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Comparison Of Avian Nest Success Among Linear Wooded Habitats In An Agricultural Landscape

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COMPARISON OF AVIAN NEST SUCCESS AMONG LINEAR WOODED HABITATS IN AN AGRICULTURAL LANDSCAPE

BY

TERRI J.E. THOMPSON

THESIS

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ABSTRACT

In the Midwest, urban expansion and more intensive agricultural practices have reduced habitat available to most species of breeding birds. Linear wooded habitats including fencerows and riparian strips are a common habitat feature in many agricultural landscapes. Changes in agricultural practices and the subsequent reduction in grasslands and fencerows have lead to greater breeding densities in species that use the remaining fencerows as nest sites. This may lead to a lower nesting success due to factors such as higher predation risk. Specifically, it is not known how such linear habitats currently contribute to avian populations in central Illinois.

We monitored the nesting success rates and measured habitat features for shrub-nesting birds in fencerow and riparian strip habitats at Prairie Ridge State Natural Area (PRSNA) in east-central Illinois and the surrounding agricultural landscape April-August 2006. We compared these data to similar data collected at PRSNA in 1997-1998. The most common nesting species for both time periods were American Robins (*Turdus migratorius*), Brown Thrashers (*Toxostoma rufum*), Mourning Doves (*Zenaida macroura*), Common Grackles (*Quiscalus quiscula*), and Northern Cardinals (*Cardinalis cardinalis*). Nest success rates varied between species, with Northern Cardinals having a significantly lower nest success rate (3.8%) in 2006 than in 1997-1998 (26.1%) ($p<0.05$). Mourning Doves also had a lower nest success rate in 2006 (11.9%) than in 1997-1998 (33.5%), but not significantly lower. American Robins, Brown Thrashers, and Blue Jays (*Cyanocitta cristata*) all had higher nest success rates in 2006 than in 1997-1998, though none was significantly higher.

Fencerow and riparian strip nest success rates did not differ significantly ($p>0.05$) and a survival analysis showed that habitat type had no significant effect on species' nest survival ($p>0.05$). We found that although riparian strip habitats were significantly wider than fencerow habitats, nests were found at similar distances from the edges for both habitats. American Robin nest success was positively correlated with nest height. Common Grackle nests with higher visibility had lower rates of nest success. Mourning Dove nest survival increased as their nests were found in larger nest trees and their nest survival was decreased if they were found nearer to crop fields than non-crop fields.

Nest success outcomes and comparisons with other studies showed that the linear habitat available to central Illinois shrub nesters is not an ideal breeding habitat. Thus, linear habitats in central Illinois may be ecological traps. We found there was no significant difference between the fencerow and riparian strip habitat features found in areas of central Illinois in terms of impact on nest survival and nest success for shrub-nesting birds. Therefore, land managers may treat them as similar habitats in evaluating the usefulness of those habitat features. Future research on fragmented linear habitats within the agricultural landscapes of the U.S. would be recommended, particularly in the area of linear forest edges as a comparison to fencerows and riparian strips.

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INTRODUCTION

In less than 200 years, land clearing due to agriculture and urban development has modified the landscape of most of North America and resulted in fragmentation of the original native forests and grasslands (Boutin and Jobin 1998). In areas like the Midwest, where agriculture is especially intense, this fragmentation is most severe. Small, family-owned farms have been consolidated into larger factory farms, leading to increases in field size and a decrease in non-crop habitats such as wetlands, woodlands, and fencerows (Best et al. 1995). Housing development removes habitat directly during construction and fragments the remaining habitat (Radeloff et al. 2005). Because of this, remaining woodlots, fencerows, riparian strips and other remnants of the original vegetation have become crucial to the survival and conservation of native shrub-nesting birds (Boutin and Jobin 1998).

Mature woody plants found in fencerows provide the essential habitat requirements of many bird species in the form of food, shelter, and nest sites (MacDonald and Johnson 1995). In addition, these habitats serve as connections between woodlands and wetlands (Boutin and Jobin 1998). Strip-cover habitats constitute a significant proportion of the habitat available to birds in areas where agriculture is widespread and intense (Heard et al. 2000), such as central Illinois.

Anthropogenic edges in a landscape may create attractive habitats for some birds (Ratti & Reese 1988). In agricultural landscapes, the presence of shrubs and trees in linear habitats increases bird abundance and species richness (Heard et al. 2000). Gates' and Gysel's (1978) ecological trap theory speculates that forest edges create areas of high songbird nest density and high nest failure rates when compared to areas with nests located farther from edges (Flaspohler et al. 2001). Thus, it is possible these linear habitats may attract high densities of breeding songbirds but not produce adequate nest success rates.

Often the main determinant of reproductive success in birds is the rate of their nest predation (Ricklefs 1969; Patten & Bolger 2003). An important choice made by birds to improve reproductive success and to avoid the risk of predation is the selection of a nest site (Filliater et al. 1994). Habitat fragmentation can lead to higher rates of nest predation (Schmidt & Whelan 1999). Nest site selection by avian species in terms of habitat characteristics is clearly limited in fragmented areas like Illinois. Patten and Bolger (2003) determined that avian nest predators of other bird nests were most common within habitat fragments than interior woodlands. Selection of nest sites by birds is supposed to be non-random and adaptive with regard to risk of predation (Weidinger 2002), but fragmented linear habitat may diminish the effectiveness of the birds' attempts at nest site selection by reducing the variety of available habitat for them to choose from.

Agricultural areas such as the Midwest have impacted habitat availability for many species of nesting birds. Changes in agricultural practices and the subsequent reduction in grasslands and fencerows have lead to greater breeding densities in species that use fencerows as nest sites (Yosef 1994). Intensively farmed areas like central Illinois have reduced habitat availability and may be forcing species to build nests in areas where there are lower rates of nesting success due to high predation risk. Patten and Bolger (2003) found that different nest predator guilds respond uniquely to habitat fragmentation and individual bird species respond differently in their vulnerability to predator guilds. So patterns of nest predation across fragmentation gradients would vary depending on the predators and their prey. Shrub-nesting birds in Midwestern linear habitats may prove to be depredated by a unique nest predator guild due to the anthropogenic background of the habitat and recent mesopredator release of the Midwest (see Estes 1996).

Whittingham and Evans (2004) reported that habitat structure affects the choice of habitats used by nesting birds based on time spent foraging and avoiding predators. They determined that nesting birds benefit most from larger hedgerows. Higher predation rates in exotic shrubs may be one cause of the higher predation rates in fragmented landscapes and along habitat edges due to lower nests, absence of sharp thorns, and branch architecture (Schmidt & Whelan 1999). Determining what factors influence nest predation is important if biologists hope to successfully manage many avian populations (Paton 1994). Linear wooded habitats are abundant in central Illinois and may serve a critical need for breeding habitat in areas of the Midwest where agriculture is most intense, yet we do not know in detail how they are performing as breeding habitats. Several recent studies have suggested that agricultural edges generally exert stronger negative effects on birds than edges of regenerating forest patches (Bayne and Hobson 1997; Darveau et al. 1997; Heske et al. 2001). More data are needed concerning potential threshold values for edge effects in a variety of landscape patterns and habitat types (Paton 1994).

