Impacts of Habitat Restoration and the Status of Avian Communities in Seattle City Parks

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Introduction

City parks present a unique opportunity for public engagement with nature, as well as providing habitat for wildlife and ecosystem services for millions of urban residents. Within the urban core of Seattle, city parks have been the focus of many habitat restoration projects to improve habitat quality and restore degraded lands – efforts supported by community members, local government, and nonprofit groups with a shared interest in maintaining biodiversity and native habitats easily accessible to the public. Because of this widespread public interest and ease of access, city parks are excellent targets for involving members of the public in long-term biological monitoring efforts at a greater frequency or scale than is typically possible for sites in remote areas or for surveys conducted by professional scientists.

In order to monitor trends in avian diversity and abundance over time, and to take advantage of the expertise and enthusiasm of volunteers from the surrounding communities, the Seattle Audubon Society started the Neighborhood Bird Project (NBP) in 1997, with a series of volunteer-led surveys in Carkeek Park. Surveys have since expanded to seven other sites, and today are conducted once a month, year-round, at each of over 200 survey points distributed in natural or restored habitats in the Seattle area. Here we present a summary of findings from the first 17 years of NBP surveys in four Seattle City Parks: Discovery Park, Golden Gardens, Carkeek Park, and Magnuson Park (see Appendix 1 for maps). The primary goals of this analysis are (1) to summarize general trends in avian diversity and abundance over time in the study area, and (2) to assess the impact of habitat restoration activities conducted in the vicinity of survey points on bird communities. Therefore, we initially examine overall trends across all species and parks and then proceed to a detailed assessment of observed differences between restored and non-restored sites.

Survey Methods and Focal Species/Groups

NBP point counts are conducted by teams of volunteers at eight city parks once each month. Point count stations are located at least 200m apart at pre-determined locations on walking loops, with each loop including 5-9 stations. Following an initial one-minute rest period after arriving at a point count station, surveyors record the species, number, and mode of detection (seen/heard/flyover) of any birds observed

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Table 1. Focal species and species groups

Group	Species	Description
Invasive Species	European starling, Eurasian collared dove, house sparrow	Non-native species known to displace natives, typically targeted for population reduction in restoration projects.
Human-Associated Species	American crow, rock pigeon, European starling, house sparrow	Common urban birds with high populations in disturbed areas.
Riparian Species	orange-crowned warbler, Wilson's warbler, song sparrow, belted kingfisher, yellow warbler, common yellowthroat	Species that nest or primarily inhabit brushy habitat adjacent to waterways. Typically targeted for population increase in restoration projects.
Warblers	orange-crowned warbler, Wilson's warbler, black-throated gray warbler, common yellowthroat, MacGillivray's warbler, hermit warbler, Townsend's warbler, yellow warbler, yellow-rumped warbler	Colorful, vocal long-distance migrants; including many of our most charismatic breeding-season taxa.
Woodpeckers	hairy woodpecker, downy woodpecker, pileated woodpecker, northern flicker, black-backed woodpecker	A diverse family with large populations in many parks – sensitive to a variety of habitat changes.
Focal Species	**Preferred Habitat**	**Notes**
Anna's hummingbird	Generalist	Documented local population increases suggest increasing availability of food and habitat, especially in winter.
savannah sparrow	Meadows, grasslands, and some shrub-steppe habitats in suitable areas.	A common breeder in open areas of Discovery and Magnuson Parks.
White-crowned sparrow	Meadows or grasslands with scattered shrubs, shrub-steppe.	Both wintering and resident populations present throughout the year.
brown creeper	Mature coniferous forest.	Colorful, vocal long-distance migrants; including many of our most charismatic breeding-season taxa.
American crow	Generalist	Perhaps Seattle's must successful species; abundant in many disturbed habitats.
Wilson's warbler	Thick mid-succession understory growth or riparian thickets.	A common neotropiocal migrant and summer resident in suitable habitat.

within 50m of the survey point in a 5-minute period. Surveyors also record a brief description of the weather and wind conditions at the time of the survey. Surveys were not conducted during very poor weather (snow, heavy rain or wind). Data collection began in Carkeek Park in 1997 and expanded to other sites through 2003 with the addition of Discovery Park.

Five groups of species were selected for focused analysis in this report in order to represent communities of particular interest to biologists and land managers and to allow us to draw some conclusion about varying trends across taxa favoring different habitat types. We also selected six focal species for extra analysis, again to allow inference of trends in species of particular interest and to draw out patterns that are not apparent in a generalized analysis of diversity and abundance. Focal species were also selected to reflect divergent habitat preferences, in order to provide some assessment of the affect of restoration in different areas on different segments of the local bird community. Species groupings and focal species are summarized in Table 1.

Statistical analyses presented in this report were conducted in R (version 3.0.2) and

visualized with the ggplot2 package. Geographic analyses and maps were prepared with ArcGIS (version 10.1, ESRI 2012).

Status and Trends in Avian Diversity in Seattle City Parks

NBP surveys recorded 232 species in Seattle City Parks over a 17-year timespan. Total species diversity (the number of species reported in a given park over the entire study period) is highest in Discovery Park with 207 species, followed by Magnuson Park (169), Golden Gardens (123), and Carkeek Park (114, Figure 1). Mean annual species diversity (the average number of species reported per year) is 130 species across all parks from 2003 to 2013, with individual parks ranked from Magnuson (87 species per year) to Golden Gardens (48 species per year).

To assess general trends in avian diversity and abundance across time, and to establish a baseline for continued long-term study of the impact of restoration activities, we focused on two measures: annual species diversity (the number of species recorded in a park in a given year) and mean abundance (the average number of birds recorded per station per survey; this can also be thought of as the frequency of occurrence). As a simple test of change over time, both measures were plotted by year and fit with a linear model. This allows us to infer relative rates of change of the populations of different species within the parks (see Figure 2). Separate models were

Figure 1: Number of species recorded in each Park.

