A MONITORING PLAN FOR WINTERING SHOREBIRDS IN THE CENTRAL VALLEY OF CALIFORNIA

Version 1.0

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REVISION HISTORY LOG

Although consistency of sampling design and survey methodology is an important component to all long-term monitoring programs, this plan should be modified as needed to meet the monitoring objectives. All changes to the monitoring plan should be detailed in this "Revision History Log".

Prev. Version #	Revision Date	Author(s) (of changes)	Changes Made	Reason for Change	New Version #
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EXECUTIVE SUMMARY

The Central Valley of California (CVC) provides habitat for large populations of migrating and wintering shorebirds in the Pacific Flyway. More than 95% of the historic wetland habitat has been lost in the CVC. Large-scale environmental changes, including urbanization, extreme weather and climate variation, agricultural flooding, and wetland restoration and management, are affecting remaining shorebird habitats throughout the Pacific Flyway. There is a need to better understand spatial and temporal trends in shorebird populations in the CVC to inform local habitat management and conservation actions, and to contribute to an understanding of shorebirds in the broader California Landscape Conservation Cooperative and Pacific Flyway through the Pacific Flyway Shorebird Survey. There is an increasing awareness that long-term, multi-spatial scale monitoring programs are needed to inform habitat management adaptation strategies to mitigate the effects of climate change. These programs must also be cost effective. We propose a statistically robust, logistically feasible, long-term monitoring program for wintering shorebirds in the CVC to track spatial and temporal population trends resulting from changing climate and habitat conditions. Specifically, we recommend a sampling design and survey protocol. We provide the data storage and analytical framework for population and trend estimates to be made annually as new data come in through the online data portal in the California Avian Data Center (CADC). We also recommend a series of needed pilot studies including evaluating methods for estimating error rates in shorebird counts, determining the appropriate scale for measuring habitat, and tracking habitat change.

Background

The Central Valley of California (CVC) provides habitat for large populations of migrating and wintering shorebirds in the Pacific Flyway (Shuford et al. 1998). The CVC provides shallow water habitat for over 200,000 individuals, representing more than 30 species, during the winter months (November – February). Two distinct regions of the CVC have been acknowledged as sites of international importance by the Western Hemisphere Shorebird Reserve Network (www.whsrn.org); the wetlands of the Grasslands Ecological Area in the San Joaquin Valley and the rice-lands and wetlands of the Sacramento Valley.

More than 95% of the historic wetland habitat has been lost in the CVC (Frayer et al. 1989). Large-scale environmental changes, including urbanization, extreme weather and climate variation, agricultural flooding, and wetland restoration and management, are affecting remaining shorebird habitats throughout the Pacific Flyway. There is a need to better understand spatial and temporal trends in shorebird populations in the CVC to inform local habitat management and conservation actions, as well to contribute to a broader understanding of shorebirds in the California Landscape Conservation Cooperative (CA LCC; www.calcc.org) and the Pacific Flyway. Currently there is no coordinated annual CVC-wide effort to monitor shorebirds despite ongoing habitat changes and that a coordinated monitoring strategy is a priority of the Central Valley Joint Venture (http://www.centralvalleyjointventure.org/assets/pdf/cvjv_shorebird_plan.pdf). Designing an efficient and robust annual shorebird monitoring program for the CVC is an essential step towards the long-term conservation and management of shorebirds in the Western Hemisphere.

The influence of habitat changes on shorebird populations is not well understood. Furthermore, due to the ability of shorebirds to change their distribution rapidly in response to changing habitat conditions (Warnock et al. 1995), the influence of local changes in abundance as the result of local habitat management or change can only be fully understood in the context of population changes at broader spatial scales. Regular monitoring of shorebirds in the CVC primarily focuses on individual sites (e.g. Sacramento Valley National Wildlife Refuge Complex, Los Banos Wildlife Area Complex), although one large-scale effort evaluated shorebird populations throughout the CVC in the early 1990s (Shuford et al. 1998). Despite the value of these historic and ongoing surveys to inform our understanding of shorebird ecology and status within CVC, they were too short in temporal duration or too localized in their spatial extent to provide a rigorous assessment of temporal and spatial trends. There is an increasing awareness that long-term, multi-spatial scale monitoring programs are needed to inform habitat management adaptation strategies to mitigate the effects of climate change (Conroy et al. 2011), but that these programs must also be cost effective.

We propose a statistically robust, logistically feasible, long-term monitoring program for wintering shorebirds in the CVC to track spatial and temporal population trends resulting from changing climate and habitat conditions. Specifically, we recommend a sampling design and survey protocol for wintering shorebirds in the CVC and provide the data storage and analytical framework for population and trend estimates to be made annually as new data come in through the online data portal in the California Avian Data Center (CADC). We also recommend a series of needed pilot studies including evaluating methods for estimating error rates in shorebird counts, determining the appropriate scale to measure habitat, and tracking habitat change. These data will also contribute the broader Pacific Flyway Shorebird Survey (PFSS; http://data.prbo.org/apps/pfss/index.php), a multi-partner, multi-scale monitoring program to quantify spatial and temporal trends and habitat associations of Pacific Flyway shorebirds.

Populations Being Monitored

Although some shorebird species occur in CVC at all times of their annual cycle (breeding, migration, and wintering), this monitoring plan focuses on the populations of wintering shorebird species for several reasons. First, winter (November – February) and migration (July – October, April) are the periods with the greatest abundance of shorebirds in the CVC (Shuford et al. 1998). Breeding shorebirds typically occur in low abundance and consist of few species (Shuford et al. 2007). Second, although migration surveys are common in regions with no wintering birds (e.g. International Shorebird Survey), they require multiple surveys each year due to the variability in the timing of migration and pulses in shorebird abundance. This high level of variability makes estimates of trends and habitat associations very uncertain (Bart et al. 2007). Lastly, winter is the longest period of consistent use by shorebirds in the CVC and thus management actions may be most effective. Subsequently, this monitoring plan targets all regularly occurring wetland-dependent shorebird species (Order: Charadriformes; Familes: Charadridae, Scolopacidae, Recurvirostridae, Haematopodidae) that winter in the CVC. Thirty-three species of shorebirds were identified in previous comprehensive surveys of the CVC, however only 13 of these occurred regularly in shallow water, wetland habitats. Nine of the thirteen were found almost exclusively in shallow water habitat and occurred regularly in winter (Table 1; Shuford et al. 1998). Additionally, there are Black-bellied Plover (*Pluvialis squatarola*), Killdeer (Charadrius vociferous), and Long-billed Curlew (Numenius americanus) that use both wetland and upland habitats. Currently this monitoring design is not intended to track wintering use of upland habitats thus inference from this plan for these species is limited. Lastly, there is a potentially large detection bias for Wilson's Snipe (*Gallinago delicata*) compared with other species given the current protocol thus data for this species should be interpreted carefully.

MONITORING OBJECTIVES

We designed this shorebird monitoring plan for the CVC to meet the following objectives.

1. Estimate trends in wintering shorebird populations so that a 50% decline over 20 years can be detected as statistically significant.
2. Identify changes in the distribution of shorebird species within key areas.

3. Quantify habitat associations of shorebirds and the effect of habitat management actions at multiple spatial scales.
4. Estimate the winter population size of shorebirds with a coefficient of variation < 20%.

STUDY AREA

The CVC extends nearly 700-km from its northern edge near the city of Red Bluff to its southern terminus near the city of Bakersfield. The region defined by this plan (Fig. 1) for the purpose of shorebird monitoring encompasses approximately 4.1 million ha and follows Stralberg et al. (2011) and is approximately the same focal region defined by the Central Valley Joint Venture Implementation Plan (Central Valley Joint Venture 2006). It is composed of nine major hydrological basins: Colusa (468,800 ha), Butte (262,800 ha), Sutter (91,000 ha), American (246,800 ha), Yolo (209,000 ha), Delta (668,500 ha), Suisun (52,300 ha), San Joaquin (829,300 ha), and Tulare (1,450,600 ha). For detailed descriptions of all CVC basins see CVJV (2006). For this plan, we define the Colusa, Butte, Sutter, American, and Yolo basins to be part of the Sacramento Valley subregion. The Delta, Suisun, San Joaquin, and Tulare Basin are each considered separate subregions.

The CVC has lost >95% of its historic wetland habitat and is now composed of large tracts of agriculture (Frayer et al. 1989). Currently, shorebirds primarily use managed wetlands, flooded agricultural fields (intentionally and unintentionally), and evaporation ponds in this region (Shuford et al. 1998, Stralberg et al. 2011).

SAMPLING DESIGN

Programs for long-term monitoring of shorebirds over a large landscape with potentially high spatial and temporal heterogeneity in habitat availability require sampling designs that are logistically feasible, and that minimize bias and variance in estimates of population size or population change (Bart and Ralph 2005, Braun 2005). It is also important to be able to link a large scale monitoring program with local management actions in a way that can inform conservation and management decisions over time (Lyons et al. 2006, Conroy et al. 2011).

Although a complete count of all birds from a region or population of interest is desirable, such comprehensive data are often impractical and time intensive to collect, while potentially unnecessary to for informed management decisions. Alternatively, both spatial and temporal sampling can be used to estimate the population within a selected region over time (Thompson et al. 1998). The spatial distribution, scale, and temporal frequency of sampling must be considered relative to the monitoring objectives, the ecology of the species, and the logistical constraints (e.g. property access, funding) in order to optimize sampling design (Reynolds et al. 2011).

To estimate population trend, habitat associations, and population size of wintering shorebirds in the CVC one must account for a highly aggregated species and habitat, potentially dynamic habitat availability, multiple habitat types which require different sampling designs, and a non-closed system (i.e. birds are non-territorial and move among habitat patches). Each of these conditions has implications for identifying the sampling frame (i.e., the area over which to draw samples), as well as when trying to apply standard survey techniques and sampling designs developed for breeding bird surveys (e.g. birds are often territorial and subsequently evenly dispersed making sampling easier).

We generally will follow a muti-stage panel design (Cochran 1977) with each sampling location being surveyed annually within the survey period of November 15 – December 15. We identify this survey period because by mid-November the majority of migration is over and surveys can likely be completed before winter storms, which can influence the distribution of shorebirds in the CVC and California (Warnock et al. 1995, Shuford et al. 1998). Subsequently, the total CVC population is largely closed, except for mortality. The same sampling locations are visited each year. This design, under certain assumptions, can effectively detect population trend while also quantifying the effect of habitat change or management actions at a location over time (Duncan and Kalton 1987). This design can also increase survey efficiency through a decline in logistical support (e.g. permits, keys, maps), since the same sites are visited every year. This design has been used effectively in other large-scale monitoring programs (e.g., Breeding Bird Survey). A potential limitation of this design is temporal correlation among repeated visits to the same site, which can reduce the efficiency of trend estimation models. However, under the assumption that the sampling units represent a random or at least representative sample of the population, data from panel designs can be combined with hierarchical models to obtain robust inference across the population of interest (Gelman and Hill 2007). Subsequently, it is critical to define the sampling frame correctly and select a random sample of the population of sampling units.

Sampling Frame

From historic survey data (Shuford et al. 1998) and the distribution of potential shorebird habitat (Stralberg et al. 2011), we defined the general sampling frame of potential shorebird habitat for the CVC (Fig. 2A). We define potential habitat to generally include areas that when flooded are used regularly by wintering shorebirds. This resulted in 2.7 million ha of potential habitat, much of which was agricultural and vernal pools which may be flooded irregularly or not at all. We completed a retrospective analysis of the spatial distribution of flooded habitat in the CVC during early winter (November – January) between 2000 and 2010 (Reiter and Liu 2011) to further refine our sampling frame. We defined the new sampling frame to include only potential habitat that was flooded during November to January in at least 30% of years 2000 – 2010 (Fig. 2B). This reduced the total area of the sampling frame within the CVC by 90%.

Habitat and Sampling

Within the sampling frame, we followed Shuford et al. (1998) and identified five general habitat types: managed wetlands; flooded croplands; agricultural evaporation ponds; sewage ponds; and miscellaneous habitat (Table 2). These habitats are not uniformly distributed across the CVC and vary in their importance to shorebirds across subregions (Fig.3). We followed Bart et al. (2005) and classify these general habitats into Type 1 (>75% of shorebirds occur in these habitats), Type 2 (<20% of shorebirds occur in these habitats), and Type 3 (<5% of shorebirds occur within these habitats), within each subregion of the CVC (Table 2). Type 1 habitats (wetlands, flooded agriculture, and evaporation ponds) should be surveyed regularly (i.e. annually) whereas Type 2 (sewage ponds) and 3 (miscellaneous) habitats could be monitored intermittently.

Managed Wetlands.- There are over 80,000 ha of managed wetlands in the CVC (Central Valley Joint Venture 2006). The distribution of wetland habitat in the CVC is weighted heavily towards the Sacramento Valley subregion, the Grasslands Ecological Area in the San Joaquin subregion, and the Suisun subregion (Fig. 4). Managed wetlands are relatively more important for shorebirds in the San Joaquin Valley subregion, where they support >85% of shorebirds counted in November surveys (Fig. 3; Shuford et al. 1998). Overall, managed wetlands are a fairly stable flooded habitat for shorebirds in the winter in the CVC (Reiter and Liu 2011). However, management actions (e.g. vegetation and water depth manipulation) likely influence the availability of suitable habitat over time (i.e. vegetation free and of the correct depth). There is large variation in the availability of suitable shorebird habitat among wetland areas which makes the distribution of birds highly spatially aggregated to these habitat patches. We will try to quantify this localized variation with habitat metrics recorded on surveys (see “Site Conditions” below).

We propose multiple strategies to sample wetlands in the CVC. First, we identified 27 federal wildlife refuges and state wildlife areas that had at least some flooded wetlands (Fig. 5A-B). These areas provide access to nearly 20,000 ha of regularly flooded wetland habitat, which is well distributed across the CVC and provides a robust sample population of publically managed wetlands. We prioritized public wetland areas that met one or more of the following criteria: (1) having at least 170 ha of flooded wetlands, (2) having >10% of the total area as flooded wetlands, and (3) having an existing monitoring program (Table 3). This resulted in 13 records in our sample that met at least 2 of the requirements.

