Term Project Proposal: The Impacts of Invasive Species and the Preservation of Native Avifauna

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While its human inhabitants often claim it to be the greatest city in the world, New York City–and much of the Eastern United States–is a shadow of what it once was (to wildlife, that is). While there are still many animals and plants which dwell within the concrete jungle (or perhaps the concrete temperate deciduous forest?), wild animals face myriad threats caused by human activities. One of such issues is the introduction of invasive species into native ecosystems. Invasive species are any organisms not originally from a particular environment that are able to thrive in their new environment and are known to have adverse effects on the native species there. In particular, birds native to New York are strongly impacted by invasive flora and fauna. However, not all hope is lost; native bird species can be conserved through management of invasive species and by creating a naturalistic space–such as an exhibit–designed for the endemic species. In my term project, I will spread awareness about the impact of invasive species by either creating a 3D model of an aviary-like space for native birds designed without invasive species or an illustration depicting a museum exhibit that narrates the introduction and effect of invasive species on indigenous ones.

Invasive plant species can hinder native bird populations by outcompeting native plant species, which provide food and shelter for birds. In the Northeastern United States (a region which includes New York), problem species include glossy buckthorn (*Frangula alnus, a.k.a. Rhamnus frangula*) and tree of heaven (*Ailanthus altissima*), which inhibit the growth of native plants by emitting toxins. Other plants such as black locust (*Robinia pseudoacacia*) and garlic mustard (*Allaria petiolata*) alter the soil chemistry through processes such as nitrogen fixation. The changes in the soil often harm native plants and promote the growth of non-native plants (Alden, 2004). These soil chemistry alterations are harmful because the native plants do not naturally exist within land that has this new soil chemistry. The soil in Southeast Asia, for example, differs from the soil in the Northeastern United States, since these two regions have different climates, naturally occurring nutrients, and native plants (which determine the composition of the soil by adding nutrients when they decompose). The new soil environment created by invasives also promotes a vicious cycle in which invasive plants grow, create favorable conditions for themselves, make it more difficult for native species to survive, and repeat. According to Alder (2004), the Japanese knotweed (*Polygonum cuspidatum*), the giant knotweed (*Polygonum sachalinense*), and a hybrid knotweed are large and severely outcompete native shrub species near rivers, roads, fields, and woodlands. These knotweeds can therefore impact the abundance of native tree species in forests, which is the dominant biome surrounding New York City.

Invasive species also alter the habitat of native birds by altering the availability of food and water for birds. The Eurasian water-milfoil (*Myriophyllum spicatum*) is an aquatic plant that can reduce the water quality of freshwater, leading to a process known as eutrophication. Eutrophication causes less oxygen in the water for fish and other animals, causing a loss of usable habitat and worse water quality for wildlife and humans (Alden, 2004). In addition to a reduction in wetlands for waterfowl, all animals (including birds) near a water-milfoil infested body of freshwater have less drinking

water, and piscivorous birds suffer with fewer fish to eat. Alder (2004) states that insectivorous birds in the Eastern U.S. are also affected by invasive ecosystem alterations: the Norway maple (*Acer platanoides*) outcompetes native trees and does not host any insects that native birds prey upon. Birds that are herbivorous or omnivorous are not exempt from a poor diet encouraged by any of the 38 invasive plants thriving in the Northeast. Among these, many of the fruit-bearers–such as the spiky water-chestnut (*Trapa natans*), the aforementioned species of knotweeds, several species of Asian honeysuckle, and winged burning-bush (*Euonymus alata*)--produce berries that either provide little to no nutrients to birds or are avoided by birds altogether.

Invasive plant species can also affect the behavior of native bird species, often deterring them from inhabiting certain areas. In terms of nesting and bird abundance, invasive plants most frequently (around 60% of the studies) had a relatively neutral effect on native birds, with a smaller percentage (about 20%) having a negative effect, and only about 15% of studies indicating an increase of individual populations in the presence of invasive plants (Nelson et al., 2017). This report implies that invasive plants have the potential to decrease the overall population of native birds in a given range.

