ASSESSING RESTORATION EFFECTS ON BIRD POPULATIONS FOLLOWING TIDAL RESTORATION AT FIR ISLAND FARM AND OTHER SITES IN THE SKAGIT-STILLAGUAMISH RIVER DELTA, WA

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1.0 Introduction

1.1 Background

Coastal estuarine habitats form the dominant transition zone between terrestrial and marine communities, perform valuable ecosystem services and functions, and support ecologically and commercially important populations of fish and wildlife species (Mitsch and Gosselink 2000). Coastal estuarine wetlands also represent one of the most endangered ecosystems due to habitat loss and degradation and face increasing threats from human development and climate change. In western Washington, the loss of coastal wetlands has resulted in a significant impact to native biodiversity, including birds (Ball *et al.* 1989, Drut and Buchanan 2000).

Restoration of tidal habitats in Puget Sound is a conservation strategy aimed at benefitting fish and wildlife populations, improving flood control, and increasing ecosystem function. Over 85% of emergent wetlands have been lost in the greater Skagit and Stillaguamish River deltas (Collins 2000). Although restoration projects are mainly driven by the goal of increasing salmon habitat, particularly for Chinook (*Oncorhynchus tshawytscha*), restoration also impacts many other estuarine-dependent species, including birds. Indeed, the loss of tidal wetlands has been suggested as an important factor in the putative declines of many shorebird species in the Pacific Flyway (Drut and Buchanan 2000, Brown *et al.* 2001). Although the specific benefits and costs of estuarine restoration to bird populations have been debated (e.g., some species will be winners, some losers), few empirical data exist. Still, most national bird management plans for wetland birds promote the restoration of wetland habitats, including tidal wetlands, as an important conservation strategy. The inclusion of bird monitoring as a component of restoration monitoring has only recently received attention in Puget Sound restoration efforts; for example at Nisqually National Wildlife Refuge and the Qwuloolt restoration project near Marysville, WA (Rice *et al.* 2011, Woo *et al.* 2011).

This study examines the effects of ongoing and planned estuarine restoration projects in North Puget Sound on bird populations that may be affected by restoration actions at Fir Island Farm and Leque Island, located within the greater Skagit and Stillaguamish River deltas.

1.2 Project Goals and Objectives

Tidal restoration aims to return physical and biological attributes to historical conditions while acknowledging modern constraints, notably human modifications to watersheds, habitats, and wildlife populations. The goal of this project is to quantify the response of bird populations to restoration actions. This study focuses on two pieces of information to evaluate bird response: 1) changes in bird composition and structure at restoration sites over time, and 2) comparisons of bird populations at restoration sites to reference marshes. We expect that bird communities at the restoration sites should become more similar to reference sites following restoration and ultimately exhibit similar trends in abundance. Both comparative and trend analyses will be used to evaluate bird response; however, these analyses are not included in this progress report. Rather, this progress report presents summary data and results from our first year of monitoring; more comprehensive statistical analyses will be included in our final report.

Specific objectives include:

1) Quantifying the numerical response in species abundance of migrating (spring and fall) and wintering shorebirds and waterfowl, including snow geese, with restoration.

2) Quantifying the numerical response in species abundance of breeding and wintering landbirds (passerines and raptors) and secretive marshbirds with restoration.

3) Investigating changes in shorebird abundance and distribution across the Skagit-Stillaguamish estuary.

2.0 Methods

2.1 Study Sites

The present study is being conducted at two restoration sites and one reference marsh site for comparison (**Fig. 1**). The Fir Island Farm and Leque Island restoration sites are at varying stages in the restoration process (described below). Both sites were formerly estuarine wetlands, but were diked for drainage and agriculture in the late 1800s. The Wiley Slough reference marsh site was selected to allow comparative analysis of bird composition and abundance data at restoration sites to data from a relatively intact and functioning wetland site.

The restoration sites under study currently contain fallow and active farmland with assorted hedgerows and shrubs (i.e., upland/agricultural habitat). Based on elevation, post-restoration plant communities predicted to become established following dike removal or setback include emergent marsh (low and high marsh) and created freshwater wetlands; tidal flat habitats immediately outside the restoration area are also expected to undergo significant physical changes (Hood 2004). These transitions will impact bird habitat at our study sites, and potentially on a landscape-scale throughout the greater Skagit-Stillaguamish estuary.

2.1.1 Fir Island Farm

Fir Island Farm is located on the eastern shore of Skagit Bay between Conway and La Conner, WA (**Fig. 2**). The restoration project will restore 55 ha of estuarine marsh habitat. Restoration plans were completed at Fir Island Farm prior to initiation of our study, and major construction activity began during 2016, with most major restoration activity completed by summer 2016. Our study site includes 55 ha of upland/agricultural habitat located behind a 1.5 km long historic marine dike that was removed during restoration. Our study site also includes approximately 25 ha of existing marsh habitat on the bay side of the dike that was included as a reference marsh site.

Pre-restoration surveys were conducted at Fir Island Farm during winter, spring and summer 2016. Construction activity was ongoing during surveys; however, we avoided areas with heavy construction for safety concerns, which also helped minimize the impact of construction activity

on bird behavior during our surveys. The historic marine dike at Fir Island Farm was breached on 01 Aug 2016 after major construction at the site was completed. This resulted in the flooding of upland/agricultural habitat at the site as natural tidal flow was restored. Thus, surveys conducted during fall 2016 at Fir Island Farm were post-restoration surveys.

2.1.2 Leque Island

Leque Island lies between Camano Island and the mainland, encompassing the land area between Skagit and Port Susan Bays (**Fig. 3**). The site is located approximately 10 km south of the Fir Island Farm restoration site. Restoration plans are currently underway for Leque Island, and alternative actions are still being considered. Final actions could range from full tidal restoration of the island to partial restoration of 115 acres on the south end of the island. Restoration may begin as soon as summer 2017.

Our Leque Island study site includes 110 ha of upland/agricultural habitat located behind a 3.8 km long historic marine dike that may be removed during restoration. Our study site also includes approximately 20 ha of existing marsh habitat located to the west of the historic dike that was included as a reference marsh site. All surveys conducted at Leque Island during 2016 were pre-restoration surveys since construction activity has not yet begun.

Our surveys at Leque Island in 2016 were interrupted due to a storm event that caused a breach in the marine dike on 10 Mar, which in turn resulted in unexpected flooding of the agricultural fields at the site. The flooding, combined with fear of additional breaches, forced us to halt our surveys for the remainder of the winter period. We were able to resume surveys by 28 Mar during our spring survey window.

2.1.3 Wiley Slough

Wiley Slough is located on the eastern shore of Skagit Bay approximately 1.5 km southeast of the Fir Island Farm restoration site (**Fig. 4**), and was used as a reference marsh site for comparative purposes. The site includes approximately 53 ha of saltmarsh plus adjacent tidal flat habitat. A standard study design in restoration ecology incorporates the use of a reference or “untreated” site as a control. Reference sites are typically similar to the desired habitat

condition of the restoration site, but can also be sites that are in various stages of recovery. Wiley Slough was selected as a reference site because the tidal marsh located there was previously restored (in 2009) and currently has wetland plant communities similar to expectations at the restoration sites under study.

2.2 Study Design

Bird monitoring methods suited for restoration monitoring in the project area include line transects, area searches and point counts (Ralph *et al.* 1995). One important issue to consider with bird monitoring is estimating species detection probability during survey efforts. Bird detectability can vary for variety of reasons, in particular changes in habitat structure and composition as would be expected to occur with habitat restoration or habitat succession (Thompson 2002). Without correcting for detectability, comparisons of species abundance or density among sites (or over time) are likely to be inappropriate. There are numerous sampling techniques that allow for the estimation of detectability; for example, double observer (Nichols *et al.* 2000), distance sampling (Buckland *et al.* 2001), and occupancy and removal modeling (Farnsworth 2002, Royle *et al.* 2005). For most of these sampling techniques, a primary assumption is that the sampled population is closed – that is no ingress or egress of individuals within the sample plots. Breeding season populations may be considered closed when birds are territorial; wintering bird populations may also be closed as species may be partially territorial and are not expected to be making long-distance movements. However, bird populations during spring and fall migration cannot be considered closed. One method that does not require a closed population is distance sampling (Buckland *et al.* 2001). For analyses of breeding and wintering bird populations we evaluated multiple methods for estimating detectability, but for analyses of bird abundance during spring and fall migration periods we restricted our analysis to distance sampling.

The following section presents the methods used to collect data for each of the three specific project objectives outlined in **Section 1.2**.

2.2.1 Shorebird and Waterfowl Surveys

Objective 1) Quantifying the numerical response in species abundance of migrating (spring and fall) and wintering shorebirds and waterfowl, including snow geese, with restoration.

Previous shorebird and waterfowl monitoring by Ecostudies Institute in estuarine and agricultural habitats in the Skagit and Stillaguamish River deltas (including at Fir Island Farm and Leque Island) provide the basis for our monitoring methods (Slater 2004). Survey methods include line transects for upland/agricultural and marsh habitats, and area searches for tidal flats and created freshwater wetland habitats.

Line Transects

Line transects were randomly placed inside the restoration areas and in reference marshes (**Figs. 2-4**). Transects were placed ≥ 250 m apart and ≥ 125 m from site boundaries. Line transects in agricultural fields are 250 m long; transects in marsh habitat are ≥ 400 m long. Trained observers walked along transects recording birds seen or heard and estimating their location from the transect line. Observers were instructed to only count birds that were ≤ 125 m from lines (perpendicular distance) to reduce the likelihood of double counting birds on adjacent transects. Observers counted all shorebirds, waterfowl, other waterbirds (e.g., herons, gulls), secretive marshbirds (e.g., rails, bitterns), and raptors detected within the survey area. Observers recorded the estimated perpendicular distance from the line for all birds detected whenever possible. Otherwise, the distance and bearing from the observer to the bird was recorded (typically any time birds were detected ≥ 20 m from the line) for later estimation of perpendicular distance from the line, which is necessary for distance analysis. Prior to conducting surveys, all observers were trained in distance estimation and conducted regular calibration and testing during the field season. Our detailed line transect survey protocol is included in **Appendix 1**; an example datasheet is included in **Appendix 2**.

At Fir Island Farm, we established four line transects in the agricultural fields located within the restoration area and two line transects ≥ 400 m long in an adjacent reference marsh (**Fig. 2**). At Leque Island, we established six line transects in agricultural fields located within the proposed

restoration area and one line transect > 800 m long in an adjacent reference marsh (**Fig. 3**). At our reference marsh site, Wiley Slough, we originally established two marsh transects ≥ 400 m long (**Fig. 4**). However, we were unable to conduct surveys on one of these transects (transect W1) during 2016 due to field conditions and site access issues. We plan to re-evaluate this transect and perhaps move its location in 2017 so that we have an additional replicate survey at this site.

