LANDSCAPES THAT PROMOTE NEST BOX OCCUPANCY IN AMERICAN KESTRELS ACROSS MASSACHUSETTS

A Major Qualifying Project submitted to the Faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree in Bachelor of Science in Biology and Biotechnology

Cara Berner, Francesca Cerio, Paula Miller, Olivia Shraibati
10-15-2015

Sponsoring Organization:
Andrew C. Vitz, Massachusetts State Ornithologist
Massachusetts Division of Fisheries and Wildlife

Project Advisor:
Professor Marja Bakermans, BBT

Abstract

American Kestrel populations in the northeast have been decreasing steadily. MassWildlife has installed over 100 nest boxes in Massachusetts in order to aid in the conservation of kestrels. This project studied landscape features surrounding the nest boxes to better understand variables that contributed to nest box occupancy. We used in depth analysis of land cover with ArcMAP and quantitative analysis of basic landscape features, including Spearman Rank Correlations and Akaike's Information Criterion, to help refine the criteria for nest box occupancy amongst American Kestrels so that we could recommend future nest box placement to MassWildlife.

Acknowledgements

Without the help from certain individuals, we could not have completed this project. Through their guidance, resources, and support we were able to come together and produce this report and related materials.

First, we would like to thank Worcester Polytechnic Institute and Professor Marja Bakermans for providing us with the support and tools necessary for this project. Without her guidance and support throughout this process, we would not have been able to complete all that we have accomplished.

We would also like to thank the Commonwealth of Massachusetts Division of Fisheries and Wildlife for the opportunity they have provided us and the wealth of information supplied. We would like to thank State Ornithologist, Andrew C. Vitz, for his input, support, and assistance throughout this project, without which we would not have been able to reach our goals for this project.

Executive Summary

The American Kestrel, *Falco sparverius,* is the most common falcon in North America (Kaufman, 2014). They are sexually dimorphic in color and size, with females presenting larger wingspans and average mass than their male counterparts (Smallwood & Bird, 2002). Females also display reddish-brown coloration on their head and wings while males exhibit grey-blue hues in addition to the reddish brown color (Hawk Mountain, 2011). Kestrels prey on a variety of small rodents, reptiles, and arthropods. They prefer open fields when hunting and use elevated perches to spot their prey before swooping down for capture (Hawk Mountain, 2015).

Kestrels are secondary cavity nesters and often nest in previously excavated nests, cliffs, natural tree hollows, building ledges, or nest boxes (RSPB, n.d.; Bird et al. 1996). Semi-open land areas such as meadows, agricultural fields, and urban areas are preferable provided that these environments also provide adequate perches and prey sources during their breeding season (Kaufman, 2014; Smallwood & Bird, 2002).

American Kestrel populations in the New England area have been experiencing continual population declines over the past several decades (Sauer et al. 2014). They have been decreasing by 5.2% annually (Sauer et al, 2014). Lack of quality habitat and food sources negatively impact reproductive success, which in turn contributes to declining kestrel populations (Strasser & Heath, 2013). Current land management practices do not fully compensate for the development of open areas of land that would otherwise be suitable kestrel habitat. However, continued efforts by Massachusetts Wildlife and Fisheries (MassWildlife) and their partners will ideally increase the kestrel populations in New England. Mass Wildlife and their partners have installed over 100 nest boxes in Massachusetts. Our project focused on the landscape cover surrounding these boxes and the effect that the cover type had on occupancy.

A.C. Vitz, a Massachusetts State Ornithologist, and his collaborators, provided data collected over the past two years for the nest boxes. We were given the Box ID, or name of the box based on its location, and the location of each box as longitude and latitude. The boxes were grouped in four regions: West, Valley, Central, and East. Out of 99 boxes, 25 were considered to be occupied in 2014, 2015, or both. The nest box locations were transferred into ArcMAP 10.0 (Environmental Systems Research Institute) and land cover around each box was analyzed and quantified in a 1.25 km radius buffer. A 1.25 km radius was used because the home range of kestrels during breeding season is typically between 4.5-5.2 km^2 (Palmer, 1988). The buffer layer was combined with a land cover layer that we downloaded from MassGIS's publicly available database on http://www.mass.gov/portal/. We selected the 2005 land use datalayer, as it was the most recent map (Office of Geographic Information, 2005). We selected the most relevant land cover types based on studies of North American Kestrel populations and their habitats and territory preferences (Hawk Mountain, 2015; Johnsgard, 1990; Kaufman, 2014; Palmer, 1988).

We used ArcMAP measuring tool to measure distances of nest boxes from features that could affect occupancy. The distance from freshwater source, distance from wetlands, distance from roads, distance from nearest perch, and distance from human disturbances were all measured in kilometers.

In order to narrow down the variables used for logistic regression models, we ran Spearman Rank Correlations to remove highly correlated variables ($p < 0.05$). We determined which variables to test based on whether there were significant correlations with many other variables. We ran 23 simple and multiple logistic regressions in order to get the log likelihood for each model to be used in AIC (Akaike's Information Criterion) modeling framework. This included a full model regression and a null model regression. The logistic regressions also determined the type of relationship each model had with occupancy (positive or negative correlation).

AIC was used to determine which models most likely affected nest box occupancy. We used AICc and ΔAICc to rank our 23 models. The top eight models had a ΔAICc less than 2, meaning they are considered to be equally likely to affect nest box occupancy. The top competing variables were also compared using their Akaike weight ratios. Based on the collective Akaike's weights, percent forest cover was the top ranked variable and was negatively related to occupancy based on its coefficient (*-0.0277*). Percent open space composition was positively correlated with occupancy and was in four of the top eight models. Using the Akaike's weights, percent forest cover's collective weight was 0.455 and was 1.32 times better at explaining occupancy than percent open space (total wi = 0.344) . Percent agriculture composition (total wi = 0.155) was also in the top ranked models, and was positively correlated with occupancy. Percent forest cover was 2.94 times better at explaining nest box occupancy than percent agriculture composition and percent open space composition was 2.22 times better at explaining occupancy than percent agriculture composition.

We recommend that future nest boxes should be placed in areas with approximately 32% forest composition, and more than 4% open space composition or approximately 24% agriculture composition. Although successional forest had a ΔAICc less than 2, further analysis and literature suggests that it did not affect nest box occupancy nearly as much as the other models. Ideally, placing nest boxes in areas that meet these parameters will increase kestrel populations in Massachusetts.

Table of Contents

List of Tables

List of Figures

Chapter 1 LITERAUTRE REVIEW

Natural History of the American Kestrel

The American Kestrel, or *Falco sparverius*, is the smallest falcon present in North America (Kaufman, 2014). American Kestrels exhibit sexual dimorphism. The male's' plumage features dark hues of grey-blue on their heads and wings while females possess rufous-brown wings (Figure 1) (Hawk Mountain, 2011).

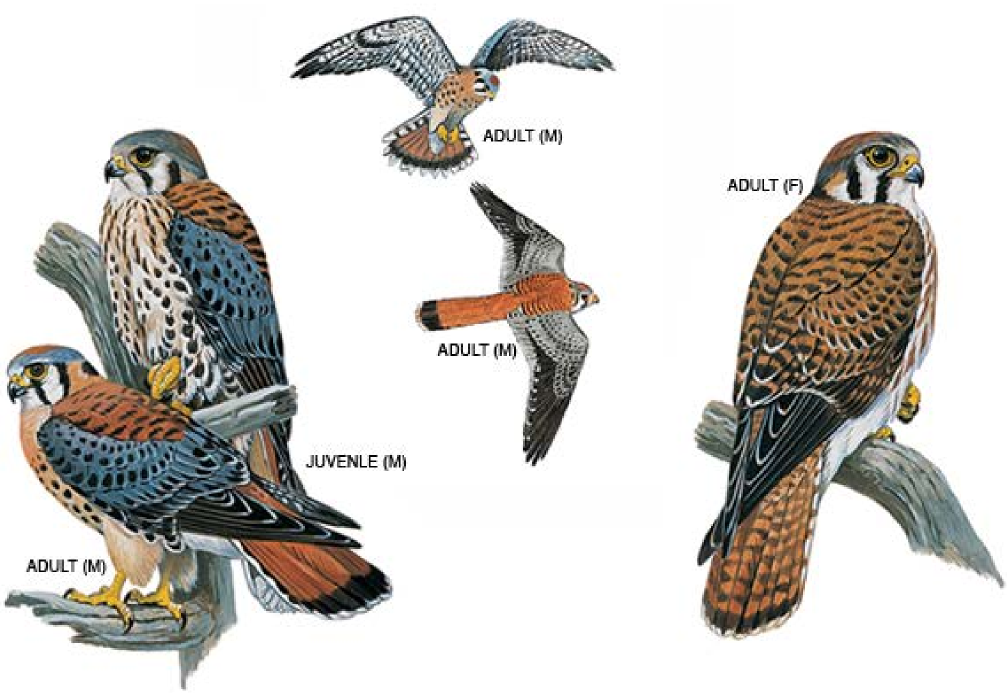

FIGURE 1: Image Comparing Male and Female American Kestrels (Alderfer, 2005).

Their average mass and wingspan also vary by gender. Females are larger than males with an average mass ranging from 86-165 g. Males have a mass ranging from 80-143 g. The females' wingspan is approximately 57-61 cm and males are about 51-56 cm (Smallwood & Bird, 2002).

Kestrels prey on small rodents, reptiles, and arthropods. Some examples of prey items for kestrels are mice, shrews, grasshoppers, dragonflies, and beetles. They will also hunt reptiles such as small snakes, frogs, and lizards (Smallwood & Bird, 2002). When hunting, these birds perch on elevated branches to visually locate prey before swooping in to capture. American Kestrels prefer open fields with perches since they hunt using a "sit-and-wait" technique and need sufficient visibility before pouncing (Hawk Mountain, 2015). Males will hunt smaller prey during the breeding season while females hunt larger prey (Smallwood & Bird, 2002).

Northern populations of kestrels typically migrate south, although some do not migrate at all. Those that migrate can go as far south as Tierra del Fuego in southern South America, although most American Kestrels that breed in North America spend the winter in the United States. Southern populations ranging from southern United States to the southernmost part of Argentina tend to remain stationary (Smallwood & Bird, 2002). The trend in the migratory patterns between northern and southern populations is a leapfrog pattern. Northern populations migrate farther than communities that are in southern areas (Hawk Mountain, 2015). American Kestrels use leading lines when undergoing seasonal migrations. These are landmarks such as the Atlantic coast or mountain ranges, and act as a guide to aid the kestrels in navigating to their destination (Hawk Mountain, 2015). Depending on prey availability and weather, some kestrels will overwinter in states that are above the southeastern sunbelt region, and most commonly in urban areas (Mass Audubon, 2011).

Kestrels are secondary cavity nesters. They use previously excavated nests from other species, such as woodpeckers, as well as cliffs, natural tree hollows, ledges on buildings, or nest boxes (RSPB, n.d.; Bird et al. 1996). Kestrels nest in cavities in semi-open land areas including meadows, agriculture fields, and urban areas (Smallwood & Bird, 2002). American Kestrels are tolerant to human activity (Strasser & Heath, 2013). They will nest in disruptive, urban areas as well as open, agricultural fields. Kestrels prefer open areas that provide adequate perches and suitable prey sources during breeding season (Kaufman, 2014). During the winter, females favor open land with short vegetation while males prefer woodland edges (Smallwood, 1988).

In the northeastern region of the United States, kestrels nest mostly in large pastures or recently fallowed fields that are greater than 25 ha in size (Smallwood & Bird, 2002). A study conducted in Pennsylvania found that occasionally and frequently used nest boxes were at least 145 m from the nearest forested areas (Rohrbaugh & Yahner, 1997). Kestrels prefer nesting away from the forest edge due to interference from competing species such as squirrels (Smallwood & Bird, 2002). During the breeding season kestrels have a home range, or territory, between 4.5-5.2 km^2 (Palmer, 1988). When the season begins for the migratory population, males will arrive before females to determine potential nesting sites in their home range (Smallwood & Bird, 2002). The female selects the nesting cavity when she arrives (Smallwood & Bird, 2002).

Clutch initiation for American Kestrels will commence anytime between January to the beginning of June, depending on location (Smallwood & Bird, 2002). Migrating kestrels that inhabit Massachusetts return during the spring migration in March and April (Peterson & Meservey, 2003). They lay their eggs from mid-April to early July (Peterson & Meservey, 2003). Southern populations mate earlier in the season and are more successful in any renesting attempts if their first clutch fails (Smallwood & Bird, 2002). The northern population mates later in the season, between the end of April and the beginning of June (Smallwood & Bird, 2002). Clutch size ranges from three to six eggs and the incubation period lasts for 28-31 days. Females will incubate the eggs, but contribution from the male varies per individual (Smallwood & Bird, 2002). After the eggs hatch, the female stays with the nestlings and the male provides a majority of the prey. After 7-10 days the nestlings can regulate their body temperature and the female can resume hunting close to the nest (RSPB, n.d.).

The young fledge 28-31 days after hatching. The parents provide food for an additional month after fledging (RSPB, n.d.). The young will be sexually mature by their first spring (Duncan & Bird, 1989). Kestrels will often use nesting sites from previous years for multiple breeding seasons. Kestrels may return to the same nesting site year after year with the same mate, although most find new partners yearly. Second attempts at breeding are relatively uncommon but are more likely in the event that a first attempt at breeding fails early in the breeding season. A second brood is less likely as latitude increases, however reports of second clutches have occurred as far north as Ontario (Bird & Palmer, 1988). According to a study performed by Steenhof and Peterson 2009, kestrels had a low turnover rate for site fidelity. Approximately 81% of males and 73% of females studied used the same nest box for two consecutive years. Yet, another study states that kestrels had a lower tendency to reoccupy the same nesting site. Twelve kestrel pairs were observed to reoccupy their nest site for two consecutive years and eight pairs reoccupied the same nest site for three consecutive years. Twenty-six kestrel pairs reoccupied their territories from the previous year, but not the same nest box (Smith et al, 1972). Reusing a nesting site means that they are familiar with the hunting grounds and landscape features, providing an advantage over other species attempting to occupy the area (Wauer & Clark, 2005).

The Massachusetts Audubon stated in their 2011 State of the Birds Report that American Kestrels are one of the fastest declining species in Massachusetts (Mass Audubon, 2011). The American Kestrel population in New England has been decreasing by 5.2% per year (Sauer et al. 2014). Figure 2 below shows the estimated population trends derived from annual point estimates (denoted in circles) from 1966 to 2013. Lines surrounding the point estimates indicate confidence intervals, with time points such as 1966 showing lower confidence intervals because of fewer routes being surveyed (Sauer et al. 2014).

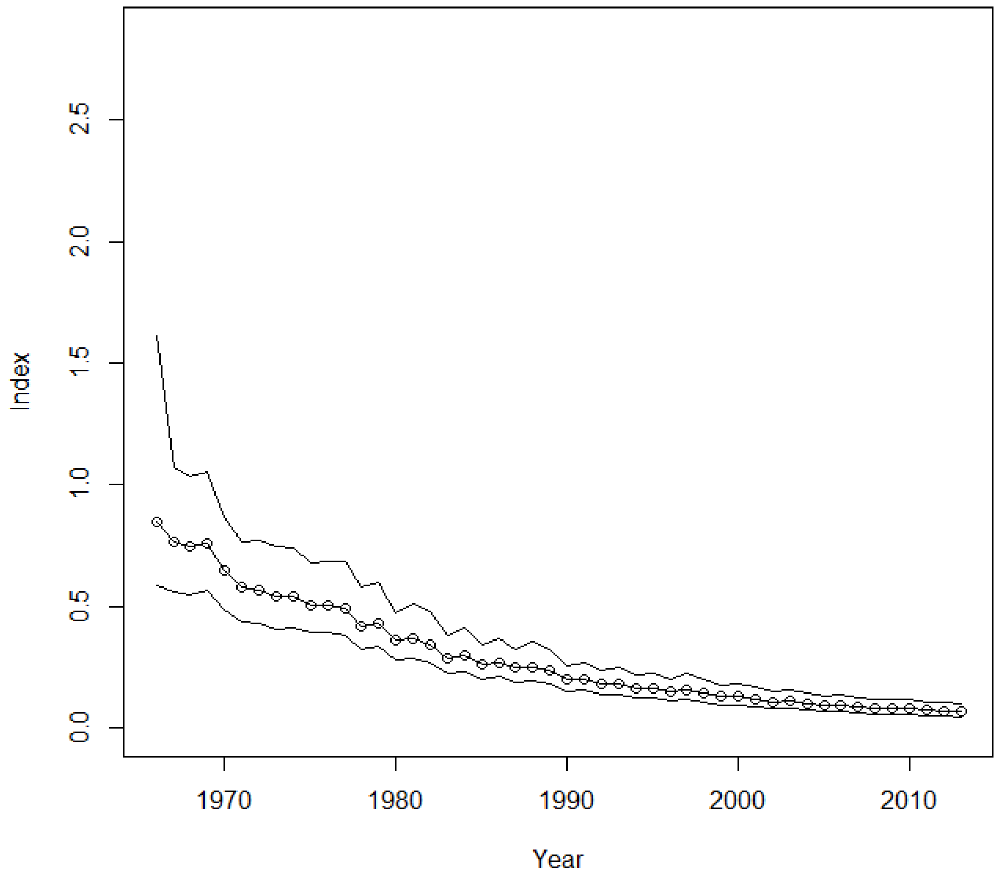

FIGURE 2: Index of population abundance in the New England/Mid-Atlantic Coast area. Point estimates (denoted in circles) show an annual decline of -5.21 birds per route (Sauer et al. 2014).