Although the decline of grass- and shrub-nesting birds is well established, few studies have been able to directly link agriculture practices to change in bird populations (Murphy 2003). Though the types of land uses within fragmented landscapes and the amount of habitat disturbance are believed to influence avian communities, the interacting effects of these factors in the landscape are not well understood (Rodewald & Yahner 2001). Many studies have considered the effects of habitat structures in agricultural landscapes on wildlife in European countries (Evans, 2004; Green et al, 1994; MacDonald and Johnson 1995; Osborne 1984; Parish et al, 1995; Whittingham and Evans 2004), but this type of information is largely lacking in the United States. To maintain or enhance avian biodiversity in agricultural landscapes of the Midwest, a better understanding is needed of how changes in the composition and quality of habitat types and their spatial arrangement affect avian species (Best et al. 1995).

With further loss of fencerows and other wooded strip habitat likely to occur in the future for shrub-nesting birds, understanding the nesting success rates of these habitats is important for the sake of conservation efforts and management concerns. Valuable data can be obtained by taking a closer look at the nesting success found in linear habitats by birds living in the mid-western United States. Specifically, it is not known if linear wooded habitats actively contribute as population sources or sinks in central Illinois.

The primary objective of this study was to examine the nesting success of shrub-nesting birds in linear wooded habitats identified as fencerows and riparian strips in east-central Illinois. Habitat characteristics were measured and analyzed as predictors of possible nest success. Nest success outcomes from this study were compared to data collected by Walk and Kershner (unpub. data) as a temporal comparison of nesting success in the same study area in 1997-1998. This study will be useful to ecologists to better understand the detailed nesting success of breeding birds in remaining linear habitats and similar agricultural landscapes within the United States. It will also be useful to current and future wildlife managers responsible for managing habitats in agricultural landscapes of the United States who are particularly concerned with conservation of passerines and avian predation risk in relation to habitat structure.

METHODS

Study Area: Prairie Ridge State Natural Area

The study area was located in Jasper County, Illinois, in and around Prairie Ridge State Natural Area (PRSNA). PRSNA is a 1,000-hectare nature preserve located 5 kilometers south of Newton, IL, owned by the Illinois Department of Natural Resources (IDNR), the Illinois Audubon Society, and The Nature Conservancy, and managed by the IDNR. The preserve currently manages for grassland wildlife and includes native and introduced grasslands, croplands, woodlands and wetlands (IDNR 1998). The original croplands acquired from farmers converted into grasslands and other habitats have created a mosaic of various habitats and agricultural fields throughout Prairie Ridge, with an abundance of mature fencerows and riparian strips to create the linear habitat suitable for this project. Presently the PRSNA management is removing the existing fencerows where they intersect prairie to promote a more open grassland habitat for Greater Prairie Chickens (*Typanuchus cupido*) and other grassland species.

Field data collection consisted of nest monitoring, as well as habitat measurements. Nests were monitored in two time periods; 1997 and 1998 (Walk and Kershner, unpubl. data); and 2006. There were also habitat variables measured at each of the nests found in 2006. Sample sites in 2006 consisted of ten fencerows and five riparian strip habitats which grew between fields and along roadsides within the PRSNA and on adjacent private land. Riparian strip habitats were, on average, wider and longer than fencerows (mean width= 49.0 m), meandering and not straight. They were located adjacent to semi-permanent or permanent waterways, were a natural habitat feature and had a higher diversity of both age structure and biodiversity of herbaceous species. Fencerow habitats were narrower (mean width = 14.8 m), straight, and shorter than riparian strips. They had denser undergrowth than the riparian habitat, and were considered an artificial habitat based on their planting in the mid-20th century. All linear habitats monitored were located within a 15 square mile area around PRSNA.

Field research in 2006 began with a systematic nest search over all of the sample sites starting at one end and walking through the entire habitat, usually in one day. Nests were located by visual searches, clueing into adult behaviors and alarm calls, as well as flushing incubating females. As nests were located they were flagged and marked within 5 m of the nest, and entered into a GPS. A mirror pole was used to look into higher nests with a maximum reach of 4.5 m. Nests that were found within the linear habitat but were clearly grassland species were not included, nor were nests found outside the linear habitat. Nests failed due to depredation, human observer errors, abandonment, or weather-related events. It was assumed that a nest had been depredated when it was found empty two or more days before a scheduled fledge date and when there was evidence of predation; including nests torn down or ripped, or the remains of nestlings or egg shell fragments found in the proximity of a nest.

Monitoring consisted of revisiting nests based on their stage:

Laying — Nests found with one or two eggs (except for MODO) were considered in the laying stage, and were revisited in 4 days.

Incubating — If nests were found during incubation they were revisited every 4 days until the nest hatched or failed.

Nestling — If a nest was found at this stage, the nestlings were aged based on Baicich and Harrison (2005) and the nest searcher's opinion. They were revisited every 4 days until the nestlings were within 2 days of an expected fledge date, then they were revisited on a 1-2 day schedule until the nestlings fledged.

Fledgling — A nest was considered successfully fledged when one or more nestlings had either been observed exiting the nest or were observed near, but outside, the nest. For fledglings that were not observed, it was assumed that a nest was successful if when visited on a fledgling date or within 1 day of the fledgling date, the nest was empty with no evidence of depredation; as well as if the adults were located near the nest and/or whitewash on or near the nest.

Habitat data were collected before the onset of the fall season, from 18 August – 4 October, 2006, while all or most of the vegetation was similar to its condition during the breeding season. Habitat variables were selected based on their likelihood as possible nest success predictors. Their descriptions are as follows:

Height — The distance from the top of the nest cup to the ground directly beneath it to the nearest 0.1 m.

Structure — Whether the nest was located in a shrub or a tree, based on species.