Area Searches

Tidal flat surveys were conducted with an area search (for details see Line Transect Protocol; **Appendix 1**; an example datasheet is included in **Appendix 3**). The survey area at restoration and reference sites begins beyond the end of the marsh transects, specifically at the point where emergent vegetation ends. The search area is a 250 m by 250 m square survey grid, extending onto adjacent tidal flats. Observers counted all shorebirds, waterfowl, other waterbirds, secretive marshbirds, and raptors detected within the survey area during a 20-min fixed survey period. Bird counts recorded here were cumulative counts for each species detected during the survey.

Survey Window

Surveys were conducted in three periods: spring migration, fall migration, and winter, reflecting the periods when shorebird and waterfowl populations are prominent in this region (**Table 1**). Winter surveys were conducted upon cessation of the hunting season (i.e., end of January), as hunting pressure likely forces shorebirds and waterfowl to make decisions on habitat use relative to safety rather than to preference, at least during the daytime. Shorebird surveys were conducted at the same times as waterfowl surveys during the winter and fall migration periods to maximize survey efficiency. However, spring migration for waterfowl occurs earlier than for shorebirds, so surveys cannot overlap. Thus, we conducted spring surveys during two distinct time periods (Spring-WF and Spring-SH). In each season, we conducted $\geq$ 3 repeated surveys at both high and low tides (6 surveys total per line transect).

2.2.2 Landbird and Secretive Marshbird Surveys

Objective 2) Quantifying the numerical response in species abundance of breeding and wintering landbirds (passerines and raptors) and secretive marshbirds with restoration.

Landbirds (e.g., passerines and raptors) and secretive marshbirds (e.g., rails, bitterns) were surveyed using point counts (Ralph *et al.* 1995), incorporating call-broadcast surveys to increase detection probability of secretive marshbirds (Conway 2011). Survey points were randomly placed ≥ 250 m apart over the restoration and reference sites and ≥ 125 m from site boundaries. Trained observers conducted 9-minute surveys at each point, recording all aural and visual detections of all species encountered within 125 m of survey points during each minute of a 5-min passive listening period, followed by a 4-min call-broadcast period for focal secretive marshbird species. Observers broadcast 30 seconds of calls followed by 30 seconds of silence for each of the following focal species: Virginia Rail (*Rallus limicola*), Sora (*Porzana carolina*), American Bittern (*Botaurus lentiginosus*), and Wilson's Snipe (*Gallinago delicata*). Distance to each bird detected was recorded as Euclidean distance from the survey point. Similar to our protocol for line transect surveys, all observers were trained in distance estimation and conducted regular calibration and testing during the field season. Our detailed point count survey protocol is included in **Appendix 4;** an example datasheet is included in **Appendix 5**.

Survey Window

At least 3 repeated surveys were conducted during the 6-week breeding season for our study area, as recommended in the Standardized North American Marshbird Protocol (Conway 2011). We also conducted 3 repeated surveys during the winter period (**Table 2**). Points were surveyed from ~30 minutes before sunrise until ~3 hours after sunrise. While the Marshbird Protocol allows for surveys in the morning or evening, we restricted our surveys to mornings so that breeding season surveys captured singing landbirds on territories. To be consistent, we also only conducted morning surveys during the winter period.

2.2.3 Landscape-scale Shorebird Surveys

Objective 3) Investigating changes in shorebird abundance and distribution across the Skagit-Stillaguamish estuary.

Although restoration will occur at the site scale, improved marsh function and connectivity between Skagit and Port Susan Bays will likely influence shorebird abundance and habitat use at the landscape scale. Given the degree of ongoing and planned estuarine restoration in the Skagit and Stillaguamish River deltas, there is a need for an estuary-wide shorebird monitoring project to understand landscape-scale effects of restoration, particularly since the region was recently listed as a Site of Regional Importance in the Western Hemisphere Shorebird Reserve Network.

During 2016, we initiated a landscape-scale shorebird monitoring project in the Skagit and Stillaguamish River deltas using a combination of aerial- and ground-based surveys. Aerial surveys have been successfully implemented for other large-scale shorebird monitoring efforts (Evenson and Buchanan 1994, Bishop *et al.* 2000). We conducted three aerial surveys for shorebirds during the winter (n = 1) and spring migration (n = 2) periods in 2016. Each survey was conducted by two experienced observers flying a fixed route at low elevations during a fixed range of tide heights when tidal flats were exposed. All shorebird flocks were counted and their location data collected using GPS, then later mapped in ArcGIS 10.2.2.

In 2012, a long-term, ground-based winter shorebird monitoring project was implemented in the Skagit and Stillaguamish River deltas as part of the Pacific Flyway Shorebird Survey. This survey, the Puget Sound Shorebird Count coordinated by Ecostudies Institute and WDFW, is an annual citizen science-based survey that counts wintering shorebirds within fixed survey areas at sites across Skagit and Port Susan Bays. During 2016, we coordinated and implemented the survey at 20 sites across the region with the help of citizen science volunteers.

3.0 Results and Discussion

3.1 Overview

During 2016, we made substantial progress towards our overall project goals by completing our study design, establishing survey protocols, and conducting initial surveys at three study sites: Fir Island Farm, Leque Island, and Wiley Slough. Our ground-based surveys began in winter 2016 (Feb), and continued through fall 2016 (Sep) following the sampling periods outlined in **Tables 1 and 2**. Our first aerial surveys for shorebirds were also conducted during winter and spring 2016 to begin examination of landscape-scale shorebird distribution and abundance. Along with aerial surveys, we coordinated and conducted the annual Puget Sound Shorebird Count during Dec 2016 to collect additional ground-based survey data to support our landscape-scale shorebird research. Finally, we also coordinated a second citizen science-based project at Leque Island to engage and inform the public about overall estuary restoration efforts in the North Puget Sound area.

3.2 Shorebird and Waterfowl Surveys

3.2.1 Survey Effort

Shorebird and waterfowl surveys were initiated on 09 Feb 2016. During 2016, we conducted 266 replicate surveys on 14 line transects established at our three estuarine study sites in North Puget Sound (**Table 3**). Surveys were conducted on all transects established at our two restoration study sites: Fir Island Farm (*n* = 110; transects = 6) and Leque Island (*n* = 136; transects = 7). Surveys were also conducted at our reference marsh site, Wiley Slough (*n* = 20; transects = 1); however, we were only able to successfully complete surveys on one of the two line transects originally established in our study design due to access issues to the site during 2016 (**Fig. 4**).

Pre-restoration surveys were conducted at both Fir Island Farm and Leque Island during 2016. At Leque Island, all surveys conducted in 2016 were pre-restoration since this restoration project remains in the planning stage at the time of this report. At Fir Island Farm, we completed our pre-restoration surveys in summer 2016; surveys conducted in fall 2016 were

post-restoration as major restoration activities at this site were substantially completed by summer 2016. We have not separated our survey results between periods (i.e., pre- and post-restoration) in this progress report since this analysis is not being conducted until we obtain additional data.

Survey effort at our estuarine study sites varied among sites for several reasons. First, the number of randomly selected line transects necessary to obtain adequate survey coverage varied per site. Second, access issues due to field conditions sometimes limited our ability to conduct surveys (especially at high tide). For example, reference marsh transects at Fir Island Farm and Wiley Slough could often not be safely accessed at high tides. Finally, severe weather events caused us to cancel some surveys. The best example of this occurred at Leque Island due to the dike breach that occurred on 10 Mar 2016, which kept us from conducting surveys for a period of 18 days.

During 2016, we also conducted 62 area search surveys at five survey sites (**Table 4**): Fir Island Farm (*n* = 40; sites = 3) and Leque Island (*n* = 22; sites = 1). Area search survey sites were generally located at the end of our reference marsh line transects; however, we also conducted surveys at a tidal pond used regularly by waterfowl at Fir Island Farm. We could not conduct area search surveys at the survey site selected at Wiley Slough because of limited visibility at the end of the marsh line transect at this study site. We plan to re-evaluate our ability to conduct area search surveys at Wiley Slough in 2017.

3.2.2 Count Data – Line Transect Surveys

The results tables included in this progress report present the raw count data from our surveys (i.e., there has been no correction for detection probability conducted at this time). We present these data to provide an overview of species composition and abundance at our estuarine study sites during the first year of our study. Analysis of distance data to estimate detection probability, density and abundance will be included in our final report. We first present our count data summarized by site, keeping in mind that survey effort varied among sites which affects comparison of species abundance per site. Next, we present our count data summarized by season pooling all sites together. This provides a snapshot of seasonal habitat use by all

species detected during our surveys. Finally, we should point out that restoration site data (pre- and post-restoration) and reference marsh data were combined in the results tables. When these data are analyzed in our final report we will begin exploration of differences in species abundance among sites, both pre- and post-restoration.

During 2016, we observed 42 species of birds on line transect surveys conducted at three estuarine study sites in North Puget Sound (**Table 6**). Number of species recorded by guild included: 13 shorebirds, 11 waterfowl, 6 waterbirds (e.g., gulls, terns, herons), and 12 raptors (includes crows, ravens). Total counts were similar among sites, with a few notable exceptions. Some waterfowl counts (e.g., American Wigeon and Mallard) were substantially higher at Fir Island Farm than at other sites. Snow Geese were also found in higher abundance at Fir Island Farm and Wiley Slough than at Leque Island. The most abundant shorebird species (Dunlin) was found at all sites, with counts lowest at Wiley Slough; this might be partially attributed to lower survey effort at this site. Other shorebird diversity and abundance appears highest at Leque Island, possibly due to the observed use of agricultural fields at this site; however, survey effort and detectability may also have influenced results.

Seasonal patterns show that certain species were observed in higher numbers on surveys during certain periods, as expected (**Table 7**). Seasonal patterns were similar among sites (data not presented). The winter period saw the highest site use by the most common species of shorebird (Dunlin) and waterfowl (American Wigeon and Mallard) observed during surveys. Surveys during the spring migration survey period reported substantially higher diversity and counts than the fall migration period for most species; the winter period reported the second highest species diversity.

3.2.3 Count Data – Area Search Surveys

Total counts on our tidal flat area search surveys were somewhat lower than expected (**Tables 8 and 9**). It is possible that this may be attributed to defects in our survey design; we will explore possible ways to improve our survey design in 2017. Overall, species composition was similar to that observed on our line transect surveys. Species composition was more diverse and total counts were higher at Fir Island Farm than Leque Island. This is partially attributable

to greater area search survey effort at Fir Island Farm; however, these results might be expected since the reference marsh and tidal flat habitat is less extensive at Leque Island.

