

THE ROLE OF EXOTIC SHRUBS IN DETERMINING NESTING SUCCESS OF
HOODED WARBLERS

A Thesis

Presented to

The Graduate Faculty of The University of Akron

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Daniel Roy Garrett

December, 2015

THE ROLE OF EXOTIC SHRUBS IN DETERMINING NESTING SUCCESS OF
HOODED WARBLERS

Daniel Garrett

Thesis

Approved:

Accepted:

Advisor
Dr. Randy Mitchell

Department Chair
Dr. Stephen Weeks

Co-advisor
Dr. Gregory A. Smith

Dean of the College
Dr. John Green

Committee Member
Dr. Mathew Shawkey

Dean of the Graduate School
Dr. Chand Midha

Date

ABSTRACT

Past research suggests that avian nests in exotic shrubs are more susceptible to predation and represent an ecological trap. In this study, we explore the relationship between exotic plants, nest predation, and nest-site selection to test the hypothesis that nests in exotic plants are more susceptible to depredation than nests in native plants. We used the Hooded warbler (*Setophaga citrina*), a forest-understory obligate, as a model species for this study. In 2013 and 2014, we monitored nests in forest parks in Summit County, Ohio. In these parks, Hooded warblers primarily selected exotic plants for nesting sites (73% of 133 nests). The preferred species for nesting sites for Hooded Warblers were *Rosa multiflora*, the genus *Lonicera*, *Lingustrum vulgare*, and native saplings (24%, 13%, 27% and 26% respectively). We analyzed the influence of nest-site choice on nest success at the nest and patch scale, and found no relationship between nesting success and exotic species. Similar to previous studies, we found no evidence that typical habitat measurements, except for nest height influenced. However, we found that nests initiated later in the season were more likely to survive to fledging. Including clutch initiation date into our model of nest fate suggested that nests placed in exotic shrubs had worse nesting success than nests placed in native plants. However, this pattern switched mid-way through the season to suggest that nests within exotic shrubs were more successful than nests in native plants. The natural nest experiment suggested a pattern of differential nesting success between nests in privet and rose. Recognizing this pattern we

set out to test it with an artificial nest experiment. The results of this experiment showed there is a significantly higher chance of a nest fledging from rose than nests in privet. All together, these results do not support the hypothesis that nests in exotic plants are ecological traps and are more susceptible to predation. In disturbed landscapes where over abundant deer populations limit the availability of native understory plants, the ability for exotic plants to tolerate deer browse may provide important habitat for Hooded warblers and other forest wildlife.

DEDICATION

I would like to dedicate this thesis to my parents and brother. They have always loved and supported me through all my endeavors and I would not be the person I am today if not for their guidance, support and love.

ACKNOWLEDGEMENTS

I'd like to acknowledge Dr. Gregory Smith. He has always inspired me to pursue a career in research and unknowingly molded me to be the thinker I am now. I would also like to acknowledge Dr. Randy Mitchell for showing me what it is to think deeper and pursue interesting questions. This work would not have been possible without the support of the Summit Metro Parks and specifically the Natural Resource Department. Finally I would like to thank Ryan Trimbath for always being an amazing friend, researcher, mentor, colleague and all around amazing human being.

TABLE OF CONTENTS

	Page
LIST OF FIGURES	viii
CHAPTER	
I. INTRODUCTION	1
II. METHODS	6
Study Area	6
Focal Species	7
Natural Nest Experiment.....	7
Artificial Nest Experiment.....	8
Data Analysis	11
III. RESULTS	12
Natural Nest Experiment.....	12
Artificial Nest Experiment.....	17
IV. DISCUSSION.....	19
Implications for Future Research, Management and Conservation.....	22
LITERATURE CITED	26
APPENDIX.....	31

LIST OF FIGURES

Figure		Page
1	The total number of natural nests and the number of nests that fledged within in exotic and native plants.....	15
2	The total number of nests and nests that fledged within each of the most commonly chosen nest-sites.	15
3	Results of General Linear Model testing the influence of clutch initiation date on nesting success.....	16
4	Results of General Linear Model testing the influence of clutch initiation date on nesting success between nests in exotic and native substrates.	16
5	The results of the General Linear Model testing the influence of clutch initiation date between nests in privet and rose on nesting success.	17
6	Results of artificial nest experiment.	18

CHAPTER I

INTRODUCTION

Natural selection favors behaviors that aid organisms in the process of identifying habitats which are more successful for reproductive output. For instance, birds show preferential selection for certain habitat types, and have evolved mechanisms to recognize environmental cues to guide them to these habitats for nesting (Martin 1998; Purcell and Verner 1998). Many of these cues are associated with the structural characteristics of vegetation (Purcell 1998 & Verner; Misenhelter & Rotenberry 2000; Anderson & Shugart 1974). Cues used by birds for territory placement and nest-site selection reflect several characteristics of a habitat that are required for survival and reproduction, such as abundant food, sufficient shelter, and resources required for nesting (Schlaepfer et al. 2002). Through evolutionarily time, these cues were used as reliable markers in the process of evaluating the quality of a habitat, and it is the use of a high quality habitat that allows birds to maximize their reproductive output.

When habitats are altered by anthropogenic disturbances, such as fragmentation, land-use change and the introduction of exotic plants, a disconnect can be created between previously reliable cues for a high quality habitat and its current state (Suvoro et al. 2012). Anthropogenically changed habitats have several negative impacts for forest

communities (Andren 1994). For avian communities, these changes increase the rate of nest predation and clutch-parasitism, and therefore reduce reproductive success and annual fecundity (Chalfoun et al. 2002; Powell et al. 2010; Robinson et al. 1995; Rolstad 1991). When organisms use cues that previously indicated high quality habitats, but result in reduced reproductive success, these habitats are considered an ecological traps (Gates and Gysel 1978; Donovan and Thompson 2001; Powell et al. 2010). An empirical example of this is seen in the work of Powell et al. (2010), which showed that Rusty Blackbirds (*Euphagus carolinus*) preferentially selected nesting sites that were adjacent to recently logged wetlands. The cue most strongly associated with nest-site selection was the density of conifer stands located on wetland edges. In this system, nests near younger regenerating stands that were created by logging had higher rates of nest depredation. This suggested that Rusty Blackbirds (*Euphagus carolinus*) used previously reliable cues to guide their decisions of nest placement, and yet now these habitats lead to elevated rates of failure.

One of the more heavily studied potential ecological traps for birds is landscapes containing exotic plants. The negative impacts associated with some exotic plants have been extremely high for birds. Aggressive invading exotic-plants, such as reed canary grass (*Phalaris arundinacea*), not only alter the composition and functionality of the vegetative communities in which they are introduced, but also alter the physiognomy of these habitats (Remes 2003; Lavoie et al. 2005). These plants can greatly alter the way in which birds choose their habitats. Depending on the species of bird and plant, territories may be established in order to avoid or include the invading plant. Kirsch et al. (2007)

showed that Song Sparrows (*Melospiza melodia*) and Yellow-throated Warblers (*Dendroica dominica*) established territories containing a larger proportion of Reed canary grass than those of Swamp Sparrows (*Melospiza georgiana*). Lloyd et al. (2005), showed that the Chestnut-collared Longspur (*Calcarius ornatus*) choose territories which contained the exotic Crested wheatgrass (*Agropyron cristatum*), and nests settled in these habitats had lower reproductive success than nests in native grasses. Similarly, Remes (2003) showed that Blackcaps (*Sylvia atricapilla*) preferentially chose a plantation containing the exotic Black Locust (*Robinia pseudoacacia*). Blackcaps selecting for this exotic habitat had significantly lower reproductive success than blackcaps which selected for adjacent native habitat.

