Avian response to habitat restoration at Fernhill Wetlands

Final report to Clean Water Services from Portland Audubon

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PORTLAND AUDUBON

TOGETHER FOR NATURE

December 2020

Executive Summary

Fernhill Wetlands has historically been an important birding location in the Portland Metro region and is a designated Important Bird Area providing ecological connectivity for local wildlife. In 2014-15 Clean Water Services (CWS) implemented a massive habitat restoration project within the larger Fernhill Wetlands complex that transformed 90 acres of unused sewage ponds into a complex of native wetland habitats designed to naturally treat wastewater. Portland Audubon (PA) has been working with CWS since spring 2015 to assess bird response to the habitat restoration effort at Fernhill Wetlands, through a community science effort involving local birders, formal bird surveys designed and conducted by PA, and analysis of historical birder surveys conducted at the site for decades and housed in eBird. Our general predictions were that use of the restored area by bird species dependent on open water will diminish while use by uncommon / vulnerable marsh species (e.g. rails, bitterns) and other species dependent on native wetland habitats will increase. Our key findings include the following:

- Species richness and diversity: eBird surveys indicated a strongly significant increase in species richness in post-restoration versus pre-restoration overall and in each season. The eBird Shannon-Weiner species diversity result is less clear (only showing a significant increase in the summer, and actually a lower diversity in winter post-restoration). This more inconclusive result for eBird species diversity versus richness could be explained by lack of species evenness (which is a component of species diversity). The eBird findings are largely corroborated by the post-treatment results from the transect+lake surveys which indicated that in both fall and spring, species richness and Shannon-Weiner species diversity increased significantly in the five years post-restoration.
- Species abundance[1]: eBird surveys indicate overall bird abundance (all seasons combined) was significantly higher post-restoration compared to pre-restoration. When examined per season, only the summer and fall seasons had significantly more bird detections in the post-restoration period. Post-restoration transect+lake data indicates in increase in overall bird abundance in spring but not in the fall. In general, both the eBird and transect+lake data sets support evidence of increased abundance post-restoration.
    - eBird data indicates significantly more bird detections in fall and winter (compared to summer and spring) during both pre- and post-restoration regardless of the restoration effort.
- Guild level and individual species abundance: eBird data analysis indicated most bird guilds in the spring and summer (combined) had higher abundances post-restoration versus pre-restoration. The same was reflected in the six individual species comparisons we made with

[1] The abundance findings reported here hold true with or without Cackling Geese included. Large flocks of this species created outliers in the data potentially skewing abundance results so we "controlled" for this by comparing results with and without this species included.

eBird data. For many species, the patterns fit the predictions we made on species' responses to the restoration based on individual species life history characteristics. Some species/guilds that require complex vegetation structure showed a strong positive response (e.g. Virginia Rail, Red-winged Blackbird, Common Yellowthroat, Pied-billed Grebes, dabbling ducks). Some guilds that prefer open water or less vegetated habitats showed a negative or no significant change in abundance (e.g. gulls/terns and shorebirds). In a few cases, trends were unexpected. For example, Killdeer, a species most adapted to open habitats, appeared to increase significantly post-restoration. Post-restoration guild and individual species level analyses using the transect+lake data also indicated increasing abundances for most of the same species/guilds (e.g. dabbling ducks, songbirds in spring) however, a notable exception is fall Red-winged Blackbird abundances appear to have decreased after a dramatic initial increase in year 2 post-restoration and we documented unexpected declines in Pied-billed Grebe and Virginia Rail detections in fall 2019.

- Comparison of survey methods: species richness estimates from eBird surveys were significantly higher when compared to transect+lake surveys. The same held true for the overall Shannon-Weiner species diversity. Differences in the field survey methodologies may help explain these differences. These results suggest that eBird data at this site should not be used as a proxy for transect survey data for estimating species richness or diversity unless a correction factor were developed and applied. When examining species abundance between the two survey methods, eBird and transect surveys were more compatible when compared at the individual species level with 4 of 6 species indicating statistically similar estimates. Nevertheless, we recommend that CWS view the transect+lake data as the most reliable as it is based on a more rigorous protocol. However, the eBird data does provide meaningful results and in many ways corroborates the formal survey results. They can still be used to inform site management but with caveats in mind as to potential sources of bias.

General Interpretation, management recommendations, and future direction:

- The overall increase in avian species richness, diversity and abundance at this site is an indication that the large-scale restoration effort has provided a net benefit to many bird species. The gradual increase in avian species richness corresponds to maturation of restored native vegetation at the site which has benefited many species. At the same time it is clear that not all species have benefited, particularly those that depend on open water and more open habitat types in general.
- At the site level, habitat improvement is more of a question of trade-offs. Creating and managing for more mud flat habitat (and the water levels that would be necessary to maintain mudflats) during spring and fall migration on the big pond would provide more shorebird stopover habitat. Many shorebird species are experiencing declines and so, from a conservation perspective, this could be a productive way for CWS to manage the site. However, given limited space, expanding one type of habitat is going to be decreasing other types of habitat.

- At Fernhill Wetlands we have learned important information for some species of conservation concern including the Virginia Rail and shorebirds (as a group) that will help inform broader restoration and conservation work with these species.
- Beyond the site scale, we recommend CWS manage its extent of properties in a way that will maximize connectivity for birds and other wildlife species, and again, where possible create habitats important for bird groups and species that are currently of conservation concern. At some point CWS may want to consider restoring properties adjacent to the Fernhill site to a more natural state. If birds have more habitat in the immediate region around them, then it won't matter as much if they get flushed from the NTS area.
- In terms of minimizing human disturbance at Fernhill Wetlands, visitors leaving established trails to get closer to water edges creates the greatest potential for disturbance. As the vegetation has grown in, there is less temptation to do so. We do recommend that existing signage restricting access to the interior berms be maintained.
- Our results indicate the eBird community science counts can provide important information on bird response to habitat restoration. It may be in the interest of CWS to continue to support and promote eBird surveys beyond the 5-years post-restoration if keeping track of the avifauna at this site is of interest in the long-term. If so, it would be important to include a correction factor to compensate for a likely estimate of species richness biased high in the eBird counts.
- PA could replicate the transect+lake survey effort in future years to obtain a longer term assessment of avian response to the original and ongoing habitat restoration and enhancement at Fernhill Wetlands. If CWS were interested we would recommend a 5-year rotation for such longer term surveys.
- We believe this project could help inform similar efforts and the authors plan to publish the results of this work in a peer-reviewed publication.

Introduction

Since the summer of 2015 Portland Audubon (PA) has been working with Clean Water Services (CWS) to document bird community response to the restoration effort at Fernhill Wetlands. This report provides the final analysis including a full 5-year post-restoration analysis (including a comparison to pre-restoration eBird data) and builds on previous interim reports submitted to CWS for this project. In the interest of brevity we do not repeat a description of the project background, goals/objectives, study design, and detailed methods in this report unless something has changed. Please refer to the 2017 interim report for in-depth project information[2]. This report concludes PA's intensive analysis of bird response to habitat restoration at Fernhill Wetlands. If CWS desires, PA could replicate this effort in future years to obtain a longer term assessment of avian response to the original and ongoing habitat restoration and enhancement at Fernhill Wetlands.

Methodology

Community science avian surveys

Community science effort at Fernhill Wetland by experienced community scientists (following the protocol developed by ASOP[3]) has been relatively consistent since 2015. However, two expert birders that contributed a significant number of checklists, Steve Nord and Jon Plissner, moved out of the area during the latter part of the 5-year post-restoration phase. This, combined with the COVID-19 pandemic in March 2020 which reduced promotion of the community science effort, has resulted in reduced effort and fewer submitted checklists in the two past years (131 in 2019 and 179 in 2020 versus well over 200/year in previous years of this project). Despite this, since the fall of 2015, when this project was started, 1041 checklists have been submitted to eBird for the Fernhill Wetlands NTS monitoring and 627 Fernhill Wetlands--area outside of NTS (ASoP/CWS survey) from over 70 community scientists. In the analyses we report below, data were used from a total of 415 checklists collected by 30 experienced eBirders.

Formal avian surveys

PA has continued formal avian surveys at the site every fall and spring following the protocol originally developed in 2015. The formal bird survey protocol includes point count surveys, a line transect survey, and a separate survey of the large lake. We developed our protocol based on standard protocols developed by others (Ralph et al. 1995[4], Lancia et al. 1996[5], Huff et al. 2000[6], Conway 2008[7]). Three skilled biologists (Candace Larson, Shawneen

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[2] Available upon request from Joe Liebezeit (jliebezeit@audubonportland.org)

[3] Link to the protocol: https://audubonportland.org/wp-content/uploads/2019/04/fernhill_community_sci_protocol_revised_Feb2019.pdf

[4] Ralph, C.J., G.R. Geupel, P. Pyle, T.E. Martin, and D.F. DeSante. 1993. Handbook of field methods for monitoring landbirds. Gen. Tech. Rep. PSW-GTR-144. Albany, California: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. 41 p.

[5] Lancia, R.A., J.D. Nichols, and K.H. Pollock. 1996. Estimating the number of animals in wildlife populations. Pps. 215-253 *In* T.A. Bookhout, ed. Research and management techniques for wildlife and habitats. Fifth ed., rev. The Wildlife Society, Bethesda, MD.

[6] Huff, M.H., K.A Bettinger, H.L. Ferguson, M.J. Brown, and B. Altman. 2000. A habitat-based point count protocol for terrestrial birds, emphasizing Washington and Oregon. General Technical Report PNW-GTR-501. U.S. Department of Agriculture, US. Forest Service.

[7] Conway, C. J. 2008. Standardized North American Marsh Bird Monitoring Protocols. Wildlife Research Report #2008-01. U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, Tucson, AZ.

Finnegan, and Joe Liebezeit) conducted the formal surveys. Between fall 2015 and spring 2020 100 formal surveys have been conducted. Please contact Joe Liebezeit for a copy of the formal avian survey protocol if desired.