3.3 Landbird and Secretive Marshbird Surveys

3.3.1 Survey Effort

Landbird and secretive marshbird surveys were initiated on 24 Feb 2016. During 2016, we conducted 90 replicate surveys at 20 point count stations established at our three estuarine study sites in North Puget Sound (**Table 5**). Surveys were completed during the 2016 wintering and breeding seasons following the survey period established in our point count protocol. However, many of the 2016 breeding season surveys were errantly conducted before our survey window (e.g., in Apr) or early in the survey window (e.g., before 15 May). Thus, the earlier surveys may have captured individuals during the migration period rather than the breeding period. We have included these data in our results here as "breeding" detections; however, we will likely reclassify some data later during analysis. We will also ensure that our 2017 breeding surveys are conducted within the proper survey period.

3.3.2 Count Data – Point Count Surveys

During 2016, we observed 34 species of birds on point count surveys conducted at three estuarine study sites in North Puget Sound (**Table 10**). Number of species recorded by guild included: 27 landbirds, 3 secretive marshbirds (Sora, Virginia Rail, and Wilson's Snipe), and 4 raptors (excludes crows and ravens). Point count data are presented in a similar way as line transect and area search survey data, with results tables showing summaries by site and season, and with raw count data only (i.e., not corrected for detection probability or varying survey effort among sites).

Species composition was more diverse at the Fir Island Farm (*n* = 21 species) and Leque Island (*n* = 25 species) restoration sites compared to the Wiley Slough reference marsh (*n* = 9 species). Total counts were also substantially higher at restoration sites; however, higher survey effort at restoration sites did influence total counts to some degree. These results were expected since both of the restoration sites included multiple point count stations within upland/agricultural

areas which are widely used by landbirds, while point count stations at Wiley Slough were exclusively within marsh habitat.

Examination of seasonal patterns shows that some species are present in much greater numbers, or exclusively, during winter (e.g., Western Meadowlark) while many are present at our study sites year round (**Table 11**). Breeding passerines that were either not present in winter, or present in lower numbers, include: Tree Swallows, Cliff Swallows, Savannah Sparrows, and Marsh Wrens. Seasonal patterns were similar at both restoration sites (data not presented).

3.4 Landscape-Scale Shorebird Surveys

We conducted three aerial shorebird surveys in North Puget Sound during the winter and spring shorebird migration periods in 2016. Survey routes for the winter survey (**Fig. 5**) and spring surveys (**Fig. 6**) were almost identical. Shorebird distribution was more dispersed over Padilla, Skagit, and Port Susan Bays during the winter survey compared to the spring surveys where most shorebirds were observed in Skagit Bay. Shorebird abundance was lower than expected during all surveys, with total counts being reported well below counts from similar surveys in previous years (Ruth Milner, personal communication).

As part of our landscape-scale shorebird surveys conducted during 2016 we also coordinated the 5th Annual Puget Sound Shorebird Count, which is part of the broader Pacific Flyway Shorebird Survey coordinated by Point Blue Conservation Science. With help from 18 volunteers, we surveyed 20 sites in North Puget Sound on 10 Dec 2016. Volunteers were recruited as citizen scientists from the Pilchuck and Skagit Audubon Society Chapters, based in the Stillaguamish and Skagit watersheds, respectively. Our survey sites were as follows: Samish Bay (Alice Bay), Padilla Bay (Whitmarsh Junction, Casino Lagoon, Padilla Bay Dike, Padilla Bay Indian Slough), Fidalgo Bay (East Fidalgo Bay, NE Fidalgo Bay), Skagit Bay (Jensen Access, Snow Goose Preserve, English Boom, SW Skagit-Price Property), Port Susan Bay (Triangle Cove, Leque Island, Livingston Bay, NE PSB-Lervick, N. Hat Slough-TNC, Warm Beach), and Whidbey Island (Deer Lagoon – West and East, Crockett Lake). Data from the surveys are being compiled and summarized at this time and will be shared with Point Blue upon completion.

3.5 Outreach Efforts

An additional objective of our estuary restoration project is to engage the public and share information about our research to help gain support for ongoing and future restoration projects throughout North Puget Sound. During 2016, we coordinated two citizen science projects to allow local residents to participate in and learn about our research. The first was the Puget Sound Shorebird Count, which is described in **Section 3.4**. The second was the Leque Island Bird Survey which was originally designed with funding from the Pilchuck Audubon Society and implemented by Ecostudies in spring 2016. With help from 15 volunteers, between spring and fall 2016 we conducted 67 area search surveys at 8 survey sites located within the Leque Island restoration site. Volunteers conducted fixed area searches for all bird species observed and counted total abundance for a period of 20 to 60 minutes.

In addition to our two citizen science projects described above, we also participated in the following public outreach events: 1) citizen science training for the Leque Island Bird Survey was conducted on 10 Apr 2016 at the Stanwood Library; 2) we presented a talk entitled "*Effects of Estuary Restoration on Bird Populations in North Puget Sound*" for the Pilchuck Audubon Society on 08 Jul 2016 at the Stanwood Library; and 3) we participated in the 11th Annual Port Susan Snow Goose & Birding Festival on 27-28 Feb 2016 in Stanwood, WA.

4.0 Acknowledgements

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5.0 Tables and Figures

Table 1. Sampling periods for waterfowl and shorebird line transect and area search surveys. Spring sampling period divided into two distinct sampling periods for waterfowl (Spring-WF) and shorebirds (Spring-SH) to coincide with peak migration for each taxon.

Taxa	Winter	Spring	Fall
Waterfowl	February – 15 March	15 March – 15 April	August – September
Shorebirds	February – 15 March	23 April – 7 May	August – September

Table 2. Sampling periods for landbird and secretive marshbird point count surveys.

Taxa	Winter	Breeding
Landbirds	February – 15 March	May – 15 June
Marshbirds	February – 15 March	May – 15 June

Table 3. Line transect survey effort at estuarine study sites in North Puget Sound, WA during 2016. Survey periods: Winter = 01 Feb – 15 Mar; Spring-WF = 15 Mar – 15 Apr; Spring-SH = 23 Apr – 7 May; Fall = 01 Aug – 30 Sep.

Study Site	#Transects	#Surveys	Winter	Spring-WF	Spring-SH	Fall
Fir Island Farm	6	110	30	28	40	12
Leque Island	7	136	28	24	42	42
Wiley Slough	1	20	2	6	6	6

Table 4. Area search survey effort at estuarine study sites in North Puget Sound, WA during 2016. Survey periods: Winter = 01 Feb - 15 Mar; Spring-WF = 15 Mar - 15 Apr; Spring-SH = 23 Apr - 7 May; Fall = 01 Aug - 30 Sep.

Study Site	#Sites	#Surveys	Winter	Spring-WF	Spring-SH	Fall
Fir Island Farm	3	40	11	12	17	0
Leque Island	1	22	4	6	6	6
Wiley Slough	1	0	0	0	0	0

Table 5. Point count survey effort at estuarine study sites in North Puget Sound, WA during 2016. Survey periods: Winter = 01 Feb – 15 Mar; Breeding = 01 Apr – 15 May.

Study Site	#Points	#Surveys	Winter	Breeding
Fir Island Farm	8	40	18	22
Leque Island	10	40	20	20
Wiley Slough	2	10	4	6

Table 6. Raw count data for species detected on line transect surveys. Data represents total number of each species counted during all surveys conducted in 2016; survey effort varied per site.

Species	Common Name	Fir Island	Leque	Wiley
AMCR	American Crow	3	0	0
AMKE	American Kestrel	0	2	0
AMWI	American Wigeon	2,999	180	130
BAEA	Bald Eagle	24	10	9
BBPL	Black-Bellied Plover	7	1	16
BUFF	Bufflehead	54	4	0
CAGO	Canada Goose	37	3	6
CATE	Caspian Tern	0	9	0
COHA	Cooper's Hawk	1	0	0
CORA	Common Raven	6	5	1
DCCO	Double-Crested Cormorant	2	21	0
DOWI	Dowitcher Spp.	3	9	0
DUNL	Dunlin	2,162	1,547	899
GADW	Gadwall	2	4	0
GBHE	Great Blue Heron	24	54	3
GRYE	Greater Yellowlegs	18	38	10
GWGU	Glaucous-Winged Gull	59	24	9
GWTE	Green-Winged Teal	646	211	34
HOME	Hooded Merganser	0	0	1
KILL	Killdeer	10	30	1
LESA	Least Sandpiper	2	4	4
LEYE	Lesser Yellowlegs	1	0	0
MALL	Mallard	3,703	363	343
MEGU	Mew Gull	61	0	0
MERL	Merlin	0	2	0
NOHA	Northern Harrier	30	27	2
NOPI	Northern Pintail	301	128	0
NOSH	Northern Shoveler	15	84	15
OSPR	Osprey	0	2	0
PEFA	Peregrine Falcon	5	2	0
PESA	Pectoral Sandpiper	0	3	0
RLHA	Rough-Legged Hawk	1	0	0
RNEP	Ring-Necked Pheasant	0	1	0
RTHA	Red-Tailed Hawk	1	14	0
SEOW	Short-Eared Owl	0	1	0
SEPL	Semipalmated Plover	8	0	0
SESA	Semipalmated Sandpiper	0	4	6
SNGO	Snow Goose	2,370	78	3,384
TRUS	Trumpeter Swan	43	0	23
UNGU	Unknown Gull	1	4	0
UNWF	Unknown Waterfowl	26	8	2
WESA	Western Sandpiper	27	226	1
WHIM	Whimbrel	0	1	0
WISN	Wilson's Snipe	0	4	1

Table 7. Raw count data for species detected on line transect surveys conducted during 2016 summarized by season (all sites combined).

