



4-27-2022

Kleinstuck Preserve: A Valuable Migratory Bird Stopover in Kalamazoo, MI

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April 2022

Acknowledgements

Dr. Sharon Gill,

Thank you for dedicating time and providing inspiration as I completed my honors thesis. I will always be honored to have worked with you!

John Brenneman,

Thank you for your dedication to my thesis and all of the birds at Kleinstuck Preserve. I am very thankful to have seen so many beautiful migrant species through your first pair of binoculars.

Victor de Brito,

Thank you for joining my thesis committee and taking the time to work with me outside of the classroom!

Thank you to the Kalamazoo Nature Center for providing over 100,000 data points on the bird surveys! It is truly phenomenal to unpack the work completed by dedicated birders in the field.

Abstract

Decreasing bird populations have been noted with habitat loss, climate change, and human development. With an estimated loss of 2.9 billion birds in North America since the 1970's (Rosenberg et al. 2019), I found it necessary to determine whether this pattern was reflected in local bird populations. At Kleinstuck Preserve, a birding hotspot in Kalamazoo, MI, I was able to access data from 48 years of bird surveys starting in 1973 with 209 total bird species documented from 1973-2021. Kleinstuck is a 60-acre nature preserve that has been protected as natural land since 1922 despite being surrounded by urban development. My study aims to determine the extent to which birds utilize Kleinstuck Preserve as a migratory stopover. Both migrant and resident bird species are portrayed to depict patterns in species composition and detect differences between the two categories of birds. My methodology follows a snapshot approach that captures the species composition in 1973, 1997, and 2021. This approach is similar to that used in Walk et al. 2010, reflecting the patterns in species composition from the beginning, middle and end points of data collection at Kleinstuck Preserve. Of the top 1% of migrant and resident species documented at Kleinstuck Preserve in these 3 years, there is a pattern of decline in migratory bird abundance. For 16 of the 29 migratory species that met this qualification, the maximum percent composition was obtained in 1973. An illustration of the species composition changes from the first, middle, and final increment depicts that migratory birds have declined relative to the total bird population at Kleinstuck preserve. The reasoning behind migratory bird declines at Kleinstuck Preserve is very complex, as there are numerous factors that contribute to such declines. Habitat loss, land development, noise and light pollution, habitat change, competition, and climate variation are among potential factors that may have contributed to bird declines at Kleinstuck Preserve. With approximately half of the major migratory species declining according to the patterns of this

snapshot, there is reason to take action to further protect migratory bird species. Based on the species count, which increased by two migrant species and four resident species from 1973 and 1997 to 2021, Kleinstuck Preserve has remained a valuable migratory stopover site for many bird species.

Introduction

Severe bird declines have been observed in the past five decades. The loss of an estimated 2.9 billion birds in North America from 1973 to 2017 is indicative of improper habitat conditions (Rosenberg et al., 2019). Widespread conversion of natural habitat into developed areas has left just a fraction of land that is suitable to sustain healthy ecosystems. Migratory birds are especially at risk given that only 9% of land they depend upon is protected (Runge et al. 2015). Resident bird species face a similar threat with diminishing habitat. Within their respective regions, 45% of land used by non-migrant species is protected (Runge et al. 2015). There is great concern over avian extinction and endangerment as habitat loss increases. While there are staggering declines in bird species across North America, rare and threatened species are not the only fauna declining. Habitat generalists and introduced bird species, which fare better due to their broader ecological niches, have declined significantly alongside native and specialist bird species (Rosenberg et al. 2019). Taking inventory of bird populations is essential to understand the species undergoing declines and the variation in ecosystem integrity that contributes to the sixth mass extinction.

Due to the energetic costs and dangers of flying long distances, migration is a risky life strategy for all migrating species. Approximately 25-33% of the annual cycle of a migratory bird is spent on migration (Bonter et al. 2009). Some migration routes span several countries. Several factors contribute to the path that a migratory bird travels along such as genetic predisposition,

proximity of a site to a geographical barrier, and weather patterns. Short-distance migrants can obtain a better sense of the weather due to their proximity to their migratory stopover site compared to long-distance migrants, or neotropical migrants, which are unable to sense conditions across continents. Migrants that travel farther are more likely to require stops at multiple sites over their migration routes to gain energy and resources. Migratory birds rely on such stopover sites for rest and dietary energy supply (Adi et al. 2021). Once a stopover site is reached, a migratory bird is often too depleted to relocate. Stopover sites of low quality pose a major risk to birds that require immediate gains for the remaining journey (Adi et al. 2021). Due to the risk of crossing a large region of uninhabitable land, migratory birds prefer to stop at sites that are located on or near geographical barriers, such as those between land and water (Bonter et al. 2009).

Environmental health and ecosystem integrity can be inferred based upon surveys of avifauna. As birds are one of the most heavily monitored animal species, analysis of data from bird surveys can be used to assess ecosystem health (Rosenberg et al. 2019). Monitoring bird species present on ecologically restored sites has been incorporated into determining the extent to which ecological restoration has occurred (Ortega-Alvarez & Lindig-Cisneros, 2012). Protecting land that migratory birds use as stopover sites during migration is essential in maintaining and restoring migratory bird populations. The 1916 Migratory Bird Treaty between the United States and Canada, the Endangered Species Act and other international treaties have been effective in minimizing avian extinctions (Rosenberg et al. 2019). Maintaining the proper habitat for birds is essential in urban locations as well. Urban stopovers provide refuge for migratory birds that may otherwise find themselves in a site without resources. Habitat fragmentation, which is the spacing of natural landscapes amongst developed land, decreases biodiversity in native vegetation and decreases populations of native wildlife (Marzluff & Ewing, 2001). Maintaining habitat fragments

and surrounding area is necessary to maintain biodiversity of flora and fauna, but it is likely that habitat fragments may only conserve a few species (Marzluff & Ewing, 2001). The creation and maintenance of urban parks in developed areas provides refuge to wildlife, including migratory birds. Migrants that fly over developed areas are especially in need of naturalized landscape when there is little foliage remaining in a region. Reducing the effects of urbanization on migratory birds can be accomplished by protecting and maintaining suitable habitat (Marzluff & Ewing, 2001).

The urban stopover site that I am studying is Kleinstuck Preserve, a 60-acre nature preserve that is open to the public in Kalamazoo, MI. The intent of this study is to investigate the extent to which Kleinstuck Preserve functions as a migratory stopover site and whether bird species have declined over time. The bird species composition at Kleinstuck provides information on the viability of the site as a migratory stopover based on the presence and abundance of migratory species. Within 48 years of accessible bird surveillance data taken from late March to late May of 1973-2021, I analyzed bird populations during the initial, intermediate, and latest survey years to explore trends in species composition. This model of data analysis reflects that used in Walk et al. (2010), where species composition was analyzed every 50 years starting in the 1900s. I seek to determine whether the community composition at Kleinstuck Preserve is unchanged with respect to migratory birds that stopover at this site. Monitoring the specific species and the presence, absence, or stagnancy of visitation in the three-year period can evaluate the extent to which the preserve functions as a stopover site considering that habitat change has occurred since surveys began in 1973. The results of each of the three years studied may determine whether Kleinstuck was a suitable habitat for migratory birds in each period. Monitoring changes in composition of resident species provides insight into whether a baseline of change has occurred at the site.

