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Reproductive Success of American Kestrels (*Falco sparverius*) Nesting in Boxes along an Interstate in Northeastern Tennessee.

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ABSTRACT

Reproductive Success of American Kestrels (*Falco sparverius*) Nesting in Boxes along an Interstate in Northeastern Tennessee

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Nest box programs provide supplemental nest sites for American Kestrels, *Falco sparverius*. When the availability of nest sites is a limiting factor, the addition of nest boxes can increase local breeding populations. These programs also facilitate the collection of data on breeding kestrels.

This study focuses on an American Kestrel (*Falco sparverius*) nest box trail along Interstate 26 in northeastern Tennessee during the breeding seasons of 1998, 1999, 2000, 2003, 2004, 2006, and 2009. Productivity measures and reproductive success of nesting birds are provided and compared to other programs. The data are analyzed across years and by box. Finally, a discussion of the habitat surrounding the most and least active boxes provides recommendations for increased efficiency of the program.

ACKNOWLEDGMENTS

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Many organizations and individuals have supported this project. Clinton Jenkins did the original work to establish the trail in 1998, and Michelle Brown King kindly initiated me into the project. The Tennessee Department of Transportation permitted the attachment of the nest boxes onto road signs. Boxes were donated by the Tennessee Department of Wildlife Resources. The JB Owen Award and Marcia Davis Award provided financial support. Many East Tennessee State University undergraduate students have assisted with the monitoring and maintenance of the trail. Phillip Powers provided assistance as well as the critical truck and ladder.

The dedication of the School of Graduate Studies and the Department of Biological Sciences to my earning this degree is much appreciated. I am especially grateful to Dean Cecilia McIntosh for her efforts in making this possible.

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CHAPTER 1

INTRODUCTION

The American Kestrel (*Falco sparverius*) is the smallest and most colorful of New World falcons. Females are the larger of the sexes, varying from 23 to 31 centimeters in length with wingspans of 57 to 61 centimeters; males range from 22 to 27 centimeters in length with wingspans of 51 to 56 centimeters. In North America, there is a decrease in size that corresponds with a decrease in latitude (Wauer 2005). American Kestrels are sexually dimorphic. The more colorful males have blue-gray wings, a rufous tail with black subterminal band and white tip, tawny breasts, and barred, rufous backs. Females have streaked, buff-colored breasts; their backs and wing coverts are chestnut colored with heavy, dark barring. Both sexes have blue crowns, two black facial lines that run vertically, and dark eyespots on the nape.

American Kestrels are eurytopic and widely distributed across North America. Figure 1 shows the species summer breeding range. In the winter, many birds from northern populations migrate southward (Wauer 2005). Kestrels are edge species and prefer open habitats such as fields, pastures, and grasslands for hunting (Toland 1987). As obligate secondary cavity nesters, American Kestrels depend on natural cavities or holes excavated by woodpeckers for nesting sites (Hamerstrom et al. 1973). However, kestrels readily accept nest boxes when provided (Nagy 1963, Hamerstrom, 1973).

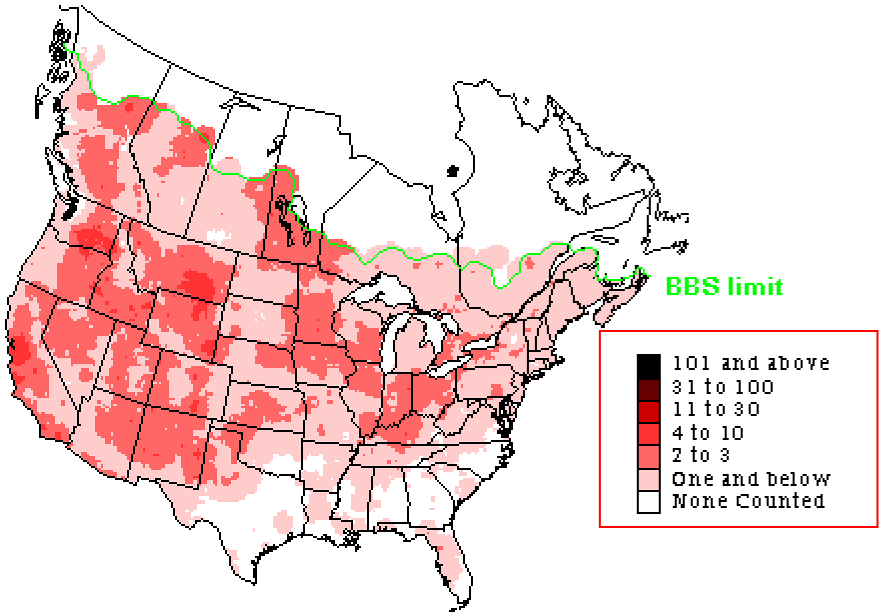

Figure 1 Breeding Range of American Kestrels in Canada and the US (USGS 2002)

Breeding Bird Surveys (Sauer 2008) have indicated that populations of American Kestrels in western regions and in New England are declining.   Figure 2 depicts the percent of change in breeding kestrel populations. Statistically significant declines have been documented at Hawk Mountain Sanctuary in Pennsylvania and at Cape May Bird Observatory, New Jersey (http://hawkmountain.org/media/American_Kestrel_CSR.pdf). Figure 3 illustrates the data from fall migration counts. Christmas Bird Counts show similar trends (NAS).