Pixley NWR was included because of existing monitoring. We also included the Yolo Bypass Wildlife Area because it has a large area of flooded agriculture and the surrounding area was selected as a possible sampling unit for that habitat (see “Rice and Other Flooded Agriculture” below). Overall, 12 of these 15 total areas already have monitoring in place along specified road routes.

Although it will be relatively easy to monitor shorebirds on public lands, more than two-thirds of the wetlands in the CVC are on private lands (Central Valley Joint Venture 2006). Data from Shuford et al. (1998) suggest that overall shorebird density on private wetlands is equal to public wetlands, indicating that wetlands are used in proportion to their availability, whether publically or privately owned and managed. Although this provides some justification to use a simple random sample of publically accessible wetlands, management changes (e.g. water availability) may occur overtime that would influence the trend on one habitat versus another. We propose to survey at least some private wetlands. We will survey private wetlands from random road transects throughout the Sacramento Valley subregion (Fig. 4) that are selected largely for agricultural land surveys (see “Rice and other flooded agriculture” below).

In the Grasslands Ecological Area (part of San Joaquin subregion) and the Suisun subregion, it is not possible to obtain a sufficient sample of wetlands from publically accessible roads. We will use parcel maps to identify individual private parcels of wetlands. We will select a random set of private wetlands in the Grasslands Ecological Area in the San Joaquin subregion and the Suisun subregion. These private wetlands will be selected at the property parcel level using Generalized Random Tessellation Stratified sampling (Stevens and Olsen 2004). This spatially-explicit sampling algorithm provides a spatially balanced design, while also providing a framework (“oversamples”) to add new points over time, or (2) to replace points if they are inaccessible, in a way that does not compromise the overall sampling design. Both features are appealing for a new monitoring program. By having a framework to increase sample size, a pilot set of sites can be included from the full sampling design and new sites added, as needed, to meet monitoring objectives once pilot data are evaluated. Also, when faced with the challenges of private land access and changing habitat, being able to replace points is also a benefit. In 2011, we will select a pilot random sample of private wetlands, with "oversamples". We will use data from this 2011 pilot year and the "oversamples" to modify the number of private wetland routes as needed in the future.

When possible, historic data or pilot data will be used to inform sample selection. Shuford et al. (1998) collected data in irregularly shaped blocks in their surveys of the Grasslands Ecological Area and surrounding wetlands. Recent spatial summaries of these historic data suggest spatial variation in the distribution of shorebirds the North Grasslands and the South Grasslands. In the Suisun subregion, there are few data on the distribution of shorebirds either from Grizzly Island Wildlife Area (DFG) or private wetlands (largely duck club). In both subregions, we will conduct area searches (see "Survey Protocol" below) of wetland sampling units within each private wetland parcel along a random pre-defined survey route. This is equivalent to the two-stage design for public wetlands (i.e., refuge then wetland units). Predefined survey routes of the same wetland sampling units will be surveyed each year within federal refuges and state wildlife areas (see "Survey Protocol" below).

***Rice and other flooded agriculture*.-** Over 160,000 ha of rice are grown annually within the CVC, primarily in the Sacramento Valley subregion (Fig. 2). Rice fields that are flooded post-harvest for stubble decomposition and waterfowl habitat also provide an important habitat in the CVC for wintering shorebirds (Elphick and Oring 1998, Shuford et al. 1998). This is apparent in the Sacramento Valley subregion where flooded agriculture provided habitat for 68% of shorebirds in previous November surveys (Fig. 3; Shuford et al. 1998). Although post-harvest rice is routinely flooded in the CVC, other crop types may also be flooded. The distribution and abundance of flooding in agriculture habitats is more variable that in the other habitats surveyed (e.g. managed wetlands, sewage ponds; Reiter and Liu 2011). Based on these data (Fig. 2) and the observations of Shuford et al. (1998), we determined that the majority of regularly flooded agriculture habitat (other than rice) is found in the Delta subregion (77% of shorebirds counted in flooded agriculture) and the Tulare subregion (20% of shorebirds counted in flooded agriculture).

To sample flooded agriculture in the CVC, we will establish random survey routes in two-stages. The first stage of the sample in the Sacramento Valley subregion and the Delta subregion will be from 6-mi x 6-mi township blocks (Public Land Survey System; http://www.nationalatlas.gov) that have >10% of the area (~900 ha) that were flooded on at least 30% of years between 2000 and 2010 (Reiter and Liu 2011). The second stage of this sample will be a randomly allocated 10-mi road transect that starts along the nearest accessible road to a randomly selected point within the township block. Each road transect has 20 survey points at half-mile intervals (see "Survey Protocol" below) and surveys 164 ha of each 9324-ha township block. This technique is most easily applied and needed in the large region of winter flooded rice in the Sacramento Valley.

We identified 35 township blocks in the Sacramento Valley subregion, 3 in the Delta subregion (Fig. 6A), but none in the Tulare, San Joaquin, or Suisun subregions met our criteria for surveying. We further prioritized the selected township blocks by the relative proportion of habitat in each one. Priority 1 sites had >50% flooded habitat. Priority 2 sites had 25 – 50% flooded habitat. Priority 3 areas had 10 – 25% flooded habitat. We will use these priority rankings to guide the survey implementation. Priority 1 and 2 blocks should be implemented first, and if resources are available Priority 3 blocks should be included. In 2010, we surveyed 20 transects in the Sacramento Valley (Fig. 6B). These sample blocks were primarily Priority 1 and 2 but also included Priority 3. They were selected because all had at least 50% rice agriculture (*note*: we had not completed the Reiter and Liu 2011 work to refine the sampling frame). The majority of flooded habitat in the Delta subregion occurs on private land that is enclosed by levees and difficult to survey without access. For each township block selected within the

Delta (*n* = 3; Fig. 6A-B), we will devise a random survey route using a combination of public and private roads.

In the Tulare subregion , where previous data (Shuford et al. 1998) suggest that flooded agriculture accounted for, on average 5,000 birds per survey, monitoring widely dispersed, and irregularly flooded agriculture areas would likely be an ineffective use of resources. However, a pilot project in the first few years of this program will be to visit a random selection of flooded shorebird habitat patches in the San Joaquin and Tulare subregions to (1) report whether they are flooded, and (2) survey the site for shorebirds. These focused survey efforts may provide additional insight into the value of extending surveys of flooded agriculture beyond the Sacramento Valley and Delta subregions.

Evaporation Ponds .-Between 1972 and 1985, 28 sets of agricultural evaporation ponds, encompassing 2,800 ha, were constructed in the Tulare subregion to capture saline agricultural runoff and wastewater (SJVDIP 1999). Open water habitat is low throughout the year in this subregion and Shuford et al. (1998) identified evaporation ponds as important shorebird habitat; 45% of all shorebirds counted during November surveys of this subregion. Evaporation ponds, at that time, were particularly important for the American Avocet, with 75% of its CVC population occurring in this habitat. Since the extensive surveys in the early 1990s, 18 evaporation ponds have closed but there are still 2,000 ha of water habitat in the remaining 10 sets of ponds (SJVDIP 1999).

At least a sample of shorebirds in this habitat is desireable but ponds are all on private land. However, currently, in order to comply with regulations, all evaporation ponds are monitored for shorebird and waterbirds throughout the year from a frequency of once per two weeks to once per two months (typically by consultants; J. Seay, personal communication). These data are available through consultants and the Central Valley Water Quality Control Board. Our initial approach will be to obtain counts as well as maps of the areas surveyed indirectly for regularly monitored sites.

Sewage Ponds.- We used information extracted from the Environmental Protection Agency wastewater discharge permit compliance system (http://www.epa.gov/enviro/html/pcs/) and raw data from Shuford et al. (1998) to identify 89 wastewater treatment facilities in our sampling region. Sewage ponds provided habitat for 6 – 14% of total shorebirds counted in November surveys in the CVC (Shuford et al. 1998). Proportional use was highest in the Tulare subregion and by Black-Bellied Plovers (40% of total plovers observed in November surveys of the CVC; Shuford et al. 1998). In other regions, this habitat composed a small proportion of total use (Fig. 2), although nearly the same number of shorebirds was counted within sewage ponds in each region.

Generally we consider sewage ponds a Type II habitat, which suggests they should be surveyed intermittently. Preliminary power analyses for this habitat using historic data suggested that at least 20% of sewage ponds in the CVC would need to be surveyed to detect a 50% decline in sewage pond populations over 20 years with 80% power at the $p = 0.05$ significance level based on the 95% CI of the trend estimate from a Poisson regression model (PRBO Conservation Science, unpublished data). However, a substantially higher percentage of sites (50 – 60%) would be needed to estimate the population with a coefficient of variation <0.20. Additional simulations suggested that with a 40% sample, surveys could be conducted every fifth year and achieve 80% power to detect a trend and provide more precise estimates of population size.

We propose a random sample of 50 facilities be surveyed every five years as part of the PFSS, supplemented by data available from more frequent existing surveys (e.g. Modesto Wastewater Treatment Facility in the San Joaquin subregion). We believe that this will provide reasonable estimates of the total population using this habitat as well as population trend.

An alternative strategy would be to select a sample of sewage ponds weighting the inclusion probability by the total birds at the site in the Shuford et al. (1998) dataset. We considered this approach in a simulation and were able to estimate population size within CV < 0.20 with only 13% of sites surveyed annually. This also achieved >90% power to detect a change of the specified magnitude (PRBO Conservation Science, unpublished data). However, historic survey data do not represent the full population of sewage ponds in the CVC, thus a weighted sampling design across all ponds is not currently possible. We proposed that data be collected to inform this alternative sampling design.

Within each selected sewage pond site, a general area search protocol will be followed (see "Survey Protocol" below) using a pre-defined survey route. If there are multiple distinct ponds, observations will be recorded for individual ponds, if not then survey points will be the sampling unit.

Open water / ponds /other. This is a fairly broad category of miscellaneous habitats that includes farm ponds, reservoirs, ditches, sloughs, streams, (flooded) pastures, etc. Shuford et al. (1998) suggest that few shorebirds use these habitats during early winter in the CVC. These habitats are extensive but support few birds. Unless there is a focused management question, large changes observed in shorebird populations in other habitats, or indication of changes to the availability of other flooded habitats, we recommend that these habitats not get surveyed.

Tidal.- A very small fraction of shorebird habitat in the CVC is from estuarine systems (i.e. tidal flat, tidal marsh, salt ponds) and is restricted to the Suisun subregion. Accessing the tidal flat habitat in Suisun is very challenging and overall this habitat is quite limited within subregion. Further pilot surveys are needed to assess an effective strategy to survey tidal habitat in the Suisun Region to complement surveys of managed wetlands (see "Managed Wetlands" above).

SURVEY PROTOCOL

Survey Routes and Sampling Units

Wetlands can only be surveyed for shorebirds from their edge without completely disturbing and dispersing the birds. Because wintering shorebirds are non-territorial, they will likely not return to a location when disturbed until that disturbance is gone. Consequently, all shorebird surveys are conducted from the edge of the habitat on either roads or trails that define a random route. We standardize the sampling unit to either a defined point or wetland cell. Based on pilot surveys to evaluate the effect of distance on the probability of detection, we recommend a distance of 161-m (0.1 miles) to define the outer edge of the sampling unit survey area (PRBO Conservation Science, unpublished data); whether this be the radius of a point count circle or the portion of a wetland cell within 161-m of the survey route. We recommend limiting surveys to this distance for several reasons: (1) our data suggest that between 150- and 200-m there can be a decline in the probability of detection certain species, (2) pilot surveys suggested that there were few sampling locations where observers could survey, unobstructed by vegetation, to >150-m, and (3) 161-m is equal to 0.1 mi thus observers can easily test their distance estimation using a car odometer. Although we recommend this survey distance restriction, we currently are incorporating data from sites where an entire wetland unit is surveyed even if observations are made from >161-m.

Because a large fraction of potential shorebird habitat occurs on private land, we must rely on surveys from public roads to track shorebird populations over a large portion of the CVC. Private flooded agricultural fields are the primary habitat type that will be sampled from roadside surveys. However, wetland habitat will also be sampled from roadside routes and captured in the site condition data (see "Site Conditions below). To insure the safety of observers along public roads and to obey traffic regulations, we developed specified routes with sample locations at safe pullouts every 0.5-miles along each route. At each sample location, all shorebirds are counted within a 161-m radius. See Appendix I for more detail of the "Road Transect Survey Protocol".

When surveys can be conducted away from public roads (e.g. on internal refuge or wildlife area roads, private roads, ATV trails, walking trails) we will follow a specified route with defined sampling units. Generally, we specify a survey route that can be repeated and use either a specific wetland cell or a point count location along the route as the sampling unit. We again restrict this protocol and only count birds within 161-m of the survey route. See Appendix I for the details of the "Wetland Area Search Protocol".

Site Conditions

Controlling for sampling variability can increase the efficiency of trend analyses and precision of population estimates. To control for sampling variation, as well as to evaluate factors influencing the use of specific locations by shorebirds, we ask observers to collect several pieces of data, in addition to shorebird observations, ("Site Conditions") at each sampling unit. For sampling variation, we record variables about weather conditions during the survey. Also, in many wetland habitats, the actual area surveyed without obstruction, a necessary condition for unbiased wintering shorebird surveys, is often much less than specified as the survey unit and may change over time with natural changes in vegetation. We record the percentage of the survey area that was able to be surveyed to account for these changes.

Currently, we do not specify the temporal duration of the survey which, similar to area surveyed, may be correlated with the number of birds observed in surveys. However, we recommend that survey areas that appear to have no shorebirds be scanned for at least 2 minutes before continuing to the next sampling unit on the route. Although there is no maximum time limit for counting birds, once all birds in the sampling unit are recorded, the count is considered completed and no additional birds recorded for that sampling unit. An assessment of data collected in rice field surveys using a similar protocol, suggested that that 90% of counts were completed within 10 minutes and that all birds, up to 1000 in a single count, could be identified and counted within 16 minutes (PRBO Conservation Science, unpublished data). Without time constraints, however, our survey times did not vary significantly, with <10% extending past 10 minutes. Consequently, we do not recommend further standardization of the time window for surveys at this time. We will record the start and end time of each count to evaluate the need to control for survey time variation as data are collected over the first couple years of this program.