Kestrels cannot excavate nest sites for themselves and require open fields for hunting (Mass Audubon, 2011). They also face competition from other species for nesting cavities, such as the species *Sturnus vulgaris*, *Passer domesticus*, and *Tachycineta bicolor* (European Starling, House Sparrow, and Tree Swallow respectively) (A.C. Vitz personal communication). Like the American Kestrel, these species are secondary cavity nesters that are tolerant of humans, although some of them have an earlier breeding timeline than American Kestrels. For instance, the European Starling's early arrival in addition to their ability to raise multiple clutches in one breeding season lengthens the amount of time nesting cavities are occupied, decreasing the number of viable nesting sites available for kestrels (Bird et al. 1996).

Furthermore, habitat loss affects all species, as declining resources reduces the number of available natural nesting sites for the nesting birds (Bird et al. 1996). Grasslands, both sandplain and cultural, in addition to shrubland and agricultural lands are suitable habitats for kestrels (Johnson & Anderson, 2002; Mass Audubon, 2013). However, the amount of agricultural land, grassland, and shrubland has been declining in Massachusetts since the early 1990s (Mass Audubon, 2013). Initially the loss of these early-successional habitats occurred due to the maturation of forests, but in the past recent decades the trend of increasing forest has halted and instead the loss of these lands appear to be primarily driven by human development (DeGraaf & Yamasaki, 2003; Mass Audubon, 2013). This is particularly problematic since shrubland birds have been shown to display high site fidelity even when the vegetation in those environments are changing rapidly (Schlossberg & King, 2009). The number of fields with suitable prey has also decreased significantly in the past decade due to human development (Mass Audubon, 2011). Preservation of fields and the placement of nest boxes in open fields aids in the increase of kestrel populations. Easy access to these fields provides kestrels with a large variety of prey items (Hawk Mountain Sanctuary Association, n.d.).

Impact of Human Disturbance on Kestrel Populations

Human-induced disturbances such as industrial development, vehicular noise, and recreational activities have shown to negatively impact kestrel reproductive success as well as nest site use and population density (Strasser & Heath, 2013). The human presence and noise pollution that accompanies industrial development leads to notable disturbance, in addition to direct habitat loss resulting from land development (Hockin, 1992). The disturbance index used by this study was created using four variables contributing to disturbance. These components focus on traffic conditions such as the number of lanes the speed limit of the road closest to each occupied nest box, as well as the number of automobiles that travelled the road each day. The proportion of developed land within the 900 meter established buffer around each nest box was considered as well (Strasser & Heath, 2013). The nests that were in the closest proximity to developed land and roads that had a higher concentration of traffic received the high scores on the disturbance index. Nests that were farther away from these disturbances or were located in undeveloped land, got scores that were lower on the spectrum. Higher levels of disturbance have been correlated to reproductive failure, higher stress levels in females, and higher nest abandonment compared to kestrels in areas of low human disturbance (Strasser & Heath, 2013).

Despite these negative factors, many kestrels choose to inhabit land in human-dominated landscapes due to favorable foraging and habitat resources available. These conditions may cause ecological traps, as their presence in human-dominated landscapes doesn't imply a tolerance for human stressors (Dwernychuk & Boag, 1972).

Current Management Practices

Northeastern American Kestrel populations rely on grasslands and open habitats, with over 95% of these habitats covering private lands in New York (NYSDEC, n.d.). The conservation of these areas is coordinated through state and federal agencies as well as non-governmental organizations, such as Kestrel Land Trust. Initiatives that promote the involvement of private landowners is also vital to the species long-term survival, such as New York's Landowner Incentive Program for Grassland Protection and Management (NYSDEC, n.d.). These programs provide landowners with grants, tax exemptions, and other incentives as a reward for preserving open fields and constructing nest boxes. In 2014, Massachusetts Governor Deval Patrick signed a 4-year environmental bond bill for $2.2 billion dollars (The Trust for Public Land, n.d.). The bill provides funding for state agencies, municipalities, and non-governmental organizations to help conserve natural resources and support and protect wildlife (The Trust for Public Land, n.d.). The bond also provides $350 million for land conservation programs with opportunities for nonprofit partners to work with local, federal, and private investments to better support the protection of the state's natural resources and landscape (The Trust for Public Land, n.d.).

"The rapid decrease in kestrel populations in New England has led to an increased conservation effort by the Massachusetts Division of Fisheries and Wildlife (MassWildlife)" (A.C. Vitz personal communication). MassWildlife has collaborated with numerous groups and individuals including Mass Audubon, Mass Department of Transportation, Department of Conservation and Recreation, Kestrel Land Trust, East Quabbin Land Trust, Keeping Company with Kestrels, and Essex County Ornithological Club. They have now placed approximately 100 nest boxes in Massachusetts and are continuously seeking out ideal habitats for new boxes.

Spearman Rank Correlation

Spearman Rank Correlation is a type of statistical analysis that ranks two variables. It is used to determine if one variable is correlated variation with another. Unlike linear regression, Spearman correlations utilize ranks instead of measurement variables and assumes that the data is not normally or linearly distributed (McDonald, 2014). The p value calculated using Spearman correlations can be used as an alternative to linear regression and is similar to linear regression because both assume that observations are independent (McDonald, 2014).

Logistic Regression

Logistic regression is a valuable tool in regression analysis because it models the relationship of a dependent variable with either one or multiple independent variables mathematically. Therefore, it is used to solve multivariable problems. Logistic regression also uses binary responses that classify an outcome as a 0 or a 1 which signify if the outcome occurred or not, respectively (Kleinbaum & Klein, 2010). There are many types of logistic regression but the two that most utilized are simple logistic regression and multiple logistic regression. The primary difference between the two types is the quantity of independent variables. Simple logistic regression features a dependent variable with binary values and a single independent variable. It is useful to use when there is a difference in the dependent variable and could cause a distinction in the independent variable (McDonald, 2014). Multiple logistic regression is the preferable model to use when there is only one dependent variable and multiple independent variables. Similarly, with simple logistic regression, it includes a binary numeral response. The overall goal to logistic regression is to describe the relationship of the independent variables with the dependent variables and how the independent variables affect the probable value of the dependent one (McDonald, 2014).

Akaike's Information Criterion

Hirotugu Akaike published a series of papers starting in the early 1970s that linked information theory to statistical theory (Burnham et al, 2010). This new class of approaches is called "information-theoretic" (Burnham et al, 2010; Mazerolle, 2004). Instead of hypothesis testing, which excludes variables in models, information-theoretic allows for multiple independent variables, or parameters, to be taken into account when determining model selection (Mazerolle, 2004). Observational studies often have multiple variables that need to be taken into account in order to understand an ecological process or pattern (Mazerolle, 2004). Hypothesis testing is often sufficient for manipulated experiments.

AIC specifically takes into account deviance and the total number of estimable parameters in the model with the equation:

$$AIC = -2\log(L) + 2K$$

Log(L) is the log likelihood. -2log(L) is the deviance. K is the total number of estimable parameters in the model (Burnham et al, 2010). AIC is computed for each R model and the model with the smallest AIC is considered “best” (Burnham et al, 2010). AIC was derived Sugiura (1978) and Hurvich and Tsai (1989) in order to compensate for second order bias (Burnham et al, 2010).

$$AICc = AIC + (2K(K+1))/(n-K-1)$$

AICc is widely used, especially when sample sizes are small (Burnham et al, 2010). ΔAICc is the difference of AICcs. ΔAICcs are essential for ranking models as it is “a measure of each model relative to the best model” (Mazerolle, 2004). The smaller the number, the smaller the information loss for each hypothesis (Burnham et al, 2010). ΔAICc less than two suggests that the model has substantial support. If the ΔAICc values are between three and seven, then the model has little support. A ΔAICc greater than 10 indicated almost no empirical support (Burnham et al, 2010; Mazerolle, 2004).

Akaike weight is also essential for ranking models (Mazerolle, 2004). The weights are a ratio of the ΔAICcs for each model compared to the whole set of models (Mazerolle, 2004). Akaike weights are the probability that a model is the best model out of a set, i.e., a model with a 0.25 weight has a 25% likelihood that it is the ‘best’ model out of set of models being considered (Mazerolle, 2004). The weights can also be used as an evidence ratio (Mazerolle, 2004). The evidence ratio compares the competing models to determine to what degree a model is better than another (Mazerolle, 2004). This is done by simply dividing the better model’s weight by the lesser model’s weight to get the ratio.

Chapter 2 LANDSCAPE FACTORS THAT PROMOTE NEST BOX OCCUPANCY FOR AMERICAN KESTRELS IN THE STATE OF MASSACHUSETTS

Abstract

American Kestrel populations in Massachusetts have been decreasing steadily. MassWildlife has installed over 100 nest boxes in Massachusetts in order to aid in the conservation of kestrels. This project studied landscape features surrounding American Kestrel nest boxes in order to better understand variables that contribute to nest box occupancy. This will aid in determining the placement of future nest boxes. Qualitative analysis of basic landscape features, such as open space, is currently the primary placement method used by MassWildlife and their partners. Further analysis of landscape features that affect nest box occupancy is necessary in order to have the most successful nest box placement. We found that percent forest composition within the home range of a nest box (1.25 km radius) was negatively correlated with occupancy and was most likely to explain nest box occupancy. Percent composition of open space and agriculture, and region, were all part of models that were considered equally likely to affect nest box occupancy. We recommend that future nest boxes are placed in the valley region of Massachusetts and in areas with less than 32% forest cover, more than 4% open space and/or more than 24% agricultural composition.

Introduction

The American Kestrel (*Falco sparverius*) inhabits a wide range of climates from southern Argentina to northern Canada. Northern populations of kestrels usually migrate, but southern populations normally remain stationary (Smallwood & Bird, 2002). Kestrels that migrate to the northeast for breeding season will arrive anywhere between April and June to select a nest (Smallwood & Bird, 2002). During the breeding season kestrels have a home range, or territory, between 4.5-5.2 km^2 (Palmer, 1988). When the season begins for migratory populations, males will arrive before females to determine potential nesting sites in their home range (Smallwood & Bird, 2002). The female selects the nesting cavity when she arrives (Smallwood & Bird, 2002).

American Kestrels are one of the fastest declining species in Massachusetts (Mass Audubon, 2011). Populations in New England have been decreasing by 5.2% every year (Sauer et al. 2014). When Mass Audubon compared atlas maps from 1979 and 2011, it was noted that kestrels were breeding in about 21% of blocks in the state when they originally bred in 51% (Mass Audubon, 2013). Though the cause of this decline is largely unknown, it can be conjectured that it is mostly due to human development of open habitat (Mass Audubon, 2013). The resulting loss of open, agricultural land has negatively impacted grassland and shrubland breeding birds in addition kestrels (Mass Audubon, 2013).

Another factor that may play into the decline of kestrel populations is disease, for instance the West Nile Virus. West Nile Virus has a high mortality rate for birds in the wild, with approximately one third of wild North Eastern kestrels having tested positive for the virus and approximately 95% of males surveyed in a 2007 study having been exposed to it (Medica et al, 2007).

Kestrels are secondary cavity nesters, meaning they use previously constructed cavities or similar sites instead of building their own nests (RSPB, n.d.). Nests in open land and away from forest edge are preferred due to interference from competing species and the availability of viable hunting grounds (Smallwood & Bird, 2002).

"MassWildlife and their partners have installed over 100 nest boxes in Massachusetts in an attempt to conserve the kestrel populations" (A.C. Vitz personal communication). Nest boxes are artificial cavities constructed from wood that are highly utilized by secondary cavity nesters such as kestrels. "Boxes are generally placed in open areas, 12 feet above the ground" (A.C. Vitz personal communication). Many factors such as distance to forest edge or the amount of open land surrounding the nest may affect nest selection (Johnsgard, 1990).

The overall goal of this project was to monitor nest box occupancy and to determine parameters that affected occupancy. In order to address unknowns, such as what landscape variables are leading factors in nest box selection for American Kestrels, this project utilized land cover statistical analysis combined with two years of nest box occupancy data. We hypothesized that distance to forest, percent composition of open space, and distance to nearest perch would significantly affect nest box selection and occupancy. We predicted that these parameters affect occupancy given that kestrels tend to avoid forested areas, require open habitat for foraging, and utilize perches in order to hunt prey. (Johnsgard, 1990; Mass Audubon, 2011; Smallwood & Bird, 2002).The recommendations resulting from this project will ideally increase box occupancy in the Northeast.

Methods

Nest Box Locations and Study Area

Data was obtained from MassWildlife on nest box locations in Massachusetts and their occupancy for 2014 and 2015. A.C. Vitz, a Massachusetts State Ornithologist, and his collaborators visited and checked nest box contents to determine occupancy status. Nest boxes were determined to be occupied during a breeding season if boxes held a breeding pair that successfully produced a clutch of eggs. We organized and thinned this data into four parameters: Box ID, longitude, latitude, and whether an American Kestrel occupied the box in either year. Box ID included the name of the nest box based on its location. The longitude and latitude were formatted in decimal degrees.

We also separated the data into regions, as they were of interest to the project's sponsoring organization. Regions in Massachusetts vary dramatically in the landscapes they support, and we were asked to determine if they played a role in American Kestrel box occupancy rates. Massachusetts was split into four regions: West, which included Berkshire County, East, which was everything east of Westborough, Central, which extended from the east side of the Quabbin to Westborough at 495, and Valley, which was the area surrounding the Connecticut River Valley (A.C. Vitz personal communication). The regions of Massachusetts in respect to this project can be seen in Figure 3.

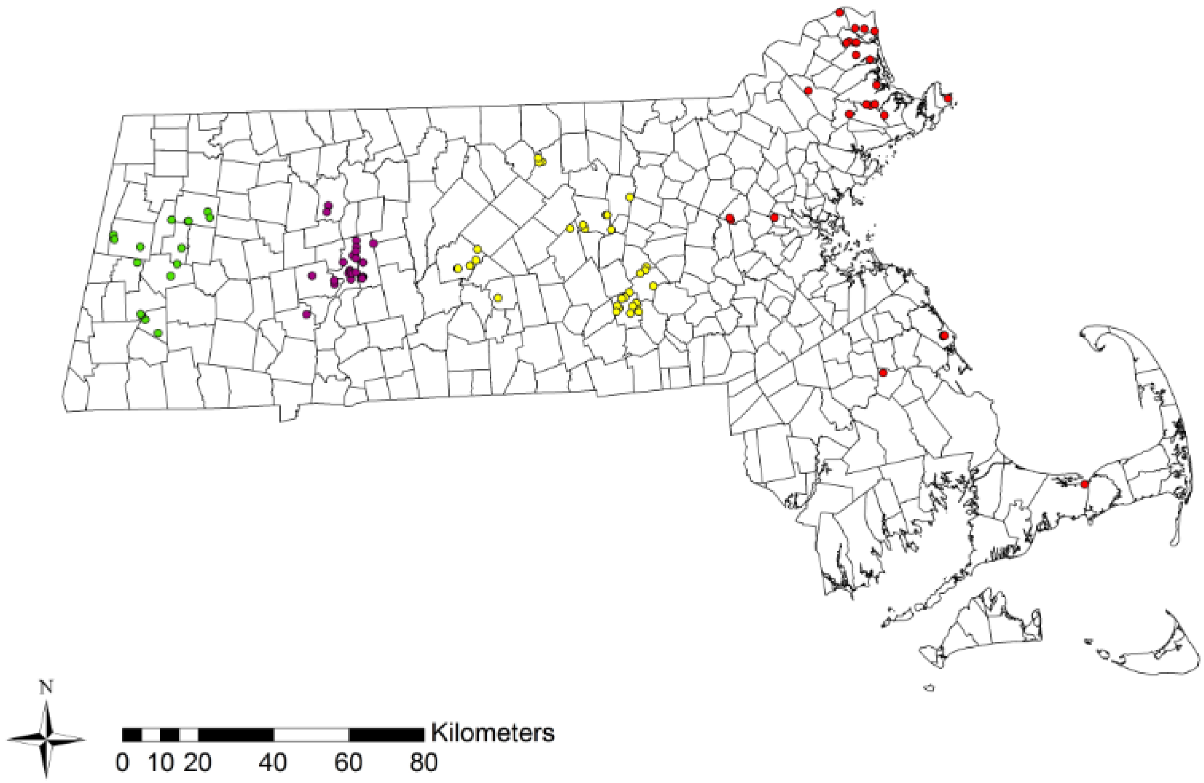

FIGURE 3: Full extent map of Massachusetts with nest boxes organized by region. From left to right, boxes are grouped in west (green), valley (purple), central (yellow), and west (red) regions.