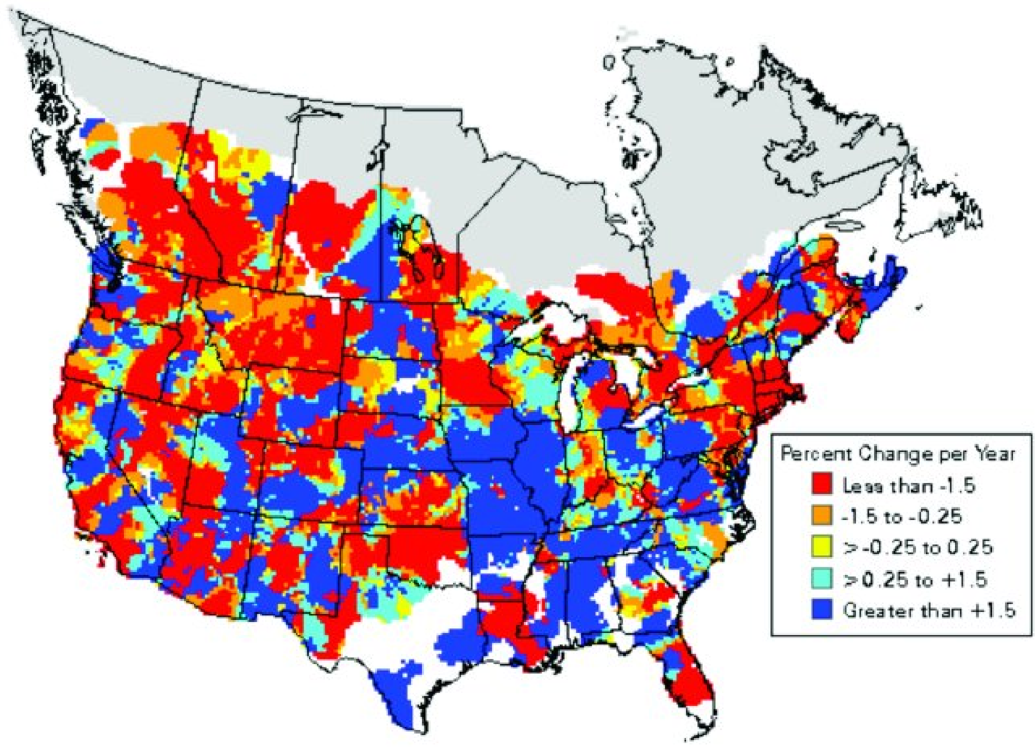

Figure 2 BBS Map of Trends in American Kestrel Populations (Sullivan and Wood 2005)

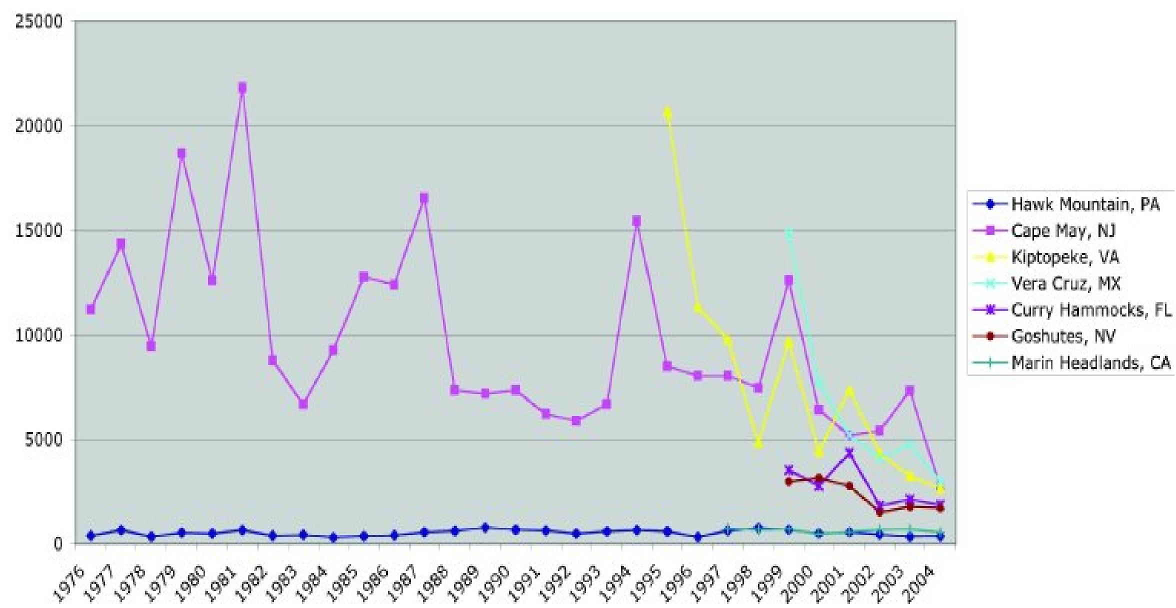

Figure 3 American Kestrel: Fall Totals from Hawkwatch Sites (Sullivan and Wood 2005)

Nest Box Use by American Kestrels

Hamerstrom et al. (1973) studied kestrels nesting in man-made boxes in central Wisconsin and determined the annual productivity of the birds as well as the percentage of occupied boxes that fledged young. Additionally, they reported an increase in the breeding population of American Kestrels after the establishment of nest boxes, suggesting that availability of nest sites is a limiting factor for the species. Subsequent studies have used nest boxes to assess various parameters of local American Kestrel populations.

Toland and Elder (1987) compared the productivity of kestrels nesting in boxes with that of birds nesting in natural cavities in central Missouri and found no difference in the number of young per nest site. However, their analysis did find an association between box placement and nesting success; boxes placed on utility poles and buildings had higher success rates than those placed on trees, possibly due to easier access to tree-mounted boxes by predators. Further, kestrels showed a preference for boxes facing in a southerly or easterly direction. After the addition of nest boxes, both the breeding and wintering populations of kestrels increased significantly (Toland and Elder 1987).

Wheeler (1992) assessed the clutch size and hatching success of kestrels nesting in boxes in Montana and Wyoming as well as the sex ratio of fledglings. In 9 of 14 cases, kestrels attempted a second nest after the failure of their first nest. Although these second nests had lower hatching success rates, the percentage of hatchlings that fledged was comparable to that of first-time nesting attempts. The sex ratio of fledglings did not vary significantly from the expected 1 to 1 ratio (Wheeler 1992).

Varland and Loughin (1993) evaluated the reproductive success of kestrels nesting in boxes in central Iowa. These nest boxes were attached to the backs of interstate signs, which provide suitable hunting territory while limiting access by predators. Varland and Loughin compared their occupancy rates, apparent success rates, clutch and brood size, hatching success, fledging success, and fledglings per brood with those from other American Kestrel nest box programs. They also determined that nests were more likely to fail during the incubation stage than during the brood rearing stage. By monitoring radio-tagged fledglings, Varland and Loughin (1993) concluded that collisions with vehicles were not a significant risk for fledglings reared along the interstate.

During a 5-year study in eastern Pennsylvania, Rohrbaugh (1994) investigated how nest box use and nesting success relate to macrohabitat, microhabitat, and microclimate. This work indicated a strong preference among kestrels for boxes with low concealment and high light-intensity. In fact, boxes meeting these criteria yielded higher success rates for nesting kestrels than did other boxes.

Due to the expanded use of nest boxes as conservation and research tools, Katzner et al. (2005) recognized a need for efficiency in the programs. Their evaluation of a 10-year data set from a nest box program in eastern Pennsylvania facilitated recommendations to maximize the use of resources and the effectiveness of the nest box trail. Kestrels that nested in particular boxes were consistently more successful in terms of number of fledglings than those nesting in other boxes. As these boxes were also used more often, maintaining and monitoring a subset of boxes could enhance the effectiveness of the nest box trail while making the most of human and financial resources. Specifically, the researchers estimated that they could reduce the work load in the field by 25% while decreasing reproduction by 2-7%. However, they caution that less desirable boxes may provide experience for young birds that will choose superior boxes in subsequent years. The potential for increased competition and behavioral changes, as well as the prospective success of birds nesting in subprime boxes, mitigate the benefits of removing subprime boxes (Katzner et al. 2005).