Visibility	Nest visibility was ranked according to the percentage that was visible at 5 m from each of the 4 cardinal directions. Ranking included 5 as 0-10% visible, 4 as 11-44% visible, 3 as 45-69% visible, 2 as 70-89% visible, and 1 as 90-100% visible. These scores were averaged to assign one visibility ranking for each nest.
Tree Size	Diameter at breast height was measured for four trees at 5.0 m distance from the nest and four trees at 10.0 m distance from the nest to the N, S, E, and W directions. At the 5.0 and 10.0 m distances at each direction, if a tree was within 1.0 m of the researcher, that tree was measured; otherwise no tree was measured.
Nest to Edge	The distance of the center of the nest to the edge of the habitat was measured to the nearest 0.1m.
Width	The width of the habitat from edge to edge for each nest, perpendicular to the linear structure, was measured to the nearest 0.1 m.
1st Nearest Field	Whether the nearest field to the nest was a row crop (corn, beans, wheat, etc.) or a non-row crop field (prairie, pasture)
2nd Nearest Field	Whether the second nearest field to the nest was a row crop (corn, beans, wheat, etc.) or a non-row crop field (prairie, pasture)

Data Analysis

Nest success evaluations, including daily survival and predation rates, were made using Mayfield's exposure method (1975). Exposure was calculated according to Mayfield's midpoint assumption. Johnson (1979) was used as an estimator method for

Mayfield's nest success predictions in order to perform a z-test to compare significance of nest success outcomes from different groups of nests. Statistical analyses of habitat variables were performed with SAS 9.1 (SAS Institute Inc., Cary, NC). For all logistic regression analyses, we used nest fate (success = 2, failure = 1) in place of Mayfield estimates. Other statistical analyses performed were an analysis of variance on habitat type and its relationship with habitat width, as well as distance of the nest to the edge of the habitat. Survival analyses were performed on total nest survival days by species and its relationship to habitat variables. In a survival analysis table, the parameter estimate and hazard ratio for each habitat variable are used to interpret the outcome of the analysis. If the parameter estimate is negative, then risk of mortality for nest survival is decreased by that parameter as a percentage, reflecting an increase in nest survival, and vice versa for a positive parameter estimate. The hazard ratio represents the unit of measure for how much mortality is increased or decreased depending on the parameter estimate (by percentage).

RESULTS

Nest Success 1997-1998

There were ten species of shrub-nesting birds and a total of 229 nests found breeding in PRSNA in 1997-1998. For comparison with data collected in 2006, only the same species monitored in linear habitats between time periods were analyzed, which reduced the species of birds to seven and the number of nests to 161. The majority of nests monitored in linear habitat were located in fencerow habitat (89-100%, depending on species). The species with the highest nesting densities were the Brown Thrasher

(*Toxostoma rufum*) (n=69), American Robin (*Turdus migratorius*) (n=37), and Mourning Dove (*Zenaida macroura*) (n=36) (Table 1).

Nest Success 2006

There were 12 species of shrub-nesting birds and a total of 174 nests found breeding in PRSNA in 2006. The species with the highest nesting densities were the American Robin (n=48), Brown Thrasher (n=27), Common Grackle (*Quiscalus quiscula*) (n=27) and Mourning Dove (n=20) (Table 2).

Nest success rates and daily predation rates for fencerow and riparian strip habitats were not significantly different ($p > 0.05$) (Figures 1 & 2). In general, daily predation rates for the species with highest nesting densities did not differ between linear habitat types (Figure 3). However, Gray Catbirds had significantly higher nest success in riparian habitats than they did in fencerow habitats.

The nest success rates for the species with the highest nesting densities (above n = 5) were compared between time periods (Figure 4). Overall nest success of all species combined was 25% in 1997-1998 and 29% in 2006 ($p > 0.05$). However, Northern Cardinal nest success was significantly lower in 2006 (4%) than it was in 1997-1998 (26%).

Habitat Analysis 2006

A forward selection logistic regression was used to analyze habitat variables with nest success as the dependent variable. This analysis included in the model only habitat variables which had a significant effect on nest success outcomes for each species individually. I found that for American Robins, nests located at greater heights had higher nest success; and for Common Grackles, less visible nests had higher nest success

(Table 3). This can be further shown by plotting the percentages of successful nests found against their associated habitat variables with the predicted values generated by the logistic regression model (Figures 5 & 6).

Riparian habitats had on average more distance between the nests and the edge of the habitats than fencerows did, but nests in both habitats were found near the edge (Figure 7). An analysis of variance test produced a highly significant relationship ($F=8.63_{163,123}$, $p < 0.0001$, $R^2 = 0.96$) between the type of nesting habitat and the width of the habitat for all species, but not a significant relationship between type of nesting habitat and the distance a nest was found from the edge of the habitat ($F=1.13_{166,84}$, $p = 0.2890$, $R^2 = 0.539$). This shows that riparian strips are significantly wider than fencerows, but their nests were not found significantly farther from the edge than fencerows.

A survival analysis performed on the nests of all 2006 species showed that there was no significant relationship between which linear habitat a bird chooses to nest in and their nest survival (Table 4). In performing a survival analysis on the nest survival data and habitat variables by species, several variables were significantly related to species' nest survival (Table 5). For American Robins, distance of the nest to the edge had a significant effect on their survival (Table 5). There was a 22.0% increase in mortality risk for every meter the nests were located away further from the edge of the habitat. In other words, as nests were located away from a habitat edge, American Robin nest survival decreased.

Similar to the logistic regression analysis (Table 3), the Common Grackle survival analysis showed that nest mortality was decreased by their nest visibility (Table 6) by

96%. As their nests decreased in visibility by rank, their chances of survival highly increased.

Mourning dove survival analysis showed they had two significant habitat variables affecting their nest survival (Table 7). The size of the chosen nest tree decreased their mortality risk by 18% as the nest trees increased in diameter. The nearest field variable increased Mourning Dove mortality risk by a large amount for each meter their nests were located nearer to row crop fields. Thus, as Mourning Dove nests were located in larger trees their risk of nest mortality decreased, and as their nests were located closer to row crop fields their risk of nest mortality increased.

DISCUSSION

Linear wooded habitat can occur as both natural and unnatural structures in the landscape. Farm-related fencerows are relatively recent, man-made habitats occurring commonly in the Midwest, and they have many names to refer to essentially the same structure, such as fencerow, shelterbelt, or hedgerow. Riparian habitats are more natural, albeit modified landscape features and more easily definable. The relationships between nest site selection and nesting success may be different than those found in habitats that have been in existence for a longer period of time (Yahner 1983). The use of linear habitat by breeding birds is a complicated dynamic for many species, especially those birds that are not typical "edge" species. There is little to no contiguous habitat in a linear feature—ecologically it is essentially one big edge. The current scientific understanding of biotic and abiotic effects of edges on wildlife is still in the early stages (Paton 1994). This is especially true for edge effects in linear habitats.

Population density for avian species can be a misleading indicator of habitat quality (Van Horne 1983; Flaspohler et al. 2001). Bock and Jones (2004) warn that human-disturbed habitats like agricultural areas can disrupt habitat quality-breeding density relationships for birds. A thorough measure of habitat quality for a population is the combination of density and individual fitness (Johnson et al. 2006). Calculated nest success rates of breeding birds are one important aspect of their breeding fitness. I considered the population census at PRSNA to be complete to nearly complete for the habitats sampled, and although actual density was not measured, some of the areas sampled had seemingly high nest densities, particularly the fencerows and the outer edges of the riparian strip habitats. We considered using nest success rates as habitat quality indicators acceptable as measures of bird fitness.

