Vegetative Nest Sites, Nest Survival, and Nest Fate of Birds within the Central Business District of Rockingham, North Carolina

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Abstract

I assessed vegetative nest sites, nest survival, and nest fate of birds within the central business district (25-block plot: 42.4 ha) of Rockingham (~9000 population) in south-central North Carolina. I documented 324 nests of 16 avian species in 1994. Most nests were built in native trees and exotic shrubs. Nest survival in platform or open-cup nests for the eight most numerous species (seven native, one exotic) was low, regardless of whether nests were clustered at low heights (Brown Thrasher, Northern Mockingbird, House Finch, Northern Cardinal) or built at greater heights (Mourning Dove, Gray Catbird, American Robin, Common Grackle). Nest fate throughout the breeding season did not vary, regardless of nest height, landscape element, origin, substrate type, or foliage type. This study demonstrates that nest records amplify relationships with vegetative habitat and elements of the landscape matrix in urban environments.

Introduction

In southeastern North America, no breeding bird censuses other than in large urban areas had been conducted in a town, and none from a central business district until McNair (2021) conducted such a census in downtown Rockingham, North Carolina in 1994. The focus was on biotic homogenization of two functional guilds - suburban adapters and urban invaders (Marzluff and Rodewald 2008) - within this urban landscape. Suburban adapters (e.g., American Robin [*Turdus migratorius*]) are typically adapted to diverse, young, edge, and disturbed habitats (Marzluff and Rodewald 2008). Urban invaders include House Finch (*Haemorhous mexicanus*) populations in eastern North America (Badyaev et al. 2012). The investigation included the relationship of species richness and the number of nest records to an estimate of the amount of vegetation within city blocks of a 25-block study plot. However, McNair (2021) did not document other breeding parameters centered around nest records within the context of vegetative habitat and elements of the landscape matrix.

Consequently, I asked the following three questions: 1) How has avian species use of nest sites depended on native or exotic vegetation; I expected most nest sites in trees to be of native species and most nest sites in shrubs to be of exotic species, following the conventional pattern of many urban landscapes where the majority of trees are native and the majority of shrubs are exotic (Burghardt et al. 2008), 2) How have different elements (e.g., solitary trees and shrubs, hedgerows) of the landscape matrix accounted for variation in avian species use of vegetative nest sites; I expected avian species to follow the general pattern of nest site use in different elements of urban environments as documented in southeastern North America by the Birds of North America species accounts, and 3) What are the patterns of nest survival and nest fate for avian species breeding in vegetation; I had a neutral expectation for both in downtown Rockingham because of mixed results from studies conducted in urban environments (Borgmann and Rodewald 2004, Chamberlain et al. 2009, Stinson and Pejchar 2018).

Methods

Field Site Description

Rockingham, North Carolina, the county seat of Richmond County, was founded in 1774 at Cole's Hill (Hutchinson 1998), a bluff rising between Hitchcock and Falling Creeks, along the contact zone (Fall Line) where the Piedmont meets the Sandhills, a subregion of the Coastal Plain. The 25-block study plot (42.4 ha) is centered on the ancient location of Cole's Hill, which comprises the central business district of Rockingham. The plot is largely comprised of buildings and other sealed surfaces, with smaller areas of a mixture of remnant native and planted exotic vegetation including lawns, and excludes town blocks of adjacent residential areas. The plot does not contain riparian or other aquatic habitats, forests, woodlands, farmland, parks, cemeteries, allotment gardens, or industrial areas. The plot contained one nest box in one block and isolated snags were present in about five blocks. A full description and map of the study plot is provided in McNair (2021).

Vegetation

Species nomenclature for scientific names, authorities, and common names follows Weakley (2015). Several other sources were consulted for nomenclature of some non-naturalized exotic species (Lance 2004, ITIS 2020, USDA-NRCS 2020). Definitions of trees, shrubs, and vines follow Radford, Ahles, and Bell (1968), Lance (2004), and Weakley (2015). A tree was defined as a woody perennial, usually with a solitary trunk or main stem, growing at maturity to over a height of 4.6-6.1 m; a shrub as a woody perennial lacking a central trunk and usually branching from the base with several main stems, growing at maturity to heights reaching 7.6-9.1 m although usually much lower; and a vine as a plant which climbs by tendrils or other means, or which trails or creeps along the ground.