To account for differences in shorebird counts likely driven by ecological mechanisms (process variance) we will collect data on the habitat conditions (e.g. percent flooded, vegetation height, habitat type) at each sampling unit. These data can be a valuable asset for understanding processes driving the spatial and temporal trends in wintering shorebird populations. See Appendix I for more details on Site Conditions.

DATA CENTRALIZATION

All data collected as part of wintering shorebird monitoring in the CVC will be entered into the California Avian Data Center (CADC; www.prbo.org/cadc). CADC is a secure, well-tested platform for managing, analyzing, and visualizing avian monitoring data. It is also a node of the Avian Knowledge Network (www.avianknowledge.net), which represents several interconnected bird data repositories.

Data will be entered into CADC through an online data entry portal developed specifically for the CVC and the broader Pacific Flyway Shorebird Survey (PFSS; http://data.prbo.org/apps/pfss/; see Appendix II for the "Data Entry" protocol). This portal allows for rapid collection of data from field surveys. It is particularly efficient for integrating data collected by many different observers across multiple monitoring programs.

For existing monitoring programs that may have their own data base management system, we will construct queries to efficiently incorporate their survey data into the broader CVC and PFSS monitoring programs.

DATA ANALYSIS

It is important to use data collected as part of this monitoring plan annually to inform trend models, habitat association models, management decisions, and the public about shorebird population changes over time. The value of this monitoring program should be measured in terms of shorebird conservation and management actions that result from the information gained. Data produced by this monitoring strategy will be used for multiple purposes.

Basic Summaries

As part of this monitoring program, we have developed an open-source interactive data summary tool (http://data.prbo.org/apps/pfss/index.php?page=explore-project-results). This tool uses shorebird data stored in CADC to produce simple summaries at user-defined spatial scales from the individual sampling unit to the entire CVC. These interactive tools also allow annual data from the CVC to be compared to PFSS monitoring data collected from throughout California and, eventually, the entire Pacific Flyway.

Trend Estimation and Habitat Associations

To achieve two primary objectives of this monitoring plan, we will estimate shorebird population trends and habitat associations using hierarchical mixed-models (Link and Barker 2010). We will fit simple models to the data using two covariates: (1) year – a continuous variable standardized to 2010 = year 1; and (2) habitat - a multi-level factor representing the CVC habitats. We will also consider an interaction term between habitat and year in our models to evaluate whether trends are different among habitats. Because there may be correlation among observations close together in space or time we will consider random effects and correlation structures in our models (Gelman and Hill 2007). The general hierarchical model form that we will apply is a follows:

Where is the count in sampling unit *i* on route *j* in year *k*; is the offset term to standardize effort among sampling units (e.g. area); is the set of fixed-effect parameters evaluated in the model; and is the set of random effects and correlation structures in the model.

As part of the model development, we will be able to evaluate sources of sampling variation in the data using covariates recorded as part of our survey protocol (e.g. proportion of survey area visible, duration of survey). A common source of modeled variation is the difference in the area surveyed in each sampling unit. This variation is often corrected for in count data by using density. An offset term can be included in models to account for differences in sampling effort (Kery 2010). This simple approach, similar to density assumes that the offset term and the count are linearly correlated. Complex, although flexible, non-linear models can also be used to further account for effort variation (Link et al. 2006). Although incorporating some of these covariates can control for sources of variation, if they vary significantly, they may confound analysis and inference, and may be better accounted for with revised sampling design and protocol. We will control significant sources of variation through changes to the protocol.

Because data will be collected annually and entered directly into CADC, we will use a Bayesian approach to model trend over time and habitat relationships through time. This will allow for our estimates of trend to be updated annually in a rigorous fashion while accounting for existing information from previous years' model analyses and updated parameter estimates (Williams et al. 2002). The hierarchical models developed above can also be used to quantify habitat associations of shorebirds and potentially the impact of management actions. This will require an initial study to develop the habitat models as well as regular tracking of shorebird habitat and management actions in CVC sampling units. Some of this work to quantify the effect of localized management changes to broader scale shorebird populations is currently underway in the CVC.

To fit complex models in a Bayesian framework, a complex simulation algorithm is used called Markov-Chain Monte Carlo (MCMC) to sample from probability distributions. During each iteration of the simulation derived parameters, such as density or trend, can be calculated. This results in a distribution of 10,000 of these derived parameters. This distribution of the derived parameter values provide the basis for rigorous estimates of variance using the 250^{th} and 9750^{th} ranked values to define the 95% credible interval (Kery 2010).

Population Estimation

Each year, we will estimate the population of shorebirds in the CVC using a simple extrapolation of the density estimates derived from hierarchical models above. We will estimate the population size by habitat as a derived parameter from each iteration of the MCMC model-fitting process (Link and Barker 2010). These derived population estimates will be calculated as the density in each habitat times the total area of that habitat available on the landscape. The variance estimate (95% credible interval) for the shorebird population estimate is calculated using the percentile method within each habitat and the derived population estimate from each iteration of the MCMC algorithm (Link and Barker 2010). A complete CVC population estimate can be derived simultaneously using the sum of the individual habitat estimates. Again the 95% credible interval will be estimated. This approach to estimating populations allows variance components to be determined for derived parameters in each level of the hierarchy and allows local changes or habitat specific changes to be evaluated in the context of the entire population (Kery 2010). The fraction of the habitat surveyed and consequently the inclusion probabilities can change if the amount of habitat within a region changes overtime. Accounting for changes in the fraction of the habitat surveyed is important to achieve unbiased estimates of population size. Tracking habitat in the CVC overtime is needed to maximize the accuracy of the population estimates from survey data collected with these surveys.

POTENTIAL BIASES

Selection Bias

Overall, the shorebird habitats in the CVC differ in their accessibility (e.g. public versus private lands). Managed wetlands occur on both public and private lands and as discrete units on the landscape (Fig. 4). Flooded agriculture occurs largely on private land and is a spatially and temporally fluctuating mosaic of potential habitat on the landscape (Fig. 6; Reiter and Liu 2011). We recommend that these areas will be surveyed by a set of randomly allocated road transects. This approach will allows for coverage of a large region and does not require high levels of coordination, but increases the potential of biased estimates if birds distribute themselves non-randomly relative to public roads. We evaluated this possible source of bias in two-ways. First, we compared the distribution of shorebird data from private land far from paved roads with those from public road-based surveys in 2009 and 2010. Second, we flew aerial surveys and recorded the location of shorebird flocks with GPS units. We then evaluated whether the distribution of these flocks was distributed randomly relative to roads.

In the comparison of survey data from private farms surveyed in the early winter 2009 and 2010 and those from 20 road transects surveyed in December 2010, overall species richness (same 13 species observed) and density estimates (both ~2 birds per ha) were comparable. This suggests public road based surveys can yield similar results to surveys where physical access to private lands is possible. Our evaluation of aerial survey data suggested that flocks were distributed randomly relative to roads (PRBO Conservation Science, unpublished data). This provides additional support for the lack of bias in public road based surveys of this region.

Sampling Bias

Significant variation in the sampling unit or probability of detection among habitats may cause significant biases in analyses that do not account for these. Currently, we control for these biases by only counting birds to a distance of 161-m and estimating the proportion of that area that is actually able to be surveyed for shorebirds (see “Site Conditions” above). Regardless, an approach to fully account for probability of detection is needed (see “Future Needs and Pilot Studies” below).

Frame Bias

Although our proposed monitoring plan provides a rigorous approach for long-term monitoring of wintering shorebirds in the CVC, we recommend continued assessments of its functionality and rigor overtime to guard against selection and frame bias (Thompson 2002). The high degree of spatial aggregation in shorebirds can lead to biased trend estimates if there is a significant shift in distribution of shorebirds from surveyed to non-surveyed sites. We believe our careful evaluation of the sampling frame and subsequent sampling design should prevent this bias from being significant. There is also the potential for new habitat to become available outside of the area covered by the current sampling frame. This potential shift in the habitat distribution may be increasingly relevant in light of rapid environmental change. Consequently, our inference about shorebird populations in CVC would be biased ("frame bias"). We recommend an evaluation of the distribution of early winter flooding, similar to that by Reiter and Liu (2011) every 5 years to assess whether the distribution of shorebird habitat has changed. Then, if necessary, make corrections in the sampling design to account for observed changes.

Survey Coordination, Logistics, and Sustainability

The survey of all sampling units in the CVC should be completed within the PFSS survey window of 15 November to 15 December. To successfully survey at all sampling units within this time period, a large number of trained observers are needed. Surveys will be conducted by both professional and volunteer biologists ("citizen scientists"). Training sessions will be held annually to familiarize new observers with survey protocols, data recording, species identification, methods of estimating shorebird numbers, and data entry through CADC. We are also partnering with existing monitoring programs (particularly in wetland habitats) to link their data collection efforts with the broader PFSS network. PRBO will take the lead role in the coordination of this annual survey in CVC and the broader PFSS. However, efficient survey coordination and widespread data collection in CVC will continue to require close partnerships between PRBO Conservation Science, the U.S. Fish and Wildlife Service, California Department of Fish and Game, and Audubon California; all have indicated an interest in contributing to this broad-based, multi-partner program.

The sustainability of a long-term monitoring program will also depend on maintaining active engagement by survey participants. We have developed the PFSS webpage (http://data.prbo.org/apps/pfss/) and will soon launch a Facebook page to engage citizen scientists and provide information about shorebirds and the PFSS. We also used survey monkey (http://www.surveymonkey.com/) to interact with citizen scientists and elicit feedback about their experience with the PFSS. We believe these social networking tools will increase citizen scientist retention and generate enthusiasm and support for shorebird monitoring and conservation in the CVC.

FUTURE NEEDS AND PILOT STUDIES

Although this monitoring plan describes an approach to tracking abundance and trends of wintering shorebirds in the CVC there is still additional work to be completed.

Habitat Tracking and Bird-Habitat Models

The area included by all sampling units that defines our potential sampling frame represents >4.1 million ha of terrestrial and wetland habitat in CVC. Throughout the CVC regular changes to the landscape affect the availability of shorebird habitat. Efforts to restore wetland habitats and riverine systems (Central Valley Joint Venture 2006) will likely affect the distribution and abundance of shorebird habitat, and climate change will also influence the habitat composition in the CVC (Snyder et al. 2004). Although we can record simple habitat metrics at surveyed sampling units annually, as part of the general monitoring protocol, changes at non-surveyed sites would go undetected. To track potential changes in shorebird habitat in the CVC, we need a consistent way of tracking landcover, at least every 3 – 5 years, or distinct changes in habitat. Currently, there is not a framework to regularly track habitat in the CVC although the ability to do so efficiently (e.g. remote sensing; Reiter and Liu 2011) is increasingly available and would benefit long-term monitoring of many ecosystems in the CVC. Furthermore, changes in the distribution and availability of shorebird habitat can result in biased estimates of population size and trend.

To understand how changes to habitat availability will influence shorebirds we need shorebird-habitat association models. Typically, shorebird habitat management occurs within a wetland or wetland complex. The effectiveness of these localized (<1 - 2 km^2) management strategies to attract shorebirds may vary due to changes in the availability of habitat in the surrounding landscape which may change over time from habitat conversion or changing agriculture strategies (e.g., amount of flooded rice). For managers to make informed management decisions requires understanding how their localized actions contribute to overall shorebird habitat in the broader landscape. Habitat association models can provide management recommendations to wetland habitat managers about how to allocate resources to maintain current shorebird population objectives.

Probability of Detection (Sampling Bias)

Often not all birds occurring within a sampling unit are detected. The probability that a bird occurring within a sampling unit is detected is called the probability of detection (Thompson 2002). The probability of detection, which is often assumed to be equal to 1 (i.e. all birds are detected), can be influenced by many factors including habitat, distance from the observer to the bird, or the amount of habitat that is actually visible. Typically, the assumption is that the probability of detection is <1. Population estimates will be negatively biased ("sampling bias") if probability of detection is not corrected for in analysis. Trend estimates are more robust to uncorrected counts as long as the probability of detection does not have a trend (i.e. the probability of detecting a bird given it is in the sampling unit is constant overtime). Probability of detection can be particularly problematic when making make comparisons of shorebird abundance among habitat types which have significant differences in probability of detection.

It is difficult to efficiently estimate the probability of detection of wintering shorebirds for two reasons. First, wintering shorebirds often occur in large groups, clustered on the landscape. Estimating the size of these large groups is very challenging and likely, there is an equal probability of under-estimation (probability of detection < 1) as there is of over-estimation (probability of detection > 1). This makes the assumption that birds are only likely undetected somewhat untenable. Reconciling this problem is a challenge. Second, several commonly used approaches to estimating the probability of detection including the double-observer (Nichols et al. 2000), the Royle count model (Royle 2004), double sampling (Bart and Earnst 2002), and distance sampling (Buckland et al. 1993) have assumptions (e.g. closure) that cannot be met with wintering shorebirds or are logistically unfeasible using citizen scientists. A modified version of the Royle count model, the "unreconciled double-observer method" (Riddle et al. 2010), may provide a rigorous approach to estimating probability of detection in a citizen scientist driven project. Similar to the traditional double-observer approach this method requires two observers counting independently at the same survey location, but does not require them to uniquely identify birds. Not having to "reconcile" individual birds among observers is valuable for surveys of large flocks. A better understanding of the magnitude of biases caused by probability of detection in shorebird surveys in interior wetland habitats is needed to delineate effective strategies for correcting for this source of bias.

CONCLUSION

Annual shorebird surveys in CVC that generate estimates of temporal trend, spatial distribution, and habitat associations at multiple spatial scales are needed and to inform conservation and management of shorebirds in the face of a changing climate, unreliable water resources, and habitat conversion. Linking observed changes in the distribution and abundance of wintering shorebirds to changes in habitat within the CVC will also measure the impacts of local management actions. Evaluating annual shorebird monitoring data from the CVC in the context of broader changes in shorebird populations across California and the Pacific Flyway as part of the PFSS will provide a multi-scale assessment of the impact of local management actions on Pacific Flyway shorebird populations. This monitoring plan details an approach to provide this essential information.