In many cases, bird breeding behavior is negatively impacted by invasive flora. Chipping Sparrows (*Spizella passerina*), which breed in New York, have lower site fidelity in habitats with the introduced spotted knapweed (*Centaurea maculosa*). Site fidelity is the tendency of a species to reside in specific areas, so a decrease in site fidelity suggests chipping sparrows are unlikely to return to areas with invasive plants. This could become concerning if spotted knapweed spreads to the vast majority of the chipping sparrow's range, as the birds would run out of preferable habitat. It is also a problem because older Chipping Sparrows will remove younger male sparrows from the less invaded habitats, causing younger generations to become distanced from the older generations and thus have less song diversity, which is problematic because songs are used for mating purposes (Nelson et al., 2017).

Some native birds may benefit from a sudden invasion of non-native plants. Interestingly, native birds (such as Northern Cardinals and Gray Catbirds) had a tendency to choose (or tolerate) nesting sites filled with invasive plants (Nelson et al., 2017). Nesting sites with invasive plants may have some benefit because of the *quantity* of plants. Invasive honeysuckles found in the study grew in abundance, leading to more protection for fledglings.

The growth time of invasive plants adds an additional layer of complexity and change to the behavior of birds. According to studies reviewed by Nelson et al. (2017), invasive plants may alter the time in which birds breed, which could be harmful if the nesting is promoted later in the year. Some invasive flora provide nesting sites for birds. If the plants grow late in the breeding season, native birds will nest alongside the time of growth and produce less offspring because they are less fertile at the end of the season.

However, if invasive plants grow best early in the season, it may increase the reproductive success of certain bird species.

There is often a connection between invasive fauna and invasive (and endemic) avians, as the former encourages the latter. In urban gardens in Tel Aviv, the abundance of non-native plant species directly correlates with the abundance of invasive bird species that visit the garden. Conversely, when more native plants were present in the garden, the diversity of native bird species was greater. In all gardens, more than half of the individuals were from one of 9 invasive species, even though a total of 65 species were recorded. The disproportionate amount of non-native individual birds is due to the fact that the vast majority (72%) of plants were also invasive. This is because native birds are more adapted to the services provided by native trees (in Israel, native birds are generally smaller and prefer to eat the smaller fruits and insects from native trees, and have better protection and shelter from predators in small, shrubby trees), and invasive species are better adapted to eat from and occupy introduced tree species for similar reasons (Paker et al., 2014). Though this article does not study New York City (or even the Northeastern U.S.) specifically, it does discuss the widespread effects of plant diversity, which can be applied to any city (or, more extensively, any space that can host wildlife). There is also some overlap between some of the species invasive to both Tel Aviv and New York: the House Sparrow (*Passer domesticus*) and Feral Pigeon or Rock Dove (*Columba livia*). Some species native to Israel are invasive to NYC, such as the Common Starling and Eurasian Collared-Dove (*Streptopelia decaocto*). Therefore, planting plants invasive to both cities would attract invasive species, and using plants that originate near Israel (which would be invasive plants in NY) would likely attract these non-native bird species as well.

Endemic birds often exacerbate the issue of quickly-spreading invasive plants. For example, the fruit of the glossy buckthorn and common buckthorn provides no nutrition for birds but rather causes increased bowel movements in birds, causing birds to eat them more to fill their stomachs. These fruits contain seeds and are dispersed through the excrement of birds. The seeds then germinate in new regions, causing more birds to spread them even further (Alden, 2004). Consumption is not the only way birds can aid the population of invasive species. Alden (2004) adds that when seeds or pieces of plants stick onto birds and other fauna, the wildlife will inadvertently spread the seeds to wherever they travel.