In addition to exploring changes in migratory species over time, I examined patterns in species composition of resident species to determine the variety of bird species that the site can support and whether population trends are similar for resident and migratory species. Habitat changes have occurred through development of agricultural, industrial, commercial, and residential zones in Kalamazoo County and surrounding areas. With this development, there are fewer natural spaces for birds to reside in. This decreases available refuge for resident birds year-round. With fewer spaces, there is increased competition between birds (Marzluff & Ewing, 2001).

Restoring habitat on the preserved land has provided refuge for wildlife amidst miles of developed land. Given the work done since the first major planting of 12,000 native pine trees in 1927, there has been ongoing restoration work at this preserve for nearly a century. Significant acts of planting, notably the planting of 600 shrubs between 1951-1967 and native grass and wildflower transplants in the past decade (Kleinstuck Preserve). The Stewards of Kleinstuck have been caretakers of the preserve since 2007. They have created and carried out a management plan that focuses upon restoring the natural community types within the preserve and promoting biodiversity. Given that Kleinstuck Preserve is located approximately 50 miles from the Lake Michigan Shoreline, this stopover site is proximate to a highly desirable geographic barrier. For migrants that continue their travels past Kalamazoo County and over the Great Lakes, stopping over at the preserve may occur as a migratory strategy to replenish energy stores before crossing large bodies of water (Bonter et al. 2009). Kleinstuck Preserve's rich marsh, which is bordered by swamp and forest, provides additional value to migrants stopping over. Food availability is highly concentrated in wetland areas such as the marsh and swamp at this preserve due to macroinvertebrates, especially flying insects, that reproduce in open water (Bonter et al. 2009). Forest cover is another indicator of stopover quality, with the majority of land-bird migrants in the

Great Lakes Basin depending on forests for breeding (Bonter et al. 2009). There are 34 Boreal Forest, 40 forest generalist, and 63 Eastern Forest avifauna in North America, which have faced between 40-65% of population declines from 1970-2017 (Rosenberg et al. 2019) Holding and preserving forest habitat is essential in preventing further declines in forest-dependent avifauna.

Methods

Study site

Kleinstuck Preserve is a 60-acre nature preserve that is open to the public in Kalamazoo, MI. The preserve has owned 48-acres since Caroline Kleinstuck donated the land in 1922 for environmental research and stewardship. The 12-acre strip of land that adjoins the preserve has also remained natural and accessible since 1922. This adjacent land was purchased by the Stewards of Kleinstuck in 2021. Western Michigan University was given full control over the property in 1968.

The 60-acre property at Kleinstuck Preserve contains upland forest, swamp forest, marsh, and shrub carr habitats. The upland forest is an Oak-Hickory Forest with maples (*Acer*) and willows (*Salix*), black cherry (*Prunus serotina*), basswood (*Tilia americana*), and hackberry (*Celtis*) trees in lower quantities. The swamp forest contains predominantly maples and willows. The shrub carr habitat exists as a transition between the swamp forest and marsh. The marsh contains some open water with emergent, submergent, and floating vegetation. Land management practices including erosion control, native planting, and invasive species removal have been implemented at the preserve for several decades. Habitat restoration work has occurred monthly and often weekly at Kleinstuck Preserve since the Stewards of Kleinstuck formed in 2007.

Survey method

In order to properly classify migratory and resident birds, I labeled birds according to the Michigan Breeding Bird Atlas II with Dr. Sharon Gill and John Brenneman. The breeding bird status comprises resident birds and sometimes migrant birds that have been documented to breed in Kalamazoo County. The migratory category comprises short-distance, long-distance (neotropical), and partial migrants.

Daily bird surveys have taken place since 1973 at Kleinstuck Preserve during the spring migration from late March to late May. Surveyors travel in a figure-eight pattern to observe all natural community types present on the preserve in a 2-mile loop. The starting point, ending point, and order of the trails taken vary according to weather or other circumstances. Regardless of the path taken, the area covered remained constant for each survey. Surveys are conducted daily from late March to late May and last approximately an hour and a half. Species were documented according to identifiable sounds such as songs or calls as well as visual sightings with the naked eye or binoculars (J. Brenneman, personal communication).

To provide an overview of the surveys, J. Brenneman provided figures for my study that illustrate the number of species and number of individuals observed during spring surveys at Kleinstuck Preserve (1973-2021). To explore the trends of individual species, I adopted a snapshot approach similar to that used by Walk et al. (2010). The total number of migrants and residents per year in 1973, 1997, and 2021 were determined and the percentage of total represented by each bird species was calculated, with migrants and residents combined. The top 99% of birds were included in the species composition snapshot for each category. If a species contributed at least

1.0% composition in 1973, 1997, or 2021, its value for each year was included in the snapshot. I plotted these data to visualize patterns in species abundances over time.

Results

Migratory and resident species at Kleinstuck

Table 1. Migratory Bird Species observed during spring bird surveys at Kleinstuck Preserve in 1973, 1997, and 2021. There are 126 migratory bird species that have been observed at Kleinstuck Preserve in 1973, 1997, and 2021. Species that are known to breed in Kalamazoo County have an asterisk after their name, although not all species with this qualification have been documented to breed at Kleinstuck Preserve.