Within forested landscapes, a growing concern for managers has been the spread of exotic understory shrubs, which are suggested to act as ecological traps for understory nesting birds (Rodewald et al. 2010; Schmidt 1999). Invasion by some exotic shrubs will modify the available habitat. These alterations are suggested to increase the use of exotic shrubs as nest-sites and rates of settlement for forest birds. This is likely due to an increase in the architectural and structural complexity of the forest understory, and as mentioned previously, vegetation structure is used as a cue for suitable nesting substrates (Schmidt 1999). However, utilization of exotic understory shrubs may increase the rate of predation and brood parasitism, and therefore reduce nesting success and annual fecundity (Rodewald et al. 2010; Remes 2003). There is a wealth of literature investigating the impacts of exotic shrubs as nesting sites, yet no consensus has been reached on the role a plant's geographic origin plays in determining nesting success

(Gleditsch & Carlo 2014; Meyer, Schmidt and Robertson 2015; Misenhelter and Rotenberry 2000; Schmidt and Whelan 1999).

Within Ohio, research which focused on exotic understory shrubs acting as ecological traps for understory nesting birds has primarily been conducted within southwestern and central Ohio. These landscapes are dominated by forests primarily containing the exotic shrub, Japanese honeysuckle (*Lonicera japonica*; Borgman and Rodewald 2004; Ingold and Craycraft 1983; Hutchinson and Vankat 1997).

Forest management decisions should be made with support from locally derived information. This will insure they are based on sound information which is relevant to their geographical region. However, this is rarely done (Rodewald 2012), most likely because regionally relevant data is rarely available to managers who require it. For example, like the rest of the forested land in Ohio, the understory community of forests within the Cuyahoga Valley region of Northeastern Ohio is dominated by exotic shrubs. However, the understory communities are more diverse and are rarely dominated by Japanese Honeysuckle (Summit County Metro Parks, Unpublished). Therefore, in this landscape, data used to support decisions for management of exotic understory shrubs should come from local relevant research.

Another context dependent variable which is important for management of exotic shrubs is the structure of forests after denuding by deer browse. Within the Cuyahoga Valley region, some forests have been overbrowsed by deer to the point in which patches without exotic shrubs typically also lack native plants and maintain little to no understory

structure (Shafer-Nolan 1997). Without exotic shrubs, the structure of the forest understory would be much less complex. Therefore, it is possible that in the absence of areas dominated by native plants, exotic shrubs may be acting as a refuge for understory nesting birds.

Here, I further test the hypothesis that exotic shrubs act as ecological traps for understory nesting birds. Furthermore, I explore nest-site selection and its repercussions for nesting success. Vegetative characteristics associated with nest-site selection are suggested to influence nesting success. These characteristics are tested as alternative reasons for failure. Based on our preliminary studies and personal experiences of Hooded Warbler nests, we predicted the success of nests within exotic and native plants will not differ. Furthermore, we predicted that increasing vegetative characteristics will positively influence nesting success.

CHAPTER II

METHODS

Study Area

Study sites were focused within the Cuyahoga River Valley region of northeast Ohio, located between the metropolitan centers of Cleveland in the north and Akron in the south. Through the 1800's and early 1900's, this landscape lost nearly all of its forests (Thorne and Green 1909; Ogden 1966; Whitney 1990) through rampant deforestation for agriculture and urban sprawl following the Civil War (Adolph 1889; Paul 1879, Leue 1889). The portions of land which were allowed to succeed into forests were typically accompanied with an understory dominated by exotic shrubs (Luken and Thieret 1996).

The forest types for this study were oak-maple or beech-maple forests. Each site was between 30 and 50 hectares in size and located within property owned and managed by Summit Metro Parks or the Cuyahoga Valley National Park. The sites were determined based on the Summit Metro Parks vegetation survey and personal experience. Broad scale vegetation measurements were taken within several parks for this survey. Using past research (Trimbath, unpublished data), the most common shrub species used by understory nesting birds was determined. The average cover for each species was quantified and a ratio of native to exotic was produced for all parks for which data were

available. The output of these analyses gave a measure of dominance for native and non-native plants for each site. From these data, parks were chosen based on the availability of both exotic and native substrates. From these data, sites with the highest concentration of native plants were chosen. Of the possible sites, six were chosen as suitable for this project (appendix 4.).

Focal Species

We used the Hooded Warbler (*Steophaga citrine*) as a focal species to investigate these relationships. This common Neo-tropical migrant has been used in several previous studies regarding anthropogenic impacts on forests (Hoover and Brittingham 1998; Moorman et al. 2002; Roth and Johnson 1993; Villard 1998). They occur in relatively high densities throughout the sites and are known to be an area-sensitive, obligate forest and understory nesting bird. Previous data gathered in this region suggests that Hooded Warblers may preferentially select exotic nesting substrate (Trimbath, unpublished data). Because they primarily nest in the understory, this species is more suited to this study than previous work done with Northern Cardinals (*Cardinalis cardinalis*). Cardinals do not appear to be constrained to forests, do well in anthropogenically disturbed habitats and may thus be less impacted by exotic plants than Hooded Warblers.

Natural Nest Experiment

For nest searching and monitoring, we followed the BBird protocol (Martin et al. 1997, Paine & Conway). This protocol entailed surveying each site at least every three days. If a nest is found, it is to be monitored every 2 to 3 days until the outcome of each

nest can be determined. In this case, the outcome is described as either successfully fledging nestlings or being depredated. During each nest check, the surveyor collects the following data: observer name, time checked, and time at nest, number of host egg, number of brood parasite eggs, and activity of parents, Julian data, and stage during nesting (building, incubating, nestling, or fledged). If the nest failed, we made our best judgment as to why (cowbird, weather or predation). This was easily facilitated by recognizing the signs of nest failure (torn nest, broken branches, and nests being askew). My past experiences of video footage during predation events of active nests, suggests that larger sized predators, such as raccoons and squirrels will tear nests away from the nesting substrates, leaving the nest on the ground. They will also leave the nest either off its horizontal axis or leave the nest torn away from its supporting branches. Depredation by lighter predators is less obvious. In these cases, if the nest was not near the fledging date (still incubating or had only recently hatched) then we felt confident in drawing the conclusion that the nest had been depredated. If the nest was near the fledging date, we would search the surrounding area to determine if the adults were in the area feeding their fledglings. If a nest fails, parents will no longer be found around the nest. They will also be much less vocal. If a nest fledges then parents will be very vocal and can be followed to the location of the fledglings. As stated previously, the most common nest predators in this system are raccoons.

Artificial Nest Experiment

We performed an artificial nest experiment using privet (*Ligustrum vulgare*) and rose (*Rosa multiflora*) to better understand the relative influence each of these exotic

shrubs on nest success. These species were chosen because they are the more dominant exotic shrub species found in these forests and, and from the natural nest study, are shown to have a significant difference in nesting success.

We chose not to include a native species in the artificial nest experiment because of the lack of suitable native patches throughout the study region. Ideally, we would have placed nests within patches dominated by either native or exotic plants. However, in this region, forests containing a matrix of native and exotic patches do not exist. This is not to suggest that native patches do not exist, simply that they are not found in association with equally large exotic patches in these forests. Native patches tend to be in unaltered and more mature forest systems where exotic plants have not been introduced. If we chose to place nests within native patches, then areas with suitable exotic patches would most likely be clustered together, unevenly mixed with native patches, and most likely be influenced by high contrast edges. There are biases built into artificial nest experiments, such as; scents left by the researcher, predator bias, and inappropriate artificial nest-site placement (Thompson & Burhans 2004; Moore & Robinson 2004). However, we attempted to control these by constraining nest height and distance from nearest foliage edge.