Invasive insects (and non-animal microorganisms) can eradicate plant species utilized by birds, causing the birds to lose portions of their habitat or decrease in population without vital sources of food and shelter. Out of all of the states, New York, New Jersey, Connecticut, and Pennsylvania have the highest numbers of invasive insects and pathogens per county, with up to 45 different pest types per county. Unfortunately, nonnative forest pests are more deadly to native populations of trees than native forest pests. Invasive insects and diseases are particularly dangerous to trees because they are the only recorded pests that have driven tree populations to local extinction. Examples

include chestnut blight, which extirpated all American chestnut (*Castanea dentata*) trees throughout the Eastern U.S. and hemlock woolly adelgid (HWA), which decimated populations of native hemlock species in the Eastern states (Lovett et al., 2016). Because they have the highest concentration of pests, states such as New York are enduring the strongest impact of invasive species. Therefore, Northeastern forests require the most management of insects and diseases in order for the birds to not be under threat.

Invasive bird species can be just as detrimental as invasive plants, insects, and diseases; they compete with native birds for nesting sites and food. Though they have little impact on most native species, studies show that European Starlings have negatively affected the populations of some sapsuckers (woodpeckers of the genus *Sphyrapicus*). Starlings and sapsuckers are both cavity-nesters, meaning they utilize the same nesting sites. Starlings may outcompete with sapsuckers for nest sites, causing less offspring and therefore a decline in sapsucker populations (Linz et. al, 2007). One species in this genus, the Yellow-Bellied Sapsucker, is known to breed in New York City and is a year round resident upstate (Tekiela, 2021). The first European Starlings in the U.S. were released in New York City, so their impacts reach New York birds.

House Sparrows (*Passer domesticus*) are another culprit of nest site theft, and they are quite aggressive. Eastern Bluebirds (*Sialia sialis*) compete with and are often killed by non-native House Sparrows in nesting sites. Of 28 deceased bluebirds found in nesting boxes over a 6-year span during breeding season, 20 had traumatic deaths. Of these 20, 90% occurred before and after House Sparrow sightings at the nest box. None of the traumatic deaths occurred in nesting sites where House Sparrows were not present. Because Eastern Bluebirds only had injuries in nesting sites where House Sparrows were present, it is likely that the House Sparrows played a role in their deaths. Additionally, a House Sparrow was directly observed attacking bluebird nestlings; the wounds found on the nestlings were identical to those identified on the deceased adult bluebirds in other sites, making it increasingly likely that the traumatic deaths at the nesting boxes were caused by house sparrows. On one occasion, a male House Sparrow entered a bluebird nesting box for 1-3 minute intervals. After 20 minutes, 4 of the 5 bluebird nestlings had head injuries, and 1 was dead. After an hour, 4 of the nestlings were killed by the sparrow, and the 5th passed the next day. Three bluebird corpses were even found on, in, or under house sparrow nests (Gowaty, 1984). Because Eastern Bluebirds only had head/breast injuries in nesting sites where House Sparrows were present, it is likely that the House Sparrows played a role in their deaths. Additionally, a House Sparrow was directly observed attacking bluebird nestlings; the wounds found on the nestlings were identical to those identified on the deceased adult bluebirds in other sites, making it increasingly likely that the traumatic deaths at the nesting boxes were caused by House Sparrows. The remains of the bluebirds prove that House Sparrows are usually the victors in a lethal competition for nesting sites.

Introduced bird species also compete with endemic birds for food. According to Tekiela's field guide, Eastern Bluebirds eat insects and fruit (they will visit feeders with

mealworms and occasionally suet), while house sparrows eat seeds, fruit, and insects (usually visit fruit feeders). Both species have similar diets, implying they may compete for food in the wild. However, as with invasive plants, the masses of invasive species may serve as some benefit for birds that are not apex predators. Bluebirds in rural areas have about twice as many surviving fledglings in comparison to urban areas, though bluebirds in urban areas tend to have a slightly higher rate of successful (at least one living fledgling) nests. Lower rates of bluebirds surviving into the fledgling phase is in part due to predation. In urban areas where both House Sparrows and bluebirds are available, birds of prey and other secondary consumers have more prey options, and by default are less likely to prey on young bluebirds, increasing their likelihood of survival (Pavlik, 2012). In this instance, the invasive house sparrow may actually provide some benefit to native avifauna–at least on the individual level.