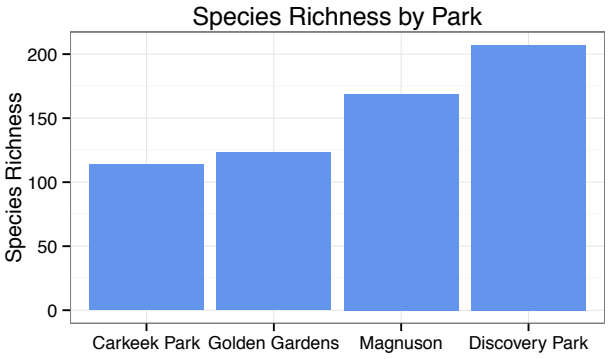
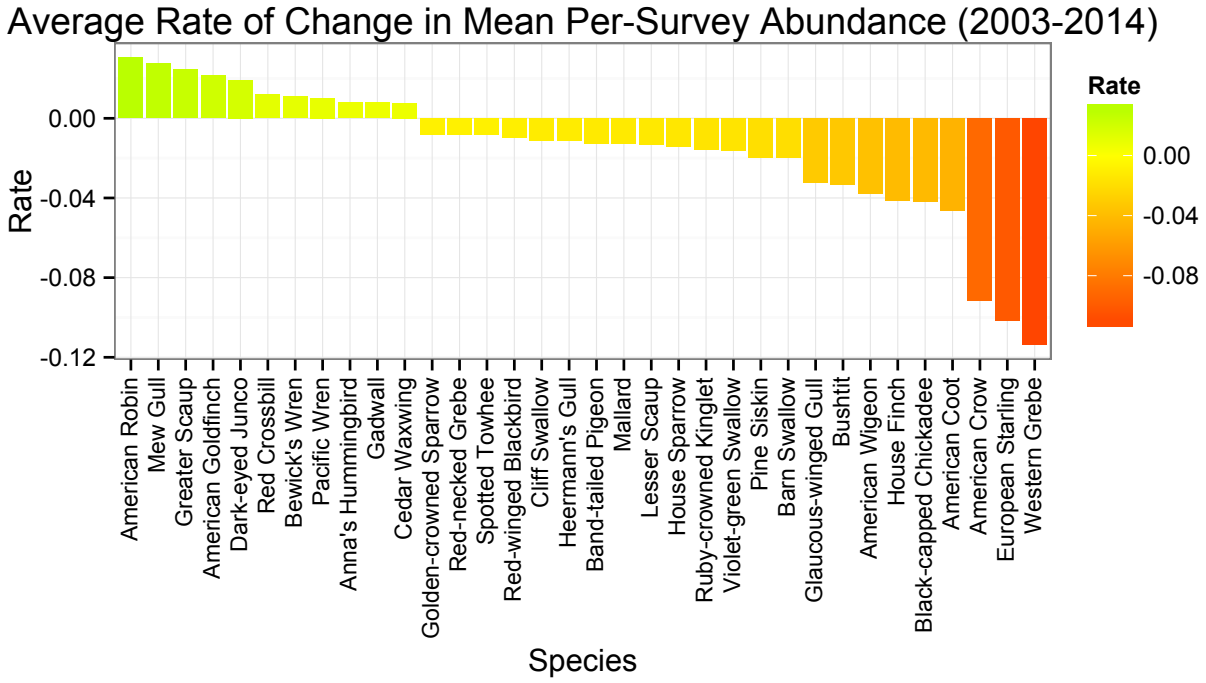


Figure 2: Ranked slopes of linear regression lines for mean number of individuals detected per-survey, per-station. Limited to species with mean annual detections greater than 10 and mean rates greater than 0.0075 detections/station/survey/year.



applied before and after 2003 for focal species and species groups analyses, as the addition of the large number of survey points in Discovery Park that year introduced new habitat diversity into the dataset and makes direct comparisons with the abundance and diversity prior to 2003 unreliable for most species.

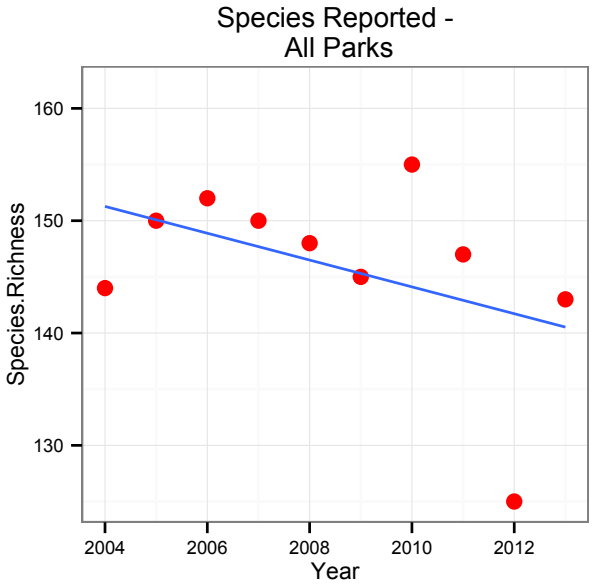
Our analysis of the NBP data found suggestive trends of decreasing species diversity through time in most locations surveyed – on the order of 1 fewer species per year across all parks – but this pattern was not strongly supported by linear models (Table 2, Figure 3). Of the four parks assessed, all but Discovery Park showed slightly decreasing species abundance, but none of the models explained more than 20% of the variation in the data, suggesting that documented trends in species diversity reflect random variation (or at least nonlinear change over time) rather than any consistent single pattern of change over the study period. Furthermore, the trend towards decreasing diversity over time disappears when the unusually low diversity numbers for 2012 - when fewer surveys were completed – are removed, suggesting that variation in survey effort is responsible for much of the decline. Although any decline in species diversity is a cause for concern, discerning long-term decline from random (or at least unmeasured) variation is a difficult task even for the best-designed surveys, and to date the NBP data shows no strongly supported pattern of change. However, continued data collection under a comparable protocol will maximize the value of data already collected and may serve to point out important trends in species diversity in the future.

Focusing on species groups, the data suggest that invasive and human-associated species have decreased in relative abundance while woodpeckers and warblers have increased. Across all parks, the frequency of invasive birds has declined consistently since the start of surveys, decreasing from over 3 per survey per station in 1997 to fewer than 1 per survey per station across all sites surveyed to date in 2014. The frequency of occurrence of

Table 2: Trends in annual species diversity over time.