Data prep - eBird Data

All available eBird data for Fernhill Wetlands was downloaded from 2010 through June 2020 and criteria for data inclusion in the analysis were maintained as reported in the previous interim reports. Pre-restoration data only included observations from 2010 through 2013 by known, experienced community scientists whom also contributed post-restoration protocol surveys. Post-restoration data included eBird data from mid-August 2015 through the end of June 2020.

Data prep - Formal NTS survey data

Formal survey data from fall 2015 through spring 2020 were included in the analysis constituting 10 seasons (five fall: 2015-19 and five spring: 2016-20). The point count sampling only included birds up to 50m out from each of the six point count stations; so we did not include analyses for that data set in this report (except for the methodology comparison). While the transect sampling is a better fit at the Fernhill site we continued point count sampling at Fernhill throughout the duration of this project in case, in the future, CWS wants to compare bird communities across sites at a more regional level and only point count data is available at other sites. Point count data may also be useful if vegetation data are available for specific areas within the NTS.

Statistical analysis

We used statistical analysis for this final report developed for the previous interim report using multivariate methods and also including a detection probability estimate for abundance estimates[8]. Multivariate methods (that include year and season as covariates) is a more appropriate analyses than the previous univariate methods in previous reporting because it controls for experiment-wise error. With this newer analysis we also control for detection probability with the formal survey data.

To compare pre- and post-restoration species richness we used general linear mixed model (GLMM), with species richness and Shannon-Weiner index (species diversity) as response variables, and treatment (pre- and post-restoration), and year as factors. Year post-restoration is included as a fixed effect.

To compare pre- and post-restoration overall, guild, and individual species abundance we used GLMM, assuming a Poisson distribution, with number of individuals/visit as response

[8] In 2020, associated flyover detections were included in analyses for the first time. It was the original intention to include these detections especially for the comparison of survey types (eBird vs. transect counts) since eBirders typically include flyover detections. Because of this, there may be some differences in previous year's results (reported in previous interim reports) with those depicted here.

variables and season, treatment (pre- and post-restoration) and year as factors. A zero-inflated model was used for the rail and yellowthroat data.

To compare post-restoration changes in abundance we first used contingency analysis of distribution of detections among distance bins for each species group and focal species to determine detection rates for the transect survey data. We then used GLMM (Poisson distribution) for regression of abundance changes across years. For species diversity comparison we used GLMM with species richness and Shannon-Weiner indices as response variables and year as factor. We did not statistically test post-restoration bird abundance at this time as additional consideration of confounding factors (such as detectability changes associated with habitat development over time) is needed. We will likely need to use non-linear model analyses since changes in avian numbers would be expected to stabilize as vegetation attains maturity over time. We intend to complete this prior to submitting a manuscript for publication.

To compare eBird and formal survey methodologies we used pair-wise comparisons (paired t-test) for species richness and for abundance of all species groups. In spring 2020 there were insufficient eBird checklists focused on the NTS to include in this analysis.

Results & Discussion

Species richness pre- and post-restoration

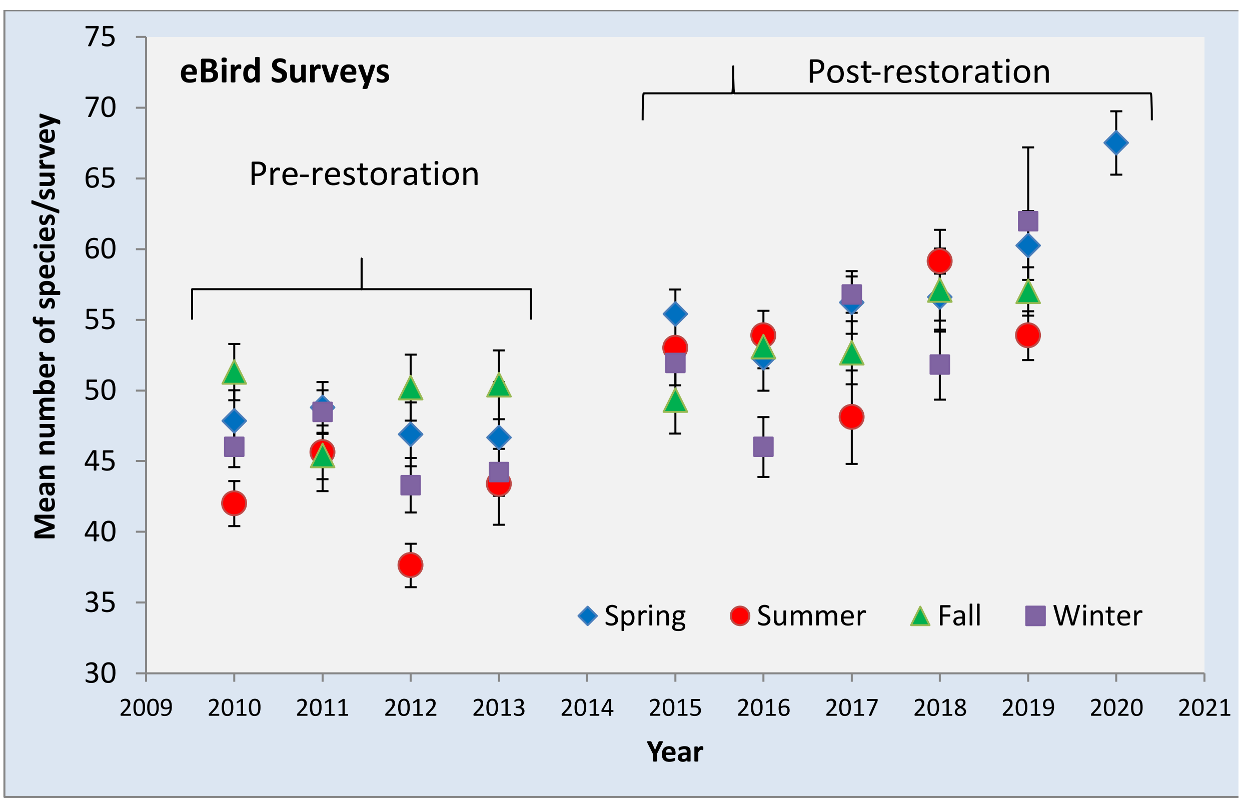


Figure 1. Species richness (Mean number of species detected per survey) during the pre-restoration period (2010-2013) compared to the post-restoration period (2015-2020) by season at Fernhill Wetlands.

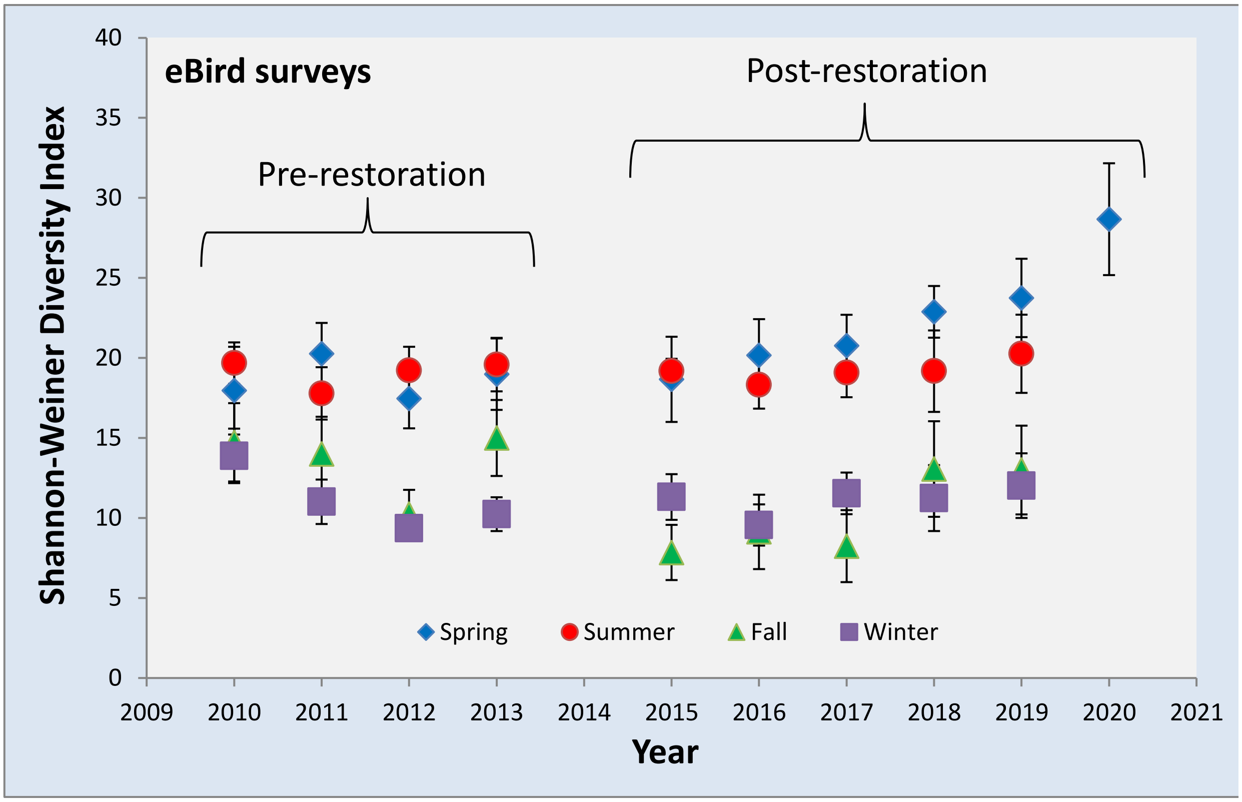


Figure 2. Species diversity (Shannon-Weiner index) during the pre-restoration period (2010-2013) compared to the post-restoration period (2015-2020) by season at Fernhill Wetlands.