Raptors and other birds of prey may be indirectly harmed by invasive species caused by improper human management. European Starlings cause agricultural and economic damage, leading to humans managing them through pest control. One such pest control method is Avitrol, a chemical intended to scare and poison starlings. The use of Avitrol can have adverse effects on native raptor populations. This is because it works by intoxicating a starling, which warns other starlings and may cause them to avoid the area. However, the starling that consumes the Avitrol may become ill or dead; birds of prey could eat the toxic starlings and also die as the poison accumulates (Linz et. al, 2007). Therefore, the effects of starlings and similar invasives can travel up the trophic pyramid.

It should be noted that native species do compete with other native species. Eastern Bluebirds compete with native Tree Swallows for cavity nests. However, data shows that paired nest boxes increase the rate of bluebirds nesting successfully. Placing nest boxes next to each other has a neutral or positive effect on both native bluebirds and swallows because they can have access to the same resources in the same location, reducing competition for prime avian real estate, or a valuable nesting site (Pavlik, 2012). In this case, a key difference between invasive species' competition and native is that the two native species can coexist with proper nesting setup, whereas house sparrows are less agreeable. As the total population of House Sparrows increases, so does the number of house sparrows removed from the nesting sites. In some areas, House Sparrows were removed from the same nest multiple times. Because these invasive sparrows repeatedly attempt to nest in the same areas, it is often difficult or even pointless to remove them, leaving fewer nest boxes for Eastern Bluebirds (Pavlik, 2012). Invasive species are problematic because they are another, more stubborn, species that natives have to compete against, making it even more difficult than it already was for native species to thrive.

Living organisms are not the only invaders of native birds' habitats; birds are also threatened by buildings which have overrun what was once forested land. Glass and excessive lighting are as prevalent in architecture as they are hazardous to birds. In fact,

buildings that cause fewer bird collisions tend to have less glass, glass behind a screen, opaque glass, and/or glass with opaque patterns (such as stickers). Buildings with less glass are generally safer to birds because glass is generally transparent, and birds cannot distinguish between glass and open space. Glass can be reflective, blending into the surrounding environment and appearing as an area that is safe for birds to fly through. On the opposite side of the spectrum, transparent glass will reveal to birds an open space beyond the glass. Additionally, dark reflections or dark areas created by glass may appear like a nesting cavity to a bird. Unaware of the invisible barrier between two safe spaces, birds will hit glass at normal flying speed, resulting in serious injury or death (Sheppard & Phillips, 2015). Clearly, glass in its default state is perplexing to birds, leading them into a false sense of security and resulting in a full-impact collision into an invisible wall. This does not mean that architects must abandon glass altogether; in fact, the way the glass is installed could diminish its danger. Glass installed at a 20-40 degree angle may be slightly more effective than glass installed as normal (perpendicular to the ground). Angled glass is most useful near bird feeders, as birds that collide with the glass will do so at a non-perpendicular angle, which results in a less forceful impact–perhaps comparable to running into an angled wall as opposed to an ordinary wall (Sheppard & Philips, 2015). The most effective way to prevent collisions, however, is to modify the glass so that it appears as a space that birds cannot access. This is usually through the form of some kind of pattern or decoration, including frosted glass, colored glass, UV strips invisible to humans but visible to birds, stickers, tape, screens, and films (Sheppard & Philips, 2015). There is great variety to the type of object attached to the window, from dots to detailed decals, so these stickers can serve secondary purposes such as allowing people to view the interior space of the building or admire the decorations on the window. These film, stickers, screens, or other opaque/semi opaque decals should not be placed randomly; they should be applied to glass using the 2 by 4 rule. The 2 by 4 rule indicates that obstructions to the window should be placed no more than two inches apart in height (from top to bottom) and 4 inches apart in width (from left to right). The 2 by 4 rule is effective because it divides glass into minuscule sections of seemingly open space, rather than a large area of habitat. This specific spacing is effective because most songbirds (the most frequent window victims and some of the smallest birds) are about this size and will not attempt to pass through a passage smaller than them (Sheppard & Philips, 2015).