Acadian Flycatcher*	Alder Flycatcher*	American Black Duck*	American Goldfinch*	American Kestrel*
American Redstart*	American Robin*	American Tree Sparrow	American Woodcock*	Baltimore Oriole*
Bank Swallow*	Bay-breasted Warbler	Barn Swallow*	Belted Kingfisher*	Black-and-white Warbler
Black-billed Cuckoo*	Blackburnian Warbler	Blackpoll Warbler	Black-throated Blue Warbler	Black-throated Green Warbler*
Blue-gray Gnatcatcher*	Blue-headed Vireo*	Blue-winged Teal*	Blue-winged Warbler*	Bobolink*
Broad-winged Hawk*	Brown Thrasher*	Brown-headed Cowbird*	Canada Warbler	Cape May Warbler
Cedar Waxwing*	Cerulean Warbler*	Chestnut-sided Warbler*	Chimney Swift*	Chipping Sparrow*
Common Grackle*	Common Merganser	Common Nighthawk*	Common Yellowthroat*	Connecticut Warbler
Dark-eyed Junco	Eastern Kingbird*	Eastern Phoebe*	Eastern Towhee*	Eastern Whip-poor-will*
Eastern Wood-Pewee*	Field Sparrow*	Fox Sparrow	Golden-crowned Kinglet*	Golden-winged Warbler*
Gray Catbird*	Gray-cheeked Thrush	Great Blue Heron*	Great Crested Flycatcher*	Great Egret*
Greater Yellowlegs	Green Heron*	Green-winged Teal*	Hermit Thrush	Hooded Merganser*
Hooded Warbler*	Horned Lark*	House Wren*	Indigo Bunting*	Kentucky Warbler
Killdeer*	Least Flycatcher*	Louisiana Waterthrush*	Magnolia Warbler	Mourning Warbler*
Mute Swan*	Nashville Warbler*	Northern Flicker*	Northern Parula	Northern Rough-winged Swallow*
Northern Waterthrush	Olive-sided Flycatcher	Orange-crowned Warbler	Osprey*	Ovenbird*
Palm Warbler	Philadelphia Vireo	Pied-billed Grebe*	Pine Siskin*	Pine Warbler*
Purple Finch	Purple Martin*	Red Crossbill	Red-eyed Vireo*	Red-headed Woodpecker*
Red-shouldered Hawk*	Red-winged Blackbird*	Ring-billed Gull	Rose-breasted Grosbeak*	Ruby-crowned Kinglet
Ruby-throated Hummingbird*	Rusty Blackbird	Sandhill Crane*	Scarlet Tanager*	Sharp-shinned Hawk
Solitary Sandpiper	Song Sparrow*	Sora*	Spotted Sandpiper*	Summer Tanager
Swamp Sparrow*	Tennessee Warbler	Tree Swallow*	Turkey Vulture*	Veery*
Virginia Rail*	Warbling Vireo*	White-crowned Sparrow	White-eyed Vireo*	Willow Flycatcher*
Winter Wren	Wood Duck*	Wood Thrush*	Worm-eating Warbler	Yellow Warbler*
Yellow-bellied Flycatcher	Yellow-bellied Sapsucker	Yellow-billed Cuckoo*	Yellow-breasted Chat*	Yellow-rumped Warbler
Yellow-throated Vireo*				

Table 2. Resident Bird Species observed during spring bird surveys at Kleinstuck Preserve in 1973, 1997, and 2021. There are 27 resident species that have been observed at Kleinstuck Preserve during these three survey years. There are 4 woodpeckers included in this group and 2 waterfowl. These birds reside in Kalamazoo County year-round and breed in the area.

American Crow*	Barred Owl*	Black-capped Chickadee*	Blue Jay*
Brown Creeper*	Canada Goose*	Carolina Wren*	Downy Woodpecker*
Eastern Bluebird*	Eastern Screech-Owl*	European Starling*	Great Horned Owl*
Hairy Woodpecker*	House Finch*	House Sparrow*	Mallard*
Mourning Dove*	Northern Bobwhite*	Northern Cardinal*	Pileated Woodpecker*
Red-bellied Woodpecker*	Red-breasted Nuthatch*	Red-tailed Hawk*	Ring-necked Pheasant*
Rock Pigeon*	Tufted Titmouse*	White-breasted Nuthatch*	

There were 153 bird species observed at Kleinstuck Preserve in 1973, 1997, and 2021. Of these birds, 126 are migratory bird species and 27 are resident species (**Tables 1 and 2**). There are 209 total bird species that have been observed at this site from 1973-2021, indicating that there are 56 other bird species that have been documented at the preserve. The 56 species not included in this study are divided amongst migrant and resident categories.

Survey Counts

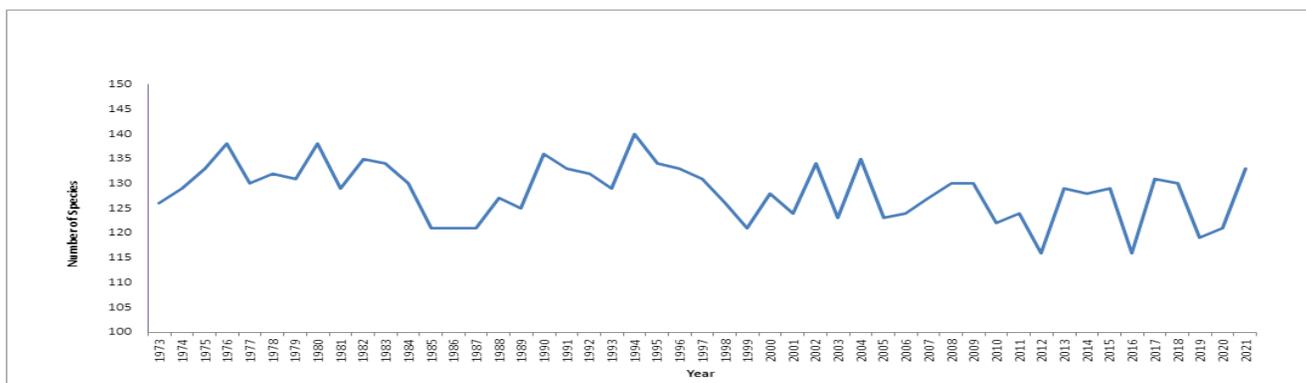


Figure 1. Illustration of Trends in Annual Bird Species Totals at Kleinstuck Preserve (1973-2021). The number of bird species observed at Kleinstuck Preserve during the spring migration ranges from 116 to 140. The highest species count occurred in 1994. The lowest species count occurred twice in both 2012 and 2016. A total of 209 bird species were observed within this period.

The progression of population changes within the three years in my study demonstrates the relative abundance of the migrant and resident species in the top 99% of all bird species observed each year. There are 209 bird species that have been observed at Kleinstuck Preserve from the continuous surveys conducted from 1973 to 2021. The trends in numbers of bird species at the preserve have changed nearly every year, with the number of species observed ranging from 116 to 140 (**Figure 1**). The years that I am studying are included in this illustration with points in the beginning, middle, and end of the graph (**Figure 1**).