Species richness was significantly higher post-restoration (2010-13 combined) versus pre-restoration periods (2015-20 combined) overall (all seasons combined, Z=-11.22, df=407, P<0.001) and in each of the four seasons separately[9] (P<0.005). Overall Shannon-Weiner species diversity was not significantly different post-restoration versus pre-restoration (all seasons combined; F=0.07, df=407, P=0.80) however species diversity was significantly higher in summer during the post-restoration (Z=-2.51, df=90, P=0.01) and significantly lower during post-restoration during the winter season (=2.13, df=85, P=0.03). The difference observed between the species richness and the more inconclusive diversity estimate suggests that species evenness[10] is influential in keeping the overall diversity low. A higher species diversity in summer post-restoration could be an indicator of more breeding habitat available for a greater number of species while the higher diversity in the winter pre-restoration may be related to higher diversity of open-water adapted species being detected (e.g. diving ducks, grebes, loons, gulls) when the site was dominated by open treatment ponds. Despite this, results for species richness provide a strong signal of an increase in avian richness post-restoration.

[9] Detailed statistical results per season: Spring (Z=-6.24, df=90, P<0.001), Summer (Z=-7.13, df=69, P<0.001), Fall (Z=-2.78, df=85, P=0.005), Winter (Z=-5.46, df=160, P<0.001).

[10] Species evenness refers to how close in numbers each species in an environment is. Species evenness and richness are the two components of species diversity.

Results - Bird abundance pre- and post-restoration

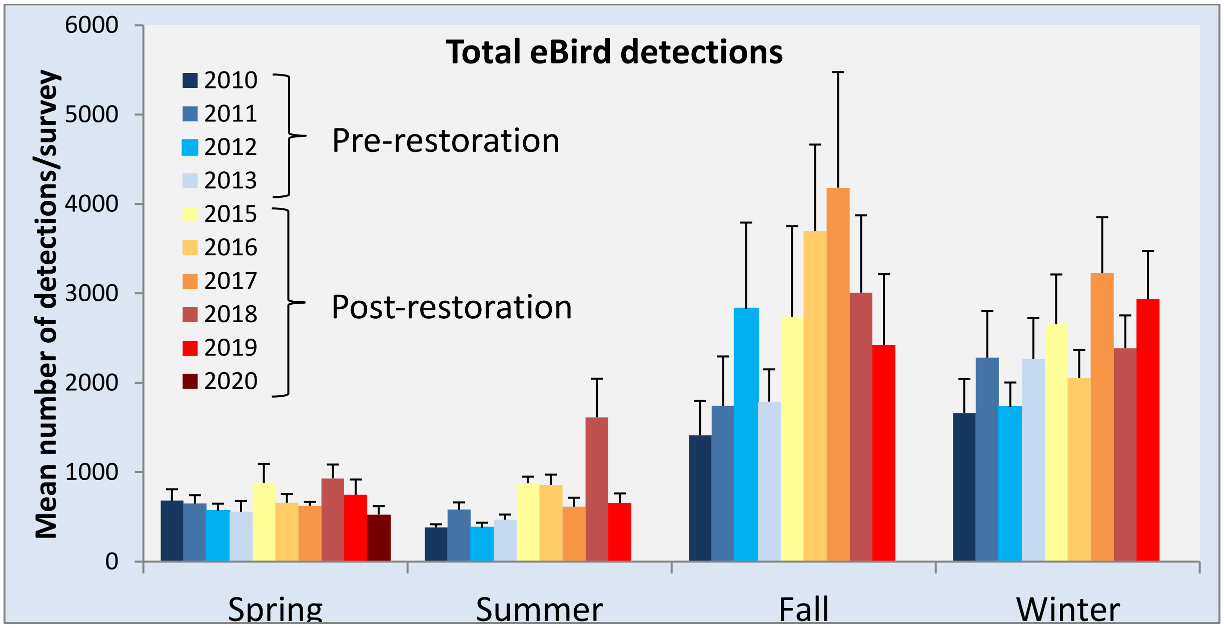


Figure 3. Total eBird detections of birds at Fernhill Wetlands during pre-restoration (2010-13) and post-restoration (2015-20) periods per season.

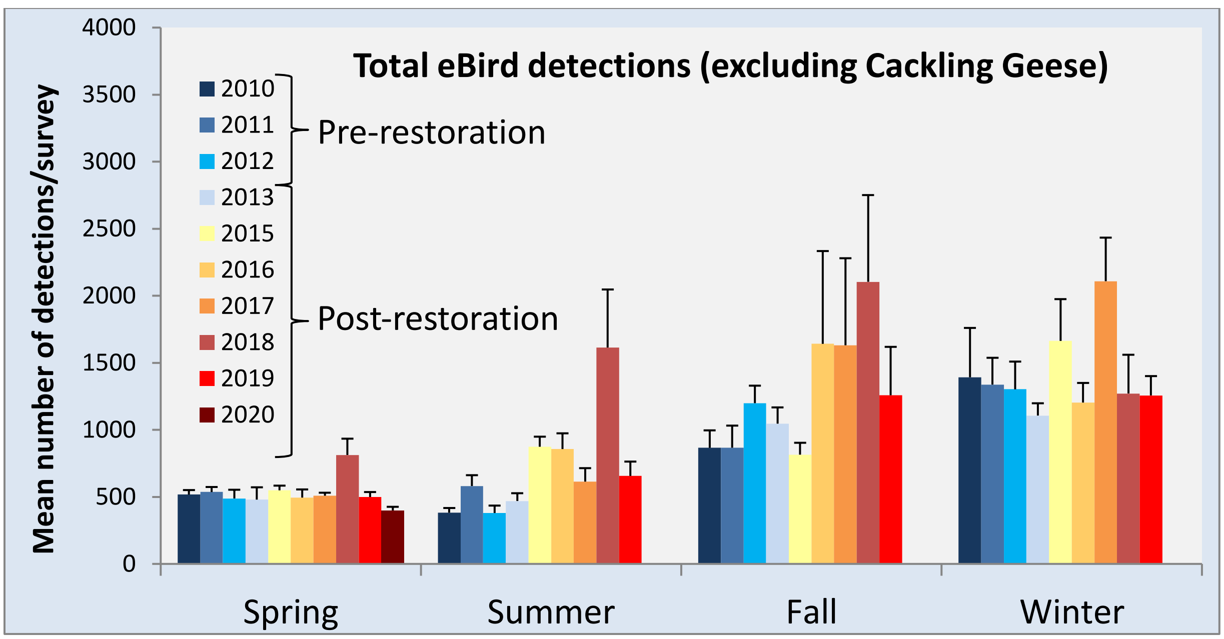


Figure 4. Total eBird detections of birds (not including Cackling Geese) at Fernhill Wetlands during pre-restoration (2010-13) and post-restoration (2015-20) periods per season.

Overall bird abundance (mean # of detections per survey, all seasons combined) was significantly higher post-restoration versus pre-restoration (Cackling Geese removed; Z=-85.52, df=410, P<0.001). There were significantly more detections of all birds in summer (Z=4.14, df=70, P<0.001) and fall (Z=1.98, df=86, P=0.48) but no significant difference between pre- and post-restoration in spring or winter (Figs. 3 and 4).

There were significantly more bird detections in fall and winter during both pre- and post-restoration (mean abundance for fall and winter significantly greater than overall mean, spring and summer abundance significantly less than the overall mean; all P<0.001). This suggests that regardless of the restoration effort, this site has supported a higher number of birds during fall migration and during the wintering season (this holds true with or without Cackling Geese included).

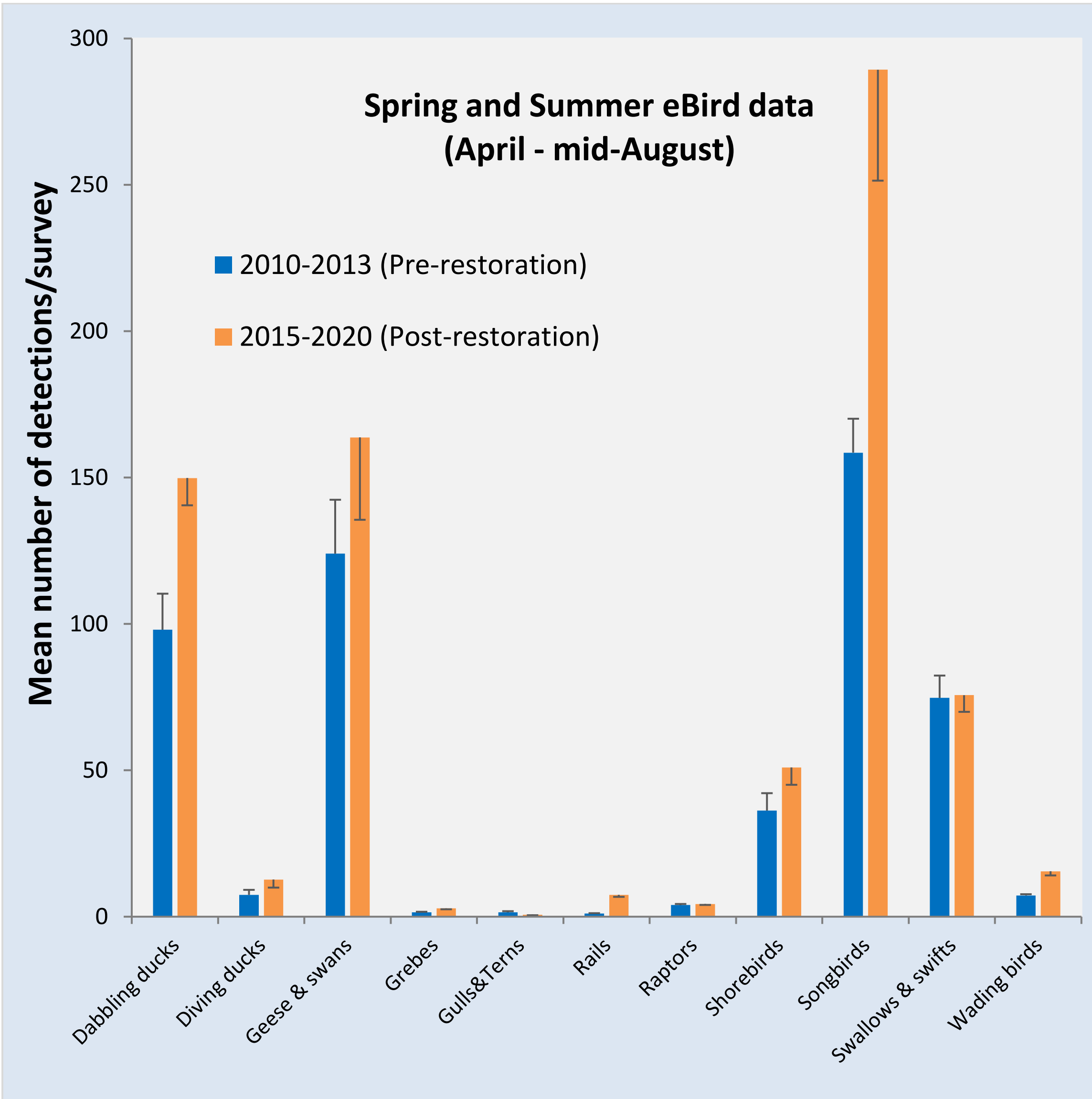
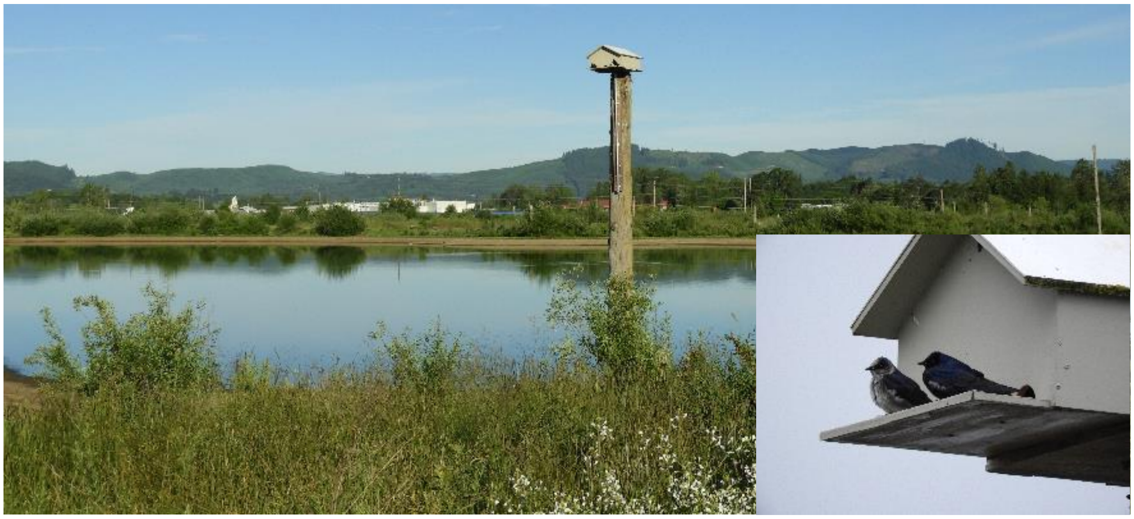