Some aspects of this new monitoring strategy were launched in 2010 in the CVC, when more than 20 citizen scientists and professional biologists conducted surveys and entered their data through our new online data portal. In 2011, we will continue to implement the plan and expand to cover all sampling locations by 2012. We will use the first two years of data (2010 and 2011) to critically evaluate this monitoring plan and revise it as needed.

ACKNOWLEDGMENTS

The development of this plan benefited from the efforts of many partners, including the Grasslands Water District, U.S. Geological Survey, U.S. Fish and Wildlife Service, Audubon California, and the California Department of Fish and Game. We are especially grateful to the citizen scientists who have dedicated their time and resources to help collect valuable shorebird data in CVC, and we look forward to their continued support. In particular, we thank M. Gilbert, L. Stenzel , M. Wolder, and L. Sparks for their assistance with this project. The PRBO Informatics Group contributed significantly to this work. Funding to complete this plan was generously provided by the California Landscape Conservation Cooperative and the David and Lucile Packard Foundation.

LITERATURE CITED

Bart, J. and S. Earnst. 2002. Double sampling to estimate density and population trends in birds. Auk 119:36–45.

Bart, J. and C. J. Ralph. 2005. Suggestions for establishing a network of landbird migration monitoring sites. USDA Forest Service Gen. Tech. Rep. PSW-GTR-191.

Bart, J., B. Andres, S. Brown, G. Donaldson, B. Harrington, V. Johnston, S. Jones, G. Morrison, and S. Skagen. 2005. The program for regional and international shorebird monitoring (PRISM). USDA Forest Service Gen. Tech. Rep. PSW-GTR-191.

Bart, J., S. Brown, B. Harrington, and R. I. G. Morrison. 2007. Survey trends of North American shorebirds: population declines or shifting distributions. Journal of Avian Biology 38:73–82.

Braun, C. E. editor. 2005. Techniques for wildlife investigations and management. Sixth edition. The Wildlife Society, Bethesda, Maryland.

Buckland, S. T., D. R. Anderson, K. P. Burnham, and J. L. Laake. 1993. Distance sampling: estimating abundance of biological populations. Chapman and Hall, London.

Cochran, W. G. 1977. Sampling techniques. Wiley Press, New York, New York.

Conroy, M. J., M. C. Runge, J. D. Nichols, K. W. Stodola, and R. J. Cooper. 2011. Conservation in the face of climate change: the roles of alternative models, monitoring, and adaptation in confronting and reducing uncertainty. Biological Conservation 144:1204-1213.

Central Valley Joint Venture. 2006. Central Valley Joint Venture Implementation Plan – Conserving Bird Habitat. U.S. Fish and Wildlife Service, Sacramento, California.

Duncan, G. J., and G. Kalton. 1987. Issues of design and analysis of surveys across time. International Statistical Review 55:97–117.

Elphick, C. S. and L. W. Oring. 1998. Winter management of Californian rice fields for waterbirds. Journal of Applied Ecology 35:95–108.

Frayer, W. E., D. D. Peters, and H. R. Pywell. 1989. Wetlands of the California central valley: status and trends. Rep. U.S. Fish and Wildlife Service, Portland, Oregon.

Gelman, A. and J. Hill. 2007. Data analysis using regression and multilevel/hierarchical models. Cambridge University Press, New York, New York.

Kery, M. 2010. Introduction to WinBUGS for ecologists: a Bayesian approach to regression, ANOVA, mixed models, and related analyses. Academic Press, Burlington, Massachusetts.

Link, W. A. and R. J. Barker. 2010. Bayesian inference with ecological applications. Academic Press London, United Kingdom.

Link, W.A., J. R. Sauer, and D. K. Niven. 2006. A hierarchical model for regional analysis of population change using Christmas Bird Count data, with application to the American black duck. Condor 108:13–24.

Lyons, J. E., M. C. Runge, H. P. Laskowski, and W. L. Kendall. 2006. Monitoring in the context of structured decision-making and adaptive management. Journal of Wildlife Management 72:1683–1692.

Nichols, J. D., J. E. Hines, J. R. Sauer, F. W. Fallon, J. E. Fallon, and P. J. Heglund. 2000. A double-observer approach for estimating detection probability and abundance from point counts. Auk 117:393–408.

Reiter, M. E., and L. Liu. 2011. The Distribution of Early-Winter Flooding in the Central Valley of California: 2000 – 2010. Report to the California Landscape Conservation Cooperative. PRBO Conservation Science, Petaluma, California.

Reynolds, J. H., W. L. Thompson, and B. Russell. 2011. Planning for success: Identifying effective and efficient survey designs for monitoring. Biological Conservation 144:1278–1284.

Riddle, J. D., K. H. Pollock, and T. R. Simons. 2010. An unreconciled double-observer method for estimating detection probability and abundance. Auk 127:841–849.

Royle, J. A. 2004. N-mixture models for estimating population size from spatially replicated counts. Biometrics 60:108–115.

SJVDIP. 1999. San Joaquin Valley Drainage Implementation Program - Evaporation ponds. Technical Report.

Shuford, W. D., G. W. Page, and J. E. Kjelmyr. 1998. Patterns and dynamics of shorebird use of California's Central Valley. Condor 100:227–244.

Shuford, W. D., J. M. Humphrey, R. B. Hansen, G. W. Page, L. E. Stenzel, and C. M. Hickey. 2007. Summer distribution, abundance, and habitat use of black-necked stilts and American Avocets in California's Central Valley. Western Birds 38:11–28.

Snyder, M. A., L. C. Sloan, and J. L. Bell. 2004. Modeled regional climate change in the hydrologic regions of California: a CO2 sensitivity analysis. Journal of the American Water Resources Association 40: 591–601.

Stevens, D. L., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262–278.

Stralberg, D., D. R. Cameron, M. D. Reynolds, C. M. Hickey, K. Klausmeyer, S. M. Busby, L. E. Stenzel, W. D. Shuford, and G. W. Page. 2011. Identifying habitat conservation priorities and gaps for migratory shorebirds and waterfowl in California. Biological Conservation 20:19–40.

Thompson, W. L. 2002. Toward reliable bird surveys: accounting for individuals present but not detected. Auk 119:18–25.

Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, San Diego, California.

Warnock, N., G. W. Page, and L. E. Stenzel. 1995. Non-migratory movements of dunlins on their California wintering grounds. Wilson Bulletin 107:131–139.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2002. Analysis and management of animal populations: modeling, estimation, and decision making. Academic Press, New York, New York.

Table 1. Species likely to be observed regularly as part of this Central Valley Shorebird Monitoring Plan

Common Name	Scientific Name
Black-bellied Plover*	*Pluvialis squatarola*
Semipalmated Plover	*Charadrius semipalmatus*
Killdeer*	*Charadrius vociferus*
Black-necked Stilt	*Himantopus mexicanus*
American Avocet	*Recurvirostra americana*
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Long-billed Curlew*	*Numenius americanus*
Western Sandpiper	*Calidris mauri*
Least Sandpiper	*Calidris minutilla*
Dunlin	*Calidris alpina*
Long-billed Dowitcher	*Limnodromus* scolopaceus
Wilson's Snipe**	*Gallinago delicata*

*species for which wetland only surveys may be incomplete sampling frame
**probability of detection bias large

Table 2. Summary of shorebird habitats in the Central Valley of California by region and importance. Type 1 habitats support >75% of the shorebird population, Type 2 support <20% of the population and, Type 3 support <5% of the population. Habitat types that are not listed under a certain region do not occur there. AG = agriculture fields; EVAP = evaporation ponds; MGWE = managed wetlands; MiscWater = lakes, ponds, riverine; SEPO = sewage ponds.

	Sacramento Valley	Delta	San Joaquin	Tulare
Type I	AG MGWE	AG MGWE	MGWE	EVAP AG MGWE
Type II	SEPO	SEPO	SEPO	SEPO
Type III	MiscWater	MiscWater	MiscWater	MiscWater

Table 3. Summary and priority ranking for shorebird surveys on U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Game (DFG) properties in the Central Valley of California. Priority ranking were determined by the percentage of flooded wetland at the site, having at least 170-ha of flooded habitat, and total birds observed on historic surveys (Shuford et al. 1998). Also indicated is whether there is an existing monitoring effort.

Agency	Site	Flooded Wetland (ha)	Proportion Wetland	Priority	Existing
DFG	GRIZZLY ISLAND WA	3119.04	0.54	1	N
USFWS	SACRAMENTO NWR	3015.45	0.62	1	Y
DFG	MENDOTA WA	2720.88	0.54	1	Y
DFG	GRAY LODGE WA	2437.38	0.59	1	N
USFWS	DELEVAN NWR	1723.23	0.67	1	Y
USFWS	COLUSA NWR	1213.20	0.66	1	Y
DFG	VOLTA WA	719.37	0.57	1	Y
DFG	LOS BANOS WA	859.32	0.30	2	Y
USFWS	SUTTER NWR	730.26	0.43	2	Y
USFWS	KERN NWR	705.69	0.15	2	Y
USFWS	MERCED NWR	303.93	0.12	2	Y
USFWS	SAN LUIS NWR	730.35	0.09	3	Y
USFWS	STONE LAKES NWR	168.93	0.02	3	Y
DFG	YOLO BYPASS WA	9.18	0.01	3	N
USFWS	PIXLEY NWR	1.26	0.00	4	Y

Figure 1. The Central Valley of California (CVC) survey region for shorebirds with major hydrological basins indicated.

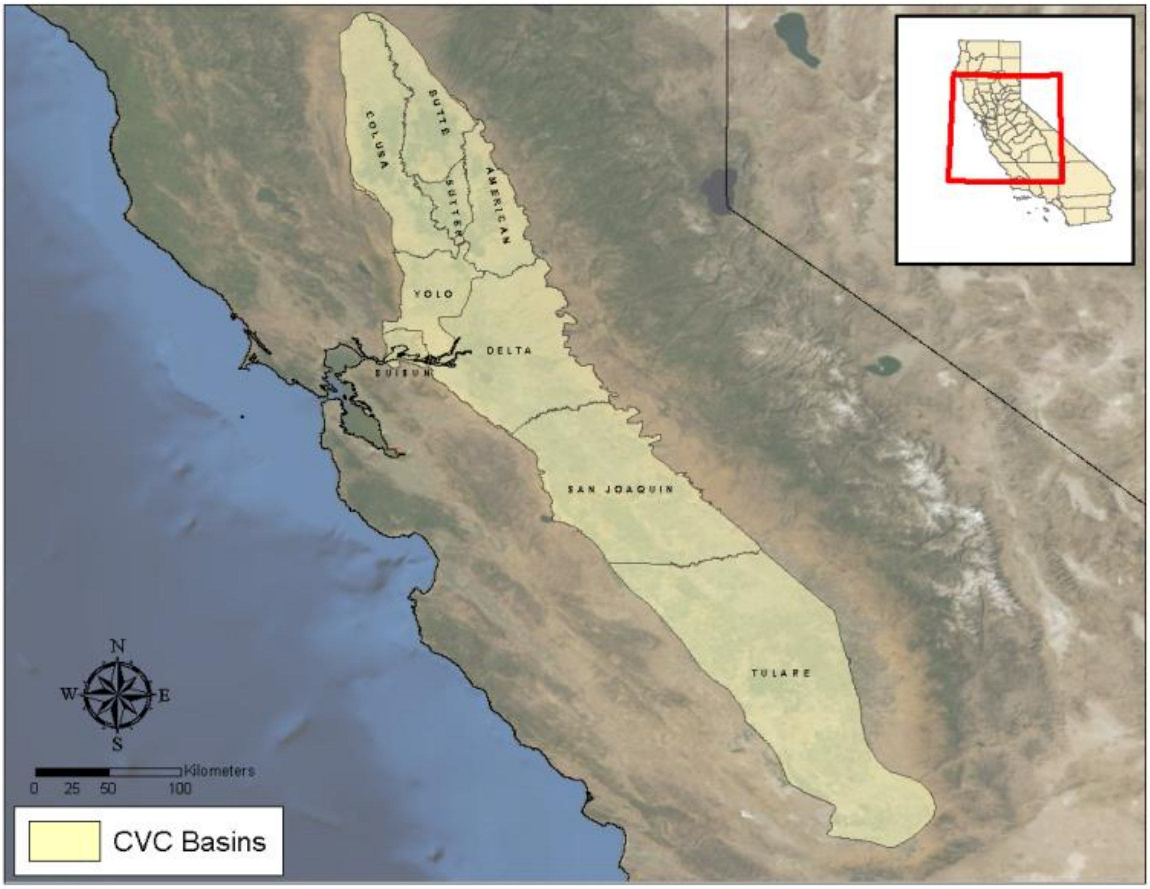


Figure 2. Distribution in the CVC of (A) all potential shorebird habitat and (B) the distribution of potential shorebird habitat that was flooded during early winter (Nov – Jan) in at least 30% of years between 2000 and 2010.