Land Cover

We used ArcMAP 10.0 (Environmental Systems Research Institute) to quantify landscape features that had the potential to affect nest box occupancy. We obtained land cover maps from MassGIS's publicly available database, http://www.mass.gov/portal/, for use in conjunction with ArcMAP. We selected the most recent map, the 2005 land use datalayer, and visually compared these 2005 land cover types with 2013-2014 aerial maps from MassGIS and found essentially no differences in amount or type of land cover. We selected the most relevant land cover types based on studies of North American Kestrel populations and their habitats and territory preferences (Hawk Mountain, 2015; Johnsgard, 1990; Kaufman, 2014; Palmer, 1988). These selected land covers can be seen in Appendix 1: Table of selected land cover types for analysis in ArcMAP 10.0.

To analyze land cover for each nest box, we created a buffer of 1.25 km radii around each location. We chose 1.25 km because the average home range is 4.5-5.2 km^2, the larger of which has a radius of 1.28 km, which we rounded down to 1.25 km (Palmer, 1988). We utilized the Geoprocessing tab in ArcMAP to create the buffers. We used an intersect overlay to combine the buffer layer and land use layer, which allowed for the land use data from MassGIS to be incorporated with the buffers so that only the land use within the buffer area appeared (Figure 4 and Figure 5).

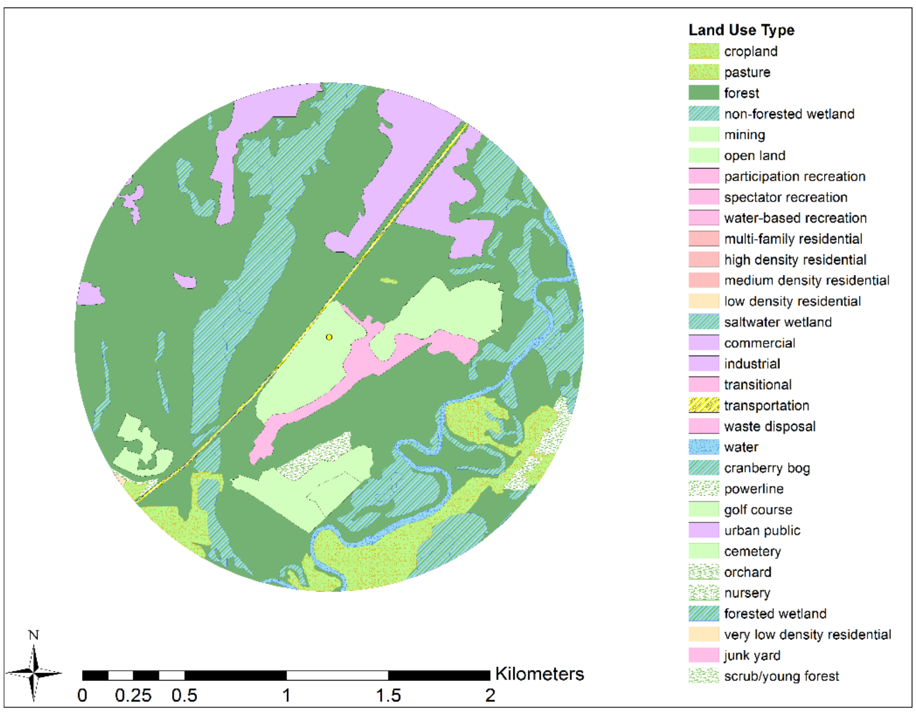

FIGURE 4: Buffer with land cover types surrounding Bolton Flats box. This box was occupied.

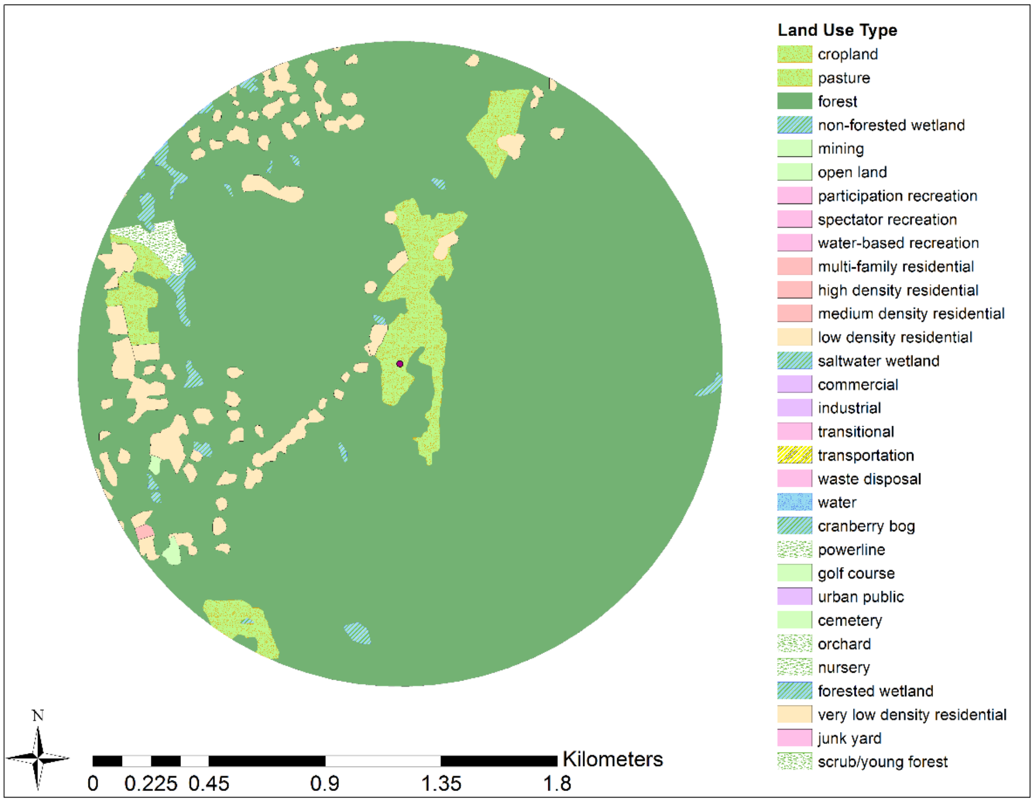

FIGURE 5: Buffer surrounding Kestrel Land Trust 1 box. This box was unoccupied.

Area Analysis

We used the measure tool in ArcMap to determine distances between nest boxes and features within the surrounding area that could affect box occupancy. These included distance from freshwater source, distance from wetlands, distance from roads, distance from nearest perch, and distance from human disturbances. We defined roads as three different types: Primary, which were highways, Secondary, which were residential roads or frequently traveled roads, and Tertiary, which were rural or dirt roads (Ralph et al, 1993). Structures defined as perches were considered fences or fence posts, singular trees or snags, interstate signs, billboards, utility poles or wires, or other (e.g. building, manmade perch) (Varland et. al, 1993). We defined human disturbances as human developments such as agricultural fields, residential areas, or areas with heavy human traffic, with the exception of roads.

Data Analysis

We ran Spearman Rank Correlations to remove highly correlated variables ($p < 0.05$) and this allowed us to narrow down the variables we used for logistic regression models. We determined which variables to test based on whether there were significant correlations with many other variables. The Spearman correlations data can be seen in Appendix 2.

We ran simple and multiple logistic regressions to calculate log likelihood values that were used in AIC (Akaike's Information Criterion) modeling framework. The variables can be seen in Table 1. We performed logistic regressions to determine the relationship between land cover type and nest box occupancy. Logistic regression was chosen because it provided descriptions of the relationship between multiple numerical values and a nominal value and because it is the most appropriate method of modeling such relationships (McDonald, 2014; Press & Wilson, 1978). We then used an online logistic regression calculator to run the analysis of our models (Pezzullo, n.d.). We ran 23 logistic regressions, including a full model regression and a null model regression. The null model was run to test whether variation in our data was best explained by variables we did not measure (i.e. random factors). The regression models can be seen in Table 2.

TABLE 1: Variables selected for logistic regression testing and used in analysis of selection by American Kestrels of nest boxes (n=99) in Massachusetts, USA, 2014-2015. Subscripts indicate the radii of buffers used (km) when obtaining variables.

Variable name	Variable description
$LDRper_{1.25}$	Percent area of low density residential areas (houses on greater than ½ acre lots and very remote/rural housing)
$OSper_{1.25}$	Percent area of open space (land that does not support large plant growth, mines/quarries, greenways, and graveyards)
$FORper_{1.25}$	Percent area of forest (areas with canopy cover of at least 50%)
$AGRper_{1.25}$	Percent area of agricultural fields
$SUCCper_{1.25}$	Percent area of predominantly shrub cover (>25%) with some immature trees
REG	Regional locations (East, West, Central, Valley)
$PERC_{0.25}$	Distance to the nearest perch (fences, singular trees/snags, signs/billboards, powerlines, and other; km)

TABLE 2: Models analyzed using logistic regression and used in analysis of selection by American Kestrels of nest boxes (n=99) in Massachusetts, USA, 2014-2015. Subscripts indicate the radii of buffers used (km) when obtaining variables. See Table 1 for explanations of each variable.

Models
Simple
$LDRper_{1.25}$
$OSper_{1.25}$
$FORper_{1.25}$
$AGRper_{1.25}$
$SUCCper_{1.25}$
REG
$PERC_{0.25}$
Multiple (excluding REG)
$FORper_{1.25}$ $OSper_{1.25}$
$FORper_{1.25}$ $AGRper_{1.25}$
$FORper_{1.25}$ $PERC_{0.25}$
$OSper_{1.25}$ $PERC_{0.25}$
Multiple, Regional
REG $LDRper_{1.25}$
REG $OSper_{1.25}$
REG $FORper_{1.25}$
REG $AGRper_{1.25}$
REG $SUCCper_{1.25}$
REG $PERC_{0.25}$
REG $FORper_{1.25}$ $OSper_{1.25}$
REG $FORper_{1.25}$ $AGRper_{1.25}$
REG $FORper_{1.25}$ $PERC_{0.25}$
REG $OSper_{1.25}$ $PERC_{0.25}$

We ran region with 11 of our regressions including region alone, as they were of interest to the project's sponsoring organization. Regions in Massachusetts vary dramatically in land use, landscape cover types, topography, weather, and we were asked to determine if they played a role in American Kestrel box occupancy rates.

Akaike's Information Criterion

Akaike's Information Criterion (AIC) was used to determine the models that were most likely to affect occupancy. A total of 23 models were used (Table 2). We ran the AIC using the -2 log likelihood calculated from our logistic regressions to rank our models by importance. We ranked the models using their ΔAICcs and their Akaike weights. We used $\Delta AIC < 2$ to determine which variables in those models to examine. The top eight competing models were compared by calculating their evidence ratios, or Akaike weight ratios. We ranked the models by which independent variables were the most likely to affect nest box occupancy.

Results

Nest Box Locations and Study Area

Using the data provided by MassWildlife, we found that 24 nest boxes out of the 99 observed were occupied in either 2014 or 2015 (Table 3). Table 3 lists the boxes that were occupied in 2014, 2015, or both.

TABLE 3: Nest box IDs for boxes (n=24) that were occupied by American Kestrels in Massachusetts in either 2014, 2015, or both. Box IDs were based on the location of the nest box and are listed in alphabetical order.

Occupied Nest Boxes		
Bolton Flats WMA	Kestrel Land Trust 13	MDOT 5
Burrage Pond WMA	Kestrel Land Trust 14	MDOT 7
Drumlin Farm 1	Kestrel Land Trust 2	RT 140 #1 Merrill Rd
EQLT-Wen Meadow	Kestrel Land Trust 3	Strawberry Hill
EQLT-Dr. Liland	Kestrel Land Trust 5	Tyringham private property 1
EQLT-Mandell Hill	Kestrel Land Trust 7	Tyringham private property 2
Heirloom Harvest CSA	MDOT 2	Wach Res North Dike
Hennessey 1	MDOT 4	Westborough WMA #1
	Lennox on utility pole	

Correlation Analysis

Based on the Spearman Rank Correlations, found in Appendix 2, we retained seven parameters: percent composition low density residential, percent composition open space, percent composition forest, percent composition successional forest, region, and distance to the nearest perch. The definition of these parameters and their abbreviated terms can be seen in Table 1.

Some of the variables measured were excluded because they were highly correlated with others we had measured. We included some variables that were highly correlated due to their possible effect on nest box occupancy and management interest. These variables were percent composition successional forest, region, and distance to the nearest perch.

Area Analysis

We calculated mean percent composition for the retained parameters for all nest boxes. These can be seen in Table 4. All means and other descriptive statistics for every variable can be found in Appendix 3.

TABLE 4: Mean percent composition (n=99) and standard deviation of variables retained, excluding Region, after Spearman Rank Correlations. For description and full names of variables, see Table 1.

Variable name	Mean	Standard Deviation
LDRper1.25	6.917	5.546
OSper1.25	3.255	3.255
FORper1.25	40.98	21.915
AGRper1.25	18.12	15.954
SUCCper1.25	1.165	1.766
PERC0.25	0.044	0.037

Figure 6 and Figure 7 below graphically represent the mean percent composition and standard error for the most important variables based on the Akaike's Information Criterion modeling. The data is split in Figure 6 based on whether the nest boxes were occupied (Description = yes) or unoccupied (Description = no). Figure 7 is split between region and occupancy, similar to Figure 6.

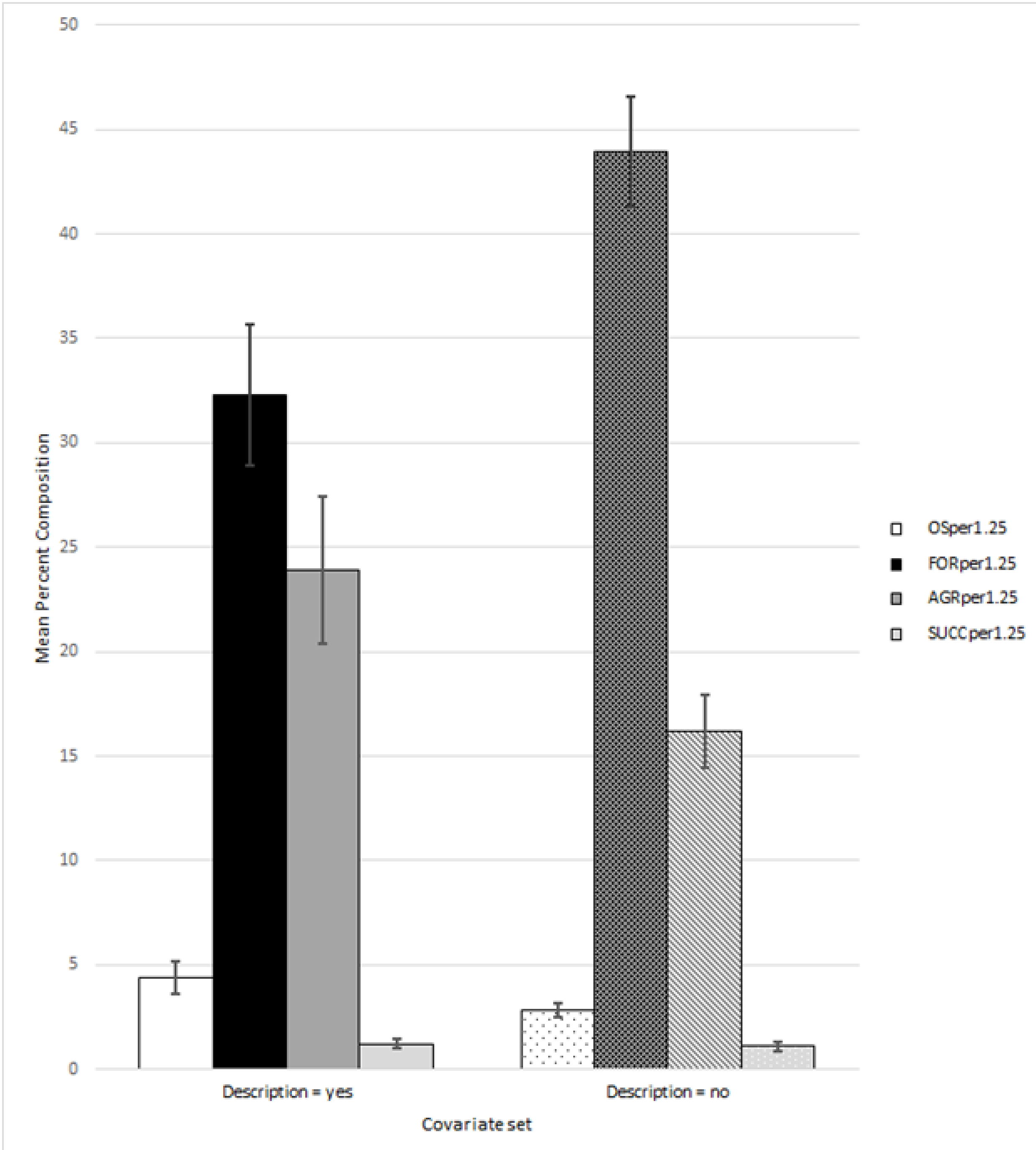

FIGURE 6: Mean percent composition for Open Space, Forest, Agriculture, and Successional Forest based on whether the boxes were occupied (Description = yes, n=25) or unoccupied (Description = no, n=74). The error bars are representative of the standard error for each variable.