Figure 5. Total eBird detections of birds by guild at Fernhill Wetlands during pre-restoration (2010-13) and post-restoration (2016-20) periods during the spring (April – mid-June).



At the guild level, during spring and summer combined, we found that 5 of 11 species groups had significantly higher post-restoration abundance versus pre-restoration (P<0.001)[11] including dabbling ducks, grebes, rails, songbirds (not including swallows/swifts), and wading birds (herons and egrets)(Fig. 5). The significant grebe responses was driven largely by Pied-billed Grebes which made up the bulk of detections. Likewise, Red-winged Blackbirds made up most of the songbird detections and were responsible for driving that significant response. The post-restoration increases for these species groups' makes biological sense in that they, in general, depend on more complex vegetated wetland habitat with smaller open water ponds (post-restoration scenario) versus large expanses of open water with little vegetation which was the scenario pre-restoration. The only species group which had higher abundances pre-restoration were gulls/terns (Fig. 5) and approached statistical significance (P=0.06). This finding also makes biological sense as gulls and terns are more associated with open water habitats. We did not compare guilds pre- and post-restoration in the fall or winter periods.

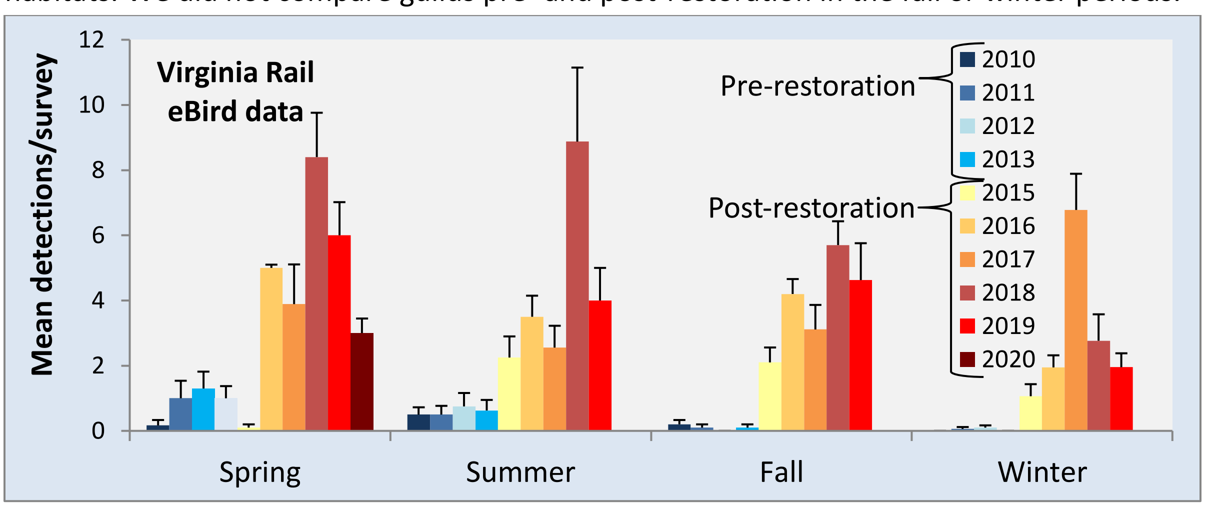


Figure 6. Virginia Rail eBird detections at Fernhill Wetlands during pre-restoration (2010-13) and post-restoration (2015-20) periods by season.

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11 Detailed statistical results per season: Dabblers (Z=3.36, df173, P<0.001), Grebes (Z=1.18, df=173, P<0.001), Rails (Z=9.17, df=173, P<0.001), Songbirds (Z=3.30, df=173, P<0.001), and Waders (Z=5.53, df=173, P<0.001).

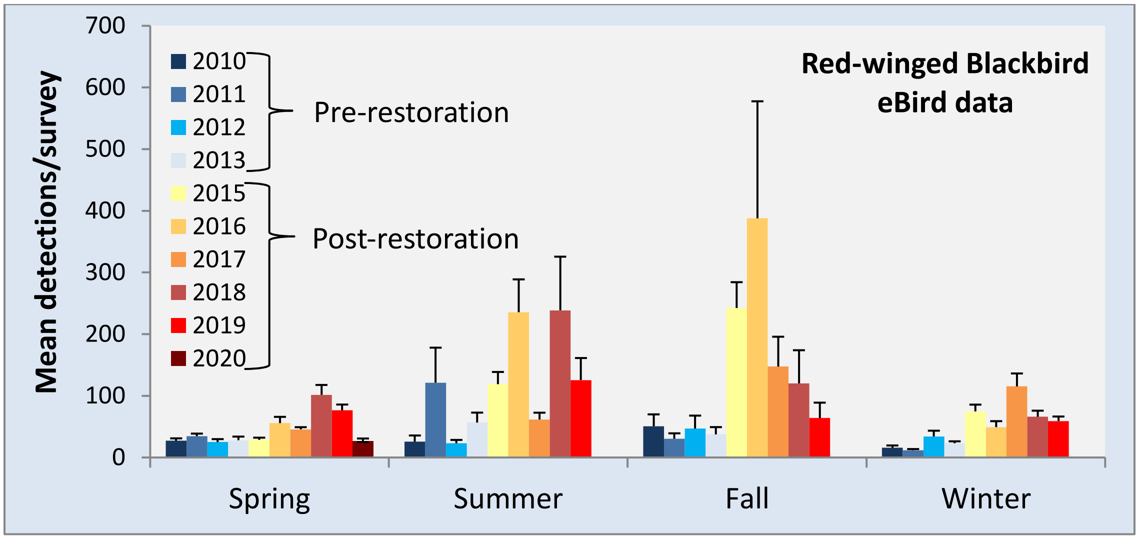

Figure 7. Red-winged Blackbird eBird detections at Fernhill Wetlands during pre-restoration (2010-13) and post-restoration (2015-20) periods by season.

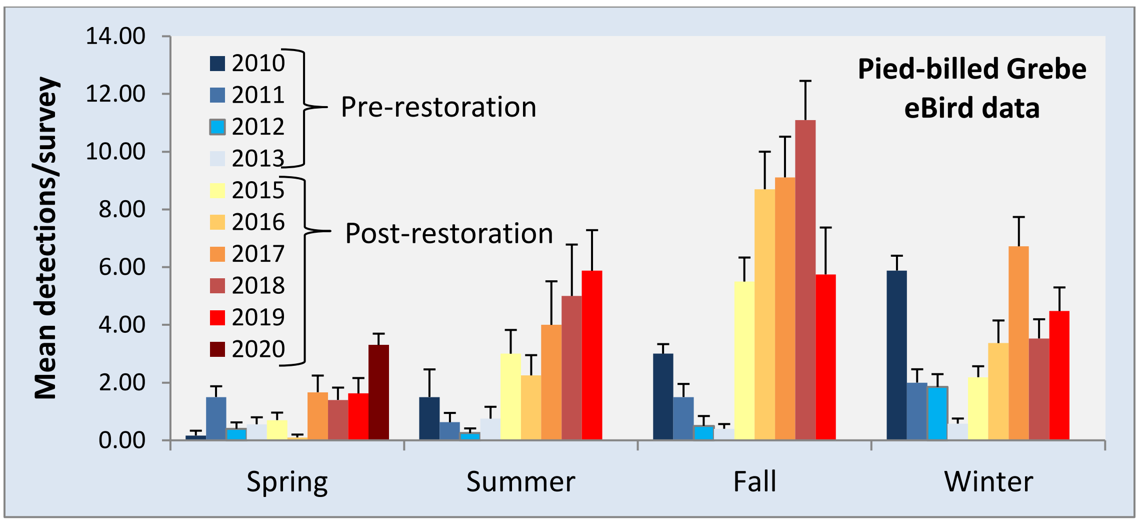

Figure 8. Pied-billed Grebe eBird detections at Fernhill Wetlands during pre-restoration (2010-13) and post-restoration (2015-20) periods by season.