Nest success outcomes and other analyses showed that the linear habitat available to central Illinois shrub nesting birds was not an ideal breeding habitat, especially in comparison to other published research. Best & Stauffer (1980) studied riparian habitats in Iowa and found a much higher nest success rate for American Robins (69% vs. 31% in this study). Murphy & Fleischer (1986) reported a nest success for Gray Catbirds (58%) and Brown Thrashers (44%) in their eastern Kansas pasture and shrub nesting study (compared to 45% and 36% in this study). Hughes et al. (2000) reported a two-year average for Mourning Dove nest success (56% vs. 13% in this study) in CRP fields in Kansas; and Flaspohler et al. (2001) reported nest success for American Robins (36% compared to 31% in this study) in their nest success study of forest edges. Filliater et al. (1994) published nest success of Northern Cardinals in an Audubon farmscape in Ohio (15% vs. 6% in this study). All of these values are higher than my averages (Table 2).

It was interesting to find that although habitat type was significantly related to the width of the habitat, it was not significantly related to the distance a nest was found to the edge of the habitat. Furthermore, there was no significant relationship between nest survival and habitat type, and no significant difference between nest success rates in fencerows or riparian habitats. In riparian habitats, the edges usually consisted of denser shrubs than the higher canopy interior where the birds were less likely to nest. In contrast, fencerow habitats tended to have high shrub density throughout. On average, most nests were located relatively close to the habitat edge (Figure 7). This leads me to conclude that the shrub-nesting species did not significantly prefer one habitat over the other and that there was no ecological difference between the fencerow habitat and the riparian strip edges found in areas of central Illinois in terms of impact on nest survival and nest success.

The management implications gleaned from these analyses show that since riparian strip and fencerow habitats do not differ in nest survival or nest success, land managers may treat them as similar habitats for nesting birds in evaluating the usefulness of those habitat features. If land managers are faced with fencerow removal to enhance their remaining habitat such as grasslands, which is the case in many wildlife management areas in Illinois, it appears that the shrub-nesting bird species would not be adversely impacted as long as there were other available riparian habitat and possibly other similar forest edge habitats in equal abundance.

In the logistic regression analysis, the fact that American Robin nest success was positively correlated with nests located higher above the ground is not surprising. Schmidt and Whelan (1999) found similar results in their American Robin study, where daily mortality rates for robin nests decreased as their nest height increased. Similarly, a riparian habitat study in Iowa determined that the percentage of bird nests that successfully fledged young increased significantly with increased nest height (Best and Stauffer1980).

It was also not surprising that both the logistic regression analysis and the survival analysis showed that Common Grackle nest success and nest survival increased with decreasing nest visibility. Gandini et al. (1999) showed that Magellanic Penguins (*Spheniscus magellanicus*), colonial nesters, had less egg predation and produced more fledglings from nests with reduced nest visibility. Although there is not a lot of published literature on Common Grackle nesting ecology, one characteristic that sets them apart from the other shrub-nesting species in this study is that Common Grackles are semi-colonial nesters (Peer & Bollinger 1997). The majority of grackle nests from this study were located in colonial groups, with only a few solitary nesters (researcher's observation). Colonial nesting is thought to have evolved (in part) as a means to avoid high rates of predation (Wittenberger & Hunt 1985). Kopachena (1991) explains that some advantages of colonial nesting in reducing predation include the use of inaccessible colony sites, predator swamping, and increased vigilance. Perhaps the most successful Common Grackle nests from this study were those in colonial groups that managed to adequately conceal their nests and reduce visibility to predators.

Habitat sinks are low quality habitats in which population growth rates are typically negative. In an ecological trap, Battin (2004) explains, animals make errors in habitat assessment based on environmental cues they use to select habitats which lead them to choose lower quality habitat preferentially over superior habitat. In other words, they are sink habitats that are preferred rather than avoided. Linear habitats, such as fencerows and riparian strips, which have replaced larger woodlots and land tracts in the agricultural U.S. are not ideal breeding areas for shrub-nesting bird species, based primarily on reported nest success rates. Considering them a sink habitat within a "source-sink" dynamic in the landscape may be erroneous, however, because that would insinuate that there is better breeding habitat available to the nesters in the same area, of which I cannot be certain. Other reported nest success rates stated earlier seemed to indicate that other agricultural habitats promoted higher nest success rates, but further research needs to be done to determine if linear agricultural habitats are less of a source for breeding birds than non-linear agricultural habitats.

Schmidt and Whelan (1999) showed how the presence of exotic shrubs in fragmented habitats directly increased American Robin nest predation and may be caused by an exotic shrub tendency for early leaf flush. Haas (1995) found that most adult American Robins and Brown Thrashers nesting in woody shelterbelts of agricultural land did not disperse from their initial breeding territories even after failed nesting attempts, but that they followed wooded corridors if they did disperse. These findings could further complicate the ability for these shrub-nesting species to reproduce successfully, if found in linear habitats like fencerows, by reducing their success rates and increasing the likelihood of the habitat becoming an ecological trap; especially if the breeding habitats are located in an isolated area away from wooded corridors. The same may be true for other shrub-nesting passerines located in fragmented, agricultural landscapes.

Habitat fragmentation is one of the primary problems breeding bird species are currently facing in the Midwest; and of the remaining habitats available in the agricultural landscape, linear habitats are in abundance. Because of this, defining linear habitat as an ecological trap may be more accurate, considering the shrub-nesting bird species we researched are typically edge species (R.E. Mirachi & T.S. Basket 1997, R. Sallabanks & F.C. James 1997, J.F. Cavitt & C.A. Haas 1997, B.D. Peer & E. K. Bollinger 1997) and may be more attracted to the large amount of edge that linear habitat creates. Linear habitats should be considered an important and perhaps hazardous influence on the present breeding environment for avian species in the agricultural landscapes of the U.S. A pattern of higher abundance and lower reproductive output in one habitat suggests the presence of an ecological trap (Battin 2004), so determining the actual densities of shrub-nesting birds found in linear habitat and comparing them to other habitats in which they nest may be necessary to further understanding how detrimental linear habitats can be to bird populations.

Future research on fragmented linear habitats within the agricultural landscapes of the U.S. would be useful, particularly in the area of linear forest edges as a comparison to fencerows and riparian strips. Recognizing the impact exotic plant species have on nesting birds within fragmented habitats would be an important component of understanding ecological traps in agricultural areas. Expanding the research to include a break down in predator composition of these habitats and monitoring avian species other than shrub-nesters would also be useful to further understanding the role of linear habitats in agricultural landscapes for breeding birds.

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Table 1. Species composition and nest success of breeding species found at PRSNA in 1997-1998 (Walk & Kershner).

	Percentage of Successful Nests (# of Nests)		
Species	**Total**	**Linear Habitat***	**Non-Linear Habitat****
Brown Thrasher	32.3 (91)	29.4 (69)	35.2 (22)
Mourning Dove	30.2 (62)	33.5 (36)	26.9 (26)
American Robin	18.0 (56)	12.6 (37)	23.4 (19)
Northern Cardinal	37.1 (12)	26.1 (10)	48.1 (2)
Blue Jay	20.6 (6)	20.8 (6)	--
Gray Catbird	9.5 (1)	0.0 (1)	--
Eastern Towhee	5.9 (1)	0.0 (1)	--

* Includes fencerows and other linear features of landscape
** Includes lone trees, small habitat patches, and other non-linear features of the landscape

Table 2. Species composition and nest success of breeding species found at PRSNA in 2006.