Artificial nests were purchased from craft stores (Michael's stores, inc). These nests mimicked the size and shape of Hooded Warbler nests and were made of whicker. We placed nests within two of the sites used in both years of the natural nest study (Hampton Hills and Deep Lock Quarry). These two sites represented forests that are

typical for this region, with a mixture of both plant species of interest (privet and rose), and contained an abundance of Hooded Warblers. Random points were chosen within each site (using ArcGIS 10.2) which were at least 50 meters from the nearest high contrast edge (e.g. roads, forest edges, parking lots). Using the random point locator, we chose 48 points for each site to place 24 nests in the beginning of July and another 24 for the beginning of June. These nests were spaced at least 25 meters apart.

Once a nest site was chosen, we placed a nest within the nearest suitable rose and Privet patches that were similar to the nest patches used for natural nests. Once a suitable patch was found, we created a waypoint and the nest was attached to the substrate. During this process, we wore latex gloves and kept the amount of time spent at the nest site to a minimum. We attempted to keep the nest height and the distance to the nearest foliage held to a constant (0.6m and 0.5m respectfully). Each nest was attached using wire provided by the distributor. We used a purchased mold to create clay eggs that mimicked the size and shape of Hooded Warbler eggs. The color of the clay was also selected based on its similarity to Hooded Warbler eggs. Each nest was baited with two clay eggs. We monitored each artificial nest following the BBird protocol (Martin, Paine & Conway 1997). Every 2 days over a 12-day period, each nest was quickly checked for the absence of the clay eggs or for teeth/beak marks on the eggs left. If these were found, then the nest was considered depredated.

Data Analysis

All analyses were done using the program JMP Pro 11 (SAS Institute Inc. Cary, NC, USA). For the natural nest experiment, we tested for between year differences of nest fate (a binary response) using Pearson's chi-square test and found no differences in nest fate between the two years studied (Pearson $X^2 = 0.673$, $P=0.4120$). Therefore all analyses were pooled between years. We then used a General Linear Model (GLM) containing a binomial distribution and a logit link function as our model for testing fate against nest-patch characteristics as well as clutch initiation date. We continued to use Pearson's chi-square tests to test between origin and species of nesting substrate. This form of GLM was chosen over the logistic exposure method due to confidence in nest outcomes, time constraints, and personal experience.

We then used an analysis of variance (ANOVA) to test for effects of nest site characteristics associated with nests between exotic and native substrates as well as between the different species nesting substrates. For the artificial nest experiment, used chi-square approximations to test for differences in depredation rates of artificial nests between: nests in rose and privet, site, and the round in which a nest was placed (round one being the beginning of June and round two being the beginning of July). There were no differences found between sites and rounds, so the fates of artificial nests were pooled between the sites and rounds. In order to determine the influence of nest-patch characteristics on the length of time a nest was exposed, we used a General Linear Regression.

CHAPTER III

RESULTS

Natural Nest Experiment

We found and monitored 133 Hooded Warbler nests between 2013 and 2014. Nests for which the outcome could not be determined were excluded. Of these nests, 72% were found in exotic substrates and 28% were found in native substrates (Figure 1). The nests used in these analysis were found primarily in *Rosa multiflora* (rose), *Lonicera* (honeysuckle), *Lingustrum vulgare* (privet), native saplings, and other exotic shrubs (28%, 13%, 24%, 25%, and %7 respectively; Figure 2).

The strongest parameter predicting nest fate was clutch initiation date within a season , such that nests built earlier in the season had a higher probability of fledging than those nests built later in the season ($X^2 = 9.990$, $P = 0.0016$, Figure 3).

The influence of clutch initiation date on nesting success was observed within exotic nest substrates ($X^2 = 11.3752$, $P = 0.0007$), However, this pattern was not observed for native nest substrates ($X^2 = 8.0483$, $P = 0.0484$, Figure 4).

Furthermore, this pattern was also present within each exotic nest substrate (Rose: $X^2 = 4.1852$, $P = 0.0408$, Honeysuckle: $X^2 = 5.1874$, $P = 0.0159$, Privet: $X^2 = 4.6183$, P

= 0.0316; Figure 5). When including only nests within privet and rose, we saw significant differences in the probability of fledging a nest between these two substrates.

There was no significant influence of origin or species of nesting substrate on the probability of fledging once clutch initiation date was removed (Origin: $X^2 = 1.130$, $P = 0.2877$, Species: $X^2 = 823$, $P = 0.3643$ (Figure 5 and Figure 6).

Of the nest-patch characteristics, only nest height was significant (at an alpha of 0.05) in influencing nesting success ($X^2 = 3.868$, $P = 0.049$). All other parameters were found to be highly non-significant (Distance to edge of foliage patch: $X^2 = 0.185$, $P = 0.667$, Percent of foliage covering nest $X^2 = 1.1414$, $P = 0.234$, Percent of exotic stems: $X^2 = 0.705$, $P = 0.401$, Overall number of stems $X^2 = 0.762$, $P = 0.383$, Distance to trail: $X^2 = 0.762$, $P = 0.674$, Distance to forest edge: $X^2 = 0.642$, $P = 0.383$).

We observed significant differences in nest-patch characteristics between native and exotic substrates. The distance to the edge of each foliage patch was significantly lower in exotic patches ($F = 14.2240$, $P = 0.0003$) and the total number of stems was higher in exotic patches ($F = 6.4226$, $P = 0.0125$). However, none of the other nest-patch characteristics showed significant differences based on origin of nesting substrate (Nest height: $F = 0.1996$, $P = 0.6558$, Overall cover: $F = 3.2448$, $P = 0.0742$, Distance to trail: $F = 0.9564$, $P = 0.3301$, Distance to forest edge: $F = 0.583$, $P = 0.4467$).

There were also significant differences in nest-patch characteristics between each species of nesting substrate. The distance to the edge of the foliage patch was significantly lower for nests in honey suckle, but not in other exotic or native substrates

($F = 6.3823$, $P = 0.0005$). Furthermore, nests in privet had a significantly higher total number of stems surrounding the nests when compared to all other substrates ($F = 10.2021$, $P = 0.0001$). Nests in privet were also found farther away from forest edges than nests in Honeysuckle (Tukey's test $P = 0.0509$). However, nest height and over all cover of foliage by the nest was not significantly different (Nest height: $F = 2.4551$, $P = 0.0665$, Overall cover: $F = 2.5140$, $P = 0.0618$). Within nests in exotic shrubs, there was a significant difference in the percent of stems that were exotic, such that nests in privet had a significantly higher concentration of exotic stems within the 1.5-meter nest patch ($F = 14.4916$, $P = 0.0001$).

