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Snag Availability and Preference of Cavity-Nesting Species in Philadelphia Urban Parks

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Abstract

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Disciplines

Environmental Sciences | Physical Sciences and Mathematics

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SNAG AVAILABILITY AND PREFERENCE OF CAVITY-NESTING SPECIES IN PHILADELPHIA URBAN PARKS

Angelique Noëlle Raezer

Summer 2022

Lisa Kiziuk
Sally Willig

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ABSTRACT

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Angelique Noëlle Raezer

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In addition to habitat destruction and fragmentation, the removal of standing dead trees, known as snags, for safety and aesthetic purposes has increased pressure on cavity-nesting species to find resources for shelter, food, and nesting especially in isolated urban forest islands. Forested, riparian habitat in two Philadelphia urban parks (Wissahickon Valley Park and Cobbs Creek Park) was monitored for cavity nesting in four 0.5-acre circular sampling plots to determine their habitat suitability. Bird presence and nests were recorded during the nesting season of mid-April through mid-July in 2021 and 2022. Habitat assessments were completed in November 2021 and April 2022. Dead or dying trees (snags), as well as living trees with cavities, were also recorded and categorized by species and diameter at breast height. Across all plots, the most abundant cavity-nesting species in 2021 and 2022 was the Red-bellied Woodpecker (*Melanerpes carolina*) while Plot C1 had the most standing deadwood. Information from this study could be used to inform management of forest islands and urban parks through nesting box programs, snag maintenance, and greater conservation efforts to improve biodiversity. Despite forest islands such as Cobbs Creek Park and Wissahickon Valley Park being adversely affected by a lack of resources, they still offer crucial habitat for many bird species, especially cavity-nesters. However, many forest islands could improve through nesting box programs, snag maintenance, and biodiversity conservation. Therefore, it is important to work on conserving the remaining woodlands of the east coast, reconnecting isolated patches where possible, and encouraging the overall health and biodiversity of these forests so that they can support and encourage healthy bird populations with an emphasis on the less well-known cavity nesting species that have more limited nesting opportunities.

Introduction

Dead standing trees, known as snags, provide habitat and food for 45% of native bird species across North America, but are frequently removed for safety and aesthetic purposes (Hutto, 2006). These snags support various bacteria, fungi, and insects in the decomposition process, thus serving as a food source for birds and mammals and as shelter for them while both standing and once they have fallen. In general, places where wildlife are able to find such resources have continued to decrease in size and quantity into isolated forest islands as human populations continue to grow and develop land for various purposes such as housing and agriculture. In addition to human encroachment, climate change is forcing many species to shift their ranges poleward, introducing new species to ecosystems and forcing current ones to leave (National Audubon Society, n.d.; Figure 1).

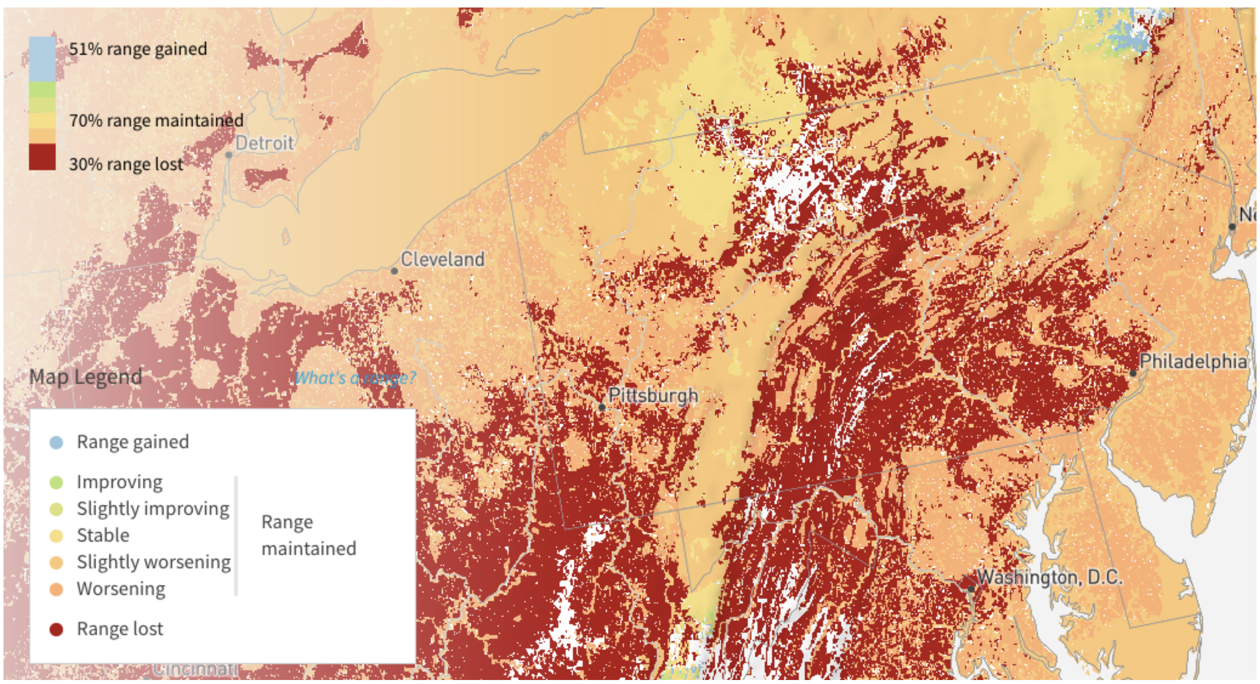

Figure 1. This map shows the change of the range of the Wood Duck in Pennsylvania with an increase in annual temperature of 3 degrees Celsius (National Audubon Society, n.d.).

This combination of factors creates a variety of problems as wildlife continue to struggle to find habitat, especially those dependent on snags such as cavity-nesting species like Wood Ducks (*Aix sponsa*), Bluebirds (*Sialia sialis*), and a variety of woodpeckers, thus causing their populations to decline. Primary cavity-nesting (PCN) birds, such as the Pileated Woodpecker (*Dryocopus pileatus*), are able to create their own cavities, while others, known as secondary cavity-nesting (SCN) species, such as Wood Ducks, are dependent on others and the process of time to clear cavities for them. These connections within the ecosystem web complicate the problem even further when resources begin to deplete.

Increases in light and noise pollution and a lack of riparian habitat exacerbate these issues in urban green spaces. Additionally, smaller forest sizes also lead to a decreased amount of available resources (Askins, 1995). However, urbanized places can be managed to minimize the loss of avian wildlife. In order to improve these spaces, wildlife stewardship techniques, such as installing bird boxes and snag maintenance, must be improved and better understood to offer more habitat opportunities for cavity-nesting species. In this research project, various characteristics of snags and cavity-nesting species were observed and documented in order to identify management suggestions for the urban parks of Philadelphia.

Literature Review

Snags are frequently removed for aesthetic or safety purposes, especially in suburban and urban locations where many people live, consequently destroying valuable nesting and roosting sites for cavity-nesting species. Important topics to consider when assessing snag availability for these species are monitoring methods, ecosystem relationships, habitat type and age, and snag characteristics.

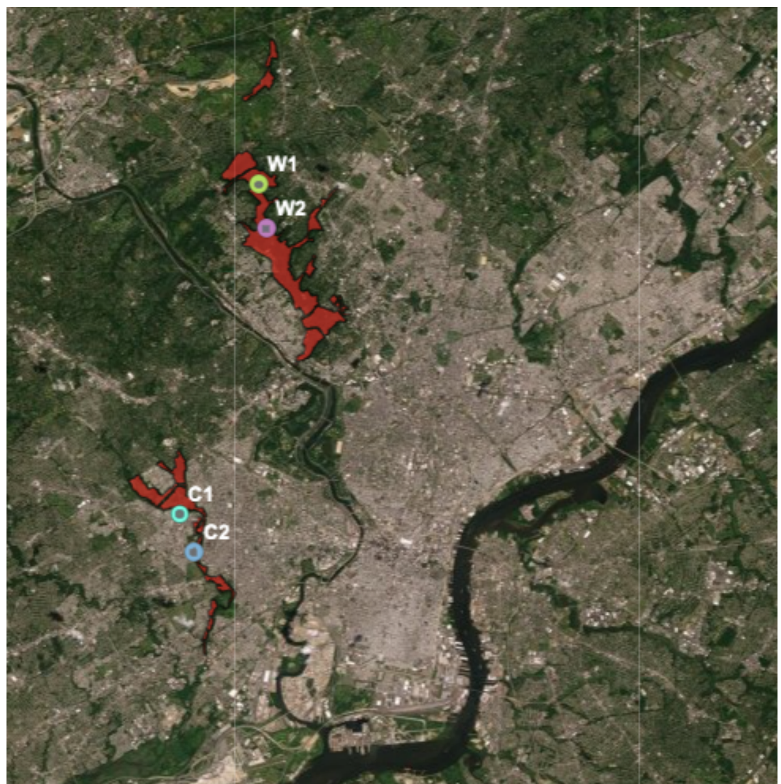

Figure 2. A satellite image of the Greater Philadelphia area with Cobbs Creek Park and Wissahickon Valley Park in red (Raezer, 2022).