Steenhof and Peterson (2009) studied mate fidelity, site fidelity, and breeding dispersal of American Kestrels nesting in boxes in southwestern Idaho. Both males and females showed low site fidelity as well as low mate fidelity regardless of prior experience or success. Steenhof and Peterson speculate that the short life spans of kestrels and the variation in habitat quality reduce selective pressures for mate and site fidelity. Dispersal distance of birds that switched boxes did differ between males and females, however. Females averaged a distance of 3.2 km, while males dispersed an average of 2.2 km (Steenhof and Peterson 2009).

Objectives

The data gained from nest box programs facilitate population monitoring and effective management of the species. In this study, I describe the reproductive success of American Kestrels nesting in boxes along an interstate in northeastern Tennessee during the breeding seasons of 1998, 1999, 2000, 2003, 2004, 2006, and 2009. I contrast the success of the incubation period to that of the brood rearing period in order to better understand where losses occur. I determine if particular boxes are more active than other boxes. I compare the productivity of kestrels using these boxes with data from other nest box programs. Finally, I make recommendations to improve the efficiency of this nest box trail in terms of conservation and resource management.

CHAPTER 2

METHODS AND MATERIALS

Study Area

The boxes are located in northeastern Tennessee along both sides of Interstate 26 between mile markers 3 and 42 in Sullivan, Washington, and Unicoi Counties. Twenty boxes were originally established in 1997. Twenty-five boxes were available in 1999 through 2008. The trail was expanded to include 27 boxes in 2009. Elevation at box locations ranges from 464.5 to 616.6 meters.

Nest Boxes

The boxes were provided by the Tennessee Wildlife Resources Agency and are constructed of western red cedar. Box dimensions are 15 inches by 10 inches by 9 inches with an opening of 3 inches. The Tennessee Department of Transportation authorized the attachment of boxes to the backs of signs, which was done by a nut and bolt that slides into the grooves or by steel bands. Boxes were placed at heights ranging from 12.5 to 19.5 feet. Boxes can be opened either from the top by means of a hook and eye latch or by removing a screw on the side panel. Figure 6 shows a nest box attached to the back of a sign on Interstate 26.

Figure 4 Nest Box Attached to Sign on Interstate 26

Monitoring the Trail

In February of each year, initial inspections and necessary repairs were made. The boxes were accessed using an extension ladder (see Figure 7). Approximately 5-6 centimeters of sawdust or wood shavings were placed in the bottom of each box. Undergraduate students from East Tennessee State University monitored the trail weekly, recording any activity at the boxes.

Beginning in early to mid-March, I would access the boxes weekly to check for nesting activity. European Starlings (*Sturnus vulgaris*) compete with American Kestrels for the boxes. Any starling nesting material and eggs were removed and new sawdust or woodchips added (see Figure 8). This continued through May of each year. Boxes with kestrel pairs were accessed weekly to monitor nesting activity and record clutch sizes, hatchling numbers, and fledgling numbers. Fledglings were banded between 2 and 3 weeks of age.

Figure 5 Accessing a Nest Box

Figure 6 European Starling Nest in Nest Box

Statistical Analyses

Analyses by Year

For each nest, I describe the clutch size, hatching success, and fledging success and report the mean of these productivity measures for each year. For each box, I determined the percentage of use (presence of one egg). A chi square test was used to test for difference in occupancy rates across years. Because the data are not normal, a Kruskal Wallis test was used to check for differences among years for eggs, hatchlings, and fledglings. Because earlier years appeared more productive than later years, the data were grouped into years of high productivity (1998-2000) or low productivity (2003-2009). A chi square test was used to indicate a relationship between time period and box use, and a Mann Whitney Test was used to indicate a difference between the two time periods.

Analyses by Box

I determined the proportion of years that each box was used (presence of at least one egg) and the average productivity of each box. A chi square independence test was then used to test for differences in box use as well as the number of eggs, hatchling, and fledglings produced per box.

CHAPTER 3

RESULTS

Analyses by Year

Table 1 provides the productivity measures of the I-26 American Kestrel nest box trail across 7 years. Table 2 summarizes the data across years and illustrates how these results compare to similar studies.

Table 1 Productivity Measures from I-26 Nest Box Trail

Column1	1998	1999	2000	2003	2004	2006	2009
# of Boxes	20	25	25	25	25	25	27
% Active	25	24	32	28	16	8	7
Mean Clutch Size	4.8	5.0	*	4.17	4.0	3.0	5.0
Mean Hatchlings per Brood	4.33	5.0	*	3.0	4.5	4.0	4.0
% Hatching	54	83	*	48	75	67	40
% Fledging	92	96	*	100	100	100	100
Mean Fledglings per Brood	4	4.8	*	3.0	4.5	2.0	4.0

* Data Unavailable

Table 2 Summary Statistics for American Kestrel Nest Box Trails

	Occupancy (%)	Mean Clutch Size	Hatching Success (%)	Fledging Success (%)	Mean Brood Size	Mean Fledgling per Brood	Apparent Success (%)[a]
Iowa (Varland and Loughin 1993)	45	4.8	62	91	3.1	2.9	69
Wisconsin (Hamerstrom et al. 1973)	25	*	*	*	*	*	20
West Virginia (Wilmers 1982)	27	4.6	67	95	*	*	73
California (Bloom and Hawks 1983)	31	4.3	79	90	4.0	3.1	83
Missouri (Toland and Elder 1987)	53	5.0	71	98	*	4.5	73
Wyoming (Wheeler 1992)	*	4.7	81	90	3.7	*	*
Tennessee (This Study)	20	4.3	61	98	4.1	3.7	63

* Data Unavailable
[a] Percent of nests that fledged at least one bird

In the later years of the study, activity at the boxes appears to decrease (Figures 7 and 8). A Chi-Square test concluded that year and box use are statistically independent, and a Kruskal Wallis test determined that there are no statistically significant differences among individual years for eggs, hatchlings, or fledgling (Table 3) .