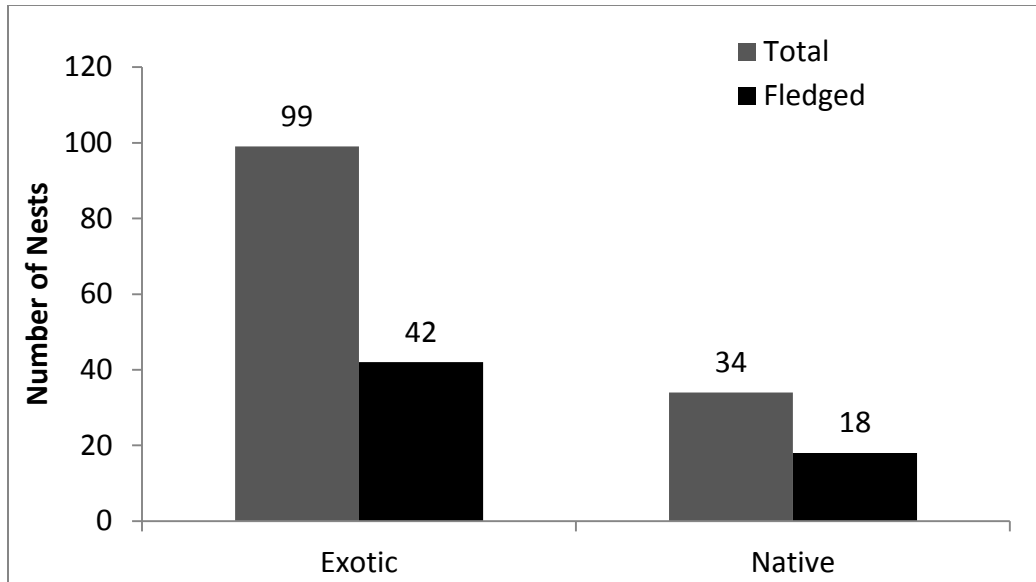


Figure 1. The total number of natural nests and the number of nests that fledged within in exotic and native plants. The relationship of nest site choice and the outcome of the nest are non-significant.

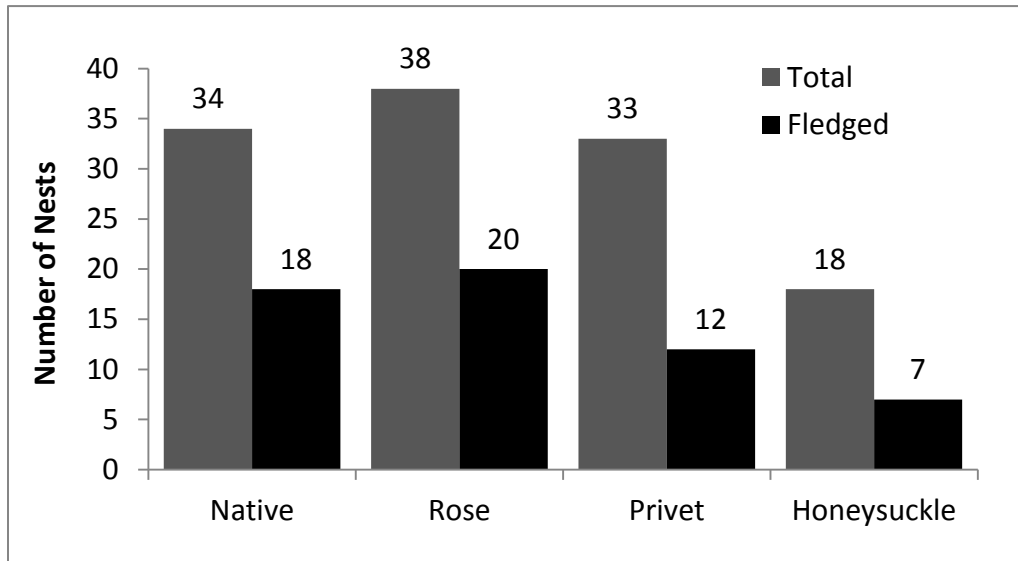


Figure 2. The total number of nests and nests that fledged within each of the most commonly chosen nest-sites. The relationship of nest site choice between each nest species and the outcome of each nest were non-significant.

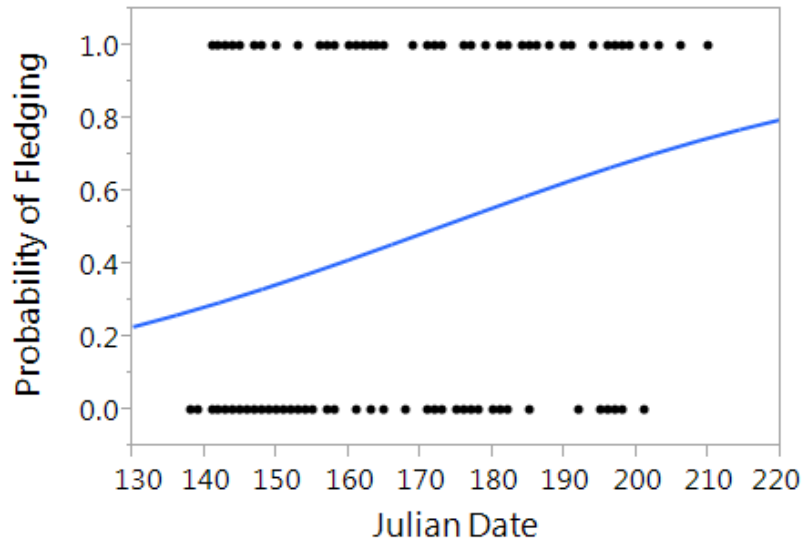


Figure 3. Results of General Linear Model testing the influence of clutch initiation date on nesting success. As the nesting season progressed, the probability of a nest fledging increased significantly.

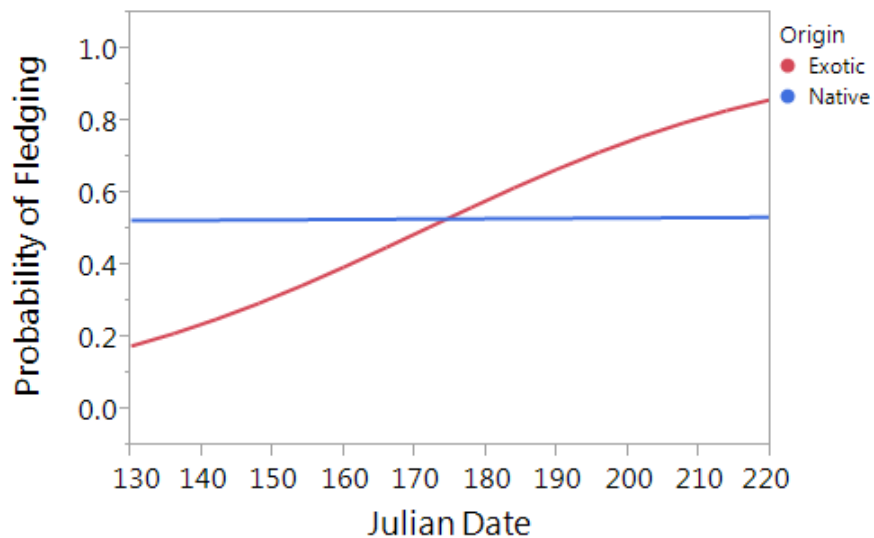


Figure 4. Results of General Linear Model testing the influence of clutch initiation date on nesting success between nests in exotic and native substrates. As the nesting season progressed, the probability of a nest fledging increased significantly for exotic plants but not for nests in native substrates. Furthermore, nests within exotic shrubs earlier in the season were less successful than nests in native plants during this same timeframe. As the season progressed, this relationship changed to nests in exotic shrubs being more successful than nests in native plants