Glass is not the only perplexing part of human civilization to birds. Light pollution, which is prevalent in cities such as New York City, also can be harmful to birds. According to Sheppard and Philips (2015), using outdoor light fixtures that cover the lightbulb and turning off excess lights at night may prevent confusion and collision in birds. Artificial lights contain red waves, which may interfere with the magnetic directional capabilities of birds, which possibly plays a role in collisions. Additionally, birds are attracted to bright lights, which (in the birds' eyes) resemble sunlight, so migrating birds may stop or get distracted by the alluring light. There is also value for humans to use lighting more efficiently, as there are associated health and economic benefits. Since both birds and humans can benefit from less lighting, city structures

should use minimal light at night. If lights are necessary, they should only be seen from below.

My term project will incorporate the concepts of how invasive plants undermine native plants which are needed by birds, encourage other members of invasive species, harbor disease, affect the reproductive (nesting/breeding) behavior of native birds, and alter the land which avifauna inhabit. I will also discuss how invasive bird species compete with native bird species for food and nesting sites, kill native birds, and may indirectly harm native birds of prey if they ingest human-made toxins intended for invasive species management. In an exhibit setting, ways to aid native birds include creating a structure with minimal, natural or covered light fixtures; patterned or opaque glass; cages that are suitable for the birds they house; and an environment that incorporates native plants that provide necessary resources, such as foraging sites and shelter, for its avian inhabitants. These scientific ideas will be incorporated through the design of the term project product–any structural components will be designed to be safe for birds, and any habitat will remain accurate to the birds' environment in the wild (whether such a habitat is intended to be real or depicted through a diorama or illustration). The term project is intended to appeal to and educate people of all ages, as anyone can be inspired to take action towards conservation of native wildlife. However, since the central focus of the term project research is New York City and nearby regions, this project's primary audience will be the people who inhabit New York, the Northeast, and other American urban areas.

Two potential directions for my creative work are as follows: a hybrid indoor/outdoor exhibit (rendered using Blender, a 3D modeling program) with live plants and animals or an museum exhibition (drawn as a 2D illustration or also made with 3D software) comparing habitats with invasive species and native species. The first idea is similar to a sanctuary or aviary, designed with the welfare of the birds in mind. Species that would reside in this habitat include Eastern Bluebirds, Downy Woodpeckers, and Black-Capped Chickadees. Information about each species could be presented in the form of cards on a wall or a brochure that could be passed along throughout the exhibit, and information on the invasives that threaten them could also be on the brochure or pieces of writing. Due to the extensive harmful nature of invasive species, none will be included within the habitat; information about the damage caused by invasive species will be featured on a brochure or within the exhibit space.

Birds who call the exhibit home deserve to have an environment that suits their needs as well. The interior of a built environment should solely include native plants and provide adequate space and enrichment. Cages for birds should be at least 1.5 times the wingspan of a bird at all times, and mesh size should similarly match the bird's size. For example, passerines (songbirds such as bluebirds, sparrows, and cardinals) should have a mesh dimension of half an inch by up to 2.5 inches. Woodpeckers should be protected by a mesh that does not exceed 1inch by 1 inch, and doves should have even smaller gaps between the mesh, being 0.5 by 0.5 inches. Birds may need to be caged to be acclimated

