

Biodiversity Inventory Hawk Rise Sanctuary & Linden Landfill 2013 Survey Results



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GOALS AND OBJECTIVES

The City of Linden initiated the Hawk Rise project to restore and maintain the site with the purpose of using this existing natural resource to provide for research, environmental education, and public access at the site. The primary area of focus is approximately 36.8 forested acres adjacent to the Linden Landfill, known as the Hawk Rise Sanctuary. New Jersey Audubon (NJA) has partnered with the City of Linden to provide educational programming, stewardship guidance, and wildlife monitoring at the site. Specifically for the purpose of this report, NJA's goal is to collect and evaluate information on wildlife populations at the Linden Hawk Rise site, as well as the adjacent Linden Landfill and Rahway River marshes, to assess the effects of habitat and other stewardship activities at the site, use this information to guide future management and aid in designing educational programming at the site. NJA initiated baseline monitoring in 2010, and collected information on birds, amphibians, and plant species present during the first year. During 2011, 2012 and 2013, NJA continued standardized surveys of bird populations in order to expand seasonal coverage, increase the number of species detected, examine inter-annual variability, and provide a baseline that can be used to assess the effects of ongoing stewardship activities on wildlife populations. This report summarizes results of surveys conducted between December, 2012 and November, 2013.

INTRODUCTION

New Jersey Audubon's mission is to foster environmental awareness and a conservation ethic among citizens; protect New Jersey's birds and other wildlife, especially endangered and threatened species; and promote the preservation of natural habitats. This mission is realized through Education and Programming, Research and Wildlife Monitoring, Conservation, Stewardship, and Environmental Advocacy. Preserving wildlife and the natural systems upon which they depend, will require reducing habitat loss and actively managing existing habitat through appropriate stewardship activities, and thus improving viability of resident and migratory populations. This goal aligns well with the needs at the Linden Hawk Rise site. NJA is working with the City of Linden to restore the forest and other habitats associated with the Linden Landfill, including breeding and migratory bird habitats, vernal pools for amphibians, wetlands and native forest species. By implementing its vision for a greenway, the City of Linden will make itself more liveable; improve its economy through tourism and civic enhancement; preserve and restore open space; and provide opportunities for physical activity to improve fitness and mental health of its residents.

NJ Audubon first entered into a Memorandum of Understanding with the City of Linden in 2008. In addition, ForesTree Consultants was hired to develop a Forest Stewardship Plan (ForesTree Consultants 2009), which was completed and approved by the State of New Jersey. The plan provides an overview of the property and a detailed description of the existing forest components and structure, and includes recommendations for management that will improve the forest composition in accordance with a mixed age forest and in line with the needs of target wildlife species. The city of Linden has also worked with a consultant group to restore habitat at the site, and work to date has included wetland restoration and understory plantings in the Hawk

Rise forest. NJ Audubon has continued working with the City in 2013 to build an educational programming platform for the Sanctuary, increase public relations and outreach, develop and implement stewardship recommendations, and continue bird surveys.

NJ Audubon initiated wildlife surveys in 2010, to obtain baseline data on the existing natural resources at the site (MacGregor and Munafo 2010). In 2011 and 2012, NJA continued a second year of baseline bird surveys, to increase seasonal coverage, increase the number of species detected, and examine inter-annual variability (Munafo and Tsipoura 2011; Munafo and Allen 2012). The 2013 results presented here represent the fourth year of standardized bird surveys at the site. As Linden continues to move forward toward the restoration of the Hawk Rise site and Linden Landfill, the baseline pre-management data will be compared with subsequent post-management data to determine the impact of stewardship activities on wildlife populations. Using robust and repeatable scientific methodology for continued monitoring at the site will also allow us to determine whether restoration efforts are effective in improving forest health and providing habitat for wildlife at this site and will identify potential areas for additional restoration.

METHODOLOGY

Bird Survey Methods

2013 represents the fourth year of bird surveys conducted at Linden Hawk Rise and the surrounding landfill and marsh habitats. Surveys were conducted using a combination of standardized point count and line transect surveys. Following standardized and scientifically rigorous protocols allows for repeatability of surveys through time and detailed analyses. In addition, all surveys include methods that will allow for future distance analyses, occupancy modeling and/or time removal sampling to account and adjust data for imperfect detectability. Spring migration and breeding season bird surveys were conducted following standard point count methodology (Ralph et al. 1995). During these time periods, birds are vocalizing and are therefore likely to be more detectable on point counts than other time periods. Winter and fall migration surveys were conducted using 200m line transect surveys (Buckland et al. 2006). Line transect surveys may be more effective for migration surveys (Wilson et al. 2000), and are particularly useful during fall and winter surveys when birds are less vocal. Detailed survey methodologies for point count and transect surveys are presented below.

Point and transect locations

To ensure repeatability of surveys through time, we continued surveys at the point and transect locations that we initially mapped in 2010 and have surveyed annually since then. Spring and Breeding Season point count locations were established following standard protocols for avian surveys (Ralph et al. 1995). In the wooded area, points were systematically located on a grid and spaced at least 200m apart to avoid duplicate counting of individuals. We created a 200m by 200m vector grid using ET GeoWizards 9.9 (ET SpatialTechniques 2009) and ESRI ArcGIS ver. 9.3. If points fell within an unsuitable or inaccessible area, they were moved slightly to a surveyable location, while maintaining the 200m distance between points. Points around the

edge of the landfill were located at least 200m apart along the access road. A total of 12 survey points were surveyed during 2010, 2011, 2012, and 2013 (Table 1 and Figure 1). The points cover a variety of habitats (Figure 6) including forest and vernal pools, the Rahway River and surrounding marsh habitats, the grass-dominated Linden Landfill, and an herbaceous/scrub/shrub edge habitat around the landfill.

Fall and winter transects were established using the existing point count grid. Each transect began at a point count location, and ran 200m from the point. We located transects at least 200m apart, and covered all habitats at the site. This selection methodology resulted in the selection of 7 transects that we have now surveyed for four years (2010-2013; Table 1 and Figure 1).

Survey methodology

Point count and transect surveys were conducted following standard protocols (Ralph et al. 1995, Buckland 2006). All surveys were conducted between one half hour before sunrise and four hours after sunrise, on days with no precipitation and wind speeds less than 12 mph (Beaufort 3).

During spring migration and breeding season surveys, observers conducted 10-minute point counts at each location, recording all birds heard or seen. Surveys were repeated three times during spring migration, between mid-April and mid-May. In 2013, the first spring survey was conducted on April 17th, the second survey was conducted on May 4th, and the third survey was conducted on May 14th. We also completed three surveys during the breeding season, between late-May and late-July: May 29th, June 18th, and July 3rd. To account for biases in population measures resulting from imperfect detectability, data collection methods were designed to allow future distance sampling (Buckland et al. 2001) and time-depletion (removal) analyses (Farnsworth et al. 2002). Repeated surveys will also allow the use of occupancy modeling (MacKenzie et al. 2006) in future analyses. Observers recorded all birds heard or seen in ten one-minute intervals, and measured exact distance, when possible, using a laser rangefinder.

Transect surveys were conducted four times during Winter 2012-2013, between December and March. Winter surveys were conducted on December 28, 2012, and January 29, March 1, and March 13, 2013. Transect surveys were also conducted four times during 2012 fall migration, between mid-August and the end of October. In 2013, surveys were conducted on August 26th, September 16th, September 26th, and October 14th. Data collection methods were designed to allow future distance analyses (Buckland et al. 2001, Buckland 2006). Observers walked along the transect line, and recorded exact distance, when possible, and direction to each bird. During both point count and transect surveys, observers also recorded observation type (heard, seen, heard and seen, or overflight) for each detection, as well as basic weather information (wind speed, temperature, sky condition) and time of day.

Data Analysis

Results presented here are a simple tabulation and summary of observations, but the data collection methods used will also allow more detailed analyses that take into account detection probabilities, such as occupancy modeling (MacKenzie et al. 2006), distance (Buckland et al. 2001) and removal analyses (Farnsworth et al. 2002).

At the entire site level, we created a list of all bird species observed during 2013 winter, spring migration, breeding, and fall migration surveys. We calculated species richness, including the total number of species observed, and total number of state Endangered, Threatened, and Special Concern species observed during each season. For each species and season, we also calculated frequency of occurrence by point, total number of individuals observed per point, and relative abundance. Frequency of occurrence by point was calculated as the number of points at which a species was observed divided by the total number of points surveyed. Relative abundance was calculated as the total number of observations of the species of interest divided by the total number of observations for all species combined. The total number of observations represents the sum of all individuals counted at each point/transect, across all surveys and locations. An individual bird may be present on multiple survey visits, and each time that individual is counted during a survey visit is considered a separate observation. For example, a Grasshopper Sparrow breeding on the landfill may be recorded once during the first breeding survey and also once during the second breeding survey. Although this may be the same individual, it would be recorded as two separate observations. We also tabulated the number of birds observed during each survey, and calculated the maximum number of individuals recorded, across all points/transects, on any one survey. The maximum number of individuals observed on any one survey may be a more realistic representation of the number of birds using a site than the total count of individuals across the entire survey period, because many individuals, particularly during the breeding season, were most likely recorded during more than one of the three surveys conducted at each point.

With the opening of the Hawk Rise Sanctuary boardwalk trails to the public and the start of formal educational and birding walks at the site, combined the growing popularity of online checklists such as eBird (eBird.org; Sullivan et al. 2014), we now have available to us new sources of observational data. We examined eBird checklists for 2013 and incorporated into our overall bird list any species that were not observed during our surveys. These data cannot be verified or included in any formal data analysis, nor can we identify the exact locations of any sightings within the site. Despite these limitations, we have decided to include these data here to better characterize the full diversity of species using the Sanctuary and surrounding areas. We included all 2013 checklists entered for the 'Linden Hawk Rise Sanctuary' eBird Birding Hotspot; however, this list may not be comprehensive because other users have entered data under eBird Personal Locations, and we have not included all of those data here.

To summarize results over the full four-year survey period (2010-2013) and examine inter-annual variability, we compiled a full list of bird species observed at the site.

RESULTS AND DISCUSSION

2013 Bird Survey Results

A total of 120 bird species were observed at the Hawk Rise Sanctuary, Linden Landfill, and adjacent Rahway River marshes, between December 2012 and November 2013. These include 114 species detected on point count and transect surveys, and an additional 6 species observed during site visits, but not recorded on the surveys (Table 2, 3a). The full list of species observed on point count and transect surveys or observed at the site is displayed in Table 3a, and survey data for each season, by point/transect and survey are presented in Tables 4-15. An additional 36 species were recorded by eBird users and other observers at the site in 2013, but were not observed during our NJ Audubon survey visits (Table 3b). Although these data have not been collected in a consistent manner and therefore cannot be verified or used in any data analyses, they help to fill in gaps for species that may have been present at the site, but not detected during our visits. Including the eBird records, a total of 156 species were observed at the site between December 2012 and November 2013.

During the 2013 surveys, we observed three state-Endangered species (Bald Eagle, Black Skimmer, and Northern Harrier), five state-Threatened species (American Kestrel, Bobolink, Grasshopper Sparrow, Osprey, and Savannah Sparrow), and thirteen species of Special Concern (Blackburnian Warbler, Black-throated Blue Warbler, Cooper's Hawk, Eastern Meadowlark, Great Blue Heron, Least Flycatcher, Northern Parula, Semipalmated Sandpiper, Snowy Egret, Spotted Sandpiper, Veery, Winter Wren, and Yellow-breasted Chat). Eastern Meadowlark, Least Flycatcher and Yellow-breasted Chat were new species in 2013 and had not been recorded during the previous three years of surveys. Two additional state-Endangered species (Peregrine Falcon and Pied-billed Grebe), two Threatened species (Black-crowned Night-Heron and Red-headed Woodpecker) and seven species of Special Concern (Black-throated Green Warbler, Brown Thrasher, Canada Warbler, Least Bittern, Nashville Warbler, Sharp-shinned Hawk, and Wood Thrush) were entered by eBird users, but not detected during our 2013 survey visits. Most of these species have been recorded in previous survey years, but Black-crowned Night-Heron, Pied-billed Grebe and Red-headed Woodpecker have not been detected during our surveys.

Some of the state-listed species recorded at the Linden site maintain their designations throughout the entire year (e.g. American Kestrel, considered threatened year-round), while other species are listed only during the breeding season or have different designations during breeding and non-breeding periods (Table 3). For example, Northern Harrier is listed as Endangered during the breeding season and as a species of Special Concern during migration, and species like Black-throated Blue Warbler are listed as species of Special Concern during the breeding season, but are considered stable and therefore not listed during non-breeding periods. Although some of these species were observed only during migration periods, we feel their occurrence is important as it indicates that they are using the habitat available at Linden during migration. These state-listed species are discussed in more detail below under 'State-listed Species'.

Winter 2012/2013

During the four winter 2012/2013 site visits, we recorded 1146 individual birds of 43 different species on transect surveys (Table 4 and 5). We observed one additional species (Blue-winged Teal) along the Rahway River during the fourth site visit, but not during the transect surveys (Table 6). One species (Northern Harrier) is listed as state-Endangered during the breeding season and as a species of Special Concern during other times of year, including winter. Two additional species (American Kestrel and Savannah Sparrow) are listed as state-Threatened; and two species (Great Blue Heron and Winter Wren) are listed as state species of Special Concern. Although only breeding populations of Great Blue Heron, Savannah Sparrow and Winter Wren are state-listed, we feel their occurrence during winter is still important as it may indicate appropriate habitat for these species at other times of year.

Song Sparrow was observed at the greatest transect frequency, occurring at all seven transects (100% frequency); followed by Canada Goose, Herring Gull, and Red-winged Blackbird, observed at 86% of all survey transects (6 out of 7 transects surveyed). American Tree Sparrow, Belted Kingfisher, Blue Jay, Mallard, and Northern Cardinal were also observed on more than 50% of the transects surveyed (Table 4). Ring-billed Gull accounted for the greatest number of observations (557), representing 48.6% of the total for all species combined (relative abundance = 0.486); and was followed by Canada Goose (257 observations), Red-winged Blackbird (54 observations), Herring Gull (36 observations), and Song Sparrow (30 observations).

The number of species observed per transect ranged from nine recorded across the four surveys at Lind_T07 at the top of the Linden Landfill to 20 species recorded at Lind_T03 along the edge of the landfill (Table 4 and Figure 2). Lind_T03 is located near a diversity of habitats including marsh, forest, open water (a large pond), and grassland (landfill), and this variety of habitats may explain the diversity of bird species also recorded there.

An additional twelve species were entered by eBird users during the Winter 2012/2013 season (December 2012 through March 2013), including one state species of Special Concern (Sharp-shinned Hawk; Table 4b). With the exception of Common Merganser, these twelve species have previously been recorded on our surveys. We have included these observations here because they allow us to fill in gaps for (mostly common) species that may have been present, but not detected, during our four survey visits. When we include these species in our total count, it brings the total Winter 2012/2013 count to 56 species.

2013 Spring Migration

During three site visits, we recorded 880 individual birds of 78 different species on point count surveys (Tables 7 and 8). An additional five species were observed at the site (Table 9), but not recorded on point count surveys, for a total of 83 species observed at the site. This includes five state-Threatened species (American Kestrel, Bobolink, Grasshopper Sparrow, Osprey, and Savannah Sparrow), and six species of Species Concern (Blackburnian Warbler, Black-throated Blue Warbler, Least Flycatcher, Northern Parula, Snowy Egret, and Yellow-breasted Chat). Although some of these species are listed only for the breeding season, we feel their presence during spring migration is also significant. While many of these species are likely passage migrants, others may breed on or near the site as they were also observed during breeding season

surveys over the four-year survey period (e.g., Bald Eagle, Grasshopper Sparrow, Osprey, Savannah Sparrow, Snowy Egret, Spotted Sandpiper).