Species	Common Name	Winter	Spring-WF	Spring-SH	Fall
AMCR	American Crow	0	3	0	0
AMKE	American Kestrel	2	0	0	0
AMWI	American Wigeon	2,971	307	16	15
BAEA	Bald Eagle	20	8	14	1
BBPL	Black-Bellied Plover	0	0	24	0
BUFF	Bufflehead	48	6	2	2
CAGO	Canada Goose	0	3	22	21
CATE	Caspian Tern	0	9	0	0
COHA	Cooper's Hawk	1	0	0	0
CORA	Common Raven	0	0	8	4
DCCO	Double-Crested Cormorant	22	0	0	1
DOWI	Dowitcher Spp.	0	0	9	3
DUNL	Dunlin	2,837	707	1,064	0
GADW	Gadwall	2	0	2	2
GBHE	Great Blue Heron	20	17	31	13
GRYE	Greater Yellowlegs	29	17	11	9
GWGU	Glaucous-Winged Gull	25	41	18	8
GWTE	Green-Winged Teal	654	197	40	0
HOME	Hooded Merganser	0	0	1	0
KILL	Killdeer	25	5	5	6
LESA	Least Sandpiper	0	0	10	0
LEYE	Lesser Yellowlegs	0	0	1	0
MALL	Mallard	3,941	328	120	20
MEGU	Mew Gull	0	58	3	0
MERL	Merlin	0	2	0	0
NOHA	Northern Harrier	23	18	11	7
NOPI	Northern Pintail	336	87	6	0
NOSH	Northern Shoveler	3	85	25	1
OSPR	Osprey	1	0	1	0
PEFA	Peregrine Falcon	3	2	1	1
PESA	Pectoral Sandpiper	0	0	0	3
RLHA	Rough-Legged Hawk	1	0	0	0
RNEP	Ring-Necked Pheasant	0	0	0	1
RTHA	Red-Tailed Hawk	7	0	3	5
SEOW	Short-Eared Owl	1	0	0	0
SEPL	Semipalmated Plover	0	0	3	5
SESA	Semipalmated Sandpiper	0	0	6	4
SNGO	Snow Goose	37	1,900	3,895	0
TRUS	Trumpeter Swan	66	0	0	0
UNGU	Unknown Gull	3	0	1	1
UNWF	Unknown Waterfowl	24	7	0	5
WESA	Western Sandpiper	0	0	250	4
WHIM	Whimbrel	0	0	1	0
WISN	Wilson's Snipe	0	4	0	1

Table 8. Raw count data for species detected on tidal flat area search surveys. Data represents total count of each species detected during all surveys conducted in 2016; survey effort varied per site.

Species	Common Name	Fir Island	Leque
AMWI	American Wigeon	27	4
BAEA	Bald Eagle	13	4
BBPL	Black-Bellied Plover	7	2
BUFF	Bufflehead	6	0
CANV	Canvasback	1	0
CATE	Caspian Tern	2	0
DOWI	Dowitcher Spp.	0	2
DUNL	Dunlin	11	5
GADW	Gadwall	3	0
GBHE	Great Blue Heron	8	8
GRYE	Greater Yellowlegs	0	1
GWGU	Glaucus-Winged Gull	10	5
GWTE	Green-Winged Teal	17	3
KILL	Killdeer	1	0
LESA	Least Sandpiper	1	0
MALL	Mallard	38	6
MEGU	Mew Gull	2	0
MERL	Merlin	0	1
NOHA	Northern Harrier	4	1
NOPI	Northern Pintail	6	2
NOSH	Northern Shoveler	7	1
PEEP	Unknown Peep	3	0
PEFA	Peregrine Falcon	0	1
SNGO	Snow Goose	3	0
TRUS	Trumpeter Swan	4	0
UNGU	Unknown Gull	6	2
WEGR	Western Grebe	1	0
WESA	Western Sandpiper	1	1
WHIM	Whimbrel	0	1

Table 9. Raw count data for species detected on tidal flat area search surveys conducted during 2016 summarized by season (all sites combined).

Species	Common Name	Winter	Spring-WF	Spring-SH	Fall
AMWI	American Wigeon	13	13	5	0
BAEA	Bald Eagle	1	8	6	2
BBPL	Black-Bellied Plover	1	4	4	0
BUFF	Bufflehead	1	1	4	0
CANV	Canvasback	0	0	1	0
CATE	Caspian Tern	0	0	2	0
DOWI	Dowitcher Spp.	0	0	1	1
DUNL	Dunlin	3	6	7	0
GADW	Gadwall	0	0	3	0
GBHE	Great Blue Heron	6	3	6	1
GRYE	Greater Yellowlegs	0	1	0	0
GWGU	Glaucus-Winged Gull	4	4	4	3
GWTE	Green-Winged Teal	9	6	5	0
KILL	Killdeer	0	0	1	0
LESA	Least Sandpiper	0	0	1	0
MALL	Mallard	14	14	15	1
MEGU	Mew Gull	0	2	0	0
MERL	Merlin	0	0	1	0
NOHA	Northern Harrier	3	2	0	0
NOPI	Northern Pintail	5	2	1	0
NOSH	Northern Shoveler	1	3	4	0
PEEP	Unknown Peep	0	0	3	0
PEFA	Peregrine Falcon	0	1	0	0
SNGO	Snow Goose	1	1	1	0
TRUS	Trumpeter Swan	3	1	0	0
UNGU	Unknown Gull	2	2	3	1
WEGR	Western Grebe	0	1	0	0
WESA	Western Sandpiper	0	0	2	0
WHIM	Whimbrel	0	0	1	0

Table 10. Raw count data for species detected on point count surveys. Data represents total number of each species counted during all surveys conducted in 2016; survey effort varied per site.

Species	Common Name	Fir Island	Leque	Wiley
AMCR	American Crow	5	6	0
AMGO	American Goldfinch	1	5	0
AMRO	American Robin	21	16	0
BAEA	Bald Eagle	4	6	3
BASW	Barn Swallow	0	2	0
BCCH	Black-Capped Chickadee	0	4	0
BHCO	Brown-Headed Cowbird	1	0	0
BRBL	Brewer's Blackbird	3	0	0
CLSW	Cliff Swallow	0	25	2
COHA	Cooper's Hawk	0	1	0
CORA	Common Raven	5	2	0
COYE	Common Yellowthroat	0	4	0
EUCD	Eurasian Collared Dove	0	1	0
EUST	European Starling	12	335	129
GCSP	Golden-Crowned Sparrow	1	0	0
MAWR	Marsh Wren	20	3	13
NOFL	Northern Flicker	0	1	0
NOHA	Northern Harrier	16	8	2
PEFA	Peregrine Falcon	1	0	0
ROPI	Rock Pigeon	0	3	0
RTHA	Red-Tailed Hawk	0	1	0
RWBB	Red-Winged Blackbird	11	36	12
SASP	Savannah Sparrow	28	134	0
SORA	Sora	0	1	0
SOSP	Song Sparrow	19	27	0
SPTO	Spotted Towhee	1	4	0
TRSW	Tree Swallow	39	5	40
UNKN	Unknown	7	2	1
VASW	Vaux's Swift	0	0	3
VGSW	Violet-Green Swallow	0	0	3
VIRA	Virginia Rail	3	1	0
WCSP	White-Crowned Sparrow	4	0	0
WEME	Western Meadowlark	1	90	0
WISN	Wilson's Snipe	4	0	0

Table 11. Raw count data for species detected on point count surveys conducted during 2016 summarized by season (all sites combined).

Species	Common Name	Winter	Breeding
AMCR	American Crow	2	9
AMGO	American Goldfinch	0	6
AMRO	American Robin	24	13
BAEA	Bald Eagle	7	6
BASW	Barn Swallow	0	2
BCCH	Black-Capped Chickadee	4	0
BHCO	Brown-Headed Cowbird	0	1
BRBL	Brewer's Blackbird	2	1
CLSW	Cliff Swallow	0	27
COHA	Cooper's Hawk	1	0
CORA	Common Raven	7	0
COYE	Common Yellowthroat	0	4
EUCD	Eurasian Collared Dove	1	0
EUST	European Starling	388	88
GCSP	Golden-Crowned Sparrow	0	1
MAWR	Marsh Wren	9	27
NOFL	Northern Flicker	1	0
NOHA	Northern Harrier	18	8
PEFA	Peregrine Falcon	0	1
ROPI	Rock Pigeon	3	0
RTHA	Red-Tailed Hawk	0	1
RWBB	Red-Winged Blackbird	31	28
SASP	Savannah Sparrow	0	162
SORA	Sora	0	1
SOSP	Song Sparrow	34	12
SPTO	Spotted Towhee	4	1
TRSW	Tree Swallow	0	84
UNKN	Unknown	6	4
VASW	Vaux's Swift	0	3
VGSW	Violet-Green Swallow	0	3
VIRA	Virginia Rail	0	4
WCSP	White-Crowned Sparrow	4	0
WEME	Western Meadowlark	90	1
WISN	Wilson's Snipe	2	2

Figure 1: Map showing the location of our estuarine study sites within the greater Skagit-Stillaguamish estuaries. Restoration sites include Fir Island Farm and Leque Island. Wiley Slough is our reference marsh site.