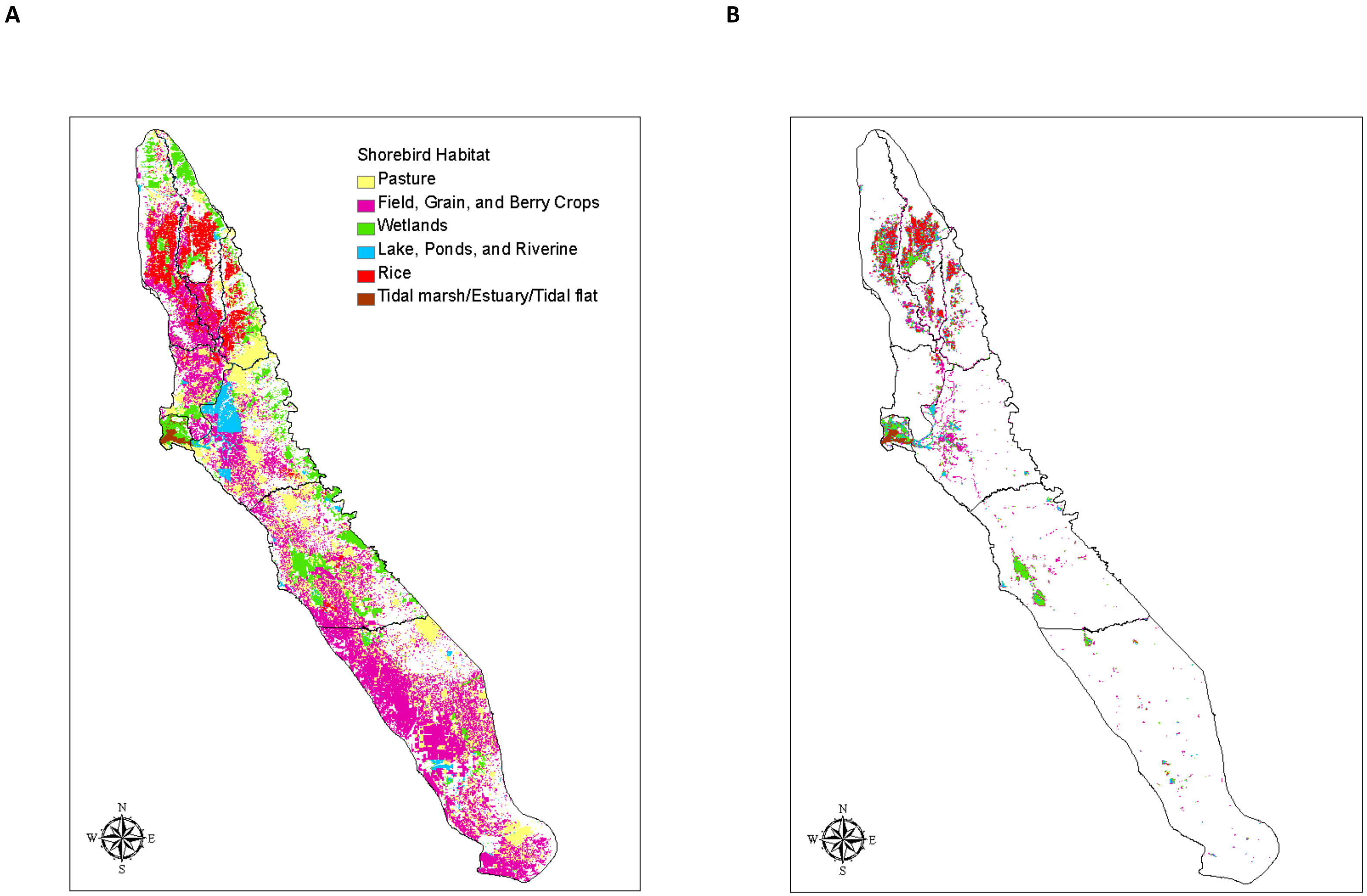


Figure 3. Total shorebirds counted by habitat in four survey subregions in the Central Valley of California based on data from Shuford et al. (1998). AG = agriculture fields; EVAP = evaporation ponds; MGWE = managed wetlands; MiscWater = lakes, ponds, riverine; PAST = pastures (very low total); SEPO = sewage ponds.

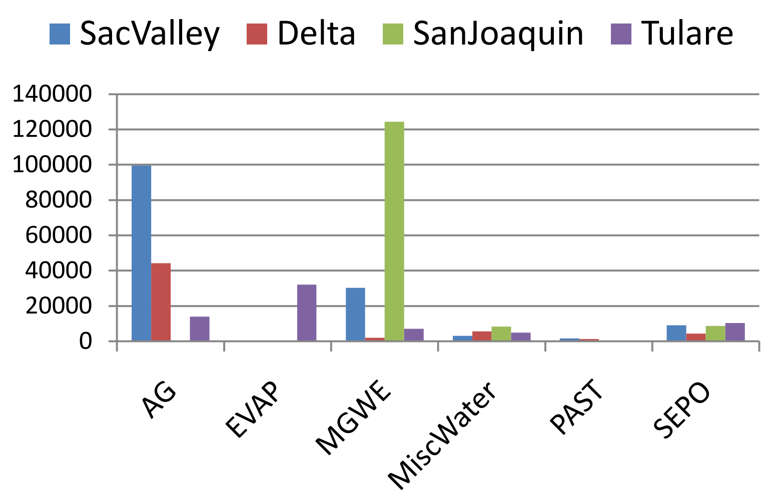


Figure 4. Distribution of wetland habitat in the CVC that was flooded in at least 30% of years during early winter (November – January) between 2000 and 2010.

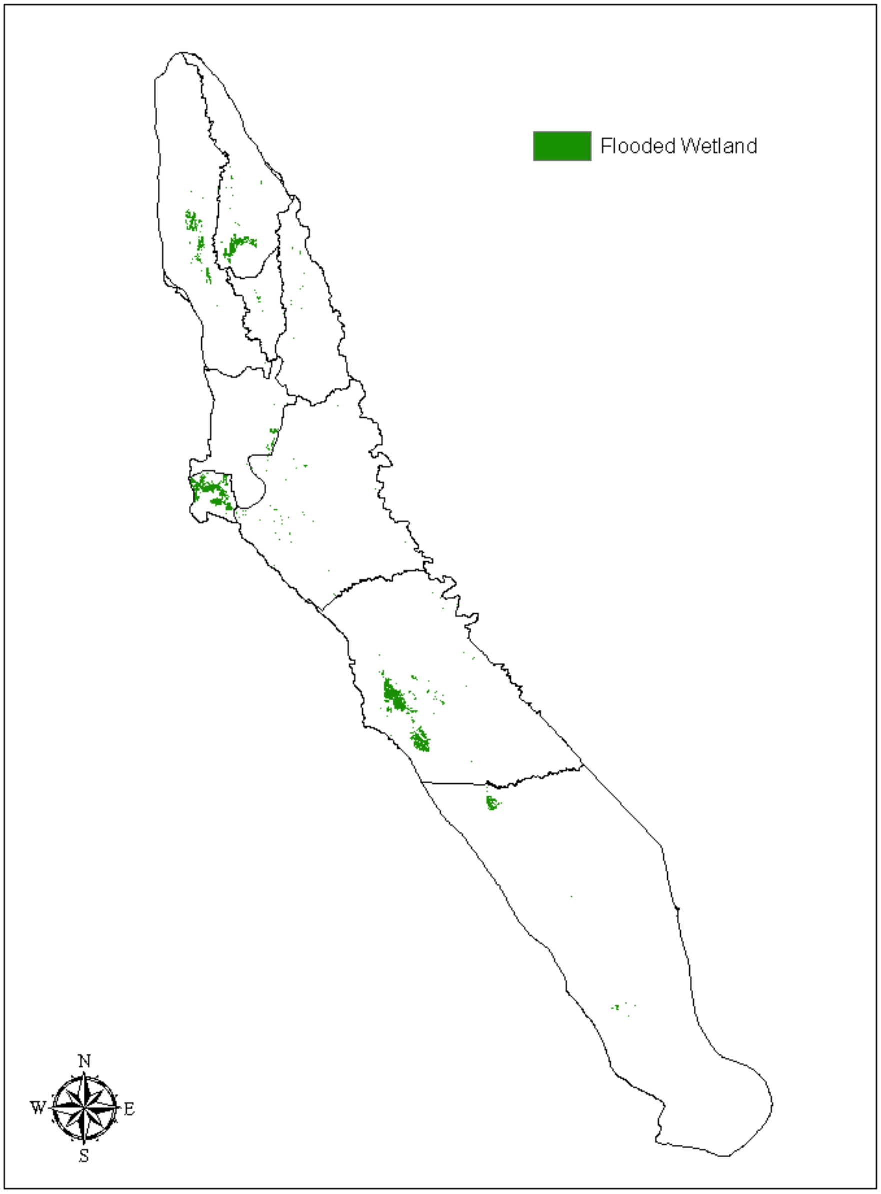
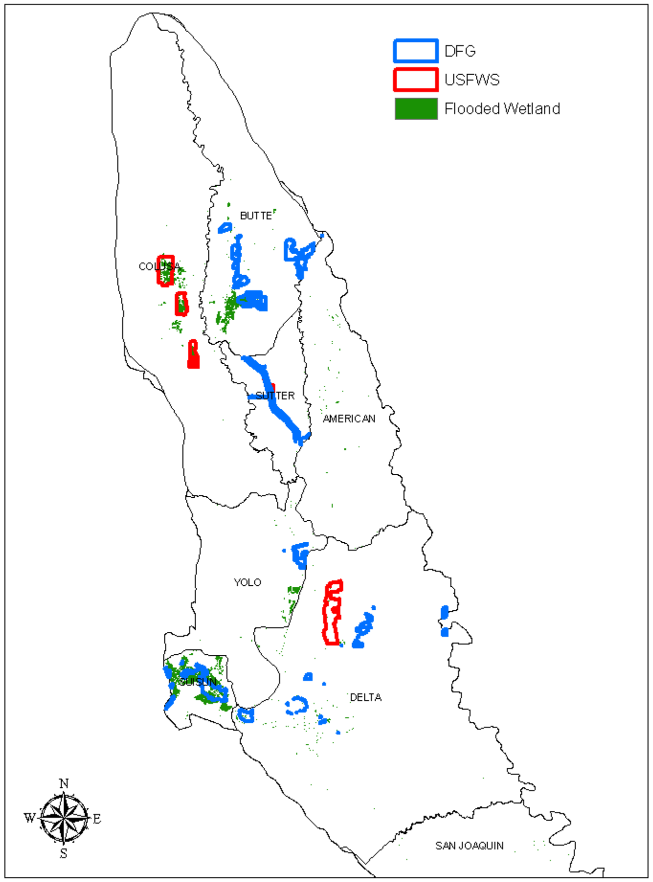


Figure 5. Distribution of state wildlife areas and federal wildlife refuges with flooded wetland habitat in the northern and southern regions in the CVC.

A



B

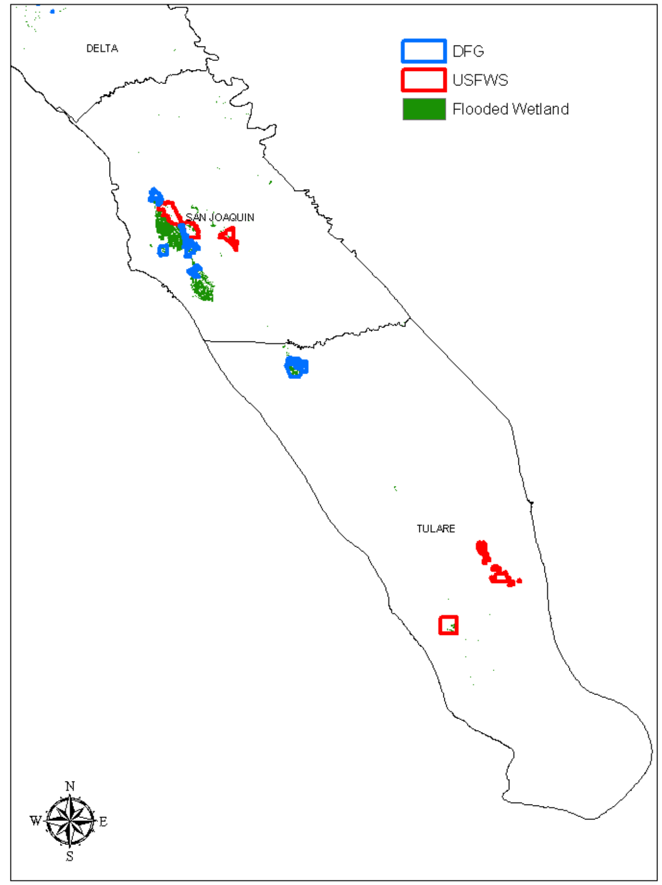


Figure 6. Distribution of (A) flooded agriculture during early winter (November – January) in 2000 – 2010 and (B) sample blocks selected for monitoring in the CVC. Priority values represent the proportion of the township block that has flooded agriculture. Blocks sampled in 2010 are indicated in bold.