Downtown Rockingham contains a mixture of cropped (maintained) remnant native vegetation and exotic vascular plants. Plants herein even if curbside plantings or cultivars are considered native species if their original range includes Rockingham; this definition excludes species naturalized beyond their original ranges by aid of cultivation such as Pecan (*Carya illinoinensis*). I consulted Weakley (2015), supplemented by several other sources (e.g., Sorrie 2011) to determine the original range of native species that occurred naturally without cultivation in North Carolina. Most exotic plants in Rockingham are of species originally from eastern Asia, although some are from other regions or continents.

Plantings on properties in the central business district usually adhered to recommendations of regulations by the City of Rockingham (2020). The landscape matrix of all vascular plant species within the study area was categorized into five elements: espaliers and trellises, solitary trees or shrubs (usually spaced at least 1.3-1.5 m apart), hedgerows (a row of closely spaced shrubs and/or low-growing trees with an occasional tall tree, which may include exotic species and remnant native vegetation), tree rows, and woodlots (as distinct from larger woodlands) which is the most complex element. The tallest tree within the study plot was a 30-m Willow Oak (*Quercus phellos*).

Vegetation Index

I developed a vegetation index for the diverse mixture of remnant native vegetation and landscaped plantings by overlaying an acetate grid of mylar squares on magnified aerial photographs from 1993 of each of the 25 blocks at a scale of 1:840 (2.54 cm:21.336 m; original measurements: 1 in:70 ft). This vegetation index relied upon estimation of the spatial coverage of vascular plants from each of the five landscape elements within each block. I verified this effort for one of these elements (espaliers and trellises) by an estimation of its spatial coverage based on field measurements. I excluded measurements of any exaggerated images of vascular plants. If vegetation filled at least 50% of a mylar square, I scored it as one square. This index excluded plants less than 1 m tall and ground vegetation, including lawns, where birds did not nest. For all blocks combined, the proportion and presence of vegetation represented from each of the five landscape elements was as follows: espaliers and trellises, 0.02 (six blocks); solitary trees and shrubs, 0.484 (25 blocks); hedgerows, 0.123 (17 blocks); tree rows, 0.078 (six blocks); and woodlots, 0.313 (six blocks).

Avian Surveys

Species nomenclature for scientific names, authorities, and common names follows Chesser et al. (2019). I conducted intensive nest searches on 94 days from 27 March to 18 September 1994; field effort was concentrated from April through July (236.75 of 252.25 hr; 94%). I recorded the plant species that contained the nest, nest substrate (tree, shrub, and/or vine), nest height, and substrate height. Most effort was devoted to obtaining information from platform or open-cup breeding species rather than cavity-nesting species. The latter's nests were generally inaccessible. Eight (seven residents, one migrant) of the 16 avian species accounted for 294 of the 307 observations (95.8%). The eight most numerous species (see Results) nesting in vegetation were multiple-brooded, except for Common Grackle (*Quiscalus quiscula*), which is usually single-brooded (Peer and Bollinger 1997).

Data Analysis

Vegetative nest sites: I compared the number of observed nests to calculation of the number of expected nests (Pearson's chi-square test of independence) for the eight most numerous species that used platform (Mourning Dove [*Zenaida macroura*]) or open-cup nests, after adjustment for their different proportions of nests in two landscape elements (solitary trees and shrubs: 0.637; hedgerows: 0.363). Eight more avian species that used vegetative nest sites were excluded because they accounted for only 13 observations. The other three landscape elements were also excluded because even when combined more than 20% of expected values <5. I then performed post-hoc Pearson's chi-square tests with Yates' correction (all expected values >5), testing pairwise comparisons of values of one species against the sum of values of the other seven; I reduced experiment-wide Type

1 error with the Bonferroni correction ($P = 0.05/8$, so $\propto = 0.0062$). I used Kruskal-Wallis test with the same Bonferroni correction to examine for any differences in nest height and substrate height among the eight species. I then used post-hoc non-parametric Mann-Whitney U-tests to examine differences among nest height and substrate height for all species pairwise-comparisons of these eight species with the Bonferroni correction ($P = 0.05/28$, so $\propto = 0.0018$).

Nest survival: Nest survival is the probability that a nest fledges at least one young. I usually recorded nest contents at least twice per week, but when possible, checked nests from a distance using binoculars. I considered nests to have been depredated if found empty and it was impossible that the young could have fledged, based on the stage of their development on the previous visit. Nest survival was verified in some cases by searching the surrounding area for fledglings or adult birds carrying food. I used 218 of 324 open-cup nests (67.3%) for nest survival analysis.