Location	Mean Annual Species Diversity	Trend	Slope (species per year)	R^2
All Parks	130	Decreasing	-1.2	0.019
Discovery Park	78.889	Increasing	1.1	0.058
Magnuson Park	86.667	Decreasing	-0.65	0.19
Carkeek Park	54.389	Decreasing	-0.3	0.055
Golden Gardens	48.222	Decreasing	-0.32	0.009

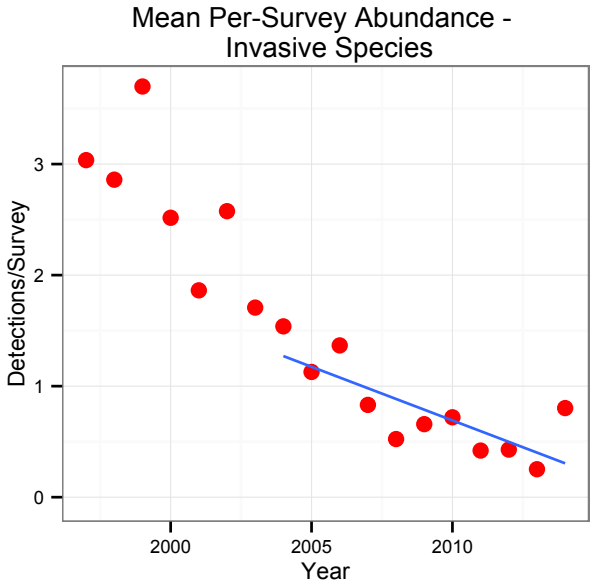
Figure 3: Annual Species Diversity over time.

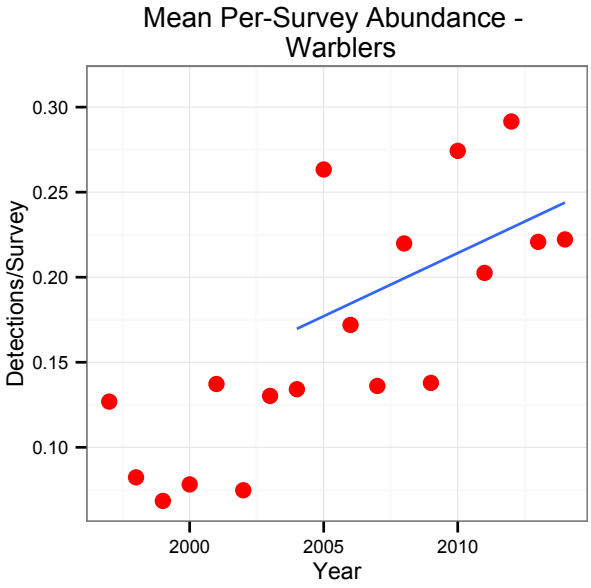


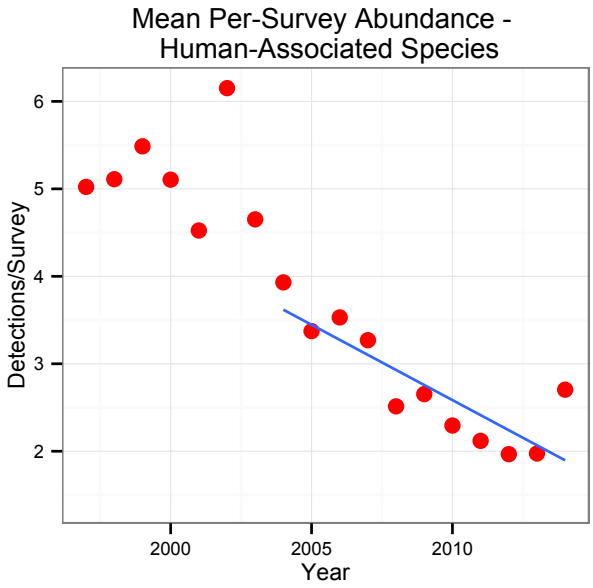
human-associated species has also declined, while frequency of riparian birds increased steadily prior to the inclusion of Discovery Park sites in 2003 and has since held steady. Both warblers and woodpeckers show slight, steady increases in frequency of occurrence across all parks (Figure 4).

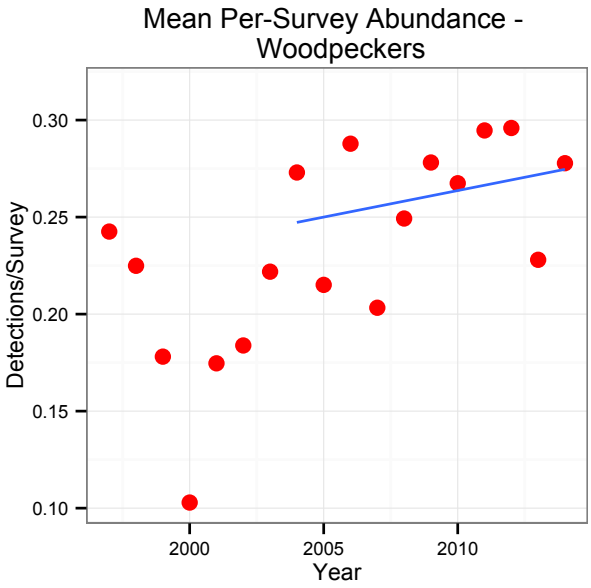
Among the focal species studied, Anna's hummingbird and brown creeper showed the most consistent trends across all parks. Anna's hummingbird increased in frequency roughly 50% from 2004 to 2013 (Figure 5) – an impressive rate of increase roughly in line with other observed increases in populations of this species throughout the northwest, likely driven

Figure 4: Species group trends in abundance.









by an increase in winter food availability from decorative plantings and hummingbird feeders. Brown creeper also increased significantly throughout the study period, though higher variation in counts of this species meant that the linear trend explained less of the total variation than was the case with the Anna's hummingbird.

Although the two focal species selected to represent birds preferring open meadow habitats – white-crowned sparrow and savannah sparrow – did not show any well-supported linear trends across all parks, local patterns of abundance were variable and deserve careful observation as restoration and maintenance work is ongoing. Savannah sparrow in particular is rarely observed in either Golden Gardens or Carkeek parks, but breeds abundantly in both Magnuson and Discovery

Figure 5: Anna's hummingbird and brown creeper change in detection frequency over the survey period.