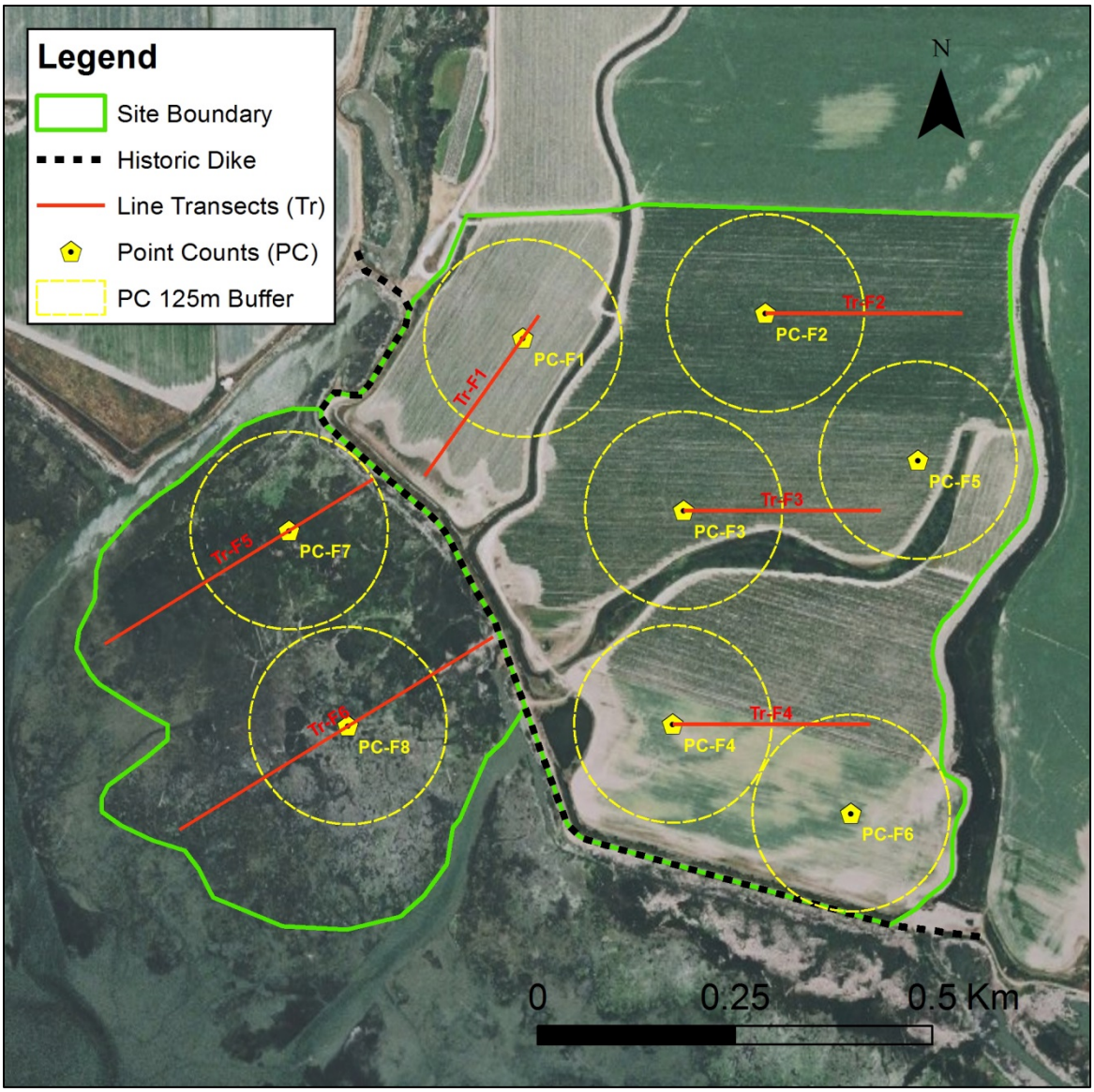

Figure 2: Study design at Fir Island Farm restoration site. The restoration area is located to the NE of the historic dike boundary; survey sites include six point count stations (PC-F1 to PC-F6) and four line transects (TR-F1 to TR-F4). The adjacent reference marsh study site includes two point count stations (PC-F5 and PC-F6) and two line transects (TR-F5 and TR-F6). However, we were unable to conduct surveys at two sites (PC-F7 and TR-F5) in 2016 due to access issues; we will re-evaluate our ability to survey this area in 2017.

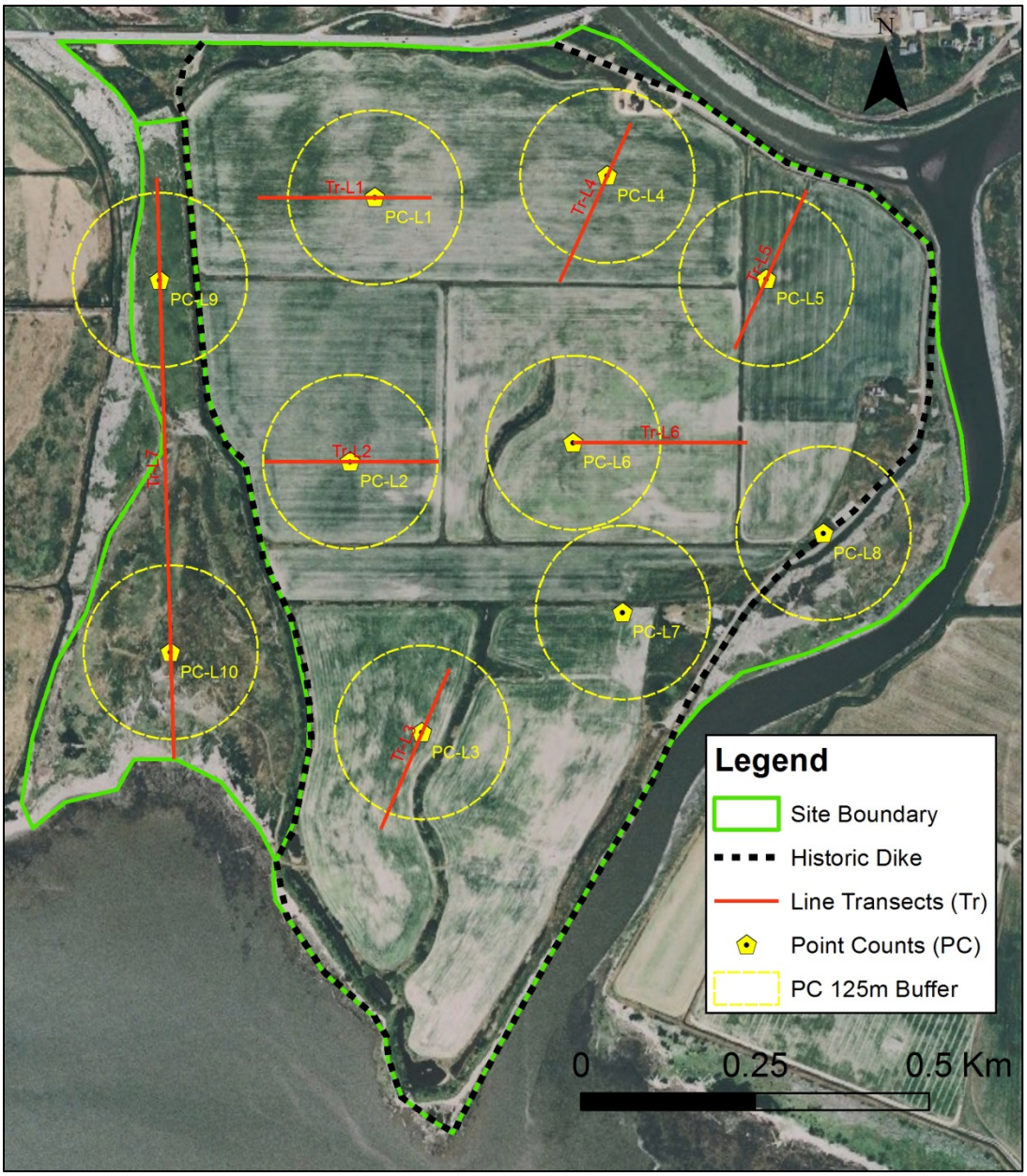

Figure 3: Study design at Leque Island restoration site. The restoration area is enclosed by the historic dike boundary; survey sites include eight point count stations (PC-L1 to PC-L8) and six line transects (TR-L1 to TR-L6). The adjacent reference marsh study site includes two point count stations (PC-L9 and PC-L10) and one line transect (TR-L7).

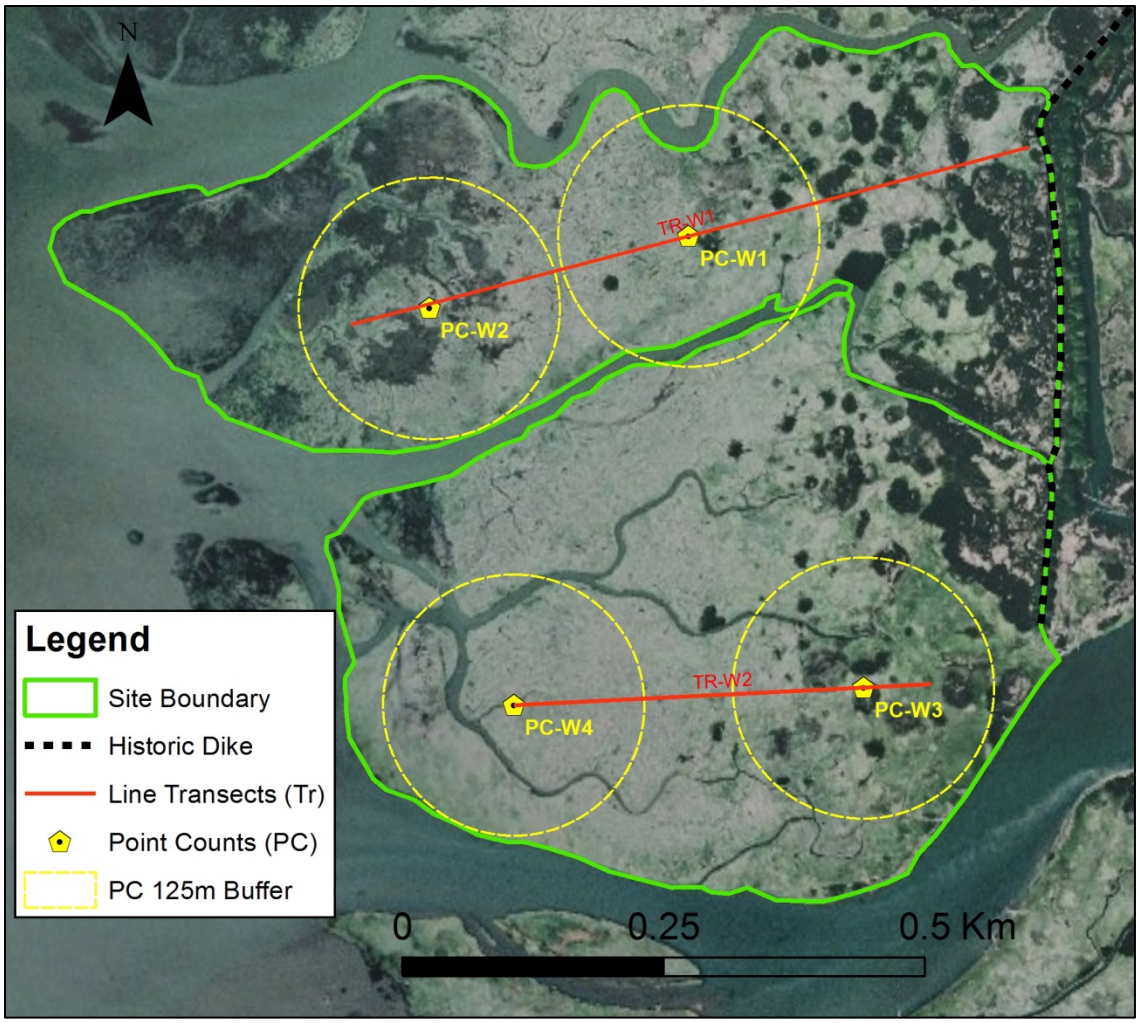

Figure 4: Study design at Wiley Slough reference marsh site. Original survey design included four point count stations (PC-W1 to PC-W4) and two line transects (TR-W1 and TR-W2). However, during 2016 we were only able to survey at sites located in the southern portion of the study area (PC-W3, PC-W4, and TR-W2) due to access issues; the study design will be re-evaluated in 2017.