to a new environment or for medical quarantine. Still, the cages need to be large enough to allow the bird to move freely. Also, bird mesh needs to be small enough to prevent a bird getting stuck and durable enough to prevent destruction or security threats. In addition to being safely contained, the exhibit or aviary should be tailored to the needs of specific birds. Birds should be provided with space to perch, forage, fly, build nests and do other natural activities. Diets and plants should replicate the diets and habitat of the wild birds (Global Federation of Animal Sanctuaries, 2019). Eastern bluebirds, for example, are omnivorous and should be provided with insects (such as mealworms) and berries from native trees (nonnative trees provide less nutritious, as aforementioned). In and around New York City, the most common native tree species include sugar maple, red maple, hemlock (*Tsuga canadensis*), white pine, white ash, black cherry, and Northern red oak (Riemann et al., 2014). These trees are all from New York forests, but many are from various genera and families, so a habitat with these trees would be relatively biodiverse and would sustain native birds. A forest is usually a climax community, so a bird habitat should also have flowers, shrubs, and grasses. According to The National Audubon Society's *Native Plants–Best Results Page* (2024), flowering plants native to New York City include American pokeweed, which attracts woodpeckers and several passerine families (including thrushes such as bluebirds). American pokeweed is beneficial for woodpeckers and passeriformes because it produces berries eaten by songbirds and nuts valued by woodpecker species. Black raspberry is a fruiting shrub which also hosts many types of birds because it provides food (blackberries). Wand panic grass is a tall grass that is thought to invite several bird families, including sparrows, chickadees, and finches. This grass provides seeds to ground feeding birds such as sparrows, hosts butterflies, and provides shelter for many types of small songbirds. These three types of plants are all suitable to grow together because they can withstand a variety of conditions including different amounts of sunlight and both wet or dry soils. These native flora could be some of the species to include in an exhibit, as they can thrive in similar conditions and appeal to various birds native to New York.

My second idea for a creative work would be akin to a museum exhibit rather than a zoo or aviary, with dioramas or illustrations depicting the impact of invasive species in an almost narrative manner. The room could be set up in a linear or rectangular plan, where the first diorama depicts an untouched ecosystem, then another diorama would exhibit the introduction of invasive species, then the various other effects of invasive species, ending with native species appearing vulnerable or even extinct. To prevent viewers from feeling hopeless, I could add another exhibit either at the end of the sequence or in a separate corner showing how people could help native birds thrive. Because museum exhibits also use writing to give context to the readers, additional scientific information could be displayed through blurbs next to each diorama/illustration; the information could also be broadcasted through an audio system throughout the exhibit.

In order to be more interactive, the museum exhibit could also be a walk-through exhibit instead of a collection of dioramas. The room could have realistic models of

plants and birds designed to look like the native flora and fauna of a New York temperate deciduous forest (as well as the invasive species that harm this habitat). Similarly to the narrative of the previously mentioned diorama idea, this form of exhibit would also tell a narrative. As visitors walk into the exhibit, they would first be immersed in an untouched, uninvaded New York ecosystem, which would become progressively more overrun and impacted by invasive plants and animals as visitors pass through. The exhibit would conclude with ways that the visitors can help local native birds, inspiring viewers as they exit from the space. For example, this end of the room could display a miniature house with a window that has decals intended to deter birds from flying into the glass, and there could be a mock-garden with native species planted which could attract and provide resources for native birds. The goals of the aviary and both of these museum iterations are to warn people of how vulnerable our native ecosystems are to invasive birds, pests, and plants as well as to demonstrate how birds can thrive in a space curated without these invasive species.

In summary, my term project will include the scientific concepts of how invasive plants undermine native plants which are needed by birds, support populations of invasive bird and plant species, harbor disease, affect the reproductive (nesting/breeding) behavior of native birds, and alter the land which avifauna inhabit. Invasive bird species compete with native bird species for food and nesting sites, kill native birds, and may indirectly harm native birds of prey if they ingest human-made toxins intended for invasive species management. The term project will also consider ways to safeguard native birds by creating a structure with minimal, natural or covered light fixtures; patterned or opaque glass; cages that are suitable for the birds they house; and an environment that incorporates native plants that provide resources for the birds. The two kinds of works which I could use to embody and explain these scientific concepts are an aviary for birds that are endemic to New York or a museum exhibit with either dioramas or a walk-through immersive space that illustrates the effects of invasive species on native birds.

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