American Robin and Red-winged Blackbird were observed at the greatest point frequency, occurring at all twelve points surveyed (100% frequency), followed by Song Sparrow, recorded at 92% of all survey points (11 out of 12 points). Thirteen additional species were recorded on at least 50% of all survey points: American Goldfinch, Baltimore Oriole, Brown-headed Cowbird, Canada Goose, Carolina Wren, Common Grackle, Downy Woodpecker, European Starling, Herring Gull, Northern Flicker, Tree Swallow, Warbling Vireo, Yellow Warbler (Table 7). The most abundant species recorded were European Starling (131 observations), Red-winged Blackbird (101 observations), American Robin (82 observations), Canada Goose (81 observations), and Song Sparrow (39 observations).

The number of species observed per point ranged from 16 at Lind_13, at the top of the Linden Landfill, and Lind_10, around the edge of the landfill, to 37 at Lind_03 within the Hawk Rise woods (Table 7 and Figure 3). There was no clear geographic pattern throughout the site, but greatest species richness was recorded in the forested area, with 37 species observed at Lind_03 and 27 species observed at Lind_05, and around the landfill edge, with 27 species observed at Lind_11 (Figure 3). Lind_03, in particular, has consistently recorded a high diversity of species during migration. Although we have not conducted quantitative vegetation surveys around this point, it is located near the forest edge and has a relatively open canopy and dense understory, characteristics that may be suitable for birds during migration.

An additional 29 species were entered by eBird users during the 2013 Spring Migration season (April 1st through May 15th), including one species (Pied-billed Grebe) designated as state-Endangered during the breeding season, and a species of Special Concern during non-breeding periods. Four other species are listed as species of Special Concern during breeding periods (Black-throated Green Warbler, Canada Warbler, Nashville Warbler, and Wood Thrush), but are considered stable during non-breeding periods. While most of the species entered have been previously recorded on our NJ Audubon survey visits, five species are new to the site list: Boat-tailed Grackle, Great Cormorant, Pied-billed Grebe, Turkey Vulture, and Yellow-bellied Sapsucker. These are species that would be expected in this area during migration, and we have included these observations here because they allow us to fill in gaps for (mostly common) species that may have been present at some point during the migration season, but not detected during our four survey visits. As species composition changes daily during migration, it is not likely that we can observe all species that are passing through during only three site visits. When we include these species in our total count, it brings the total Spring 2013 count to 112 species.

2013 Breeding Season

A total of 899 individual birds of 53 species were counted on the three Breeding Season point count survey visits (Tables 10 and 11). Five additional species were observed at the site, but not recorded on point count surveys, including the state-Endangered Black Skimmer (Table 12). Breeding status at the site was not determined for individual species as part of the survey protocol, but point count survey results indicate that a variety of species are using the site during the breeding season. Some species recorded (e.g. Blackpoll Warbler) were likely late spring

migrants, rather than breeding birds, but the majority of species are likely local breeders. Breeding season observations included two state-Endangered species (Bald Eagle and Black Skimmer), three state-Threatened species (Grasshopper Sparrow, Osprey and Savannah Sparrow), and two state species of Special Concern (Great Blue Heron, and Spotted Sandpiper). A single Bald Eagle was recorded during the first survey visit, a Black Skimmer was observed foraging over the pond near Lind_12 during the second visit, and Ospreys were recorded during the second survey. Grasshopper Sparrow and Savannah Sparrow, both grassland-nesting songbirds, were found at two survey points during breeding season surveys exhibiting territorial singing behavior: Lind_12 along the northern edge of the landfill and Lind_13 at the top. These species are discussed in more detail under ‘State listed species of conservation concern.’

Red-winged Blackbird and Song Sparrow were found at the greatest frequency, each occurring at 11 out of the 12 survey points (92%), followed by American Robin and Herring Gull, occurring at 10 survey points. Eight other species were recorded on at least 50% of all survey points: Barn Swallow, Common Grackle, Common Yellowthroat, European Starling, Gray Catbird, Orchard Oriole, and Warbling Vireo, and Willow Flycatcher (Table 10). The most abundant species recorded were European Starling (255 total observations), Red-winged Blackbird (120 observations), Herring Gull (75 observations), Song Sparrow (45 observations), and American Robin (42 observations).

The number of species observed per point ranged from 11 at Lind_13, at the top of the Linden Landfill, to 26 at Lind_12, at the northern edge of the landfill (Table 10 and Figure 4). Over the course of this study, the greatest numbers of species have consistently been observed along the edge of the landfill, where there is a diversity of forest edge, landfill, and wetland habitats.

An additional 29 species were recorded by eBird users and other observers during the 2013 Breeding Season (May 16th through July), including two state-Endangered raptors (Northern Harrier and Peregrine Falcon), one state-Threatened species (American Kestrel), and ten species of Special Concern (Black-billed Cuckoo, Black-throated Blue Warbler, Black-throated Green Warbler, Brown Thrasher, Least Bittern, Least Flycatcher, Nashville Warbler, Semipalmated Sandpiper, Snowy Egret, and Veery; Table 12b). Five species had not been previously recorded on our NJ Audubon surveys: Alder Flycatcher, Black-billed Cuckoo, Boat-tailed Grackle, Green Heron, and Purple Martin. Of the 28 species entered, some are late spring migrants (e.g. Black-throated Blue Warbler, Black-throated Green Warbler), while others are early fall migrant shorebird species that begin to arrive in July. We have included these observations here because they allow us to fill in gaps for (mostly common) species that may have been present, but not detected, during our three Breeding Season survey visits. When we include these species in our total count, it brings the total 2013 Breeding Season species count to 86 species.

2013 Fall Migration

During four 2013 fall migration visits, we recorded a total of 686 individual birds of 62 different species on transect surveys (Tables 13 and 14) and observed one additional species (Merlin) at the site (Table 15). We observed three state-Threatened grassland species (American Kestrel, Bobolink, and Savannah Sparrow). Bobolink is considered Threatened during the breeding season and a species of Special Concern during the rest of the year, and only breeding Savannah

Sparrows are designated Threatened. We also observed Osprey, a Threatened breeding species, on multiple occasions throughout the fall, and recorded seven species of Special Concern: Black-throated Blue Warbler, Cooper's Hawk, Eastern Meadowlark, Great Blue Heron, Northern Parula, Semipalmated Sandpiper, and Snowy Egret. Five of these species (Black-throated Blue Warbler, Cooper's Hawk, Great Blue Heron, Northern Parula, and Snowy Egret) are listed as species of concern during the breeding season only; however, we feel that their use of the Linden site during migration is also significant.

Red-winged Blackbird was observed at the greatest frequency of transects, occurring at six of the seven transects surveyed. American Goldfinch, American Robin, Common Yellowthroat, Herring Gull, Palm Warbler, Song Sparrow, and Yellow-rumped Warbler were each recorded along five survey transects (71% of the transects surveyed). Four other species were recorded at four transects: Northern Flicker, Red-bellied Woodpecker, Savannah Sparrow, and Swamp Sparrow. The most abundant species recorded was Song Sparrow (91 individuals recorded). Herring Gull was the second most abundant species with 82 observations, followed by Red-winged Blackbird (63 observations), Ring-billed Gull (49 observations), and Mallard (41 observations).

The number of species observed per transect ranged from 15 at Lind_T07, at the top of Linden Landfill, to 28 at Lind_T03, along the landfill/forest edge. Greater than 20 species were also observed at Lind_T01, in the Hawk Rise woods, and Lind_T06, along the edge of the Linden Landfill (Figure 5).

An additional 36 species were entered by eBird users during the 2013 Fall Migration season (August 15th through November), including one species (Northern Harrier) designated as state-Endangered during the breeding season, and a species of Special Concern during non-breeding periods. Red-headed Woodpecker, a state-Threatened species, has not been previously recorded at the site, but was observed on multiple occasions by eBird users during late-fall, 2013. Black-crowned Night-Heron, a Threatened species during the breeding season and a Special Concern species during non-breeding periods, was also recorded during the Fall Migration period. Four other species are listed as species of Special Concern during breeding periods (Black-throated Green Warbler, Brown Thrasher, Least Flycatcher, and Winter Wren), but are considered stable during non-breeding periods. While most of the species entered have been previously recorded on our NJ Audubon survey visits, three species are new to the list: Green Heron, Pine Warbler, and Red-headed Woodpecker. We have included these eBird observations here because they allow us to fill in gaps for (mostly common) species that may have been present at some point during the migration season, but not detected during our four survey visits. As species composition changes daily during migration, it is not likely that we can observe all species that are passing through during only three site visits. When we include these species in our total count, it brings the total Fall 2013 count to 99 species.

2010 - 2013 Combined Bird Survey Results

Cumulative species list

Table 16 presents a full bird species list for the first four years of NJ Audubon surveys at Linden Hawk Rise and the surrounding Linden Landfill and Rahway River marshes. A total of 157 bird species were observed during the four year period. During 2013, the fourth year of surveys at the site, we added an additional 16 species that were not observed during the 2010-2012: American Pipit, Bank Swallow, Blue-winged Teal, Eastern Meadowlark, Fish Crow, Forster's Tern, Fox Sparrow, Least Flycatcher, Louisiana Waterthrush, Merlin, Red-breasted Merganser, Ring-necked Pheasant, White-winged Crossbill, Wilson's Warbler, Yellow-breasted Chat, and Yellow-throated Vireo. Of the 157 total species, 76 species (48.4% of the total) were observed during all four survey years; 25 species (15.9%) were recorded in three out of four years; 14 species (8.9%) were observed during two of the four years; and the remaining 42 species (26.8%) were observed during only one year. Most of the species observed during only one year were observed during migration periods, when bird use changes daily, but some (e.g. Acadian Flycatcher, Yellow-billed Cuckoo) were observed during the breeding season.

We suspect the number of species observed during the survey period may be an underestimation of the total number of species that use the site, particularly during spring and fall migration periods. Bird use changes daily during migration periods, and thus we are likely to miss some species with only three to four site visits during the entire migration period. Bird use also changes annually, and some species may not be present at the site every year. Combining data across multiple years increases our chance of detection, as evidenced by the number of species observed during only one year of the survey, and the fact that we have continued to add new species to the list every year. In addition, some species groups (e.g. nocturnal owls and secretive marsh birds) may be underrepresented in the dataset. NJA staff did find a single owl pellet during a site visit in 2010, followed by confirmation of Great Horned Owls nesting in the small patch of woods east of the landfill in 2012, and continued observations of owls through 2013. We also have observed both Clapper and Virginia Rails in the salt marshes adjacent to the Rahway River, but we feel these hard-to-detect groups may not be fully represented.

With the recent opening of the Hawk Rise boardwalk trail to the public, coupled with an increase in educational programming at the site, we now have available to us a collection of eBird checklists. These data cannot be verified or used in formal data analyses, but they can be used to fill in some of the gaps in our knowledge of species presence at the site. eBird users and other observers recorded 17 species that have not been recorded during our survey visits (Table 17). When we include these species in our count, it brings the 2010-2013 total to 174 species.

State-listed species of conservation concern

During the four years of standardized surveys at Linden Hawk Rise Sanctuary and the surrounding Linden Landfill and Rahway River marshes, we observed four state-Endangered species (Bald Eagle, Black Skimmer, Northern Harrier, and Peregrine Falcon), six state-Threatened species (American Kestrel, Bobolink, Grasshopper Sparrow, Horned Lark, Osprey, and Savannah Sparrow), and eighteen species of Special Concern (Blackburnian Warbler, Black-throated Blue Warbler, Black-throated Green Warbler, Brown Thrasher, Canada Warbler,

Cooper's Hawk, Eastern Meadowlark, Great Blue Heron, Least Flycatcher, Nashville Warbler, Northern Parula, Semipalmated Sandpiper, Sharp-shinned Hawk, Snowy Egret, Spotted Sandpiper, Veery, Winter Wren, Wood Thrush, and Yellow-breasted Chat; Table 16). In addition, eBird users and other observers have recorded two state-Endangered species (Least Tern and Pied-billed Grebe), two state-Threatened species (Black-crowned Night-Heron and Red-headed Woodpecker), and three species of Special Concern (Black-billed Cuckoo, Blue-headed Vireo, and Least Bittern; Table 17). Each of these state-listed species is discussed in more detail below.

State-listed raptors

The Hawk Rise forest, Rahway River and adjacent marshes, and Linden Landfill provide habitat for a variety of raptor species during breeding and/or migratory/winter periods. In particular, we have observed seven state-listed raptor species over the four-year survey. Bald Eagle is listed as state-Endangered during the breeding season and state-Threatened during non-breeding periods. Previously federally endangered, Bald Eagle populations have recovered throughout the US, resulting in recent federal de-listing. Breeding Bald Eagles were nearly eliminated from New Jersey by the 1970s, but have recovered following the ban of DDT, combined with restoration management, reaching a total of 148 breeding pairs statewide in 2013 (Smith and Clark 2013). A single Bald Eagle was observed flying over the Rahway River during the third fall migration survey in 2011. In 2012, single individuals were recorded during the first spring migration survey and the first breeding season survey. These individuals were observed flying around the site, and also perched and eating prey both on the top of the landfill and on an island in the Rahway River. In 2013, a single adult Bald Eagle was observed flying east along the Rahway River during the first survey on May 29th. This species was also recorded by eBird users on multiple occasions between May and June. Landfill staff have also reported seeing Bald Eagles occasionally at the site, but these additional reports have not been documented or confirmed. The state Endangered and Nongame Species Program reports one Bald Eagle nest (the "Linden" nest) in Union County. This was a new nest first reported in 2012 (Smith and Clark 2012), and the pair then moved to a new nest tree and fledged one young in 2013 (Smith and Clark 2013). It is likely that the individuals reported along the Rahway River during the 2012 and 2013 breeding seasons may have been individuals of this pair.

Northern Harrier is listed as Endangered during the breeding season and a species of Special Concern during the non-breeding period. In New Jersey, this species breeds primarily in salt marshes and occasionally in large freshwater marshes or large inland grasslands (Walsh et al. 2009). Northern Harriers were observed during fall migration during the first three years of the survey and during 2011/2012 and 2012/2013 winter surveys, foraging over the open marsh area adjacent to the Rahway River and in the grasslands on the landfill. In 2013, eBird observers also recorded Northern Harriers using the site on multiple occasions between late-July and October.

Peregrine Falcon is another species listed as Endangered during the breeding season and a species of Special Concern during the non-breeding period. Peregrine Falcons were eliminated from NJ during the mid-1900s, and were reestablished beginning in the 1970s. In New Jersey, Peregrine Falcons nest on towers, buildings, bridges and natural cliffs, with 26 active pairs recorded in 2013, including a nesting pair in Elizabeth (Clark et al. 2013). A single Peregrine Falcon was observed actively hunting near transect Lind_T04 during the third 2012 fall

migration survey. This species was not observed during any of the 2013 survey visits, but was observed flying over the site by an eBird observer on July 12, 2013.

Osprey is a threatened species in New Jersey, but populations have been increasing in recent years, reaching over 500 nesting pairs in 2013 (Clark and Wurst 2013). Although the majority of the breeding population occurs in southern New Jersey (Clark and Wurst 2013), NJA identified a large number of nests along the Raritan River (Tsipoura and Mylecraine 2010), and significant nesting populations have been documented along the Hackensack-Hudson Rivers and the Raritan Bay area (Clark and Wurst 2013). Osprey were frequently seen flying along the Rahway River in all three years of this survey, during both migration and breeding seasons, but no breeding activity was recorded in the immediate area. In 2013, they were recorded on Spring Migration, Breeding Season, and Fall Migration surveys; and were also recorded by eBird observers on multiple occasions during the same time period.