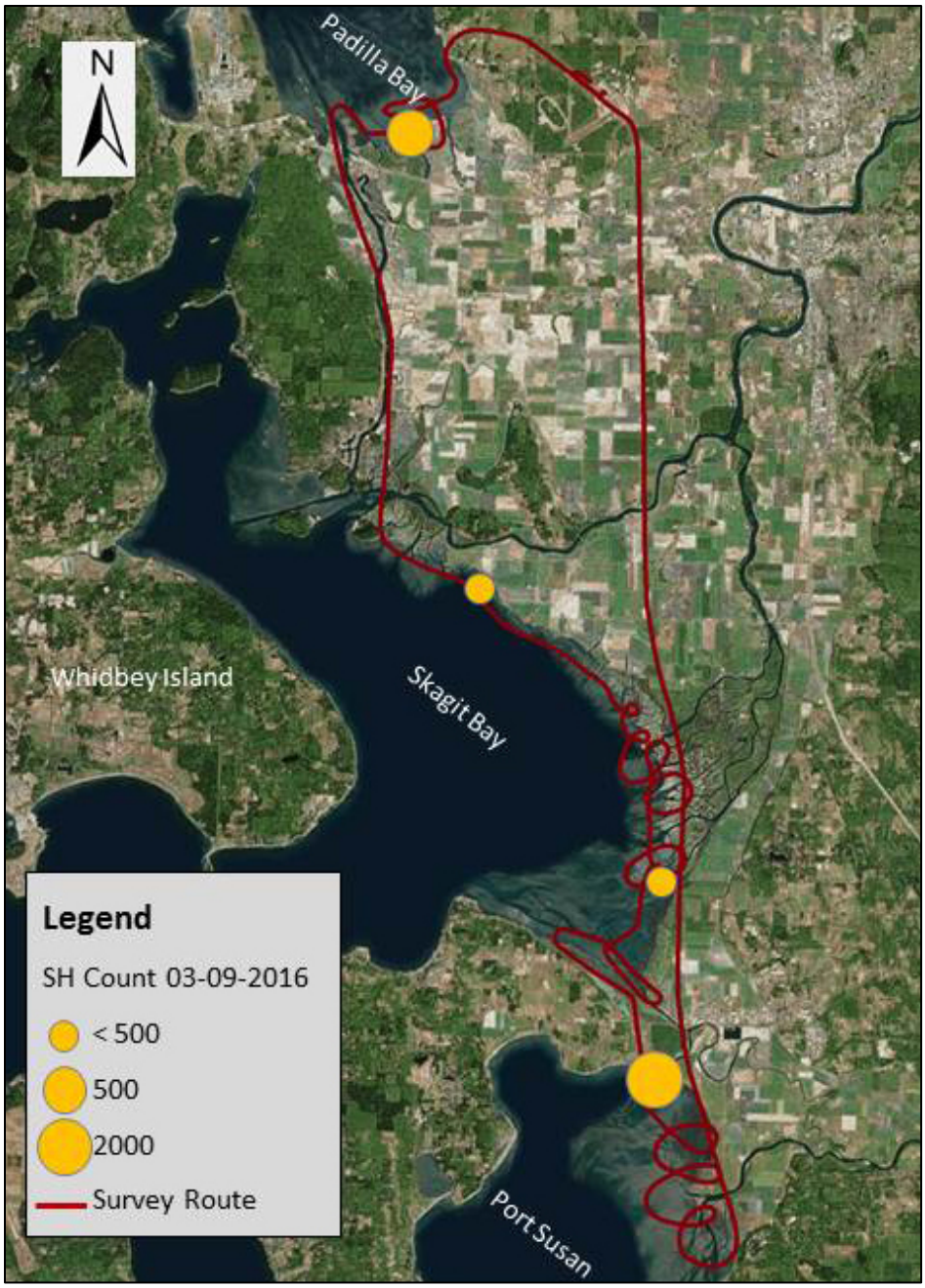

Figure 5: Shorebirds counted on aerial survey conducted on 09 March 2016 (orange circles) during the winter period. Red line shows the survey route flown. Exact counts for small flocks with < 500 shorebirds not recorded since flocks were in flight during the survey.

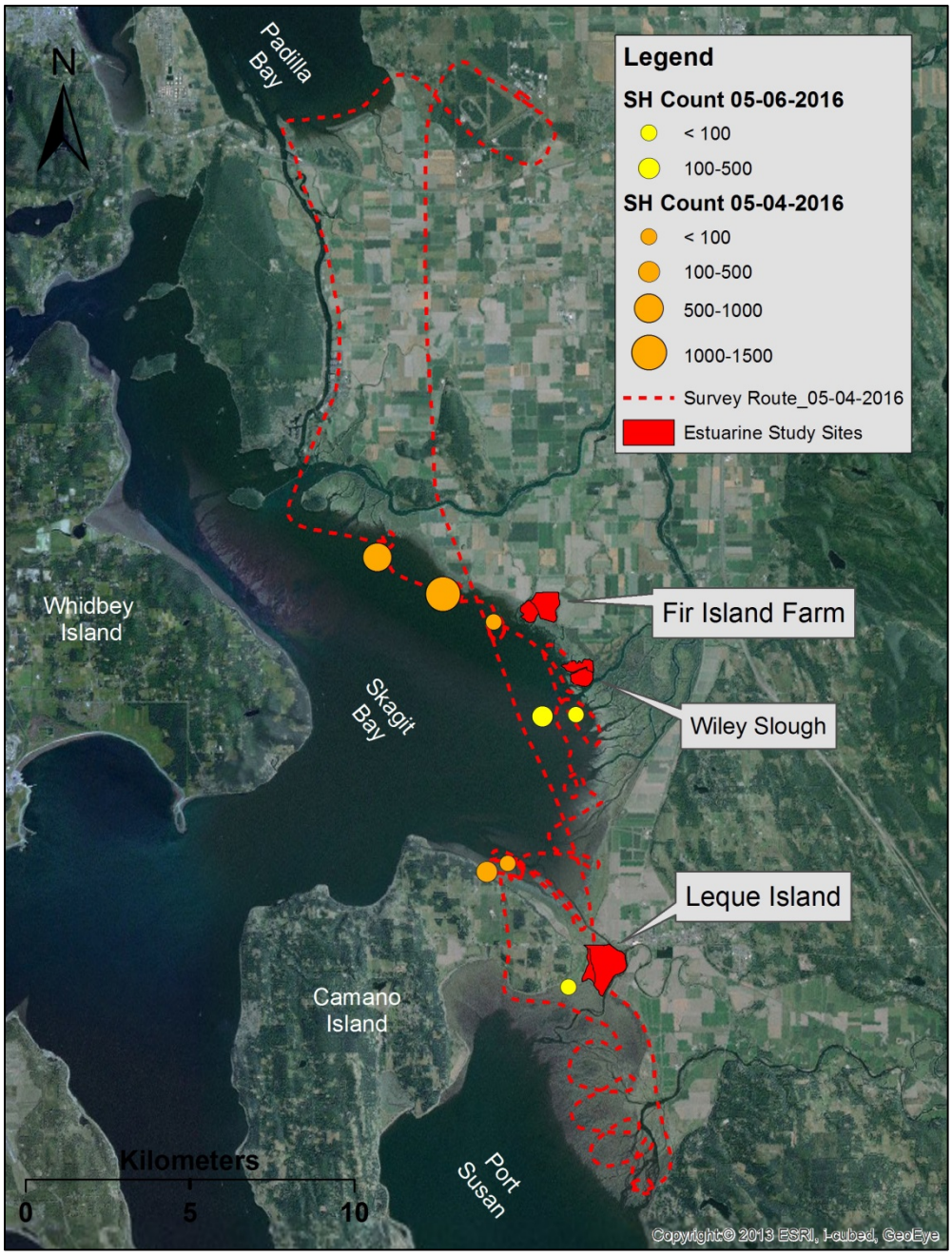

Figure 6: Shorebirds counted on aerial surveys conducted on 04 May 2016 (orange circles) and 06 May 2016 (yellow circles) during the spring migration period. Red dashed line shows the survey route flown on 04 May; similar route flown on 06 May. Estuarine study sites are shown (red polygons) for reference.

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7.0 Appendices

7.1 Appendix 1: Line Transect Survey Protocol

17 February 2016

Line Transect Survey Protocol

Survey dates: We will attempt to conduct 6 repeated surveys (3 per tide; see below) at each line transect during each of the sampling periods indicated in **Table 1**. Surveys during the spring period should be conducted during two sub-periods since waterfowl and shorebird migrations do not coincide. Thus, for spring surveys we will attempt to conduct 6 repeated surveys at each line transect during both the waterfowl and shorebird survey windows as indicated below (i.e., 12 surveys in total). Ideally visits should be separated by 7-14 days, but this may not be practical for spring surveys.

Table 1. Sampling periods for waterfowl and shorebird line transect surveys

Taxa	Winter	Spring	Fall
Waterfowl	February – 15 March	15 March – 15 April	August – September
Shorebirds	February – 15 March	23 April – 7 May	August – September

Time of day/tide/weather: Transect surveys are tide-dependent rather than being dependent on time of day. Observers should attempt conduct 3 high tide surveys (> 6 feet; La Connor tide station) and 3 low tide surveys (< 6 feet) per transect per survey period. Low tide surveys should be conducted over a range of tide levels: 1 survey at 0-2 feet; 1 survey at 2-4 feet; and 1 survey at 4-6 feet. Surveys should not be conducted in rain heavier than a light drizzle, high winds, heavy fog (< 150 m visibility), or other conditions that substantially reduce bird activity or the surveyor's ability to detect bird activity; occasional short rain showers or light drizzle are acceptable.

Note: High tide surveys at transects located in marsh habitat should only be conducted if conditions are safe for the duration of the survey. Surveyors should consider conducting these surveys on the dropping tide only as a safety precaution. Pay particular attention to tide forecasts as well as river flood levels to avoid conducting surveys in unsafe conditions.

Survey order/route: There are no defined survey routes. However, surveyors should attempt to conduct the 3 replicate low tide surveys at each line transect at a range of tide levels as described above, so the order of surveys may vary to accommodate this requirement.

Arriving and conducting the survey: Navigate to the predetermined site. Minimize unnecessary noise while travelling to the site as this can flush birds and otherwise alter bird behavior. Similarly, do not wear bright, flashy clothes or gear as this may also cause birds to flush. Approach the transect in a direct line towards the starting point rather than at perpendicular angles to reduce flushing of birds. Always record the starting point for each line transect survey on the datasheet.