	Percentage of Successful Nests (# of Nests)		
Species	Total	Fencerow Habitat	Riparian Strip Habitat
American Robin	30.5 (47)	35.7 (29)	23.9 (18)
Brown Thrasher	35.7 (27)	42.3 (17)	24.3 (10)
Common Grackle	40.7 (27)	38.1 (19)	48.4 (8)
Mourning Dove	13.4 (20)	11.9 (12)	17.1 (8)
Northern Cardinal	6.0 (16)	3.9 (14)	34.6 (3)
Gray Catbird	45.3 (15)	23.6 (10)	100.0 (5)
Blue Jay	65.5 (7)	60.2 (1)	100.0 (6)
Red-winged Blackbird	11.4 (5)	12.4 (2)	10.8 (3)
Eastern Towhee	27.3 (2)	0.1 (1)	100.0 (1)
Indigo Bunting	0.0 (2)	0.0 (1)	0.0 (1)
Rose-breasted Grosbeak	100.0 (1)	-- (0)	100.0 (1)
Yellow-billed Cuckoo	100.0 (1)	100.0 (1)	-- (0)
Unknown Species	0.0 (2)	0.0 (1)	2.9 (1)

Table 3: Logistic regression of habitat variables on 2006 population at PRSNA. American Robin and Common Grackle nest success rates were significantly affected by measured variables in their habitat.

Species	Parameter	DF	Estimate	St. Err	Wald Chi^2	P-value
Am. Robin	Intercept	1	-1.32	0.82	2.78	0.11
	Nest Height	1	0.81	0.41	3.89	0.048
Co. Grackle	Intercept	1	-3.75	2.11	3.19	0.074
	Nest Visibility	1	1.63	0.79	4.25	0.039

Table 4: Survival analysis of habitat type on all shrub-nesting species in 2006. There is no significant relationship for any of the species monitored with regard to the habitat type their nests were located in.

Species	DF	Parameter Estimate	Standard Error	P-value	Hazard Ratio
Am. Robin	1	0.251	0.429	0.558	1.286
Br. Thrasher	1	0.415	0.591	0.483	1.515
Co. Grackle	1	-0.933	1.073	0.385	0.393
Gr. Catbird	1	-18.13	4147	0.997	0.000
Mo. Dove	1	-0.044	0.603	0.941	0.957
No. Cardinal	1	-0.906	1.051	0.389	0.404

Table 5: Survival Analysis of American Robin nests, including the effects of habitat variables. Parameter estimates and hazard ratios give the percent increase or decrease in mortality for nestlings based on each habitat variable.

Habitat Variable	DF	Parameter Estimate	Standard Error	Chi-Sq	P-value	Hazard Ratio
Dist. To Edge	1	0.19521	0.08850	4.8653	0.0274	1.216

Table 6: Survival Analysis of Common Grackle nests, including the effects of habitat variables. Parameter estimates and hazard ratios give the percent increase or decrease in mortality for nestlings based on each habitat variable.

Habitat Variable	DF	Parameter Estimate	Standard Error	Chi-Sq	P-value	Hazard Ratio
Nest Visibility	1	-3.25780	1.68288	3.7475	0.0529	0.038

Table 7: Survival Analysis of Mourning Dove nests, including the effects of habitat variables. Parameter estimates and hazard ratios give the percent increase or decrease in mortality for nestlings based on each habitat variable.

Habitat Variable	DF	Parameter Estimate	Standard Error	Chi-Sq	P-value	Hazard Ratio
Nest Tree Size	1	-0.20415	0.10250	3.9669	0.0464	0.815
Closest Field	1	11.82660	4.98029	5.6391	0.0176	136844.7

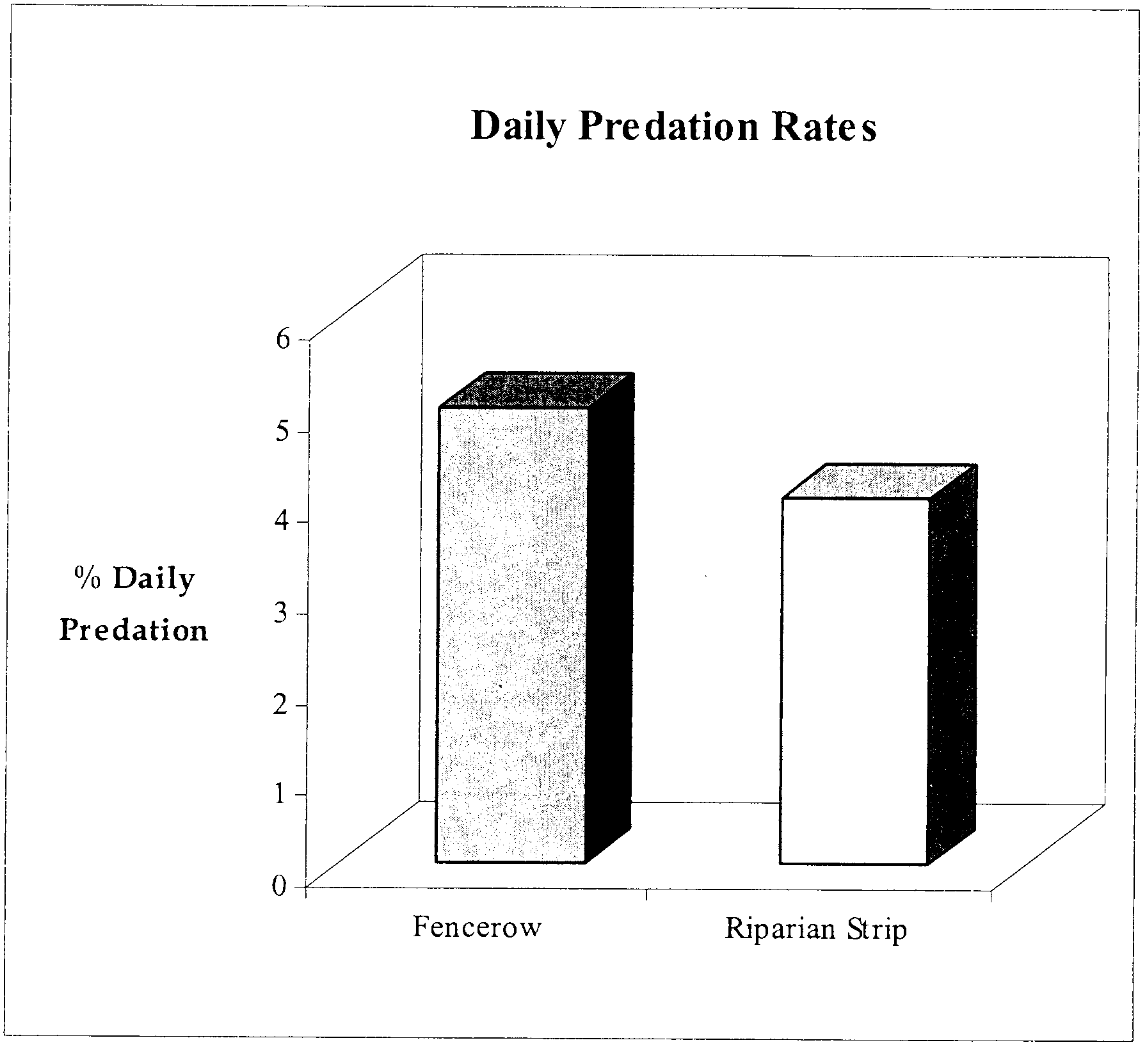

Figure 1: Daily predation rates of breeding birds (all species combined) found in fencerow and riparian strip habitats at PRSNA.