American Kestrel has recently been elevated to threatened status in the state. This small cavity-nesting falcon breeds in nest boxes, old buildings and barns near open habitats (Walsh et al. 1999), and forages in open areas during migration and winter (Smallwood and Bird 2002). American Kestrels were observed foraging over the Linden Landfill on multiple occasions during 2010 fall migration and through the first winter survey. They were also observed during both spring and fall migration in 2011, and during winter 2011/2012 and fall 2012 surveys, in the vicinity of the landfill. In 2013, kestrels were observed during winter, spring, and fall migration surveys; and were recorded by eBird observers during the same time periods. These falcons readily take to nest boxes in the appropriate habitat and may be enticed to breed at the site if an appropriate one were erected.

Two woodland accipiter species were encountered in and around the edge of the Hawk Rise forest during the first four years of surveys. Cooper's Hawk and Sharp-shinned Hawk are both state species of Special Concern; Cooper's Hawk during the breeding season only, and Sharp-shinned Hawk during both breeding and non-breeding periods. Sharp-shinned Hawk was observed on LIND_T01 during the third 2010 fall survey, and along the forest edge during the third 2011 fall survey. This species was not observed during 2012 or 2013 surveys, but was recorded by eBird observers during October, 2012, and January, 2013. Cooper's Hawk was observed during winter surveys in 2011 and 2012, and during fall migration surveys in 2012 and 2013.

State-listed waterbirds

The Rahway River, adjacent marshes and open water ponds provide habitat for long-legged colonial wading birds, shorebirds, and other waterbird species. Observations of Great Blue Heron and Snowy Egret (both species of Special Concern during the breeding season), along with Great Egret, suggest that the marshes surrounding the Linden site provide important foraging habitat for these colonial nesting waterbirds. All three species were observed during both breeding and migration periods during all three years of the survey. Black-crowned Night-Heron (state-Threatened) was also recorded by at least one eBird user in 2013, but has not been recorded on any of our survey visits. Great Blue Heron is an inland colonial-nesting species, breeding in trees over fresh or brackish water (Walsh et al. 1999). Great Egret, Snowy Egret, and Black-crowned Night-Heron are coastal and colonial nesting species, which breed in mixed

island colonies in the NY/NJ Harbor, also with Glossy Ibis, Yellow-crowned Night-Heron, Little Blue Heron, Tri-colored Heron, Cattle Egret, and Green Heron (Craig 2010). These “Harbor Herons” are known to leave the nesting colonies during the day and use wetland habitats in New Jersey and New York as foraging habitat during the breeding season, and also use these areas during the post-breeding and migratory seasons (Harbor Herons Subcommittee 2010).

Spotted Sandpiper is a state species of Special Concern during the breeding season. This species breeds near freshwater ponds, lakes, rivers and streams (Walsh et al. 1999), and was observed during three survey periods (spring migration, breeding, and fall migration) in 2010, during spring migration and the breeding season in 2011 and 2012, and during breeding season surveys in 2013. In 2010, Spotted Sandpiper was observed at LIND_06 during spring migration, LIND_12 during breeding season surveys, and near LIND_T05 during the first fall survey. During 2011, Spotted Sandpiper was observed at Lind_06 during spring migration, and near LIND_12 during breeding season surveys. Similarly, in 2012, this species was observed near LIND_12 during spring migration and breeding surveys. During 2013 breeding surveys, Spotted Sandpipers were observed near LIND_06 and LIND_12. The presence of this species near open pond areas during the breeding season suggests possible breeding activity at or near the site, but breeding status was not determined.

Open mudflat areas and other habitats surrounding the Rahway River provide habitat for a number of other shorebird species during migration, including the Semipalmated Sandpiper, a state species of Special Concern. Semipalmated Sandpiper is a northern breeding shorebird species that migrates through New Jersey during spring and fall migration. Spring migration is condensed, with highest concentrations along Delaware Bay; fall migration is more protracted and this species is one of the most common shorebirds seen in fall migration in the state (Walsh et al. 1999). Semipalmated Sandpipers were observed on LIND_T03 during the first fall survey in 2010; LIND_T05 and LIND_T06 during the first 2012 fall survey; and LIND_T03 during the first 2013 fall survey. The presence of this species, along with other migratory shorebirds (Least Sandpiper, Semipalmated Plover, Solitary Sandpiper, Dunlin, Wilson’s Snipe, Greater and Lesser Yellowlegs), suggests that the Rahway River and adjacent habitats may provide important habitat for these species during spring and fall migration.

The Rahway River and surrounding marshes also provide habitat for other waterbird species of conservation concern. Black Skimmer is an Endangered beach-nesting species, occurring mostly in southern New Jersey (Walsh et al. 1999). In 2010, breeding was confirmed at Sandy Hook for the first time since 1985 (Scott Barnes, personal communication). A single Black Skimmer was observed foraging along the edge of the Rahway River during the third breeding season survey of 2010 (July 1st), and an individual was observed foraging over the pond near LIND_12 during the second 2013 breeding survey (June 18th). The age and breeding status was not determined for these individuals. Least Tern, another state-Endangered beach-nesting species, was recorded by Scott Barnes (NJ Audubon staff) in June, 2012, and recorded in eBird. Typical Least Tern nesting habitat includes sandy beaches, sand spits, and deposited dredge materials. The species may also use alternative habitats such as parking lots, sand mines, bare land at airports, and flat, gravel roof tops (Thompson et al. 1997). In New Jersey, Least Terns breed from the Meadowlands and Raritan Bay to Cape May (Boyle 2011) and have nested at Newark Airport. A single Pied-billed Grebe (state-Endangered during the breeding season and a species of

Special Concern during non-breeding periods), was recorded by Scott Barnes in April, 2013. Pied-billed Grebe is a rare and local breeder in New Jersey (Boyle 2011), and this individual was likely a spring migrant.

State-listed grassland passerines

Grasshopper Sparrow and Savannah Sparrow are both state-threatened species during the breeding season, and rely on a variety of large open grassland habitats, including manmade habitats such as managed airports and landfills (Walsh et al. 1999, Vickery et al. 2005). Grasshopper Sparrow is listed as a species of Special Concern during non-breeding periods, and Savannah Sparrow is only listed during the breeding season. Grasshopper Sparrows prefer moderately open grassland habitats with patches of bare ground, and they have been known to use capped landfills in the eastern U.S. (Vickery 1996). Savannah Sparrows breed in a variety of different open grassland habitats (Wheelwright and Rising 2008). Large numbers of Savannah Sparrows use landfill habitats during migration in the NJ Meadowlands (Mike Newhouse, personal communication). NJ Audubon staff and citizen science volunteers have documented singing Grasshopper and Savannah Sparrows during the breeding season at other landfills throughout the state, as part of the Grassland Bird and Lower Raritan bird surveys (NJ Audubon, unpublished data). During the four years of baseline surveys, NJA staff observed both species on the Linden Landfill during migration and exhibiting territorial singing behavior during breeding season surveys. Although the survey is not specifically designed to confirm breeding status, repeated observations of territorial behavior suggest that both species have likely nested at the site. In addition, we also observed juvenile Savannah Sparrows during the breeding season (July 3, 2013), providing strong support for local breeding. Restricting mowing activities to outside of the breeding season will be important if these ground-nesting species are attempting to breed at the site. An important next step for this project may be to determine whether these state-Threatened grassland sparrows are breeding at the site, and if so, to what extent they are successfully producing young.

In 2010, Grasshopper Sparrows were observed at two landfill survey points during spring migration surveys, but were not observed during any of the breeding season surveys, suggesting that these individuals may have been migrants. Grasshopper Sparrows were not recorded during the 2011 surveys. In 2012, Grasshopper Sparrows were observed during spring migration, breeding season, and fall migration surveys. This was the first year in which this species was observed throughout the breeding season with up to five individuals present at once. In 2012, at least five singing male Grasshopper Sparrows were present on the landfill on June 1st, with three recorded during surveys and two additional birds observed between surveys. Grasshopper Sparrows were again present during the second and third spring migration surveys in 2013, and singing individuals remained through all three breeding surveys. Although breeding status was not confirmed, these repeated observations during the breeding season suggest possible breeding at the site.

Savannah Sparrows have been consistently observed at LIND_13, at the top of the Linden Landfill, during the breeding season surveys in all four years. Repeated observations of singing and other territorial behaviors, along with the presence of three juveniles attended by an adult, during 2013 breeding surveys strongly support local breeding at the site. During migration periods, larger numbers of Savannah Sparrows have been consistently observed at the top of the

landfill, as well as using the taller herbaceous and shrubby edge surrounding the base of the landfill.

Horned Lark is a state-Threatened species during the breeding season and a species of Special Concern during non-breeding periods. This species was observed during the fourth fall survey in 2010 and 2011, and during the breeding season in 2011, but was not recorded in 2012 or 2013. In 2010, a small group of three individuals was observed flying over during an Oct. 29th transect survey at LIND_T06. In 2011, a single bird was observed flying over during a Nov. 1st survey at LIND_T05. A single Horned Lark was observed during the 2011 breeding season surveys, in an area of bare ground at the top of the Linden Landfill on May 31st, which may have been a wandering individual with no territory, or possibly a local breeder. This species prefers natural and man-made short-grass and barren habitats during the breeding season, and is also a late fall migrant and winter resident in New Jersey (Walsh et al. 1999).

A single Bobolink was observed flying over the landfill during the second spring migration survey in 2011. In 2012, one individual was observed at the top of the landfill during the third spring survey, and multiple individuals were observed during the first three fall migration surveys. Similarly, a single individual was observed displaying on the landfill during the third 2013 spring survey, and multiple individuals were observed on LIND_T06 during the second fall migration survey. Bobolink is a state-Threatened species during the breeding season, and a species of Special Concern during non-breeding periods.

Eastern Meadowlark, another grassland-dependent species, was a new species for the site in 2013. A single individual was observed on the landfill during the fourth fall survey. Eastern Meadowlarks have declined throughout New Jersey (Boyle 2011) and are listed as a state species of Special Concern during both breeding and non-breeding periods.

In 2012, an additional grassland-dependent species, the Dickcissel, was found singing on the landfill during the breeding season (June 22nd) at point Lind_08. Dickcissels breed primarily in the prairie grassland region of the U.S., but breed sporadically outside of their typical core and peripheral range (Temple 2002). They are typically scarce migrants and local and rare summer residents, with a small number of pairs attempting to nest in some years (Boyle 2011). This species is not considered Threatened or Endangered in New Jersey, but its presence is a further indication that the site may be providing suitable habitat for grassland birds.

State-listed forest birds

A variety of migrant passerines of conservation concern have been observed using the Hawk Rise forest area during spring and fall migration and breeding periods. In particular, Blackburnian Warbler, Black-throated Blue Warbler, Black-throated Green Warbler, Brown Thrasher, Canada Warbler, Least Flycatcher, Nashville Warbler, Northern Parula, Veery, Winter Wren, Wood Thrush, and Yellow-breasted Chat are Species of Concern during the breeding season. All of these species, with the exception of Wood Thrush, were observed only during non-breeding periods (winter, spring and/or fall migration), but not during any of the breeding surveys. Although these species breed in some parts of NJ, the individuals recorded were most likely migrants. Several of these species (Black-throated Blue Warbler, Black-throated Green Warbler, Canada Warbler, Nashville Warbler and Winter Wren) have restricted ranges, primarily

in northwestern NJ (Walsh et al. 1999, Boyle 2011). Northern Parula and Veery breed more widespread throughout the state, but they were not observed during the breeding season at the Hawk Rise site. Two additional state-listed forest passerines (Black-billed Cuckoo and Blue-headed Vireo) have been recorded by eBird observers. Blue-headed Vireo was observed during fall migration, while the Black-billed Cuckoo was recorded during the breeding season (June 20, 2013). Black-billed Cuckoo is an uncommon, but widespread breeder in the state, and is known to wander erratically during the breeding season, presumably in search of insect food sources (Boyle 2011).

Wood Thrush, a forest-breeding species of special concern that breeds in the understory, was observed in forested habitat during both spring migration and breeding surveys in 2010 and 2011. In 2010, they were observed at Lind_05 and Lind_02 during spring surveys, and at Lind_02 during the breeding season. In 2011, Wood Thrush was also recorded at Lind_02 during 2011 spring migration and breeding surveys. Although we did not determine breeding status, the presence of this species in both years suggests possible breeding at the site during the first two years of this project. Wood Thrush was not observed during the 2012 or 2013 breeding season, but was recorded at Lind_01 during the second spring survey and at LIND_T01 during the second fall migration survey in 2012. This species was not recorded on any 2013 surveys, but was recorded by Scott Barnes on a NJ Audubon-led field trip on May 15, 2013. Stewardship activities intended to increase understory vegetation at the site have the potential to improve habitat for this declining species.

In 2013, a Red-headed Woodpecker was recorded by eBird users on multiple occasions between October and December. This is a state-Threatened species during both breeding and non-breeding periods, and is a scarce and erratic resident and migrant in New Jersey (Boyle 2011). Red-headed Woodpecker is a deciduous forest species, preferring open forests with the availability of snags for nesting and/or roosting (Smith et al. 2000).

In addition to the state-listed species discussed above, a wide diversity of Neotropical migrants and other forest species have been observed using the Hawk Rise woods during breeding and non-breeding periods. In particular, two less common migratory forest passerines found during the 2012 breeding season were Yellow-billed Cuckoo and Acadian Flycatcher, both singing males. Both species were observed on only a single day, so it is likely that they were wandering unpaired individuals.

Other wildlife observations

Throughout the 2013 surveys, NJA staff kept records of other wildlife species observed on site; however, systematic surveys were not conducted, and this is not a full representation of wildlife using the site. Species observed include: White-tailed Deer, Red Fox, Chipmunk, Green Frog, and Bullfrog. We also observed multiple feral cats at the site. This is significant because feral cats have been shown to kill a substantial number of birds in the U.S., and may be the single greatest source of anthropogenic mortality for birds and mammals (Loss et al. 2013). Over the previous three years of the survey we have also observed: Eastern Gray Squirrel, Eastern Garter Snake, Eastern Box Turtle, Red-bellied Turtle, and Fowler's Toad. We have also observed

indirect evidence of Snapping Turtle (shell) and Opossum (tracks), as well as possible River Otter tracks near the boardwalk.

CONCLUSIONS

The Hawk Rise site, Linden Landfill and surrounding Rahway River marshes provide an impressive diversity of high quality forest, wetland, and open habitat types within a surrounding urban landscape. This habitat diversity is used by a variety of birds and other wildlife species, demonstrating the importance of remaining habitat within urban landscapes. During the first four years of surveys, NJA observed a total of 157 bird species using the site, and an additional 17 species have been recorded by public eBird users, field trip leaders during educational programming walks at the site, and SHARP surveyors. The most abundant species recorded during 2013 included common, widespread species such as American Robin, Canada Goose, European Starling, Mallard, Red-winged Blackbird, Ring-billed Gull, Herring Gull, and Song Sparrow; however, a wide diversity of other less common species, including several species of conservation concern were recorded at the site. Bird use of each habitat type is discussed in more detail below.

Forest Habitat

The forested portion of the Linden Hawk Rise Sanctuary is dominated by mixed hardwoods, including pin oak, sweet gum and red maple. During previous vegetation surveys, we found a large number of saplings in the smallest height class, but larger saplings were largely absent. We have also observed evidence of heavy deer browsing on recent restoration plantings of native forbs and shrubs suggesting a significant negative impact on forest understory vegetation. (Groups of 5 to 15 deer are regularly encountered in the forest during bird surveys.) In 2013, the new boardwalk trail has been completed and the Hawk Rise woods are now open to the public.