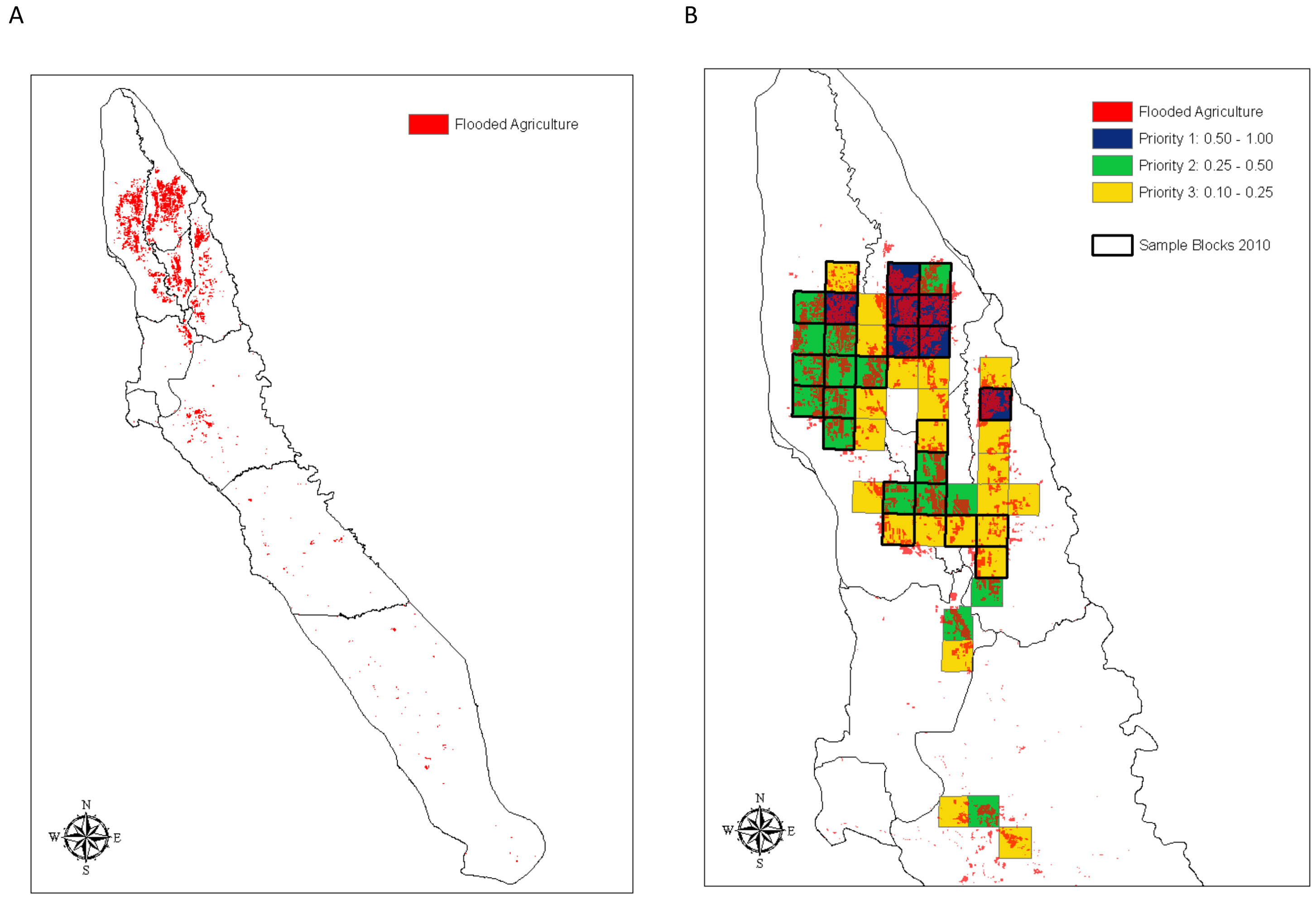
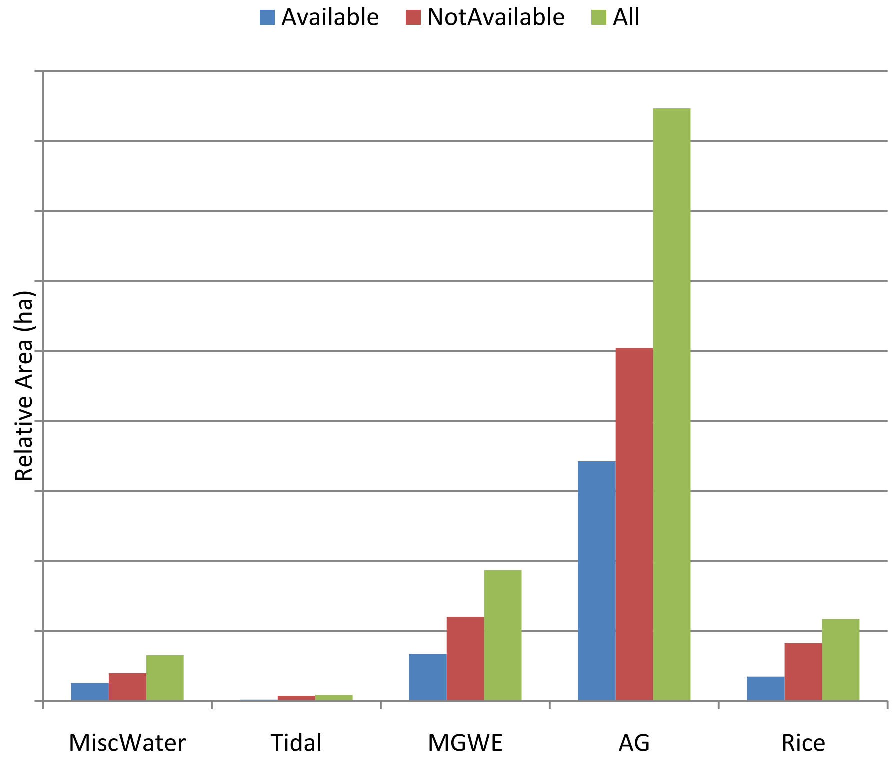


Figure 7. Relative abundance of shorebird habitat (ha) in the CVC and the percentage of each habitat that is accessible. Accessible is all habitat on public lands or < 161m from a public road.



APPENDIX I:

PROTOCOLS

Protocol for Surveying Shorebirds along Road Transects

PLEASE READ: *The usefulness of data collected as part of these surveys requires that all observers closely follow the protocol outlined here. Please read the protocol and associated documents thoroughly before conducting a survey. If you have any questions please contact Khara Strum (kstrum@prbo.org). Thank you in advance for your hard work and enthusiasm for birds.*

PURPOSE

These surveys are designed to obtain data on annual variation and long-term trends in wintering shorebird use of the agricultural and wetland landscapes in the Central Valley of California. These data will be combined annually with shorebird survey data from across California and the Pacific Flyway. We will assess spatial and temporal patterns of shorebird abundance at a scale larger than the Central Valley habitats which will allow for trends observed along our road transects to be put into a broader context.

SURVEY DESIGN

Each survey consists of a series of fixed-radius area searches for shorebirds at specified survey locations. Observers will drive a predefined 10-mile route (please see appropriate road transect map) to each of 20 survey locations. Survey locations are located approximately 0.5 miles along the route. In the process of developing the survey routes, the survey locations were evaluated for safety and visibility. Some locations have been adjusted away from the 0.5 mile locations and this is noted in the survey route description. At each survey location, an observer will count all shorebirds and raptors within a 0.1 mile radius (see "PFSS_SpeciesList.pdf").

SURVEY PROTOCOL AND DATA COLLECTION

**Surveys should not be conducted in weather with winds >24 mph (>5 on scale below), heavy fog (<200m visibility), or steady rain.

**Surveys should be conducted by one observer. Having multiple observers counting simultaneously may bias results. We recommend working in pairs where one person counts birds and a second person records data.

** Please get out of your vehicle to conduct counts.

**Read accompanying datasheet along with this protocol.

** We encourage you to drive your survey route prior to the day of the survey to familiarize yourself with the route and assess potential obstructions and/or route diversions.

****THINK SAFETY** Some survey routes will be along gravel roads with low traffic volume, others will be along main roads with highway speeds where we feel there are adequate pull-offs for conducting surveys. The increased speed and traffic volume of some roads make them more hazardous. When conducting surveys please use the following common sense rules:

- Use hazards when driving below the speed limit or looking for pull-out
- Wait until traffic has cleared before moving around your vehicle
- Do not enter private property even if it improves your view
- Finally, do not survey if it is not safe!

Conduct each count from the pre-defined survey location along the survey route (see Road Transect map). *It is critical to the validity of the analyses that the survey occur at the same survey location each year*. *Please do your very best to insure that this occurs by following the narrative associated with each survey route that details the route and pull-outs*. Each survey location is associated with an area ("survey area") defined by a 0.1 mile (160-meter) radius circle around the survey location. This will include area on both sides of the road. Birds should only be counted if the occur within the survey area.

We recommend that observers calibrate their distance estimates prior to conducting surveys. The radius distance (0.1 mile) can most easily be estimated by stopping at an obvious landmark (such as a telephone pole), driving 0.1 mile, then getting out of the vehicle and looking back at the starting landmark. Do this several times to get a sense of what 0.1 miles looks like in the field. You can then test yourself by predicting where 0.1 miles should be in front of you, then drive to that point and see if it was 0.1 mile. With practice, observers will get used to estimating the distance.

Begin each count of a survey area by indicating the **start time** on the datasheet (24-hr clock; e.g. 3PM = 1500). Then count and identify to species all shorebirds using each survey area. This <u>includes birds that enter or leave</u> the survey area during the count. For a shorebird to be considered "using" the survey area, it needs to be on the ground within the defined survey area for at least part of the time it takes to do the survey. Thus, shorebirds that fly over the survey area but do not land in the survey area should <u>NOT</u> be counted. Try not to double count shorebirds if they leave and then re-enter the survey area. Also, record the number and species of raptors that are in, perched adjacent to, or soaring over the survey area.

Survey areas that appear to have 0 birds should be scanned for 2 minutes before continuing to the next survey location on the route. Although there is no maximum time limit for counting birds, once all birds in the survey area have been recorded, the count is considered complete. At that point, note the **end time** on the datasheet and thereafter <u>NO</u> additional birds should be recorded for that survey area. It may be helpful to split survey effort to each side of the road. However, birds recorded on one side of the road should not be counted again on the other side of the road, if they move.

Species are recorded in the appropriate column of the datasheet. Regardless of whether the observer tracks sub-tallies in the **tally** column for each species (see “PFSS_RecTips.pdf” for sub-tally techniques), ONLY the total number of each species observed during the count of each survey area should be entered into the **Count** column. It usually will be possible to make exact counts of small groups of birds (<50 individuals), but estimation may be needed for larger flocks. Please see the accompanying document (“PFSS_HowToCount.pdf”) for recommendations on counting techniques and estimating the abundance of birds in flocks.

Because of poor lighting, quick or distant views, similarity of species, or other factors, it may not be possible to identify a few or, sometimes, even large numbers of shorebirds. If individual species cannot be identified and counted within a flock, note the species that are in the flock and estimate the total flock size. Even better, estimate the proportion or the ratio of the species in a flock and use this along with the total in the flock to estimate the number of each species. If the proportion of each species CANNOT be determined, species should be recorded as a mix of the species identified in the flock. Please see the species list provided (“PFSS_SpeciesList.pdf”) for commonly recorded mixed-species flocks.

To sum up in preferred order:

- Identify species and their abundance (i.e. 148 Western Sandpipers, 153 Dunlin, 308 Least Sandpipers)
- Estimate the proportion of species in flock (i.e. 600 birds: 25% Western Sandpipers, 25% Dunlin, 50% Least Sandpipers) and use the proportions and total flock size to calculate the total of each species (150 Western Sandpipers, 150 Dunlin, 300 Least Sandpipers).
  **This is not necessarily preferable to below if the proportions are highly inaccurate. Please use a mixed-species code if necessary.
- Estimate size of flock and species present (i.e. 600 birds, composed of Western Sandpipers, Dunlin and/or Least Sandpipers) – use appropriate mixed species code to record data and enter into CADC.

Following bird observations, please fill out the remainder of the datasheet completely, including **Date** (mm/dd/yyyy), **Observer** who counted birds (full name), and Site Conditions (e.g. **weather, habitat;** see below) before proceeding to the next survey location. Data should be recorded on a separate datasheet for each unique **Survey Location** along a **Transect.**

WHAT TO TAKE IN THE FIELD:

Site Map(s)
Protocol
Datasheets
Species list
Pencils or Permanent Ink Pen (NO ballpoint pens)
Binoculars
Scope and tripod
Watch

Sunscreen
Water
Field guide

DATA ENTRY

Data should be entered directly into the CVSS project in CADC within a few days of the survey. If you have not registered for a CADC account please see http://data.prbo.org/apps/pfss for instructions on how to register with CADC and enter data.

SHOREBIRD SPECIES IDENTIFICATION

View or download instructional shorebird identification materials at PRBO's Pacific Flyway Shorebird Survey website: http://data.prbo.org/apps/pfss/.

Area Search Protocol for Shorebirds in the Central Valley

PLEASE READ: *The usefulness of data collected as part of these surveys requires that all observers closely follow the protocol outlined here. Please read the protocol and associated documents (area description(s), map(s), and data forms) thoroughly before conducting a survey. If you have any questions please contact Matt Reiter (mreiter@prbo.org). Thank you in advance for your hard work and enthusiasm for birds.*

PURPOSE

These surveys are designed to obtain data on annual variation and long-term trends in wintering shorebird use of wetland habitat in the Central Valley of California. These data will be combined annually with shorebird survey data from across California and the Pacific Flyway to assess spatial and temporal patterns of shorebird abundance at a scale larger than localized wetland habitat in the Central Valley. This will allow for trends observed in the Central Valley to be put into a broader context of shorebird populations.

SURVEY DESIGN

These surveys consist of searching a set of pre-defined wetland survey areas for all shorebirds present identify them to species and estimating their abundance. Surveys will be conducted once annually during the survey window (November 15 – December 15), and efforts will be made to coordinate the timing of these surveys across individual wetland complexes (e.g. San Luis National Wildlife Refuge). Surveys will be conducted along a specified survey route. Data are collected within pre-defined wetland units along this route.

SURVEY PROTOCOL AND DATA COLLECTION

**Surveys should NOT be conducted in weather with winds >24 mph (>5 on scale below), heavy fog (<200m visibility), or steady rain, or when dirt roads are saturated and impassable from prior rains.

**Surveys should be conducted by one observer. Having multiple observers counting simultaneously may bias results. We recommend working in pairs where one person counts birds and a second person records data.

**Read accompanying datasheet along with this protocol.

** Please get out of your vehicle to conduct counts.

** If possible, we urge you to visit your survey area(s) prior to the day of the survey so you are certain how to easily survey them.

** Some areas require access keys and permits. Make sure to know if this applies to you.

Begin each count of each survey route by indicating the **start time** on the datasheet (24-hr clock; e.g. 3PM = 1500). Then proceed in your vehicle along survey route to each primary survey area within each wetland unit defined in the “Survey Route Narrative” document. The primary survey area within each wetland unit is defined by a boundary at 0.1 miles (~160m) from the survey route road.

Count and identify to species all shorebirds using each primary survey area within each wetland unit indicated on the route map and on the datasheet. This includes birds that enter or leave the survey area during the count. For a shorebird to be considered “using” the survey area, it needs to be on the ground within the defined survey area for at least part of the time it takes to do the survey. Thus, shorebirds that fly over the survey area but do not land in the survey area should NOT be counted. Try not to double count shorebirds if they leave and then re-enter the survey area. Also, record the number and species of raptors that are in, perched adjacent to, or soaring over the survey area.

Species are recorded separately for each primary survey area within a wetland unit in the appropriate location on the datasheet. The datasheet has been organized by the wetland units you will encounter along the transect to help keep data organized. It usually will be possible to make exact counts of small groups of birds (<50 individuals), but estimation may be needed for larger flocks. Please see the accompanying document (“PFSS_HowToCount.pdf”) for recommendations on counting techniques and estimating the abundance of birds in flocks.