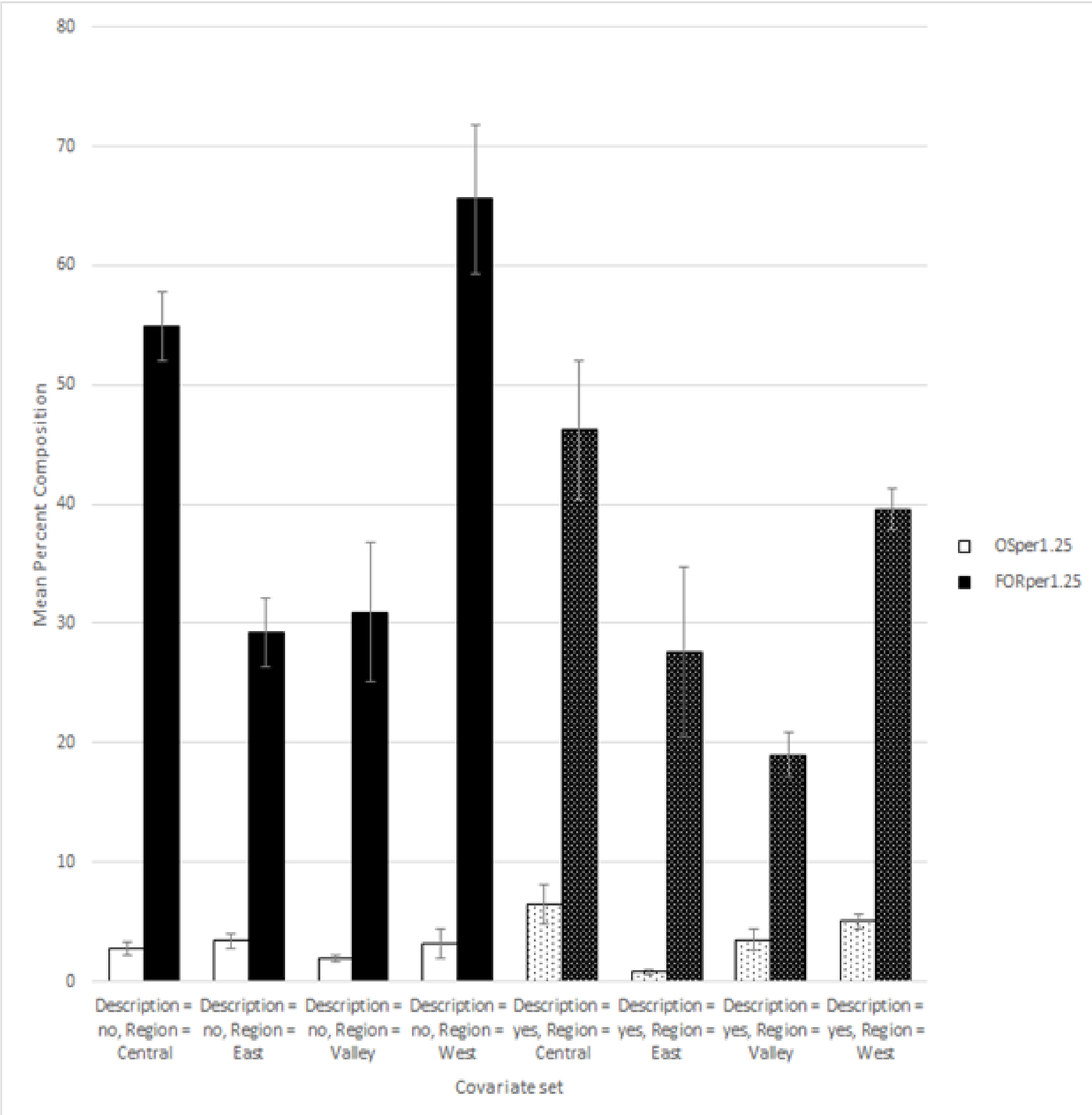

FIGURE 7: Mean percent composition for Open Space and Forest, separated by region and nest box occupancy where occupied was "Description = yes" and unoccupied was "Description = no". The different sets are Central and unoccupied (n=23), East and unoccupied (n=24), Valley and unoccupied (n=14), West and unoccupied (n=13), Central and occupied (n=9), East and

occupied (n=3), Valley and occupied (n=10), and West and occupied (n=3). The error bars are based on the standard error for each variable set.

Akaike's Information Criterion

There were a total of 23 models. The top eight models had ΔAICc less than two; therefore they are considered equally likely (Table 5). Based on the collective Akaike's weights, percent forest cover was the top ranked variable and is negatively related to occupancy based on its coefficient *(-0.0277)*. Percent open space composition is positively correlated with occupancy and is in four of the top eight models. Using the Akaike's weights, percent forest cover's collective weight is 0.455 and is 1.32 times better at explaining occupancy than percent open space (total $w_i = 0.344$). Percent agriculture composition (total $w_i = 0.155$) is also in the top ranked models, and is positively correlated with occupancy. Percent forest cover is 2.94 times better at explaining nest box occupancy than percent agriculture composition and percent open space composition is 2.22 times better at explaining occupancy than percent agriculture composition.

TABLE 5: Models run using Akaike's Information Criterion comparing landscape types to determine the best fitting explanation for nest box occupancy in Massachusetts, USA, 2014-2015. K is the number of model parameters, ΔAICc is the difference from the top model in Akaike's Information Criterion adjusted for small sample size, w_i is the model weight, and deviance is the -2LogLikelihood. See Table 1 for description and names of all variables.

Model	K	ΔAICc	w_i	Deviance
$FORper_{1.25}$ $OSper_{1.25}$	3	0.000	0.154	103.92
$FORper_{1.25}$	2	0.155	0.142	106.20
$FORper_{1.25}$ $AGRper_{1.25}$	3	1.090	0.089	105.00
REG $FORper_{1.25}$ $OSper_{1.25}$	4	1.573	0.070	103.32
$AGRper_{1.25}$	2	1.701	0.066	107.74
REG $OSper_{1.25}$	3	1.37	0.061	105.75
$SUCCper_{1.25}$	2	1.880	0.060	107.92
$OSper_{1.25}$	2	1.925	0.059	107.97

Discussion

Due to loss of habitat for the American Kestrel, it is vital to manage and conserve the remaining suitable environments (Mass Audubon, 2011; Schlossberg et al, 2010). We have shown that surrounding land cover types have driven nest box occupancy across Massachusetts. Nest box occupancy by kestrels was highest on average with 32% forest composition within a 1.25 km radius, and this was 23% less than landscapes where boxes were not occupied. Percent forest composition has a negative correlation coefficient when compared to nest box occupancy. It is well documented that kestrels select cavities away from the forest edge during breeding season (Rohrbaugh & Yahner, 1997; Smallwood & Bird, 2002). This does not mean that forests in Massachusetts should be cut down completely. Forests are host to a wide range of other species and the major loss of open space, which has led to a decrease in kestrel populations, has not been from forest succession, but from urban development on successional lands (Mass Audubon, 2013).

While minimal forest cover is important for American Kestrel nesting habitats (Rohrbaugh & Yahner, 1997; Smallwood & Bird, 2002), open space is also important to supporting kestrel populations (Mass Audubon, 2011). Occupancy of nest boxes was highest in landscapes with an average of 4% open space composition within 1.25 km, and this was 54% greater than landscapes where boxes were not occupied. Open space had a positive correlation to nest box occupancy in relation to our data. It has been documented that open space, mainly shrubland, has been decreasing in Massachusetts State due to human development (DeGraaf & Yamasaki, 2003; Mass Audubon, 2013; Schlossberg et al, 2010). This may be why we found such a low average percent composition during our study. Shrubland and other open spaces are used by kestrels as hunting grounds due to the abundance of their typical prey sources- arthropods and small invertebrates such as rodents (Hawk Mountain, 2015; Smallwood & Bird, 2002). Open spaces are currently being developed at higher rates, which have led to decreased populations of American Kestrels, and conservation of these areas should be made a priority (Mass Audubon, 2013).

American Kestrels have also historically been known to nest in agricultural areas due to the availability of perches and open hunting space (Kaufman, 2014; Smallwood & Bird, 2002). There has been a decrease of agricultural land in Massachusetts due to urbanization across the state (Mass Audubon, 2013). Our data showed that nest box occupancy increased with increased amounts of agriculture. Kestrels occupied nest boxes in landscapes with an average of 24% agriculture composition within a 1.25 km radius and this was 50% greater than landscapes where boxes were not occupied. Our results agree with observations about the species habitat preference. Since the early 20th century, declining agricultural production in Massachusetts has led to a decrease in lands used by farms and a switch to more urban landscapes, which has led to declining kestrel populations (Mass Audubon, 2013). It is important to note that farms provide valuable resources for kestrels and utilizing them in conservation is highly recommended.

Our data did not show that there was an appreciable difference in nest box occupancy between regions; however, regions present varying landscapes. We found that the Valley was the most likely to be occupied, with approximately 42% of boxes located in the region occupied. On average, occupied boxes in this region had 3% open space composition and 19% forest composition. Our data showed a positive correlation between the region and nest box occupancy, a positive correlation between open space composition and nest box occupancy, and a negative correlation between forest cover and nest box occupancy. Lowlands and floodplains surrounding the Connecticut River serve as agricultural fields and characterize the Valley region. The Valley also contains sand plains and rocky ridges (Galvin, 1984). This composition provides open space for American Kestrel's hunting grounds as well as limited forest, which helps prevent competition (Rohrbaugh & Yahner, 1997; Smallwood & Bird, 2002). Our data agrees with these observations.

Though successional forests was an equally likely model to explain nest box occupancy, literature shows that American Kestrel's prefer nesting locations with less tree cover, as they hunt via perches in open fields (Hawk Mountain, 2015; Smallwood & Bird, 2002). To determine the influence of percent successional forest composition on nest box occupancy, more studies on landscape effects and nesting habits would need to be conducted.

Management Recommendations

Kestrel populations have been in decline due to decreasing amounts suitable habitat, which is due to the urbanization of the state. We found that percent composition of open space and percent composition of agriculture in the landscape positively influence nest box occupancy of kestrels. We recommend increasing open space and agricultural areas to help promote conservation of kestrel populations.

We recommend that future nest boxes should be placed in areas with approximately 32% forest composition, and more than 4 % open space composition or approximately 24% agriculture composition. Although successional forest had a ΔAICc less than 2, further analysis and literature suggests that it did not affect nest box occupancy nearly as much as the other models. Placing nest boxes in areas that meet these parameters will ideally increase kestrel populations in Massachusetts. Factors that should be studied in the future include the effect of successional forests on nest box occupancy, site fidelity for nesting kestrels in Massachusetts, and the effect of human disturbance around nest sites.

References

Alderfer J. 2005. “National Geographic Complete Birds of North America” [Internet]. National Geographic. [cited 2015 Sep 1] Available from: http://animals.nationalgeographic.com/animals/birding/american-kestrel/

Bird DM, Palmer RS. 1988. American Kestrel. Pages 253-290 *in* Handbook of North American birds. Vol. 5: diurnal raptors. Pt. 2. (Palmer, R. S., Ed.) Yale Univ. Press, New Haven, CT.

Bird DM, Varland DE, Negro JJ. 1996. Raptors in Human Landscapes: Adaptation to Built and Cultivated Environments [Internet]. San Diego (CA): Academic Press Inc. [cited 2015 Oct 06] Available from: https://books.google.com/books?hl=en&lr=&id=bHZrahW9XKEC&oi=fnd&pg=PP1&dq=american+kestrels+human+tolerance&ots=F_NJI3ENQR&sig=WICjh3po-xQhSYqApkfbB6eG_7g#v=onepage&q&f=false

Burnham KP, Anderson DR, Huyvaert KP. 2010. AIC model selection and multimodel inference in behavioral ecology: some background, observations, and comparisons. Behavioral Ecology and Sociobiology [Internet]. [cited 2015 Oct 13] 65:23–35. Available from: http://www.ericlwalters.org/Burnham_etal_2011

DeGraaf RM, Yamasaki M. 2003. Options for managing early-successional forest and shrub land bird habitats in the northeastern United States. Forest Ecology and Management [Internet]. [cited 2015 Oct 08] 185:179-191. Available from: https://www.rivercare.org/local/upload/file/Early-succession-journal-article.pdf

Duncan JR., Bird DM. 1989. "The influence of relatedness and display effort on the mate choice of captive female American kestrels" (PDF). Animal Behavior (The Association for the Study of Animal Behaviour) 37:112–117. doi:10.1016/0003-3472(89)90011-0.

Dwernychuk LW, Boag DA. 1972. "Ducks nesting in association with gulls-an ecological trap?". Canadian Journal of Zoology 50(5):559–563.

Environmental Systems Research Institute, Inc., n.d. ArcMap. [Internet]. [cited 2015 Sept 22].

Galvin WF. 1984. Historic & Archaeological Resources of the Connecticut River Valley [Internet]. (MA): The Massachusetts Historical Commission; [2007, cited 2015 Oct 13] Available from: https://www.sec.state.ma.us/mhc/mhcpdf/regionalreports/CTValley.pdf

Hawk Mountain Sanctuary Association. n.d. Nestboxes for American Kestrels. [Internet]. [cited 2015 Jul 8]. Available from: http://www.hawkmountain.org/data/streamfile.aspx?id=NzMzMDY%3d&name=kestrelnestbox.pdf

Hawk Mountain. 2015. American Kestrel [Internet]. [cited 2015 Aug 03]. Available from: http://www.hawkmountain.org/raptorpedia/hawks-at-hawk-mountain/hawk-species-at-hawk-mountain/american-kestrel/page.aspx?id=498

Johnsgard P. 1990. Hawks, Eagles, and Falcons of North America [Print]. United States: Smithsonian Institution.

Johnson AS, Anderson SH. 2002. Conservation Assessment for the American Kestrel in the Black Hills National Forest, South Dakota and Wyoming [Internet]. Laramie (WY): Wyoming Cooperative Fish and Wildlife Research Unit. [cited 2015 Oct 13] Available from: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5226874.pdf

Kaufman K. 2014. American Kestrel [Internet]. [cited 2015 Jul 5]. Available from: http://www.audubon.org/field-guide/bird/american-kestrel

Kleinbaum DG, Klein M. 2010. Logistic Regression A Self-Learning Text [Internet]. 3rd. New York (NY):Springer ; [cited 2015 Oct 01] Available from: http://download.springer.com/static/pdf/140/bok%253A978-1-4419-1742-3.pdf?originUrl=http%3A%2F%2Flink.springer.com%2Fbook%2F10.1007%2F978-1-4419-1742-3&token2=exp=1443734071~acl=%2Fstatic%2Fpdf%2F140%2Fbok%25253A978-1-4419-1742-3.pdf%3ForiginUrl%3Dhttp%253A%252F%252Flink.springer.com%252Fbook%252F10.1007%252F978-1-4419-1742-3*~hmac=e2ec5d748d53235eabb7aedacce7c8c315b2bdf8bce43ccd6e17471c7113bd40

Mass Audubon. 2011. State of the Birds. Mass Audubon Bird Conservation Programs [Internet]. [cited 2015 Jul 16]. Available from: http://www.massaudubon.org/content/download/9510/156446/file/state-of-the-birds-2011-document.pdf

Mass Audubon. 2013. State of the Birds. Mass Audubon Bird Conservation Programs [Internet]. [cited 2015 Oct 04]. Available from:

http://www.massaudubon.org/content/download/9511/156450/file/state-of-the-birds-2013-document.pdf

Mazerolle MJ. 2004. Making sense out of Akaike's Information Criterion (AIC): Its use and interpretation in model selection and inference from ecological data [Internet]. Quebec, Canada: University of Laval. [cited 2015 Oct 13] Available from: http://theses.ulaval.ca/archimede/fichiers/21842/apa.html

McDonald JH. 2014. Handbook of Biological Statistics [Internet]. 3rd. Baltimore (MD): Sparky House Publishing. [2015 Jul 20, cited 2015 Sep 15] Available from: http://www.biostathandbook.com

Medica DL, Clauser R, Bildstein K. 2007. Prevalence of West Nile Virus Antibodies in a Breeding Population of American Kestrels (Falco sparverius) in Pennsylvania. Journal of Wildlife Diseases [Internet]. [cited 2015 Oct 12] 43:538-541. Available from: http://www.bioone.org/doi/pdf/10.7589/0090-3558-43.3.538

New York State Department of Environmental Conservation. American Kestrel Management and Research Needs. NYSDEC [Internet]. n.d. [cited 2015 July 5]. Available from: http://www.dec.ny.gov/animals/87381.html

Palmer R. 1988. Handbook of North American Birds Volume *5*. Yale University: Yale University Press [Print].