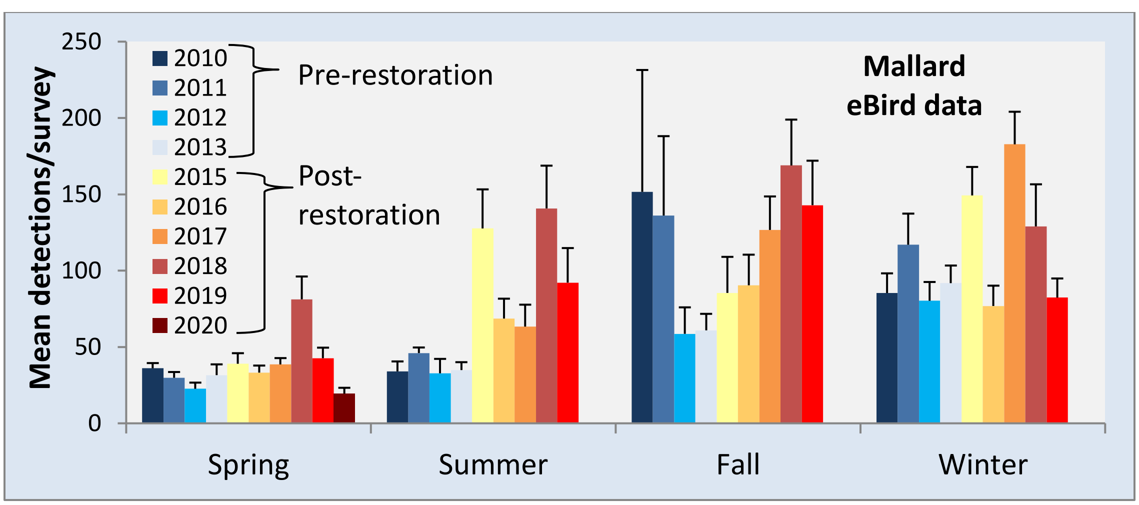

Figure 9. Mallard eBird detections at Fernhill Wetlands during pre-restoration (2010-13) and post-restoration (2015-20) periods by season.

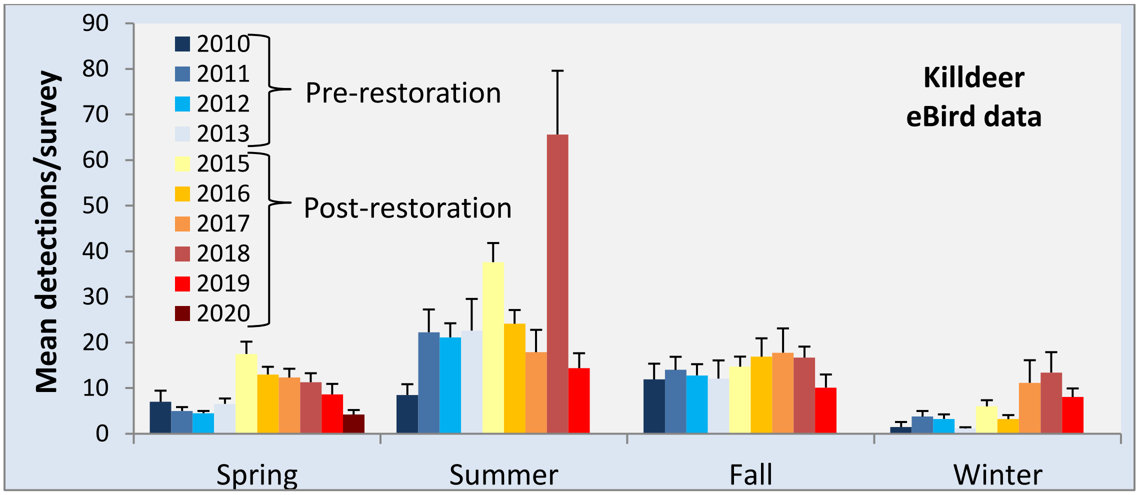

Figure 10. Killdeer eBird detections at Fernhill Wetlands during pre-restoration (2010-13) and post-restoration (2015-20) periods by season.

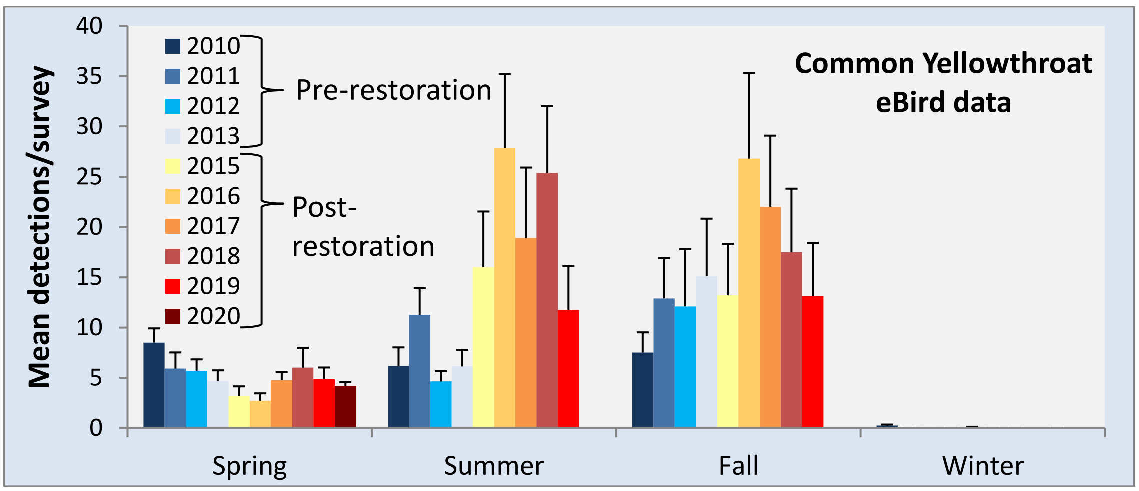

Figure 11. Common Yellowthroat eBird detections at Fernhill Wetlands during pre-restoration (2010-13) and post-restoration (2015-20) periods by season.

At the individual species level, we see the most dramatic responses between pre- and post-restoration periods for the six focal species we compared. In general, the patterns fit the predictions we made on species group response to the restoration (see Table 1 in the 2017 report). Virginia Rail, Red-winged Blackbird, and Pied-billed grebe abundances were significantly higher post-restoration overall and in all four seasons ($P \leq 0.005$; Figs 6, 7, 8). Mallard, Killdeer, and Common Yellowthroat also were detected significantly more post-restoration overall ($P<0.001$, $P=0.01$ for yellowthroat) and in all seasons except for fall (Figs. 9, 10, 11). Of these 6 comparisons, only the result for Killdeer is surprising in that this species generally prefers open habitats and so we were not expecting it to have a positive response to the restoration. It is possible that the increased availability of mudflat foraging habitat on the big lake during certain times of year may have influenced the increased Killdeer detections. Also, if there has been an increase in graveled areas (foot paths, etc.) at the site that might have also increased available nesting habitat.

Post-restoration changes in species richness and diversity

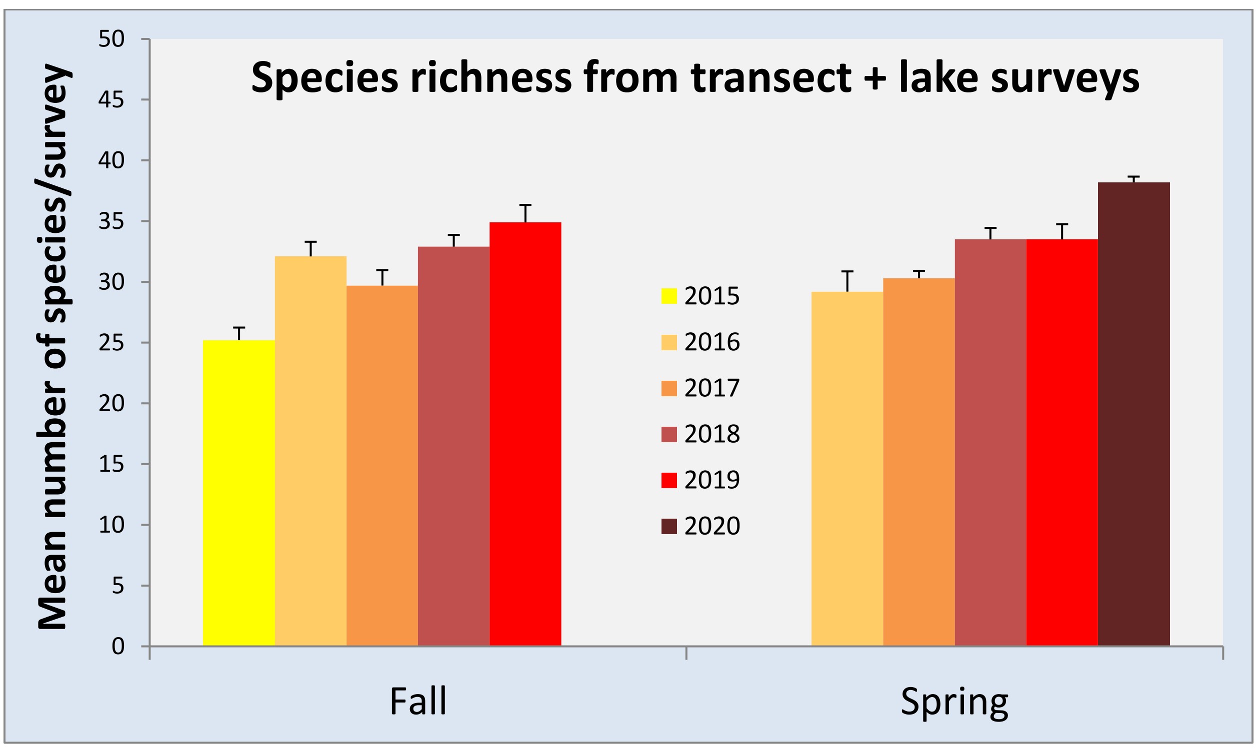

Figure 12. Species richness within the Natural Treatment System at Fernhill Wetlands post-restoration period during fall and spring seasons (no formal surveys conducted spring of 2015 or fall of 2020).