Survey areas that appear to have 0 birds should be scanned for at least 2 minutes before continuing to the next survey location on the route. Although there is no maximum time limit for completion the survey route, once all birds in the survey areas along a route have been recorded, the count is considered complete. At that point, note the **end time** on the datasheet and thereafter NO additional birds should be recorded for that survey route. When there are wetland units on both sides of the road that are both being surveyed, birds recorded on one side of the road should not be counted again on the other side of the road, if they move. To minimize bias due to bird movement please survey wetland units along both sides of the road during one pass along the route. Do not survey one side of the road traveling in one direction and then turn around the other side of the road on the return trip through the route.

Because of poor lighting, quick or distant views, similarity of species, or other factors, it may not be possible to identify a few or, sometimes, even large numbers of shorebirds. If individual species cannot be identified and counted within a flock, note the species that are in the flock and estimate the total flock size. Even better, estimate the proportion or the ratio of the species in a flock. If the proportion of each species is determined this should be used along with the total in the flock to estimate the number of each species. If the proportion of each species CANNOT be determined species should be recorded as a mix of the species identified in the flock. Please see the species list provided (“PFSS_Species.pdf”) for commonly recorded mixed-species flocks.

Try to count or estimate numbers by whatever technique works best as listed here in order of preference:

- Identify species and their abundance (i.e., 148 Western Sandpipers, 153 Dunlin, 308 Least Sandpipers)

- Estimate the proportion of species in flock and use the proportions and total flock size to calculate the total of each species (i.e., 600 birds: 25% Western, 25% Dunlin, 50% Least = 150 Western, 150 Dunlin, and 300 Least) **This is not necessarily preferable to below if the proportions are highly inaccurate. Please use a mixed-species code if necessary.
- Estimate size of flock and species present (i.e., 500 birds, composed of Western, Dunlin, and Least.).

Following bird observations on the survey transect, please fill out the remainder of the datasheet completely, including **Date** (mm/dd/yyyy), **Observer(s)** who counted birds (full name[s] – multiple observers should only be recorded if observers changed during the route as their should only be one observer for a primary survey area), **Total observers** (number of people counting birds), and **site conditions** (see below). Please fill out site condition data **<u>even if no birds were detected in the wetland unit</u>**. This will help us determine the total effort expended during each survey and knowing that zero birds were observed is important data too.

SITE CONDITION PROTOCOL

June 28, 2011

PLEASE READ: *Site Conditions should be recorded for each sampling unit surveyed as indicated on the data form. The usefulness of data collected as part of these surveys requires that all observers closely follow the protocol outlined here. If you have any questions please contact Khara Strum (kstrum@prbo.org).*

WEATHER

Wind speed (**Wind**):

**Do not conduct surveys when wind speed is > 24mph (category 5 below).*

0 – *calm*: smoke rises vertically (<1 mph)
1 – *light air*: smoke drifts (1 – 3 mph)
2 – *light breeze:* felt on face, leaves rustle (4 – 7 mph)
3 – *gentle breeze*: leaves and small twigs in constant motion (8 – 12 mph)
4 – *moderate breeze*: dust, leaves, and loose paper rise up; small branches move (13 – 18 mph)
5 – *fresh breeze*: small trees sway (19 – 24 mph)
6 – *strong breeze*: large branches in motion (25 – 30 mph)

Cloud cover (**Cloud**):
Enter numeric percentage (0 – 100)

Precipitation (**Precip**):
0 – none
1 – light intermittent; mist, sprinkle, drizzle
2 – fog
3 – steady rain
(NOTE: surveys should not be conducted in heavy rain but if there if the survey is conducted despite some rain please record 3 for this code).

HABITAT

Dominant Cover Type (**Type**):
*Record the cover type that best describes the dominant characteristic of the survey area. Please attempt to describe the survey area using only 1 of the descriptions below.

1 – *Wetland*: open water with tules, cattails, and some grasses and sedges.
2 – *Rice:* flooded or dry field with clearly defined internal levees; if dry, the field may be tilled or have standing stubble.
3 – *Pasture*: predominantly grasses; if irrigated it will be green year round.
4 – *Hay*: various types of grass/herbs mowed and cured for fodder.
5 – *Irrigated Row Crop:* likely dirt field with raised beds or with standing stubble (e.g. corn, tomatoes, cotton)
6 – *Winter crop*: emergent green vegetation from tilled soil (e.g. winter wheat)
7 – *Freshwater Lake / Pond*: large body of freshwater including reservoirs
8 – *Evaporation Pond*: settling pond constructed to collect agricultural wastewater
9 – *Wastewater Pond*: pond associated with wastewater treatment facility
10 – *Orchard:* trees (e.g. almonds, apples etc.)
11 – *Forest*: extensive woody vegetation, non-agricultural (e.g. willows in riparian)
12 – *Developed*: houses, cemetery, parking lot, etc.

13 – *Salt pond:* impounded water without vegetation around an estuary
14 – *Tidal marsh:* tidally flooded marsh with vegetation
15 – *Tidal Flat:* areas of exposed mud below high tide level with <5% vegetation cover
16 – *Beach*
17 – *Rocky shoreline*
18 – *Agriculture field* (non-orchard) includes categories 3, 4, 5 and 6 from above. Use this category only when unable to determine a more specific field type.
99 – *Other*: describe in notes

Area Surveyed (**Visible Area**):
**Because wintering shorebirds can only be detected through visual observation, visual obstructions (e.g. levee, tall vegetation, distance) may limit your ability to survey some portions of the survey area from the survey location.*
Please indicate the percentage of the survey area you could see and subsequently count.
Enter numeric percentage (0 – 100)
-or-
U– Cannot Determine

<u>The following 3 variables (PercFlood, PercBare, PercVeg) should not sum to >100.</u>
Percent of visible area with open standing water (**PercFlood**)
Enter numeric percentage (0 – 100)
-or-
U– Cannot Determine

Percent of visible area with bare ground (**PercBare**)
Enter numeric percentage (0 – 100)
-or-
U– Cannot Determine

Percent of visible area with vegetation (**PercVeg**)
Enter numeric percentage (0 – 100)
-or-
U– Cannot Determine

Vegetation Height (**VegHt**)
*Visual estimate of the average vegetation height in the visible survey area. If the survey area is flooded, estimate the height of the vegetation emerging from the water.
0: Bare
1: 1 – 6 in.
2: >6 – 12 in.
3: >12 – 18 in.
4:>18 – 24 in.
5: >24 in.

PACIFIC FLYWAY SHOREBIRD SURVEY SPECIES LIST

The following list contains species that you are likely to see during winter shorebird surveys within California. This list is NOT comprehensive and we ask that you record all shorebirds (suborder: Charadrii) that you identify. The California Avian Data Center (CADC) will allow you to look up the "Species Code" for species that are not listed here (see "PFSS_CADCprotocol.pdf"). Most protocols, as part of PFSS, ask that you only record shorebirds and diurnal raptors. These species are listed first as "Primary Species". Additional species that may be counted as part of other protocols are listed below as well.

SECTION I: PRIMARY SPECIES

SHOREBIRDS

Species	Species Code
Black-bellied Plover	BBPL
American Golden-Plover	AMGP
Pacific Golden-Plover	PAGP
Snowy Plover	SNPL
Semipalmated Plover	SEPL
Killdeer	KILL
Mountain Plover	MOPL
Black Oystercatcher	BLOY
Black-necked Stilt	BNST
American Avocet	AMAV
Spotted Sandpiper	SPSA
Solitary Sandpiper	SOSA
Wandering Tattler	WATA
Greater Yellowlegs	GRYE
Lesser Yellowlegs	LEYE
Greater/Lesser Yellowlegs	XYEL
Willet	WILL
Whimbrel	WHIM
Long-billed Curlew	LBCU
Whimbrel/Curlew	XNUM
Marbled Godwit	MAGO
Curlew/Godwit	XCGO
Whimbrel/Curlew/Godwit	XWCG
Godwit/ Whimbrel/Willet/Curlew	XWNG
Ruddy Turnstone	RUTU
Black Turnstone	BLTU
Surfbird	SURF
Red Knot	REKN

Sanderling	SAND
Semipalmated Sandpiper	SESA
Western Sandpiper	WESA
Least Sandpiper	LESA
Baird's Sandpiper	BASA
Pectoral Sandpiper	PESA
Rock Sandpiper	ROSA
Dunlin	DUNL
Western/Least Sandpiper	XWLS
Western/Least/Dunlin	XWLD
Stilt Sandpiper	STSA
Ruff	RUFF
Short-billed Dowitcher	SBDO
Long-billed Dowitcher	LBDO
Short-billed/Long-billed Dowitcher	XDOW
Wilson’s Snipe	WISN
Wilson's Phalarope	WIPH
Red-necked Phalarope	RNPH
Red Phalarope	REPH
Wilson's/Red-necked Phalarope	XWRP
Wilson's/Red-necked/Red Phalarope	XPHL

DIURNAL RAPTORS

Species	Species Code
Turkey Vulture	TUVU
Osprey	OSPR
White-tailed Kite	WTKI
Bald Eagle	BAEA
Northern Harrier	NOHA
Sharp-shinned Hawk	SSHA
Cooper's Hawk	COHA
Unidentified Hawk	XXHA
Red-shouldered Hawk	RSHA
Swainson's Hawk	SWHA
Red-tailed Hawk	RTHA
Ferruginous Hawk	FEHA
Rough-legged Hawk	RLHA
Golden Eagle	GOEA
American Kestrel	AMKE
Merlin	MERL
Peregrine Falcon	PEFA
Prairie Falcon	PRFA

TIPS FOR COUNTING SHOREBIRDS

This document includes information to help with identifying shorebirds, counting multi-species flocks, counting techniques, keeping track of where you are, and handling field difficulties. Because most non-breeding shorebirds occupy unvegetated or sparsely-vegetated habitat in which they can be easily observed, the accepted method of estimating their abundance in an area is to count them directly through visual observation. This requires that a person conducting an area survey (an observer) possess two important skills, in addition to being familiar with the survey protocol: (1) the ability to ***readily*** identify all species likely to occur in the area, and (2) the ability to count the number of each species present.

Identifying Shorebirds. Attending field trips led by experienced observers is a good way to learn shorebird identification; these are often offered by local Audubon, natural history societies, colleges, adult education programs, and PRBO Conservation Science (see http://data.prbo.org/partners/pfss/). Practicing on your own with one of the many good field guides available is essential to honing your skills. If you are a beginner, ultimately, you will need to go out with an experienced observer to validate your identification skills. Observers must develop a slightly different set of skills than casual bird watchers because they are counting all the birds in an area, not just those that are conveniently near or well lit for viewing. You may need to identify shorebirds that are in silhouette, shorebirds that are tightly packed in a roosting flock, or very large numbers of shorebirds in mixed flocks. You need to be able to identify them fairly rapidly, before they have a chance to move or fly; this is particularly an issue where raptors are active. Familiarity with the subtle differences in the shape, posture, behavior, and coloring between species is invaluable during a census.

Counting techniques. Direct counting is useful for low numbers of birds, and estimation is essential for large flocks. Some techniques involve a combination of counting and estimation. It is not unusual in the middle of a census to have shorebird flocks fly up, circle in the air, and land again; they may land where they previously arose, may land to join a nearby flock, or may leave the immediate area. Rising or falling tide levels, human disturbance, and raptors in the areas may cause this to happen multiple times during a census. In order to obtain counts before flock movement causes you to have to start counting over again, you need to balance the need for highly refined counts with the need to complete the count quickly.

For fewer than 50, or widely scattered, shorebirds you probably will count individual birds. This may not be the most accurate count method for large flocks because of flock movement. With larger flocks, you should start at one side of the flock and count 5, 10, 20, or 50 shorebirds at a time. Once you have a good idea of what, say, 20 birds look like in that flock, you can count the remainder of the flock in groups of 20 birds. For very large flocks, it may be necessary to count in much larger multiples. After you have conducted many surveys you will hone your ability to quickly estimate group sizes of birds.

However, it always is useful to count out bird groups in the beginning of each survey, as a defense against developing estimating biases.

Counting shorebirds in multi-species flocks. When beginning a survey of shorebirds at a site you must quickly decide whether to count all the birds together or scan the flock successively for each species present. With experience you will learn which method is most efficient for you, given the abundance, species composition, and dispersion of the shorebirds. Mixed species assemblages may be present as two or more species in relatively equal abundance, as predominantly one species with a few uncommon species, or some combination. We recommend having a recording assistant to whom you can enumerate the uncommon species as you maintain a running count of the most common species while you scan the flock. With experience, you may learn to count more than one species simultaneous as you are scanning or you may develop your own technique for handling multiple species counts.

Keeping track of where you are is essential when you are conducting a survey. Few areas can be covered from a single vantage point and you will have to move between points to count all birds. It often is difficult to relocate where you left off counting from a new vantage point, so think about all possible clues you will be able to use from your next location. Geographically distinct points in the wetland or background habitat (think about what it will look like from your next vantage point), a break in the flocks, or an individual of an uncommon species can be used to mark where you have left off counting. Move quickly to the next vantage point, locate where you left off, and begin counting.

Recording shorebird counts in the field involves counting multiple species, keeping track of where you are in the flock, and writing it all down. The way you keep your written field records will determine how difficult it is to tally a final count afterwards. On a separate handout (“PFSS_RecTips.pdf”), there are some tips on recording your data in the field. However, to minimize recording errors it is best if a second person can serve as the data recorded.

Some other techniques you may find useful:

- Obtaining an initial impression of the numbers of shorebirds you will be counting can be very useful if a survey is interrupted because the birds have flown out of easy viewing range. When you first arrive at a viewing location, make on-the-spot order of magnitude estimates of the numbers of at least the most abundant species.
- Order of magnitude estimates (OMEs) can be based on powers of ten, using arithmetic divisions of low, mid, or high ranges. With this method, if there were more than 9 but fewer than 100 shorebirds, you would estimate either low tens (10-39), mid-tens (40-69), or high tens (70-99); estimates are similar for low, mid, or high hundreds (100-399, 400-699, 700-999), thousands, and so on.
- If you are training or refreshing yourself in counting methods, you might make OMEs first, then count the birds you’ve spot estimated, to check and refine your estimating accuracy.