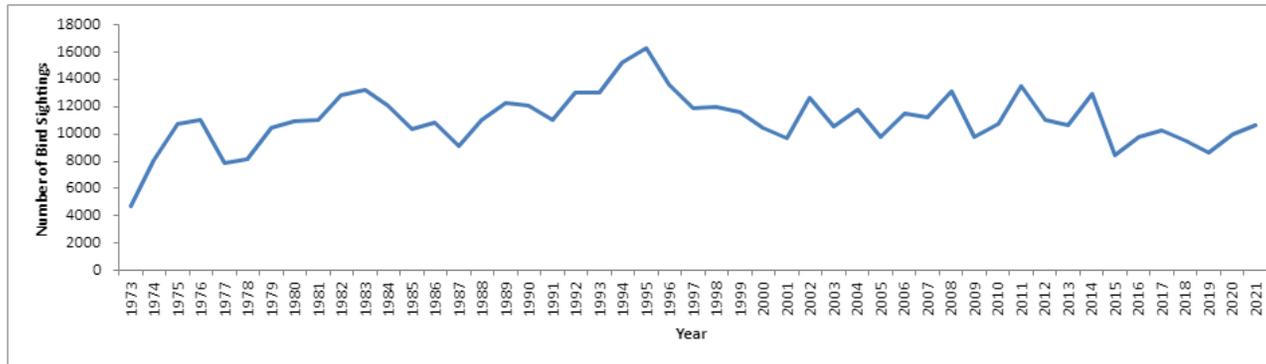


Figure 2. Illustration of Trends in Annual Bird Sightings at Kleinstuck Preserve (1973-2021). Between 4,000 and 16,000 bird sightings occurred at Kleinstuck Preserve from early March to late May in 1973-2021. The majority of the years have records between 9,000 and 13,000 sightings.

The number of bird observations, which count each individual bird recorded during each survey, increased from its minimum point of approximately 4,000 sightings in the first year of surveys (**Figure 2**). The amount of bird surveys in the three years of my study varied with approximately 4,000 in 1973, approximately 12,000 in 1997, and approximately 10,000 in 2021 (**Figure 2**).

Patterns of change in bird composition over time

Table 3. Migratory Species Composition Snapshot. The percentage composition of the top 99% migratory species from 1973, 1997, and 2021 is included in this figure. The total composition of each migratory species greater than 1% of composition of any of the three years is included in the final column. The bird species are sorted from highest total composition to lowest total composition with the Red-Winged Blackbird at 5.49% of all bird observations at the highest and the Purple Finch with 0.34% of all bird observations at the lowest.

Migratory Species	% Composition 1973	% Composition 1997	% Composition 2021	Total % Composition
Red-winged Blackbird*	7.27	3.24	7.28	5.49
American Goldfinch*	1.69	5.97	2.53	3.91
American Robin*	2.32	2.83	5.65	3.83
Song Sparrow*	2.96	3.52	1.46	2.63
Brown-headed Cowbird*	3.92	1.74	2.16	2.28
Yellow-rumped Warbler	2.36	2.64	0.60	1.80
Ruby-crowned Kinglet	2.21	1.79	1.44	1.73
Golden-crowned Kinglet*	0.07	1.56	2.11	1.51
Common Grackle*	3.43	0.73	1.50	1.49
Hermit Thrush	0.78	1.87	0.97	1.33
Dark-eyed Junco	0.58	0.88	1.91	1.23
Gray Catbird*	1.52	1.09	1.08	1.16
Winter Wren	0.18	1.47	1.09	1.10
Wood Duck*	0.18	1.09	1.50	1.09
Ovenbird*	1.25	1.40	0.57	1.06
Nashville Warbler*	2.70	0.56	0.72	0.99
Rose-breasted Grosbeak*	1.65	0.56	0.95	0.90
Least Flycatcher*	1.43	1.00	0.51	0.89
Red-eyed Vireo*	1.65	0.89	0.48	0.86
Black-throated Green Warbler*	1.43	0.94	0.47	0.85
Tennessee Warbler	3.34	0.15	0.41	0.80
Northern Flicker*	1.74	0.48	0.70	0.78
Magnolia Warbler	1.20	0.58	0.25	0.56
Chimney Swift*	2.32	0.12	0.22	0.54
Pine Siskin*	0.69	0.00	1.01	0.51
Cedar Waxwing*	1.69	0.19	0.26	0.47
Chestnut-sided Warbler*	1.49	0.32	0.20	0.47
Brown Thrasher*	1.56	0.22	0.11	0.41
Purple Finch	1.52	0.07	0.12	0.34

The migratory species composition snapshot includes 29 migratory bird species that contained at least 1% composition in one of the years in my study (**Table 3**). This table denotes that the species with the highest total composition is the Red-winged Blackbird with 5.49% total composition among the 3 years in my study (**Table 3**). Some documented species, such as the Pine Siskin, Wood Duck, and Chimney Swift have zero or close to zero percent composition in one of the three years of this study (**Table 3**). The general trend in each species of at least 1% composition in any of the three years is depicted in this figure from highest total composition to lowest (**Table 3**). A decline in percentage composition over the years indicates that the number of birds in a certain species does not contribute as much to the total bird population in that given year. Numerous migratory bird species had their maximum percent composition in 1973. (**Table 3**). Steady declines following this maximum value in 1973 are documented in 8 species: the Ruby-crowned Kinglet, Gray Catbird, Least Flycatcher, Red-eyed Vireo, Black-throated Green Warbler, Magnolia Warbler, Chesnut-sided Warbler, and the Brown Thrasher (**Table 3**). The opposite trend, in which a species increases steadily in resident and migrant composition, is depicted in 4 species: the American Robin, Golden-Crowned Kinglet, Dark-eyed Junco, and the Wood Duck (**Table 3**). The rest of the migratory species included in this snapshot had varying levels of species composition, although the majority of them are showing declines from 1973 (**Table 3**). Migratory species that decreased and then increased in relative abundance include the Red-Winged Blackbird, Brown-headed Cowbird, Common Grackle, Rose-breasted Grosbeak, and Pine Siskin (**Table 3**).

Table 4. Resident Species Composition Snapshot. The resident species at Kleinstuck Preserve at organized by the highest to lowest total % composition of all resident and migrant bird species in the selected survey years. Only residents with 1% composition or higher in any of the three years were included in the figure. The Northern Cardinal has the highest percent composition at 13.75% followed by the next highest value, 5.19%, which belongs to the Black-capped Chickadee. The Ring-necked Pheasant has the lowest total percent composition with 0.23% total due to declines from 1.32% in 1973 to 0.01% in 1997 and 0% in 2021.