History

Before colonization, the eastern United States had mature forests with patches of meadow, which were maintained by lightning strikes or by Native Americans through prescribed burning (Wessels, 1997). However, when Europeans arrived, they quickly cleared almost the entire region of trees for lumber and agriculture. Once people began to move to the mid-western states, farms were abandoned and the process of succession began to affect agricultural fields released from tilling and mowing. Today, a majority of the eastern United States is forested, but it lacks diversity in age as many of the trees are about 100 or so years old.

The Philadelphia urban parks are the perfect example of forest islands (Fig. 2). The forests surrounding the city were cut down for the growing industrial sector in the 1800's (Eckfeldt, 1917; Friends of the Wissahickon, n.d.). Additionally, as was common in the area, most streams were dammed to provide water power for mills - creating goods like textiles, paper, and gunpowder. Most of these mills lining the waterways do not exist anymore and the adjacent forests have largely grown back, but the surrounding developed area now constitutes the fifth largest city in the nation.

Ecosystem Relationships

A few studies have examined the relationships between primary cavity nesters and secondary cavity nesters (Martin & Eadie, 1999; Stauffer & Best, 1982). Examining both is vital as secondary cavity nesters, such as the Wood Duck (Fig. 3), rely on the presence of primary ones to create cavities (Martin & Eadie, 1999). Additionally, primary cavity nesters prefer cavities that are higher up, while the angles of the chosen limbs that contained cavities varied for secondary cavity nesters (Stauffer & Best, 1982). Another study considered habitat that is created for amphibians, reptiles, and mammals once the snags fall (Moorman et al., 1999). Surrounding snags must also be considered for their potential as foraging sites (Martin & Eadie, 1999).

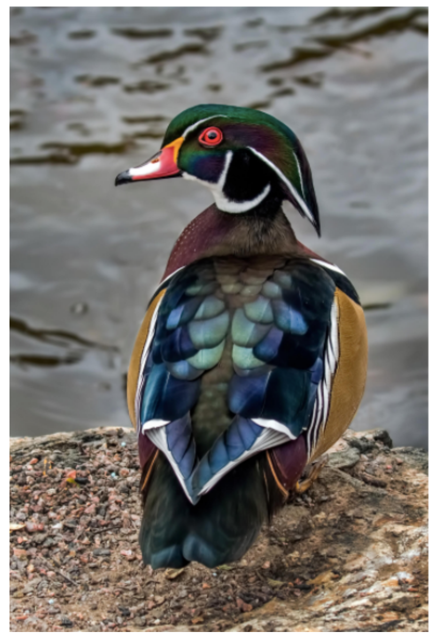

Figure 3. A male wood duck, secondary cavity nester, prefers riparian habitat. (Key, n.d.).

Habitat Type

Habitat type plays a role in determining snag availability, as wetter locations have higher rates of decay (Bell et al., 2021). Several studies observed and compared different habitats. One study compared areas of varying levels of urbanization and found that the density of snags in suburban areas with forested habitat was very similar to that of more wild areas (Blewett & Marzluff, 2005). Another study looked at species abundance in fragmented, edge, wet, and deciduous areas (Martin & Eadie, 1999). Another important factor was the age of the stand and the presence of cavities in younger trees versus larger and older ones, with older forests supporting the most snags (Bell et al., 2021; Lundquist & Mariani, 1991; Moorman et al., 1999).

Forest Island Characteristics

Habitat in forest islands differs in quality. Forest islands can be man-made, through cutting for agriculture and urbanization, or they can be natural, such as a forested island surrounded by water (Brotons et al., 2003). There are also several characteristics that set forest islands apart from each other and determine habitat suitability: structure, size, shape, and surrounding matrix.

Forest island structure includes characteristics of the vegetation, such as tree age, species composition and abundance, and vegetation type. If the trees in a forest island are mature, they are more likely to attract forest-interior species that require secluded, older tracts of forest (Connor & Adkisson, 1977; Table 1). Additionally, a healthy forest has plenty of regeneration, meaning that trees of all ages are visible and growing up through canopy gaps (Wessels, 1997). It is also important for all layers of the forest, including canopy, midstory (or shrubs), and an herbaceous layer be present to offer food and habitat. A forest with no regeneration may indicate heavy pressure from deer herbivory and invasive species and could lead to a failing forest. Additionally, with an increase in vegetation species, there also comes an increase in bird species (Askins et al., 1987).

Table 1. A list of cavity-nesting species and their preferred habitat type.

Species	Cavity-Nesting Type	Habitat Preference
Carolina Chickadee	Secondary	Generalist
Downy Woodpecker	Primary	Generalist
Great-Crested Fly Catcher	Secondary	Generalist
Northern Flicker	Primary	Generalist
Pileated Woodpecker	Primary	Forest-interior
Red-bellied Woodpecker	Primary	Generalist
Tufted Titmouse	Secondary	Generalist
White-breasted Nuthatch	Secondary	Generalist
Wood Duck	Secondary	Riparian
Red-headed Woodpecker	Primary	Forest-interior

Forest island size and shape go hand in hand when trying to discern the suitability of a forest island. It is frequently noted that the size of a forest island and its bird populations and richness are positively correlated (Brotons et al., 2003; Martin, 1980; Gallie et al., 1976; Askins, 1995). With larger areas, there are bound to be more resources for shelter and food. There also tends to be less predation in larger forest islands as they have less edge habitat, which favors predatory species like racoons and feral cats, as well as parasitism from Brown-Headed Cowbirds (*Molothrus ater*)and European Starlings (*Sturnus vulgaris*) (Askins, 1995; Semel &

Sherman, 1995)). Additionally, according to Gallie et al. (1976), forest-interior species will not occur unless there is at least a 0.8 hectare (ha) of forest; comparatively, only edge or generalist species, those able to adapt to and live in urbanized areas, were found at 0.2 ha. In addition to size, the shape of the forest island is important, as there could be a forest island that covers hundreds of hectares, but is too narrow and made up of mostly edge habitat.

The final characteristic, and largely the most important, is the surrounding matrix of the forest island. If a forest island is surrounded by urban streets, the habitat acts as if it is truly an island because no resources or stop-over habitat can be obtained from the surrounding area (Brotons et al., 2003). More suitable forest island would be one that is surrounded by agriculture followed by meadow, as the area can be used by generalist species that might search for food in the surrounding grasslands but roost and stay overnight in the forest. The most favorable would be a forest island that is surrounded by more trees, but ones that are not necessarily a part of a mature forest. This type of habitat offers the most resources and while generalist species will do the best in this situation, forest-interior species could still use these surrounding areas.

Despite their isolated nature and limitations, forest islands provide many species critical habitat for migration and nesting every year. While they may be less favorable than a national forest, they can be crucial as stop-over points and can even be preferred if the species wintering habitat is similar in composition or also a forest island (Martin, 1980). Colony-nesting species, such as purple martins which migrate and nest in large groups, actually use forest islands' small size to their benefit for smaller predator to bird ratios (Fournier et al., 2019).

Another characteristic that is determined by the size of the forest island is the availability of deadwood, especially snags (Gallie et al., 1976). With a larger, more mature forest, there is a higher likelihood of more snags, upon which cavity-nesting species are dependent for the breeding season. Cavity-nesting species are those that nest within excavated holes within dead trees, although living trees can also be used (Kilgo & Vukovich, 2014). Primary cavity-nesters, those that are able to excavate holes, include the Pileated Woodpecker (*Dryocopus pileatus*), Red-bellied Woodpecker (*Melanerpes carolinus*), and Northern Flicker (*Colaptes auratus*). Secondary cavity-nesters, species that cannot excavate holes and are reliant on primary cavity nesters, include the Tufted Titmouse (*Baeolophus bicolor*), Carolina Chickadee (*Poecile carolinensis*), and Wood Duck (*Aix sponsa*) (Martin & Eadie, 1999). However, even if a forest island has deadwood available, woodpeckers are less likely to utilize urban areas for habitat than other species, which could negatively impact the secondary cavity-nesters in that area as well (Zuckerburg et al., 2011).

Snag Characteristics

The most frequent data collected about snag characteristics includes diameter at breast height (DBH), snag height, level of decay, and species (Blewett & Marzluff, 2005; Lundquist & Mariani, 1991; Martin & Eadie, 1999; Moorman et al., 1999; Stauffer & Best, 1982).