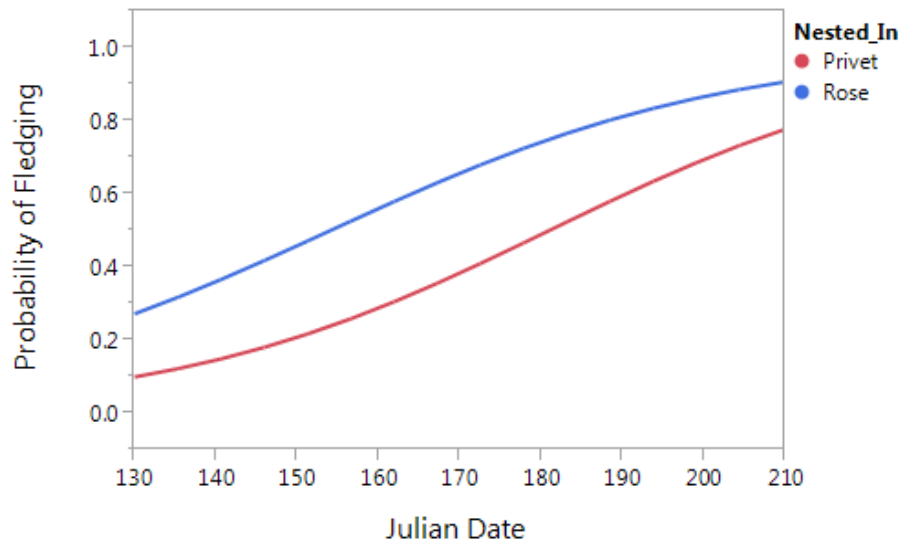


Figure 5. The results of the General Linear Model testing the influence of clutch initiation date between nests in privet and rose on nesting success. The influence of substrate choice significantly influenced the nests outcome. Nests in rose had a higher probability of fledging than nests in privet.

Artificial Nest Experiment

We placed and monitored 86 artificial nests. The number of nest depredated was significantly different between nests in privet and nests in rose ($X^2 = 5.865$, $P = 0.0154$). However, this pattern was only seen for nests placed in the first round (Round 1: $X^2 = 6.894$, $P = 0.0086$, Round 2: $X^2 = 0.612$, $P = 0.4314$). There were also significant differences of nest-patch characteristics between nests placed in privet and nests placed in rose (Number of stems: $F = 21.15$, $P = <.0001$, Percent of Exotic stems: $F = 31.53$, $P = <.0001$). However, none of these were significant in influencing the outcome of each artificial nest (Nest height: $X^2 = 0.0626$, $P = 0.8024$, Number of stems: $X^2 = 0.7521$, $P = 0.2461$, Percent of Exotic Stems: $X^2 = 0.5180$, $P = 0.04717$, Overall Cover by Foliage: $X^2 = 1.5392$, $P = 0.2147$)

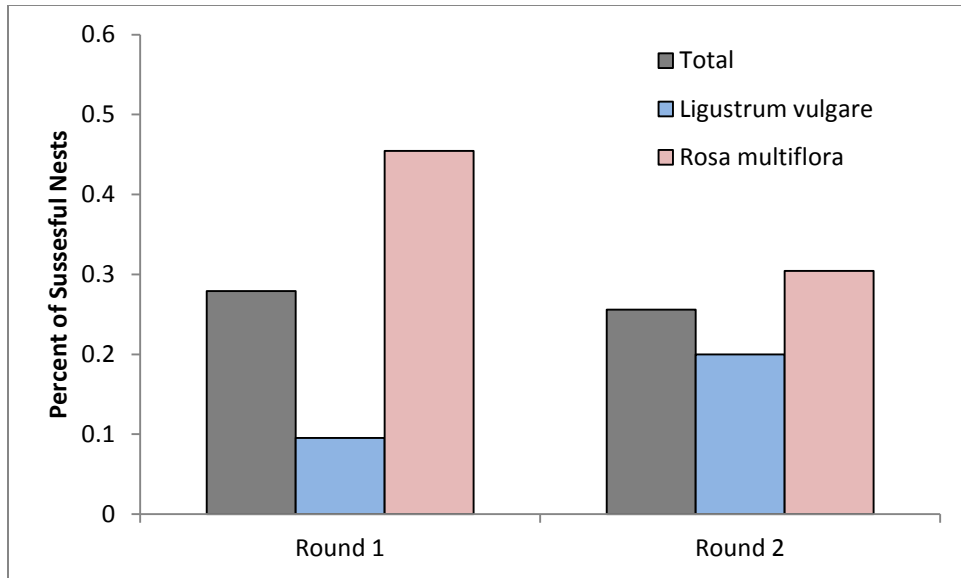


Figure 6. Results of artificial nest experiment. Eighty-six nests were set and monitored. Of these nests, 15% of nests placed in privet were successful and 38% of nests placed in rose were successful. The results on the chi-square approximations showed a significant difference, and that nests placed in rose were more successful than nests placed in privet.

CHAPTER IV

DISCUSSION

We tested the hypothesis that exotic plants act as an ecological trap as appearing as suitable nesting sites, yet negatively impact their nesting success. The natural nest experiment found no support for this, and therefore did not lend itself to the hypothesis that exotic shrubs are less successful nest-sites. However, when incorporating clutch initiation date, there were significant differences in nest success between natural nests within privet and rose. This pattern suggested that when used as nest-sites, rose was more successful than privet.

One of the significant patterns found in this study was the influence of clutch initiation date on nesting success, which showed that nests built earlier in the season failed more than nests built later in the season. This outcome of seasonality influencing nesting success has been seen in many studies (Hirsch-Jacobson et al. 2012; Sperry et al. 2008; Grant et al. 2015). In this study, nests within native substrates were not initiated until later in the season. The first nest in a native plant was found on Julian day 145, which was 10 days after our first nest in an exotic shrub was observed. Of the nests built during this first 10 day period of the study, sixty percent failed (15 out of 25). If exotic plants present cues (e.g. the early leaf-out seen in exotic shrubs) that provide

opportunities for birds to build nests earlier in the season (when it may not be the most suitable), then exotic plants could be acting as an ephemeral ecological trap. The hypothesis that exotic plants act as an ephemeral ecological trap is relatively new (McCusker 2010; Rodewald 2009; Kearns and Rodewald 2012; Stoklosa 2014). The early leaf-out of exotic plants may steer understory nesting birds into initiating nest building sooner than would be favorable. However, early leaf-out of exotic, but not native, plants could facilitate nest searching by predators. Forests with clustered patches of exotic plants which are leafing out create a patchily distributed understory, and this patchy distribution of feasible nest sites could guide foraging behaviors of nest predators (Chase 2002, Schmidt and Whelan 1998). For example, Rodewald et al. (2010) found that nests in the exotic genus *Lonicera* failed at a much higher rate than nests in native substrates prior to the Julian date of 168. After this date, the probability of having a successful nest in *Lonicera* increased at a faster rate than nests in native plants. We found similar results. However, birds were more successful nesting in the exotic plant *Multiflora rose* and the day in which the probability of nesting success switched from native to exotic plants was Julian day 172. In these cases, it may be more advantageous if nesting parents held off nest building until the landscape as a whole has leafed-out. As the season progressed, the probability of fledging in native nests decreased compared to that of nests in exotic substrates. This may suggest that nests in exotic substrates act as an ephemeral ecological trap. Yet there is not a net loss of nesting within exotic plants, because the probability of fledging from a native substrate will decrease as nests in exotic plants increase during the nesting season. Monitoring more nests may bring greater

resolution to this dilemma and would give more clarity to analyzing nests based on species instead of grouping them based on origin.

The hypothesis that vegetative characteristics (regardless of if the plant was a native or exotic species) drive nesting success was also not supported by this study. Even though we saw differences between nest-patch characteristics based on the species in which we found a nest, none (except for nest height) appeared to be a significant factor in determining nest success. These findings do not support current literature which typically suggests increases in vegetative structure (e.g. foliage cover of nest and distance to edge) benefit nest success by concealing nests from foraging predators (Martin and Roper 1988; Martin 1992). Though counter intuitive, there are studies that suggest that structural characters play less of a role in nesting success than one would expect. For example, Howlett & Stuchbury (1996) experimentally removed vegetation around nests of Hooded Warblers, thereby increasing visibility of each nest. They found no significant difference in the outcome of nests with vegetative removal and nests in which vegetation was not removed. Filliater et al. (1994) found that differences of nest site selection (i.e. Nest height, Vegetation mid-Height, Nest Concealment etc.) of Northern Cardinals were non-significant with respect to daily survival rates between failed and successful nests. Furthermore, Weinder (2002) found that nest concealment in thrushes had a neutral impact in determining nesting success. In this case, parental care played a larger role in predicting nest fate.