If you flush birds as you arrive to a line transect, they should be included in your count. Record the bird from the location that it was flushed and estimate the perpendicular distance from the line (assuming the bird was past the starting point of the line and within 125 m of the line when first detected).

Count all waterbirds (e.g., ducks, geese, herons, etc.), secretive marshbirds (e.g., rails and bitterns), shorebirds and raptors detected within 125 m perpendicular distance from the line transect on either side (i.e., the line transect strip width). When starting the survey, only count birds in front of you within the strip width. Use 4-letter AOU species acronyms to record species names.

Survey duration and counting methods: Line transects may be walked in any direction; however, indicate the starting point for each survey so that the direction walked is recorded (which is important for later statistical analysis). Lines are 250 m in length in ag fields, with points at 50 m intervals. Lines are longer (varied length) in marsh habitat, with points at 100 m intervals. Imagine a 125 m buffer on either side of the line, creating a square that is 250 m wide and 250 m long in ag fields (longer in marsh habitat, but same width). This is the survey area. This means that when starting, there will likely be birds very near you that are not counted (i.e., do not count birds behind you). The same situation occurs at the end of the line (i.e., do not count birds ahead of you past the end of the line).

Mark the start and end time of the survey. Transects should take 15-20 minutes to complete in ag fields (longer in marsh habitat). Surveyors should walk at a slow and even pace, stopping briefly to record bird detections. Pause momentarily at the 50 m (or 100 m) marks in order to look around, ensure that you are following the line, and confirm that you are not missing visible birds. The exact pace will be dependent on the number of birds detected, which could slow down your pace along the transect. Make up time along the transect when possible to keep the total time per transect to approximately 15-20 minutes; however, it is better to extend the total time required to complete the survey than to walk the remainder of the transect at too fast a pace. Do not leave the transect to investigate a bird (although you can return after the survey is complete to confirm identification).

Note: While walking the line you should focus your attention on detecting birds ahead of you. However, you may also record new birds that you detect in the survey area behind you – *only if you are certain they are new individuals that you did not previously count.* See the "Behavior" section below for the proper method to record these types of detections.

Estimating distance: Prior to every survey event, all observers ***must*** calibrate their distance estimation by estimating distances to $\geq$ 3 objects and then checking their estimate with the rangefinder. All observers should be within 15% of the actual distance. If not, continue estimating until all observers have estimated within 15% for 3 locations.

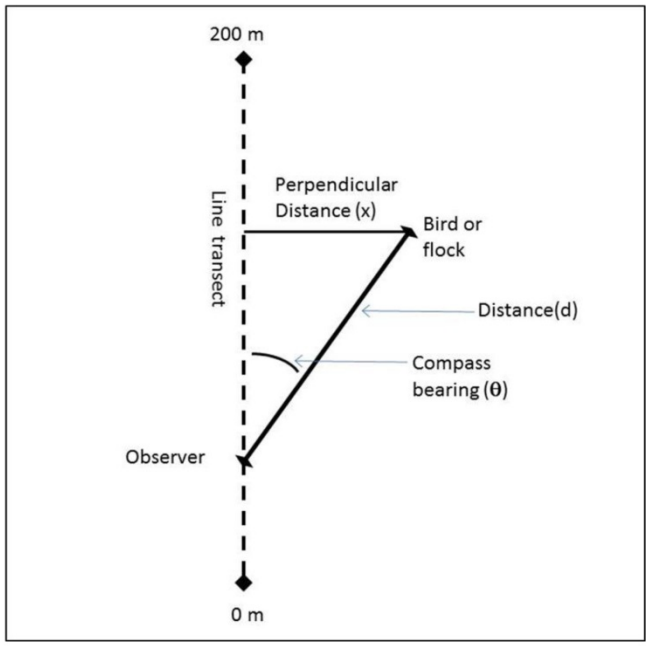
Each individual bird constitutes a unique detection with the exception of flocks (see below), and each bird gets its own line on the datasheet. Record the distance from the line transect for all birds that are detected within 125 m of the line on either side (see next paragraph). It is important to estimate the distance from where the individual was first detected, not at its closest distance. When estimating distances of detected birds, estimate to the nearest meter. Do not use decimal points. Do not round to the nearest 5 or 10 m, even if you feel this is as accurate as you can reasonably estimate. It will affect the statistical analysis later and make the data harder to use. It is important to use your rangefinder to get the most accurate distance estimates whenever possible.

For line transect surveys, the perpendicular distance from the line transect will be used to estimate density (**Figure 1**). If you can confidently estimate the perpendicular distance from the line for a detection, enter this distance in the appropriate column on the datasheet and enter a "dash (-)" in the "Compass Bearing" column to indicate that the measured distance represents the perpendicular distance. As a general rule of thumb, however, observers should not estimate perpendicular distance when birds are > 25 m from the transect line or the observer, unless the observer is perpendicular to the bird. When you cannot accurately estimate perpendicular distance, which will often be the case, use a compass to record the bearing from your location on the transect line to the bird and use a rangefinder

to measure the distance from your location to the bird; enter these data in the appropriate columns on the datasheet. These measurements will be used later to calculate the perpendicular distance.

Note: Remember, it is important that you record your starting point for each line transect survey because this information is necessary to later adjust the compass bearing recorded to the "true bearing" from the line enabling calculation of the perpendicular distance necessary for statistical analysis.

Figure 1. Bearing (θ) and distance (d) measurements from observer's location on the transect line to birds/flocks can be used to calculate perpendicular distance (d cos θ).



Counting flocks: Remember, each individual bird constitutes a unique detection with the exception of flocks. A unique detection means that it gets its own line on the datasheet, whereas a flock may have 2+ individuals on the same line. On line transects flocks will regularly be encountered for waterfowl and shorebirds. When counting flocks, the column "Flock Size" should be used to record the estimated number of individuals in a flock, and this number should agree to the entry in the "Number" column for single-species flocks. In some instances, flocks may include "mixed" flocks of several species. For mixed flocks record a count for each species on its own line and the total flock size in the "Flock Size" column; use brackets to indicate which count entries are associated with the flock size entry.

Note: For flocks, measure the distance from the line transect (using the same methods described above) to the center of the flock rather than to the location of individual birds. Thus, you will only need to record one distance measurement for the entire flock.

Cue: For line transect surveys there are three "Detection Types": Aural, Visual, and Flyover. For transect surveys it is not necessary to record the type of Aural detection (e.g., call vs. song). Record how the bird was first detected. For example, if you first hear a bird call and then later see it, "Cue" should remain "A" (Aural). However, in this instance you may also wish to record the subsequent visual detection by also entering "(V)" in parentheses in the "Cue" column if this aided you in species identification or distance estimation.

If a bird (or flock of birds) flies over the "detection area" without landing and is obviously not using the area within the survey area, it is considered a flyover and no distance estimation is required. Notable exceptions are raptors— if foraging their behavior is not considered a flyover because they are actively using the area, not just cruising through on the way from one place to another. For foraging raptors, record the estimated perpendicular distance from the line transect when first observed foraging within the survey area.

Behavior: Record the behavior of birds using the codes on the datasheet. The first two codes: foraging (F) and loafing (L) are self-explanatory. We are most interested in recording and counting birds that are actively using the survey area. Birds that flyover (FO) the survey area but do not stop and land should be recorded, but no distance estimation is necessary. Birds that move into the survey area during the transect survey should be recorded with behavior code (M) – see below. Any other behaviors observed should use code (O), and a short description of the behavior should be recorded.

During your transect survey, you may observe birds that walk into the survey area ahead of you (e.g., a flock of mallards first seen foraging > 125 m from the line moves into the survey area), or fly and land in the survey area behind you (e.g., a flock of shorebirds that you did not previously count on the transect arrives and begins to forage in the survey area). Birds that move into the survey area should be counted and distance from the line should be estimated; a unique behavior code (M) will be used to record these birds because we may decide to exclude these data from later statistical analysis. Estimate the distance to the line from the location where the birds are first observed, or where they first land in the survey area using the methods described previously.

% Water cover: Record the percent of the survey area (i.e., area within a 125 m buffer to each side of the line transect) that is covered with standing water during the survey. Exclude permanent water features such as ponds and tidal channels in your estimate of percent water cover. Since water levels may change during transect surveys due to tidal influences, record the percent water cover at the start and end of the survey, and average these numbers to derive the overall "% Water Cover".

Area searches: As part of our line transect surveys in marsh habitat we will also conduct area searches at the end of the transects. We will also conduct area searches at select points near existing ponds in ag areas and at any ponds created after restoration. Use the "Area Search Datasheet" to record data.

In marsh habitat, stand at the end of the line transect and conduct a 20-min area search of the tidal flat habitat located past the end of the transect that is directly adjacent to the marsh. The area to be searched will be all tidal flats (exposed or flooded) in a 250 m square grid starting at the transition between marsh and tidal flat habitat; include any permanent water features (e.g., tidal channels) in the areas searched.

In ag fields, conduct area searches at select ponds from a pre-determined point that allows a clear view of the entire pond. The search area will be the entire pond. Use this point for all repeated surveys conducted at any pond. Surveyors should attempt to conduct 3 high tide and 3 low tide surveys at ponds following the protocol for line transect surveys.

Count all waterbirds, shorebirds and raptors observed in the search area. Your count should be a cumulative count of all birds using the search area over the entire duration of the survey, so keep track of birds that move on or off the search area. Try to avoid double-counting any flocks that leave the search area and return later during the survey.

Note: We will not be estimating distances from the line transect for area searches.