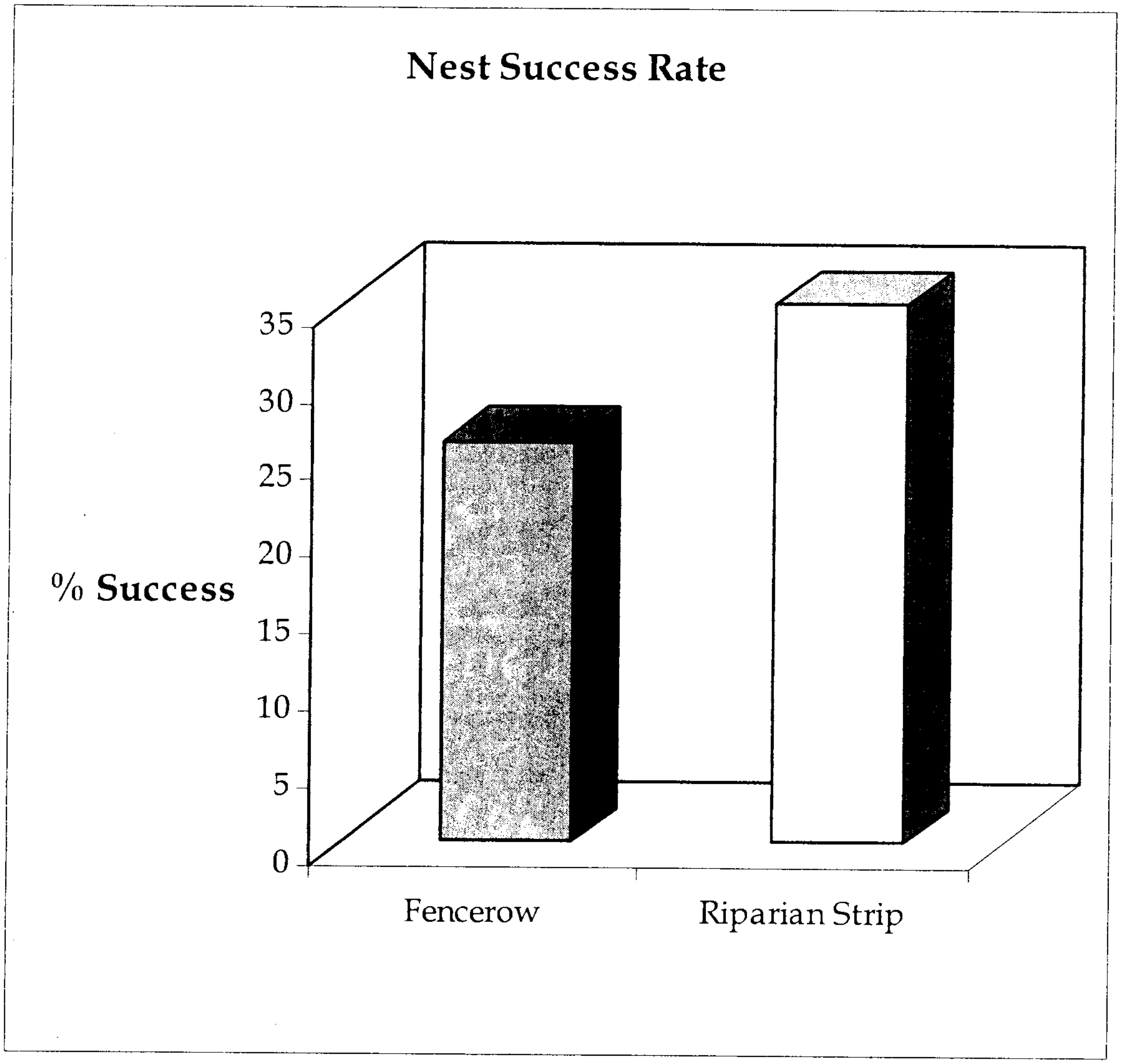

Figure 2: Nest success rates of breeding birds (all species combined) found in fencerow and riparian strip habitats at PRSNA.

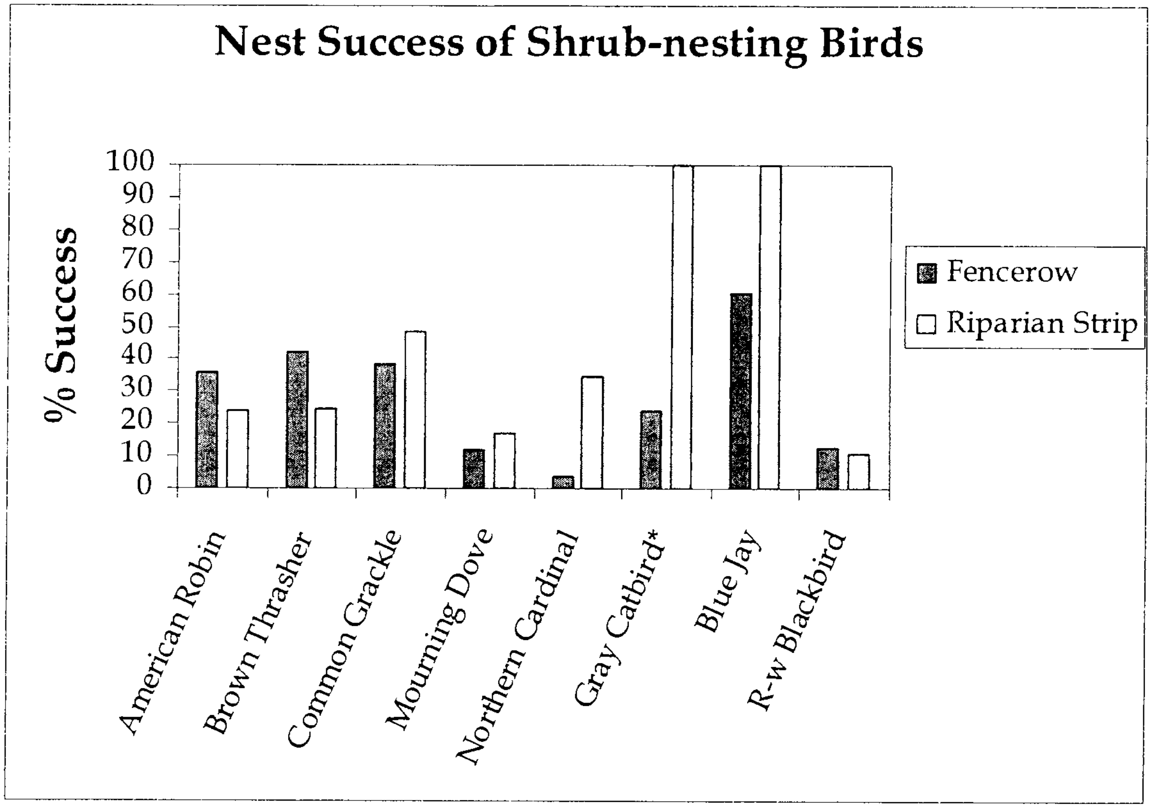

Figure 3: Nest success rate variation between fencerow and riparian strip habitats in 2006. * Indicates the difference between nest success rates for that species is significant ($p < 0.05$).