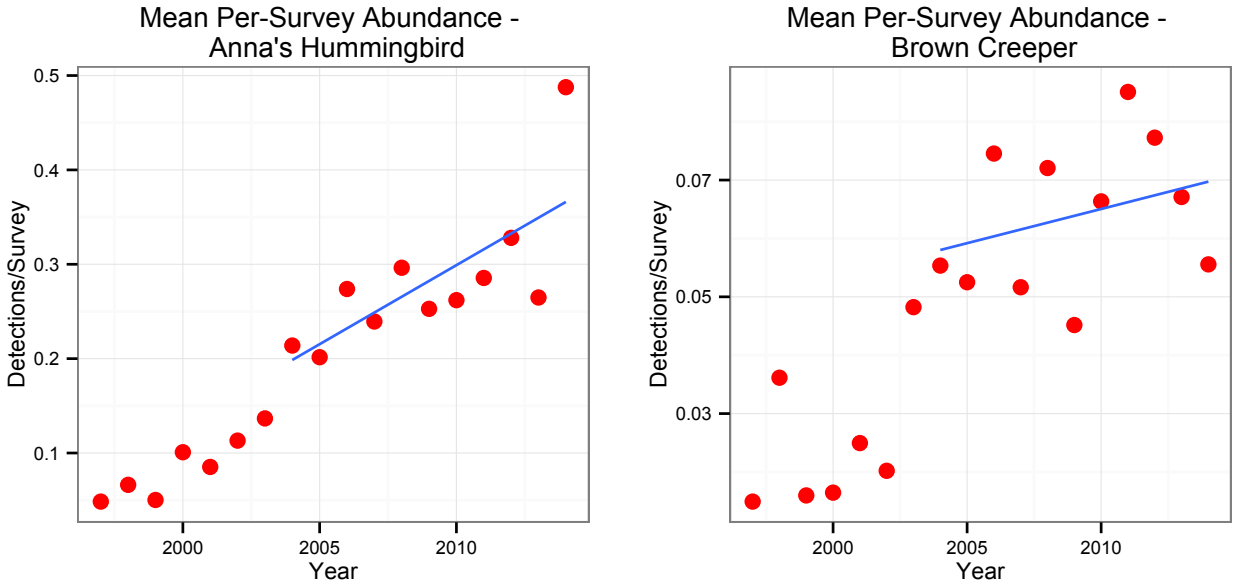
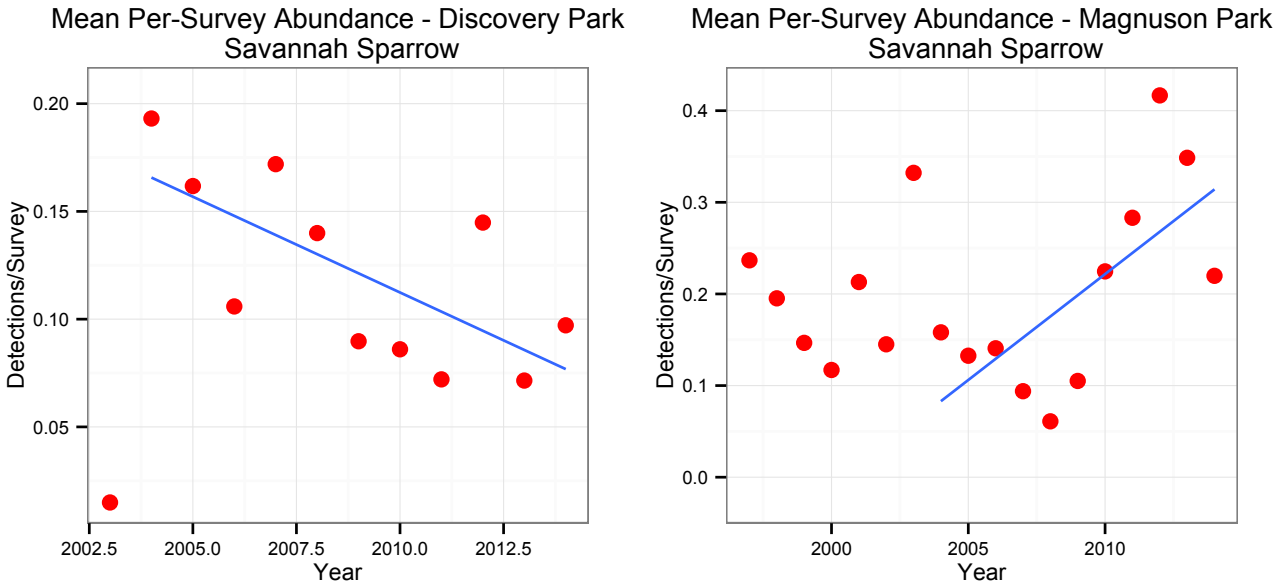


Figure 6: Trends in Savannah Sparrow abundance in Discovery and Magnuson Parks.



Parks. Since the beginning of data collection savannah sparrow frequency has nearly doubled in Magnuson Park, but has declined by roughly half in Discovery Park (Figure 6).

The cause of these local changes in savannah sparrow abundance is not directly addressed by this data, but differences in the timing and amount of restoration and land management activities between sites likely plays a role. As the timing of mowing in grassland habitats in Discovery Park and its impact on grassland-nesting birds has long been a point of contention between birders and land managers at the site, this study's observation of long-term decline in abundance should serve as a useful data point in calibrating further management actions in the area.

Impacts of Habitat Restoration

Green Seattle Partnership (GSP) has been conducting both professional and volunteer-driven habitat restoration projects throughout the Seattle area since 2004 and currently organizes ongoing restoration and monitoring projects within 50m of the majority of survey points incorporated in the NBP dataset (see Appendix 1). GSP restoration projects typically proceed through four phases: 1 – invasive removal, 2 – planting, 3 – active maintenance, and 4 – monitoring and adaptive management. The vast majority of currently active restoration zones have yet to proceed to phase 4, and establishment of stable native communities often takes many years after the completion of active restoration. Analyses of restoration outcomes in this report should thus be viewed as baselines for future research and potential inputs for adaptive management or project planning rather than settled assessments of success in individual areas, as restoration has yet to be "completed" in most areas covered.

In order to assess the impact of GSP restoration activities on bird communities, we compared mean abundance (the average number of individuals per survey) and mean annual species diversity (the number of species reported annually per point) among survey points located within 50 meters of restoration zones in each phase, using a Tukey test to ask if there is a significant difference in either value across points in different restoration phases (Figure 7). This analysis found no significant difference in either diversity or abundance between points that had or had not undergone restoration, or among differing levels of restoration point class. Although the data presents some suggestive trends of decreasing abundance and diversity in phase 3 or 4 zones, this variation is within mean standard error of phase 1 and 2 zones and is not significant ($p > 0.05$) in Tukey tests. It should be noted that this test as currently employed has limited power because very few of the zones have proceeded beyond phase 3, and most are in phases 1 or 2. Apparent lower species diversity in Phase 4 zones, for example, is largely driven by just two low-diversity points.