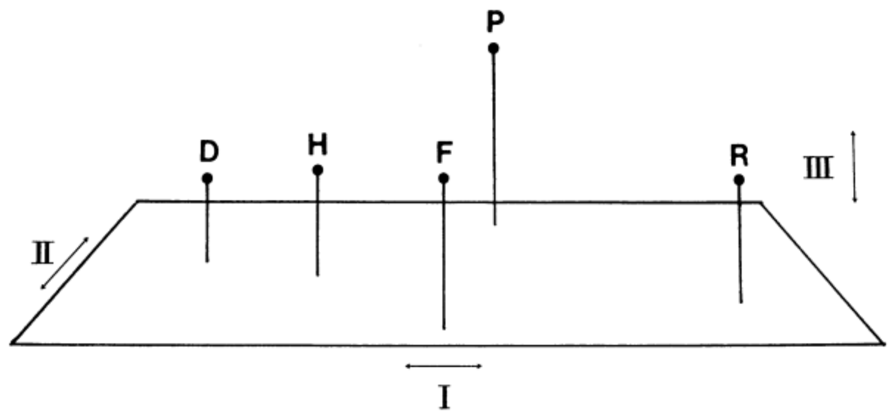

Figure 4. A visual of the preferences of woodpeckers: Downy (D), Hairy (H), Flicker (F), Pileated (P), and Red-headed (R). Preference I is forest maturity, least on the left and most on the right. Preference II is density with more open in the front and more dense in the back. Preference III is tree diameter, smaller on the bottom and larger at the top (Connor & Adkisson, 1977).

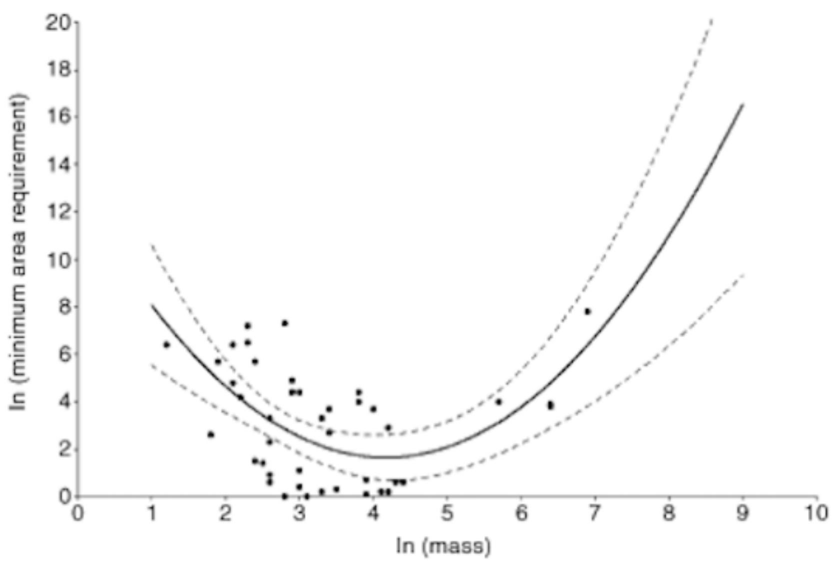

Figure 5. A graph showing how body size (mass) is positively correlated with larger species and negatively correlated with smaller species, with medium sized birds requiring the least. (Brown & Sullivan, 2005).

A few studies examined other snag characteristics such as year of death, cavity height, cavity orientation, and angle of trunk or limb (Moorman et al., 1999; Stauffer & Best, 1982). The preferences for each of these snag characteristics varied from species to species, such as the black-capped chickadee preferring snags with a smaller DBH than others (Stauffer & Best, 1982).

Some cavity-nesting species, such as the Northern Flicker, may be well-suited to the environment offered by forest islands. This species frequently nests in clear-cut areas or on the edge of clearing and woodlands (Connor & Adkisson, 1977). Additionally, they prefer open habitat, as they have been noted to forage in suburban and urban areas, as well as on farms and in orchards (Bent, 1939). However, they also prefer more mature habitat compared to the Downy woodpecker (*Dryobates pubescens*) and Hairy woodpecker (*Dryobates villosus*), but less mature habitat than the Pileated woodpecker prefers (Figure 4; Connor & Adkisson, 1977). However, because the Pileated woodpecker is larger than other cavity-nesters, it also requires larger trees in regards to diameter at breast height (DBH) to support a larger cavity.

Medium-sized cavity-nesters like the Black-Capped Chickadee (*Poecile atricapillus*), Great-Crested Flycatcher (*Myiarchus crinitus*), Tufted Titmouse, and the House Wren (*Troglodytes aedon*) are almost completely unaffected by fragmentation compared to other species of similar size that are not cavity-nesters (Brown & Sullivan, 2005; Figure 5).

Hairy and Downy woodpeckers could potentially do well in forest islands because they are more of a generalist species (Connor & Adkisson, 1977). They do not require large cavities or mature forest and they have been noted as nesting in either dense or more open areas. However, their numbers have also been recorded as increasing with increased shrub presence (Doherty & Grubb, 2000).

Meanwhile, Pileated woodpeckers may be the least suitable for forest islands. They require mature trees that are quite large to fit the size of their cavity (Connor & Adkisson,1977). They also prefer denser areas as compared to a more open forest. Therefore, these birds would require mature interior forests for nesting, which not every forest island can offer. Red-headed woodpeckers (*Melanerpes erythrocephalus*) require the same but to an even more extreme degree.

Additionally, Wood Ducks are unlike other cavity-nesters in that they require water near the snags (Gilmer et al., 1978). As wetland birds, they require riparian habitat or wetlands within the forest island. Although proximity to water seems to be the main preference, Wood Ducks were also found to gravitate towards canopy gaps and clearings. As larger secondary cavity-nesters, the presence of larger woodpeckers such as Northern Flickers and Pileated Woodpeckers is also beneficial so their habitat requirements will have a cascading effect.

Monitoring Methods

Most studies examining bird populations, nests, or snags, involve in-person traditional point and count methods to collect data (Blewett & Marzluff, 2005; Decker, 1959; Lundquist & Mariani, 1991; Martin & Eadie, 1999; Moorman et al., 1999; Stauffer & Best, 1982). However, one study collected data using satellite images and compared them over time to identify snags but found the process of snag decay to be too slow to effectively show up in the images (Bell et al., 2021).

Methods

Data for this study was collected from two of the major urban parks in Philadelphia, Pennsylvania: Wissahickon Valley Park and Cobbs Creek Park (Figs. 6 & 7). These parks were selected for their relatively large size, extensive wooded area including riparian habitat, and their location within a major urban center. Permission to collect data on these properties was acquired

Figure 6. A close-up of the two plots in Wissahickon Valley Park (Raezer, 2022).

Figure 7. A close-up of the two plots in Cobbs Creek Park (Raezer, 2022).

Figure 8. A ground view of Plot C2 in Cobbs Creek Park (by author, 2021).

by contacting the Philadelphia Parks and Recreation Department, the Cobbs Creek Environmental Education Center, and the Friends of Wissahickon to speak with each park's land or wildlife manager.

The data collected for this project included determining snag and other deadwood availability and the presence and abundance of cavity-nesting species. This information was collected in the field through in-person monitoring. Abundance of species was determined during the months of April through July in 2021 and in 2022 (Li & Martin, 1991; Lundquist & Mariani, 1991; Stauffer & Best, 1982). A habitat assessment was completed in November 2021 and in March 2022. Sampling locations of 0.5-acre circular plots, two in each park, were randomly selected within the parks' boundaries using mapping. In order to sample the riparian habitat, the sampling locations in each park were randomly selected along the riparian corridor; five points along the creek were created and numbered and then a random number generator selected two sites for the project (Stauffer & Best, 1982; Figures 8, 9, and 10). Initially, a plot was selected for Plot C2 in Cobbs Creek Park, but due to it being inaccessible, another plot location was randomly selected.

Figure 9. A ground view of Plot W1 in Wissahickon Valley Park (by author, 2022).

Figure 10. A ground view of Plot W2 in Wissahickon Valley Park (by author, 2022).

Similar to a study done by Lundquist and Mariani (1991), species monitoring within the sampling location occurred seven times at each plot during the 2021 nesting season. Due to safety concerns, Cobbs Creek Park was only monitored in 2021 and not in 2022. The traditional point-and-count method was used to collect the numbers of each bird species spotted within the sampling location and identification was completed through sight and hearing. Nests and their coordinates within the plot were noted at this time (Stauffer & Best, 1982). Binoculars and various print and digital field guides were used to aid in this process including eBird, Audubon, Merlin, and BirdNet identification guides. Sampling locations were monitored for one hour at a

Figure 11. A red-bellied woodpecker, primary cavity nester, perches near a cavity (Rhododendrites, 2021).

time between 6:00 AM and 11:00 AM. When birds were identified, their location within the plot was marked in a grid to determine the difference between several birds. If a bird was heard clearly, it was included in the data. If the bird sounded quieter, muffled, or farther away, it was not included.