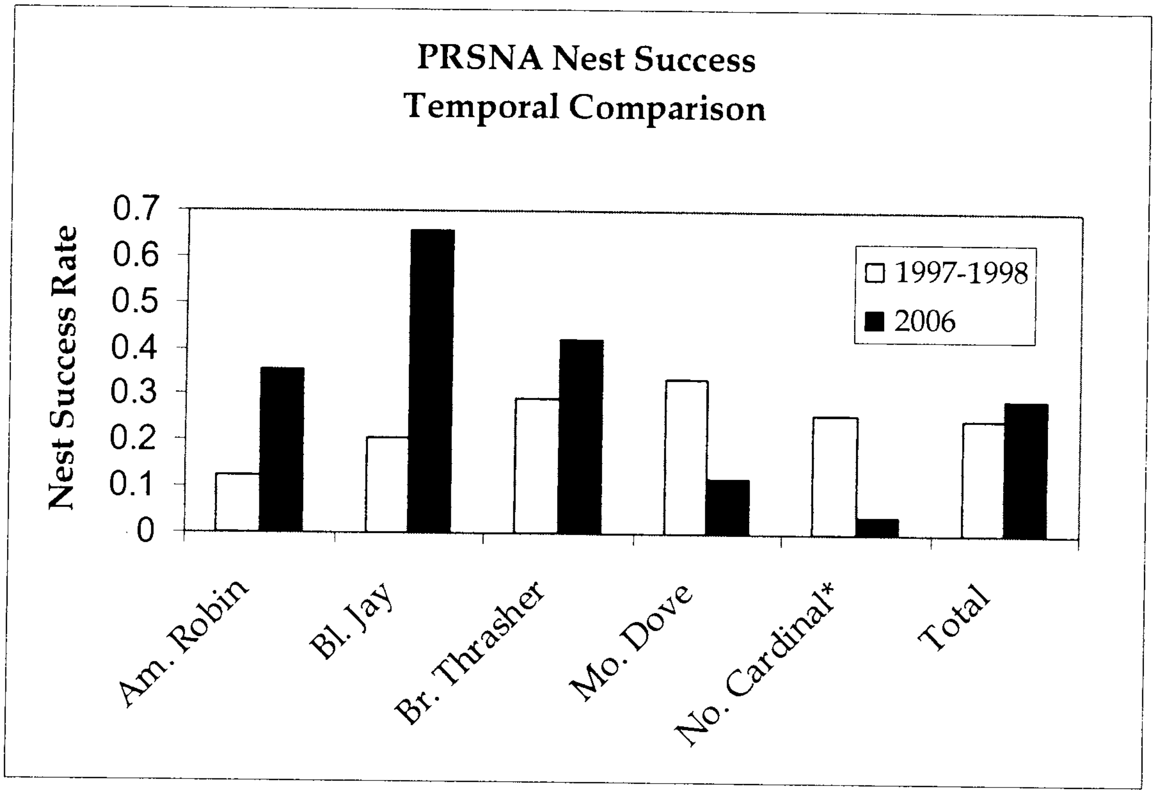

Figure 4: Temporal comparison of 5 species breeding on PRSNA between 1997-1998 and 2006, and their total success rates. * Indicates significant difference between nest success rates ($p < 0.05$).

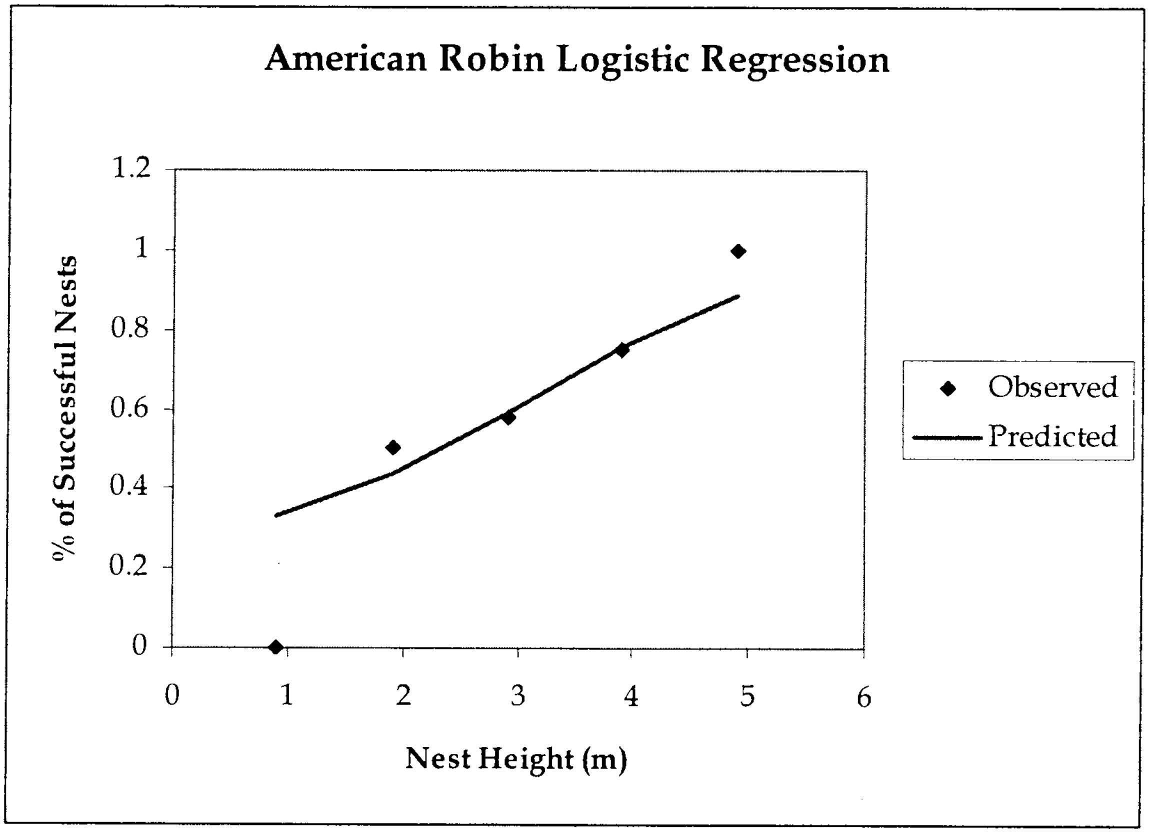

Figure 5: Relationship between American Robin nest success and the height of their nests.