For all NBP survey points adjacent to GSP zones and with data series extending before the initiation of restoration activities, we also compared mean abundance and annual species diversity before and after the initiation of restoration work and used a paired *t*-test to assess the significance of any difference found. This procedure was repeated across species groups and focal species (Table 4, Figure 8).

We found that mean abundance declined for all

Figure 7: Mean species diversity across stations located within 50m of areas at different stages of progress in habitat restoration. Error bars report one standard error.

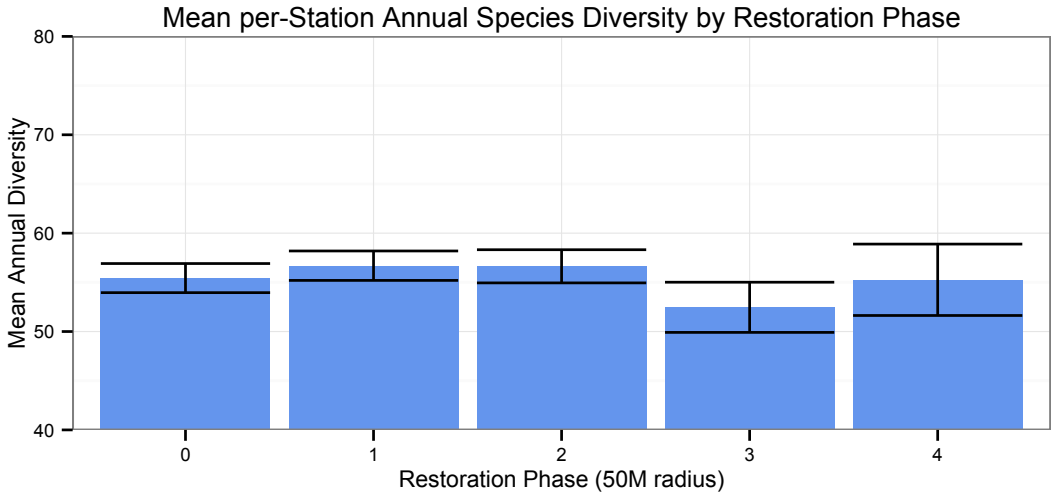


Figure 8: Pre-restoration vs. ongoing restoration average annual species diversity and per-survey abundance. Error bars report one standard error.

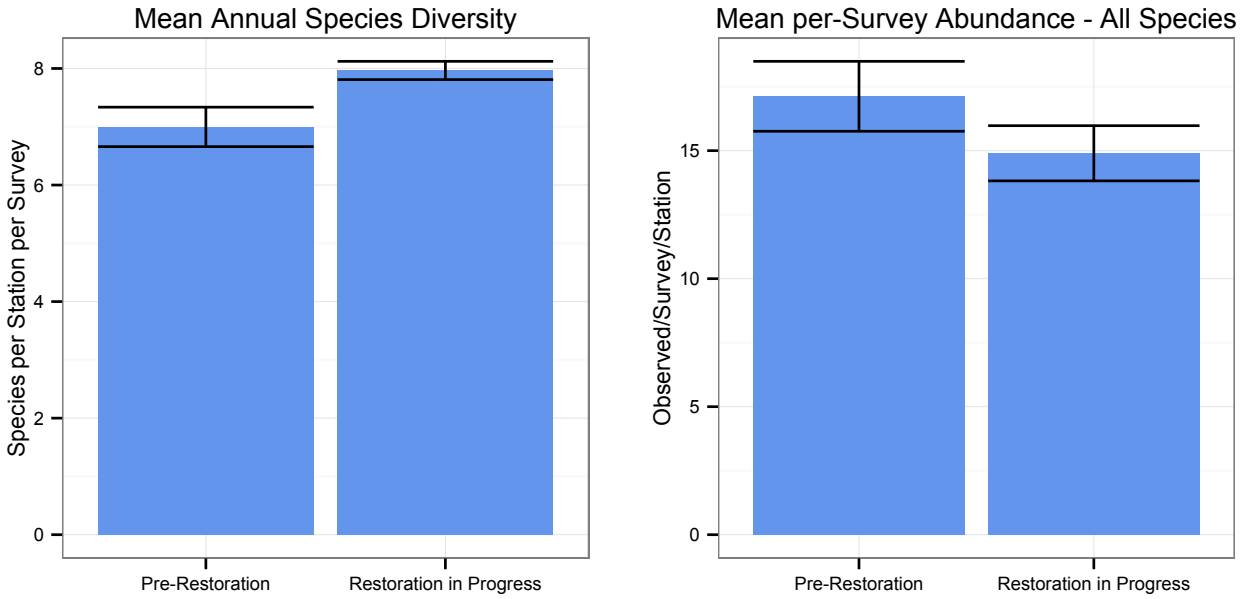


Table 4: Comparisons of measures of avian diversity and abundance before and after initiation of GSP habitat restoration work. Significantly different measures are in bold.

	Pre-Restoration Mean	**Ongoing Restoration Mean**	**Difference**	***t***	***p***
Per-Survey Species Diversity	5.1264	5.3072	0.1808	1.8828	0.06289
Annual Species Diversity	6.9976	7.966	0.9684	1.757	0.08225
Total Birds	**17.12316**	**14.8978**	**-2.22536**	**3.9131**	**1.75E-04**
Riparian Birds	**2.175**	**2.0178**	**-0.1572**	**2.3677**	**0.02002**
Invasive Species	9.4986	7.5239	-1.9747	1.314	0.1952
Warblers	2.0004	1.9077	-0.0927	0.3293	0.7428
Woodpeckers	1.3468	1.3393	-0.0075	0.1639	0.8702
Human-Associated Birds	**5.757**	**4.0898**	**-1.6672**	**4.3402**	**3.65E-05**
Wilson's warbler	1.3073	1.2823	-0.025	0.2297	0.8193
Savannah Sparrow	2.1143	1.9341	-0.1802	1.1502	0.2624
Anna's Hummingbird	1.2777	1.2443	-0.0334	0.842	0.4126
White-crowned Sparrow	2.0662	1.7324	-0.3338	1.6589	0.1066
Orange-Crowned Warbler	1.3962	1.255	-0.1412	1.2733	0.2109
Golden-Crowned Kinglet	3.8999	3.3793	-0.5206	1.723	0.08907
Song Sparrow	**2.0926**	**1.9225**	**-0.1701**	**2.6953**	**8.39E-03**

species and groups assessed after the onset of restoration activities, though only total bird abundance, riparian bird abundance, and human-associated bird abundance showed significant differences in a *t*-test. The decline in human-associated birds explained roughly three-quarters of the decline in total bird abundance, which should be viewed as a cautious success for restoration, as these species are already abundant in surrounding urban habitats and often outcompete native species in heavily disturbed areas. The significant decline in riparian birds is a more worrying sign for the impact of restoration projects on bird communities, but this drop was nearly entirely explained by the significant decline in song sparrow populations – likely a reflection of the song sparrow's success in living with Himalayan blackberry, one of the most common invasive species removed during phase-1 restoration activities.