I used the exposure-days method of Mayfield (1961, 1975) to measure mean nest survival for Mourning Dove and seven species of passerines that built open cup nests in vegetation. I terminated the exposure period for nests with uncertain fate with the last observed active date, and for nests with known fate with the midpoint between last observed active date and first observed inactive date (Manolis et al. 2000). After periodically monitoring active nests and recording the stage and fate of eggs and nestlings, I calculated mean nest survival using the combined length of the incubation and nestling periods taken from the Birds of North America species accounts (Mourning Dove: 28 days, Otis et al. 2008; American Robin: 26 days, Vanderhoff et al. 2016; Gray Catbird (*Dumetella carolinensis*): 23.5 days, Smith et al. 2011; Brown Thrasher (*Toxostoma rufum*): 24 days, Cavitt and Haas 2014; Northern Mockingbird (*Mimus polyglottos*): 24.5 days, Farnsworth et al. 2011; House Finch: 29.5 days, Badyaev et al. 2012; Common Grackle: 27 days, Peer and Bollinger 1997; Northern Cardinal (*Cardinalis cardinalis*): 22 days, Halkin and Linville 1999). Following Mayfield (1975), I did not document any significant differences in mean nest survival between the incubation and nestling periods for each species (P for all Pearson's chi-square tests ≥ 0.25), except American Robin ($P = 0.047$). I still combined the two periods for American Robin since the difference in mean nest survival between separate and combined calculations was only 0.02. Thereafter, I used the method of Johnson (1979) to calculate the standard error and 95% confidence intervals of mean nest survival for all eight species.

Nest fate: I used non-parametric tests to assess any differences in nest fate (failure, success. uncertain); removal of uncertain fates produced similar results, so I used the full data set ($n = 214$) for the above eight species (Manolis et al. 2000). First, I used Kruskal-Wallis test with the Bonferroni correction ($0.05/3$, so $\propto = 0.017$) to examine for any differences in nest fate by nest height; all three fate groups had a distribution with the same shape. Second, I used the chi-square test to examine for any differences in nest fate by date of initiation of incubation. I compressed the date of initiation of incubation to six time periods (late March-early April, late April, early May, late May, June, July-September) to meet sample size requirements (every expected cell ≥ 5). Third, I used separate chi-square tests to examine for any differences in nest fate across all open-cup nesting species by four vegetative characteristics at nest sites (landscape element, origin [native or exotic], substrate type, foliage type). For nest-site landscape element, I compressed three of the five categories (espaliers and trellises, tree rows, woodlots) into one category to meet sample size requirements; I also used a separate chi-square test on just the two main categories (solitary trees and shrubs, hedgerows) because of the disparate nature of the compressed category. For nest site origin, I removed two unknown cases. For nest site substrate type, I merged the two hybrid categories containing vines (tree-vine, shrub-vine) with vines to form one category. For nest site foliage, I used four types (deciduous, tardily deciduous-subevergreen, evergreen, mixed deciduous-evergreen) and removed one unrecorded case. Finally, I performed a chi-square test to examine for any differences in nest fate for the comparison of the two most numerous landscape elements (solitary trees and shrubs, hedgerows) and substrate types (trees, shrubs). All analyses were performed with statistical software available in McDonald (2014) and Real Statistics Using Excel (2019).

Results

Vegetative Nest Sites

Species composition: Sixteen avian species nested in native and exotic trees, shrubs, vines, or a combination of these three nest site substrates, representing 30 native and 35 exotic plant species (Appendix 1). The number of native plants (180; 50.7%) and of nests built in native plants slightly exceeded the number of exotic plants (175; 49.3%) and of nests built in exotic plants that were used to support 303 nests (Table 1). One hundred ninety-seven nests were built in trees (65%) and 59 in shrubs (19.5%). Over twice the number of nests in trees were built in native plants (especially Water [*Quercus nigra*] and Willow oaks) compared to exotic plants, even though the number of native species used (25; 58%) was not much greater than exotic tree species (18). In contrast, all nests in shrubs were built in 12 exotic species (especially Chinese Holly [*Ilex cornuta*] and Japanese Rose [*Rosa multiflora*]). The remaining number of nests (47; 15.5%) were built in vines or a combination of the three nest site substrates (Table 1). Vines, alone or tangled among trees and shrubs (especially the native Common Greenbriar [*Smilax rotundifolia*] and exotic Japanese Honeysuckle [*Lonicera japonica*]), were incorporated as support for 39 of the 303 nests (12.9%). I identified an additional 14 native (10 trees and shrubs, four vines) and 44 exotic species (41 trees and shrubs, three vines) in which I did not detect an avian nest on the study plot.