NJA staff have observed a greater diversity of bird species using the forested area during spring and fall migration than during the breeding season, including several species of Special Concern (Blackburnian Warbler, Black-throated Blue Warbler, Black-throated Green Warbler, Canada Warbler, Least Flycatcher, Nashville Warbler, Northern Parula, Veery, Winter Wren, Wood Thrush, and Yellow-breasted Chat). Migrant diversity has been particularly and consistently notable and in the east-facing woodland edge habitat near point Lind_03. Recent studies have shown the importance of riparian forests within urban landscapes as stopover habitat for Neotropical migrants (e.g. Pennington et al. 2008). Our results suggest that this site, a rare island of habitat within the densely-populated urban fringe of New York City, is used by a variety of songbirds during migration, and habitat management activities that increase the quality of migratory habitat could potentially benefit these migratory birds. A more detailed study looking at stopover length and migrant condition could provide important information about the migratory habitat quality of the site.

The appearance of the first Red-headed Woodpecker during fall 2013 suggests that this site has the potential to provide non-breeding habitat for this state-Threatened species, as well as other

more common woodpecker species. A single Red-headed Woodpecker was consistently recorded by eBird users between October and December, and a variety of more common woodpeckers have routinely been recorded at the site (e.g. Downy, Hairy and Red-bellied Woodpecker). Up to four individual Red-headed Woodpeckers have also been reported at the nearby Ernest L. Oros Wildlife Preserve (Woodbridge, Middlesex County) through the same time period. Throughout their range, Red-headed Woodpeckers were formerly common in urban areas with trees, but have been declined in these areas due to increased pruning of dead branches and removal of dead trees (Smith et al. 2000). The maintenance of dead snags within and along the edges of the Hawk Rise forest may help improve habitat for this species.

Although our survey protocol is not necessarily designed to detect nocturnal owls, a pair of Great Horned Owls was confirmed nesting in a tree in a small forested patch to the east of the Linden Landfill. That nest was lost, possibly during Hurricane Sandy, before the start of the 2013 nesting season; however, Great Horned Owls were observed in the Hawk Rise woods on multiple occasions during winter and spring 2013 surveys.

The forested area also provides breeding habitat for a variety of common songbird species, such as Black-capped Chickadee, Blue Jay, Gray Catbird, Tufted Titmouse, White-breasted Nuthatch, and several woodpecker species. Wood Thrush, a species of Special Concern, was also observed during the breeding season in 2010 and 2011, but breeding status was not determined and this species was not recorded during the subsequent 2012 or 2013 breeding seasons. Wood Thrush generally requires a well developed understory shrub layer, and generally nests within 6 meters of the ground in understory trees or shrubs vegetation. Although Wood Thrush generally prefers larger-area forests, they may also nest in smaller woodland fragments and wooded residential areas and parks, sometimes with reduced fecundity (Evans et al. 2011). Management activities to reduce the deer populations, combined with habitat restoration efforts to increase native understory species would benefit Wood Thrush and other understory-nesting species at the Hawk Rise site.

Rahway River and Wetlands

The Rahway River and adjacent marsh habitat provide winter, migratory, and breeding habitat for a variety of waterfowl, passerines, shorebirds, and other waterbird species. The open pond wetland near Lind_12 also provides a unique habitat that has been consistently used by waterfowl during migration and a variety of shorebirds and other waterbird species, including a foraging Black Skimmer in 2013. A number of state-listed species were observed using these wetland areas during breeding and non-breeding periods. Many of these species likely use the habitats at Linden for foraging during breeding and migration periods (e.g. Bald Eagle, Osprey, Northern Harrier, herons, egrets, Black Skimmers), as discussed in the “State-listed species of conservation concern” section above. A variety of migratory shorebird species were observed during both spring and fall migration, including Semipalmated Sandpiper, a state species of Special Concern, suggesting that the Rahway River and adjacent open mudflat habitats may provide migratory habitat for shorebird species. Although the survey protocol did not target secretive marsh birds, Clapper Rails were heard during all four years of the survey, during spring migration and/or breeding season surveys. A Virginia Rail was also heard during spring

migration surveys in 2012. During the 2011-2013 breeding seasons, NJA also conducted marsh bird surveys at three points near the Linden Hawk Rise site, as part of the Saltmarsh Habitat and Avian Research Program (SHARP; <http://www.tidalmarshbirds.org/>). Surveyors recorded both Clapper and Virginia Rails, and also a Least Bittern that responded to a playback recording during a mid-May survey visit in 2013. Least Bitterns are a state species of Special Concern, and rely on fresh and brackish water marshes with tall, emergent vegetation (Poole et al. 2009). This single observation may have been a migrant, but breeding populations exist in similar habitats in northern New Jersey including the Meadowlands (Boyle 2011). This observation suggests that more intensive surveys, conducted in the early morning (pre-dawn) hours and using recorded playbacks may be beneficial to determine the distribution and abundance of secretive marsh birds at the site. Spotted Sandpiper, a state species of Special Concern, has been observed at the site during the breeding season during all four survey years, suggesting possible breeding activity at or near the site. A variety of common songbird species were also observed using the marshes, including Red-winged Blackbird, Marsh Wren, Common Yellowthroat, Song Sparrow, and Swamp Sparrow.

Linden Landfill

The grassland habitats on Linden Landfill are used by a variety of common bird species, including Canada Goose, Killdeer, Wild Turkeys and Eastern Kingbird, but also provides migratory and breeding habitat for state-listed grassland breeding species. Grasshopper Sparrow, Savannah Sparrow, and Horned Lark were all observed using the landfill during breeding surveys over the course of the four-year survey. Eastern Meadowlark and Bobolink have also been observed during non-breeding periods. In addition, a variety of raptors, including the state-Threatened American Kestrel, have been observed foraging over the landfill during migration and/or winter surveys. American Kestrel has suffered steep declines throughout the state (Boyle 2011); this species readily uses nest boxes and may be attracted to breed at the Linden site if one were erected. Both Grasshopper Sparrow and Savannah Sparrow, state-Threatened species, were consistently observed during breeding season surveys exhibiting territorial singing behavior. A singing male Dickcissel, a non-listed grassland bird, was also found on the landfill during the 2012 breeding season. Two of these species (Grasshopper Sparrow and Savannah Sparrow) are likely breeding at the site, as evidenced by repeated territorial behavior for both species and the presence of juvenile Savannah Sparrows during the breeding season. An important next step for this project would be to determine how successfully these species are breeding. These grassland species would benefit from active grassland management at the site and by avoiding mowing practices during the breeding season.

The taller herbaceous and shrubby border along the road at the lower edge of the landfill provides habitat for a diversity of species, including Willow Flycatcher, a migratory shrub-scrub nesting bird that was common in this habitat during the breeding season. Sparrows were especially abundant in this habitat, particularly during migration. Species observed here include American Tree Sparrow, Field Sparrow, Savannah Sparrow, Song Sparrow, Swamp Sparrow, Lincoln's Sparrow, White-crowned Sparrow, and White-throated Sparrow, as well as Palm and Yellow-rumped Warblers. In 2011, a pair of Blue Grosbeaks were recorded using the area around the landfill throughout the breeding season and through the first fall survey, but breeding

status was not confirmed. In 2012, we observed an adult male Blue Grosbeak with three probable fledglings during the first fall survey. The species continued at the site during the 2013 breeding season. Blue Grosbeak breeds in a variety of open, and forest edge habitats and uses small trees, shrubs or other vegetation for nesting sites (Lowther and Ingold 2011), primarily in southern New Jersey (Boyle 2011). This species has been expanding its range northward in the state, and it will be interesting to see if they continue to be observed at the Linden site during subsequent breeding seasons.

Next Steps

This report summarizes the fourth year of standardized bird surveys at the Linden Hawk Rise site, adjacent Linden Landfill and Rahway River marshes. As Linden moves forward with deer management and habitat restoration at the site, these baseline data will be compared with post-restoration data to determine the impact of these activities on wildlife populations. It will be important to continue post-management surveys in a consistent and rigorous manner, in order to detect any changes in bird use. Using robust and repeatable scientific methodology for continued monitoring at the site will also allow us to determine whether restoration efforts are effective in improving forest health and providing habitat for wildlife at this site and will identify potential areas for additional restoration. Results presented here are a simple tabulation and summary of observations, but the data have been collected using methods that allow more detailed analyses. These methods (e.g., occupancy modeling, distance analyses) take into account detection probabilities and will allow us to better identify any changes in abundance through time.

In addition to the current survey protocol, an important next step may be to determine breeding status for species of conservation concern, particularly Grasshopper Sparrow and Savannah Sparrow, two state-Threatened species observed using the landfill throughout the breeding season. If time and resources allow, the project would also benefit from more frequent surveys during migration periods. Bird use changes daily during migration periods, and three to four site visits during each migration period may not be sufficient to fully document species use. Continuing to encourage public use, educational programming, and eBird recording of observations will also create a better overall understanding of the bird life using the site.

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TABLE 1. Survey point (a) and transect (b) coordinates, and number of surveys conducted between December 2012 and November 2013 at Linden Hawk Rise and Linden Landfill. See Figure 1 for point and transect locations.

a. Point Count Locations (Spring Migration and Breeding Surveys)

Point ID	Latitude	Longitude	# of Surveys	
			Spring	Breeding
LIND_01	40.6088770	-74.2485147	3	3
LIND_02	40.6070809	-74.2508848	3	3
LIND_03	40.6070758	-74.2485214	3	3
LIND_04	40.6052797	-74.2508915	3	3
LIND_05	40.6052746	-74.2485282	3	3
LIND_06	40.6034749	-74.2492576	3	3
LIND_08	40.6016721	-74.2485417	3	3
LIND_09	40.6008945	-74.2450797	3	3
LIND_10	40.6018735	-74.2414513	3	3
LIND_11	40.6041716	-74.2414425	3	3
LIND_12	40.6040603	-74.2443652	3	3
LIND_13	40.6028206	-74.2461757	3	3

b. Transect Locations (Winter and Fall Migration Surveys)

Transect ID	Start		End		# of Surveys	
	Latitude	Longitude	Latitude	Longitude	Winter	Fall
LIND_T01	40.6070758	-74.2485214	40.6070809	-74.2508848	4	4
LIND_T02	40.6052797	-74.2508915	40.6052746	-74.2485282	4	4
LIND_T03	40.6043067	-74.2420302	40.6040603	-74.2443652	4	4
LIND_T04	40.6018515	-74.2423162	40.6026809	-74.2406807	4	4
LIND_T05	40.6010062	-74.2469331	40.6010275	-74.2446046	4	4
LIND_T06	40.6034749	-74.2492590	40.6018461	-74.2490883	4	4
LIND_T07	40.6026476	-74.2469603	40.6026395	-74.2445971	4	3

TABLE 2. Summary of surveys conducted at Linden Hawk Rise Sanctuary and Linden Landfill, December 2012 through November 2013, including winter, spring and fall migration and breeding bird surveys.

	Winter 2012-2013	Spring 2013	Breeding 2013	Fall 2013	Total
Points/transects surveyed	0/7	12/0	12/0	0/7	12/7
Species recorded on point/transect counts	43	78	53	61	114
Total species observed	44	83	58	63	120
T&E species	3	5	5	4	8
Special Concern species	2	7	2	7	13
Total individuals counted	1146	880	899	686	3611

TABLE 3. Full list of bird species (a) observed between December 2012 and November 2013 at Linden Hawk Rise and Linden Landfill, during winter, spring and fall migration, and breeding season surveys; and (b) additional species entered by eBird users and other observers. State-listed species are in red (Endangered), blue (Threatened), or green (Species of Concern).

a. Species observed during 2013 surveys

Species	<u>Winter 12/13</u>		<u>Spring 13</u>		<u>Breeding 13</u>		<u>Fall 13</u>	
	Survey	Obs	Survey	Obs	Survey	Obs	Survey	Obs
American Black Duck	x			x		x		x
American Crow	x							
American Goldfinch	x		x		x			x
American Kestrel	x		x					x
American Pipit	x							
American Redstart			x		x			x
American Robin	x		x		x			x
American Tree Sparrow	x							
American Woodcock								x
Bald Eagle ^{Br, T non-Br}					x			
Baltimore Oriole			x		x			
Bank Swallow					x			
Barn Swallow			x		x			x
Belted Kingfisher	x		x					x
Black Skimmer						x		
Black-and-White Warbler			x					x
Blackburnian Warbler ^{Br}			x					
Blackpoll Warbler			x		x			
Black-capped Chickadee								x
Black-throated Blue Warbler ^{Br}			x					x
Blue Grosbeak					x			
Blue Jay	x		x		x			x
Blue-gray Gnatcatcher			x		x			
Blue-winged Teal		x						
Bobolink ^{Br, SC non-Br}			x					x
Brown-headed Cowbird			x		x			x
Bufflehead	x							
Canada Goose	x		x		x			x
Carolina Wren	x		x		x			x
Cedar Waxwing					x			
Chestnut-sided Warbler			x					
Chimney Swift					x			x
Clapper Rail			x					
Common Grackle			x		x			x
Common Raven								x
Common Yellowthroat			x		x			x
Cooper's Hawk ^{Br}								x
Dark-eyed Junco			x					x
Double-crested Cormorant	x		x					x
Downy Woodpecker	x		x		x			x
Eastern Kingbird					x			
Eastern Meadowlark								x
Eastern Wood-Pewee					x			
European Starling	x		x		x			x
Fish Crow			x					
Forster's Tern			x					
Fox Sparrow	x							
Gadwall	x		x					

TABLE 3. (cont'd)

Species	<u>Winter 12/13</u>		<u>Spring 13</u>		<u>Breeding 13</u>		<u>Fall 13</u>	
	Survey	Obs	Survey	Obs	Survey	Obs	Survey	Obs
Golden-crowned Kinglet	x						x	
Grasshopper Sparrow ^{Br, SC non-Br}			x		x			
Gray Catbird			x		x		x	
Great Black-backed Gull	x		x		x		x	
Great Blue Heron ^{Br}	x				x		x	
Great Crested Flycatcher						x		
Great Egret			x		x		x	
Great Horned Owl	x		x				x	
Greater Yellowlegs			x				x	
Green-winged Teal	x		x					
Hairy Woodpecker	x		x				x	
Herring Gull	x		x		x		x	
Hooded Merganser	x							
House Finch			x					
House Sparrow			x		x			
House Wren			x		x		x	
Indigo Bunting					x			
Killdeer	x		x			x	x	
Laughing Gull					x		x	
Least Flycatcher ^{Br}			x					
Lesser Yellowlegs							x	
Louisiana Waterthrush			x				x	
Magnolia Warbler			x				x	
Mallard	x		x			x	x	
Marsh Wren			x		x			
Merlin	x							x
Mourning Dove	x		x				x	
Northern Cardinal	x		x		x		x	
Northern Harrier ^{Br, SC non-Br}	x							
Northern Flicker			x		x		x	
Northern Mockingbird			x				x	
Northern Parula ^{Br}			x				x	
Northern Rough-winged Swallow			x		x			
Northern Waterthrush				x				
Orchard Oriole			x		x			
Osprey ^{Br}			x		x		x	
Ovenbird			x					
Palm Warbler				x			x	
Prairie Warbler			x					
Red-bellied Woodpecker			x		x		x	
Red-breasted Merganser	x							
Red-breasted Nuthatch			x					
Red-eyed Vireo					x		x	
Red-tailed Hawk	x		x					
Red-winged Blackbird	x		x		x		x	
Ring-billed Gull	x		x				x	
Ring-necked Pheasant			x		x			
Ruby-crowned Kinglet			x					
Ruby-throated Hummingbird			x					
Savannah Sparrow ^{Br}	x		x		x		x	
Semipalmated Sandpiper							x	
Snowy Egret ^{Br}			x				x	