For the habitat assessment, descriptions of the plot were recorded including successional stage, percent cover, and species present for the upper story, midstory, and groundcover. The percent cover of running water and human-made corridors within the plot were also recorded along with their estimated width and material, respectively. Percent cover of deadwood was also noted. Trees with potential for cavity-nesters, such as dying or dead trees or living trees with cavities, were tallied and categorized by their diameter at breast height (DBH) along with their species (Gibbs, Hunter, & Melvin, 1993). An example of a snag and cavity can be seen in Figure 11. The standing deadwood in the habitat assessment was divided into six DBH categories: (A) 10-20 cm, (B) 21-30 cm, (C) 31-40 cm, (D) 41-50 cm, (E) 51-60 cm, and (F) >60 cm. A second habitat assessment was completed for the Wissahickon Valley Park plots but only the most recent version was used to compare to the Cobbs Creek Park habitat assessments. A Biltmore reach stick and compass were used to delineate the plot while a standard arborist's stick was used to determine DBH (Figure 12). A clinometer was used to determine the heights of the snag and cavities.

Figure 12. An arborist's stick being used to measure the diameter at breast height of a tree within Plot C1 (by author, 2021).

Once the habitat assessment was complete, graphs using Excel were created to determine if any patterns present themselves with the characteristics of the snags. Additionally, the bird populations for each park were graphed and compared to each other and in relation to snag availability. To determine if the plots were in edge habitat, the coordinates were plotted in ArcGIS along with an outline of the two parks found from a public database of local parks (Figures 4 and 5; Pennsylvania Department of Conservation & Natural Resources, 2015). As previously mentioned, at 0.2 ha only edge species are present and interior birds start to appear at 0.8 ha (Gallie et al., 1976). Therefore, a spatial analysis was completed by adding a buffer of the width of 0.2 ha (44.7 m) to each plot, as well as a buffer the width of 1 ha (100 m). The measuring tools in ArcGIS were also used to determine distances.

Results

Cavity-Nesting Species Present

The most commonly observed cavity-nesting species was the Red-bellied Woodpecker (RBWO) with 78 observations out of 193 (or 40%) at the four plots (W1, W2, C1, and C2) combined in 2021 and 53 observations out of a total of 141 (or 37%) total observations at the two plots (W1, W2) combined in 2022 (Table 2 and 3). In 2021, this is followed by the Northern Flicker (NOFL) with 41/193 total observations (21%), the Tufted Titmouse (TUTI) at 26/193 observations (13%), and the Wood Duck (WODU) at 23/193 total observations (12%) (Figure 13). In 2022, the Wood Duck had 32/141 total observations (23%) followed by the Northern Flicker at 18/141 (13%) and the Carolina Chickadee at 11/141 (8%) (Figure 14). Of those in 2021, the plot C2 had the highest percentage of those observations for the Northern Flicker at 56% (23/41) and the Red-bellied Woodpecker at 37% (29/78) while plot C1 had the highest for the Tufted Titmouse (46%, 12/26) and plot W2 had the highest for Wood Ducks with (48%, 11/23) (Figure 15). In 2022, Plot W2 had the higher percentage of the Wissahickon Valley Park sites, though only slightly, with 55% of the Red-bellied Woodpecker (10/18) and Northern Flicker sightings (29/53), 50% of the Wood Duck sightings (16/32), and 81% of the Carolina Chickadee sightings (9/11) (Figure 16).

Table 2. All 2021 observations of cavity-nesting species at each plot along with their totals by species and totals by plot.

2021 Cavity-Nesting Species Observations					
	W1	W2	C1	C2	Total
CACH	0	0	1	0	1
DOWO	3	1	0	4	8
GCFL	0	0	0	1	1
NOFL	13	5	0	23	41
PIWO	5	4	0	0	9
RBWO	26	11	12	29	78
TUTI	7	5	12	2	26
WBNU	1	0	1	4	6
WODU	7	11	5	0	23
Sum	62	37	31	63	193

Table 3. All 2022 observations of cavity-nesting species at each plot along with their totals by species and totals by plot.

2022 Cavity-Nesting Species Observations			
	W1	W2	Total
CACH	2	9	11
DOWO	7	3	10
GCFL	0	0	0
NOFL	8	10	18
PIWO	6	1	7
RBWO	24	29	53
TUTI	1	3	4
WBNU	5	1	6
WODU	16	16	32
Sum	69	72	141

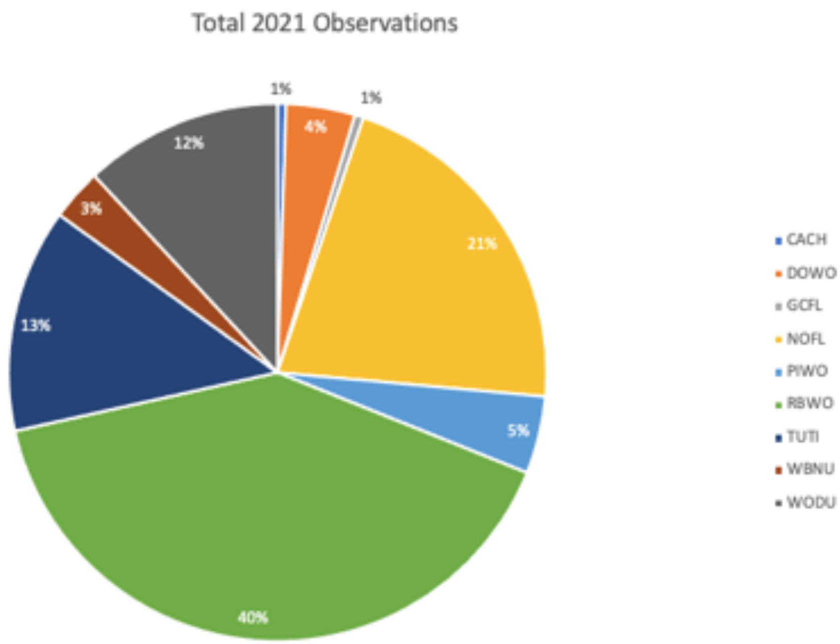

Figure 13. Total 2021 cavity-nesting species observations across all four plots.

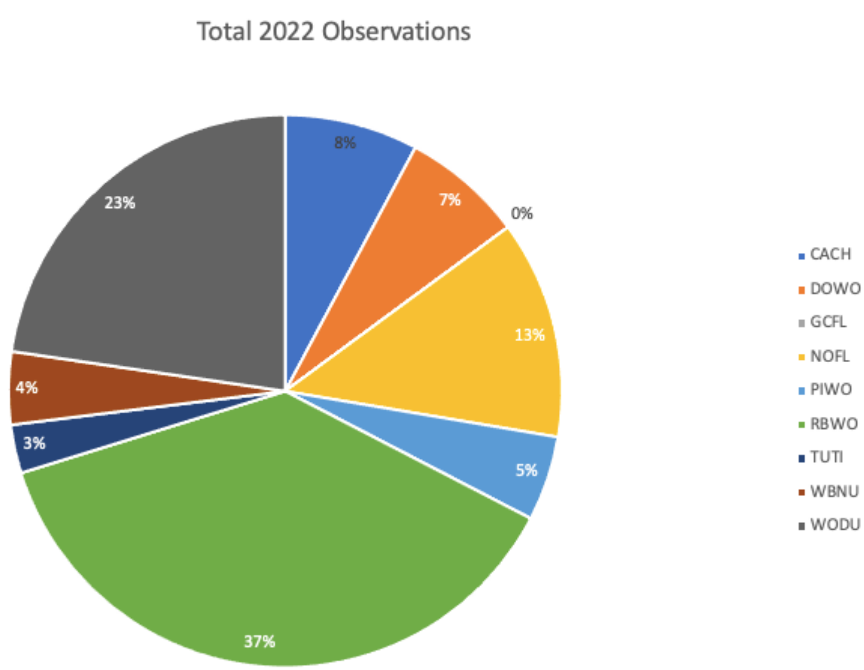

Figure 14. Total 2022 cavity-nesting species observations across all four plots.