Landscape elements: Solitary trees and shrubs (55%) and hedgerows (30%) were the two major elements of the landscape matrix that contained nests by 16 breeding species on the study plot in 1994. Two of the eight most numerous species had strong associations for landscape elements ($\chi^2_7 = 46.6$, $P< 0.001$; Figure 1), American Robin for solitary trees (and shrubs) ($\chi^2 = 13.2$, $P< 0.001$) and Gray Catbird for hedgerows ($\chi^2 = 16.9$, $P< 0.001$). House Finch only built nests in two landscape elements (solitary trees and shrubs, espaliers and trellises), the most restricted use by any of the eight species.

Nest and substrate heights: Differences in median nest height (n = 295) and substrate height (n = 290) among eight avian species were highly significant (H = 123.62 and 123.54, respectively, df = 7, $P< 0.001$). Four species (Brown Thrasher, Northern Mockingbird, House Finch, Northern Cardinal) were clustered at low heights, whereas the other four (Mourning Dove, Gray Catbird, American Robin, Common Grackle) were

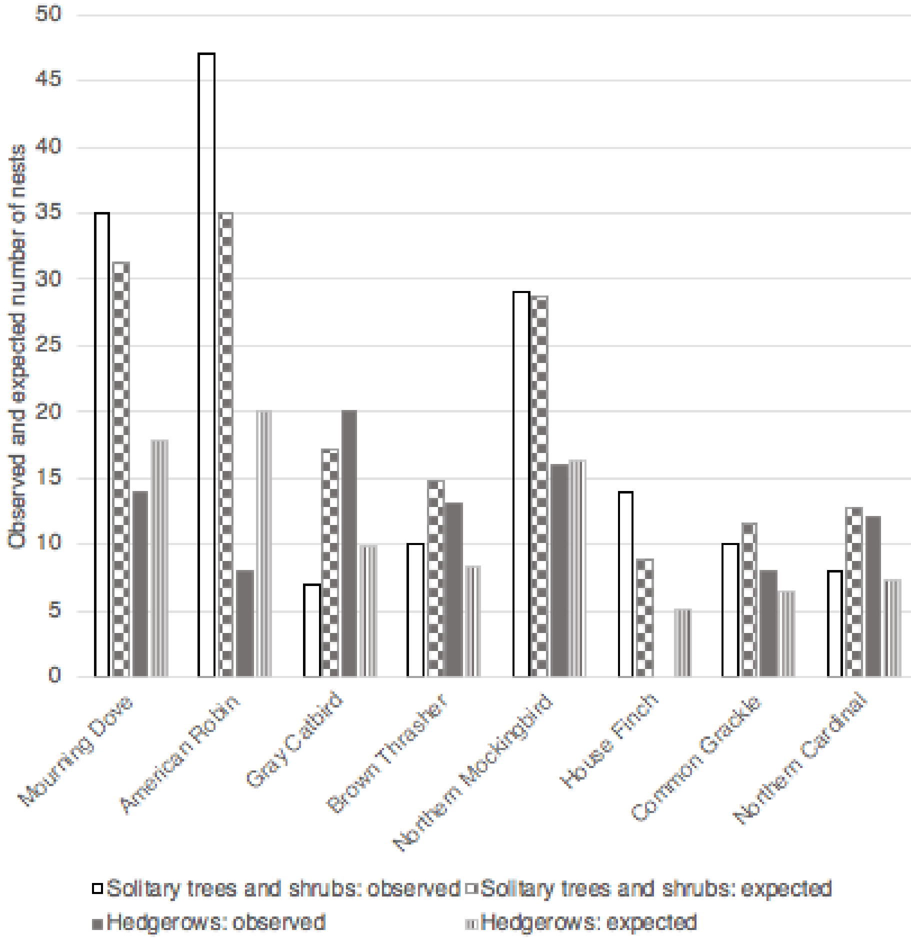

Figure 1. The number of observed and expected nests at two elements (solitary trees and shrubs, hedgerows) of the landscape matrix for eight avian species on the study plot in downtown Rockingham, NC, in 1994.

at greater heights (Figure 2a, b). American Robin nested at the greatest height and in the tallest vegetation, Brown Thrasher at the lowest height and in the shortest vegetation.

Median nest heights of the four species clustered at low heights were not significantly different from each other or from Gray Catbird but were significantly lower than the other three species (post-hoc Mann-Whitney U tests, all $P < 0.001$; Figure 2a). The median nest height of American Robin was significantly greater than Mourning Dove and Gray Catbird (all $P < 0.001$), but all other pairwise comparisons among the four species with greater median nest heights were not significant.