Resident Species	% Composition 1973	% Composition 1997	% Composition 2021	Total Composition
Northern Cardinal*	3.25	16.12	15.71	13.75
Black-capped Chickadee*	1.81	5.86	5.94	5.19
Blue Jay*	5.97	4.75	5.01	5.06
Tufted Titmouse*	2.27	5.17	3.66	4.09
American Crow*	1.18	5.93	1.67	3.47
White-breasted Nuthatch*	1.34	2.40	3.47	2.63
Downy Woodpecker*	0.98	3.04	2.72	2.56
Red-bellied Woodpecker*	0.11	1.39	2.74	1.69
Canada Goose*	0.00	1.80	2.18	1.64
Mallard*	1.36	1.35	1.00	1.22
Hairy Woodpecker*	0.20	0.99	1.39	1.01
Mourning Dove*	1.54	0.75	0.90	0.94
House Finch*	0.00	1.30	0.82	0.89
European Starling*	1.85	0.22	0.48	0.60
Rock Pigeon*	2.34	0.10	0.02	0.45
Ring-necked Pheasant*	1.32	0.01	0.00	0.23

In the Resident Species Composition Snapshot, the percent composition of resident species, of which 16 qualify for being 1% or higher in composition during one of the three survey years, is depicted from highest to lowest total composition (**Table 4**). Steady declines in the species composition are noted in only two species: the Rock Pigeon and Ring-necked Pheasant, which occupy the two lowest positions due to minimum percent composition (**Table 4**). The opposite pattern of continued growth in abundance is noted in 5 species: the Black-capped Chickadee, White-breasted Nuthatch, Red-bellied Woodpecker, Canada Goose, and the Hairy Woodpecker

(Table 4). While there are 7 species that follow direct trends of increasing or decreasing, there are 9 species with varying percent composition. The species with the maximum total composition, the Northern Cardinal, has a sharp increase from 3.25% composition in 1973 to 16.12% composition in 1997, with a slight decrease in relative abundance at 15.71% composition in 2021 **(Table 4)**. The Blue Jay is one species that remains relatively stable, between 4.75% and 5.97% composition among the three years **(Table 4)**. Notable observations include the increase contribution of Canada Goose to species composition, which was absent in 1973, yet doubled from the second to third sample. This contradicts the steady presence of the Mallard, which remained between 1-1.36% of the bird population within the 3 samples **(Table 4)**. Both the Canada Goose and Mallard are residents that occupy similar habitat, yet their presence varies in the snapshot. Similar findings of increase in Canada Goose population were noted in Walk et al (2010).

Table 5. Migrant and Resident Bird Populations in 1973, 1997, and 2021. The number of migratory and residential species are provided for the years 1973, 1997, and 2021 with the total number of species provided in the bottom row. There were 153 total species observed. Of the species observed in these three years, 126 were migratory and 27 were residential. The number of migratory species and residential species remains the same from 1973 to 1997. The number of migratory species increases to 103 and the number of residential species increases to 24 from 1997 to 2021. The percentage of migratory species in all three years combined is 82.4%, which is the average of 81.1% composition in 2021 and 83.5% in 1973 and 1997. The percentage of resident species in the combined period is 17.6%, which is the average of 18.9% composition in 2021 and 16.5% in 1973 and 1997.

Year	Migrant Species	Resident Species	% migrant species	% resident species	Species total
1973	101	20	83.5	16.5	121
1997	101	20	83.5	16.5	121
2021	103	24	81.1	18.9	127
Combined	126	27	82.4	17.6	153

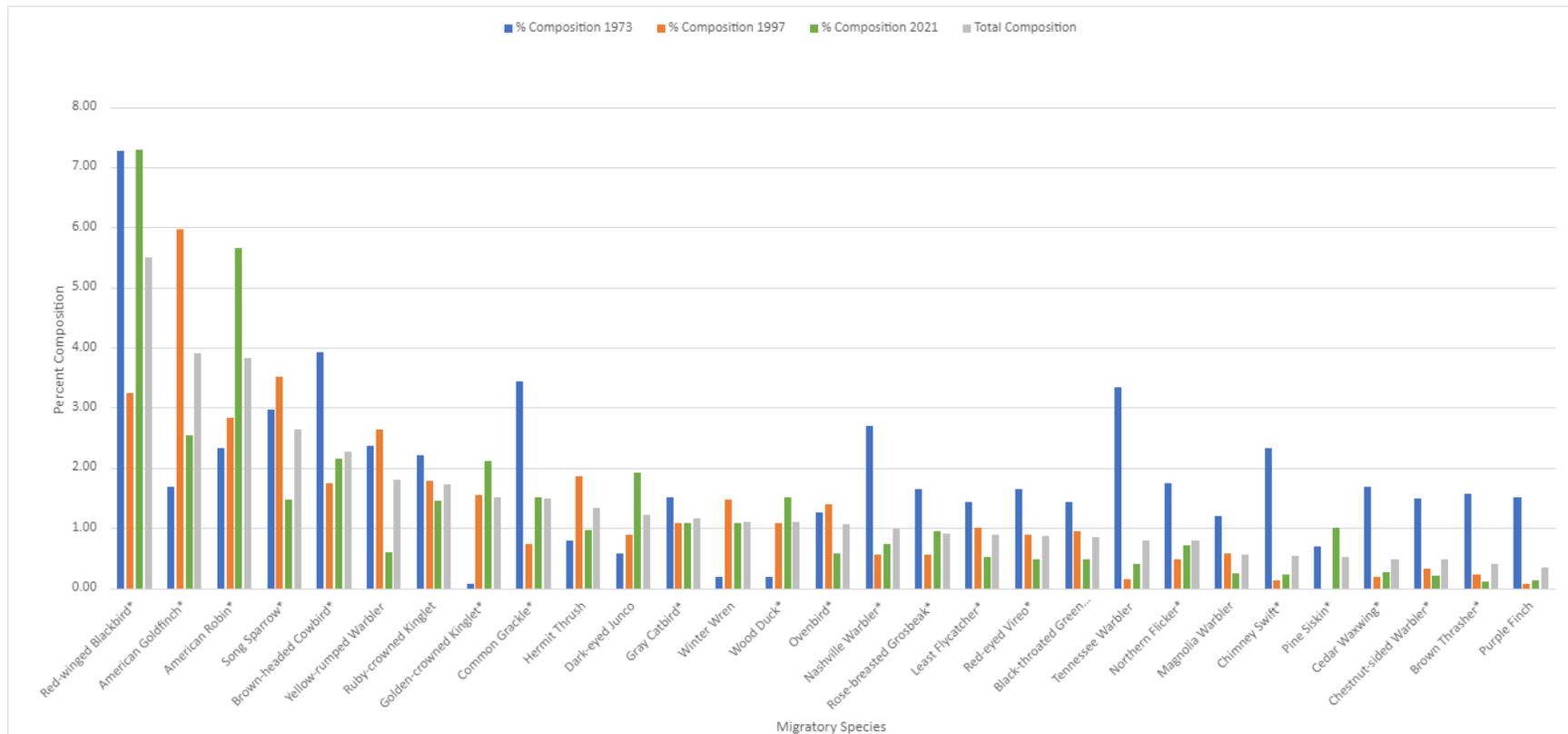


Figure 3. Illustration of Trends in Migratory Species Composition in 1973, 1997, and 2021. The percent composition of each migratory species that holds 1% composition or higher in 1973 (blue), 1997 (orange), or 2021 (green) is included in descending order of total composition (grey). Multiple blue bars are at higher levels than orange, green, and grey bars, as the percent composition of multiple species is highest in 1973. The highest percent composition of any year is approximately 7%, which is represented by the Red-winged Blackbird in both 1973 and 2021. Cases in which the blue bar is the lowest of the progression are seen in the American Goldfinch, which peaked in 1997, the American Robin, the Golden-crowned Kinglet, Hermit Thrush, Dark-eyed Junco, Winter Wren, and Wood Duck. The Grey Catbird is the most stable of the 29 migrant species included in the figure.