Peterson WR, Meservey WR. 2003. Massachusetts Breeding Bird Atlas. Massachusetts: The Massachusetts Audubon. P 106-7.

Pezzullo, J. n.d. Logistic Regression [Internet]. Interactive Statistics. [2015 Jul 22, cited 2015 Oct 3]. Available from: http://statpages.org/logistic.html

Press SJ, Wilson S. 1978. Choosing between logistic regression and discriminant analysis. Journal of the American Statistical Association. 73:699-705.

Ralph CJ, Geupel GR, Pyle P. 1993. Handbook of Field Methods for Monitoring Landbirds [Internet]. Albany (CA): United States Department of Agriculture. [Cited 2015 Sep 22] Available from: https://books.google.com/books?id=oIT6WRY4YvsC&pg=PA30&lpg=PA30&dq=primary+secondary+tertiary+roads+birds&source=bl&ots=_gOXP6hDAN&sig=r73KPLCMOlLk1wm0iuUGkVirom4&hl=en&sa=X&ved=0CDQQ6AEw

Rohrbaugh RW, Yahner RH. 1997. Effects of Macrohabitat and Microhabitat on Nest-Box Use and Nesting Success of American Kestrels. Wilson Bull [Internet]. [cited 2015 Jul 8] 109(3):410-423. Available from: https://sora.unm.edu/sites/default/files/journals/wilson/v109n03/p0410-p0423.pdf

RSPB. n.d. The Kestrel's Year [Internet]. The Royal Society for the Protection of Birds. [cited 2015 Jul 8]. Available from: http://www.rspb.org.uk/discoverandenjoynature/discoverandlearn/birdguide/name/k/kestrel/kestrel_year.aspx

Schlossberg S, King DI. 2009. Postlogging Succession and Habitat Usage of Shrubland Birds. Journal of Wildlife Management [Internet]. [cited 2015 Oct 13] 73(2):226–231. Available from: http://onlinelibrary.wiley.com/doi/10.2193/2007-518/epdf

Schlossberg S, King DI, Chandler RB, Mazzei BA. 2010. Regional Synthesis of Habitat Relationships in Shrubland Birds. Journal of Wildlife Management [Internet]. [cited 2015 Oct 12] 74(7):1513–1522. Available from: http://au4sb9ax7m.search.serialssolutions.com/?url_ver=Z39.88-2004&url_ctx_fmt=info:ofi/fmt:kev:mtx:ctx&rft_val_fmt=info:ofi/fmt:kev:mtx:journal&rft.atitle=Regional%20Synthesis%20of%20Habitat%20Relationships%20in%20Shrubland%20Birds&rft.aufirst=Scott&rft.aulast=Schlossberg&rft.date=2010&rft.epage=1522&rft.genre=article&rft.issn=0022-541X&rft.issue=7&rft.jtitle=JOURNAL%20OF%20WILDLIFE%20MANAGEMENT&rft.pages=1513-1522&rft.spage=1513&rft.stitle=J%20WILDLIFE%20MANAGE&rft.volume=74&rfr_id=info:sid/www.isinet.com:WoK:UA&rft.au=King%2C%20David%20I%2E&rft.au=Chandler%2C%20Richard%20B%2E&rft.au=Mazzei%2C%20Benjamin%20A%2E&rft_id=info:doi/10%2E2193%2F2008-601

Smallwood J, Bird D. 2002. American Kestrel (Falco sparverius), America Online [Internet]. Ithaca (NY): Cornell Lab of Ornithology; cited 2015 Jul 8]. Available from: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/602 doi:10.2173/bna.602

Smallwood JA. 1988. A Mechanism of Sexual Segregation by Habitat in American Kestrels (Falco Sparverius) Wintering in South-Central Florida. Auk [Internet]. [cited 2015 Aug

3] 105:36-46. Available from: https://sora.unm.edu/sites/default/files/journals/auk/v105n01/p0036-p0046.pdf

Smith DG, Wilson CR, Frost HH. 1972. The Biology of the American Kestrel in Central Utah. The Southwestern Naturalist. [cited 2015 Oct 13] 17 (1): 73-83. Available from: http://www.jstor.org/stable/pdf/3669841.pdf?acceptTC=true

Strasser E, Heath J. 2013. Reproductive failure of a human-tolerant species, the American kestrel, is associated with stress and human disturbance. Journal of Applied Ecology [Internet]. [cited 2015 Jul 1] 50:912-919. Available from: http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12103/abstract

Steenhof K, Peterson BE. 2009. Site Fidelity, Mate Fidelity, and Breeding Dispersal in American Kestrels. The Wilson Journal of Ornithology [Internet]. [cited 2015 Oct 13] 121(1):12-21. Available from: http://www.bioone.org/doi/pdf/10.1676/07-177.1

The Trust for Public Land. n.d. Land Conservation in Massachusetts. Conservation Almanac [Internet]. n.d. [cited 2015 July 5]. Available from: http://www.conservationalmanac.org/secure/almanac/newengland/ma/index.html

Wauer RH, Clark WS. 2005. The American Kestrel: Falcon of Many Names [Print]. Johnson Books. ISBN 1-55566-353-2.

Appendices

Appendix 1: Table of selected land cover types for analysis in ArcMAP 10.0

Land Use Code	Land Use Name	Description
1/2	Agriculture	Generally tilled land used to grow row crops. Boundaries follow the shape of the fields and include associated buildings (e.g., barns). This category also includes turf farms that grow sod. Fields and associated facilities (barns and other outbuildings) used for animal grazing and for the growing of grasses for hay.
3	Forest	Areas where tree canopy covers at least 50% of the land. Both coniferous and deciduous forests belong to this class.
4/37/14/25/23	Wetlands	DEP Wetlands (1:12,000) WETCODEs 4, 7, 8, 12, 23, 18, 20, and 21. DEP Wetlands (1:12,000) WETCODEs 14, 15, 16, 24, 25 and 26. DEP Wetlands (1:12,000) WETCODEs 11 and 27. DEP Wetlands (1:12,000) WETCODEs 1, 2, 3, 6, 10, 13, 17 and 19 Both active and recently inactive cranberry bogs and the sandy areas adjacent to the bogs that are used in the growing process. Impervious features associated with cranberry bogs such as parking lots and machinery are included. Modified from DEP Wetlands (1:12,000) WETCODE 5.
6/5/26/34	Open Space	Vacant land, idle agriculture, rock outcrops, and barren areas. Vacant land is not maintained for any evident purpose and it does not support large plant growth. Includes sand and gravel pits, mines and quarries. The boundaries extend to the edges of the site's activities, including on-site machinery, parking lots, roads and buildings.

		Includes the greenways, sand traps, water bodies within the course, associated buildings and parking lots. Large forest patches within the course greater than 1 acre are classified as Forest (class 3). Does not include driving ranges or miniature golf courses. Includes the gravestones, monuments, parking lots, road networks and associated buildings.
10/11/12	High Density Residential	Duplexes (usually with two front doors, two entrance pathways, and sometimes two driveways), apartment buildings, condominium complexes, including buildings and maintained lawns. Note: This category was difficult to assess via photo interpretation, particularly in highly urban areas. Housing on smaller than 1/4 acre lots. See notes below for details on Residential interpretation. Housing on 1/4 - 1/2 acre lots. See notes below for details on Residential interpretation.
13/38	Low Density Residential	Housing on 1/2 - 1 acre lots. See notes below for details on Residential interpretation. Housing on > 1 acre lots and very remote, rural housing. See notes below for details on Residential interpretation.
15/16/29/31	Urban	Malls, shopping centers and larger strip commercial areas, plus neighborhood stores and medical offices (not hospitals). Lawn and garden centers that do not produce or grow the product are also considered commercial. Light and heavy industry, including buildings, equipment and parking areas. Include parking lots and associated facilities but not docks (in class 18) Lands comprising schools, churches, colleges, hospitals, museums, prisons, town halls or court houses, police and fire

		stations, including parking lots, dormitories, and university housing. Also may include public open green spaces like town commons.
18	Transportation	Airports (including landing strips, hangars, parking areas and related facilities), railroads and rail stations, and divided highways (related facilities would include rest areas, highway maintenance areas, storage areas, and on/off ramps). Also includes docks, warehouses, and related land-based storage facilities, and terminal freight and storage facilities. Roads and bridges less than 200 feet in width that are the center of two differing land use classes will have the land use classes meet at the center line of the road (i.e., these roads/bridges themselves will not be separated into this class).
20	Water	DEP Wetlands (1:12,000) WETCODEs 9 and 22.
24/35/36/40	Successional Forest	Powerline and other maintained public utility corridors and associated facilities, including power plants and their parking areas. Fruit farms and associated facilities. Greenhouses and associated buildings as well as any surrounding maintained lawn. Christmas tree (small conifer) farms are also classified as Nurseries. Predominantly (> 25%) shrub cover, and some immature trees not large or dense enough to be classified as forest. It also includes areas that are more permanently shrubby, such as heath areas, wild blueberries or mountain laurel.

Appendix 2: Spearman Rank Correlation X^2 and p values for all variables. Significant values are bolded within the table.

	Percent Agriculture	Percent Forest	Percent Wetland	Percent Open Space	Percent High Density Res	Percent Low Density Res	Percent Urban
Percent Agriculture	x	-0.3141	-0.30941	0.049	0.0321	-0.02879	0.29095
	x	**0.0015**	**0.0018**	0.6301	0.7524	0.7773	**0.0035**
Percent Forest	x	x	-0.26592	-0.28823	-0.53195	-0.08881	-0.47204
	x	x	**0.0078**	**0.0038**	**< 0.0001**	0.382	**< 0.0001**
Percent Wetland	x	x	x	0.06624	0.06096	0.06949	-0.01205
	x	x	x	0.5148	0.5489	0.4943	0.9058
Percent Open Space	x	x	x	x	0.34737	0.06138	0.38913
	x	x	x	x	**0.0004**	0.5461	**< 0.0001**
Percent High Density Res	x	x	x	x	x	0.27113	0.52591
	x	x	x	x	x	**0.0066**	**< 0.0001**
Percent Low Density Res	x	x	x	x	x	x	0.03178
	x	x	x	x	x	x	0.7548
Percent Urban	x	x	x	x	x	x	x
	x	x	x	x	x	x	x
Percent Transportation	x	x	x	x	x	x	x
	x	x	x	x	x	x	x
Percent Water	x	x	x	x	x	x	x
	x	x	x	x	x	x	x
Percent Successional Forest	x	x	x	x	x	x	x
	x	x	x	x	x	x	x
Percent Other	x	x	x	x	x	x	x
	x	x	x	x	x	x	x
Longitude	x	x	x	x	x	x	x
	x	x	x	x	x	x	x
Latitude	x	x	x	x	x	x	x
	x	x	x	x	x	x	x
Distance Fresh Water	x	x	x	x	x	x	x
	x	x	x	x	x	x	x
Distance Wetland	x	x	x	x	x	x	x
	x	x	x	x	x	x	x
Distance Road	x	x	x	x	x	x	x
	x	x	x	x	x	x	x
Distance Perch	x	x	x	x	x	x	x
	x	x	x	x	x	x	x
Distance Human Disturbance	x	x	x	x	x	x	x
	x	x	x	x	x	x	x

Percent Transportation	Percent Water	Percent Successional Forest	Percent Other	Longitude	Latitude	Distance Fresh Water	Distance Wetland	Distance Road	Distance Perch	Distance Human Disturbance
0.14979	-0.12212	0.17196	0.05765	-0.3129	-0.05053	-0.02416	-0.10256	-0.22594	0.25876	0.04374
0.1389	0.2285	0.0888	0.5708	**0.0016**	0.6194	0.8124	0.3226	**0.0245**	**0.0097**	0.6673
-0.39569	-0.46477	0.03666	-0.51056	-0.23279	-0.03529	0.41129	0.28669	0.19477	-0.05163	0.05528
< 0.0001	**< 0.0001**	0.7187	**< 0.0001**	**0.0204**	0.7287	**< 0.0001**	**0.0049**	0.0534	0.6118	0.5868
0.18412	0.28659	-0.29119	0.01896	0.46641	-0.00411	-0.167	-0.28519	-0.16836	0.00029	0.08208
0.0681	**0.004**	**0.0035**	0.8522	**< 0.0001**	0.9678	0.0985	**0.0051**	0.0957	0.9977	0.4192
0.37274	0.29278	0.1538	0.43188	0.08754	-0.25212	-0.22954	-0.06415	0.02766	0.16591	-0.06674
0.0001	**0.0033**	0.1285	**< 0.0001**	0.3889	**0.0118**	**0.0223**	0.5368	0.7858	0.1008	0.5116
0.31647	0.27273	0.11441	0.54546	0.2631	-0.04028	-0.24192	-0.24074	-0.04279	0.11504	-0.16408
0.0014	**0.0063**	0.2595	**< 0.0001**	**0.0085**	0.6922	**0.0158**	**0.0188**	0.6741	0.2568	0.1046
-0.05561	0.03159	0.23193	0.03478	0.14892	-0.14967	-0.14122	-0.31105	0.05714	0.05314	-0.29264
0.5846	0.7562	**0.0209**	0.7325	0.1413	0.1392	0.1632	**0.0022**	0.5743	0.6014	**0.0033**
0.32602	0.0584	0.14253	0.68782	0.02035	0.03455	-0.02528	-0.12897	-0.11389	0.23821	-0.05539
0.001	0.5659	0.1593	**< 0.0001**	0.8415	0.7343	0.8038	0.2129	0.2617	**0.0176**	0.5861
x	0.10443	-0.10183	0.35131	0.24487	-0.10342	-0.09411	-0.10177	-0.39641	-0.04023	-0.07766
x	0.3036	0.3159	**0.0004**	**0.0146**	0.3083	0.3541	0.3264	**< 0.0001**	0.6925	0.4448
x	x	-0.05279	0.2006	0.31614	-0.03513	-0.5573	-0.02334	-0.03537	-0.09605	-0.07326
x	x	0.6038	**0.0465**	**0.0014**	0.73	**< 0.0001**	0.8224	0.7282	0.3443	0.4711
x	x	x	0.23193	-0.28178	-0.07462	0.0013	-0.13779	-0.01287	0.04524	-0.16047
x	x	x	**0.0209**	**0.0047**	0.4629	0.9898	0.183	0.8994	0.6566	0.1126
x	x	x	x	0.06494	-0.05155	0.02021	-0.16637	-0.00824	0.17145	-0.10647
x	x	x	x	0.5231	0.6124	0.8426	0.1071	0.9355	0.0897	0.2942
x	x	x	x	x	0.13221	-0.16621	-0.03602	-0.25141	-0.20555	-0.29726
x	x	x	x	x	0.1921	0.1001	0.729	**0.0121**	**0.0412**	**0.0028**
x	x	x	x	x	x	0.02731	0.05476	-0.19733	-0.27058	-0.02261
x	x	x	x	x	x	0.7884	0.5982	0.0503	**0.0068**	0.8242
x	x	x	x	x	x	x	0.17944	0.18212	0.03928	0.17817
x	x	x	x	x	x	x	0.0819	0.0712	0.6995	0.0777
x	x	x	x	x	x	x	x	0.12299	0.00053	-0.02557
x	x	x	x	x	x	x	x	0.2351	0.9959	0.8057
x	x	x	x	x	x	x	x	x	0.18721	0.31936
x	x	x	x	x	x	x	x	x	0.0635	**0.0013**
x	x	x	x	x	x	x	x	x	x	0.14421
x	x	x	x	x	x	x	x	x	x	0.1544
x	x	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	x	x

Appendix 3: Descriptive Statistics for selected variables based on sorting by occupied (Description = yes), unoccupied (Description = no), region (Central, West, East, Valley), and both occupancy and region.