Differences in median substrate heights paralleled results on nest heights, with the following exceptions (Figure 2b). The median substrate height of Gray Catbird was significantly greater than Brown Thrasher, Northern Mockingbird, and Northern Cardinal (all $P < 0.001$), but not House Finch; likewise, the median substrate height of Common Grackle was not significantly greater compared to House Finch. Finally, the median substrate height of American Robin was significantly greater than Gray Catbird and Common Grackle (all $P < 0.001$), but not Mourning Dove.

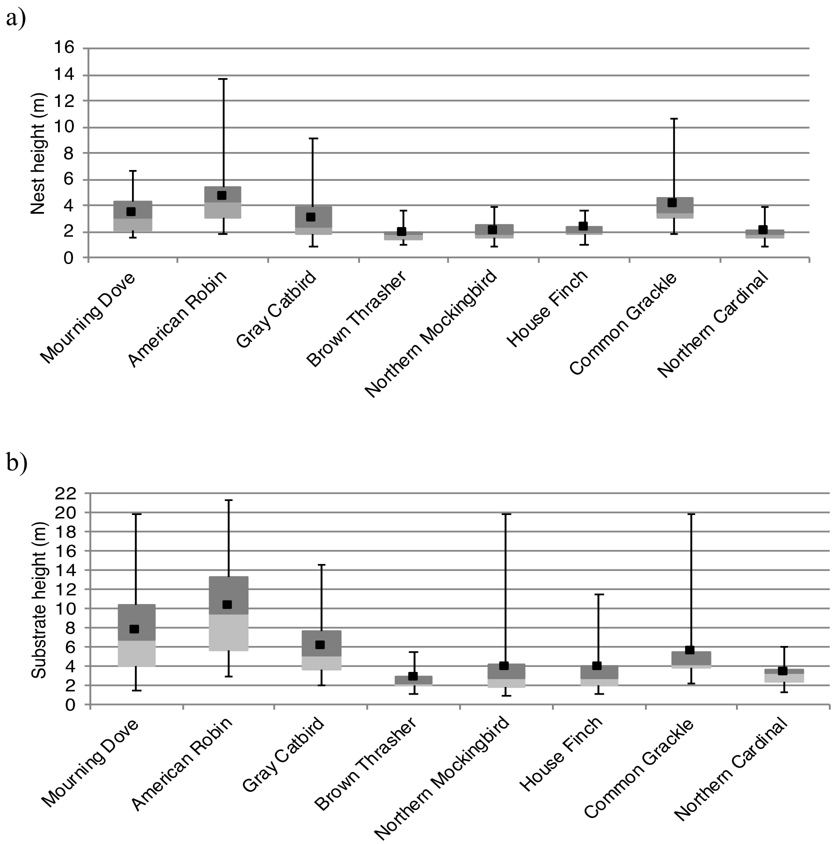

Figure 2. Box-and-whisker plots that display the median, Q1-Q3, and min-max values of nest heights (m) (Figure 2a) and substrate heights (m) (Figure 2b), respectively, at vegetative nest sites for eight avian species on the study plot in downtown Rockingham, NC, in 1994. Small solid black squares represent the mean value for each species.

with values of the four species nesting at low heights. Common Grackles usually nested close to the top of vegetation, which was particularly pronounced in an American Holly (*Ilex opaca*) tree row which contained the only semi-colony within the study plot.

Table 1. Number of nests in native, exotic, and mixed vegetation by nest site substrate.

Nest Site Substrate	**Native**	**Exotic**	**Mixed**[a]	**Unknown**	**Total**
Tree	137	59	0	1	197
Tree/shrub	0	2	6	0	8
Tree/shrub/vine	0	0	1	0	1
Tree/vine	8	7	8	0	23
Shrub	0	57	0	2	59
Shrub/vine	0	2	3	0	5
Vine	2	6	2	0	10
TOTAL	147	133	20	3	303

[a] *Mixture of native and exotic vegetation.*

Nest Survival

Mean nest survival for Mourning Dove and seven species of passerines that used open-cup nests in vegetation was low, ranging from 0.24 (American Robin) to 0.39 (Gray Catbird, House Finch; Table 2). No significant differences in nest survival were documented between any of the eight species; 95% confidence intervals were wide, especially at the upper end which were over 0.50 except for Mourning Dove and American Robin (Table 2). Infrequent visits to some nests contributed to a high proportion of uncertain fates for all eight species, ranging from 19.5% (American Robin) to 37.5% (Northern Cardinal).