Results from the artificial nest experiment support the observed pattern of nests in *Rosa multiflora* being (rose) being more successful than nests in *Ligustrum vulgare*

(privet). The intent of the artificial nest experiment was to analyze nest survival between these two species while removing parental behaviors associated with nesting, and to test the pattern of differential nesting success between nests in rose and privet. Furthermore, we wanted to gather data that would inform managers on issues of species removal. This experimental nest study suggests that managers wishing to remove non-native species based on nesting outcomes should remove privet, as this species is suggested to lead to lower breeding success when used as nesting sites. Privet has a growing structure similar to that of the native saplings of this region used by Hooded warblers (i.e. beech, maple), both forming patches that congregate together to form a dense structure in terms of number of stems. However, in these heavily degraded systems, this pattern of growth may be more detrimental to nesting success than that of the growth patterns of rose or honeysuckle, which tend to grow in denser patches and create a more complex and overarching architecture. This architecture could prevent larger sized predators from reaching a nest (Winter et al. 2005), which would explain the outcomes of both the artificial and natural nests being more successful in rose than in privet.

Implications for Future Research, Management and Conservation

The field of avian and invasion ecology has come a long way since researchers began investigating these systems, yet the application of this knowledge at the level of land managers remains far from settled. With the countless amounts of money and labor going towards managing invasive plants, managers should seriously start considering if these efforts are futile. Researchers should also consider redirecting efforts to understand impacts of nesting in individual species and decide if scaling up from species-level

strategies to larger scales (i.e. exotic and native habitats or landscapes) would be more beneficial.

For example, the interaction between nesting success and exotic plants as nesting substrate is complex. Considerable thought should be put into novel interactions and realize that an individual plant in which a bird places its nest may not be the most suitable scale to understand this relationship. Landscape level processes have been shown to be strong drivers of nesting success and urban landscapes contain elevated levels of nest predators. For instance, Borgman and Rodewald (2004) found that nests in *Lonicera* had greater mortality in urban landscapes than in rural landscapes, while nests in native plants had significantly higher mortality rates in rural landscapes than in urban landscapes. This suggests that there is an interaction between the landscape and the species of plant used as nest-sites.

Though landscape level processes are important to incorporate into understanding the interaction of exotic plants and nesting success, researchers should call into question if birds are even useful taxa to consider for these studies. Insect abundance and richness is known to be impacted by invading exotic plants (Bezmer et al. 2014), and this modification of prey abundance is suggested to decrease both parental and nestling health (Hollander et al. 2013). Dietary studies of both parents and nestlings may be more beneficial and may better inform researchers on fledgling condition than what we know from nest success studies. Furthermore, post-fledgling survivorship is heavily understudied and rarely done, no doubt due to the difficulties of these studies.

Quantifying fledging success is important, but understanding if a fledgling survives until reproductive age will provide critical information on overall success in exotic habitats.

Managers should keep in mind that removal of exotic shrubs may not facilitate the return of native shrubs or of an intact avian community and may even alter nesting success (Zavaleta 2001; Rodewald et al. 2015). Once systems have been invaded and functional roles replaced by exotic plants, removal of these species without the addition of native plants may facilitate the introduction of new exotic species or the recolonization of the previously removed species (Flory and Clay 2009). Furthermore, managers should keep in mind what the structure of a forest looks like after the removal of exotic plants as well as its current state with large herbivores such as white-tailed deer. Within forests similar to that of the Cuyahoga Valley region in which there is an absence of exotic shrubs in the understory, there is also an absence of native woody vegetation. This is likely due to deer, which selectively browse native stems and reach such large population densities that they denude the understory of structure (Shafer-Nolan 1997). Exotic shrubs are often able to withstand higher levels of deer browsing than native shrubs (Inderjit 2012; Knight et al. 2009), and for these reasons, it may be the case that without exotic shrubs, the structure of forest understories would be much less complex. Therefore, it is plausible that in the absence of areas dominated by native species, exotic shrubs act as a refuge for understory nesting birds. Further research needs to be done on the interaction of white-tailed deer populations, native forest regeneration, and exotic plant removal on nesting success of birds for managers to make educated decisions.

LITERATURE CITED

- Alpert, P., E. Bone, and C. Holzappel. 2000. Invasiveness, Invasibility and the role of environmental stress in the spread of non-native plants. *Perspectives in plant ecology, evolution and ...* 3:52
fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. *Oikos* 71:355–366.
- Bakermans, M., A. Rodewald, and M. Brittingham. 2006. Scale-dependent Habitat Use of Acadian Flycatcher in Central Ohio. *The Auk* 123:368.
- Bezemer, T. 2014. Response of native insect communities to invasive plants. *Annual review of ...* 59:119–41.
- Borgmann, K., and A. Rodewald. 2004. Nest predation in an urbanizing landscape: the role of exotic shrubs. *Ecological Applications* 14:1757–1765.
- Chalfoun, A. 2002. Nest predators and fragmentation: a review and meta-analysis. *Conservation ...* 16:306–318.
- Chase, M. 2002. Nest site selection and nest success in a Song Sparrow population: the significance of spatial variation. *The Condor*:103–116.
- Filliater, T., R. Breitwisch, and P. Nealen. 1994. Predation on Northern Cardinal nests: Does choice of nest site matter? *Condor* 96:761–768.
- Flory, S., and K. Clay. 2009. Invasive plant removal method determines native plant community responses. *Journal of Applied Ecology* 46:434–442.
- Gates, J., and L. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. *Ecology* 59:871–883.
- Gleditsch, J. M., and T. a. Carlo. 2014. Living with Aliens: Effects of Invasive Shrub Honeysuckles on Avian Nesting. *PLoS ONE* 9:e107120.
- Grant, T., T. Shaffer, and E. Madden. 2005. Time-specific variation in passerine nest survival: new insights into old questions. *The Auk* 122:661–672.

- Hirsch-Jacobson, R., and W. Cox. 2012. Parents or predators: examining intraseasonal variation in nest survival for a migratory passerine. *The Condor* 114:358–364.
- Hollander, F., N. Titeux, and H. Dyck. 2013. Habitat dependent prey availability and offspring provisioning explain an ecological trap in a migratory bird. *Functional Ecology* 27:702–709.
- Hoover, J., and M. Brittingham. 1998. Nest-site selection and nesting success of Wood Thrushes. *The Wilson Bulletin* 110:375–383.
- Howlett, J., and B. Stutchbury. 1996. Nest concealment and predation in Hooded Warblers: experimental removal of nest cover. *The Auk* 113:1–9.
- Hutchinson, T., and J. Vankat. 1997. Invasibility and effects of Amur honeysuckle in southwestern Ohio forests. *Conservation Biology* 11:1117–1124.
- Inderjit. 2012. Exotic plant invasion in the context of plant defense against herbivores. *Plant physiology* 158:1107–14.
- Ingold, J., and M. Craycraft. 1983. Avian frugivory on honeysuckle (*Lonicera*) in southwestern Ohio in fall. *Ohio Journal of Science* (Ohio) 83:256–258.
- Kearns, L., and A. Rodewald. 2013. Within-season use of public and private information on predation risk in nest-site selection. *Journal of Ornithology* 154:163–172.
- Kirsch, E., B. Gray, T. Fox, and W. Thogmartin. 2007. Breeding bird territory placement in riparian wet meadows in relation to invasive reed canary grass, *Phalaris arundinacea*. *Wetlands* 27:644–655.
- Knight, T., J. Dunn, L. Smith, J. Davis, and S. Kalisz. 2009. Deer facilitate invasive plant success in a Pennsylvania forest understory. *Natural Areas Journal* 29:110–116.
- Lake, J., and M. Leishman. 2004. Invasion success of exotic plants in natural ecosystems: the role of disturbance, plant attributes and freedom from herbivores. *Biological conservation* 117:215–226.
- Lavoie, C., C. Dufresne, and F. Delisle. 2005. The spread of reed canarygrass (*Phalaris arundinacea*) in Québec: a spatio-temporal perspective. *Ecoscience* 12:366–375.
- Leston, L., and A. Rodewald. 2006. Are urban forests ecological traps for understory birds? An examination using Northern cardinals. *Biological Conservation* 131:566–574.