TABLE 3. (cont'd)

Species	<u>Winter 12/13</u>		<u>Spring 13</u>		<u>Breeding 13</u>		<u>Fall 13</u>	
	Survey	Obs	Survey	Obs	Survey	Obs	Survey	Obs
Song Sparrow	x		x		x		x	
Spotted Sandpiper ^{Br}					x			
Swainson's Thrush				x				
Swamp Sparrow	x		x		x		x	
Tree Swallow			x		x			
Tufted Titmouse	x		x		x		x	
Veery ^{Br}				x				
Warbling Vireo			x		x			
White-breasted Nuthatch							x	
White-throated Sparrow	x		x				x	
White-winged Crossbill	x							
Wild Turkey			x		x			
Willow Flycatcher					x			
Wilson's Warbler			x					
Winter Wren ^{Br}	x							
Wood Duck					x			
Yellow Warbler			x		x			
Yellow-breasted Chat ^{Br}			x					
Yellow-rumped Warbler			x				x	
Yellow-throated Vireo			x					

^{Br}Indicates breeding season status only

TABLE 3. (cont'd)

b. Additional species entered by eBird users and other observers in 2013

Species	Winter 12/13	Spring 13	Breeding 13	Fall 13
Acadian Flycatcher			X	
Alder Flycatcher			X	
Black-billed Cuckoo			X	
Black-crowned Night-Heron				X
Black-throated Green Warbler ^{Br}		X	X	X
Boat-tailed Grackle		X	X	
Brown Creeper	X	X		X
Brown Thrasher ^{Br}			X	X
Canada Warbler ^{Br}		X		
Chipping Sparrow				X
Common Merganser	X			
Eastern Phoebe	X	X		X
Eastern Towhee		X		X
Field Sparrow				X
Great Cormorant		X		
Green Heron			X	X
Hermit Thrush		X		X
Horned Grebe		X		
Least Bittern*			X	
Least Sandpiper		X	X	X
Nashville Warbler ^{Br}		X	X	
Peregrine Falcon ^{Br, SC non-Br}			X	
Pied-billed Grebe ^{Br, SC non-Br}		X		
Pine Warbler				X
Purple Martin			X	
Red-headed Woodpecker				X
Rock Pigeon	X	X	X	
Scarlet Tanager		X		X
Semipalmated Plover			X	
Sharp-shinned Hawk	X			
Solitary Sandpiper		X	X	X
Tennessee Warbler		X		
Turkey Vulture		X		
Wilson's Snipe		X		
Wood Thrush ^{Br}		X		
Yellow-bellied Sapsucker		X		

^{Br}Indicates breeding season status only

* Observed during a SHARP survey (see text for details)

TABLE 4. Total species list and number of individuals observed during Winter 2012-2013 transect surveys at Linden Hawk Rise and Linden Landfill, by transect. Frequency (freq.) was calculated as the number of transects at which a species was observed divided by the total number of transects surveyed. Relative abundance was calculated as the number of individuals of that species divided by the total number of individuals of all species. State-listed species are in red (E), blue (T), or green (SC). See figure 1 for transect locations.

Species	# of Transects	Freq.	Transect ID							Total	Rel. Abundance
			T01	T02	T03	T04	T05	T06	T07		
American Black Duck	3	0.43				5	5	5		15	0.013
American Crow	3	0.43	2	1	2					5	0.004
American Goldfinch	1	0.14	4							4	0.003
American Kestrel	1	0.14							1	1	0.001
American Pipit	1	0.14				2				2	0.002
American Robin	2	0.29			1			1		2	0.002
American Tree Sparrow	5	0.71		4		11	1	3	1	20	0.017
Belted Kingfisher	4	0.57		1	1	1	1			4	0.003
Blue Jay	4	0.57	1	1	1			2		5	0.004
Bufflehead	3	0.43				3	2	2		7	0.006
Canada Goose	6	0.86	5		29	119	23	36	45	257	0.224
Carolina Wren	3	0.43	3	3				1		7	0.006
Double-crested Cormorant	2	0.29						1	1	2	0.002
Downy Woodpecker	3	0.43	2	4	1					7	0.006
European Starling	2	0.29			5		2			7	0.006
Fox Sparrow	1	0.14	1							1	0.001
Gadwall	1	0.14			15					15	0.013
Golden-crowned Kinglet	1	0.14		1						1	0.001
Great Black-backed Gull	2	0.29					7	5		12	0.010
Great Blue Heron ^{Br}	1	0.14							1	1	0.001
Great Horned Owl	1	0.14		1						1	0.001
Green-winged Teal	1	0.14			9					9	0.008
Hairy Woodpecker	3	0.43	2	1	1					4	0.003
Herring Gull	6	0.86		1	3	2	8	5	17	36	0.031
Hooded Merganser	1	0.14			2					2	0.002
Killdeer	3	0.43			3		1	1		5	0.004
Mallard	4	0.57	4		5	8	2			19	0.017
Merlin	1	0.14							1	1	0.001
Mourning Dove	1	0.14			1					1	0.001
Northern Cardinal	4	0.57	5	1	1		1			8	0.007
Northern Harrier ^{Br, SC non-Br}	2	0.29			1				1	2	0.002
Red-breasted Merganser	1	0.14				1				1	0.001
Red-tailed Hawk	1	0.14	1							1	0.001
Red-winged Blackbird	6	0.86	11	4	5	8	8	18		54	0.047
Ring-billed Gull	3	0.43	3				267	287		557	0.486
Savannah Sparrow ^{Br}	3	0.43				1	3	4		8	0.007
Song Sparrow	7	1.00	3	2	5	6	4	8	2	30	0.026
Swamp Sparrow	1	0.14						1		1	0.001
Tufted Titmouse	2	0.29	5	5						10	0.009
White-throated Sparrow	2	0.29	8		1					9	0.008
White-winged Crossbill	1	0.14						2		2	0.002
Winter Wren ^{Br}	1	0.14		1						1	0.001
Unidentified Chickadee	2	0.29	2	1						3	0.003
Unidentified Crow	1	0.14			1					1	0.001
Unidentified Duck	1	0.14							2	2	0.002
Unidentified Gull	1	0.14							3	3	0.003
Total # of Individuals			62	32	93	167	336	382	74	1146	
Total # of Species			17	16	20	12	16	17	9	43	

^{Br}Indicates breeding season status only

TABLE 5. Total species list and number of individuals observed during Winter 2012-2013 transect surveys at Linden Hawk Rise and Linden Landfill, by survey. Maximum represents the maximum number of individuals observed on any one survey (across all transects). State-listed species are in red (E), blue (T), or green (SC).

Species	Survey 1 12/28/2012	Survey 2 1/29/2013	Survey 3 3/1/2013	Survey 4 3/13/2013	Total	Max per Survey
American Black Duck	3	2	2	8	15	8
American Crow		2		3	5	3
American Goldfinch		2	2		4	2
American Kestrel			1		1	1
American Pipit				2	2	2
American Robin			1	1	2	1
American Tree Sparrow		6	9	5	20	9
Belted Kingfisher	1	1	2		4	2
Blue Jay		2	1	2	5	2
Bufflehead	2	2	2	1	7	2
Canada Goose	78	13	88	78	257	88
Carolina Wren		2	3	2	7	3
Double-crested Cormorant				2	2	2
Downy Woodpecker	3	2	1	1	7	3
European Starling			4	3	7	4
Fox Sparrow			1		1	1
Gadwall			4	11	15	11
Golden-crowned Kinglet		1			1	1
Great Black-backed Gull	2	5	5		12	5
Great Blue Heron ^{Br}		1			1	1
Great Horned Owl				1	1	1
Green-winged Teal			8	1	9	8
Hairy Woodpecker	2	1	1		4	2
Herring Gull	6	8	1	21	36	21
Hooded Merganser			2		2	2
Killdeer			2	3	5	3
Mallard		10	7	2	19	10
Merlin				1	1	1
Mourning Dove				1	1	1
Northern Cardinal	1			7	8	7
Northern Harrier ^{Br, SC non-Br}	2				2	2
Red-breasted Merganser			1		1	1
Red-tailed Hawk		1			1	1
Red-winged Blackbird		3	32	19	54	32
Ring-billed Gull	112	3	442		557	442
Savannah Sparrow ^{Br}	1		3	4	8	4
Song Sparrow	2	5	8	15	30	15
Swamp Sparrow		1			1	1
Tufted Titmouse	2	5	1	2	10	5
White-throated Sparrow	8			1	9	8
White-winged Crossbill	2				2	2
Winter Wren ^{Br}				1	1	1
Unidentified Chickadee		3			3	3
Unidentified Crow			1		1	1
Unidentified Duck		2			2	2
Unidentified Gull		3			3	3
Total # of Individuals	227	86	635	198	1146	
Total # of Species	16	23	28	27	43	

^{Br}Indicates breeding season status only

TABLE 6. Additional species observed at Linden Hawk Rise (a) during Winter 2012-2013, but not encountered on transect surveys; and (b) entered into eBird by other observers. State-listed species are in red (E), blue (T), or green (SC).

a. Additional species observed during NJ Audubon survey visits

Species	Notes
Blue-winged Teal	7 individuals observed on Rahway River during 4th survey (3/13/2013), but not recorded on transect survey

b. Additional species entered into eBird by other observers

Species	Notes
Black-capped Chickadee	eBird observation
Brown Creeper	eBird observation
Common Grackle	eBird observation
Common Merganser	eBird observation
Dark-eyed Junco	eBird observation
Eastern Phoebe	eBird observation
House Sparrow	eBird observation
Red-bellied Woodpecker	eBird observation
Rock Pigeon	eBird observation
Sharp-shinned Hawk	eBird observation
White-breasted Nuthatch	eBird observation
Wild Turkey	eBird observation

TABLE 7. Total species list and number of individuals observed during 2013 Spring Migration point count surveys at Linden Hawk Rise and Linden Landfill, by point. Frequency (freq.) was calculated as the number of points at which a species was observed divided by the total number of points surveyed. Relative abundance was calculated as the number of individuals of that species divided by the total number of individuals of all species. State-listed species are in red (E), blue (T), or green (SC). See figure 1 for point locations.

Species	# of Points	Freq.	Point ID											Total	Rel. Abundance		
			01	02	03	04	05	06	08	09	10	11	12			13	
American Goldfinch	6	0.50	6					1	2	4	2		5		20	0.023	
American Kestrel	4	0.33									1		2	1	1	5	0.006
American Redstart	1	0.08	1													1	0.001
American Robin	12	1.00	10	12	5	10	9	5	4	3	4	6	10	4	82	0.093	
Baltimore Oriole	7	0.58	1	1	2	1	2	1				1			9	0.010	
Barn Swallow	2	0.17						1					2		3	0.003	
Belted Kingfisher	1	0.08									1				1	0.001	
Black-and-White Warbler	1	0.08			1										1	0.001	
Blackburnian Warbler ^{Br}	1	0.08			1										1	0.001	
Blackpoll Warbler	2	0.17		1			1								2	0.002	
Black-throated Blue Warbler ^{Br}	1	0.08			1										1	0.001	
Blue Jay	5	0.42		2	2	2	2	1							9	0.010	
Blue-gray Gnatcatcher	3	0.25			1	1	1								3	0.003	
Bobolink ^{Br, SC non-Br}	1	0.08										1			1	0.001	
Brown-headed Cowbird	8	0.67			1		1	3	1	3	11	2	3		25	0.028	
Canada Goose	8	0.67		2	1			11	2		5	1	26	33	81	0.092	
Carolina Wren	8	0.67	2	3	1	2	2	2				1		1	14	0.016	
Chestnut-sided Warbler	1	0.08			1										1	0.001	
Clapper Rail	1	0.08								1					1	0.001	
Common Grackle	8	0.67	1	2		2	14	1		1	1			2	24	0.027	
Common Yellowthroat	5	0.42			1	3					1	3	1		9	0.010	
Dark-eyed Junco	3	0.25	1		2		1								4	0.005	
Double-crested Cormorant	3	0.25							3	33	2				38	0.043	
Downy Woodpecker	6	0.50		1	1	2	3	2				2			11	0.013	
European Starling	8	0.67	1		1			32	11	16	24	21	25		131	0.149	
Fish Crow	2	0.17							1	2					3	0.003	
Forster's Tern	1	0.08							4						4	0.005	
Gadwall	3	0.25								4		3	2		9	0.010	
Grasshopper Sparrow ^{Br, SC non-Br}	3	0.25									2		1	1	4	0.005	
Gray Catbird	4	0.33			5	1	1				1				8	0.009	
Great Black-backed Gull	1	0.08							2						2	0.002	
Great Egret	1	0.08											1		1	0.001	
Great Horned Owl	1	0.08					2								2	0.002	
Greater Yellowlegs	1	0.08								1					1	0.001	
Green-winged Teal	1	0.08								5					5	0.006	
Hairy Woodpecker	1	0.08					1								1	0.001	
Herring Gull	7	0.58	1	1	13			1	4	8				8	36	0.041	
House Finch	1	0.08	3												3	0.003	
House Sparrow	1	0.08	1												1	0.001	
House Wren	2	0.17			2							4			6	0.007	
Killdeer	4	0.33					1			2			2	2	7	0.008	
Least Flycatcher ^{Br}	2	0.17					1					1			2	0.002	
Louisiana Waterthrush	1	0.08		1											1	0.001	
Magnolia Warbler	1	0.08			1										1	0.001	
Mallard	2	0.17						1					3		4	0.005	
Marsh Wren	4	0.33				1			1	3	1				6	0.007	
Mourning Dove	1	0.08			1										1	0.001	
Northern Cardinal	5	0.42	2	2	2		2					2			10	0.011	

TABLE 7. (cont'd)

Species	# of Points	Freq.	Point ID											Total	Rel. Abundance	
			01	02	03	04	05	06	08	09	10	11	12			13
Northern Flicker	8	0.67	1	2	3	1	1			1	1	5		15	0.017	
Northern Mockingbird	4	0.33	1							1	1	1		4	0.005	
Northern Parula ^{Br}	4	0.33		1	1	1	1							4	0.005	
Northern Rough-winged Swallow	3	0.25						3			3	5		11	0.013	
Orchard Oriole	3	0.25					1					1	1	3	0.003	
Osprey ^{Br}	2	0.17						3	3					6	0.007	
Ovenbird	2	0.17		2			2							4	0.005	
Prairie Warbler	1	0.08			1									1	0.001	
Red-bellied Woodpecker	4	0.33		1	2		2				1			6	0.007	
Red-breasted Nuthatch	1	0.08			1									1	0.001	
Red-tailed Hawk	2	0.17										2	1	3	0.003	
Red-winged Blackbird	12	1.00	1	2	1	8	4	15	9	14	14	8	16	9	101	0.115
Ring-billed Gull	2	0.17										1		1	2	0.002
Ring-necked Pheasant	2	0.17					1	1						2	0.002	
Ruby-crowned Kinglet	3	0.25		1	1							1		3	0.003	
Ruby-throated Hummingbird	1	0.08											1	1	0.001	
Savannah Sparrow ^{Br}	4	0.33						2	7	2			3	14	0.016	
Snowy Egret ^{Br}	2	0.17							1		1			2	0.002	
Song Sparrow	11	0.92	1		1	2	3	5	6	6	6	4	4	1	39	0.044
Swamp Sparrow	2	0.17						2	1					3	0.003	
Tree Swallow	6	0.50						1	1		1	1	7	1	12	0.014
Tufted Titmouse	4	0.33	2	1	2		1							6	0.007	
Warbling Vireo	6	0.50	2		2	1		1				2	2	10	0.011	
White-throated Sparrow	2	0.17			4								1	5	0.006	
Wild Turkey	1	0.08			1									1	0.001	
Wilson's Warbler	1	0.08			1									1	0.001	
Yellow Warbler	6	0.50			2	1		2			1	1	2	9	0.010	
Yellow-breasted Chat ^{Br}	1	0.08										1		1	0.001	
Yellow-rumped Warbler	5	0.42	3	2	5	1	2							13	0.015	
Yellow-throated Vireo	1	0.08			1									1	0.001	
Total # of Individuals			41	40	75	40	63	95	65	112	76	80	123	70	880	
Total # of Species			19	19	37	17	27	22	18	21	16	27	23	16	78	

^{Br}Indicates breeding season status only

TABLE 8. Total species list and number of individuals observed during 2013 Spring Migration point count surveys at Linden Hawk Rise and Linden Landfill, by survey. Maximum represents the maximum number of individuals observed on any one survey (across all points). State-listed species are in red (E), blue (T), or green (SC).