Covariate set and variable name	N	Minimum	Maximum	Mean	Std. Deviation
Unsorted					
$LDRper_{1.25}$	99	0.000	27.080	6.917	5.546
$OSper_{1.25}$	99	0.105	14.266	3.255	3.255
$FORper_{1.25}$	99	0.066	93.016	40.980	21.915
$AGRper_{1.25}$	99	0.000	67.747	18.120	15.954
$SUCCper_{1.25}$	99	0.000	10.111	1.165	1.766
$PERC_{0.25}$	99	0.007	0.255	0.044	0.037
Description = no					
$LDRper_{1.25}$	74	0.000	27.080	6.681	5.206
$OSper_{1.25}$	74	0.105	11.827	2.866	2.955
$FORper_{1.25}$	74	0.066	93.016	43.911	22.729
$AGRper_{1.25}$	74	0.000	60.030	16.168	14.981
$SUCCper_{1.25}$	74	0.000	10.111	1.112	1.938
$PERC_{0.25}$	74	0.007	0.255	0.044	0.041
Description = yes					
$LDRper_{1.25}$	25	0.029	26.569	7.613	6.520
$OSper_{1.25}$	25	0.431	14.266	4.407	3.855
$FORper_{1.25}$	25	10.067	71.741	32.305	16.875
$AGRper_{1.25}$	25	3.109	67.747	23.897	17.612
$SUCCper_{1.25}$	25	0.000	4.276	1.231	1.127
$PERC_{0.25}$	25	0.007	0.095	0.045	0.026
Region = Central					
$LDRper_{1.25}$	32	0.029	21.504	6.913	5.329
$OSper_{1.25}$	32	0.133	14.266	3.792	3.719
$FORper_{1.25}$	32	20.484	75.642	52.492	15.199
$AGRper_{1.25}$	32	3.513	31.071	13.442	7.158
$SUCCper_{1.25}$	32	0.000	10.111	1.380	2.383
$PERC_{0.25}$	32	0.012	0.095	0.046	0.021
Region = East					
$LDRper_{1.25}$	27	0.00	27.080	8.503	7.115
$OSper_{1.25}$	27	0.105	9.528	3.091	3.081
$FORper_{1.25}$	27	0.066	65.556	29.013	12.817
$AGRper_{1.25}$	27	0.000	45.587	10.719	11.774
$SUCCper_{1.25}$	27	0.000	3.698	0.541	0.942
$PERC_{0.25}$	27	0.008	0.052	0.023	0.014
Region = Valley					
$LDRper_{1.25}$	24	2.168	19.676	6.933	4.388
$OSper_{1.25}$	24	0.159	8.306	2.571	2.111
$FORper_{1.25}$	24	6.177	87.299	25.950	17.918
$AGRper_{1.25}$	24	5.560	67.747	37.673	17.240
$SUCCper_{1.25}$	24	0.000	6.107	1.608	1.569
$PERC_{0.25}$	24	0.007	0.145	0.056	0.036

Region = West					
LDRper$_{1.25}$	16	0.247	12.037	4.223	3.568
OSper$_{1.25}$	16	0.182	11.827	3.486	3.986
FORper$_{1.25}$	16	19.812	93.016	60.681	22.837
AGRper$_{1.25}$	16	1.715	22.442	10.638	6.664
SUCCper$_{1.25}$	16	0.000	4.276	1.122	1.483
PERC$_{0.25}$	16	0.007	0.255	0.058	0.076
Description = no, Region = Central					
LDRper$_{1.25}$	23	0.160	17.626	7.209	4.443
OSper$_{1.25}$	23	0.133	10.627	2.760	2.564
FORper$_{1.25}$	23	31.387	75.642	54.945	13.845
AGRper$_{1.25}$	23	3.513	31.071	13.665	7.421
SUCCper$_{1.25}$	23	0.000	10.111	1.590	2.752
PERC$_{0.25}$	23	0.012	0.080	0.045	0.021
Description = no, Region = East					
LDRper$_{1.25}$	24	0.000	27.080	7.909	6.506
OSper$_{1.25}$	24	0.105	9.528	3.383	3.150
FORper$_{1.25}$	24	0.066	65.556	29.188	14.217
AGRper$_{1.25}$	24	0.000	45.587	11.067	12.410
SUCCper$_{1.25}$	24	0.000	3.698	0.542	1.000
PERC$_{0.25}$	24	0.008	0.052	0.025	0.014
Description = no, Region = Valley					
LDRper$_{1.25}$	14	2.168	19.676	6.191	4.787
OSper$_{1.25}$	14	0.159	4.536	1.911	1.154
FORper$_{1.25}$	14	6.277	87.299	30.931	21.902
AGRper$_{1.25}$	14	5.560	60.030	34.955	19.175
SUCCper$_{1.25}$	14	0.000	6.107	1.467	1.903
PERC$_{0.25}$	14	0.012	0.144	0.061	0.040
Description = no, Region = West					
LDRper$_{1.25}$	13	0.247	12.037	4.010	3.339
OSper$_{1.25}$	13	0.182	11.827	3.130	4.350
FORper$_{1.25}$	13	19.812	93.016	65.549	22.663
AGRper$_{1.25}$	13	1.715	22.442	9.783	7.132
SUCCper$_{1.25}$	13	0.000	3.571	0.938	1.362
PERC$_{0.25}$	13	0.007	0.355	0.058	0.076
Description = yes, Region = Central					
LDRper$_{1.25}$	9	0.029	21.504	6.158	7.406
OSper$_{1.25}$	9	1.544	14.266	6.429	4.963
FORper$_{1.25}$	9	20.484	71.741	46.223	17.508
AGRper$_{1.25}$	9	5.221	27.886	12.870	6.826
SUCCper$_{1.25}$	9	0.000	2.492	0.844	0.850
PERC$_{0.25}$	9	0.024	0.095	0.049	0.023

Description = yes, Region = East					
$LDRper_{1.25}$	3	5.988	26.569	13.253	11.548
$OSper_{1.25}$	3	0.431	1.207	0.759	0.402
$FORper_{1.25}$	3	16.312	40.896	27.613	12.411
$AGRper_{1.25}$	3	3.109	11.000	7.936	4.231
$SUCCper_{1.25}$	3	0.285	0.702	0.535	0.220
$PERC_{0.25}$	3	0.010	0.025	0.015	0.009
Description = yes, Region = Valley					
$LDRper_{1.25}$	10	3.910	14.128	7.971	3. 748
$OSper_{1.25}$	10	0.790	8.306	3.494	2.799
$FORper_{1.25}$	10	10.067	31.588	19.001	5.948
$AGRper_{1.25}$	10	20.250	67.747	41.477	14.173
$SUCCper_{1.25}$	10	0.625	3.255	1.807	0.993
$PERC_{0.25}$	10	0.007	0.084	0.048	0.030
Description = yes, Region = West					
$LDRper_{1.25}$	3	2.030	11.142	5.140	5.200
$OSper_{1.25}$	3	3.838	6.037	5.028	1.110
$FORper_{1.25}$	3	37.500	42.878	39.586	2.885
$AGRper_{1.25}$	3	12.555	15.689	14.342	1.612
$SUCCper_{1.25}$	3	0.578	4.276	1.917	2.049
$PERC_{0.25}$	3	0.035	0.076	0.053	0.021

Appendix 4: Table of nest boxes (n=99) in Massachusetts with the % land cover composition, land cover composition (km^2), occupancy, distances to features, and region.

ID/Land Cover Type	%Agriculture	%Forest	%Wetlands	%Open Space	%High Density Residential	%Low Density Residential	%Urban	%Transportation	%Water	%Successional Forest	%Other
Bolton Flats WMA	6.669	51.653	17.381	9.384	0.000	0.029	8.659	0.625	1.616	1.501	2.483
Burrage Pond WMA	3.109	25.630	49.688	0.431	0.000	7.203	0.115	0.000	13.181	0.619	0.024
Dalton on utility pole	22.442	64.733	0.903	3.484	1.392	1.748	1.504	0.000	0.637	3.155	0.001
Davis Farm 1	30.891	35.020	6.953	0.692	0.527	10.259	1.755	0.438	0.000	10.111	3.354
Davis Farm 2	31.071	32.026	8.331	1.499	0.368	9.289	3.681	0.536	0.046	9.799	3.354
Drumlin Farm1	10.999	40.896	16.030	0.638	1.513	26.569	1.255	0.813	1.001	0.285	0.000
Drumlin Farm2	14.605	38.471	11.742	0.690	2.911	27.080	1.270	1.467	1.478	0.285	0.000
ECOC	6.955	15.416	53.494	0.453	1.806	6.167	0.512	0.000	14.886	0.000	0.312
ECOC_Cider Hill Farm	14.415	41.981	7.685	2.605	12.185	14.851	1.630	0.000	0.356	3.514	0.779
ECOC-Appleton Farms1	42.077	34.767	13.634	2.453	0.129	4.054	1.422	0.640	0.824	0.000	0.000
ECOC-Appleton Farms2	45.587	40.799	5.477	2.182	0.000	3.080	0.476	0.380	2.020	0.000	0.000
ECOC-BillForwardWMA	12.036	43.925	35.682	1.182	0.000	5.202	0.000	0.415	1.387	0.000	0.171
ECOC-CoopersNorthPasture	21.942	28.285	17.974	2.552	10.021	0.696	13.592	2.461	0.385	0.000	2.092
ECOC-Little_River	22.359	31.899	21.668	0.956	15.797	0.634	1.988	3.655	0.855	0.055	0.134
ECOC-NEB	27.418	27.822	21.588	1.539	0.859	15.819	3.126	0.208	0.694	0.768	0.160
ECOC-Newburyport1	4.599	15.132	10.671	9.528	12.375	3.201	38.244	2.020	0.845	0.392	2.994
ECOC-Newburyport2	3.900	13.653	9.469	9.331	15.015	3.027	39.482	1.993	0.845	0.212	3.074
ECOC-Osprey	2.141	48.282	15.391	1.766	4.217	14.648	4.569	0.000	8.363	0.000	0.622
ECOC-PF	3.256	25.705	41.189	1.644	11.658	8.384	3.714	0.726	0.999	0.556	2.170
ECOC-SBSP1	0.107	33.116	38.438	0.770	2.732	4.924	4.201	0.000	11.333	1.348	3.033
ECOC-SPSP2	0.000	0.066	62.981	0.105	1.414	0.000	0.207	1.115	25.531	0.000	8.581
ECOC-Waring Field	7.011	25.115	12.745	6.315	27.633	12.690	2.943	0.000	0.501	3.698	1.349
ECOC-WHF	3.320	65.556	10.801	1.031	0.000	15.745	0.000	0.000	3.147	0.034	0.365
EQLT - Keelip Farm	19.201	58.620	7.441	3.223	0.339	7.002	1.223	0.843	0.744	0.879	0.485
EQLT - WenMeadow	11.766	51.559	8.231	3.337	0.710	21.504	1.467	0.000	0.104	0.963	0.358
EQLT-Dr. Liland	16.549	71.741	6.919	2.363	0.000	1.089	1.220	0.000	0.000	0.000	0.119
EQLT-Mandell Hill	27.886	60.081	4.531	1.544	0.000	2.913	0.312	0.479	0.287	1.226	0.742
Gilbertville 1	16.712	74.074	4.504	0.883	0.000	3.118	0.000	0.000	0.032	0.542	0.135
Gilbertville 2	16.665	73.189	5.078	0.660	0.000	3.711	0.000	0.000	0.020	0.492	0.184
Heirloom Harvest CSA	7.217	20.484	50.021	3.974	0.722	8.604	4.114	1.406	0.032	0.000	3.427
Hennessey 2	10.058	64.683	8.787	2.300	0.123	10.800	0.000	1.807	0.184	1.094	0.163
Hennessey I	13.995	56.334	8.875	2.009	0.123	14.605	0.000	2.617	0.184	1.094	0.163
High Ridge 1	10.489	74.755	10.963	0.133	0.256	2.156	0.000	0.133	0.037	0.839	0.241
High Ridge 2	9.415	71.047	8.732	1.053	0.000	3.073	5.094	0.122	0.000	1.242	0.223
High Ridge 3	7.805	75.642	10.153	0.990	0.000	0.160	4.111	0.878	0.255	0.007	0.000
Hinsdale Flats	10.632	42.130	41.020	1.035	0.076	4.413	0.221	0.337	0.132	0.003	0.000
Kestrel Land Trust 1	5.560	87.299	1.182	0.159	0.062	5.187	0.000	0.000	0.002	0.550	0.000
Kestrel Land Trust 11	13.467	39.895	4.836	3.528	14.943	6.611	9.413	0.000	2.229	0.312	4.766
Kestrel Land Trust 12	14.413	51.005	7.750	1.196	1.562	19.676	2.474	0.000	0.351	0.773	0.799
Kestrel Land Trust 13	54.994	20.721	6.553	1.127	0.000	13.461	1.610	0.000	0.092	1.204	0.238
Kestrel Land Trust 14	38.438	23.923	4.644	0.790	4.932	10.628	1.587	0.000	12.274	0.886	1.898
Kestrel Land Trust 15	21.281	38.247	8.501	1.741	8.936	6.854	9.251	0.000	0.038	3.663	1.487
Kestrel Land Trust 16	19.260	41.209	7.832	1.156	9.262	4.767	10.465	0.000	0.326	3.977	1.745
Kestrel Land Trust 17	19.034	44.341	7.447	1.287	3.817	4.539	11.059	0.000	0.547	6.107	1.823
Kestrel Land Trust 2	38.344	10.067	22.378	5.762	3.456	5.801	3.815	3.459	0.126	3.223	3.569
Kestrel Land Trust 3	21.363	31.588	4.330	4.166	11.734	6.829	12.364	0.350	1.078	1.828	4.371
Kestrel Land Trust 4	53.174	15.684	9.736	1.598	1.136	2.999	9.205	0.214	1.997	2.833	1.424
Kestrel Land Trust 5	48.045	16.830	9.998	1.522	1.182	9.722	6.124	0.214	2.387	3.255	0.721
Kestrel Land Trust 6	59.431	16.481	8.181	1.936	1.107	3.124	6.061	0.214	2.518	0.491	0.456
Kestrel Land Trust 7	67.747	13.187	7.216	1.704	0.000	5.629	1.050	0.000	2.715	0.751	0.000
Kestrel Land Trust 8	60.030	19.488	4.383	4.536	5.296	3.071	0.000	0.000	2.794	0.402	0.000
Lenox on utility pole	12.555	38.380	20.768	6.037	0.745	11.142	0.293	0.612	3.357	4.276	1.835
MAS	3.819	33.367	4.154	1.714	33.469	9.364	9.837	0.960	0.341	0.000	2.979
MAS Daniel Webster 1	5.208	17.292	37.584	8.461	17.721	5.156	1.182	3.003	3.115	0.471	0.808
MAS Daniel Webster 2	5.249	16.637	36.815	8.377	17.920	4.600	1.723	3.756	3.259	0.347	1.317
MAS Daniel Webster 3	5.973	16.848	40.706	7.203	13.791	4.242	1.413	4.240	4.029	0.415	1.143
MAS Daniel Webster 4	6.712	18.641	44.859	5.262	8.923	3.831	0.727	4.374	4.924	0.650	1.096
MAS-Ipswich	3.245	43.197	45.229	0.185	0.064	7.911	0.118	0.000	0.051	0.000	0.000
MAS-Long Pasture	3.674	24.538	28.911	4.882	3.045	14.511	0.860	0.416	18.848	0.257	0.060
Mason Road	14.702	66.741	14.864	0.847	0.000	2.361	0.000	0.000	0.485	0.000	0.000
MDOT 1	45.468	18.669	8.536	2.811	1.744	12.700	4.700	4.525	0.150	0.335	0.361
MDOT 2	42.768	18.858	8.666	2.764	2.132	14.128	4.277	4.444	0.135	0.625	1.206
MDOT 3	37.459	34.685	13.661	0.585	0.226	8.189	1.639	3.520	0.036	0.000	0.000
MDOT 4	38.592	20.631	9.978	7.531	8.537	4.536	4.692	0.556	1.373	2.789	0.787
MDOT 5	44.232	18.614	3.254	1.274	13.114	3.910	7.736	2.167	0.939	1.940	2.820
MDOT 6	37.191	11.395	7.683	2.534	2.407	4.450	17.445	4.157	0.871	1.065	10.802
MDOT 7	20.250	15.591	14.204	8.306	7.775	5.066	16.748	4.127	0.000	1.566	6.367
MDOT 8	58.743	8.453	3.590	1.542	8.255	2.338	8.617	4.630	0.088	0.019	3.729
MDOT 9	44.856	6.177	1.139	2.144	15.396	2.168	4.152	8.020	10.719	0.009	5.219
Merriam Road Conservation Area	17.210	49.127	14.771	3.121	2.624	10.992	0.557	0.962	0.184	0.132	0.320
North Brigham Hill Road 1	7.679	50.523	7.594	4.049	6.279	11.548	2.890	1.129	4.877	1.354	2.077
North Brigham Hill Road 2	6.977	50.010	7.499	1.660	19.540	7.640	2.259	2.475	0.867	0.076	0.998
Old Upton Road	11.903	40.924	7.569	10.627	12.404	13.351	1.803	0.433	0.048	0.416	0.522
Pell Farm	7.237	65.615	11.028	1.390	0.283	9.838	0.039	0.000	1.881	2.688	0.000
Pittsfield-Berkshire CC 1	7.951	61.345	5.970	10.102	2.562	6.953	3.079	0.000	0.108	1.076	0.855
Pittsfield-Berkshire CC 2?	17.101	40.901	11.386	9.779	3.528	12.037	3.128	0.000	0.168	0.502	1.471
Pittsfield-Canoe Meadows	15.653	19.812	12.715	1.172	36.566	8.212	3.273	0.000	1.271	0.000	1.326
Potter Hill Meadows	3.513	59.387	10.334	3.590	0.872	17.626	1.102	0.000	0.345	1.843	1.389
RT 140 #1, Merrill Rd	14.261	50.736	8.072	7.462	1.745	4.048	2.689	5.706	1.821	2.492	0.968
RT 140 #2	15.660	50.948	8.989	4.528	6.009	4.031	1.897	3.242	1.271	2.557	0.869
Strawberry Hill	9.700	16.312	47.556	1.207	5.227	5.987	1.471	0.000	11.476	0.702	0.363
Tufts Veterinarian School	20.869	48.161	15.042	2.292	0.000	3.669	7.687	1.332	0.074	0.000	0.875
Tufts Veterinarian School1	20.646	48.113	15.263	2.266	0.000	3.873	7.604	1.289	0.074	0.000	0.873
Tufts Veterinarian School2	8.277	53.423	11.936	2.994	2.184	9.713	7.689	1.160	0.128	1.323	1.173
Tyringham Breakneck Rd.	14.246	58.314	23.715	0.441	0.184	2.952	0.000	0.000	0.129	0.000	0.019
Tyringham private property 1	14.782	42.878	33.643	3.838	0.000	2.030	0.508	0.124	1.037	0.578	0.581
Tyringham private property 2	15.689	37.500	31.689	5.209	0.000	2.247	3.885	0.445	1.858	0.898	0.581
Tyringham private property 3	18.820	60.541	16.746	0.556	0.186	2.322	0.765	0.000	0.000	0.064	0.000
Wach Res North Dike	5.221	25.163	2.258	14.266	0.000	0.648	0.868	0.550	49.170	0.317	1.541
Washington	2.914	86.005	8.215	0.240	0.000	2.290	0.000	0.000	0.013	0.135	0.188
Washinton private property	4.171	59.966	16.630	11.827	0.000	2.890	0.000	0.873	2.898	0.312	0.432
Webber CR	4.979	46.330	17.203	3.130	7.946	12.098	3.439	2.605	1.585	0.313	0.371
Westborough WMA #1	12.263	28.262	20.888	13.524	0.521	1.987	13.090	0.545	7.384	0.000	1.536
Westborough WMA #2	14.650	31.387	12.390	9.263	0.845	4.323	6.129	0.000	19.114	0.000	1.898
Westborough WMA #3	7.697	43.983	15.678	2.282	14.074	5.174	7.957	0.115	0.290	0.858	1.893
Windsor at Notchview	4.929	88.644	0.464	0.182	0.000	2.680	0.000	0.000	0.032	3.069	0.000
Windsor on utility pole	4.884	83.845	1.144	1.196	0.000	4.943	0.000	0.000	0.416	3.571	0.000
Windsor private property 1	1.715	92.892	4.464	0.336	0.000	0.441	0.000	0.000	0.000	0.153	0.000
Windsor private property 2	1.715	93.016	4.533	0.336	0.000	0.247	0.000	0.000	0.000	0.153	0.000