Species diversity, measured both as mean annual diversity across survey points and as the average number of species reported per-survey per-point, increased on average by roughly one species per year after the initiation of restoration. Although this increase fell just short of statistical significance (p=0.06 per-survey, p=0.08 annual), the pattern is compelling and should be followed in future assessments of restoration impacts.

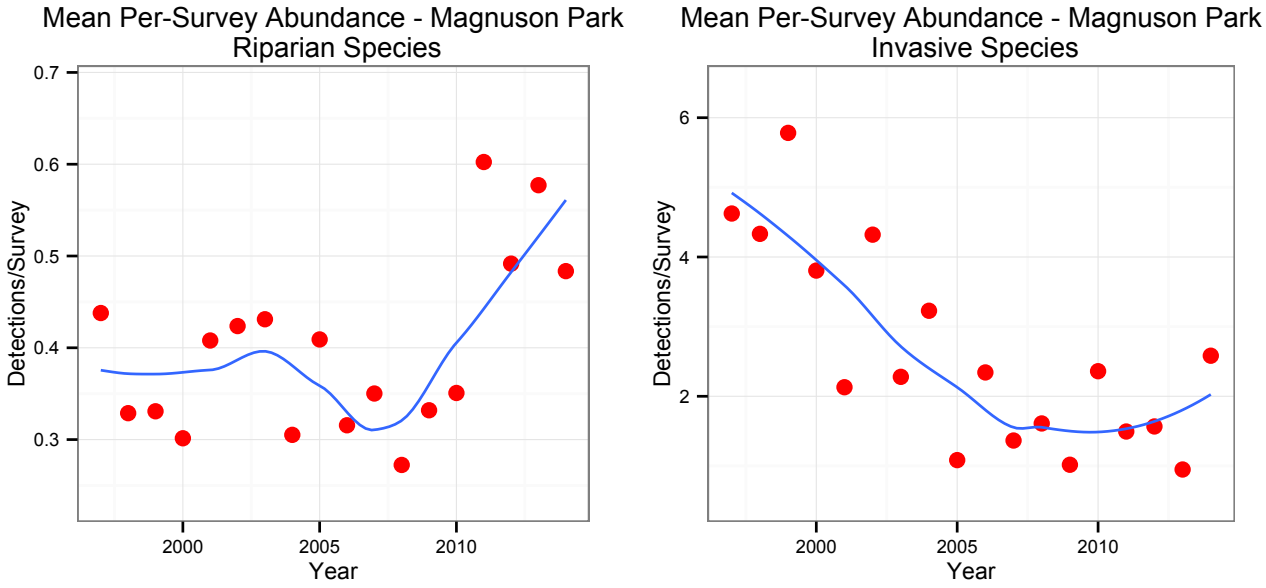
Overall, our assessment of the impact of GSP restoration activities on avian communities is cautiously positive. Observed declines in total bird counts (roughly 2 fewer birds per survey) are mostly explained by declines in counts of human-associated species, suggesting that restoration activities are, as intended, returning habitats to a more "natural" state less conducive to occupation by common urban birds. The consistent pattern of decline in abundance across species groups and focal species is somewhat worrying, but likely reflects the ongoing disturbance caused by active work on a site as well as the time lag between establishment of native habitats in a restored area and establishment of bird populations using that habitat. Because most GSP restoration projects in the NBP study area were started in 2007 or later, very few zones have "completed" restoration. Thus our assessment provides a snapshot of the impact of active restoration on bird communities during a transitional phase in habitat quality. As more restoration zones are completed, we expect that patterns of increasing species diversity will continue, while patterns of declining abundance among non-human-associated species will level off; however, continued long-term monitoring will be necessary to assess these trends and make concrete recommendations for future restoration activity planning.

Magnuson Park Wetlands Restoration

From 2008 to 2011, Seattle City Parks undertook a large-scale habitat restoration project in Magnuson Park to remove invasive plants and hugely expand a complex of wetlands on the southern half of the park. This habitat restoration effort was much larger in scale than typical GSP sites assessed earlier in this report, encompassing an area over 14 acres and costing over $3 million. Because NBP data collection in Magnuson Park began prior to the restoration and continued both during and post-construction, data from this site allows us to view how bird communities respond to restoration projects both during and after heavy construction. Because construction activities and changed topographies required some survey points to move, these data should be viewed as somewhat less conclusive than those from other NBP survey points, but the patterns observed are instructive and can help inform our view of how avian communities may respond to the end of work on the many smaller GSP restoration sites assessed here.

Counts of riparian birds were relatively constant from the beginning of data collection in 1998 through 2006, when they experienced a slight decline. This decline persisted through the end of active construction in 2011, when riparian bird counts rebounded to roughly 50% above their pre-restoration baseline. Since 2011, frequency of riparian birds has been higher than in any year prior to the

Figure 9: Species group abundance in Magnuson Park. Active construction on the wetlands ran from 2008 to early 2011.



initiation of restoration. Meanwhile, abundance of human-associated species and invasive species has declined consistently since the beginning of data collection, reaching a minimum during the active construction phase and since maintaining relatively constant levels (though note that early results from 2014 surveys suggest a rebound in populations; Figure 9).

These patterns are encouraging early news for the success of this large project in increasing the abundance and diversity of native wildlife in Magnuson Park. The data also aligns well with standard expectations of progress in restoration projects, in which the highly visible short-term costs of large-scale construction to local wildlife are balanced by a long-term increase in abundance and diversity. Indeed, the speed with which riparian bird counts rebounded following construction – riparian bird frequency reached its maximum recorded level in the same year that heavy construction ended on the site – is surprising, and suggests that some of this increase in local abundance is the result of shifting populations from surrounding lower-quality habitats outside the park rather than an increase in the absolute number of riparian birds in the region, though an increase in available habitat should increase regional populations over the medium and long-term.