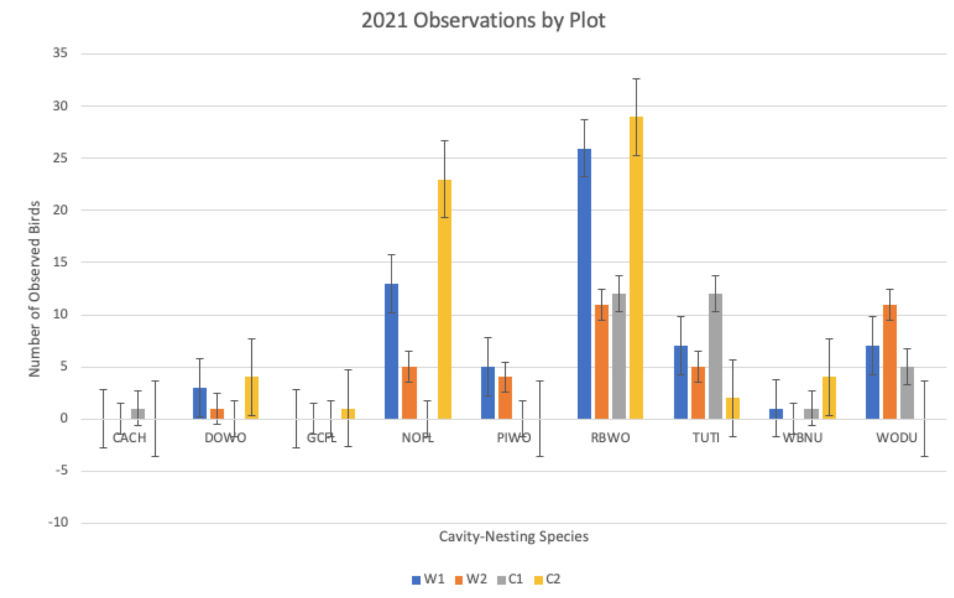

Figure 15. Distribution of all 2021 cavity-nesting species observations by species and plot.

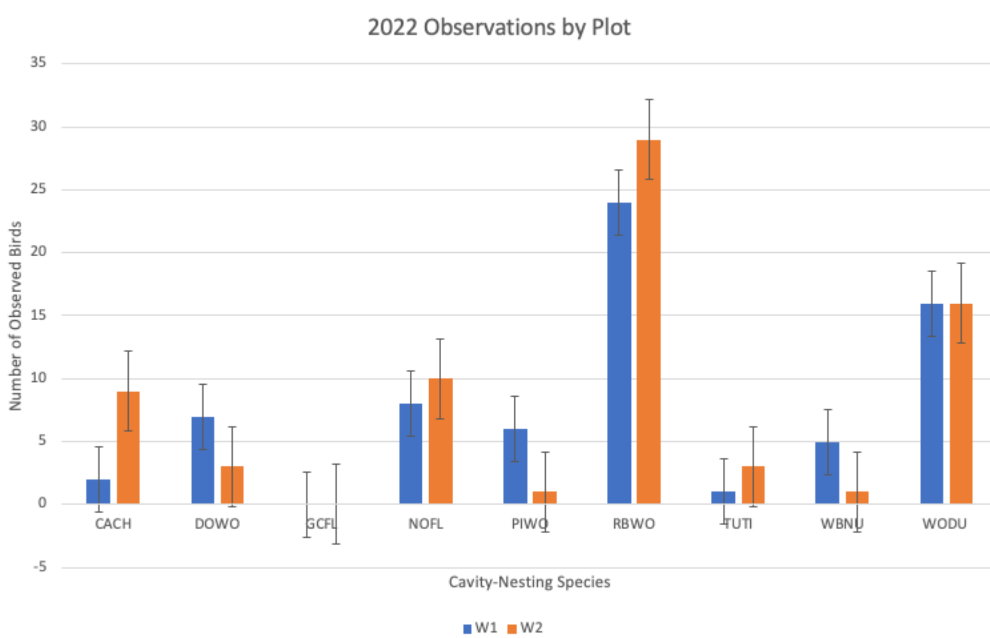

Figure 16. Distribution of all 2022 cavity-nesting species observations by species and plot.

Other cavity-nesting species recorded included the Carolina Chickadee (CACH) at Plot C1 in 2021 and Plots W1 and W2 in 2022; the Downy Woodpecker (DOWO) at Plots C2, W1, and W2 in 2021 and W1 and W2 in 2022; the Great-crested Fly Catcher (GCFL) at Plot C2 in

Figure 17. The male from the red-bellied woodpecker pair sticks his head out of the nest after feeding the young.

Figure 18. A juvenile male wood duck swims down the Wissahickon Creek.

2021; the Pileated Woodpecker (PIWO) at Plot W1 and W2 in both 2021 and 2022; and the White-breasted Nuthatch (WBNU) at Plots C1, C2, and W1 in 2021 and W1 and W2 in 2022.

Nesting

Only one nest was observed over the course of the 2021 nesting season: a Northern Flicker pair at plot C2 in a snag. The nest was first identified on May 15, 2021 and appeared to be finished on June 18, 2021. In 2022, again only one nest in a snag was observed: a Red-bellied woodpecker pair at Plot W2. The nest was identified on April 19, 2022 and fledglings could be heard on the last monitoring day on July 3, 2022 (Figure 17).

Additionally, other young birds were seen though no nest was identified within the plot for these. Five Wood Duck fledglings were observed at Plot W2 on May 2, 2021 in the creek with the mother while three fledglings were observed with their mother at the same plot on May 14, 2022. A juvenile Red-bellied Woodpecker was seen foraging for food on a tree on June 11, 2022 at Plot W1 and a juvenile male wood duck was seen swimming on July 3, 2022 (Figure 18).

Habitat

The habitat assessments found all four plots to have little to no regeneration of canopy species and to have heavy invasive species presence in the midstory and understory. Most of the plots, with the exception of C1, were in the mixed but mostly mid-successional stage with an abundance of maples and tulip poplars, though some oaks and other late successional species were present. Each plot included a human-made trail, although plot W2 had a significantly greater impacted area, with a gravel road taking up 30% (see Appendix for habitat assessments). Additionally, the running water present for plots C2, W1, and W2 were all about 25-30% with streams greater than 5 meters in width. Plot C1, meanwhile, had a stream of only 2-5m and only 15% of the plot was running water. Most plots, with the exception of the northern-most plot (C1), are within the boundaries of the park and are not considered within edge habitat. However, most of them come within the width of 2 ha of the edge of the park. Additionally, a total area of

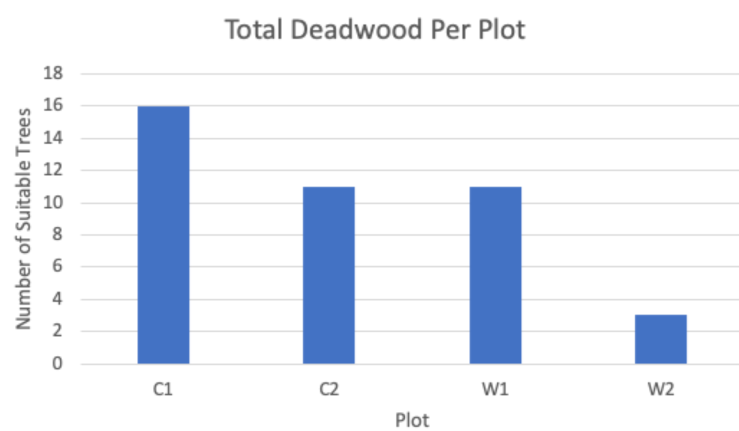

Figure 19. Total deadwood available at each site included dying or dead trees or living trees with cavities. Data from Plot C1 and C2 is from 2021 and data from Plot W1 and W2 is from 2022.

each park was also calculated using ArcGIS as well as the width of each at its narrowest point. Cobbs Creek Park is a total of 545.87 ha with a width of 59.1 m at its smallest area while Wissahickon Valley Park is 1,300.92 ha with a width of 307.6 m at its smallest.

Standing Deadwood Availability

The deadwood available, including dying trees, dead trees, and living trees with cavities, was found to be the highest in plot C1 with 16 total observed prospect trees, followed by C2 and W1 with 11 total each, and W2 with 3 total (Figure 19). Plot C1 had 7 dying, 8 dead, and 1 living tree with a cavity. Plot C2 had 4 dying and 7 dead. Plot W1 had 6 dying, 4 dead, and 1 living tree with a cavity. Finally, Plot W2 only had 3 dying trees. The most prevalent DBH category among the deadwood was (B) 21-30 cm with 10 total across all plots, 7 of which were in Plot C1 (Figure 20). Plot C1 also had the most diverse deadwood availability in terms of size class with at least one observation in each size category and all three deadwood types present. Species of the deadwood were also recorded, with Black Cherry and White Oak being the most common in Plot C1 and Black Walnut being the most common in Plot W1.