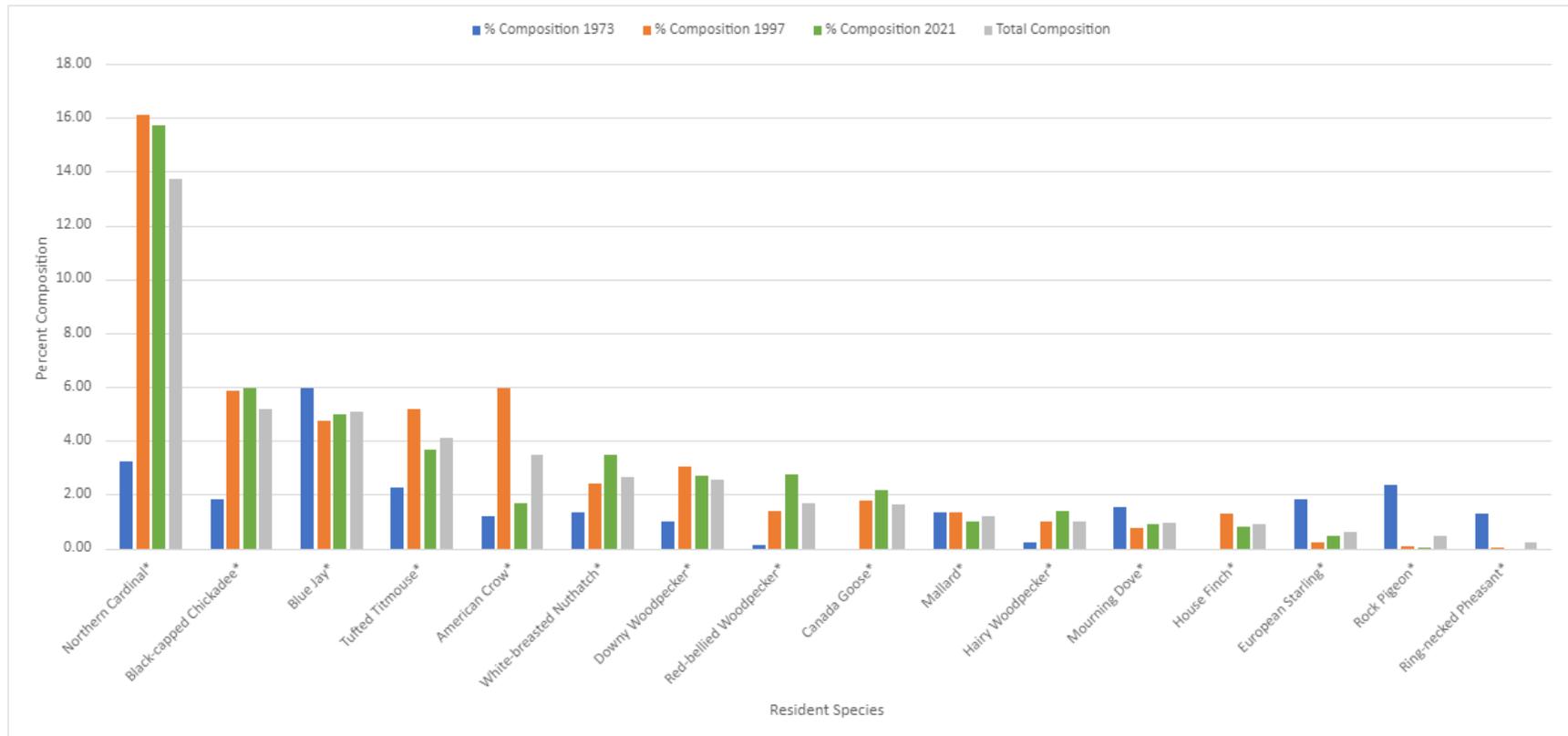


Figure 4. Illustration of Trends in Resident Species Composition in 1973, 1997, and 2021. The resident species that were at least 1% of the total bird composition are ordered from highest to lowest total percent composition (in grey). Ten of the sixteen resident species in the figure have the lowest value of composition in the first year of surveillance. The European Starling, Blue Jay, Rock Pigeon, and Ring-necked Pheasant have decreased in percent composition from 1973 to 1997 and 2021. The Mallard, Blue Jay, and Mourning Dove have relatively stable trends during these three years.

Of the 209 species documented at the preserve, a total of 153 species were observed within the 3-year snapshot at Kleinstuck Preserve. The number of species per year in this study increased from 121 species in 1973 and 1997 to 127 species in 2021 (**Table 5**). Species with 1% or higher composition in any of the three samples were included in the snapshot to monitor trends in the greater portion of the population. Of the 153 species, 28 migratory species and 15 resident species were included in the snapshot after meeting at least 1% composition in any of the three sample years (**Table 5**). The percentage of migratory bird species only changes by 2.4% with an increase of 2 species in 2021 (**Table 5**). The number of species increases in both the residential and migratory categories from 1973 and 1997, which have the same count, to 2021 (**Table 5**). While there are 153 unique bird species observed within these time frames, the level of biodiversity seems to be maintained from the earliest to most recent survey (**Table 5**).

There are general declines in species composition of the migratory species, seen through outstanding heights of the blue bars representing percent composition in 1973 (**Figure 3**). It is notable that 16 of the 29 species have their maximum value in 1973, meaning that approximately half of the species have declined in relative abundance out of the entire migrant and resident population in this study (**Figure 3**). The trends mentioned in **Table 3** are depicted in this figure, with the level of variance per sample illustrated in the three colorful bars and the total composition of each species in grey (**Figure 3**).

The illustration of the resident species snapshot portrays the 16 resident species that contained at least 1% composition in any of the 3 sample years (**Figure 4**). The rock pigeon composition steadily decreased with the 3 samples alongside the Ring-necked Pheasant, which reached 0% by 2021 (**Figure 4**). While these percentages decreased, there were relatively stagnant species counts within the migratory and residential categories (**Table 5**). The residential

composition of the bird population also exists within a thin margin with only 2.4% change, as well (Table 5). This graph does not depict the same declining trend seen in the migratory snapshot (Figure 3 and 4). The abundance of the resident species is increasing overall based upon the orange and green bars being higher than the blue bars in the graph (Figure 4). In addition to this, the total composition bars (in grey) are higher than the blue bar in all but 6 of the 16 resident species (Figure 4).