Viewing the observed trends in bird abundance and diversity around the smaller GSP restoration sites in the context of the Magnuson Park data, an optimistic interpretation would suggest that the observed declines in abundance across species near GSP sites are temporary and will be replaced by higher counts once restoration work is complete and sites are allowed time undisturbed for wildlife to discover the new habitats. The trends observed here also point to the critical role of long-term data collection in assessing the impact of restoration activities. In the case of Magnuson Park, this assessment of the response of avian communities was possible only because NBP's volunteer surveys in the pre-restoration years had established a baseline level of bird abundance and diversity against which to compare the mid- and post-construction figures. NBP surveys to date have provided a similar baseline for many of the smaller GSP restoration sites and some early figures for in-progress sites are analyzed here, but

assessment of overall restoration impacts will require continued data collection both through the active work phase (currently in progress in nearly all zones assessed) and after the completion of active work.

Conclusions and Recommendations

As summarized in this report, the Neighborhood Bird Project has been successful in recording broad-scale trends in avian diversity and abundance in Seattle City Parks over its 17-year lifespan. Fueled by the efforts of over 130 dedicated volunteers, the program has provided an all-too-rare opportunity for community members to contribute meaningfully to science-based conservation and restoration projects in their own neighborhoods. With the growing interest in habitat restoration and its near-ubiquity across managed parklands in the Seattle area, long-term monitoring efforts like the NBP are also the most cost-effective way to gather the data necessary to make informed decisions about the management of some of our most heavily used public lands.

In order to maintain the integrity of the existing NBP dataset and to maximize its utility in future analyses, several modest improvements to survey methodology and design should be considered. First, although a partial distance-sampling protocol limiting observations to a 50M radius is included in the current NBP protocol, additional training or field protocols designed to ensure that surveys are limited to recording birds within 50M of an observation point should be implemented, as several Audubon staff and surveyors have mentioned that the distance sampling rules are not followed by all survey teams at all times. The simplest measure available here would be to place flagging or otherwise visibly mark objects 50M from each observation point to give surveyors a frame of reference. Full distance sampling – the standard approach for professional avian point counts – involves recording the distance and direction to each individual bird recorded, but given the lack of this data for previous years and the difficulty of correctly locating and estimating distance to a bird detected only by sound without prior training, we do not recommend adopting this approach at this time.

Survey teams should also make every effort to avoid moving survey point locations, and should provide any new or moved point locations with new names rather than reusing the old ones. Although most survey points have remained in a single location throughout the period of data collection, construction, changes in topography, and changes in personnel over the years have all occasionally resulted in a point shifting location or being retired. Maintaining survey points in their historic locations for as long as possible will maximize the comparability of data across years, and keeping accurate records of locations is crucial to drawing any conclusions as to differences in bird community traits across landscapes.

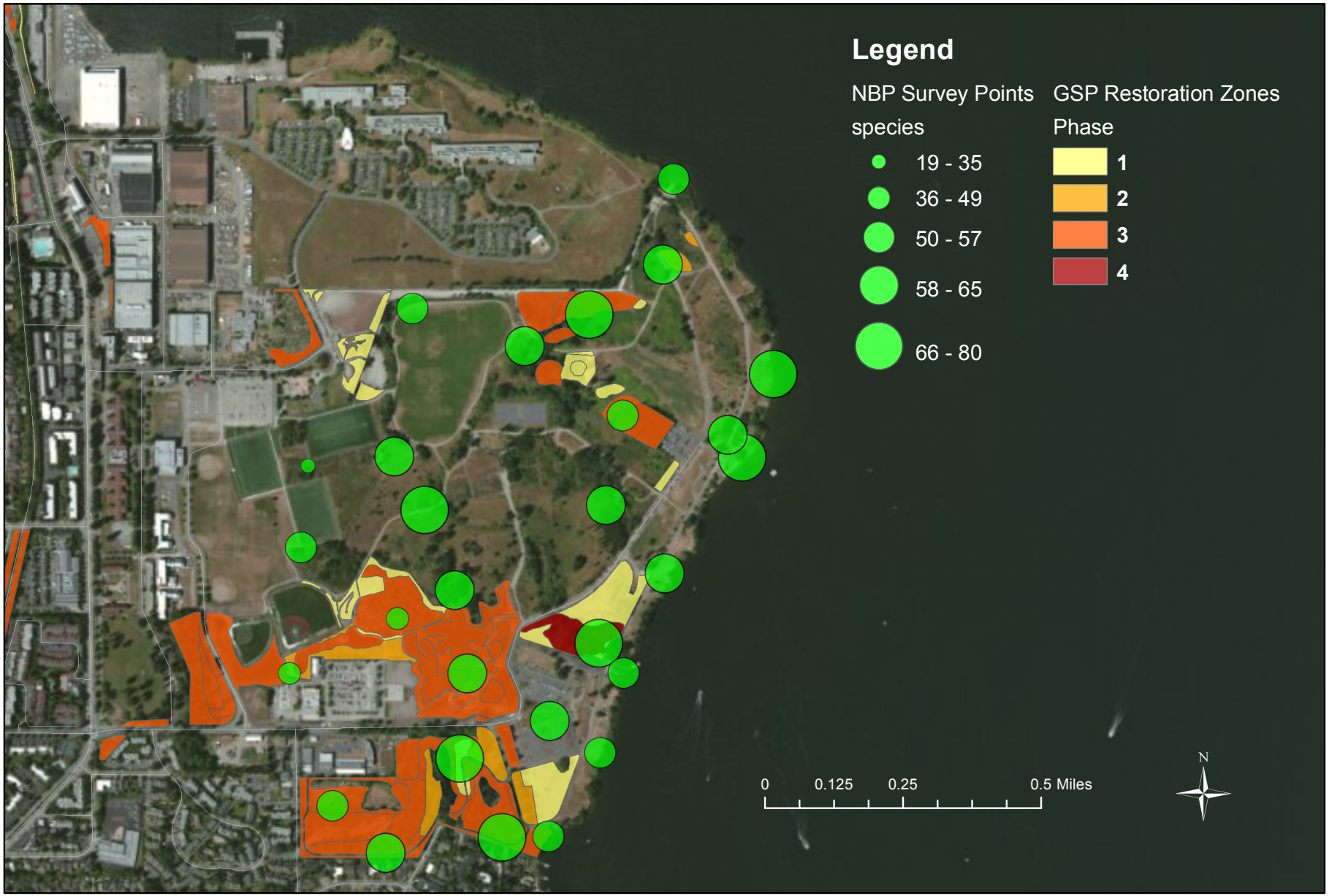
Finally, the question of equality of effort between different surveyors is a constant worry both in volunteer and professionally conducted bird surveys. People with differing levels of familiarity with local birdsong, auditory capacity, visual acuity, and experience as a point counter can record very different numbers of birds in a given area, and over time these differences in surveyor ability can skew interpretation of the data. Although guaranteeing complete equality of ability between survey teams will never be possible for volunteer programs like the NBP, park leaders should do their best to ensure that all survey teams working on a given day are of roughly comparable ability. The most practical way to implement this recommendation is to ensure that each survey team has at least one member capable of birding by ear and identifying nearly all the birdsong heard during a point count on every survey.