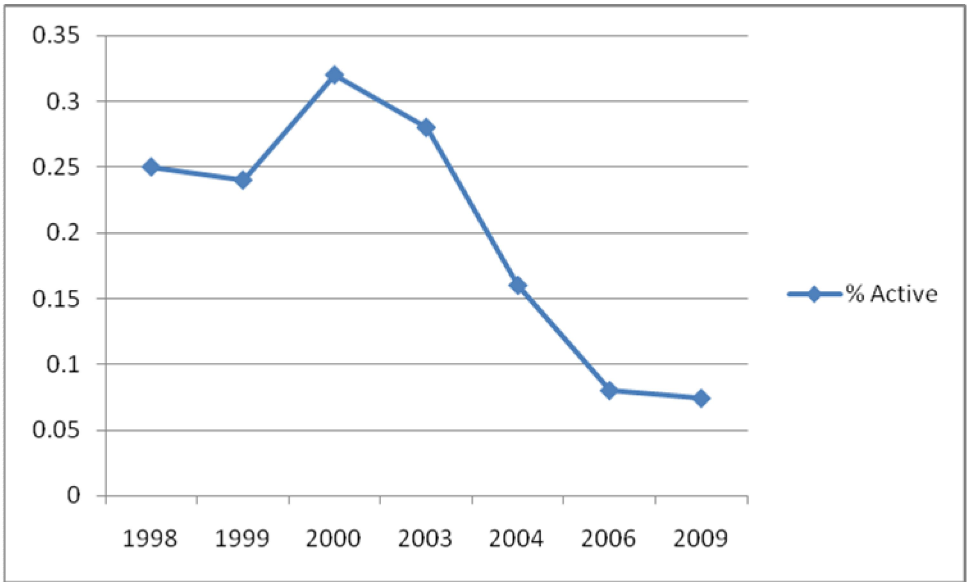

Figure 7 Percent of Active Boxes Per Year

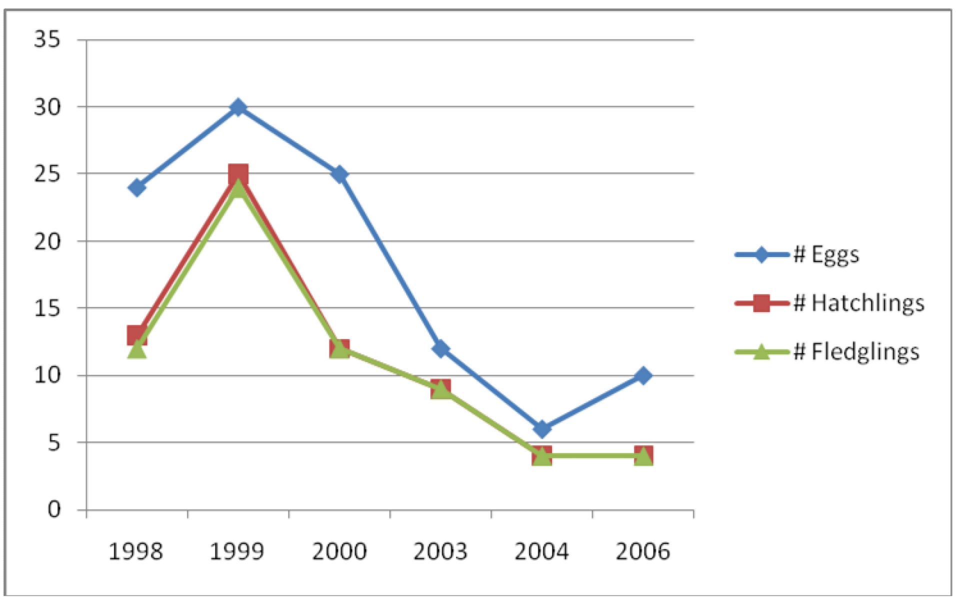

Figure 8 Numbers of Eggs, Hatchlings, and Fledglings per Year

Table 3 Analysis of Box Use and Productivity across Years

Year/Box Use (Chi Square)	Eggs/Year (Kruskal Wallis)	Hatchlings/Year (Kruskal Wallis)	Fledglings/Year (Kruskal Wallis)
χ^2=8.03 df=6 p=0.24	χ^2=7.42 df=6 p=0.28	χ^2=8.58 df=6 p=0.20	χ^2=7.55 df=6 p=0.27

As these results could be a result of small sample size, I divided the data into an early period when activity appears higher (1998-2000) and a later period when activity appears to decrease (2003-2009). I then checked for significance between the two periods using a Chi-Square test, which did indicate a relationship between time period and box use (χ^2=4.16, df=1, p=0.04). I used the non-parametric Mann-Whitney test to compare the productivity of the two time periods (Table 4). Again, the two time periods differed significantly.

Table 4 Mann Whitney Test Comparing Productivity of Early and Later Years (N=170)

Time Period	Eggs Summary of Ranks (Expected)	Hatchlings Summary of Ranks (Expected)	Fledglings Summary of Ranks (Expected)
1998-2000	6268 (5814)	6543.5 (6055)	6491.5 (6055)
2003-2009	8267 (8721)	8334.5 (8823)	8386.5 (8823)
Z score (p-value)	2.147 (0.03)	2.575 (0.01)	2.345 (0.02)

Analyses by Box

During this study particular boxes were used more frequently than other boxes, and some boxes were never used at all (Figure 10). A significant Chi-Square showed that there are differences in box use and number of eggs by box. However, there are no statistically significant differences by box for hatchlings or fledglings (Table 5). (Two boxes not established until 2009 were excluded from the analyses).

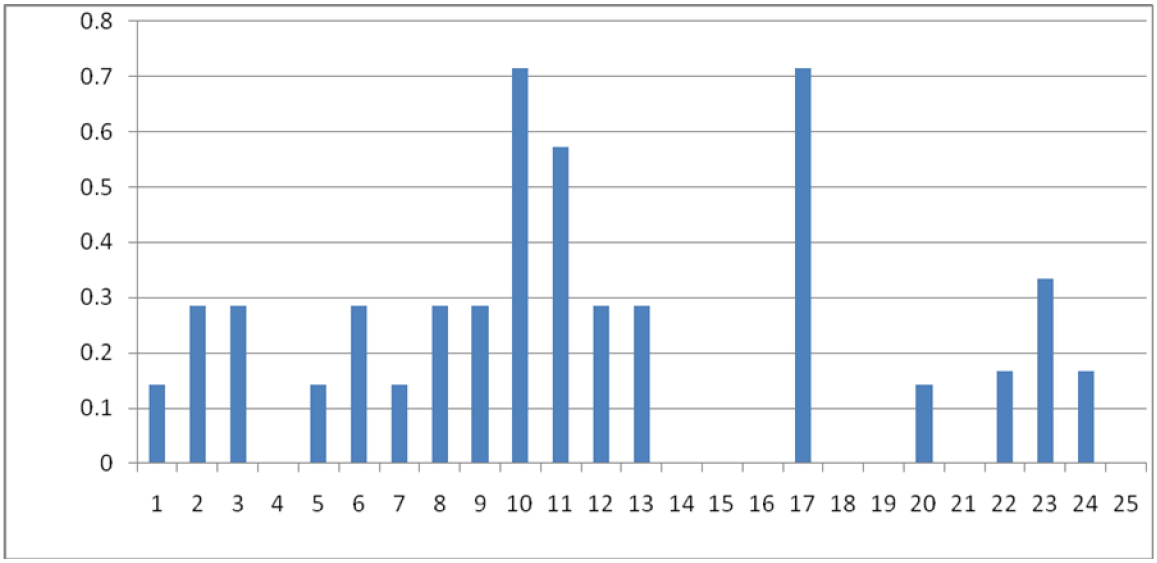

Figure 9 Proportion of Years Each Box was Used

Table 5 Chi-Square Results for Box Use and Productivity

Box Use	Eggs/Box	Hatchlings/Box	Fledglings/Box
χ^2=45.11 df=26 p=0.01	χ^2=42.78 df=26 p=0.02	χ^2=32.43 df=26 p=0.18	χ^2=32.46 df=26 p=0.18

CHAPTER 4

DISCUSSION

The occupancy rate of boxes along I-26 (20%) is lower than that reported in other studies (Table 2). This may be in part due to higher densities in other study areas, particularly California and Iowa. However, the 20% occupancy rate in this study falls more closely in line with occupancy rates from states reporting densities similar to Tennessee such as West Virginia (27%) and Wisconsin (25%) (Figure 1). It is also possible that nest site availability is not a primary limiting factor for kestrels in the study area.