Discussion

There is an overall decline in migratory bird composition and a general increase in residential bird composition in the progression of my three sample years. While the number of bird species has stayed relatively the same with only a small increase in both resident and migrant species in 2021, there are overall declines in abundance of migratory bird species. The most notable observation is that there are 16 migratory species with their maximum value of composition in 1973 with eight of these species depicting constant declines following each of the three years. Also notable is that there are 10 out of 16 resident species with total composition values that surpass the level of composition in 1973. My study aimed to determine the extent to which migratory birds use Kleinstuck Preserve as a stopover site. I found that migratory birds are decreasing in abundance out of the total population from 1973 to 1997 and 2021. These patterns correlate with the estimated loss of 2.9 billion birds in North American starting in the 1970s (Rosenberg et al. 2019). While Kleinstuck Preserve is not exempt from the declines in birds seen during the sixth mass extinction, there are still stagnant species counts in the migratory and resident bird categories according to my study (Rosenberg et al. 2019). Despite the decline in migratory bird composition, there are relative increases in resident bird populations. There are

several potential explanations for the decrease in migratory bird abundance seen in my study, though there is not one single reason for this decrease in avifauna. Due to the complexity of migratory birds, it is much more difficult to find why migratory birds are declining (Dr. Sharon Gill, personal communication). I am predicting that a mosaic of these complex factors, such as increased development, loss of habitat, changes in habitat type, hazardous climate conditions, interspecies competition, low survival rates, and preserve traffic have led to this change.

The lack of stability in those that were not present for each survey indicates that the species composition varied greatly amongst the 48 years of surveys. The species composition at the preserve has shifted to accommodate more species suited to the woodland habitat, with a higher concentration of woodpecker species (Brenneman, personal observation). The decline for these species can be explained by the change in dominant habitat at Kleinstuck Preserve—woodland coverage has increased since the surveys have begun, decreasing the amount of open grass habitat that this species desires (Brenneman, personal observation). Brambly shrub cover in the marsh land that surrounds the open water at the preserve has appeared since the surveys began, introducing another attraction to birds seeking shelter and nesting material.

Habitat changes in Kleinstuck alone may be significant to some species that require certain habitat types, but widescale changes in land use can also account for changes in species composition. Population dynamics can be assessed using the snapshot approach to monitor changes in sites over time. The percent composition of each species measured does not compare the number of each species observed over the 3 years but demonstrates the relative abundance of that species compared to all species documented in a given year. Monitoring changes in abundance for species that require different habitats would aim to measure the extent of restoration success in typical studies in which one restoration event took place. With Kleinstuck

Preserve, restoration has occurred continuously for nearly a century, so quantifying changes in abundance would not reveal whether restoration success has been achieved. It would be difficult to assign specific restoration events to the change in bird composition.

This study is focused on three years of data from over 50 consecutive years of accessible data. The snapshot approach taken does not summarize the entirety of the data collected at Kleinstuck Preserve. Nocturnal species are especially misrepresented in this study due to the absence of night surveillance in this data due to inconveniences associated with night surveillance. Additional research on species composition of the remaining years would be needed to detect precise trends. Species composition has been known to change annually, with some limits in detection considering a bird may be at the preserve at times other than during surveys (Brenneman, personal observation). Further directions for migratory bird research at Kleinstuck Preserve should focus on the length of stopover time, number of nesting migrants, or correlations in abundance with climate data. With climate variation, the timing and duration of migratory stopovers are changing (Brenneman, personal observation). The change in climate and increased development has been deemed to affect such stopover duration and timing (Adi et al. 2021). Understanding the connection between temperature, weather, arrival time, and stopover duration is important in determining the future population health of migratory species. The survey method at Kleinstuck Preserve, performed through Kalamazoo Nature Center, is thorough and constant. Ongoing surveillance of Kleinstuck is necessary to monitor progress and trends. Public outreach to spread bird surveillance in surrounding areas in Kalamazoo County and beyond would be useful to better monitor residential and migratory bird populations. Because this level of thoroughness is not necessarily possible in most locations, other methods such as Radar could be applied to monitor birds. Institutions that are using Radar to monitor stopover sites in the Great Lakes Basin are

recognizing their work as a tool to determine heavily concentrated stopover locations to allocate funds and protections (Bonter et al. 2009). Radar is a useful tool for quantifying the bird population, although it is not species specific. The use of Radar at Kleinstuck Preserve and surrounding areas would solidify the migratory bird concentration trends and provide insight into travel patterns to and from the preserve. The number of birds entering and exiting the preserve would be measured through this program, which would determine the concentration of bird species at the preserve. Timing and duration of migratory stopovers as a whole could be determined through Radar in larger regions.

New species of migratory birds have begun nesting at Kleinstuck Preserve as of March 2022. As of April 24, 2022, John Brenneman and I were able to watch a Barred Owl and Red-Shouldered Hawk roost at their nesting sites. There is at least one breeding pair of Barred Owls, Red-Shouldered Hawks, and Pileated Woodpeckers (a resident) that are using the preserve this spring (Brenneman, personal observation). Numerous migrant and resident bird species that are found at Kleinstuck Preserve are legally protected due to conservation efforts. When there are such species that are state threatened, such as the Red-Shouldered Hawk, nesting at the preserve, the importance of protecting Kleinstuck Preserve increases. Quantifying the level of breeding in migrant birds at Kleinstuck is another method of determining the extent to which migrants use the preserve, as these findings could determine additional levels of protection and funding for Kleinstuck in the future. There are some efforts to monitor nesting birds at Kleinstuck Preserve, but all nesting birds cannot be accounted for due to the level of traffic at the preserve. In relation to habitat change at the preserve, the availability of nesting sites may be related to the changes in species composition found in my study. For example, the increase in woodpecker species may be

related to the increasing forest availability, which cavity nesters are drawn to during their breeding seasons (Dr. Sharon Gill, personal communication).

Land protection is essential in preventing the further decline of migratory birds (Rosenberg et al. 2019). The decrease in habitat due to urbanization has made it difficult for migratory birds to find shelter and acquire resources. It would be interesting to compare the number of bird species that were present at Kleinstuck before European Settlement began to determine whether the declared bird hotspot is attracting large numbers of bird species because of scarcity elsewhere. This could be interpreted through radar with special interest in the concentration of natural areas and birds. Establishing native patches between reserves may create habitat corridors that can protect many species or buffering native land to increase its area are two ways in which habitat may be improved despite urbanization (Marzluff & Ewing, 2001). Increasing native plant cover in the area surrounding Kleinstuck Preserve may increase desirability of the site to both residential and migratory birds.