In both fall and spring, species richness increased significantly in the five years post-restoration (Fall: F=21.52, df=1,47, p<0.001; Spring: F=38.02, df=1,48, P<0.001; Fig. 11) based on our formal survey data. The gradual increase in avian species richness corresponds to maturation of restored native vegetation at the site (see Cascade Environmental Group 2019[12]). Species diversity (as measured by the Shannon-Weiner index) also showed a statistically significant positive annual change post-restoration in both seasons (Fall: F=4.65, df=1,48, p=0.04; Spring: F=12.24, df=1,48, p=0.001). The trend for species diversity is less pronounced as that with species richness. This result could be explained by lack of species evenness (which is a component of species diversity). For example, large flocks of Cackling Geese and/or blackbirds in the spring would results in lower species evenness which could lower the overall species diversity estimate. We documented this same pattern with the eBird data (See Figs. 1 and 2).

<u>Post-restoration changes in bird abundance</u>

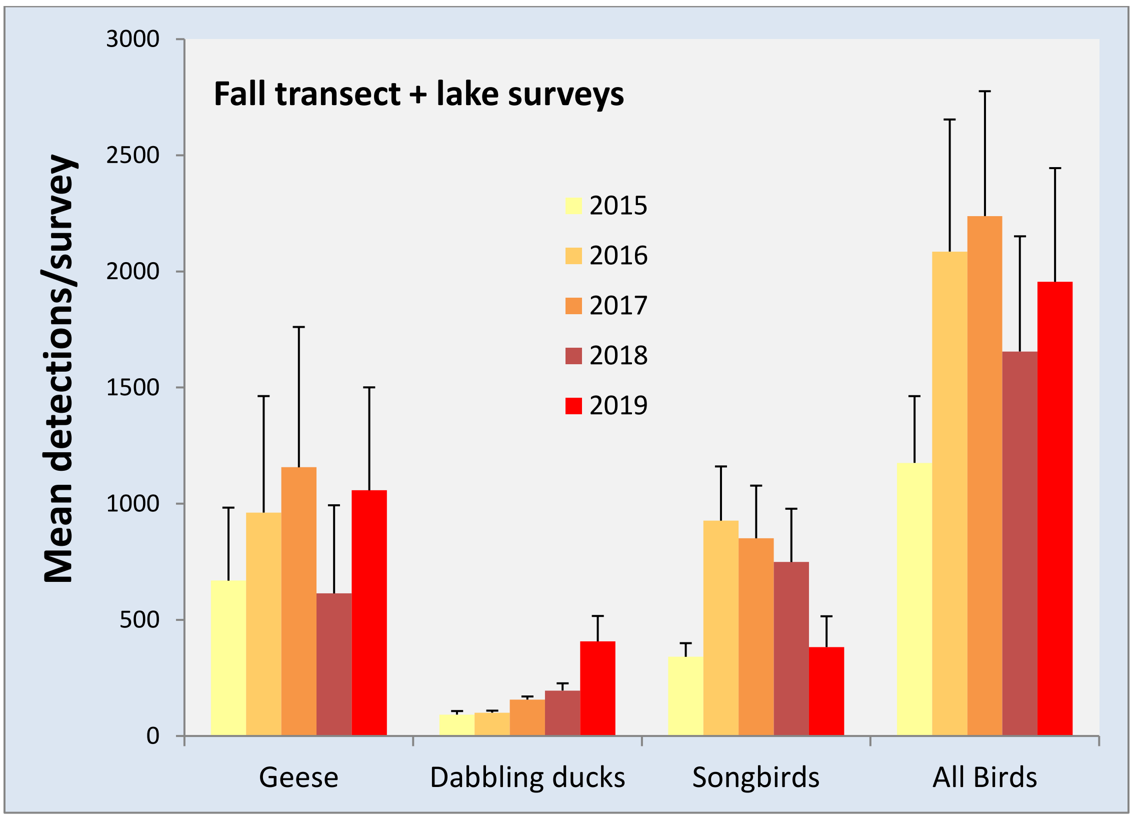

Figure 13. Average detections per survey for all birds and most common bird guilds in the Fernhill Wetlands NTS post-restoration during fall for the 5-year period post-restoration.

[12] Cascade Environmental Group. 2019. Fernhill South Wetlands Year 4 annual vegetation monitoring report

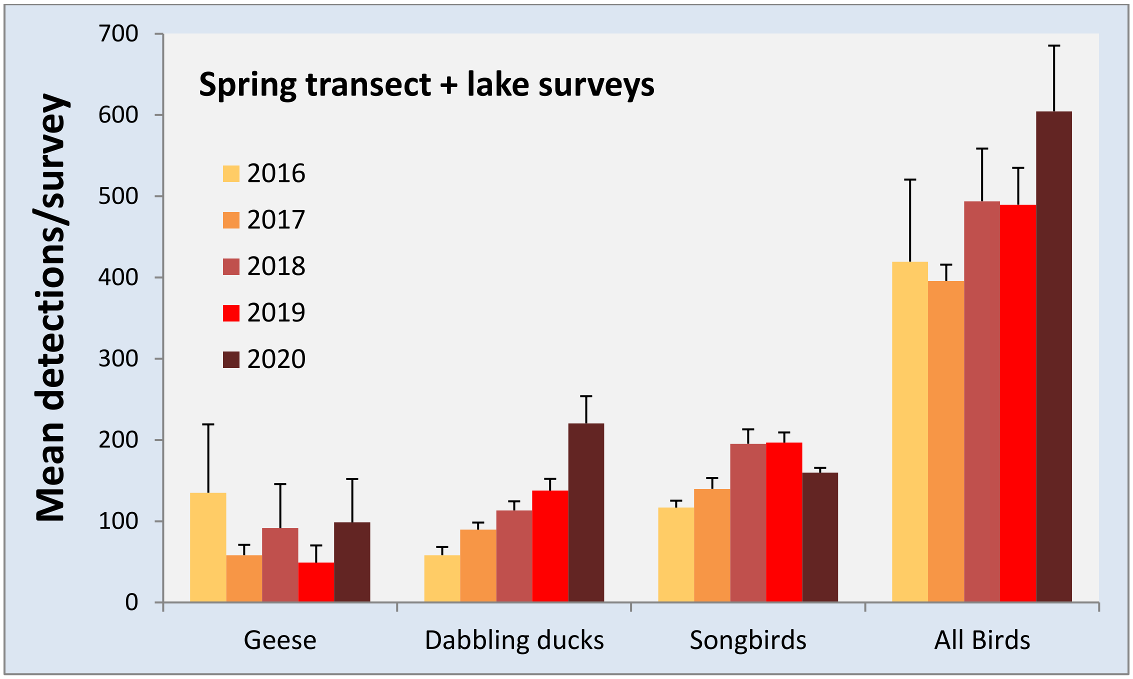

Figure 14. Average detections per survey for all birds and the most common bird guilds at the Fernhill Wetlands NTS post-restoration during spring for the 5-year period post-restoration.