Mean clutch size was 4.3, and hatching success was 61%. Although hatching success was slightly lower than that of other studies, this may not be significant. Fledgling per brood averaged 3.7 with a fledgling success rate of 98%. This high percentage of successful fledgings is very promising.

Apparent success defined as the percentage of nests that fledged at least one bird was 63%. Although California had a high apparent success rate (83%), the average apparent success of the other studies was also 63%.

There has been a significant decrease in box activity and productivity during the 2003-2009 period. A nest box program in Pennsylvania experienced a 57% decline in productivity and a 40% decline in nesting attempts between from 2000 to 2004 (http://hawkmountain.org/media/kestrelCSR_June07.pdf) Whether this reflects a decrease in kestrel density, reduced prey abundance or availability, changes in habitat near the boxes, or an increase in the availability of natural nest sites is unknown.

Habitat and Box Use

Kestrels nested in certain boxes more than expected and others less than expected. Variability in habitats in the region of each box might play a key role in this result. Various studies have shown that kestrels prefer a particular habitat structure when selecting nest sites (Toland 1987, Rohrbaugh 1994, Ardia and Bildstein 1997, Williams et al. 2000). In his study of vegetation cover's effect on distribution and foraging success of American Kestrels, Toland (1987) found that kestrels used disturbed grassland and fields (mowed fields, hayfields, and grazing pastures) 68% of the time during the breeding season (this habitat structure constituted 18% of available habitat). Overgrown pastures (5% of available habitat) and woodlots (15% of available habitat) were used only 2% of the time each. Likewise, plowed fields and field with light stubble were used only 11% of the time (11% of available habitat). These preferences seem to be related to hunting success. Kestrels hunting in disturbed grasslands and fields were successful in 83% of hunting attempts; however, those hunting in woodlots and overgrown pastures were successful in only 33% of attempts (Toland 1987). Other studies have also indicated a strong preference by kestrels for low ground cover as well as no canopy cover or vegetation around nest sites (Bloom and Hawks 1983, Rohrbaugh 1994, Ardia and Bildstein 1997).

Availability of perches may also play a role in habitat selection. Hunting from perches is particularly energy efficient (Toland 1987). American Kestrels in Boone County, Missouri spent 63% of their day hunting from perches (Toland 1987). The addition of suitable perches from which to hunt has led to increases in local kestrel populations (Wolff et al. 1999, Kim et al. 2003).

Boxes 10 and 17 were occupied by kestrels five and eight times respectively across 12 breeding season, whereas boxes 14, 15, 16, and 19 were never used by kestrels. These results potentially reflect differences in habitat quality.

Box 14 is located near Mile Marker 11 in the west lane on I-26. Figure 7 is a Google Earth image of the location focused on a 0.15 mile radius around the box. The habitats here are somewhat mixed. While there are pastures, a significant number of trees are located in the vicinity of the nest box. Residential and industrial areas are also nearby. These factors might deter kestrels search for nest sites.

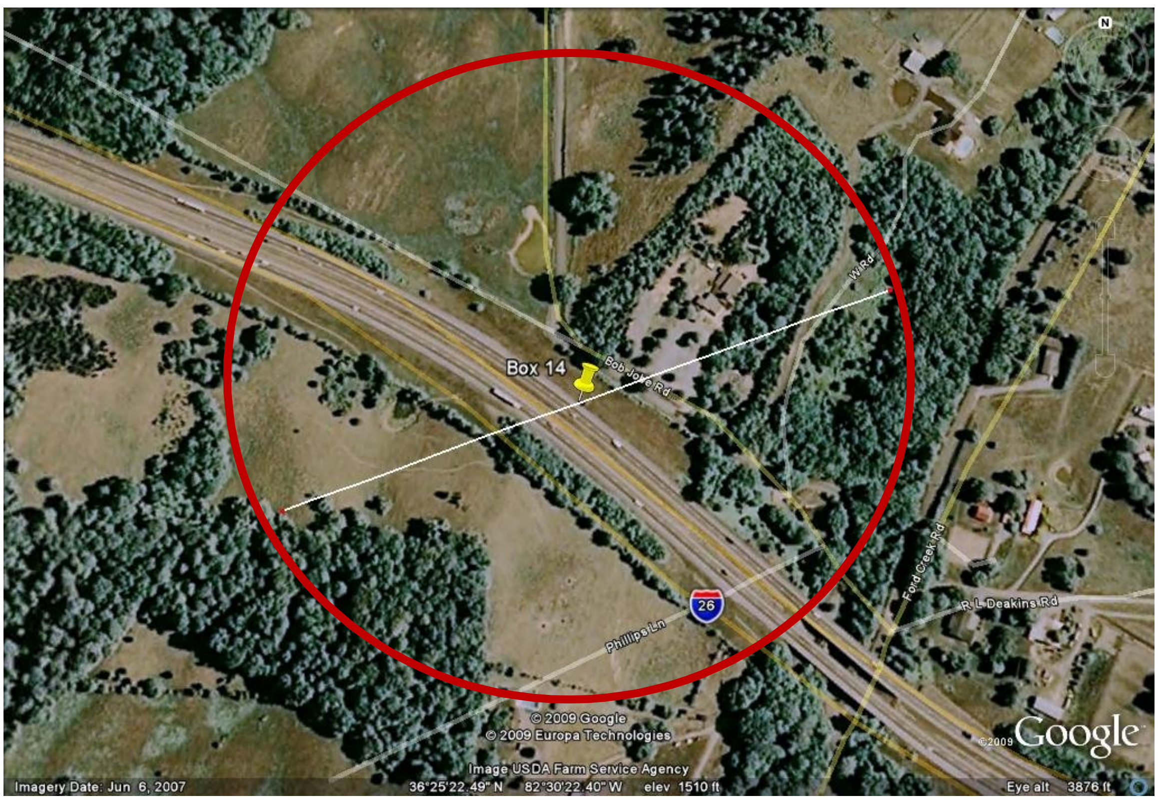

Figure 10 Google Earth Image of Box 14

Box 15 is located approximately one mile west of box 14 near mile marker 10 in the west lane. Roughly half of the region around the box is comprised of trees and industry (Figure 8). It is likely that the failure of this particular box to recruit kestrels is due to the lack of appropriate habitat.