Species	Survey 1 4/17/2013	Survey 2 5/4/2013	Survey 3 5/14/2013	Total	Max per Survey
American Goldfinch	4	13	3	20	13
American Kestrel	2	3		5	3
American Redstart			1	1	1
American Robin	32	30	20	82	32
Baltimore Oriole		2	7	9	7
Barn Swallow			3	3	3
Belted Kingfisher	1			1	1
Black-and-White Warbler			1	1	1
Blackburnian Warbler ^{Br}			1	1	1
Blackpoll Warbler			2	2	2
Black-throated Blue Warbler ^{Br}			1	1	1
Blue Jay	3	4	2	9	4
Blue-gray Gnatcatcher		3		3	3
Bobolink ^{Br, SC non-Br}			1	1	1
Brown-headed Cowbird	16	8	1	25	16
Canada Goose	42	14	25	81	42
Carolina Wren	8	4	2	14	8
Chestnut-sided Warbler			1	1	1
Clapper Rail		1		1	1
Common Grackle		8	16	24	16
Common Yellowthroat	1	3	5	9	5
Dark-eyed Junco	4			4	4
Double-crested Cormorant	3	32	3	38	32
Downy Woodpecker	7	3	1	11	7
European Starling	45	44	42	131	45
Fish Crow	2	1		3	2
Forster's Tern			4	4	4
Gadwall	5	4		9	5
Grasshopper Sparrow ^{Br, SC non-Br}		1	3	4	3
Gray Catbird		2	6	8	6
Great Black-backed Gull	2			2	2
Great Egret			1	1	1
Great Horned Owl		1	1	2	1
Greater Yellowlegs		1		1	1
Green-winged Teal	5			5	5
Hairy Woodpecker	1			1	1
Herring Gull	23	12	1	36	23
House Finch		3		3	3
House Sparrow			1	1	1
House Wren	1	3	2	6	3
Killdeer	3	1	3	7	3
Least Flycatcher ^{Br}			2	2	2
Louisiana Waterthrush			1	1	1
Magnolia Warbler			1	1	1
Mallard	1	1	2	4	2
Marsh Wren	1	1	4	6	4
Mourning Dove		1		1	1
Northern Cardinal	3	5	2	10	5
Northern Flicker	8	3	4	15	8
Northern Mockingbird	1	2	1	4	2

TABLE 8. (cont'd)

Species	Survey 1 4/17/2013	Survey 2 5/4/2013	Survey 3 5/14/2013	Total	Max per Survey
Northern Parula ^{Br}		2	2	4	2
Northern Rough-winged Swallow	6	1	4	11	6
Orchard Oriole		2	1	3	2
Osprey ^{Br}	3	2	1	6	3
Ovenbird		2	2	4	2
Prairie Warbler			1	1	1
Red-bellied Woodpecker		2	4	6	4
Red-breasted Nuthatch		1		1	1
Red-tailed Hawk		1	2	3	2
Red-winged Blackbird	41	38	22	101	41
Ring-billed Gull	1	1		2	1
Ring-necked Pheasant		2		2	2
Ruby-crowned Kinglet	2		1	3	2
Ruby-throated Hummingbird		1		1	1
Savannah Sparrow ^{Br}	11		3	14	11
Snowy Egret ^{Br}			2	2	2
Song Sparrow	16	13	10	39	16
Swamp Sparrow	1	1	1	3	1
Tree Swallow	3	3	6	12	6
Tufted Titmouse		5	1	6	5
Warbling Vireo		4	6	10	6
White-throated Sparrow	5			5	5
Wild Turkey		1		1	1
Wilson's Warbler			1	1	1
Yellow Warbler		2	7	9	7
Yellow-breasted Chat ^{Br}			1	1	1
Yellow-rumped Warbler	2	5	6	13	6
Yellow-throated Vireo			1	1	1
Total # of Individuals	315	303	262	880	
Total # of Species	37	51	59	78	

^{Br}Indicates breeding season status only

TABLE 9. Additional species observed at Linden Hawk Rise (a) during 2013 Spring Migration surveys, but not recorded on point count surveys; and (b) entered by other eBird users. State-listed species are in red (E), blue (T), or green (SC).

a. Additional species observed during NJ Audubon survey visits

Species	Notes
American Black Duck	Observed on river during 1st survey (4/17/13) and 3rd survey (5/14/13)
Northern Waterthrush	Observed near LIND_03 during 3rd survey (5/14/13)
Palm Warbler	Observed near LIND_03 during 1st survey (4/17/13)
Swainson's Thrush	Observed near LIND_05 during 3rd survey (5/14/13)
Veery ^{Br}	Observed near LIND_02 during 3rd survey (5/14/13)

b. Additional species entered into eBird by other observers

Species	Notes
American Crow	eBird observation
Black-capped Chickadee	eBird observation
Black-throated Green Warbler ^{Br}	eBird observation
Boat-tailed Grackle	eBird observation
Brown Creeper	eBird observation
Canada Warbler ^{Br}	eBird observation
Cedar Waxwing	eBird observation
Eastern Kingbird	eBird observation
Eastern Phoebe	eBird observation
Eastern Towhee	eBird observation
Golden-crowned Kinglet	eBird observation
Great Cormorant	eBird observation
Hermit Thrush	eBird observation
Hooded Merganser	eBird observation
Horned Grebe	eBird observation
Laughing Gull	eBird observation
Least Sandpiper	eBird observation
Nashville Warbler ^{Br}	eBird observation
Pied-billed Grebe ^{Br, SC non-Br}	eBird observation
Rock Pigeon	eBird observation
Scarlet Tanager	eBird observation
Solitary Sandpiper	eBird observation
Tennessee Warbler	eBird observation
Turkey Vulture	eBird observation
Wilson's Snipe	eBird observation
White-breasted Nuthatch	eBird observation
Wood Duck	eBird observation
Wood Thrush ^{Br}	eBird observation
Yellow-bellied Sapsucker	eBird observation

^{Br}Indicates breeding season status only

TABLE 10. Total species list and number of individuals observed during 2013 Breeding Season point count surveys at Linden Hawk Rise and Linden Landfill, by point. Frequency (freq.) was calculated as the number of points at which a species was observed divided by the total number of points surveyed. Relative abundance was calculated as the number of individuals of that species divided by the total number of individuals of all species. State-listed species are in red (E), blue (T), or green (SC). See figure 1 for point locations.

Species	# of Points	Freq.	Point ID													Total	Rel. Abundance
			01	02	03	04	05	06	08	09	10	11	12	13			
American Goldfinch	5	0.42			1				2		4	3	4		14	0.016	
American Redstart	1	0.08										1			1	0.001	
American Robin	10	0.83	7	6	7	5	6	2	3		2	1	3		42	0.047	
Bald Eagle ^{Br, T non-Br}	1	0.08									1				1	0.001	
Baltimore Oriole	5	0.42	1	4	1	1	1								8	0.009	
Bank Swallow	1	0.08									2				2	0.002	
Barn Swallow	7	0.58						4	1	8	1	3	6	18	41	0.046	
Blackpoll Warbler	2	0.17										1	1		2	0.002	
Blue Grosbeak	1	0.08							1						1	0.001	
Blue Jay	3	0.25		1	2		1								4	0.004	
Blue-gray Gnatcatcher	1	0.08		1											1	0.001	
Brown-headed Cowbird	2	0.17			1				2						3	0.003	
Canada Goose	3	0.25								6			19	2	27	0.030	
Carolina Wren	5	0.42	3	3		2	1						1		10	0.011	
Cedar Waxwing	2	0.17		4			4								8	0.009	
Chimney Swift	5	0.42			1	1	2	3				4			11	0.012	
Common Grackle	6	0.50				2	3	2		1	2			6	16	0.018	
Common Yellowthroat	8	0.67	2	1		2	2	3		2		1	1		14	0.016	
Downy Woodpecker	5	0.42	1	4	1	1	1								8	0.009	
Eastern Kingbird	1	0.08						1							1	0.001	
Eastern Wood-Pewee	2	0.17		1			1								2	0.002	
European Starling	8	0.67	3					39	32	41	16	19	80	25	255	0.284	
Grasshopper Sparrow ^{Br, SC non-Br}	2	0.17											1	2	3	0.003	
Gray Catbird	7	0.58	3	1	7	2	4				3		1		21	0.023	
Great Black-backed Gull	1	0.08									1				1	0.001	
Great Blue Heron ^{Br}	1	0.08											1		1	0.001	
Great Egret	1	0.08								1					1	0.001	
Herring Gull	10	0.83	1		2	1		1	6	28	7	8	10	11	75	0.083	
House Sparrow	1	0.08	2												2	0.002	
House Wren	3	0.25				2						2	2		6	0.007	
Indigo Bunting	4	0.33	1		2							2	1		6	0.007	
Laughing Gull	1	0.08											1		1	0.001	
Marsh Wren	5	0.42						5	6	7	3	3			24	0.027	
Northern Cardinal	5	0.42	3	5	4	1	2								15	0.017	
Northern Flicker	5	0.42		2	2		3	1					2		10	0.011	
Northern Rough-winged Swallow	3	0.25						1			1		3		5	0.006	
Orchard Oriole	6	0.50			2	1	1	2				1	2		9	0.010	
Osprey ^{Br}	2	0.17								1	1				2	0.002	
Red-bellied Woodpecker	4	0.33		3	1	2	3								9	0.010	
Red-eyed Vireo	1	0.08		1											1	0.001	
Red-winged Blackbird	11	0.92	1	3		9	1	24	3	30	23	14	9	3	120	0.133	
Ring-necked Pheasant	2	0.17									1			3	4	0.004	
Savannah Sparrow ^{Br}	2	0.17											1	11	12	0.013	
Song Sparrow	11	0.92	2	1	1	2		5	9	6	8	2	8	1	45	0.050	
Spotted Sandpiper ^{Br}	2	0.17							1				2		3	0.003	
Swamp Sparrow	1	0.08									2				2	0.002	
Tree Swallow	4	0.33						1	2				1	1	5	0.006	

TABLE 10. (cont'd)

Species	# of Points	Freq.	Point ID											Total	Rel. Abundance	
			01	02	03	04	05	06	08	09	10	11	12			13
Tufted Titmouse	4	0.33	3		3	2	3								11	0.012
Warbling Vireo	6	0.50	1		3		2	1				1	1		9	0.010
Wild Turkey	1	0.08	2												2	0.002
Willow Flycatcher	6	0.50			2			4	1	2	1	2			12	0.013
Wood Duck	1	0.08												3	3	0.003
Yellow Warbler	5	0.42				1		1			1	3	1		7	0.008
Total # of Individuals			36	41	43	37	41	100	69	136	77	71	165	83	899	
Total # of Species			16	16	18	17	18	18	13	14	17	18	26	11	53	

^{Br}Indicates breeding season status only

TABLE 11. Total species list and number of individuals observed during 2013 Breeding Season point count surveys at Linden Hawk Rise and Linden Landfill, by survey. Maximum represents the maximum number of individuals observed on any one survey (across all points). State-listed species are in red (E), blue (T), or green (SC).

Species	Survey 1 5/29/2013	Survey 2 6/18/2013	Survey 3 7/3/2013	Total	Max per Survey
American Goldfinch	2	4	8	14	8
American Redstart	1			1	1
American Robin	17	15	10	42	17
Bald Eagle ^{E, T non-Br}	1			1	1
Baltimore Oriole	3	4	1	8	4
Bank Swallow	2			2	2
Barn Swallow	19	9	13	41	19
Blackpoll Warbler	2			2	2
Blue Grosbeak	1			1	1
Blue Jay	1		3	4	3
Blue-gray Gnatcatcher	1			1	1
Brown-headed Cowbird	1	2		3	2
Canada Goose	2	1	24	27	24
Carolina Wren	4	2	4	10	4
Cedar Waxwing		4	4	8	4
Chimney Swift	5	2	4	11	5
Common Grackle	4	5	7	16	7
Common Yellowthroat	4	7	3	14	7
Downy Woodpecker	2	1	5	8	5
Eastern Kingbird	1			1	1
Eastern Wood-Pewee	2			2	2
European Starling	70	119	66	255	119
Grasshopper Sparrow ^{Br, SC non-Br}	1	1	1	3	1
Gray Catbird	6	6	9	21	9
Great Black-backed Gull			1	1	1
Great Blue Heron ^{Br}			1	1	1
Great Egret			1	1	1
Herring Gull	45	2	28	75	45
House Sparrow	1	1		2	1
House Wren	3	3		6	3
Indigo Bunting		3	3	6	3
Laughing Gull	1			1	1
Marsh Wren	6	7	11	24	11
Northern Cardinal	4	5	6	15	6
Northern Flicker	2	3	5	10	5
Northern Rough-winged Swallow		1	4	5	4
Orchard Oriole	4	4	1	9	4
Osprey ^{Br}		2		2	2
Red-bellied Woodpecker	3	4	2	9	4
Red-eyed Vireo	1			1	1
Red-winged Blackbird	39	42	39	120	42
Ring-necked Pheasant	1	1	2	4	2
Savannah Sparrow ^{Br}	2	5	5	12	5
Song Sparrow	13	17	15	45	17
Spotted Sandpiper ^{Br}	1	1	1	3	1
Swamp Sparrow		1	1	2	1
Tree Swallow	1	3	1	5	3
Tufted Titmouse	3	3	5	11	5

TABLE 11. (cont'd)

Species	Survey 1 5/29/2013	Survey 2 6/18/2013	Survey 3 7/3/2013	Total	Max per Survey
Warbling Vireo	3	4	2	9	4
Wild Turkey		2		2	2
Willow Flycatcher	6	5	1	12	6
Wood Duck		3		3	3
Yellow Warbler	4	2	1	7	4
Total # of Individuals	295	306	298	899	
Total # of Species	43	39	37	53	

^BIndicates breeding season status only

TABLE 12. Additional species (a) observed at Linden Hawk Rise during 2013 Breeding Season surveys, but not encountered on point count surveys; and (b) recorded by eBird users and other observers. State-listed species are in red (E), blue (T), or green (SC).

a. Additional species observed during NJ Audubon survey visits

Species	Notes
American Black Duck	Observed on pond near LIND_12 during 2nd survey (6/18/13)
Black Skimmer	Observed foraging over pond near LIND_12 during 2nd survey (6/18/13)
Great Crested Flycatcher	Observed near LIND_06 during 2nd survey (6/18/13)
Killdeer	Observed at multiple locations during 3rd survey (7/3/13)
Mallard	Observed during 1st survey

b. Additional species recorded by eBird users and other observers

Species	Notes
Acadian Flycatcher	eBird observation
Alder Flycatcher	eBird observation
American Kestrel	eBird observation
Belted Kingfisher	eBird observation
Black-billed Cuckoo^{Br}	eBird observation
Black-throated Blue Warbler^{Br}	eBird observation
Black-throated Green Warbler^{Br}	eBird observation
Boat-tailed Grackle	eBird observation
Brown Thrasher^{Br}	eBird observation
Double-crested Cormorant	eBird observation
Forster's Tern	eBird observation
Green Heron	eBird observation
House Finch	eBird observation
Least Bittern	Responded to playback during SHARP survey
Least Flycatcher^{Br}	eBird observation
Least Sandpiper	eBird observation
Mourning Dove	eBird observation
Nashville Warbler^{Br}	eBird observation
Northern Harrier^{Br, SC non-Br}	eBird observation
Peregrine Falcon^{Br, SC non-Br}	eBird observation
Purple Martin	eBird observation
Rock Pigeon	eBird observation
Semipalmated Plover	eBird observation
Semipalmated Sandpiper^{Br}	eBird observation
Snowy Egret^{Br}	eBird observation
Solitary Sandpiper	eBird observation
Veery^{Br}	eBird observation
White-throated Sparrow	eBird observation
Yellow-rumped Warbler	eBird observation

^{Br}Indicates breeding season status only

TABLE 13. Total species list and number of individuals observed during 2013 Fall Migration surveys at Linden Hawk Rise and Linden Landfill, by transect. Frequency (freq.) was calculated as the number of transects at which a species was observed divided by the total number of transects surveyed. Relative abundance was calculated as the number of individuals of that species divided by the total number of individuals of all species. State-listed species are in red (E), blue (T), or green (SC). See figure 1 for transect locations.