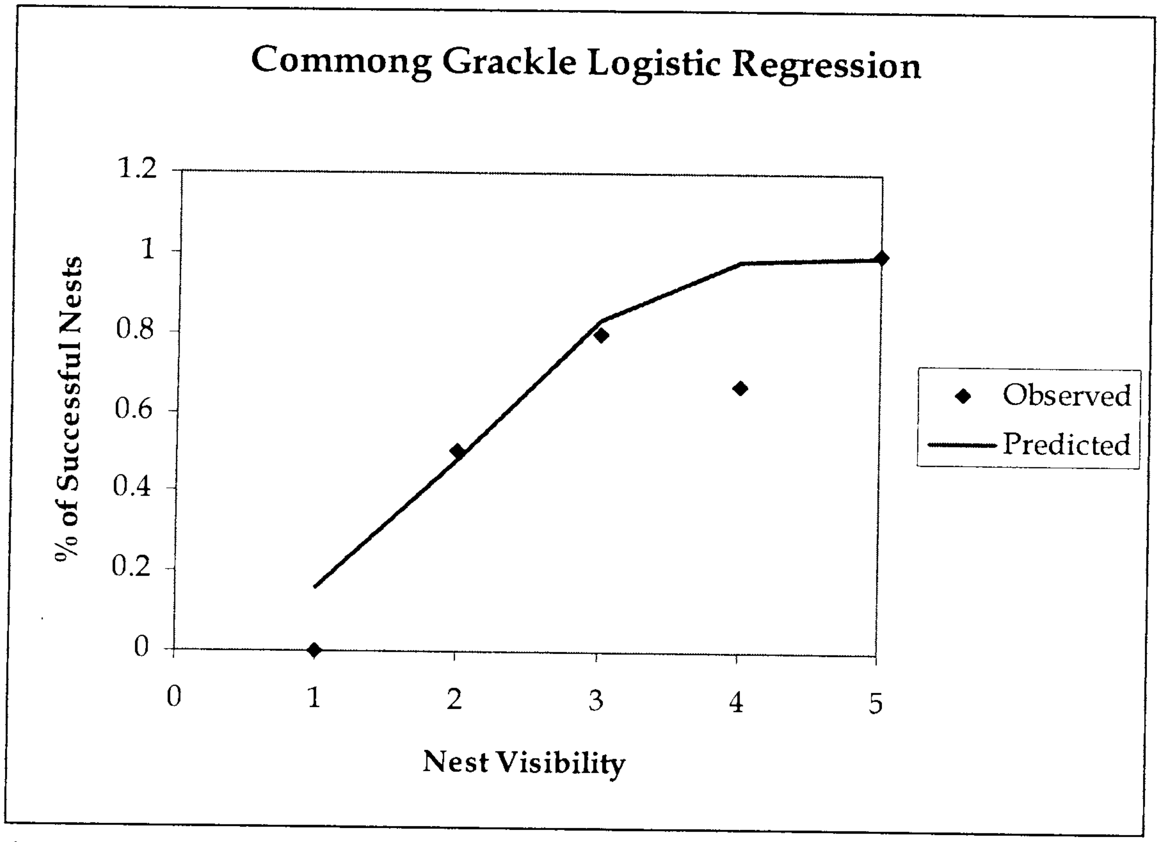

Figure 6: Relationship between Common Grackle nest success and the visibility of their nests. Refer to methods for visibility ranking.

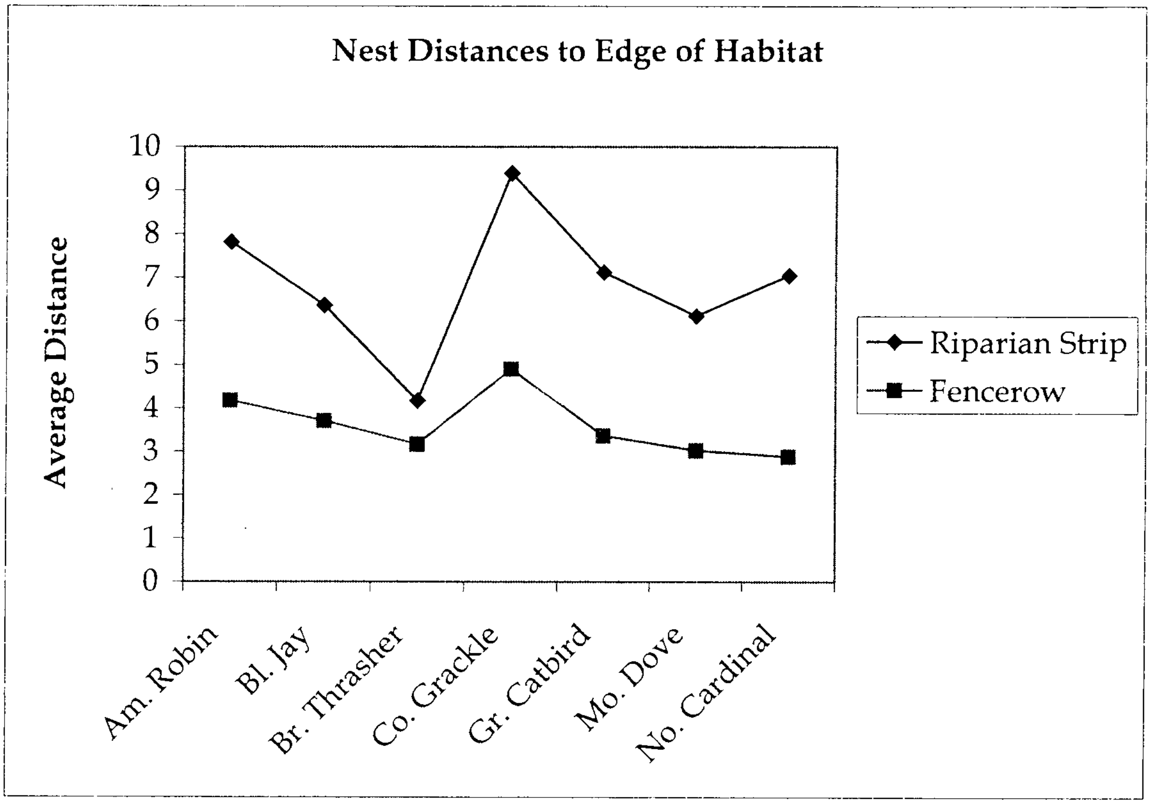

Figure 7: Comparison of the average distance nests were located away from the edge of a habitat for fencerow and riparian strips.