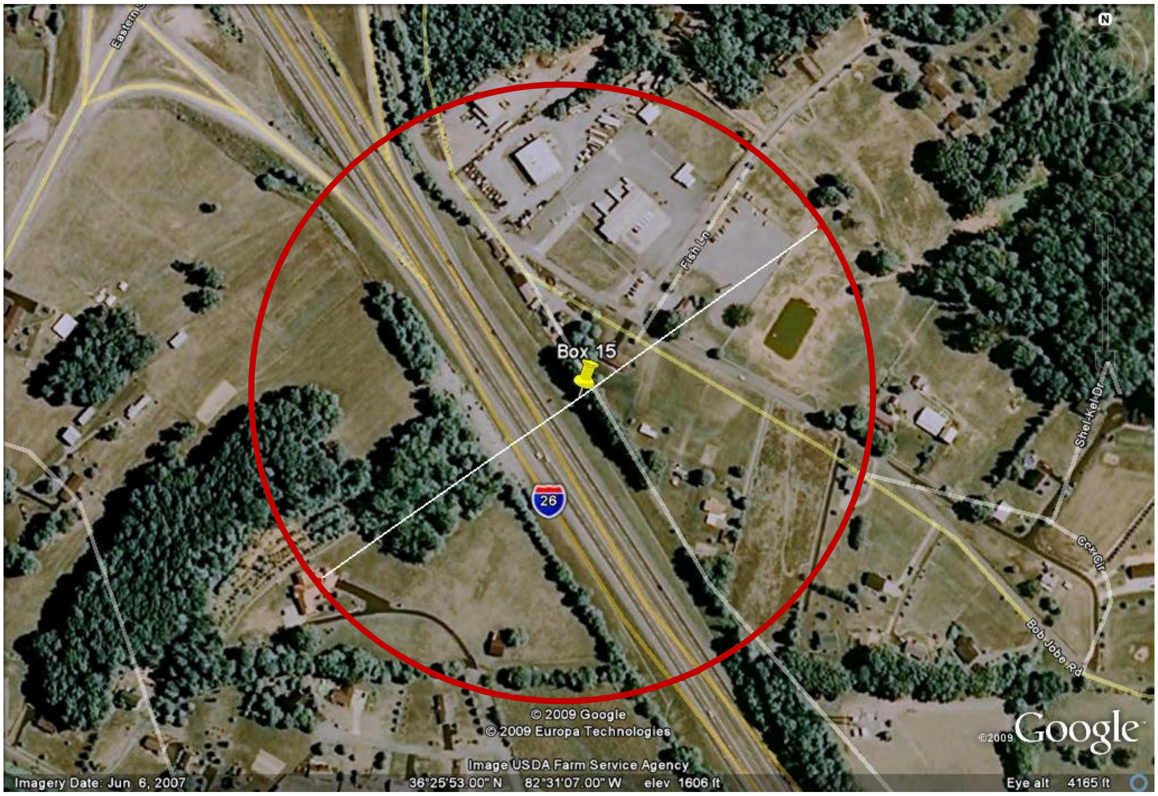

Figure 11 Google Earth Image of Box 15

In the east lane at mile marker 12, box 16 is surrounded by many trees as well as residential areas (Figure 9). Only a small proportion of the area is ideal territory for kestrels.

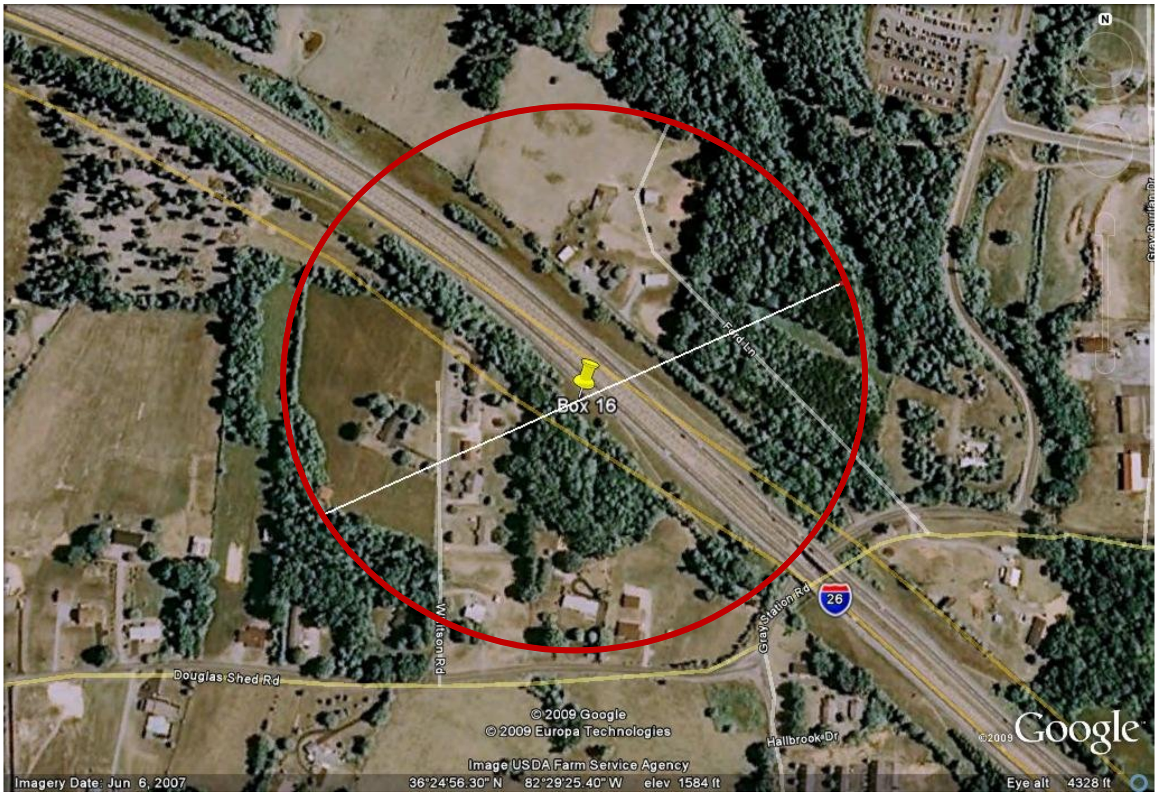

Figure 12 Google Earth Image of Box 16

Box 17 has the highest occupancy rate across the 12 years that the trail has been in place. It is located near mile marker 17 in the eastbound lane. Here we see primarily disturbed pastures. Running through the pastureland and almost directly over the boxes are high power lines that provide perches (Figure 10). The treeline is also further from the box. These factors provide optimal habitat for kestrels.