Nest Fate

Median nest heights across all eight species between nests that failed, were successful, or whose fate was uncertain (n = 111, 48, and 55, respectively) were significantly different (Kruskal-Wallis H = 6.53, df = 2, $P = 0.04$); nests of uncertain fate were located higher in vegetation than successful nests (3.05 m vs 1.98 m; Mann-Whitney U = 928, P = 0.01). The fate of nests by date of initiation of incubation across all eight species from late March to early September was not significantly different ($\mathcal{X}^2$ = 7.64, df = 10, P = 0.66). Among vegetative characteristics at nest sites, nest fate by origin, substrate type, and foliage type was not significant ($\mathcal{X}^2$ = 1.74, df = 4, P = 0.78; $\mathcal{X}^2$ = 7.75, df = 6, P = 0.26; $\mathcal{X}^2$ = 8.85, df = 4, P = 0.06), respectively. Nest fate by landscape element was significant ($\mathcal{X}^2$ = 14.52, df = 4, P = 0.006), but when the disparate compressed category was removed, nest fate between solitary trees and shrubs compared to hedgerows was not significant ($\mathcal{X}^2$ = 3.60, n = 183, df = 2, P = 0.17); examination of individual cells in the former analysis revealed that the difference could primarily be attributed to House Finches nesting in espaliers and trellises and higher success than expected for Common Grackles nesting at their semi-colony in a tree row. Finally, nest fate for the comparison of the two most numerous landscape elements (solitary trees and shrubs, hedgerows) and substrate types (trees, shrubs) was not significant ($\mathcal{X}^2 = 3.10$, n = 161, df = 6, P = 0.80).

Table 2. Nest survival of Mourning Dove and seven species of passerines that used open-cup nests in vegetation on the Rockingham study plot in 1994.

Common Name (*Scientific Name*)	**Sample Size**	**Fate**		**Total Exposure-Days**	**Mayfield Nest Survival: Mean (± 95% CI)**
		Uncertain	**Known**		
Mourning Dove (*Zenaida macroura*)	48	12	36	603	0.25 (0.15, 0.42)
American Robin (*Turdus migratorius*)	41	8	33	448	0.24 (0.13, 0.43)
Gray Catbird (*Dumetella carolinensis*)	18	4	14	181	0.39 (0.19, 0.79)
Northern Mockingbird (*Mimus polyglottos*)	38	10	28	429	0.35 (0.21, 0.57)
Brown Thrasher (*Toxostoma rufum*)	22	7	15	248	0.37 (0.20, 0.69)
House Finch (*Haemorhous mexicanus*)	19	4	15	285	0.39 (0.20, 0.72)
Common Grackle (*Quiscalus quiscula*)	16	5	11	156	0.29 (0.11, 0.73)
Northern Cardinal (*Cardinalis cardinalis*)	16	6	10	156	0.27 (0.11, 0.64)

Discussion

The diverse mixture of landscaped plantings and remnant native vegetation in downtown Rockingham in 1994 supported a breeding avifauna dominated by seven native and one exotic species. As expected (Burghardt 2008), these species nested in native trees and exotic shrubs distributed among five elements of the landscape matrix. The NC Forest Service (2020) publishes a recommended list of street trees for North Carolina (five species each of native and exotic plants accounted for 33% and 37%, respectively, of individual trees used as nest sites in this study). The list of suitable trees documented in this study is generally more useful as a guide for plantings in south-central NC, but full information is now available in the North Carolina Gardener Toolbox (North Carolina State Extension 2021). Although only ~21% of shrubs compared to trees were used as nest-sites in downtown Rockingham, planting of shrubs is encouraged by the City of Rockingham (2020) which has regulations that specify the proportion of land to be landscaped. The breeding bird avifauna dependent on vegetation in downtown Rockingham could be improved by additional plantings of landscaped trees and shrubs and less cropping of remnant native vegetation, although increasing tree cover (Ibáñez-Álamo et al. 2019; cf., Morelli et al. 2018) is less important now because of the collapse of the local American Robin and Common Grackle breeding populations (McNair 2021). Enhancement of or creation of hedgerows for Gray Catbirds, especially in blocks with a low amount and proportion of vegetation, is one way the urban landscape of downtown Rockingham could be improved.