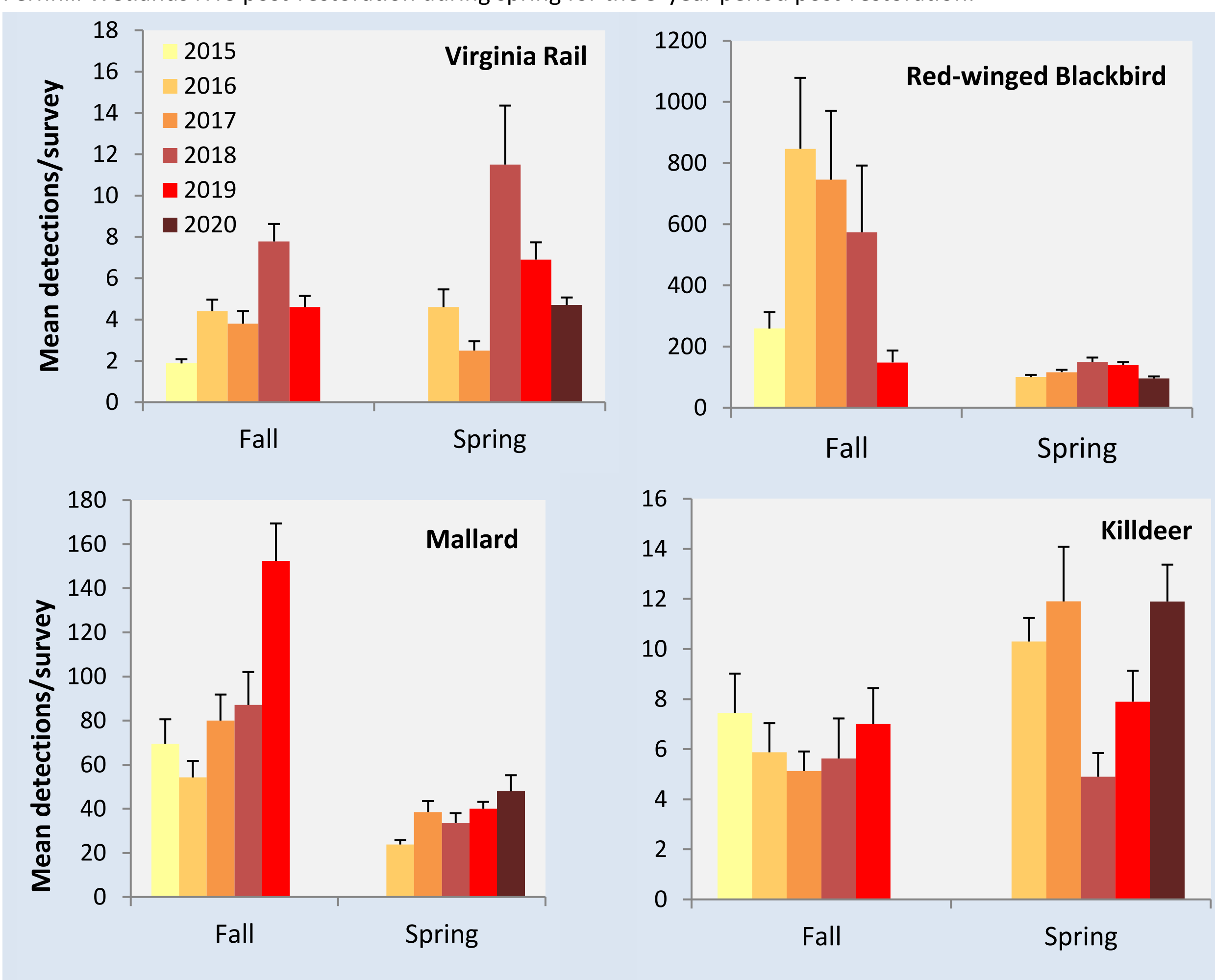

Figure 15. Select individual species average detections per survey at Fernhill Wetlands NTS in fall and spring during the 5-year post-restoration period (2015-20).

Overall bird abundance was variable from year 1 post-restoration (2015) to year 5 (2020) during both the fall and spring (Figs. 13 and 14). In fall there is no noticeable change in overall bird trend across years however in the spring, an increasing trend in bird abundance is noticeable[13]. We did not conduct formal bird surveys in the spring of 2015 as that was prior to the partnership with PA and CWS. The increasing abundance during the spring post-restoration period is likely explained by increasing habitat complexity as the vegetation planted during restoration activities in 2014-15 has reached or is nearing maturation.

At the individual species level, for the four species we examined we documented increasing abundance during the post-restoration period (see Virginia Rail in fall and Mallard both seasons in Fig. 15) while others actually showed a less clearly defined response (see Killdeer in Fig. 15) and some showed a decreasing trend after an initial increase (see Virginia Rail in spring and Red-winged Blackbirds in fall in Fig. 15). These results correspond to what we found for the same species comparisons with the eBird data (see Figs. 6-11) with the exception of Killdeer which shows higher variability in annual estimates in the transect+lake data set compared to the eBird estimate. The next section compares the two data survey methods we used in this project.

Comparisons of eBird and formal survey - Species Richness, diversity & abundance

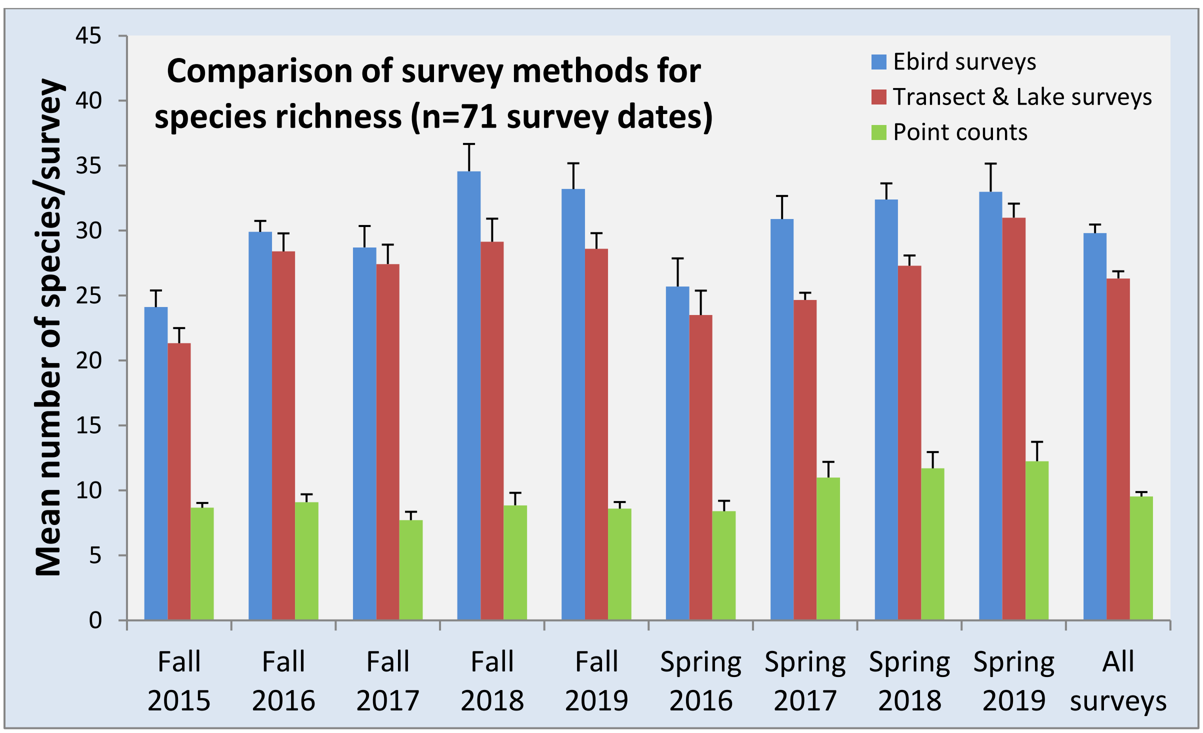

Figure 15. Species richness comparison between eBird surveys and formal surveys (line-transect+lake) and point count surveys for each season/year in the Fernhill NTS. Note: Point count data in this graph does not include lake data. There was insufficient eBird data collected in spring 2020 to be used for this comparison.

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[13] We did not conduct statistical tests for the overall and individual species post-restoration abundance trends. We did not have time as we need to consider different analyses methods than those used for other analyses in this report (see methods section). We plan to do these analyses in advance of submitting a manuscript for publication.

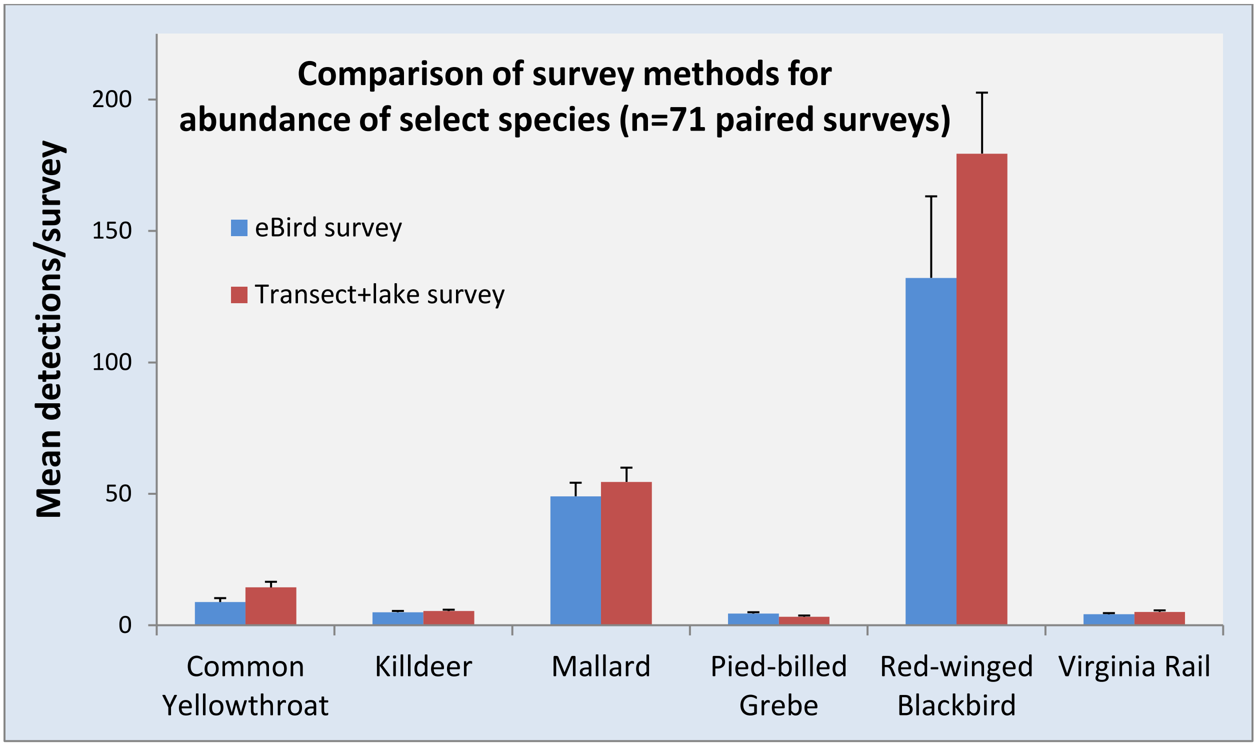


Figure 16. Species abundance comparison between eBird surveys and formal surveys (line-transect+lake) for 6 common species detected during the 5-year post-restoration period in the Fernhill NTS.

Overall species richness estimates during eBird surveys were significantly higher when compared to transect+lake surveys (T=-6.52, df=70, P<0.001; Fig. 15). The same held true for the overall Shannon-Weiner species diversity (T=2.74, df=70, P=0.008). There could be multiple reasons for this disparity. One important difference is that the survey routes used by eBirders versus transect surveyors were quite different. eBirders followed a circuitous route around the NTS while line-transect surveyors followed a transect that bisects the NTS thus increasing the likelihood of differing estimates. Because of the survey route differences, eBirders were potentially at greater risk of accidentally including "non-NTS" birds in their sample as their surveys were performed from the boundary of the NTS. Also, eBird surveys were conducted from an upraised berm providing greater view of the sampling area compared to transect surveys perhaps allowing better detection probability. Another area of potential bias is in survey effort. eBird surveys included in the analysis ranged from 1.25 to 5 hrs while transect/lake survey ranged from 1.75 to 3 hrs to complete.