Agriculture	Forest	Wetlands	Open Space	High Density Residential	Low Density Residential	Urban	Transportation	Water	Successional Forest	Other
0	253.4513897	490.6822921	12.18154975	0	0	42.4860034	3.067398339	7.930618641	7.365451129	58.7985182
30.56041893	125.7134024	491.0555659	0.117162653	84.46518917	0	0	0	64.65185411	3.038382432	153.1688077
2.764463741	317.637384	491.879195	4.248790026	8.397117967	0.127080148	1.950832702	0	3.125742469	7.08463363	5.242188652
25.41789108	171.8316678	496.5972867	2.677177273	9.020068182	1.662668674	0	2.150184764	0	0	63.18177311
22.4591246	157.1396887	506.046258	2.677177273	5.460036942	5.322868622	0	2.631291172	0.22500688	0	67.75752121
116.6889822	200.6569854	495.8824018	0	0	0	0.922185375	3.991014461	4.911024875	1.400388756	84.72258737
112.6088435	188.7604545	495.9616561	0	0	0	0.922185375	7.196783687	7.249471861	1.400388756	65.32378204
35.77325442	75.66613154	493.343471	0	4.07241341	0	0.673230423	0	73.06600999	0	78.98266478
81.39750598	191.5611353	457.5235342	6.556736678	0	0	1.931354833	0	1.625434077	2.640858821	29.2869168
7.938761527	170.6278395	490.7707755	0.642640709	0	0	6.33637798	3.139140425	4.043087763	0	43.86396736
2.539331639	200.2296036	490.7725277	0	0	0	2.334922432	1.862568484	9.913460487	0	27.00262804
14.13497377	215.6013977	490.8388854	0	0	0	0	2.037719438	6.808374862	0	40.02572204
38.14350106	138.8367667	492.2240606	60.54853663	0	0	13.95633888	12.0808369	1.892069314	0	39.258708
48.53544992	156.5785737	490.8564742	9.679027034	0	0	0.194617551	17.94296111	4.197433298	0.268992921	54.25454085
53.66376922	136.5431232	491.3217084	0.642640709	0	0	14.15009987	1.020628316	3.404092929	2.582854794	63.84946653
24.54529551	74.27718972	521.6695201	128.162289	0.078821666	0	49.88124244	9.915402433	4.146344102	1.845466268	15.96249565
25.22175331	67.01549516	522.0112681	129.5337658	0.060469128	0	53.00321	9.784091487	4.146344102	0.977890931	15.8311847
82.07648453	236.9496866	499.9340777	9.333613871	0	0	3.912230893	0	41.04380428	0	79.02040285
59.68311367	126.1802392	503.5559669	2.807667831	0	0	6.904015054	3.562336095	4.90256506	0.373102065	61.34572334
21.47357678	162.5561106	508.6460186	4.779805043	1.115221557	0	0.778717761	0	55.6300777	0	88.62879781
0	0.239091759	360.6290082	0.747771811	112.4081909	0	0	4.020191759	92.07237353	0	96.09256529
98.37382352	88.98350909	359.4866389	0	19.11795327	19.51053404	6.222564886	0	1.776160774	13.10182782	18.35165995
43.52075194	321.7480198	490.7964754	0	0	0	1.373964614	0	15.44681395	0.167805208	56.89103654
30.41970113	287.6046318	496.1313895	1.68615045	0	0	0.492964667	4.13392283	3.649378873	4.312727538	14.14149693
90.08740651	252.9395439	495.570327	3.729794989	4.725844315	0	0.238469371	0	0.510557096	0	10.30122982
2.69899973	351.9854002	496.621746	0.583645908	0	0	0	0	0	0	16.43584732
3.490927358	294.7691591	491.6668889	3.642187733	0	0	0.481922908	2.348194726	1.408730878	6.01277897	20.07007503
5.109183434	363.4222938	490.6175263	0	0	0	0	0	0.158848016	2.657098786	13.07479897
4.61795477	359.0796027	490.6176499	0	0	0	0	0	0.099536191	2.415278413	13.36549459
36.73574141	100.4920376	495.8057754	14.96053585	0	0	10.93300876	6.897399646	0.159108902	0	228.6487698
41.29061755	317.3139457	490.5688594	0.801276011	0	0	0	8.866748121	0.902329895	0.30749068	38.0455385
62.76550322	276.3566702	490.5706171	0.801276011	0	0	0	12.83761608	0.902329895	0.30749068	37.53208551
8.487228884	366.8445168	490.7316562	1.184031391	4.116533256	0	0	0.650617847	0.181346857	0	16.24961466
12.83465205	348.6482368	490.7310643	5.726127573	4.972170575	0	20.36684948	0.597745615	0	0	22.10806306
0.289749363	371.201271	490.7369822	0	0	0	20.17500398	4.309857212	1.24996758	0.03320222	22.03110408
9.342547581	206.7149937	491.2800512	0	0	0	0.463333618	1.655864212	0.647263482	0.016023569	142.1407298
18.69494364	428.331322	490.650208	0	0	0	0	0	0.007645415	0	5.733107905
30.79039509	195.7305769	494.3293694	12.28647073	1.532171614	10.50431445	35.09430547	0	10.93731041	0	32.60067748
88.44064961	250.2216424	501.582334	0	0	0	1.137922767	0	1.719813577	0	22.82771544
44.0916461	101.6606123	491.62543	4.484819816	0	0	2.399491062	0	0.452583241	4.061043851	16.23105595
47.01271207	117.3758696	492.7467166	8.726408908	0	0	3.740285462	0	60.21952308	4.345925149	69.85862241
58.58301006	187.645051	494.9505015	0	1.498748805	1.479215503	41.05175884	0	0.186830692	10.50847224	29.34772275
52.69943073	202.1751196	495.644664	0	1.498748805	0	46.31398153	0	1.598602366	11.10723918	28.69811788
21.72423866	217.5428574	495.1937785	0	2.136590761	0	49.67580814	0	2.683221555	12.04624235	41.97376235
34.96461667	49.39125299	490.6386339	0.13952325	0	0	22.71281637	16.97143656	0.619912766	6.156808335	76.4380448
57.48036245	154.9789881	496.7863946	0.257138949	1.802679308	14.77393044	54.37460813	1.716682917	5.289622172	6.260319534	17.25566386
14.61936151	76.95097335	529.8887385	2.640438542	0	0	3.25359199	1.04856606	9.800030758	4.95207044	45.16784614
43.03770806	82.57235829	513.0889351	0.139243759	0	0	7.439558066	1.04856606	11.70939123	3.232542812	54.92935337
12.61704978	80.8601003	516.0262702	2.432093401	0	0	1.898264075	1.04856606	12.35260762	2.047607274	41.77213186
9.25260621	64.69904134	491.6565694	2.870032934	0	0	1.246145086	0	13.31945608	3.68559234	35.3787514
30.1889322	95.61109892	490.6202591	0	0	19.02596652	0	0	13.70747087	1.97265118	20.79673232
46.97526143	188.3096265	490.644707	0	16.98620476	0	1.704991712	3.005154164	16.46891966	3.991951422	64.26377046
136.971494	163.7133556	496.4192873	1.816483355	0	5.620686059	40.67617515	4.711022173	1.67366336	0	26.62665467
105.1038515	84.82104105	493.8286212	1.9850118	1.539957818	39.28769828	4.70199776	14.7299576	15.27896076	0.76865186	141.9715133
100.51766	81.60748695	495.2236854	2.381442512	0.580939468	38.87474961	5.962366554	18.42308561	15.9881463	1.121636281	141.5604009
78.54384021	82.64361192	494.5919719	1.885803084	0.841337945	33.11404666	5.071966128	20.79773699	19.76484339	1.194459718	153.0912918
57.12143595	91.43834533	492.8939709	1.885803084	1.43043523	23.59629232	3.406315059	21.45628047	24.15419536	1.759525953	166.9983327
34.1897838	211.9946415	490.7622658	0.578633419	0	0	0	0	0.251968969	0	75.24529864
75.26342961	120.333584	493.9417209	0.187880446	52.41893781	22.72701626	0.675847138	2.038161835	92.43028608	1.259448867	102.0901593
7.47113809	327.467136	490.6522065	0	0	0	0	0	2.380868716	0	71.93701435
43.02979709	91.6103161	499.7009524	13.79784275	0	0	0.257705818	22.20376263	0.735060909	1.645374229	49.12733615
50.65062905	92.53352112	499.9400503	11.48385059	0.775573073	0	0.257705818	21.80469974	0.6616648	1.645374229	50.61873911
39.34491826	170.1964577	492.024978	6.704952312	0	0	0	17.27265698	0.176827501	0	53.00348584
24.75096156	101.2256945	503.0894966	7.56359343	2.625279445	7.832836286	3.900061	2.728932191	6.737259119	11.05666625	35.41645532
17.88203845	91.3300058	491.9844335	2.787281196	1.20502239	0	36.61772693	10.63373376	4.606252469	6.817504966	22.28367942
12.60597916	55.90642623	490.6429444	7.014632594	1.20502239	0	85.59069689	20.3954381	4.27437812	1.878017237	56.12092737
48.38298615	76.49695527	528.3402669	0	0	0	50.53701457	20.24946127	0	7.683990252	40.6815735
8.849957185	41.47120497	517.9979242	2.046042158	0.09199797	0	14.37951026	22.71528209	0.431536226	0	38.75095569
17.56358358	30.30686126	500.3718886	1.301518428	0.046084275	0	18.75853972	39.34931086	52.58786515	0	95.76958736
53.64523648	240.9991494	490.5953962	0.801276011	0	0	2.704244019	4.719773326	0.902329895	0	65.934421
53.79305932	247.8502359	500.1691351	2.126144695	0	0	3.580829428	5.540162575	23.92295042	6.64446314	51.97421329
51.32785314	245.3318706	499.0232045	4.295192022	0	0	0.906685399	12.14128985	4.251679972	0.37227553	38.65125384
76.98898654	200.7591295	498.5502845	0.357396868	0	34.38227847	0.855046066	2.125423323	0.234923169	1.301718904	26.9808863
25.2994308	321.8837082	490.7546978	0	0	0	0	0	9.228882017	0	52.59113903
25.22653008	301.0050065	490.6766086	0	0	0	15.10742498	0	0.528160579	5.278899357	12.76405609
44.19932273	200.6883047	490.6714578	2.775223124	0	0	15.34866621	0	0.823060603	2.461525385	9.869800253
59.16391365	97.21159414	491.0998589	0	0	0	15.61879949	0	6.237024422	0	34.53439677
71.34513634	291.3294685	490.5635366	6.110260575	0	0	4.742770589	0	1.694686214	9.041155013	41.15376207
22.05708438	248.9351782	497.9085402	7.471599474	0	0	4.143714418	27.99842688	8.937131189	10.95238929	63.01914162
32.97709731	249.978024	497.1095493	2.048543483	0	0	2.82892426	15.90531077	6.238107649	9.269359051	63.81974014
26.99134756	80.059737	492.2757958	0.897110922	5.525566627	0	4.841034679	0	56.32615152	3.443322383	61.00147582
14.12496023	236.2691853	490.5814632	3.528468374	0	0	34.18012611	6.532123789	0.361554598	0	47.18953876
15.07234869	236.0342496	490.5815427	3.122779167	0	0	34.18012611	6.323783878	0.361554598	0	46.85061696
45.48389931	262.0802838	493.5738067	17.97811665	0.249952159	0	21.38640374	5.688344838	0.627337913	6.238866662	42.01308715
4.793388863	286.0792122	490.5849439	0	0	0	0	0	0.633274383	0	11.17643954
5.145783349	210.3573122	493.442016	2.491372051	0	0	0	0.609171947	5.088552538	2.83740034	40.34511637
3.949512398	183.9694244	497.6632659	14.8390806	0	0	0	2.180883339	9.117556594	4.403637308	47.63073856
1.589316173	296.9951512	491.2582988	0	0.314108232	0	3.063377812	0	0	0	3.054743988
2.010670409	123.4594741	492.6927741	0.882701067	0.293039953	0	2.212514826	2.696822521	241.2512076	1.260181888	251.6740075
9.14305719	421.9629833	490.6281899	0	0	0	0	0	0.062366566	0.661970945	25.14839771
5.144721426	294.2197086	490.6408581	2.121499938	0	0	0	4.281312012	14.21999551	1.530139036	37.21999766
63.44398122	227.2856378	498.0373675	7.021840977	1.363994141	0	7.488459468	12.78008718	7.777575451	0.169950812	49.56877608
9.974672078	138.653878	490.6057124	41.25423941	0	58.69812294	23.54255691	2.676170859	36.22601552	0	95.37959825
19.27664461	153.9832586	491.1364647	0.126752105	0	36.29631016	29.40841913	0	93.7746153	0	119.4574761
75.1186565	215.7786278	507.1789111	7.970779057	0.395100258	9.675627052	14.48639522	0.562665216	1.424410214	2.285720339	35.65214565
5.114535849	434.9719176	490.6975008	0	11.91467229	0	0	0	0.15549823	0	4.768980234
11.04459403	411.4205516	490.6905511	0	14.81255184	0	0	0	2.039305421	2.711641979	4.17674943
0.536170293	455.8072626	490.6876366	0	0	0	0	0	0	0.751175909	14.33366912
0.430056736	456.4178951	490.6878801	0	0	0	0	0	0	0.751175909	14.675406