Understanding whether surrounding urbanization has changed the composition of bird species is important in determining the extent to which habitat fragmentation has damaged bird populations. In addition, the extent to which ecological restoration has aided in bird populations at the preserve can be determined through the diversity of bird species. The success of restoration and the presence of birds occur simultaneously with ecological integrity of a stopover site (Ortega-Alvarez & Lindig-Cisneros, 2012). The study of birds at Kleinstuck may provide guidance when assessing the quality of the restoration process (Ortega-Alvarez & Lindig-Cisneros, 2012). The levels of noise and light pollution in areas that surround the preserve are also likely to impact the level to which migrant and resident birds tolerate this site. Traffic noise outside of the preserve and pedestrian traffic within the preserve may also contribute to the species

composition noted in this study, given that different species have different tolerance levels to human disturbances. Birds that can survive and prosper in developed habitats have shown notable shifts in their range, with increased habitat cover due to their ability to adapt to and thrive in developed land despite the loss of natural habitat (Walk et al. 2010).

Climate change has led to variation among migration seasons that may put migratory species in danger. In 2021 alone, drought, heat spells, and cold spells occurred, limiting resources such as highly nutritional insects and shelter from extreme temperatures (Brenneman, 2021). Fluctuations in weather, which have increased since 1973 as we progressively rise in average global temperature, are likely to deter short-distance migrants (Brenneman, personal observation). Short-distance migrants can sense shifts in weather patterns that may change their route and prevent them from visiting the same stopover sites each migration. Long-distance migrants, which are also known as neotropical migrants, are less likely to sense undesirable conditions due to the drastic intercontinental route they must travel to reach their migratory destination (Brenneman, personal observation). Climate change is a potential cause for changes in bird distribution and abundance according to Walk et al. 2010. Northward range shifts are usual responses to climate change, with drastic changes in bird populations as they shift in range (Walk et al. 2010). The complexity of climate change, habitat loss, and the shifts made in response reflect the mosaic of issues that may cause the change in abundance and distribution of migratory and residential birds found in my study (Walk et al. 2010).

Conclusion

The decline in migratory species abundance that I found in this study aligns with the major loss of approximately 2.9 billion birds in North America (Rosenberg et al. 2019). Due to

approximately half of migratory bird species declining from the beginning of bird surveys in 1973 to the median year, 1997, and the most recent year, 2021, additional actions need to be taken in order to prevent further losses. Land protection, species protection, rebuilding natural habitat, and promoting the implementation of urban stopovers may provide some relief to both migrant and resident birds as they lose habitat to human development. The continued surveillance of bird populations at Kleinstuck Preserve will serve in monitoring future trends. The continuous restoration at Kleinstuck Preserve has likely aided in maintaining species counts, but restoration success cannot be measured due to multiple restoration events occurring during the course of these surveys.

Personal Reflection

Kleinstuck Preserve is a well-known migratory bird stopover in Kalamazoo due to its high species count and community conservation mission to “Keep Kalamazoo Wild.” Kleinstuck Preserve holds a special place in the hearts of many members of Kalamazoo County. The connectedness of volunteers with the wild inhabitants, both flora and fauna, remains a major motivator in the protection of the preserve. The legacy of the preserve continues on, as it is continuously surveyed by bird enthusiasts such as John Brenneman and maintained by beloved stewards such as Paul MacNellis.

Kleinstuck Preserve takes its land preservation very seriously, with its stewards raising enough money to purchase the approximately \$700,000 12-acre woodland that connects to its land (Robinson, 2020). The woodland, which was destined for the residential development of 100 homes, was successfully purchased by the Stewards of Kleinstuck in the summer of 2021. Paul MacNellis, a beloved Steward of Kleinstuck, provided walking tours of the 12-acre property in

July of 2021, highlighting the pristine quality of the land with many mature trees and few invasive species (MacNellis, personal communication). There is a rich history at Kleinstuck that prompts the protection placed upon it by many from the Three Fires Confederacy, the Kleinstuck family, Western Michigan University, and the Stewards of Kleinstuck. The stewards issued a statement that acknowledged that the land upon which Kleinstuck Preserve resides is the ancestral homeland of the Three Fires Confederacy and was stewarded by the Ojibwe, Odawa, and Bodewadmi nations prior to colonial times (Moore, 2021). Very few natural spaces remain in Kalamazoo due to residential and commercial development. Asylum Lake Preserve, which is a nearby nature preserve that is also owned by Western Michigan University, was recently downsized to create a business and technology park that houses the Engineering campus. Land near Asylum Lake Preserve was threatened as recently as January of 2020, when a car-wash company presented a proposal to build residential homes on the land which had a Natural Features Protection designation (Robinson, 2020). The Kalamazoo City Commission rejected the proposal under the protest of conservation members. Due to the everlasting threats of development in natural areas of Kalamazoo after purchase of the 12-acre woodland, the Stewards of Kleinstuck continue to hold a fundraiser to “Keep Kalamazoo Wild,” naming the mission after their efforts to protect and maintain natural spaces in Kalamazoo (Robinson, 2020).

I was drawn to Kleinstuck Preserve by Paul MacNellis, who took the time to guide me through each section of the property and explain its history. As I became invested in the preserve by planning and hosting a volunteer workday event, I learned more of the community’s dedication to maintaining this land. Monthly restoration events occur at the preserve, but especially an especially dedicated crew named the “Wednesday Warriors” visits the preserve, and many other properties, each week. The native planting initiative is sparked with help from a group called the

Seed pluggers, who collect native grass and wildflower seed weekly in the fall. I have been able to personally collect wildflower seeds with this group and found refuge in the monotony of harvesting under vibrantly colored falling leaves. Furthermore, I was able to watch the progression of the seeds that were sowed under the direction of Christopher Jackson at the Finch Greenhouse on Western Michigan University's campus. I have been able to collect, sow, and water native seeds for two consecutive years now. It is incredibly rewarding to send healthy seedlings, or in some cases, mature plants that have flowered under the greenhouse's roof, off to Kleinstuck for planting. The steppingstones taken to propagate native plants exemplify the strong network within the Kalamazoo nature conservation community.

Two major concerns for birds at this moment that I am interested in are the Avian Flu and the predation of ground-nesting birds by outdoor cats and off-leash dogs. Kleinstuck Preserve and the Kalamazoo Nature Center provide signage to notify dog-owners that they must leash their dogs and send out memos to prevent Avian Flu outbreaks in Kalamazoo County. Because Kleinstuck Preserve is a stopover site with rapidly changing migrant abundance, it is likely that migratory birds that stop at residential bird feeders could carry the virus. The abundance of vegetation, insects, and other consumable natural resources at Kleinstuck prevents the need for feeders, which decreases the risk for disease transmission. Efforts to maintain feral cat populations and discourage outdoor roaming of pet cats are needed in order to decrease predation of birds by this non-native species. By keeping the preserve open to the public, the cat population can be monitored more closely by visitors to prevent cat-related predation on wildlife.

As I enter veterinary school with a special interest in wildlife medicine and animal welfare, I find myself interested in a career that ties the issues of conservation and overpopulation together. I am very thankful to have had such an educational and inspiring experience while completing this

project. I hope to obtain the skills that can aid in the efforts needed at Kleinstuck Preserve as a veterinarian and environmental advocate in the future.

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