Species	# of Transects	Freq.	Transect ID							Total	Rel. Abundance
			T01	T02	T03	T04	T05	T06	T07		
American Black Duck	1	0.14			7					7	0.010
American Goldfinch	5	0.71			3	8	2	3	4	20	0.029
American Kestrel	1	0.14							1	1	0.001
American Redstart	1	0.14	3							3	0.004
American Robin	5	0.71	3	1	1	3			1	9	0.013
American Woodcock	1	0.14	1							1	0.001
Barn Swallow	3	0.43			3	1			4	8	0.012
Belted Kingfisher	2	0.29			1			1		2	0.003
Black-and-White Warbler	1	0.14	2							2	0.003
Black-capped Chickadee	1	0.14	2							2	0.003
Black-throated Blue Warbler ^{Br}	1	0.14	1							1	0.001
Blue Jay	2	0.29	9	2						11	0.016
Bobolink ^{Br, SC non-Br}	1	0.14						3		3	0.004
Brown-headed Cowbird	1	0.14						3		3	0.004
Canada Goose	3	0.43				4		8	20	32	0.047
Carolina Wren	2	0.29	3	4						7	0.010
Chimney Swift	2	0.29			3	1				4	0.006
Common Grackle	2	0.29	2	1						3	0.004
Common Raven	1	0.14						1		1	0.001
Common Yellowthroat	5	0.71	1		2	2	1	3		9	0.013
Cooper's Hawk ^{Br}	1	0.14		1						1	0.001
Dark-eyed Junco	1	0.14		1						1	0.001
Double-crested Cormorant	2	0.29				1	17			18	0.026
Downy Woodpecker	3	0.43	5	3	1					9	0.013
Eastern Meadowlark	1	0.14							1	1	0.001
European Starling	2	0.29			10				10	20	0.029
Golden-crowned Kinglet	1	0.14	2							2	0.003
Gray Catbird	3	0.43	6		3			2		11	0.016
Great Black-backed Gull	2	0.29					2	2		4	0.006
Great Blue Heron ^{Br}	2	0.29					2	1		3	0.004
Great Egret	3	0.43			2	1	1			4	0.006
Great Horned Owl	1	0.14		1						1	0.001
Greater Yellowlegs	1	0.14						1		1	0.001
Hairy Woodpecker	1	0.14	2							2	0.003
Herring Gull	5	0.71	4		5		37	29	7	82	0.120
House Wren	1	0.14	2							2	0.003
Killdeer	2	0.29					2	7		9	0.013
Laughing Gull	1	0.14					3			3	0.004
Lesser Yellowlegs	1	0.14			1					1	0.001
Louisiana Waterthrush	1	0.14		1						1	0.001
Magnolia Warbler	1	0.14			1					1	0.001
Mallard	3	0.43			18	3	20			41	0.060
Mourning Dove	2	0.29					1		2	3	0.004
Northern Cardinal	2	0.29	6		2					8	0.012
Northern Flicker	4	0.57	6	1	7				2	16	0.023
Northern Mockingbird	3	0.43			1		1	1		3	0.004
Northern Parula ^{Br}	1	0.14	1							1	0.001

TABLE 13. (cont'd)

Species	# of Transects	Freq.	Transect ID							Total	Rel. Abundance
			T01	T02	T03	T04	T05	T06	T07		
Osprey ^{Br}	2	0.29			1	2				3	0.004
Palm Warbler	5	0.71	1		1	1		1	4	8	0.012
Red-bellied Woodpecker	4	0.57	2	2	1	1				6	0.009
Red-eyed Vireo	1	0.14	2							2	0.003
Red-winged Blackbird	6	0.86		1	32	3	9	7	11	63	0.092
Ring-billed Gull	2	0.29					46	3		49	0.071
Savannah Sparrow ^{Br}	4	0.57			3	1	2		14	20	0.029
Semipalmated Sandpiper	1	0.14			8					8	0.012
Snowy Egret ^{Br}	1	0.14			5					5	0.007
Song Sparrow	5	0.71			12	7	21	30	21	91	0.133
Swamp Sparrow	4	0.57		1	1	1		4		7	0.010
Tufted Titmouse	3	0.43	4	6	1					11	0.016
White-breasted Nuthatch	2	0.29	1	2						3	0.004
White-throated Sparrow	3	0.43	14	1				1		16	0.023
Yellow-rumped Warbler	5	0.71	2	4		1		3	6	16	0.023
Total # of Individuals			87	33	136	41	167	114	108	686	
Total # of Species			26	17	28	17	16	21	15	62	

^{Br}Indicates breeding season status only

TABLE 14. Total species list and number of individuals observed during 2013 Fall Migration transect surveys at Linden Hawk Rise and Linden Landfill, by survey. Maximum represents the maximum number of individuals observed on any one survey (across all transects). State-listed species are in red (E), blue (T), or green (SC).

Species	Survey 1 8/26/2013	Survey 2 9/16/2013	Survey 3 9/26/2013	Survey 4 10/14/2013	Total	Max per Survey
American Black Duck			3	4	7	4
American Goldfinch	13	3	2	2	20	13
American Kestrel ^{Br}				1	1	1
American Redstart	1	1	1		3	1
American Robin	5	1	2	1	9	5
American Woodcock		1			1	1
Barn Swallow	8				8	8
Belted Kingfisher		1		1	2	1
Black-and-White Warbler			2		2	2
Black-capped Chickadee			2		2	2
Black-throated Blue Warbler ^{Br}			1		1	1
Blue Jay	3	3	1	4	11	4
Bobolink ^{Br, SC non-Br}		3			3	3
Brown-headed Cowbird				3	3	3
Canada Goose	3	10	8	11	32	11
Carolina Wren	2	1	2	2	7	2
Chimney Swift	4				4	4
Common Grackle		2	1		3	2
Common Raven	1				1	1
Common Yellowthroat	1	4	4		9	4
Cooper's Hawk ^{Br}	1				1	1
Dark-eyed Junco				1	1	1
Double-crested Cormorant	1	14	3		18	14
Downy Woodpecker	1	3	4	1	9	4
Eastern Meadowlark				1	1	1
European Starling	10	1	5	4	20	10
Golden-crowned Kinglet			2		2	2
Gray Catbird	4	3	4		11	4
Great Black-backed Gull		2	2		4	2
Great Blue Heron ^{Br}	1	1	1		3	1
Great Egret	1	3			4	3
Great Horned Owl	1				1	1
Greater Yellowlegs			1		1	1
Hairy Woodpecker		2			2	2
Herring Gull	59	16	4	3	82	59
House Wren	2				2	2
Killdeer		1	5	3	9	5
Laughing Gull		3			3	3
Lesser Yellowlegs				1	1	1
Louisiana Waterthrush		1			1	1
Magnolia Warbler		1			1	1
Mallard	22	2	6	11	41	22
Mourning Dove	2			1	3	2
Northern Cardinal	1	3	3	1	8	3
Northern Flicker	3	4	8	1	16	8
Northern Mockingbird		1	1	1	3	1
Northern Parula ^{Br}			1		1	1
Osprey ^{Br}	2			1	3	2

TABLE 14. (cont'd)

Species	Survey 1 8/26/2013	Survey 2 9/16/2013	Survey 3 9/26/2013	Survey 4 10/14/2013	Total	Max per Survey
Palm Warbler		3		5	8	5
Red-bellied Woodpecker	1	1		4	6	4
Red-eyed Vireo		1	1		2	1
Red-winged Blackbird				63	63	63
Ring-billed Gull	9	3	8	29	49	29
Savannah Sparrow ^{Br}		3		17	20	17
Semipalmated Sandpiper	8				8	8
Snowy Egret ^{Br}		4		1	5	4
Song Sparrow	6	26	17	42	91	42
Swamp Sparrow				7	7	7
Tufted Titmouse	5	2	3	1	11	5
White-breasted Nuthatch		1		2	3	2
White-throated Sparrow				16	16	16
Yellow-rumped Warbler			1	15	16	15
Total # of Individuals	181	135	109	261	686	
Total # of Species	30	37	32	34	62	

^{Br}Indicates breeding season status only

TABLE 15. Additional species observed at Linden Hawk Rise during 2013 Fall Migration surveys, but not encountered on transect surveys. State-listed species are in red (E), blue (T), or green (SC).

a. Additional species observed during NJ Audubon survey visits

Species	Notes
Merlin	Observed near pond during 3rd survey (9/26/13)

b. Additional species entered into eBird by other observers

Species	Notes
American Crow	eBird observation
American Kestrel	eBird observation
Baltimore Oriole	eBird observation
Black-crowned Night-Heron ^{Br, SC non-Br}	eBird observation
Black-throated Green Warbler ^{Br}	eBird observation
Blue Grosbeak	eBird observation
Brown Creeper	eBird observation
Brown Thrasher ^{Br}	eBird observation
Bufflehead	eBird observation
Cedar Waxwing	eBird observation
Chipping Sparrow	eBird observation
Eastern Phoebe	eBird observation
Eastern Towhee	eBird observation
Eastern Wood-Pewee	eBird observation
Field Sparrow	eBird observation
Green Heron	eBird observation
Hermit Thrush	eBird observation
Hooded Merganser	eBird observation
House Sparrow	eBird observation
Indigo Bunting	eBird observation
Least Flycatcher ^{Br}	eBird observation
Least Sandpiper	eBird observation
Marsh Wren	eBird observation
Northern Harrier ^{Br, SC non-Br}	eBird observation
Northern Rough-winged Swallow	eBird observation
Ovenbird	eBird observation
Pine Warbler	eBird observation
Red-headed Woodpecker	eBird observation
Red-tailed Hawk	eBird observation
Ruby-crowned Kinglet	eBird observation
Scarlet Tanager	eBird observation
Solitary Sandpiper	eBird observation
Swainson's Thrush	eBird observation
Tree Swallow	eBird observation
Wild Turkey	eBird observation
Willow Flycatcher	eBird observation
Winter Wren ^{Br}	eBird observation

^{Br}Indicates breeding season status only

TABLE 16. Full list of bird species observed at Linden Hawk Rise and Linden Landfill during four years of baseline surveys (2010-2013). State-listed species are in red (E), blue (T), or green (SC) text.

Species	Spring 10	Breeding 10	Fall 10	Winter 10/11	Spring 11	Breeding 11	Fall 11	Winter 11/12	Spring 12	Breeding 12	Fall 12	Winter 12/13	Spring 13	Breeding 13	Fall 13
Acadian Flycatcher										x					
American Black Duck			x	x	x	x	x	x			x	x	x	x	x
American Crow	x	x	x	x		x	x	x			x	x			
American Goldfinch	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
American Kestrel			x	x	x		x	x			x	x	x		x
American Pipit												x			
American Redstart	x		x				x		x		x		x	x	x
American Robin	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
American Tree Sparrow				x				x				x			
American Woodcock				x				x							x
Bald Eagle ^{Br, T non-Br}							x		x	x				x	
Baltimore Oriole	x	x	x		x	x			x	x			x	x	
Bank Swallow														x	
Barn Swallow	x	x	x		x	x	x		x	x	x		x	x	x
Belted Kingfisher			x	x			x	x			x	x	x		x
Black Skimmer		x												x	
Black-and-White Warbler	x		x		x				x		x		x		x
Blackburnian Warbler ^{Br}						x							x		
Black-capped Chickadee	x		x	x	x		x								x
Blackpoll Warbler	x		x			x	x		x		x		x	x	
Black-throated Blue Warbler ^{Br}			x				x				x		x		x
Black-throated Green Warbler ^{Br}					x						x				
Blue Grosbeak						x	x				x			x	
Blue Jay	x	x	x	x	x		x	x	x	x	x	x	x	x	x
Blue-gray Gnatcatcher	x	x			x								x	x	
Blue-winged Teal												x			
Blue-winged Warbler	x														
Bobolink ^{Br, SC non-Br}					x				x		x		x		x
Brown Creeper							x				x				
Brown Thrasher ^{Br}					x						x				
Brown-headed Cowbird	x				x	x			x	x			x	x	x

TABLE 16. (cont'd)

Species	Spring 10	Breeding 10	Fall 10	Winter 10/11	Spring 11	Breeding 11	Fall 11	Winter 11/12	Spring 12	Breeding 12	Fall 12	Winter 12/13	Spring 13	Breeding 13	Fall 13
Bufflehead	x			x				x				x			
Canada Goose	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Canada Warbler ^{Br}			x												
Carolina Wren	x	x	x	x	x	x	x		x	x	x	x	x	x	x
Cedar Waxwing		x	x			x	x			x	x			x	
Chestnut-sided Warbler									x				x		
Chimney Swift			x			x	x			x	x			x	x
Chipping Sparrow									x						
Clapper Rail	x					x			x				x		
Common Goldeneye				x											
Common Grackle	x	x	x		x	x	x		x	x	x		x	x	x
Common Raven									x	x	x				x
Common Yellowthroat	x	x	x		x	x	x		x	x	x		x	x	x
Cooper's Hawk ^{Br}				x				x			x				x
Dark-eyed Junco			x		x								x		x
Dickcissel										x					
Double-crested Cormorant	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Downy Woodpecker	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Dunlin	x														
Eastern Kingbird	x	x			x	x			x	x				x	
Eastern Meadowlark															x
Eastern Phoebe			x	x			x	x			x				
Eastern Towhee	x		x		x						x				
Eastern Wood-Pewee						x			x	x	x			x	
European Starling	x	x	x	x	x	x	x	x	x	x		x	x	x	x
Field Sparrow			x								x				
Fish Crow													x		
Forster's Tern													x		
Fox Sparrow												x			
Gadwall	x	x					x	x	x		x	x	x		
Golden-crowned Kinglet			x				x	x			x	x			x
Grasshopper Sparrow ^{Br, SC non-Br}	x								x	x	x		x	x	
Gray Catbird	x	x	x		x	x	x		x	x	x		x	x	x