- Leue, A. 1889. Forth Annual Report of the Ohio-State Forestry Bureau. Columbus.
- Lloyd, J., and T. Martin. 2005. Reproductive success of Chestnut-collared Longspurs in native and exotic grassland. *The Condor* 107:363–374.
- Loomis, J., and G. Cameron. 2014. Impact of the invasive shrub Amur honeysuckle (*Lonicera maackii*) on shrub-layer insects in a deciduous forest in the eastern United States. *Biological Invasions* 16:89–100.
- Luken, J., and J. Thieret. 1996. Amur honeysuckle, its fall from grace. *BioScience* 46:18–24.
- Martin, T. 1998. Are microhabitat preferences of coexisting species under selection and adaptive? *Ecology* 79:656–670.
- Martin, T., C. Paine, and C. Conway. 1997. BBIRD field protocol. ... Wildlife Research Unit, ... 59812.
- McCusker, C., M. Ward, and J. Brawn. 2010. Seasonal responses of avian communities to invasive bush honeysuckles (*Lonicera* spp.). *Biological Invasions*:2459–2470.
- Misenhelter, M., and J. Rotenberry. 2000. Choices and consequences of habitat occupancy and nest site selection in Sage Sparrows. *Ecology* 81:2892–2901.
- Moorman, C., D. G. Jr, and J. Kilgo. 2002. Hooded warbler nesting success adjacent to group-selection and clearcut edges in a southeastern bottomland forest. *The Condor* 104:366–377.
- Ogden, J.-G. 1966. Forest History of Ohio . I , Radiocarbon Dates and Pollen Stratigraphy of Silver Lake , Logan County , Ohio. *Ohio Journal of Science (Ohio)* 66:387–400.
- Paul. 1879, November 12. The Summit County Beacon (Akron). The Summit County Beacon (Akron):70. Akron.
- Powell, L. L., T. P. Hodgman, W. E. Glanz, J. D. Osenton, and C. M. Fisher. 2010. Nest-Site Selection and Nest Survival of the Rusty Blackbird: Does Timber Management Adjacent to Wetlands Create Ecological Traps? *The Condor* 112:800–809.
- Purcell, K. L., and J. Verner. 1998. Density and Reproductive Success of California Towhees and Reproductive Success of California Towhees. *Conservation Biology* 12:442–450.

- Remes, V. 2003. Effects of Exotic Habitat on Nesting Success, Territory Density, and Settlement Patterns in the Blackcap (*Sylvia atricapilla*). *Conservation Biology* 17:1127–1133.
- Robinson, S. K., F. R. Thompson, T. M. Donovan, D. R. Whitehead, and J. Faaborg. 1995. Regional forest fragmentation and the nesting success of migratory birds. *Science* (New York, N.Y.) 267:1987–90.
- Rodewald, A. D. 2012. Spreading messages about invasives. *Diversity and Distributions* 18:97–99.
- Rodewald, A. D., R. P. Rohr, M. a. Fortuna, and J. Bascompte. 2015. Does removal of invasives restore ecological networks? An experimental approach. *Biological Invasions* 17:2139–2146.
- Rodewald, A. D., D. P. Shustack, and L. E. Hitchcock. 2009. Exotic shrubs as ephemeral ecological traps for nesting birds. *Biological Invasions* 12:33–39.
- Rolstad, J. 1991. Consequences of forest fragmentation for the dynamics of bird populations: conceptual issues and the evidence. *Biological Journal of the Linnean Society* 42:149–163.
- Roth, R. R., and R. K. Johnson. 1993. Long-term Dynamics of a Wood Thrush Population Breeding in a Forest Fragment 110:37–48.
- Schlaepfer, M. A., M. C. Runge, and P. W. Sherman. 2002. Ecological and evolutionary traps. *Trends in Ecology & Evolution* 17:474–480.
- Schmidt, K. A., and C. J. Whelan. 1999. Effects of Exotic *Lonicera* and *Rhamnus* on Songbird Nest Predation. *Conservation Biology* 13:1502–1506.
- Sciences, B., E. Studies, B. Ab, and N. York. 2005. Invasive Shrubs and Songbird Nesting Success: Effects of Climate Variability and Predator Abundance. *Ecological Applications* 15:258–265.
- Shafer-Nolan, A. L. 1997. The science and politics of deer overabundance at Cuyahoga Valley National Recreation Area, Ohio. *Wildlife Society Bulletin* 25:457–461.
- Sperry, J., and R. Peak. 2008. Snake activity affects seasonal variation in nest predation risk for birds. *Journal of Avian ...*:379–383.

- Stoklosa, S. K., L. J. Kearns, and A. D. Rodewald. 2014a. Risky edges: temporal variation in brood parasitism of Northern Cardinals. *The Wilson Journal of Ornithology* 126:94–97.
- Stoklosa, S. K., L. J. Kearns, and A. D. Rodewald. 2014b. Risky edges: temporal variation in brood parasitism of Northern Cardinals. *The Wilson Journal of Ornithology* 126:94–97.
- Suvorov, P., and J. Svobodová. 2012. The Occurance of Ecological Traps in Bird Populations: Is Our Knowledge Sufficient? A Review. *Journal of Landscape Ecology* 5.
- Thompson, F. R., and D. E. Burhans. 2004. Differences in Predators of Artificial and Real Songbird Nests: Evidence of Bias in Artificial Nest Studies. *Conservation Biology* 18:373–380.
- Thorne, C. E., and W. J. Green. 1909. Third Annual Report on Forest Condititons in Ohio. Ohio Agricultural Experiment Station. Ohio Agricultural Experiment Station, Wooster, Ohio.
- Villard, M.-A. 1998. On Forest-Interior Species , Edge Avoidance , Area Sensitivity , and Dogmas in Avian Conservation. *The Auk* 115:801–805.
- Weidinger, K. 2002. Interactive effects of concealment, parental behaviour and predators on the survival of open passerine nests. *Journal of Animal Ecology* 71:424–437.
- Whitney, G. G. 1990. The History and Status of the Hemlock-Hardwood Forests of the Allegheny Plateau. *Jornsl of Ecology* 78:443–458.
- WINTER, M., D. H. JOHNSON, and J. A. SHAFFER. 2005. Variability in Vegetation Effects on Density and Nesting Success of Grassland Birds. *Journal of Wildlife Management* 69:185–197.
- Zavaleta, E. S., R. J. Hobbs, and H. a. Mooney. 2001. Viewing invasive species removal in a whole-ecosystem context. *Trends in Ecology & Evolution* 16:454–459.

