990), and 47% in Missouri (Kridelbaugh 1983). The larger proportion of unbanded shrikes at the start of each breeding season in Midewin, in particular when a high proportion of the previous year's population was banded at the end of the preceding breeding season, suggests either a significant level of recruitment into the population, or that a large number of shrikes is not being located annually. The dedicated survey effort focused on locating shrikes; the lack of additional pairs being located as the season progresses and the relatively low number of color-banded birds that was found to have been missed in previous years suggests that recruitment is the more likely scenario.

Although our sample sizes are low, the trend appears to be a higher-than-expected return rate of adult female shrikes in Midewin. Higher return rates are expected for male birds as they gain a greater advantage by reoccupying sites that are familiar to them (Greenberg 1980), whereas for female birds the advantage is gained in mating with the most fit male or male with the best territory (Greenberg 1980). In addition, serial polyandry in shrikes suggests that females move more within a season, so that identification of returning females is likely harder to document (Haas and Sloane 1989). Altogether, it would appear that male-biased mortality is occurring for shrikes in Midewin.

Nestling Return Rates

Although only three (6%) shrikes banded as nestlings or HY birds have been relocated as breeders in Midewin, the natal return rate for shrikes in Midewin is similar to that noted elsewhere: 3.1 to 12% in Ontario (Okines and McCracken 2003), 3.6 and 1.7% in Virginia (Luukkonen 1987, Blumton 1989), 2.4% in Indiana (Burton and Whitehead 1990), 1.2% in Alberta (Collister and DeSmet 1997), 1.1% in Missouri (Kridelbaugh 1982), 0.8% in Manitoba (Collister and DeSmet 1997), 0.8% in North Dakota (Haas 1995), and 0% in Minnesota (Brooks and Temple 1990). However, the fact that all returns have been females is unusual, as males are generally the more philopatric sex in birds (Greenberg 1980). Further, studies of shrikes elsewhere support the expectation of male-biased site fidelity in the species (Kridelbaugh 1983, Haas and

Sloane 1989, Collister and DeSmet 1997, Okines and McCracken 2003), with as much as a fivefold difference between the sexes in some areas (Kridelbaugh 1983, Haas and Sloane 1989). Our results on return rates of nestling shrikes further support bias in overwintering mortality in males as driving population demographics in the loggerhead shrike breeding in Midewin.

Dispersal

The natal and breeding dispersal distances of shrikes in Midewin are similar to those noted in other portions of the species range. In Ontario, adult birds returned to within 47 km (mean of 2.2 km in 2000, 3.8 km in 2001, 8.5 km in 2002, and 18.6 km in 2003) of the territory (as measured from nest tree to nest tree) on which they were banded and to within 145 km (mean of 9.9 km in 2000, 10.6 km in 2001, 47.0 km in 2002, and 15 km in 2003) of their natal site (Okines and McCracken 2003). In western Canada, Collister and DeSmet (1997) found that returning adults dispersed an average of 2.7 km, with 95% of adult shrikes returning to within 4.7 km of their previous year's nest site, and young birds moved an average of 14.7 km from their natal site. In North Dakota, natal dispersal distance of shrikes averaged 3.5 km (Haas 1995). Although we did not measure dispersal beyond the boundaries of Midewin, evidence from eBird indicates that there are no other known breeding populations within several hundred miles of our study site. Thus, although we are unable to capture long-range dispersal events, our smaller-scale results are likely comparable with those elsewhere.

Age Ratios

The proportion of SY to ASY birds in the annual breeding population of shrikes in Midewin has varied considerably during our study. Since 2007, from which time the majority of the population has been aged as SY or ASY, an equal or greater number of the SY birds has been female (with the exception of 2008). As noted above, this result is unusual on the basis of dispersal patterns of birds in general (Greenberg 1980) and data from shrikes in other populations (Kridelbaugh 1983, Haas and Sloane 1989, Collister and Wicklum 1996, Okines and McCracken 2003) and may suggest lower overwintering survival of young males in this population.