Equipment checklist:

- Site maps with survey locations
- Datasheets, clipboard and pencils
- GPS unit
- Watch or timer
- Compass
- Rangefinder
- Binoculars
- Spotting scope

7.2 Appendix 2: Line Transect Datasheet

Transect Surveys

Date: **Site Name:** **Transect ID/start:** **Observers:**

Start time: **Stop time:** **Tide: Low High** **Tide height (ft):**

Wind:
0 = less than 1mph
1 = 1-3; wind direction shown by smoke
2 = 4-7; leaves rustle at times
3 = 8-12; leaves and twigs in constant motion
4 = 13-18; raises dust and loose paper
5 = 19-24; small trees sway

Sky:
0 = clear, or few clouds
1 = partly cloudy (roughly half – clouded)
2 = mostly cloudy (overcast; few sky openings)
3 = fog or smoke
4 = light drizzle

Cue:
A = Aural
V = Visual
F = Flyover

Behavior:
F = Foraging
L = Loafing
FO = Flyover
M = Moved onto site during survey (either walking or flying)
O = Other (enter description)

% Water start: **% Water end:** **% Water cover:** **Temp:**

Species	Number	Flock Size	Compass Bearing	Distance (m)	Cue	Habitat Ag field (dry), flooded field, marsh veg, marsh water, channel, pond, dike	Behavior See codes above

Entered by: ________ Date: ________
Checked by: ________ Date: ________

7.3 Appendix 3: Area Search Datasheet

Area Searches

Date:	Site Name:	Point ID:	Observers:
Start time:	Stop time:	Tide: Low High	Tide height (ft):

Temp:

Wind:

0 = less than 1mph
1 = 1-3; wind direction shown by smoke
2 = 4-7; leaves rustle at times
3 = 8-12; leaves and twigs in constant motion
4 = 13-18; raises dust and loose paper
5 = 19-24; small trees sway

Sky:

0 = clear, or few clouds
1 = partly cloudy (roughly half – clouded
2 = mostly cloudy (overcast; few sky openings
3 = fog or smoke
4 = light drizzle

Distance to tideline: **% of search area w/water:**

Species	Number	Habitat	Behavior
		Flooded (birds are floating), exposed (birds are upright/standing - can be in shallow water)	Foraging, loafing, flyover

Entered by: _____ Date: _____

Checked by: _____ Date: _____

7.4 Appendix 4: Point Count Survey Protocol

17 February 2016

Point Count Survey Protocol

Survey dates: We will conduct 3 repeated surveys at each site during the winter period: 1 February – 15 March. We will also survey each site 3 times during the breeding season: 1 May – 15 June. Ideally visits should be separated by 7-14 days.

Time of day/tide/weather: Counts should begin ~30 minutes before sunrise and end ~3 hours later or when bird activity is noticeably diminished, whichever occurs first. Counts may be conducted at any tide; however, for survey sites located in marsh habitat counts will likely need to be conducted at lower tides (< 7.5 feet). Counts should not be conducted in rain heavier than a light drizzle, high winds, heavy fog (< 150 m visibility), or other conditions that substantially reduce bird activity or the surveyor's ability to detect bird activity; occasional short rain showers or light drizzle are acceptable.

Survey order/route: There are no defined survey routes. In order to avoid a "time of day" effect for point counts, alternate starting points for each site visit (e.g., walk clockwise through the survey sites one visit and counter-clockwise during the next visit).

Arriving and conducting the survey: Navigate to the predetermined site. Minimize unnecessary noise while travelling to the site as this can flush birds and otherwise alter bird behavior. Similarly, do not wear bright, flashy clothes or gear as this may cause some birds to flush, or attract other birds (e.g., hummingbirds) that may not have otherwise been detected in a count.

If you flush birds as you arrive to a point count survey site, they should be included in your count. Record the bird from the location that it was flushed and estimate distance from the survey point (assuming the bird was within 125 m of the point when first detected – see below).

While conducting the count, stand at the exact GPS location of the point for the duration of the count. It is important to turn around periodically so that you are not ignoring birds behind you, but do not wander from the point. "Pishing" of birds shall not be done during the survey. Pishing can be done to identify previously unidentified species after the survey is completed.

Count all landbirds (passerines and raptors) and secretive marshbirds (rails, bitterns and snipe) detected within 125 m horizontal distance from the point count survey site in any direction. Horizontal distance means, for example, that if a bird is at the top of a 25 m tall telephone pole, and you are standing 1 m from the pole, the distance that you record is 1 m.

Note: Juveniles are not counted on any breeding season point count surveys.

Survey duration and counting methods: The duration of each point count survey will be 9 minutes, with counts broken down into two time periods: (1) a 5-minute passive listening period for all landbirds and secretive marshbirds, and (2) a 4-minute call-broadcast period for ***focal secretive marshbirds only*** (see below). During the first 5 minutes of each point count, record all landbirds and secretive marshbirds detected in the survey area. For landbirds, note which minute of the count each individual (or flock) was "first" detected in the "Time" column (i.e., you will have a single entry in the "Time" column for each record). For secretive marshbirds, note "every" minute of the count each individual was detected in the "Time" column (i.e., you may have multiple entries in the "Time" column for each record). Use 4-letter AOU species acronyms to record species names.

The final 4 minutes of each count will be used to broadcast calls for 4 focal species of secretive marshbirds (SORA, VIRA, AMBI, WISN). Following the Standardized North American Marshbird Protocol, calls for each focal species will be broadcast for a 30-second broadcast period followed by a 30-second passive listening period for each species. During the 4-minute call-broadcast period count only detections of the 4 focal species and note "every" minute of the count that each individual was detected in the "Time" column; again, you may have multiple entries in the "Time" column for each record here.

Note: Also record any additional detections of focal secretive marshbirds made outside the survey area (i.e., > 125 m from points) in the "Comments" column of the datasheet.

Estimating distance: Prior to every survey event, all observers ***must*** calibrate their distance estimation by estimating distances to ≥ 3 objects and then checking their estimate with the rangefinder. All observers should be within 15% of the actual distance. If not, continue estimating until all observers have estimated within 15% for 3 locations.

Each individual bird constitutes a unique detection with the exception of flocks (see below), and each bird gets its own line on the datasheet. Record the distance from the survey point for all birds that are detected within 125 m of the point. It is important to estimate the distance from where the individual was first detected, not at its closest distance. Also, if you first detect a bird at a distance > 125 m, but during the count it moves in closer, ***do not*** record the detection. When estimating distances of detected birds, estimate to the nearest meter. Do not use decimal points. Do not round to the nearest 5 or 10 m, even if you feel this is as accurate as you can reasonably estimate. It will affect the statistical analysis later and make the data harder to use. It is important to use your rangefinder to get the most accurate distance estimates whenever possible.

Estimating distances for birds detected by audible cues is more difficult. In these instances, if you later see the bird that was first detected by an audible cue you may use this visual cue to aid you in your distance estimation. However, it is still important to record the distance from the point at the time of first detection to the best of your ability. If you do this, note this in the "Comments" column of the datasheet.

For point counts, you may not be able to use the rangefinder during the count because the vegetation may be too dense, another reason why it is important to calibrate daily before conducting surveys. You can sometimes select an object, like a tree, that you feel is a similar distance away from a bird detection and use that rangefinder estimate. Continually calibrate and re-calibrate your estimates. After the point count, you may also try to locate an individual to verify the estimated distance, but do not spend more than 5-10 minutes doing so. Note that estimating distance in open areas is very different from estimating in dense vegetation, in part due to differences in vocalization volume depending on which way the bird is facing.

Counting flocks: Remember, each individual bird constitutes a unique detection with the exception of flocks. A unique detection means that it gets its own line on the datasheet, whereas a flock may have 2+ individuals on the same line. For point count surveys, large flocks may be encountered for some species (e.g., AMCR, STAR, RWBB) and these flocks should be recorded on a single line on the datasheet. However, many other species (e.g., chickadees, kinglets) may occasionally form smaller, loose flocks. These individuals should get their own line on the form unless there is an unusually large and

cumbersome flock. When recording flocks, the column "Flock Size" should be used to record the estimated number of individuals in the flock.

Note: For flocks, measure the distance from the survey point to the center of the flock rather than to the location of individual birds.

Cue: For point count surveys there are four "Detection Types": Aural (either Call or Song; see below), Visual, and Flyover. Record how the bird was first detected. For example, if you first hear a bird call, and then later it sings, "Cue" should remain "C" (Calling). However, in the "Comments" column you should record if a bird ultimately sang which is important in identifying sex.

Aural (Call or Song)
For many species distinguishing between calling and singing is obvious, for others it isn't. When in doubt, refer to Sibley's. For hummingbirds the male's flight display and associated sounds (actually made by structures on their feathers) constitutes song. All hummingbird vocalizations are calls. Corvids (ravens, crows, jays) never sing. All corvid vocalizations are calls. Chestnut-backed chickadees never sing. For black-capped chickadees, the song is the "sweet notes"; the "dee-dee-dee" and other sounds are calls. Recording if a bird ever sings in the comments column allows individuals to be assigned as males even if first detected visually or calling.

Visual
Individual birds first detected visually shall be annotated with a "V", even if they subsequently vocalize. If birds are visually detected after initially being detected aurally, you should record this in the "Comments" column if this helped you to later identify the species or sex, or if it aided you in estimating distance.

Flyover
If a bird (or flock of birds) flies over the "detection area" without landing and is obviously not using the area within the survey area, it is considered a flyover and no distance estimation is required. It doesn't matter if they're calling, singing, or seen. Notable exceptions are raptors and swallows— if foraging their behavior is not considered a flyover because they are actively using the area, not just cruising through on the way from one place to another. For these species, record the estimated distance from the survey point when first observed within the detection area.

% Water cover: Record the percent of the survey area (i.e., 125 m buffer surrounding the point) that is covered with standing water at the start of the survey. Exclude permanent water features such as ponds and tidal channels in your estimate of percent water cover.

Equipment checklist:
- Site maps with survey locations
- Datasheets, clipboard and pencils
- GPS unit
- Watch or timer
- Compass
- Rangefinder
- Binoculars
- Spotting scope

7.5 Appendix 5: Point Count Datasheet

Point Count Surveys

SITE:	POINT:	DATE:	TIME:
OBSERVER:	TEMP:	% WATER COVER:	TIDE HEIGHT (FT):

Time Period:
1 = 0-1 min
2 = 1-2 min
3 = 2-3 min
4 = 3-4 min
5 = 4-5 min
6 = 5-6 min
7 = 6-7 min
8 = 7-8 min
9 = 8-9 min

Wind Codes:
0 = less than 1mph
1 = 1-3; wind direction shown by smoke
2 = 4-7; leaves rustle at times
3 = 8-12; leaves and twigs in constant motion
4 = 13-18; raises dust and loose paper
5 = 19-24; small trees sway

Sky Codes:
0 = clear, or few clouds
1 = partly cloudy (half-clouded)
2 = mostly cloudy (overcast; few sky openings)
3 = fog or smoke
4 = light drizzle

Bird Noise (BN) Codes:
1: No BN most of survey
2: Faint BN >half survey
3: Mod. BN, difficulty hearing >100m
4: Loud BN, difficulty hearing >50m
5: Intense BN, difficulty hearing >25m

Focal Species (for call-broadcast):
SORA
VIRA
AMBI
WISN

Sex:
M = male
F = female
U = unknown

Cue (1st Detection):
A = Aural
C = Call
S = Song
V = Visual
F = Flyover

TIME	SPECIES	DISTANCE	CUE	SEX	FLOCK SIZE	COMMENTS

Entered by: _________ **Date:** __________
Checked by: ________ **Date:** __________