Distance to Freshwater Source (km)	Distance to Wetland (km)	Distance from Roads (km)	Type of Road	Distance from Nearest Perch (km)	Type of Perch	Distance from Human Disturbance (km)
0.647161	0.363706	0.102005	Secondary	0.023808	singular tree/snag	0.0514414
0.033641	0.040562	0.023608	Tertiary	0.010014	singular tree/snag	0.012055
0.494177	0.060074	0.19197	Secondary	0.015187	forest edge	0.142742
1.269757	0.0299611	0.04303	Tertiary	0.067795	lamp post	0.073294
1.144935	0.0243931	0.0118782	Secondary	0.018742	singular tree/snag	0.041237
0.0156067	0.0248164	0.0385	Tertiary	0.009672	forested	0.033057
0.108178	0.257528	0.175714	Secondary	0.022313	singular tree/snag	0.055176
0.335471	0.141041	0.013756	Secondary	0.045389	singular tree/snag	0.155798
0.140174	0.0001	0.064884	Tertiary	0.051627	other (flagpole)	0.056288
0.051479	0.241634	0.030876	Secondary	0.024381	singular tree/snag	0.112002
0.196468	0.325185	0.010719	Secondary	0.011761	singular tree/snag	0.058991
0.893586	0.091687	0.110354	Primary	0.011031	singular tree/snag	0.421663
0.801796	0.043112	0.101526	Primary	0.023022	singular tree/snag	0.437199
0.68288	0.068806	0.068661	Primary	0.045242	singular tree/snag	0.382001
0.243884	0.144178	0.061599	Secondary	0.017139	forested	0.352588
0.231602	0.155487	0.087861	Secondary	0.011404	singular tree/snag	0.052858
0.331971	0.094919	0.277721	Primary	0.01707	singular tree/snag	0.065447
0.017388	0.061502	0.177762	Secondary	0.019312	singular tree/snag	0.13318
0.078121	0.085647	0.211706	Secondary	0.04725	other (post)	0.081974
0.536632	0.072301	0.095647	Tertiary	0.016385	singular tree/snag	0.396362
0.566	0.269455	0.180742	Secondary	0.012328	singular tree/snag	0.261697
0.2689	0.110829	0.171443	Secondary	0.018033	singular tree/snag	0.069182
0.630062	0.081937	0.134626	Secondary	0.018002	fence or fence post	0.082798
0.810755	0.049182	0.075463	Secondary	0.012307	singular tree/snag	0.190258
0.384096	0.128885	0.277329	Secondary	0.037675	singular tree/snag	0.262807
1.580127	0.250985	0.318167	Secondary	0.045097	singular tree/snag	0.237177
1.48127	0.52423	0.471742	Secondary	0.066044	singular tree/snag	0.154283
0.226539	0.185829	0.074735	Tertiary	0.044405	singular tree/snag	0.067497
0.38548	0.248497	0.088961	Tertiary	0.020469	singular tree/snag	0.086215
1.212759	0.083827	0.143271	Tertiary	0.094665	singular tree/snag	0.044885
0.497696	0.067715	0.416691	Secondary	0.047776	singular tree/snag	0.337829
0.141754	0.074187	0.180308	Secondary	0.0337	singular tree/snag	0.187461
1.824536	0.289835	0.052786	Tertiary	0.054141	singular tree/snag	0.57925
1.508541	0.21458	0.005911	Tertiary	0.015703	singular tree/snag	0.978195
0.400219	0.384966	0.010394	Tertiary	0.023868	singular tree/snag	0.901821
0.183002	0.046603	0.120864	Secondary	0.17765	singular tree/snag	0.222418
1.364121	0.161268	0.249013	Secondary	0.119003	singular tree/snag	0.101989
0.11355	0.052228	0.566983	Secondary	0.143623	singular tree/snag	0.388561
0.351818	0.025983	0.279048	Secondary	0.043513	forest edge	0.15463
0.708408	0.013127	0.518571	Secondary	0.006642	forested	0.322843
0.422115	.	0.178944	Secondary	0.007136	scrub	0.095048
1.084893	0.125517	0.114873	Secondary	0.044947	forest edge	0.087495
0.77057	0.229635	0.098277	Secondary	0.042636	singular tree/snag	0.080462
0.41132	0.172859	0.104326	Secondary	0.107953	singular tree/snag	0.045386
0.310757	0.097146	0.324442	Secondary	0.058378	singular tree/snag	0.285612
0.50422	0.120457	0.152721	Secondary	0.082114	singular tree/snag	0.114969
0.11188	0.128267	0.254303	Secondary	0.090262	singular tree/snag	0.255752
0.194599	0.123882	0.333431	Tertiary	0.084008	tree line	0.372716
0.127695	0.111367	0.451975	Tertiary	0.0736	tree line	0.540446
0.275065	0.204832	0.147479	Tertiary	0.059931	tree line	0.909632
0.055482	0.18934	0.129156	Secondary	0.052353	singular tree/snag	0.21625
0.254519	0.006586	0.08588	Secondary	0.046065	singular tree/snag	0.187789
0.508605	0.219228	0.211208	Secondary	0.048364	singular tree/snag	0.118419
0.099664	0.039647	0.061677	Tertiary	0.012711	tree line	0.081225
0.145561	0.038346	0.129751	Tertiary	0.016898	tree line	0.153999
0.070473	0.031549	0.004631	Tertiary	0.020292	tree line	0.33723
0.045125	.	0.093167	Tertiary	0.022511	singular tree/snag	0.590849
1.148624	0.145169	0.155499	Secondary	0.008229	singular tree/snag	0.227597
0.24113	0.074867	0.116749	Secondary	0.049034	tree line	0.109525
0.351412	0.172958	0.005656	Secondary	0.062597	lamp post	0.183321
0.745981	0.06949	0.004581	Primary	0.042821	singular tree/snag	0.304999
0.593807	0.108573	0.004284	Primary	0.022627	singular tree/snag	0.207832
0.156126	0.16955	0.004352	Secondary	0.037842	singular tree/snag	0.053108
0.185053	0.209679	0.004581	Secondary	0.06486	singular tree/snag	0.240851
0.091443	0.058723	0.00656	Secondary	0.024489	lamp post	0.247769
0.067957	0.029721	0.004977	Secondary	0.026925	tree line	0.258898
0.373482	0.038959	0.006152	Primary	0.073687	singular tree/snag	0.304126
0.802002	0.052732	0.057212	Primary	0.021213	singular tree/snag	0.235642
0.277209	0.587923	0.045544	Primary	0.011509	singular tree/snag	0.047101
1.009601	0.160922	0.886847	Secondary	0.029101	singular tree/snag	0.679107
0.747089	0.387404	0.170729	Secondary	0.039553	singular tree/snag	0.109554
1.031513	0.065098	0.46901	Primary	0.071063	tree line	0.39277
0.544694	0.292354	0.120153	Secondary	0.047187	singular tree/snag	0.048523
0.357358	0.365352	0.264194	Secondary	0.022459	singular tree/snag	0.222004
0.833944	0.266503	0.82924	Secondary	0.032748	singular tree/snag	0.249078
0.204561	0.024224	0.494139	Secondary	0.053541	tree line	0.412777
0.540188	0.315647	0.392752	Secondary	0.255065	singular tree/snag	0.355387
0.700409	0.215399	0.257382	Secondary	0.068156	singular tree/snag	0.193301
0.761336	0.178818	0.006244	Secondary	0.035174	singular tree/snag	0.123288
0.257574	0.180941	0.013608	Secondary	0.030822	singular tree/snag	0.054313
0.318547	0.058009	0.143569	Tertiary	0.024758	singular tree/snag	0.235738
1.092675	0.218761	0.081271	Secondary	0.065619	singular tree/snag	0.242895
1.103226	0.215121	0.094005	Secondary	0.077615	singular tree/snag	0.237927
1.149442	0.067172	0.134578	Secondary	0.039606	tree line	0.268368
0.251128	0.03719	0.01682	Tertiary	0.047846	singular tree/snag	0.456698
0.706997	.	0.629222	Secondary	0.035007	singular tree/snag	0.736682
0.437079	0.032988	0.173806	Secondary	0.076448	singular tree/snag	0.201611
2.489943	0.033636	0.36053	Secondary	0.094061	singular tree/snag	0.470609
0.141049	0.60705	0.591375	Tertiary	0.069475	tree line	0.75379
0.412828	0.318435	0.366282	Secondary	0.007833	singular tree/snag	0.353382
0.301332	0.169821	0.03354	Tertiary	0.015865	singular tree/snag	0.166838
0.289133	0.189357	0.162834	Secondary	0.056922	tree line	0.111588
0.229118	0.150716	0.110946	Secondary	0.033782	singular tree/snag	0.227772
0.178679	0.176346	0.590335	Secondary	0.080073	singular tree/snag	0.712785
0.378955	.	0.306539	Secondary	0.048926	tree line	0.374391
0.691808	0.418349	0.211237	Secondary	0.018629	singular tree/snag	0.213543
0.078523	0.179281	0.136542	Tertiary	0.012299	singular tree/snag	0.165154
2.368318	0.188914	1.850619	Secondary	0.014986	singular tree/snag	1.56931
2.477673	0.169315	1.953041	Secondary	0.007249	singular tree/snag	1.683284

Longitude	Latitude	Description	Region
-71.6483	42.47529000	yes	Central
-70.881045	42.01257300	yes	East
-73.127222	42.49194400	no	West
-71.72898	42.43766000	no	Central
-71.725934	42.43758900	no	Central
-71.329711	42.40343500	yes	East
-71.332633	42.40892300	no	East
-70.841227	42.75870900	no	East
-70.927616	42.87561000	no	East
-70.85245	42.64913300	no	East
-70.86505	42.65240000	no	East
-70.8853	42.77195000	no	East
-70.904533	42.80516700	no	East
-70.91285	42.80238300	no	East
-70.837333	42.65146700	no	East
-70.881467	42.80101700	no	East
-70.881483	42.80198300	no	East
-70.810166	42.62376600	no	East
-70.851766	42.83231400	no	East
-70.881467	42.83550000	no	East
-70.818883	42.82456700	no	East
-70.601233	42.65030000	no	East
-71.048094	42.69646400	no	East
-72.157591	42.35172800	no	Central
-72.094262	42.25876200	yes	Central
-72.14991	42.37735300	yes	Central
-72.177073	42.33952900	yes	Central
-72.218668	42.33475900	no	Central
-72.216499	42.33505800	no	Central
-71.594293	42.26106800	yes	Central
-71.649745	42.21940100	no	Central
-71.652484	42.22373200	yes	Central
-71.9237	42.57451000	no	Central
-71.9326	42.57335000	no	Central
-71.93458	42.58485000	no	Central
-73.099722	42.42388900	no	West
-72.482384	42.40733200	no	Valley
-72.685454	42.33986200	no	Valley
-72.711409	42.24875700	no	Valley
-72.562028	42.32510800	yes	Valley
-72.5830882	42.36716610	yes	Valley
-72.522932	42.32975400	no	Valley
-72.525102	42.32880500	no	Valley
-72.525485	42.32560100	no	Valley
-72.551293	42.38202000	yes	Valley
-72.5193334	42.36371430	yes	Valley
-72.56371	42.34744400	no	Valley
-72.569096	42.34070500	yes	Valley
-72.56227	42.34345100	no	Valley
-72.557814	42.33880300	yes	Valley
-72.544956	42.34097300	no	Valley
-73.244608	42.39535800	yes	West
-71.189263	42.40141900	no	East
-70.679316	42.08733800	no	East
-70.679424	42.08881200	no	East
-70.677254	42.08900900	no	East
-70.674574	42.08867000	no	East
-70.922045	42.63318000	no	East
-70.27029	41.70737200	no	East
-71.84766	42.41164000	no	Central
-72.61909	42.50294000	no	Valley
-72.6204	42.50423000	yes	Valley
-72.62638	42.48909000	no	Valley
-72.53704	42.41674000	yes	Valley
-72.53899	42.40117000	yes	Valley
-72.54017	42.39151000	no	Valley
-72.54224	42.37488000	yes	Valley
-72.615646	42.31657800	no	Valley
-72.615174	42.32514600	no	Valley
-71.664687	42.21710400	no	Central
-71.7113352	42.21442000	no	Central
-71.673733	42.22012500	no	Central
-71.646916	42.20051500	no	Central
-73.316162	42.20245300	no	Central
-73.31435	42.46345100	no	West
-73.232466	42.45268100	no	West
-71.718472	42.43181100	no	West
-71.80035	42.20616700	no	Central
-71.80509	42.40862000	yes	Central
-70.826683	42.41880000	no	Central
-71.672323	42.69678300	yes	East
-71.672133	42.25019800	no	Central
-71.687625	42.25040300	no	Central
-73.23	42.23899800	no	Central
-73.241333	42.25861100	no	West
-73.243333	42.26966700	yes	West
-73.190833	42.27250000	yes	West
-71.71584	42.22500000	no	West
-73.139833	42.40186000	yes	Central
-73.116944	42.35883300	no	West
-71.697501	42.38694400	no	West
-71.611864	42.23651400	no	Central
-71.616263	42.30762700	yes	Central
-71.633141	42.29967600	no	Central
-73.009333	42.29320300	no	Central
-73.003667	42.50650000	no	West
-73.074167	42.49233300	no	West
-73.07416700	42.48633300	no	West
-73.07300000	42.48683300	no	West

Appendix 5: AIC spreadsheet used for calculating ranks

Model	Neg2LogLik	K	AICc	delta AICc	Ex	Akaike Weight
Forest and Open Space	103.92	3	110.168	0.000	1.000	0.154
Forest	106.20	2	110.322	0.155	0.926	0.142
Forest and Agriculture	105.00	3	111.257	1.090	0.580	0.089
Reg and Forest and OS	103.32	4	111.741	1.573	0.455	0.070
Agriculture	107.74	2	111.869	1.701	0.427	0.066
Reg and Open Space	105.75	3	112.004	1.837	0.399	0.061
Successional Forest	107.92	2	112.048	1.880	0.391	0.060
Open Space	107.97	2	112.093	1.925	0.382	0.059
Reg and Forest	106.07	3	112.318	2.150	0.341	0.052
Forest and Dist to Perch	106.20	3	112.450	2.282	0.319	0.049
Reg and Forest and Agr	104.93	4	113.356	3.189	0.203	0.031
Null	111.89	1	113.930	3.762	0.152	0.023
Reg and Agriculture	107.74	3	113.995	3.827	0.148	0.023
Open Space and Perch	107.92	3	114.176	4.008	0.135	0.021
Reg and OS and Perch	105.75	4	114.176	4.008	0.135	0.021
Reg and Forest and Perch	106.06	4	114.488	4.321	0.115	0.018
Region	110.51	2	114.633	4.466	0.107	0.016
Low Density Residential	111.37	2	115.498	5.331	0.070	0.011
Dist to Nearest Perch	111.87	2	115.995	5.828	0.054	0.008
Reg and Low Dens Res	109.85	3	116.104	5.936	0.051	0.008
Reg and Successional For	110.33	3	116.580	6.412	0.041	0.006
All Parameters	99.12	8	116.719	6.551	0.038	0.006
Reg and Dist to Perch	110.50	3	116.756	6.588	0.037	0.006
					6.506	1.000

Appendix 6: AIC values for all models run

Model	K	ΔAICc	w_i	Deviance
$FORper_{1.25}$ $OSper_{1.25}$	3	0.000	0.154	103.92
$FORper_{1.25}$	2	0.155	0.142	106.20
$FORper_{1.25}$ $AGRper_{1.25}$	3	1.090	0.089	105.00
REG $FORper_{1.25}$ $OSper_{1.25}$	4	1.573	0.070	103.32
$AGRper_{1.25}$	2	1.701	0.066	107.74
REG $OSper_{1.25}$	3	1.37	0.061	105.75
$SUCCper_{1.25}$	2	1.880	0.060	107.92
$OSper_{1.25}$	2	1.925	0.059	107.97
REG $FORper_{1.25}$	3	2.150	0.052	106.07
$FORper_{1.25}$ $PERC_{0.25}$	3	2.282	0.049	106.20
REG $FORper_{1.25}$ $AGRper_{1.25}$	4	3.189	0.031	104.93
NULL	1	3.762	0.023	111.89
REG $AGRper_{1.25}$	3	3.827	0.023	107.74
$OSper_{1.25}$ $PERC_{0.25}$	3	4.008	0.021	107.92
REG $OSper_{1.25}$ $PERC_{0.25}$	4	4.008	0.021	105.75
REG $FORper_{1.25}$ $PERC_{0.25}$	4	4.321	0.018	106.06
REG	2	4.466	0.016	110.51
$LDRper_{1.25}$	2	5.331	0.011	111.37

$PERC_{0.25}$	2	5.828	0.008	111.87
REG $LDRper_{1.25}$	3	5.936	0.008	109.85
REG $SUCCper_{1.25}$	3	6.412	0.006	110.33
ALL	8	6.551	0.006	99.12
REG $PERC_{0.25}$	3	6.589	0.006	110.50