Turning to the trends in avian abundance and diversity documented in this report, we find grounds for cautious optimism as to the status of avian communities in Seattle City Parks. Both invasive species and human-associated species show long-term declines in abundance across all parks surveyed. Meanwhile, riparian birds, woodpeckers, and warblers - all groups that do well in native vegetation and are relatively

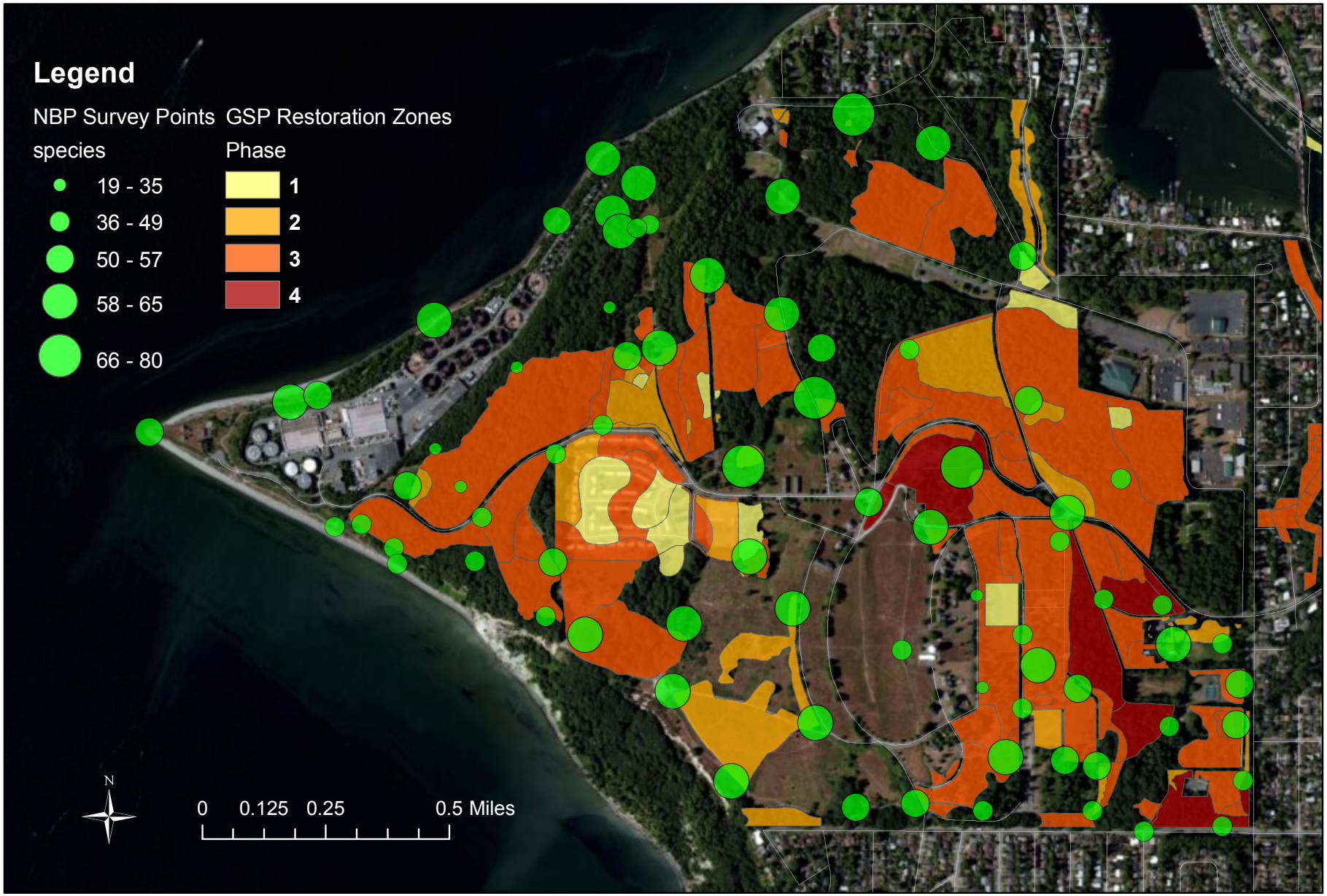
scarce in the surrounding urban environments – are either increasing or holding steady in average abundance. Species-specific trends such as the marked decline in savannah sparrow abundance in Discovery Park point to the continued need for monitoring and adaptive management across the parks, and suggest that NBP data may provide useful information for land managers seeking to balance the needs of recreation and wildlife in the parks.

NBP data has also provided useful measures of the impacts of habitat restoration projects on avian communities. In Magnuson Park, a 14-acre wetland restoration project appears to have resulted in a marked increase in riparian bird abundance and coincides with the continued decline in abundance of invasive and human-associated species – both positive signs. Early observations from the many GSP restoration zones covering most of the parks included in the NBP dataset are more equivocal – diversity is slightly up, while abundance is down across the board. These declines in abundance may represent temporary impacts from active construction as were documented at Magnuson Park from 2008-2011, but long-term monitoring of GSP sites post-restoration will be necessary to draw better conclusions. The increases in species diversity, meanwhile, suggest that restoration has been modestly successful at introducing new habitat diversity to our parks. The trend should be watched carefully in the future.

Magnuson Park NBP Points & GSP zones



Discovery Park NBP/GSP zones



Carkeek Park NBP/GSP zones

Golden Gardens NBP/GSP zones