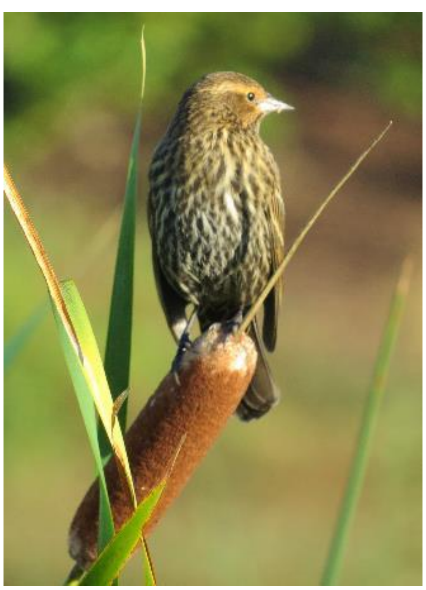
We found that 4 of the 6 individual species comparisons between eBird and transect+lake surveys abundances were not significantly different (p>0.08) suggesting for those species (Killdeer, Mallard, Red-winged Blackbird, and Virginia Rail) these two survey types yield similar abundance estimates. However, Common Yellowthroats were detected significantly more in transect+lake surveys versus eBird surveys (t=-4.85, df=70, P<0.001) and Pied-billed Grebes were detected significantly more during eBird surveys (t=3.66, df=70, P<0.001).

The point count survey data provided estimates well below those of both the eBird and line-transect surveys (Fig. 15). This is likely due to a number of factors most important of which are:

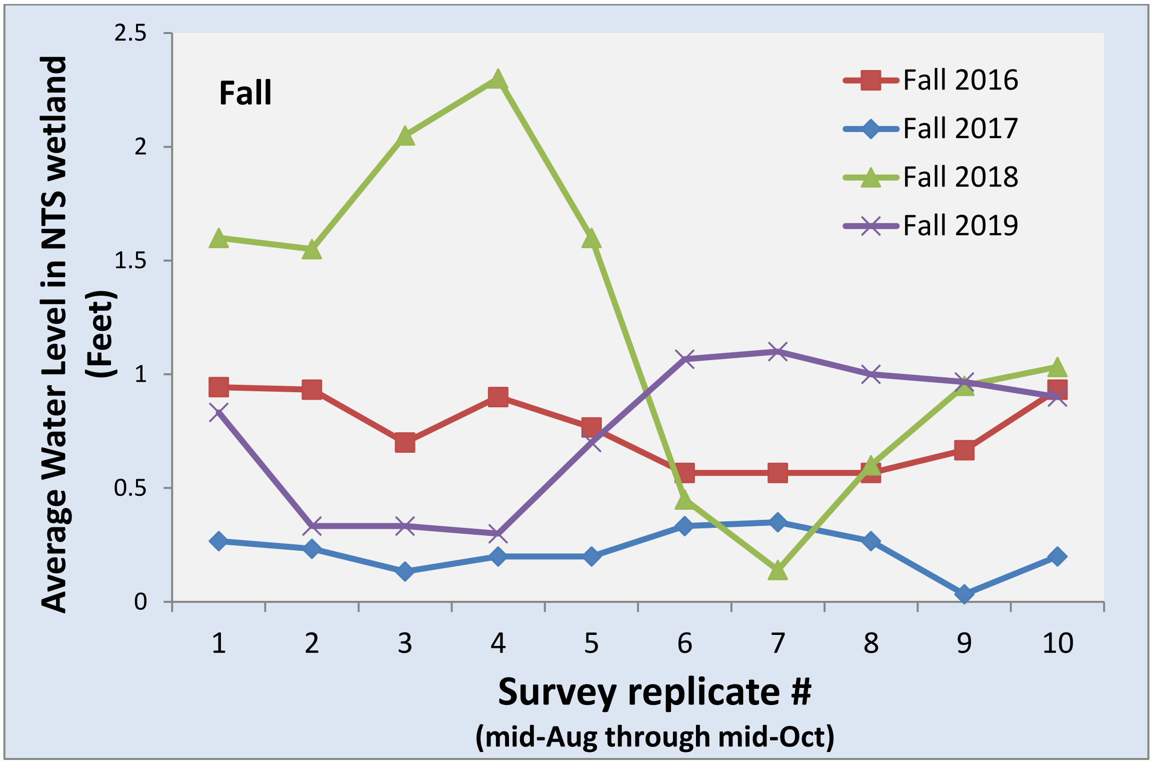
1) point count surveys only included bird data within 50m of each point count station whereas transect data included bird detections out to the edge of the NTS (>100m), 2) line-transect surveys results in more birds flushing due disturbance by the walking surveyor, and 3) the mobility of transect surveys allowed the surveyor better views of the habitat. This was particularly true in later years post-restoration as new-grown vegetation almost completely obscured the ability to detect birds visually at several point count stations.

The differences we documented in results per survey type is not likely related to observer experience as only data from experienced eBirders was used and the professional surveyors that conducted transect surveys were comparably experienced, however the sheer number of eBird surveyors versus professional transect surveyors (30 vs. 3 respectively), increases the chance of observer variability in data collection.

In any case, these results suggest that eBird data at this site should not be used as a proxy for transect survey data for estimating species richness or diversity unless a correction factor were developed. In terms of comparing abundances, the mixed results lend some support to eBird data as a proxy for the transect surveys but only for select species. We recommend that CWS view the transect+lake data as the most reliable as it is based on a more rigorous protocol in particular for documenting changes in abundance over time and between seasons. At the same time eBird data, for the most part, consistently provides findings that corroborate the transect+lake results (both species richness/diversity and abundance). Even in cases where it does not corroborate, the two survey methods do provide estimates that appear to track each other over time. For example, fall 2015 and spring 2016 estimates of species richness were low for both survey types whereas in fall 2018 and spring 2019 the highest species richness estimates were reported for each survey type (Fig. 15). Thus, eBird data still does provide meaningful and valuable information and we believe it can still be quite useful to inform site management. This is particularly important for the winter and summer months when transect+lake surveys were not performed.



NTS wetland water levels



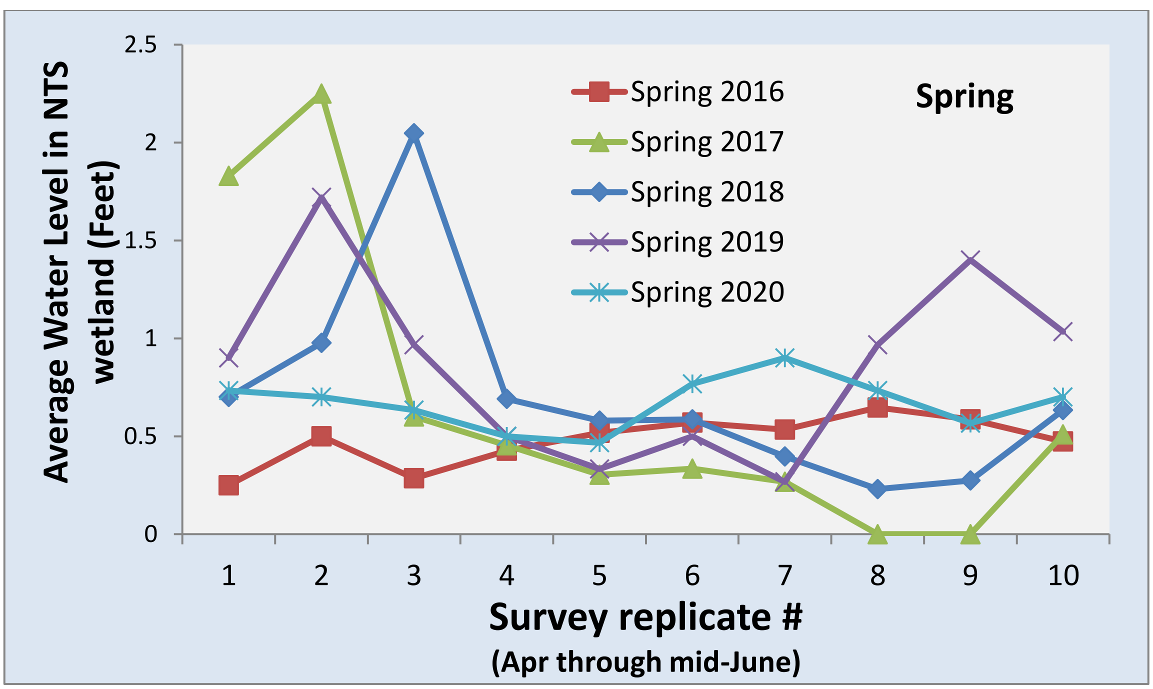


Figure 17. Average water levels in the NTS area (in Feet) as measure by three staff gauges during the bird monitoring periods in spring (early April to early June) and fall (mid-August to mid-October) in 2016-20.

The average water level in the wetland NTS area (as measured from 3 water gauges placed within 10m of the transect line – one in each NTS cell) was consistently less than 1 foot in the fall in all years except in 2018 when the levels rose to over 1.5 feet from mid-August to mid-September. In the spring again average levels were below 1 foot for most of the season except in 2017-19 when water levers rose above 1ft level in April. In spring 2019 there was also another rise in level above 1ft near the end of the sampling period in June (Fig. 17).

We originally intended to include water level information in our analyses as a predictor of bird abundance. However, the data are not robust enough (only from 3 gauges) to include in statistical analyses. This data still may be useful to CWS to provide a rough estimate on how differences in water level may influence bird abundance and diversity.

Acknowledgements

Special thanks to our team of community scientists as well as volunteer Janet McCurdy who helped with data entry. We thank Clean Water Services for their support and collaboration including Carol Murdock and Jared Kinnear. All photos taken at Fernhill Wetlands by Candace Larson except American Bittern by Phil Kahler, Virginia Rail chick on log by John Cepek, and sunrise by Shawneen Finnegan.