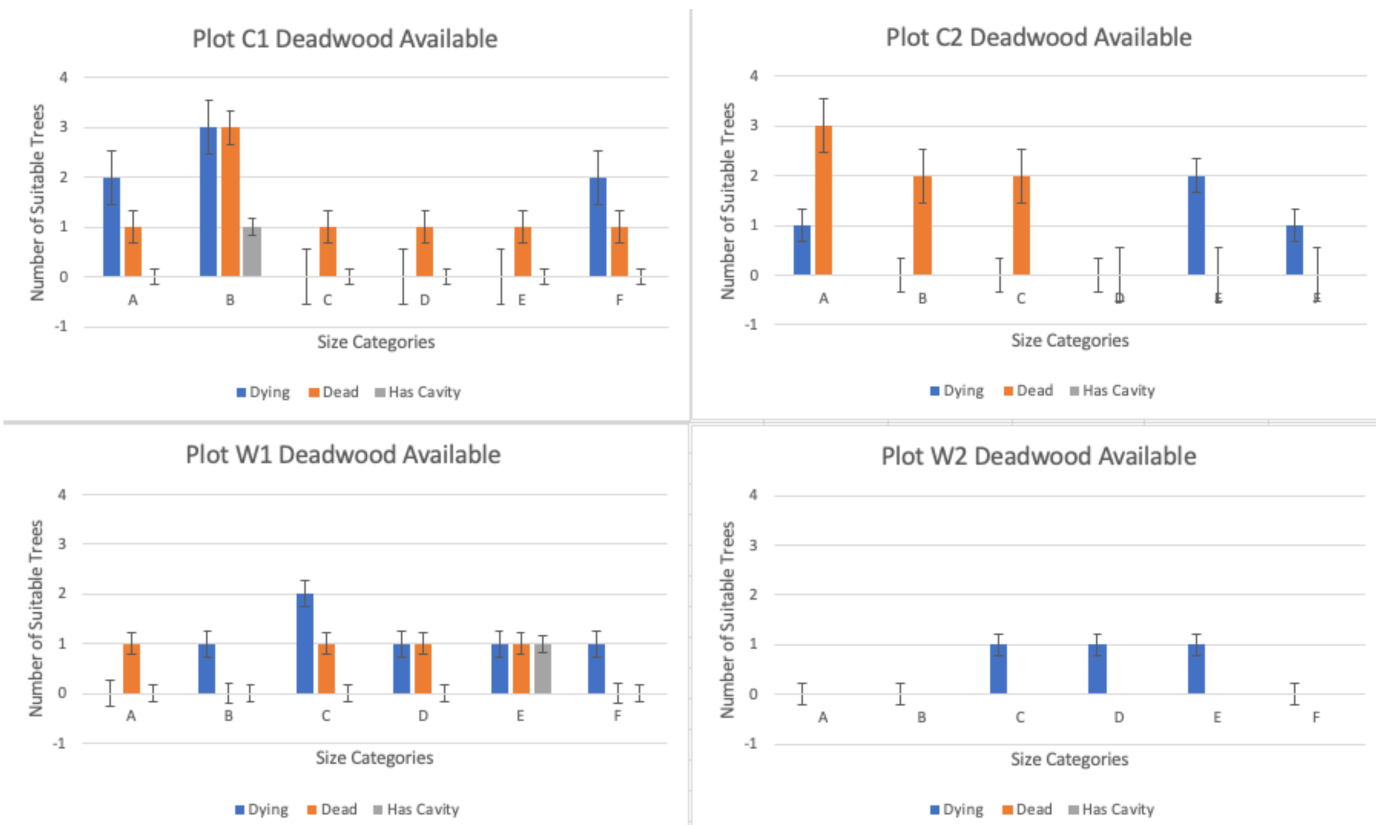

Figure 20. Number of suitable nesting trees by size at each plot.

Discussion

Primary & Secondary Cavity-Nester Relationship

Because secondary cavity-nesters, such as Wood Ducks, are dependent on primary cavity-nesters to create cavities, it is very important for primary cavity nesting species to be present. Therefore, it is a good sign that Red-bellied Woodpeckers were the most commonly observed species. The most observed Red-bellied Woodpeckers and Northern Flickers in 2021 were seen at Plot C2, which overlapped with the most observed White-breasted Nuthatches, a secondary cavity-nester. However, the most Tufted Titmice and Wood Ducks (other secondary cavity-nesters), were seen more commonly at C1 and W2, respectively. In 2022, some species were more present at one plot than the other, but secondary and primary cavity nesters were distributed somewhat evenly: Plot W2 had the most of Red-bellied woodpeckers (PCN), Northern Flickers (PCN), and Carolina Chickadees (SCN) while Plot W1 had the most Pileated Woodpeckers (PCN), Downy Woodpeckers (PCN) and White-breasted Nuthatches (SCN).

Deadwood Availability & Species Relationship

The most deadwood suitable for nesting was at Plot C1, with the highest recorded number of suitable trees or snags at 16 and high diversity in sizing. The abundance of deadwood is most likely due to nearby beaver activity within Cobbs Creek Park. Several stumps with distinctive chew marks were noted, leading to successful treefall. However, the only species that was most observed at this location was the Tufted Titmouse. Conversely, Plot W2 was the least diverse with sizing and had the least amount of suitable snags with only three noted but had the highest number of observed birds in 2022 and the highest number of Wood Duck observations in 2021.

Black cherry, white oak, and black walnut trees were the most commonly observed trees that were suitable for nesting (dead, dying, or with cavities) but seemingly not by a significant amount, with 4 each (Figure 21). However, the hemlocks present at Plot W2 showed signs of being afflicted by the hemlock woolly adelgid, an invasive insect, which if left untreated could lead to more deadwood available at this location.

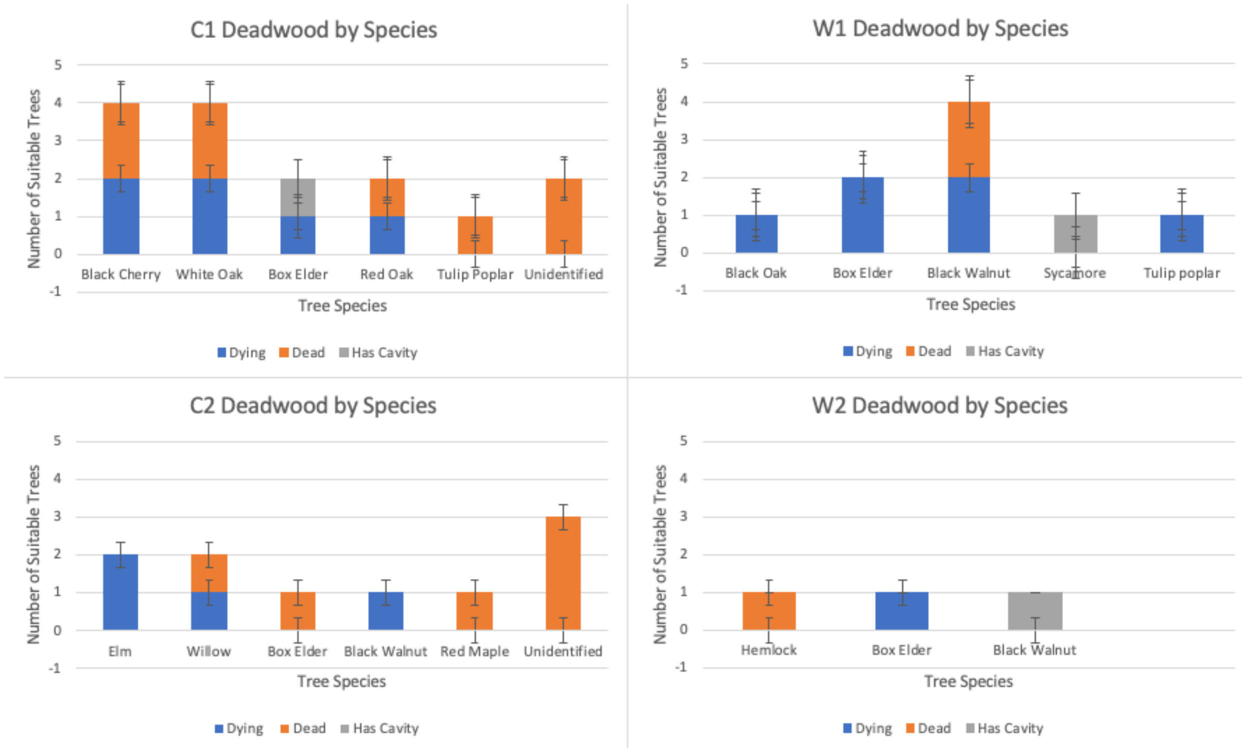

Figure 21. Number of suitable nesting trees (dead, dying, or living with a cavity) by species at each plot.

Other Habitat Characteristics

All four plots are affected by noise pollution as there are roads and trails near each plot. However, Plot C1 is located near a train and bus station which generate continuous noise. Both plots in Wissahickon Valley Park are near Forbidden Drive, a very popular and heavily-trafficked foot and bike trail, but Plot W2 is the closest, with 30% of the plot consisting of human-made corridors. This difference in level of disturbance may be reflected in the lower number of total birds observed in 2021 at C1 and W2, 32 and 37, respectively when compared to the higher numbers observed at less disturbed C2 and W1, 63 and 62, respectively (Table 2). Conversely, Plot W2 proved to be just as successful at harboring birds as W1 in 2022 despite being closer to the main trail (Table 3).