Figure 13 Google Earth Image of Box 17

It is interesting that Box 19 near mile marker 18 in the eastbound lane has never attracted kestrels. Like box 17, this area is dominated by pastureland. However, there are trees lining the periphery of the sign, and a busy exit is nearby. Boxes 17 and 19 are approximately one mile apart, and the failure of box 19 could reflect kestrel density or territorial requirements. However, kestrels appear to have consistently selected box 17 over box 19.

The area surrounding Box 10 near mile marker 28 is roughly three-fourths disturbed pastureland and hayfields. Three barns and high power lines are in close proximity to the box. This area likely provides an abundance of small mammals and birds, as well as suitable perches from which to hunt. The box faces an open area with no vegetation blocking the entrance. These qualities provide ideal territory for kestrels (Toland 1987, Rohrbaugh 1994).

Figure 14 Google Earth Image of Box 19

While it is possible that unused boxes reflect low kestrel density or the availability of natural cavities, the efficiency of the I-26 nest box trail might be improved by moving previously unused boxes in inferior habitats to areas with more favorable habitat structure. I suggest relocating boxes 4, 19, and 14 through 16 to areas where no trees surround the sign obscuring visibility from the box and blocking the entrance to the box. Disturbed pastureland with an appropriate amount of ground cover may also attract breeding pairs by providing an abundance of prey and optimizing prey availability (Dawson and Bortolotti 2000). Suitable perches such as the high power lines near boxes 10 and 17 may well attract kestrels to a territory by facilitating hunting. Finally, a detailed habitat analysis could provide further recommendations for box placement. Provided a suitable sign is nearby, locating boxes in prime habitat will possibly improve the occupancy rate of the nest boxes. This, in turn, encourages the students and volunteers needed to maintain and monitor the I-26 nest box program.

Figure 15 Google Earth Image of Box 10

Observations

European Starlings occupied all boxes not occupied by kestrels. After removal of a nest, starlings were often observed reconstructing the nest within an hour. Kestrels did nest in boxes that were previously occupied by starlings whose nests had been removed, and on one occasion, kestrel eggs were found inside an empty starling nest. However, a starling nest was also found in a box in which a female kestrel had previously been seen.

Kestrels attempted a second nest after the loss of the first nest on two known occasions In one instance, the nest was lost after three eggs were laid; the second attempt successfully fledged four chicks. In the second instance, two eggs were laid, but the one hatchling did not fledge. Three nestlings fledged from the second nest. In fact, more losses occurred during the incubation stage than in the brood rearing stage (Table 2). On at least three occasions, entire clutches were lost within a week. No egg fragments were found, and the losses were presumably due to avian predators.

Varland et al. (1993) radio-tagged 61 kestrels fledging from boxes along an interstate in Iowa. Two of the tagged birds were killed by collisions with cars (3.28%), leading these researchers to conclude that traffic is not a significant threat to birds nesting along roadways. I witnessed the death of one fledgling in 2003 that had wondered onto the highway.

The USGS Bird Banding Lab reports a recovery rate of 1.67% for American Kestrels banded between 1955 and 2004. No previously banded birds were recovered during the study, indicating that fledglings were not returning to their natal territories to breed. Jacobs (1995) reported a median dispersal distance of 16 km for males and 30 km for females. Miller and Smallwood (1997) noted that 94% of fledglings dispersed more than three kilometers from their home ranges and therefore concluded that this put them outside their natal areas.

Accounts of nest site fidelity in American Kestrels vary, and they may be loosely philopatric (Bowman et al. 1987). Hamerstrom et al. (1973) found that kestrels in Wisconsin were not reusing nest sites. In Missouri, however, reported that 62% of kestrel pairs consecutively reused a nest site (Toland and Elder 1987). In Pennsylvania, Katzner et al. (2005) found that 45% of females used different boxes in successive years. In Idaho, 58% of females and 48% of males used different boxes (Steenhof and Peterson 2009). Given these facts and the short life spans of American Kestrels, it is not surprising that no band recoveries have been made.

Summary

The I-26 nest box trail has been established for 12 breeding season. This study established the productivity of the trail and compared these parameters to similar studies. Although occupancy rate was somewhat lower in this study, the trail is successful overall with a sound clutch mean and a high percentage of hatchling fledging. Relocating boxes that have consistently been inactive might increase the occupancy rate. This nest box trail, like others, provides a valuable tool for studies of breeding American Kestrels, which is central to population management.

REFERENCES

Ardia DR, Bildstein KL. 1997. Sex-related differences in habitat selection in wintering American Kestrels, *Falco sparverius*. Anim Behav 53:1305-11.

Bloom PH, Hawks SJ. 1983. Nest box use and reproductive biology of the American Kestrel in Lassen County, California. Raptor Res 17:9-14.

Bowman R, Duncan JR, Bird DM. 1987. Dispersal and inbreeding avoidance in the American Kestrel: are they related? In: Bird DM and Bowman R, editors. The ancestral kestrel. Raptor Res Found, Inc and Macdonald Raptor Res. Centre of McGill Univ Ste. Anne de Bellevue, Quebec. p. 145-50.

Dawson RD, Bortolotti GR. 2000. Reproductive success of American Kestrels: the role of prey abundance and weather. The Condor 102:814-22.

Hamerstrom F, Hamerstrom FN, Hart J. 1973. Nest boxes: an effective management tool for kestrels. J Wildl Manage 37(3):400-3.

Hawk Mountain. 2007. American Kestrel conservation status report. Accessed December 6, 2009. Available at http://hawkmountain.org/media/kestrelCSR_June07.pdf.

Katzner T, Robertson S, Robertson B, Klucsarites J, McCarry K, Bildstein K. 2005. Results from a long-term nest box program for American Kestrels: implications for improved population monitoring and conservation. J Field Ornithol 76(3):217-26.

Kim, DH, Chavex-Ramirez F, Slack RD. 2003. Effects of artificial perches and interspecific interactions on patch use by wintering raptors. Can J Zool 81:2038-47.

Jacobs, EA. 1995. American Kestrel reproduction and dispersal in central Wisconsin. J Raptor Res 29(2):135-7.

Miller KE, Smallwood JA. 1997. Natal dispersal and philopatry of Southeastern American Kestrels in Florida. Wilson Bull 109(2):226-32.

Nagy AC. 1963. Population density of sparrow hawks in eastern Pennsylvania. Wilson Bull 75:93.

Rohrbaugh RW. 1994. Effects of macrohabitat, microhabitat, and microclimate on nest-box use and nesting success of American Kestrels in eastern Pennsylvania [thesis]. [Pittsburg (PA)]: Pennsylvania State University.