Plantings of more native shrubs with replacement of some lawns and reduction of impervious surfaces has been identified as one of the most important challenges for small-scale bird conservation on commercial and non-commercial properties in central business districts (Snep et al. 2016, Ibáñez-Álamo et al. 2019; cf., Borgmann and Rodewald 2004). Nelson et al. (2017) found that nest survival was typically neutral even for birds that preferred nesting in exotic vegetation, but Stinson and Pejchar (2018) stated the probability of a significant decrease in nest survival (and productivity) was higher for birds using exotic shrubs. Certain exotic shrubs such as Japanese Rose, which was frequently used in Rockingham, increased the risk of nest predation for Northern Cardinals in Illinois (Rodewald et al. 2009). However, Northern Cardinals and Gray Catbirds have nested in other shrubs in Illinois and have shown positive responses to exotic vegetation (Schneider and Miller 2014). Favored exotic shrubs for nest sites at Rockingham, such as solitary Chinese Holly, in clumps (cf., Rousseau et al. 2015, Rega-Brodsky and Nilon 2016), or as a hedge (Filliater et al. 1994, Burghardt et al. 2008, McCuster et al. 2010, Schlossberg and King 2010, Meyer et al. 2015, Nelson et al. 2017) should not be discouraged until plantings of favorable native shrubs are established.

This study demonstrated that two native open-cup nesting species (American Robin, Gray Catbird) used particular elements of the landscape matrix in which to build nests, which conforms with documented habitat and nest-site preferences of these two species (Pitts 1984, Smith et al. 2011, Vanderhoff et al. 2016). These two species, plus the other six most numerous species, regardless of differences in their abundance and distribution within the study plot (McNair 2021), used appropriate nest-site types (e.g., shrubs and short trees for Northern Mockingbird, Farnsworth et al. 2011). The eight species also generally built nests at expected heights in suitable substrates (op. cit.), including higher nest heights of American Robin and Common Grackle that are usually found in urbanized environments as opposed to natural habitats (Savard and Falls 1981).

Nonetheless, vegetative characteristics for elements of the landscape matrix, origin, substrate type, and foliage appeared to have little influence on nest outcomes for open-cup nesting species whose nest survival was apparently low across the breeding season in 1994. Improving the frequency of examination of nest contents, especially of nests located at greater heights will increase sample sizes, reduce the proportion of uncertain fates, and increase precision (reduce wide confidence intervals) for estimates of nest survival. Nest survival of 41% for three species (American Robin, Gray Catbird, Northern Cardinal) at vacant lots in Baltimore, Maryland (Rega-Brodsky and Nilon 2016) was higher compared to Rockingham; nest survival was also higher for Northern Mockingbirds in urbanized environments of Gainesville, Florida (Stracey and Robinson 2012). In contrast, nest survival of Gray Catbirds at two of three suburban sites in Maryland (metropolitan areas of Washington, DC) was low (Balogh et al. 2011). Balogh et al. (2011) concluded that predation pressure was the ecological driver for these two population sinks. A large suite of predators (native and exotic terrestrial mammals, native avian predators, native snakes) plus cropping of vegetation during the breeding season was likely responsible for apparent low nest survival in downtown Rockingham.

However, additional data beyond one year are required to determine whether downtown Rockingham is a population sink for nesting birds.

Badyaev et al. (2012) stated the exotic House Finch does not seem to compete with any native species for nest-sites. Over half of House Finch nests in vegetation in downtown Rockingham were built in espaliers and trellises, even though this landscape element comprised only a very small proportion of the vegetation. The only other species to use this landscape element for their nests was Northern Mockingbird. House Finches also nested along streets in solitary Crape-myrtle (*Lagerstroemia indica*), which mockingbirds occasionally used. Potential competitive effects between House Finches and Northern Mockingbirds among nest sites and elements of the landscape matrix in urban areas of southeastern North America, where mockingbirds are increasing (Hanauer et al. 2010, Stracey and Robinson 2012), need to be more fully investigated.

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Appendix 1. List of native and exotic plants (trees, shrubs, vines) used as nest sites by 16 avian species in downtown Rockingham in 1994.