The ratio of SY to ASY individuals can be a valuable metric for estimating avian productivity, as it can be estimated across large geographic and temporal scales (Peery et al. 2007). Ratios of juveniles to adults have been used to estimate productivity for a range of animal taxa for both theoretical and applied purposes (Ricklefs 1997, Rodway et al. 2003, Flanders-Wanner et al. 2004, Rohwer 2004, Peery et al. 2007). The degree to which the age structure of the shrikes in Midewin compares with other populations is unknown. Comparison of data with other

stable populations and declining populations would likely yield important insight into the demographics driving population trends across their range and whether these are being experienced in synchrony within age and sex cohorts, suggesting broad-scale limiting factors rather than local factors. Further, data on age ratios could be used in conjunction with Breeding Bird Survey data to assess if population trend can be correlated to age ratios, validating the interpretation of age-ratio data as a predictor of population trend for shrikes.

Reproductive Success

The population of loggerhead shrikes at Midewin has experienced a high degree of nest loss in several years over the course of our study. Despite this, because of the species persistence in renesting, most pairs successfully fledge young. Although the energetic costs of nest loss at the egg state is less costly than feeding young (Ricklefs 1996), the long-term impact of increased energetic demands resulting from renesting efforts has not been quantified, and may be affecting the long-term sustainability of the population.

Clutch size in shrikes ranges from four to six eggs (Yosef 1996). Predation of eggs appears to be more common than that of nestlings in Midewin, and predation of first nests appears more common than predation of nests later in the season. This could be due to experience gained by breeders over the breeding season, better nest concealment later in the breeding season after trees have leafed out, or increased nest height noted in renesting attempts, making nests more inaccessible to predators.

Nest loss due to predation has been identified as a cause for concern elsewhere in the species' range (R. Bailey, West Virginia, personal communication; A. Kearns, Indiana, personal communication). Predation rates can be affected by a variety factors, including density of predators, the occurrence of novel predators, biophysical aspects of the habitat (e.g., grass height, which may provide more or less cover to potential predators), and landscape effects (e.g., increased edge effect in smaller patches of suitable habitat can lead to increased predation). These and other potential questions related to predation and its impact on loggerhead shrikes in Midewin and beyond warrant further study.

Population Size and Trend

The population of loggerhead shrikes has varied more than threefold over the study period, with no stable increasing or decreasing trend. As single birds cannot be reliably sexed, it is not possible to determine if single birds are biased toward males or females, which would yield further insight on whether sex-biased mortality is affecting the population. However, in totality, our data suggest that male-biased mortality, for both young birds before breeding and older males, likely experienced during the nonbreeding

season, may be a significant driver to the population size and trend for loggerhead shrikes in Midewin.

CONCLUSIONS

Our study, although focused on a small population of loggerhead shrikes, demonstrates the value of long-term study for species of conservation concern. Population size and trend of shrikes in Midewin has varied by orders of magnitude over the past decade, in some years suggesting that the population would soon be lost. The persistence of shrikes in this area suggests that conservation efforts are warranted for even small populations of this species. Indeed, the apparent importance of conspecific attraction within the species may assist population recovery where even a few pairs remain.

Although our sample sizes are small, long-term examination of population demographics using simple metrics has yielded significant insight into the threats faced by the species in Midewin and we can now develop multiple testable hypotheses to address in future study, although our sample sizes will likely continue to be low. What remains to be known is how these results compare with those elsewhere, especially given broad-scale concern for the species and continued population declines including in the southern portions of the species range where populations were once considered to be high and stable in the "core" of the species' historic range (Cade and Woods 1996). Coordinated banding and demographic study is urgently needed to identify local and range-wide threats.

Our results suggest that immigration into the Midewin population is high. Undoubtedly, at least some first-year breeders (SY birds) result from reproduction of shrikes within Midewin. However, given that the majority of adult birds are banded at the end of each season, and the apparently isolated nature of the population of shrikes in Midewin, the source of breeding shrikes in their second or later breeding season (ASY) is unknown. Future research to identify the provenance of immigrants is required, which will establish the metapopulation boundaries within which Midewin is encompassed, and thus the scale at which future study of demographics could be undertaken. Our results suggest that male-biased mortality on the wintering grounds is likely a significant factor affecting the population's stability. Identifying the wintering ground for this population and quantifying the wintering ecology of the species is needed to better identify the cause of mortality on individual cohorts. Nonetheless, the persistence of the population in Midewin over the past decade suggests that the species still has time in which to realize the benefit of additional research and recovery efforts.

ACKNOWLEDGMENTS

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