TABLE 16. (cont'd)

Species	Spring 10	Breeding 10	Fall 10	Winter 10/11	Spring 11	Breeding 11	Fall 11	Winter 11/12	Spring 12	Breeding 12	Fall 12	Winter 12/13	Spring 13	Breeding 13	Fall 13
Great Black-backed Gull		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Great Blue Heron ^{SC}	x		x	x		x	x			x	x	x		x	x
Great Crested Flycatcher		x				x								x	
Great Egret	x	x	x		x	x	x		x	x	x		x	x	x
Great Horned Owl								x				x	x		x
Greater Yellowlegs	x	x	x		x		x		x				x		x
Green-winged Teal	x			x				x				x	x		
Hairy Woodpecker	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Hermit Thrush									x						
Herring Gull	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Hooded Merganser				x			x	x				x			
Horned Lark ^{Br, SC non-Br}			x			x	x								
House Finch			x					x		x			x		
House Sparrow	x	x				x				x			x	x	
House Wren	x	x	x		x	x	x		x	x			x	x	x
Indigo Bunting	x	x			x	x			x	x	x			x	
Killdeer	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Laughing Gull			x								x			x	x
Least Flycatcher ^{Br}													x		
Least Sandpiper	x	x	x		x				x		x				
Lesser Yellowlegs			x		x				x						x
Lincoln's Sparrow											x				
Louisiana Waterthrush													x		x
Magnolia Warbler			x			x	x		x		x		x		x
Mallard	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Marsh Wren	x	x	x		x	x	x		x	x	x		x	x	
Merlin												x			x
Mourning Dove	x	x	x	x	x		x	x	x	x	x	x	x		x
Nashville Warbler ^{Br}	x														
Northern Cardinal	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Northern Flicker	x	x	x	x	x	x	x		x	x	x		x	x	x
Northern Harrier ^{Br, SC non-Br}			x				x	x			x	x			

TABLE 16. (cont'd)

Species	Spring 10	Breeding 10	Fall 10	Winter 10/11	Spring 11	Breeding 11	Fall 11	Winter 11/12	Spring 12	Breeding 12	Fall 12	Winter 12/13	Spring 13	Breeding 13	Fall 13
Northern Mockingbird	x	x	x		x	x	x	x	x	x			x		x
Northern Parula ^{Br}	x				x				x		x		x		x
Northern Rough-winged Swallow	x	x			x				x	x			x	x	
Northern Shoveler									x						
Northern Waterthrush	x		x		x								x		
Orange-crowned Warbler			x												
Orchard Oriole	x	x			x	x			x	x			x	x	
Osprey ^{Br}	x	x	x	x	x	x			x	x	x		x	x	x
Ovenbird	x				x				x		x		x		
Palm Warbler	x		x	x	x		x		x		x		x		x
Peregrine Falcon ^{Br, SC non-Br}											x				
Pine Siskin			x								x				
Prairie Warbler											x		x		
Red-bellied Woodpecker	x	x	x	x	x	x	x	x	x	x	x		x	x	x
Red-breasted Merganser												x			
Red-breasted Nuthatch											x		x		
Red-eyed Vireo	x	x				x			x					x	x
Red-tailed Hawk	x		x	x	x	x	x	x	x		x	x	x		
Red-winged Blackbird	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Ring-billed Gull		x	x	x			x	x	x		x	x	x		x
Ring-necked Pheasant													x	x	
Rock Pigeon	x	x	x			x			x						
Rose-breasted Grosbeak									x						
Ruby-crowned Kinglet	x		x				x		x		x		x		
Ruby-throated Hummingbird							x						x		
Rusty Blackbird				x	x										
Savannah Sparrow ^{Br}	x	x	x		x	x	x	x	x	x	x	x	x	x	x
Scarlet Tanager					x										
Semipalmated Plover			x												
Semipalmated Sandpiper ^{non-Br}			x								x				x
Sharp-shinned Hawk			x												
Snow Goose								x							

TABLE 16. (cont'd)

Species	Spring 10	Breeding 10	Fall 10	Winter 10/11	Spring 11	Breeding 11	Fall 11	Winter 11/12	Spring 12	Breeding 12	Fall 12	Winter 12/13	Spring 13	Breeding 13	Fall 13
Snowy Egret ^{Br}	x	x	x		x	x			x	x	x		x		x
Solitary Sandpiper	x		x												
Song Sparrow	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Spotted Sandpiper ^{Br}	x	x	x		x	x			x	x				x	
Swainson's Thrush	x								x				x		
Swamp Sparrow	x	x	x		x	x	x		x		x	x	x	x	x
Tennessee Warbler									x						
Tree Swallow	x	x			x	x	x		x	x	x		x	x	
Tufted Titmouse	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Veery ^{Br}	x				x								x		
Virginia Rail									x						
Warbling Vireo	x	x	x		x	x			x	x	x		x	x	
White-breasted Nuthatch			x	x			x				x				x
White-crowned Sparrow							x								
White-eyed Vireo										x					
White-throated Sparrow	x		x	x	x		x	x	x		x	x	x		x
White-winged Crossbill												x			
Wild Turkey	x	x	x		x	x	x	x	x	x	x		x	x	
Willow Flycatcher		x				x			x	x	x			x	
Wilson's Snipe					x										
Wilson's Warbler													x		
Winter Wren ^{Br}							x				x	x			
Wood Duck			x				x	x		x	x			x	
Wood Thrush ^{Br}	x	x			x	x			x		x				
Yellow Warbler	x	x	x		x	x			x	x			x	x	
Yellow-billed Cuckoo										x					
Yellow-breasted Chat ^{Br}													x		
Yellow-rumped Warbler	x		x	x	x		x		x		x		x		x
Yellow-throated Vireo													x		

TABLE 17. Additional bird species recorded by eBird users and other observers, but not encountered during NJ Audubon survey visits to Linden Hawk Rise (2010-2013). State-listed species are in red (E), blue (T), or green (SC) text.

Species	NJ Status	Notes
Alder Flycatcher		eBird observations from June, 2013
Black-billed Cuckoo ^{Br}	SC (Br)	eBird observation from June, 2013
Black-crowned Night-Heron ^{Br, SC non-Br}	T (Br); SC (non-Br)	eBird observation from October, 2013
Blue-headed Vireo ^{Br}		eBird observation from October, 2012
Boat-tailed Grackle		eBird observations from May and June, 2013
Common Merganser		eBird observation from February, 2013
Great Cormorant		eBird observation from April, 2013
Green Heron		eBird observations from July through September, 2013
Horned Grebe		eBird observation from April, 2013
Least Bittern	SC	Responded to playback during SHARP survey, May 2013
Least Tern	E	eBird observation from April, 2012
Pied-billed Grebe ^{Br, SC non-Br}	E (Br); SC (non-Br)	eBird observation from April, 2013
Pine Warbler		eBird observations from October, 2013
Purple Martin		eBird observation from July, 2013
Red-headed Woodpecker	T	eBird observations between October and December, 2013
Turkey Vulture		eBird observation from April, 2013
Yellow-bellied Sapsucker		eBird observations from April, 2013 and October, 2012

FIGURE 1. Bird survey points and transects at Linden Hawk Rise and Linden Landfill. All points were surveyed during 2013 spring migration and breeding season surveys, and transects were surveyed during 2012-2013 Winter and 2013 fall migration surveys.



FIGURE 2. Bird species richness (total number of species observed), by transect, during winter 2012-2013 bird surveys at Linden Hawk Rise and Linden Landfill.

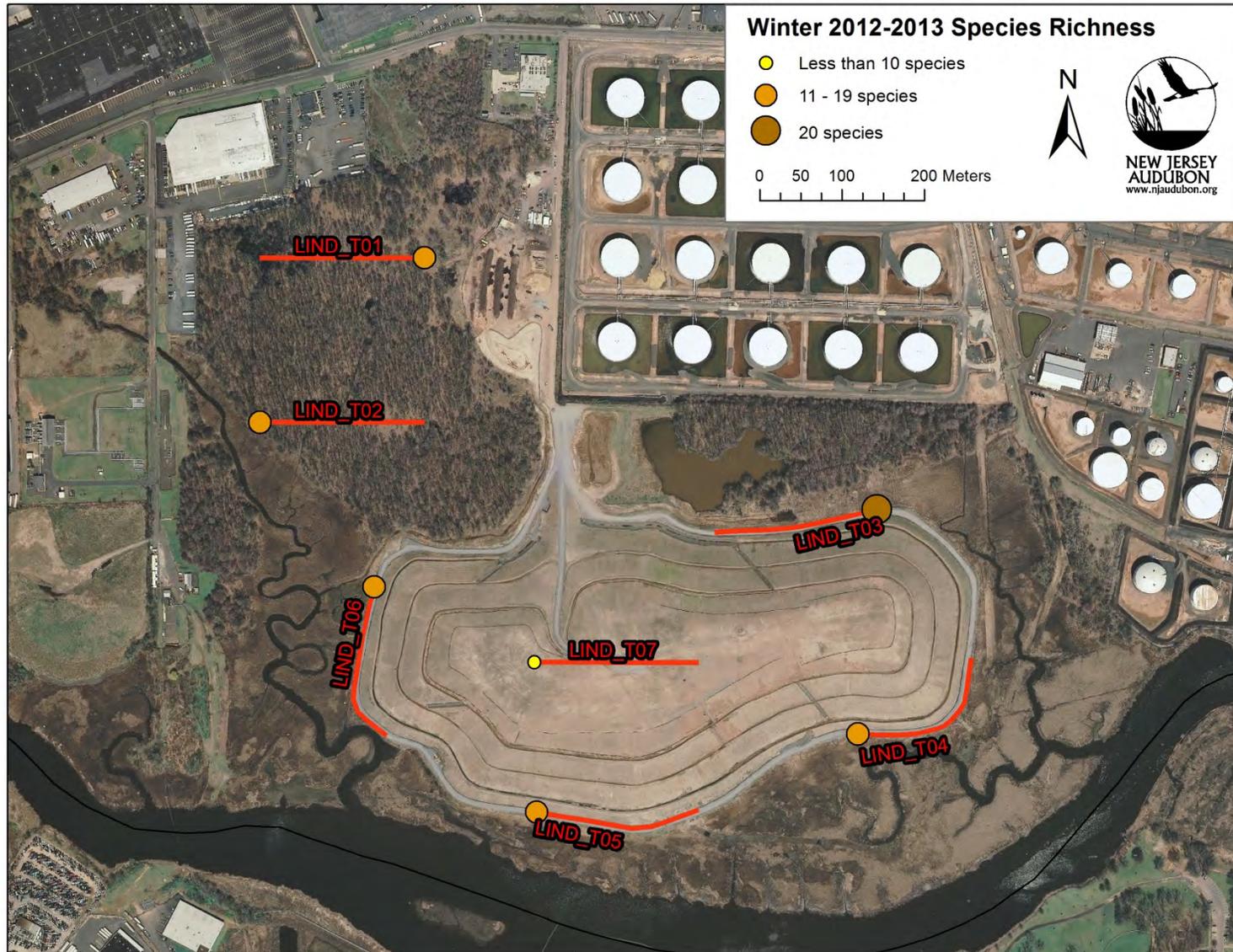


FIGURE 3. Bird species richness (total number of species observed), by point, during 2013 Spring Migration bird surveys at Linden Hawk Rise and Linden Landfill.



FIGURE 4. Total bird species richness (total number of species observed), by point, during 2013 Breeding bird surveys at Linden Hawk Rise and Linden Landfill.



FIGURE 5. Bird species richness (total number of species observed), by transect, during 2013 Fall Migration surveys at Linden Hawk Rise and Linden Landfill.

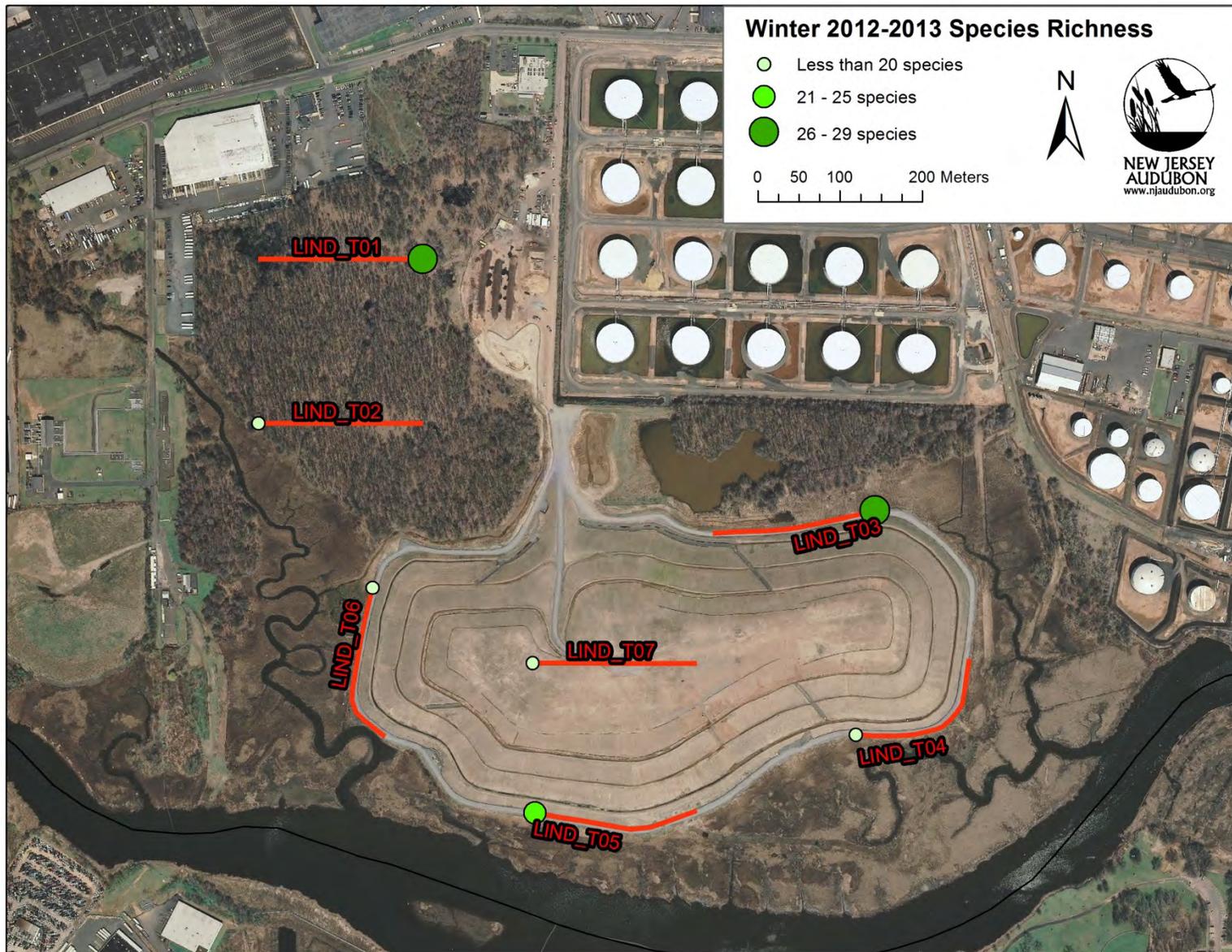


FIGURE 6. Diversity of habitats present at Linden Hawk Rise and Linden Landfill, including survey points (a) Lind_01, (b) Lind_02, (c) Lind_05, and (d) Linden_06, (e) Lind_12, and (f) Linden Landfill.

a. Lind_01



b. Lind_02



c. Lind_05



d. Lind_06



e. Lind_12



f. Linden Landfill