Sauer JR, Hines JE, Fallon J. 2008. The North American Breeding Bird Survey, results and analysis 1966-2007, Version 5.15.2008. USGS Patuxent Wildlife Research Center. Laurel, Maryland, USA.

Steenhof K, Peterson BE. 2009. Site fidelity, mate fidelity, and breeding dispersal in American Kestrels. The Wilson Journal of Ornithology 121(1):12-21.

Sullivan BL, Wood CL. 2005. The changing seasons: a plea for common birds. North American Birds 59(1):18-30.

Toland BR. 1987. The effect of vegetative cover on foraging strategies, hunting success, and nesting distribution of American Kestrels in central Missouri. J Raptor Res 21(1):14-20.

Toland BR, Elder WH. 1987. Influence of nest-box placement and density on abundance and productivity of American Kestrels in central Missouri. Wilson Bull 99(4):712-7.

United States Geological Survey. 2002. American Kestrel *Falco sparverius* summer distribution map. Accessed November 27, 2009. Available at http://www.mbr-pwrc.usgs.gov/Infocenter/i3600id.html.

United States Geological Survey. 2009. The North American bird banding program. Accessed November 27, 2009. Available at http://www.pwrc.usgs.gov/bbl/.

Varland DE, Klaas EE, Loughin TM. 1993. Use of habitat and perches, causes of mortality and time until dispersal in post-fledging American Kestrels. J Field Ornithol 64:169-78.

Varland DE, Loughin TM. 1993. Reproductive success of American Kestrels nesting along an interstate highway in central Iowa. Wilson Bull 105(3):465-74.

Wauer RH. 2005. The American Kestrel falcon of many names. Boulder, CO: Johnson Books. 103p.

Wheeler AH. 1992. Reproductive parameters for free ranging American Kestrels (*Falco sparverius*) using nest boxes in Montana and Wyoming. J Raptor Res 26(1):6-9.

Williams CK, Applegate RD, Lutz RS, Rusch DH. 2000. A comparison of raptor densities and habitat use in Kansas cropland and rangeland ecosystems. J Raptor Res 34(3):203-9.

Wilmers TJ. 1982. Kestrel use of nest boxes on reclaimed surface mines in West Virginia and Pennsylvania. [thesis]. [Morgantown, (WV)]: West Virginia University.

Wolff JO, Fox T, Skillen RR, Wang G. 1999. The effects of supplemental perch sites on avian predation and demography of vole populations. Can J Zool 77:535-41.

APPENDICES

Appendix A. I-26 Box Location Data

Box Number	**Coordinates**	**Nearest Mile Marker**	**Elevation (feet)**	**Height (feet)**
1	36°13’48.9”N 82°20’18.5”W	30 East	1948 ft.	17.0
2	36°10’40.4”N 82°23’0.5”W	35 East	1804	18.0
3	36°10’8.1”N 82°23’41.9”W	36 East	1767	16.0
4	36°9’36.7”N 82°24’21.1”W	37 East	1709	19.5
5	36°7’34.0”N 82°26’40.6”W	40 East	1663	16.0
6	36°5’57.1”N 82°28’27.4”W	42 East	1772	18.0
7	36°8’20.7”N 82°25’47.7”W	37 West	Unknown	16.5
8	36°11’24.2”N 82°22’20.3”W	33 West	Unknown	17.0
9	36°12’10.7”N 82°21’27.0”W	32 West	2023	15.0

10	36°15’7.3”N 82°19’25.9”W	28 West	1733	16.0
11	36°15’50.2”N 82°19’18.3”W	27 West	1729	19.0
12	36°23’58.6”N 82°27’47.5”W	14 West	1620	13.0
13	36°24’15.2”N 82°28’17.5”W	13 West	1524	13.0
14	36°25’22.5”N 82°30’22.4”W	11 West	1497	13.0
15	36°25’53.0”N 82°31’7.0”W	10 West	1625	14.5
16	36°24’56.3”N 82°29’25.4”W	12 East	1555	13.5
17	36°23’29.2”N 82°26’43.3”W	16 East	1623	15.0
18[1]	Unavailable	17 East	--------	---------
19	36°22’9.6”N 82°24’58.9W	18 East	1543	16.0
20	36°5’22.3”N 82°29’11.7”W	43 East	1805	18.5
21	36°30’1.2”N 82°33’47.3W	3.5 West	1207	16.0

22	36°28’40.8”N 82°32’38.7”W	6 East	Unknown	15.0
23	36°27’39.2”N 82°32’24.5”W	7 East	1538	13.0
24[1]	Unavailable	9 East	_____	______
25	36°26’19.4”N 82°31’24.3”W	10 East	1588	15.0
26	36°11’4.7”N 82°22’44.9”W	34 West	1810	15.5
27	36°10’18.9”N 82°23’19.1”W	35 West	1543	15.0
28[2]	36°6’15.8”N 82°27’58.3”W	41.5 West	1750	13.0
29[2]	36°6’50.5”N 82°6’15.8”W	41 West	1670	12.5

[1]Box unavailable in 2009
[2] Box used in 2009 only

Appendix B. Band Numbers of American Kestrels Fledging from I-26 Nest Boxes

Band Number	Band Date	Sex	Box Number
86601	5-26-1999	Male	9
86602	5-26-1999	Female	9
86603	5-26-1999	Male	9
86604	5-26-1999	Male	9
86605	5-26-1999	Male	9
86606	5-26-1999	Female	17
86607	5-26-1999	Male	17
86608	5-26-1999	Female	17
86609	5-26-1999	Female	17
86610	5-26-1999	Female	17
86611	6-3-1999	Male	10
86612	6-3-1999	Male	10
86613	6-3-1999	Female	10
86614	6-3-1999	Male	10
86615	6-14-1999	Male	12
86616	6-14-1999	Male	12
86617	6-14-1999	Female	12
1363-86701	5-29-2000	Female	2
1363-86702	5-29-2000	Male	2
1363-86703	5-29-2000	Female	2

Green over light blue over orange	6-12-2000	Male	8
1363-86704	8-2-2000	Female	23
1363-86705	8-2-2000	Male	23
1363-86706	8-2-2000	Female	23
1493-15617	5-21-2004	Unknown	5
1493-15618	5-21-2004	Unknown	5
1493-15619	5-21-2004	Unknown	5
1493-15620	5-21-2004	Unknown	5
1493-15613	6-2-2004	Unknown	17
1493-15614	6-2-2004	Unknown	17
1493-15615	6-2-2004	Unknown	17
1493-15616	6-2-2004	Unknown	17
1363-86629	5-22-2009	Male	8
1363-86630	5-22-2009	Female	8
1363-86631	5-22-2009	Female	8
1363-86632	5-22-2009	Female	8

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