When considering the size and the width of these parks, it is understandable to assume that Wissahickon Valley Park is able to support more forest-interior species, as it is more than double the area of Cobbs Creek Park. For example, Red-Bellied Woodpeckers have relatively small breeding ranges, as small as 3 ha in some instances (Miller et al., 2020). This species has even been recorded nesting in the same tree as another pair. Additionally, medium-sized birds are expected to increase in density and require the least amount of forested area (Brown & Sullivan, 2005). Therefore, it fits that this bird was the most commonly occurring at each plot.

Additionally, while most of the plots were away from the edge habitat, there are several species that do very well in urban and suburban settings including the Tufted Titmouse, the White-breasted Nuthatch, and the Northern Flicker. In the case of the Flicker and the Tufted Titmouse, these birds occurred the second and third most, respectively. However, this did not necessarily fit with the data for the White-Breasted Nuthatch, as this species was only identified six times across each nesting season. Some cavity-nesting species which would have been expected due to being generalists but were not noted at all include the House Wren both years and the Great-Crested Flycatcher in 2022.

Another species that was not spotted as much was the Pileated Woodpecker, with only 9 occurrences in 2021 and 7 occurrences in 2022 (Tables 2 & 3). However, this is likely due to the species' need for larger breeding habitat, with ranges anywhere from 20 ha to 150 ha of mature forest with higher densities and taller trees (Bull & Jackson, 2020). Additionally, larger birds naturally require a larger home range (Brown & Sullivan, 2005). Therefore, it also is understandable that this bird was not seen at all at the Cobbs Creek plots. Similarly, the Red-headed Woodpecker is the most particular about its nesting site and therefore, it makes sense that this species was not recorded at all (Connor & Adkisson, 1977).

A positive correlation between available standing deadwood and cavity-nesting birds was expected but this was not the case in this study. With higher numbers of snags, more woodpeckers and other cavity-nesters should be present but the plot that had the most snags and the most variance in the DBH of the snags was plot C1, which had the least overall number of cavity-nesting species occurrences. Additionally, while not necessarily beneficial as a food resource, invasive shrubs such as Privet (*Ligustrum sp.*) and Japanese Honeysuckle (*Lonicera japonica*) are quite common, offering the shrubby habitat seen to be linked with Downy and Hairy Woodpecker presence (Doherty & Grubb, 2000).

At the conclusion of the 2021 nesting season, it was thought that the reason for differing numbers at the different sites was due to noise pollution. Plots C1 and W2 had the lowest number of bird sightings; C1 is located near a bus SEPTA train station and W2 is located near a picnic area. However, this could have been a sign that the location was too close to human activities, thus creating some edge effect which could be the true reason for a lack of occurrences of more forest-interior species. Considering all of this, it must be acknowledged that there could be some bias with regards to bird identification skills, which improved as the nesting seasons progressed.

Management Suggestions

While forest islands offer varied habitat, it may be possible to improve their ability to offer the best resources possible for a larger amount of bird species by increasing the availability of food and sheltering resources, maximizing the shape and size of the forest island, and bolstering the quality of the surrounding matrix.

Nesting Boxes

If there is concern over the number of available snags, many cavity-nesting species are able to nest in man-made boxes (Waters et al., 1990). While these boxes need to be maintained (cleaned out at the end of the nesting season and prepped for the next), they can be beneficial in creating habitat. Many blueprints are available online as well as information on how to properly set them up per bird preferences (NestWatch, n.d.). The structures can be helpful for secondary-cavity nesters, especially wood ducks. Additionally, nest boxes should generally be placed in more hidden areas to reduce the likelihood of European Starlings taking over the box (Semel & Sherman, 1995). Other than maintenance, this option is relatively low-cost and does not require many person hours. It can also offer the public the opportunity to observe and monitor bird species.

Deadwood Management

To the detriment of cavity-nesting species, deadwood is frequently removed for aesthetic and safety reasons, especially in public places like parks (Hutto, 2006). Cluttered woodlands are considered messy and many park managers worry about trees falling on bikers and hikers along paths. However, these can be carefully managed to ensure public safety and maintain habitat quality. If a snag is further away from the path, it should be left standing as a resource for birds (and other wildlife). Additionally, careful consideration should be made to leave snags of varying ages, species, decay level, and height (Zarnowitz et al., 1985; Sedgewick & Knopf, 1986). Efforts should be made to leave snags standing if they contain previously made cavities to aid secondary cavity-nesters (Sedgewick & Knopf, 1986; Figure 22). Whenever possible, if a snag is closer to a path, the top part of the tree can be removed, a method called topping, to prevent toppling into the path and the lower portion of at least two meters tall should remain (Bull & Partridge, 1986). To create more snags in areas that do not have many, invasive trees, such as the Tree-of-Heaven (*Ailanthus altissima*) and Weeping Japanese Cherry (*Prunus subhirtella*), can be killed and left in place. Trees can be killed using girdling, herbicide, fungi,

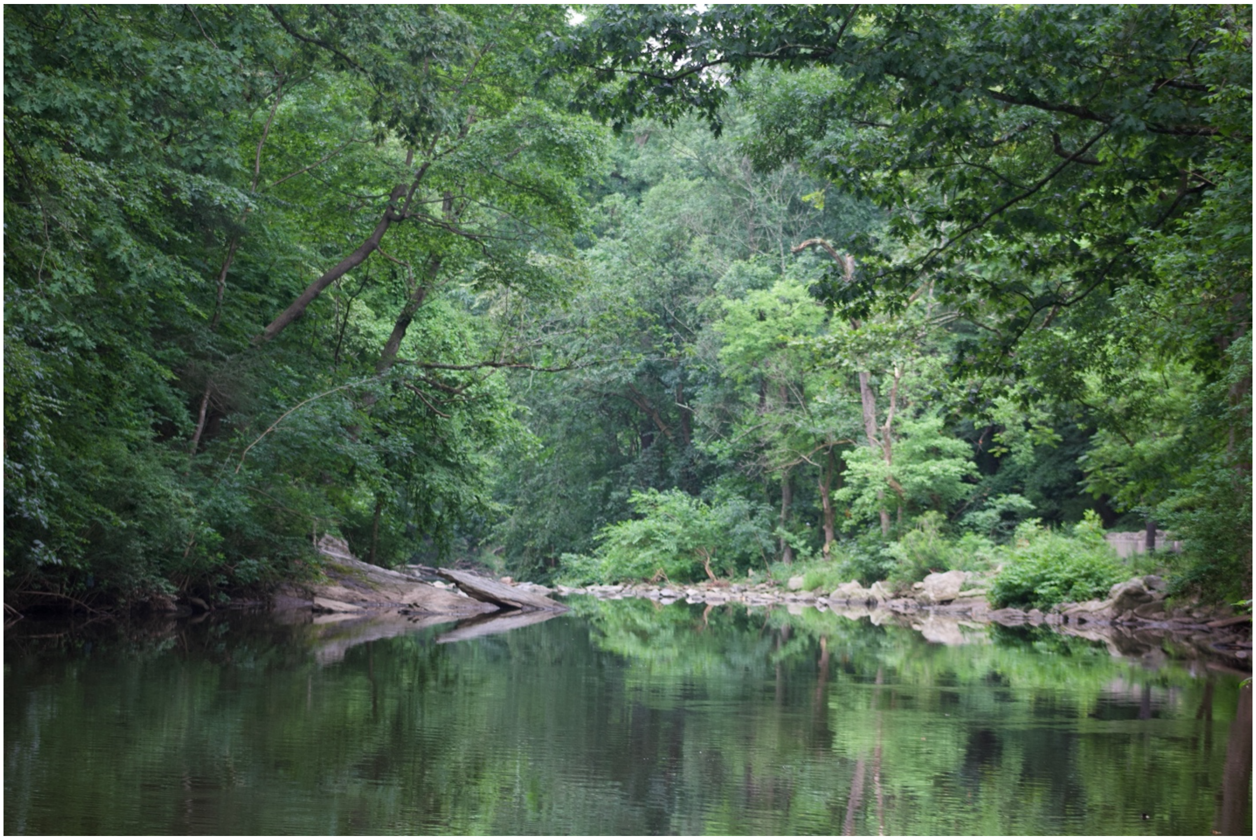

Figure 22. A view of Wissahickon Valley Park's riparian corridor with a snag visible on the right bank (by author, 2022).

or topping but the most effective is topping as it was found to be used more frequently by woodpeckers and fall less frequently (Bull & Partridge, 1986). While this option can be more expensive, it can be useful and more efficient at creating habitat.

Regional Efforts

When looking at the aerial views of both parks, the surrounding matrix is very different between the two forest islands. Cobbs Creek is mostly surrounded by urban and developed areas and the trees stop abruptly at the boundary of the park. In contrast, Wissahickon Valley Park is surrounded by more vegetation growing in adjacent parks, golf courses, and residential properties as well as along streets. However, this expands and improves that matrix and offers resources to more bird species, even if it mainly helps the edge and generalist species (Brotons et al., 2003). To improve this, more efforts should be made to plant street trees and green up other urban areas. Organizations like the Philadelphia Orchard Project and Tree Philly work to introduce more nature to the city (Philadelphia Orchard Project, n.d.; Tree Philly, n.d.). The former organization works to establish orchards while the latter organization also offers free street trees in addition to other tree services. This is also an added benefit for the surrounding communities as it has been shown that some greenery and nature improve mental and physical health in highly developed areas (Kondo et al., 2018).