APPENDIX

Exotic	Fail	Fledge	Total	% Fledged
Common privet (<i>Ligustrum vulgare</i>)	21	12	33	36.36
European buckthorn (<i>Rhamnus cathartica</i>)	1	0	1	0.00
Honeysuckle (<i>Lonicera sp.</i>)	11	7	18	38.89
Japanese barberry (<i>Berberis thunbergii</i>)	6	2	8	25.00
multiflora rose (<i>Rosa multiflora</i>)	18	20	38	52.63
Buckthorn sp. (<i>Rhamnus sp.</i>)	0	1	1	100.00
	57	42	99	42.42
Native	Fail	Fledge	Total	% Fledged
American beech (<i>Fagus grandifolia</i>)	2	2	4	50.00
American elm (<i>Ulmus americana</i>)	2	0	2	0.00
Common blackberry (<i>Rubus allegheniensis</i>)	0	1	1	100.00
Sugar maple (<i>Acer saccharum</i>)	2	1	3	33.33
Gray dogwood (<i>Cornus racemosa</i>)	1	1	2	50.00
Low blueberry (<i>Vaccinium pallidum</i>)	1	1	2	50.00
Maple-leaved viburnum (<i>Viburnum acerifolium</i>)	1	2	3	66.67
Quaking asp.en (<i>Populus tremuloides</i>)	0	2	2	100.00
Red maple (<i>Acer rubrum</i>)	1	0	1	0.00
Oriental Bittersweet (<i>Celastrus orbiculatus</i>)	1	1	2	50.00
Ash sp. (<i>Fraxinus sp.</i>)	1	2	3	66.67
Grape sp. (<i>Vitis sp.</i>)	0	1	1	100.00
Raspberry sp. (<i>Rubus sp.</i>)	4	4	8	50.00
	16	18	34	52.94
All Species	73	60	133	45.11

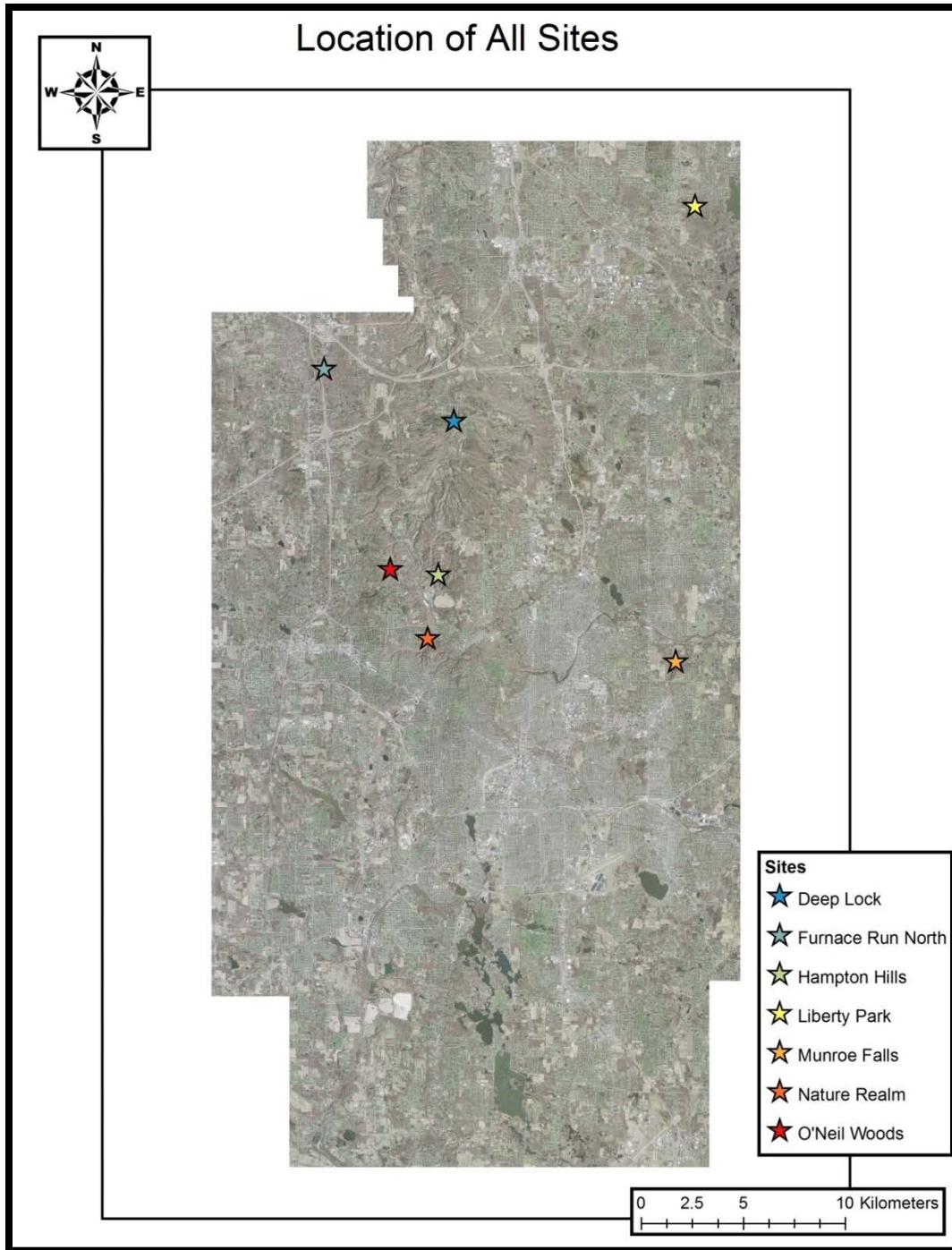
Appendix 1. The species of plant each nest was found in, as well as the number of failed, fledged, and total number of nests found within each species.

Variable	LogLikelihood	DF	ChiSquare	Prob>ChiSq	
Nest Height(m)	0.64 (0.02)	1.934	1	3.868	0.049
Distance to Edge of Foliage Patch (m)	1.27 (0.09)	0.092	1	0.185	0.667
Overall Cover of Nest By Foliage (%)	67.1 (2.48)	0.707	1	1.414	0.234
Percent of Exotic Stems	0.76 (0.03)	0.352	1	0.705	0.401
Total Number of Stems	39.1 (1.57)	0.381	1	0.762	0.383
Distnace to Trail	81.77 (10.55)	0.337	1	0.674	0.412
Distance to Forest Edge	55.33 (3.48)	0.321	1	0.642	0.423

Appendix 2. Results of the General Linear Model (GLM) testing the influence of nest-site characteristics on nesting success. Of all the variable tested, only nest height had a significant influence on nesting success.

Variable	Nest substrate		Prob > F
	Exotic	Native	
Nest Height(m)	0.64 (0.02)	0.67 (0.04)	0.478
Distance to Edge of Foliage Patch (m)	1.07 (0.09)	1.86 (0.21)	< 0.001
Overall Cover of Nest By Foliage (%)	68.85 (2.86)	73.59 (4.88)	0.12
Total Number of Stems	41.41 (1.87)	32.35 (2.54)	0.011
Distance to Trail	60.61 (5.78)	38.23 (33.48)	< 0.001
Distance to Forest Edge	56.52 (4.32)	52.22 (5.63)	0.5833

Appendix 3. Means and standard error of habitat characteristics between nests found in exotic and native plants. Results of analysis of variances (ANOVA) between nests in exotic and native substrates. All but nest height did not have a significant influence on nesting success.



Appendix 4. Location and names of parks which were used in this study. This study took place in Summit county Ohio within parks owned and managed by the Summit County Metro Parks,