Scientific Name **(Common Name)**	**Nest Site Substrate**[a]	**Number**
Native Species (n = 30)[b]		
Acer rubrum L. (Red Maple)	T	2
Betula nigra L. (River Birch)	T	2
Campsis radicans (L.) Seemann ex Bureau (Trumpet-creeper)	V	2
Celtis laevigata Willdenow (Sugarberry)	T	14
Cercis canadensis L. (Eastern Redbud)	T	6
Chamaecyparis thyoides (L.) Britton, Sterns, & Poggenburg (Atlantic White Cedar)	T	3
Cornus florida L. (Flowering Dogwood)	T	10
Crataegus L. 1753 (Hawthorn)	T	1
Ilex opaca Aiton (American Holly)	T	18
Juglans nigra L. (Black Walnut)	T	1
Juniperus virginiana L. (Eastern Red Cedar)	T	9
Liriodendron tulipifera L. (Tulip-tree)	T	2
Malus coronaria (L.) P. Miller (Wild Crabapple)	T	2
Morella cerifera L. (Common Wax-myrtle)	T	1
Morus rubra L. (Red Mulberry)	T	4
Muscadinia rotundifolia Michaux (Muscadine)	V	6
Parthenocissus quinquefolia (L.) Planchon (Virginia-creeper)	V	1
Pinus taeda L. (Loblolly Pine)	T	13
Pinus virginiana P. Miller (Virginia Pine)	T	1
Platanus occidentalis L. (American Sycamore)	T	1
Populus deltoides Bartram ex Marshall (Eastern Cottonwood)	T	2
Prunus serotina Ehrhart (Wild Black Cherry)	T	2
Quercus nigra L. (Water Oak)	T	27
Quercus phellos L. (Willow Oak)	T	28
Salix nigra Marshall (Black Willow)	T	1
Sassafras albidum (Nuttall) Nees (Sassafras)	T	2
Smilax bona-nox L. (Catbrier)	V	1
Smilax rotundifolia L. (Common Greenbriar)	V	12
Ulmus alata Michaux (Winged Elm)	T	1
Ulmus americana L. (American Elm)	T	5
Subtotal	T=25; V=5	180
Exotic Species (n = 35)[c]		
Acer saccharum Marshall (Sugar Maple)	T	3
Ailanthus altissima (P. Miller) Swingle (Tree-of-Heaven)	T	9
Albizia julibrisson Durazzini (Mimosa)	T	3
Araucaria araucana (Molina) K. Koch (Monkeypuzzle Tree)	T	2
Carya illininoensis (Wangenheim) K. Koch (Pecan)	T	8
Cedrus deodara (Roxburgh ex D. Don) G. Don (Deodar Cedar)	T	3
Clematis terniflora A.P. de Candolle (Yam-leaved Clematis)	V	4
Deutzia scabra Thunberg (Roughleaf Deutzia)	S	1
Elaeagnus pungens Thunberg (Thorny-olive)	S	2
Ginkgo biloba L. (Ginkgo)	T	2
Hedera helix L. (English Ivy)	V	4

Ilex cornuta Lindley (Chinese Holly)	S	25
Ilex crenata Thunberg (Japanese Holly)	S	4
Lagerstroemia indica L. (Crape-myrtle)	T	12
Ligustrum japonicum Thunberg (Japanese Privet)	S	4
Ligustrum sinense Loureiro (Chinese Privet)	S	7
Lonicera fragrantissima Lindley & Paxton (Sweet-breath-of-spring)	S	3
Lonicera japonica Thunberg (Japanese Honeysuckle)	V	16
Magnolia grandiflora L. (Southern Magnolia)	T	6
Magnolia × *soulangeana* Soulange-Bodin (Saucer Magnolia)	T	4
Paulownia tomentosa (Thunb.) Siebold & Zucc. ex Steud. (Princesstree)	T	2
Photinia Lindley 1821 (Photinia)	S	1
Photinia glabra (Thunberg) Maxim. (Japanese Photinia)	S	3
Populus L. 1753 (Poplar)	T	2
Prunus caroliniana (P. Miller) Aiton (Carolina Laurel Cherry)	T	1
Pueraria montana (Loureiro) Merrill (Kudzu)	V	2
Pyracantha M.J. Roemer 1847 (Firethorn)	S	5
Pyracantha koidzumii (Hayata) Rehder (Formosan Firethorn)	S	2
Pyrus calleryana Decaisne (Bradford Pear)	T	3
Quercus palustris Muenchausen (Pin Oak)	T	1
Quercus virginiana P. Miller (Live Oak)	T	10
Rosa multiflora Thunberg ex Murray (Multiflora Rose)	S	15
Tsuga canadensis (L.) Carrière (Eastern Hemlock)	T	1
Wisteria sinensis (Sims) A.P. de Candolle (Chinese Wisteria)	V	4
Zelkova serrata Thunberg (Zelkova)	T	1
Subtotal	T=18; S=12; V=5	175
TOTAL	T=43; S=12; V=10	355

[a] *T=Tree; S=Shrub; V=Vine. See text for full definitions.*

[b] *See text for full explanation.*

[c] *See text for full explanation.*