However, the most important aspect of improving forest islands is conservation. The only way to increase the acreage available, even in isolation is to create and protect larger forests (Askins et al., 1987). Parks, conservation organizations, and other environmental agencies should work together on a regional scale to ensure that all habitat types are present, especially mature forests. The best method for having more forests is to protect them.

In the future, this study could be expanded upon with more plots within each park or plots in additional urban parks in Philadelphia, such as Pennypack Park or Fairmount Park. Additionally, more observers skilled in bird observation monitoring at one time could improve identification accuracy. More public engagement is important to change perspectives on the aesthetics of snags and deadwood. Involving the community in making and checking nest boxes could also educate people on cavity-nesters, as well as increase excitement and ownership of their local urban parks.

Conclusion

Despite forest islands such as Cobbs Creek Park and Wissahickon Valley Park being adversely affected by introduced, invasive plant species, predation from raccoons and snakes, parasitism, and a lack of resources, they still offer crucial habitat for many bird species, whether they are migrating, nesting, or just stopping by. Importantly, they can offer a home to primary and secondary cavity-nesting species, which have a difficult time finding suitable nesting sites due to the frequent removal of snags. Even though limited nests were found in this study of the two parks during the summer of 2021 and 2022, many young birds were observed, suggesting that suitable habitat was nearby, but outside of the plots. Wissahickon Valley Park seems like a suitable forest island for more forest-interior birds due to its size and shape and Cobbs Creek Park seems like a suitable one for more generalist species. However, many forest islands are not as hospitable and could use serious improvement, such as nesting box programs, snag maintenance, and biodiversity conservation. Therefore, it is important to work on conserving the remaining woodlands of the east coast, reconnecting isolated patches where possible, and encouraging the overall health and biodiversity of these forests so that they can support and encourage healthy bird populations with an emphasis on the less well-known cavity nesting species that have more limited nesting opportunities.

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Appendix

Capstone Habitat Assessment							
Date: 10/16/21		**Plot:** C1		**Observer(s):** Noelle Raezer, Jacob Goudy			
Describe habitat type: Riparian wooded area dominated by oaks and tulip poplars with heavy invasive species presence in all layers, little regeneration with beaver pressure and many soon-to-be-dead trees					**Successional stage (circle one):**		
					Late	Mid	Early
Vegetative							
Average Height of:		**Canopy:** 48 degrees at 50 ft		**Shrubs:** 5 ft		**Herbaceous Vegetation:** 3 ft	
Vegetative Layers	**Cover (%)**	**Main Species**					
Upperstory	40%	red oak, white/swamp oak, tulip poplar, norway maple, locust?					
Midstory	10%	mimosa, holly, honeysuckle, box elder, walnut, mystery shrub (check pics), cherry					
Ground cover	85%	japanese knotweed, stiltgrass, white snakeroot, wineberry, poison ivy, celastrus, deer tongue					
Non-vegetative							
	Cover (%)	**Features (circle)**					
Running water	15%	>0.5m	0.5-2m	2-5m	>5m?		
Human-made Corridor	>1%	paved	gravel	dirt	mown		
		road	track	trail	other		
Dead Wood							
	10-20cm	**21-30cm**	**31-40cm**	**41-50cm**	**51-60cm**	**>60cm**	
Snags (Count)							**see Deadwood tab**
Dying Trees (Count)							
Living with cavities							
	Cover (%)			**Type (circle)**			
Dead Wood	20%	leaves	twigs	branches	old logs	treefall	
Notes							
	Don't count dead branches						
	Lots of snags just out of plot						

Capstone Habitat Assessment							
Date: 10/9/21		**Plot:** C2		**Observer(s):** Jacob Goudy, Noelle Raezer			
Describe habitat type: Riparian area dominated by maples and sycamores with excessive invasive species and vines in understory, excessive trash and noise pollution from roadways, zero regeneration, steep banks					**Successional stage (circle one):**		
					Late	Mid	Early
Vegetative							
Average Height of:		**Canopy:** 35 degrees at 50 f		**Shrubs:** 20 ft		**Herbaceous Vegetation:** 1 ft.	
Vegetative Layers	**Cover (%)**	**Main Species**					
Upperstory	50%	sugar maple, sycamore, box elder, black walnut, silver maple, mockernut hickory					
Midstory	15%	unknown shrubs, pics for ID					
Ground cover	60%	lonicera, stiltgrass, knotweed, nettle, grape, english ivy, snakeroot, clearweed, poison ivy, bittersweet, pennisetum, hops					
Non-vegetative							
	Cover (%)	**Features (circle)**					
Running water	30%	>0.5m	0.5-2m	2-5m	>5m		
Human-made Corridor	1%	paved	gravel	dirt	mown		
		road	track	trail	other	2 streams meet	
Dead Wood							
	10-20cm	**21-30cm**	**31-40cm**	**41-50cm**	**51-60cm**	**>60cm**	
Snags (Count)							**see deadwood tab**
Dying Trees (Count)							
Living with cavities							
	Cover (%)			**Type (circle)**			
Dead Wood	5%	leaves	twigs	branches	old logs	treefall	
Notes							
	ground cover determined by what wasn't water or dirt						
	bottom out but falls into plot- doesn't count - put it towards dead wood						
	if split below DBH, count as two individuals						

Capstone Habitat Assessment							
Date: 4/24/22		**Plot:** W1		**Observer(s):** Noelle Raezer, Tara Spears			
Describe habitat type: Wooded riparian corridor dominated by black walnuts and tulip poplars with little regeneration and heavy presence of invasives in understory, some noise pollution from trail				**Successional stage (circle one):**			
				Late	Mid		Early
Vegetative							
Average Height of:		**Canopy:** 80 ft		**Shrubs:** 10 ft		**Herbaceous Vegetation:** 4 in	
Vegetative Layers	**Cover (%)**	**Main Species**					
Upperstory	40%	tulip poplar, sycamore, box elder, beech, black walnut, black oak					
Midstory	15%	bush lonicera, redbud, tulip poplar, privet, bladdernut					
Ground cover	70%	oriental bittersweet, celandine, claytonia, privet, garlic mustard, rose, wineberry, wild onion, violets, lonicera, trout lily, poison ivy					
Non-vegetative							
	Cover (%)	**Features (circle)**					
Running water	25%	>0.5m	0.5-2m	2-5m	>5m		
Human-made Corridor	30%	paved	gravel	dirt	mown		
		road	track	trail	other	sand	
Dead Wood							
	10-20cm	**21-30cm**	**31-40cm**	**41-50cm**	**51-60cm**	**>60cm**	
Snags (Count)							**see deadwood tab**
Dying Trees (Count)							
Living with cavities							
	Cover (%)	**Type (circle)**					
Dead Wood	5%	leaves	twigs	branches	old logs	treefall	
Notes							
frequently floods > little light deadwood			f				

Capstone Habitat Assessment							
Date: 04/24/22		**Plot:** W2		**Observer(s):** Tara Vent, Noelle Raezer			
Describe habitat type: Riparian buffer with road-like trailway dominated by box elder, hemlock, and tulip poplar with heavy invasive pressure in midstory with some regeneration and heavy erosion and foot traffic				**Successional stage (circle one):**			
				Late	Mid		Early
Vegetative							
Average Height of:		**Canopy:** 62 degrees at 50 ft		**Shrubs:** 10 ft		**Herbaceous Vegetation:** 6 in	
Vegetative Layers	**Cover (%)**	**Main Species**					
Upperstory	35%	box elder, hemlock, tulip poplar, black walnut, sycamore					
Midstory	40%	privet, jetbead, spicebush					
Ground cover	40%	Japanese knotweed, celandine, violets, wineberry, lonicera, ferns, soloman's seal, dandelions					
Non-vegetative							
	Cover (%)	**Features (circle)**					
Running water	30%	>0.5m	0.5-2m	2-5m	>5m		
Human-made Corridor	30%	paved	gravel	dirt	mown		
		road	track	trail	other		
Dead Wood							
	10-20cm	**21-30cm**	**31-40cm**	**41-50cm**	**51-60cm**	**>60cm**	
Snags (Count)							**see deadwood tab**
Dying Trees (Count)							
Living with cavities							
	Cover (%)	**Type (circle)**					
Dead Wood	10%	leaves	twigs	branches	old logs	treefall	
Notes							
plot is 1/3 trail, 1/3 creek, 1/3 vegetated							
big recreation area with picnic area to the North							
wooly adelgid presence in hemlocks with tags (9598, 9599, 9600, 9597)							