Tally your survey total for each species, on the day you conduct the survey. If there are any uncertainties or errors in what you wrote in the field, you will best be able to decipher or catch them when the survey is fresh in your mind. See “PFSS_DataEntry.pdf”.

TIPS FOR RECORDING COUNTS IN THE FIELD

Version 2 - September 22, 2010

Be sure that the way you record shorebird counts in the field doesn't confuse you when you tally the final counts afterwards. Here are some commonly used recording techniques that you can try to keep your notes readable when you are hurriedly trying to get it all down on paper.

For species that occur in large flocks, counts of birds are commonly recorded as numbers separated by a "+" or a "," or blank space:

225 + 48 + 677 + 32 OR 225, 48, 677, 32 OR 225 48 677 32

When you record this way, be sure that commas are distinguishable from "1"s, plus signs cannot be mistaken for numbers, and that blanks are wide enough to unambiguously separate numbers.

For species that are counted in smaller multiples, symbolic recording techniques may be helpful. Below are two that are commonly used. If, for some species, you use both numbers and symbols, physically separate them on the recording sheet.

❶ Most people are accustomed to crossed slashes for tallying in groups of 5, where:

1 = I 2 = II 3 = III 4 = IIII 5 = ┼┼┼┼

You can take shortcuts with this method. For example, if you have already tallied two (II) and you next see three, you could simply cross the vertical slashes (┼┼─), knowing that every horizontal slash indicates 5, even if it crosses fewer than 4 verticals. We use the X (Roman numeral) symbol within this system to indicate 10, and C to indicate 100. ***Do not intersperse this symbolic method with regular numbers***, where eleven is indicated as 11 (use X I in tally form) or one hundred eleven as 111 (use C I in tally form).

❷ Ten birds also can be accumulated with a symbolic combination of dots and connecting lines. You keep adding them till you have an X inside a box. The first through the fourth birds are indicated by dots at the four corners of a square: 1 = . 2 = . . 3= : . 4 = ::

The next four birds are indicated by connecting the dots: 5= I : 6 = I I 7 = Π 8 = □

The ninth and tenth birds are added with the two diagonal slashes to create an X within the box (**%** and ☒).

APPENDIX II

CALIFORNIA AVIAN DATA CENTER

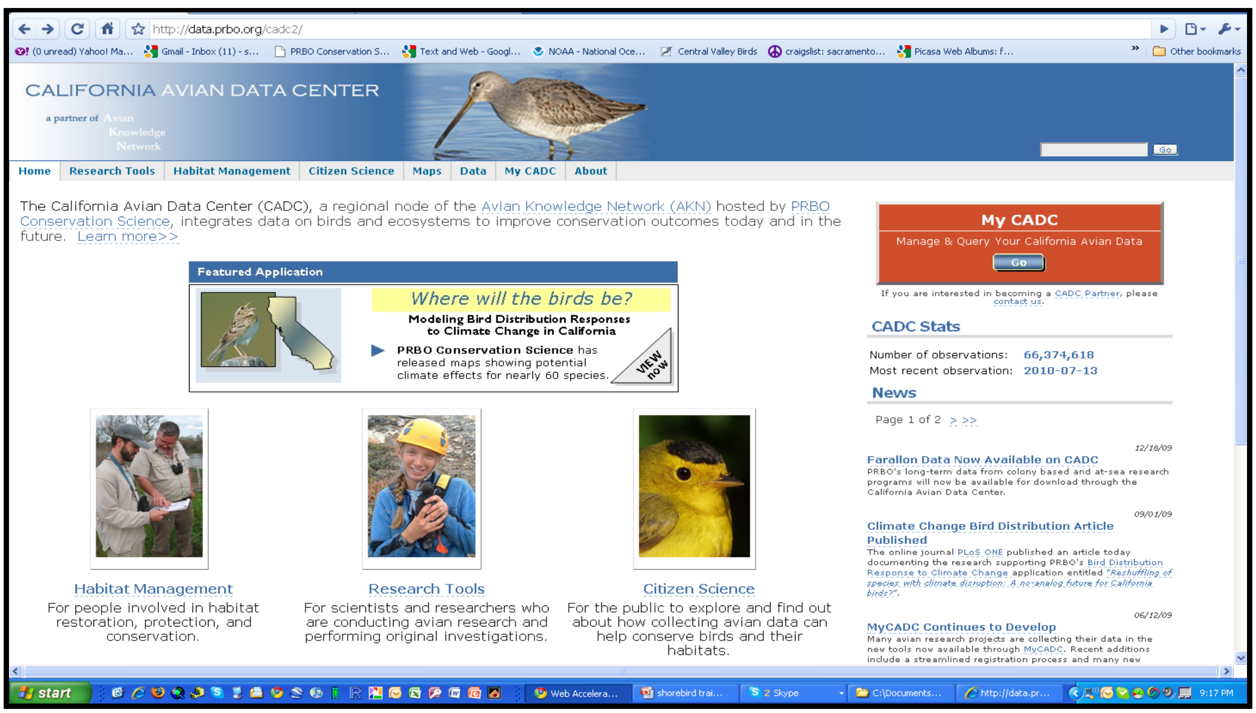
REGISTRATION & DATA ENTRY

October 1, 2010

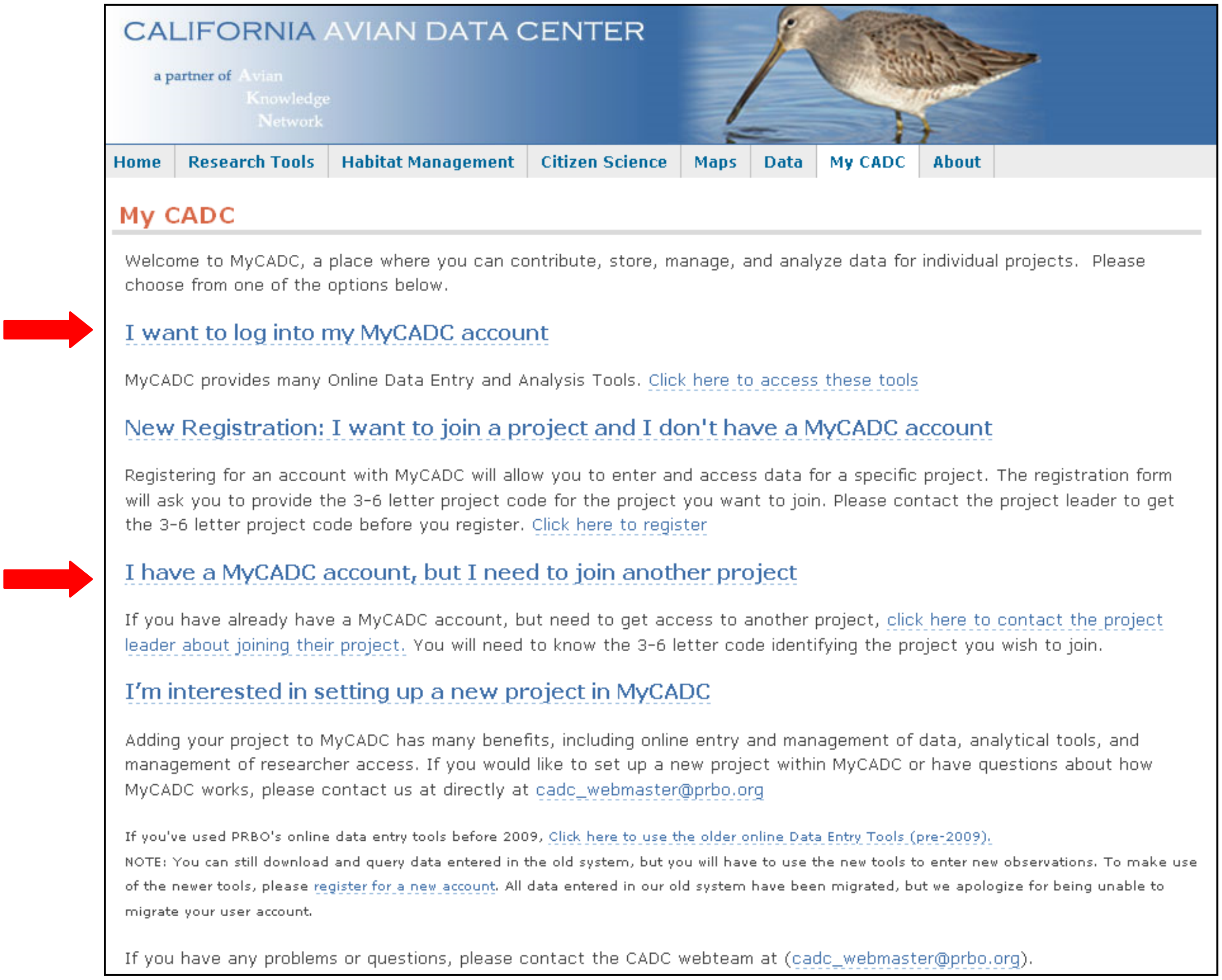
TO REGISTER

First time users must first register and create and user name and password.

1. Go to www.prbo.org/cadc
2. Click on the blue "**Go**" button in the red box in the upper right hand part of the page.



3. Select the appropriate selection on the next screen (below). Most will select "New Registration: I want…". However if you already have a MyCADC account you may join additional projects by selecting "I have a MyCADC account, but…".



CALIFORNIA AVIAN DATA CENTER

a partner of Avian Knowledge Network

Home | Research Tools | Habitat Management | Citizen Science | Maps | Data | My CADC | About

My CADC

Welcome to MyCADC, a place where you can contribute, store, manage, and analyze data for individual projects. Please choose from one of the options below.

I want to log into my MyCADC account

MyCADC provides many Online Data Entry and Analysis Tools. Click here to access these tools

New Registration: I want to join a project and I don't have a MyCADC account

Registering for an account with MyCADC will allow you to enter and access data for a specific project. The registration form will ask you to provide the 3-6 letter project code for the project you want to join. Please contact the project leader to get the 3-6 letter project code before you register. Click here to register

I have a MyCADC account, but I need to join another project

If you have already have a MyCADC account, but need to get access to another project, click here to contact the project leader about joining their project. You will need to know the 3-6 letter code identifying the project you wish to join.

I'm interested in setting up a new project in MyCADC

Adding your project to MyCADC has many benefits, including online entry and management of data, analytical tools, and management of researcher access. If you would like to set up a new project within MyCADC or have questions about how MyCADC works, please contact us at directly at cadc_webmaster@prbo.org

If you've used PRBO's online data entry tools before 2009, Click here to use the older online Data Entry Tools (pre-2009).
NOTE: You can still download and query data entered in the old system, but you will have to use the new tools to enter new observations. To make use of the newer tools, please register for a new account. All data entered in our old system have been migrated, but we apologize for being unable to migrate your user account.

If you have any problems or questions, please contact the CADC webteam at (cadc_webmaster@prbo.org).

4. Enter the information requested on the following page.

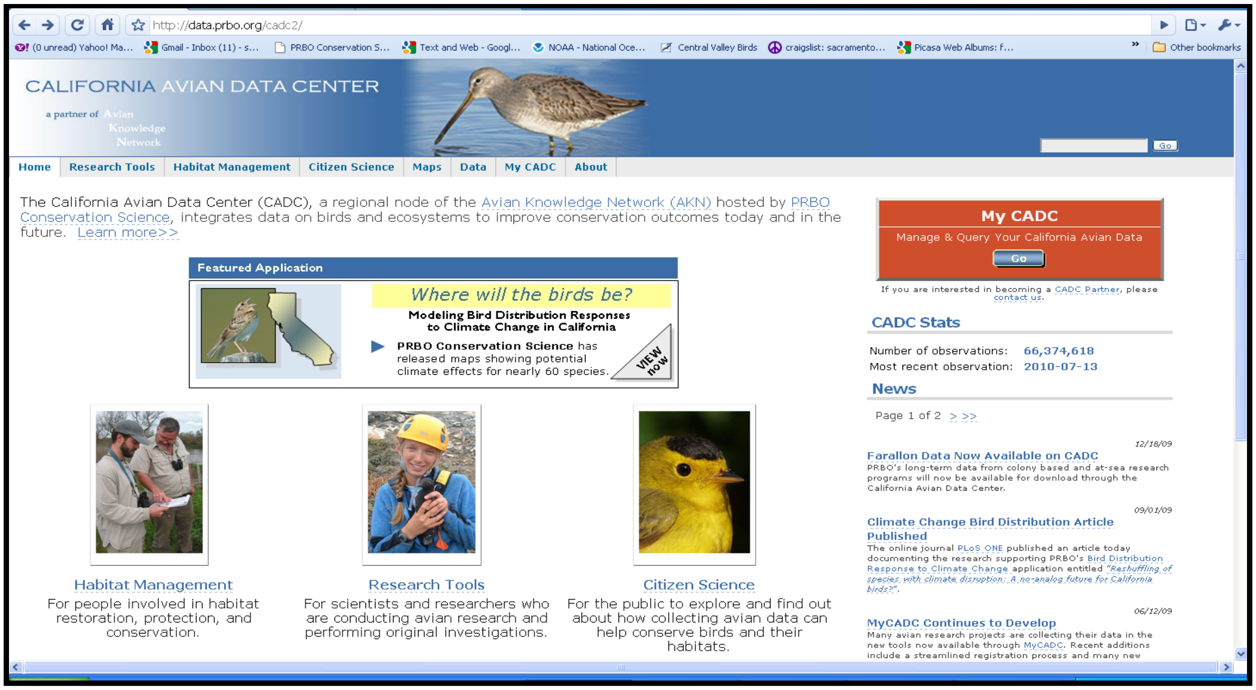
*****Note:*** In Step 5 of the registration process when asked "Please enter the project you would like to join", enter **XXXX. (*Project code here*)**

After completing the registration page, an email from "no-reply@prbo.org" will be sent to the email account you entered. You will need to click the link provided in the email in order to complete your registration. The link will expire in 24 hours and you will have to re-register. If you do not receive your confirmation email promptly, check your junk or spam folder. After checking your spam folder, if you did not receive an email from no-reply@prbo.org please contact CADC help at "cadc_webmaster@prbo.org" with your name and email address used to register.

TO ENTER DATA:

A. Log-In

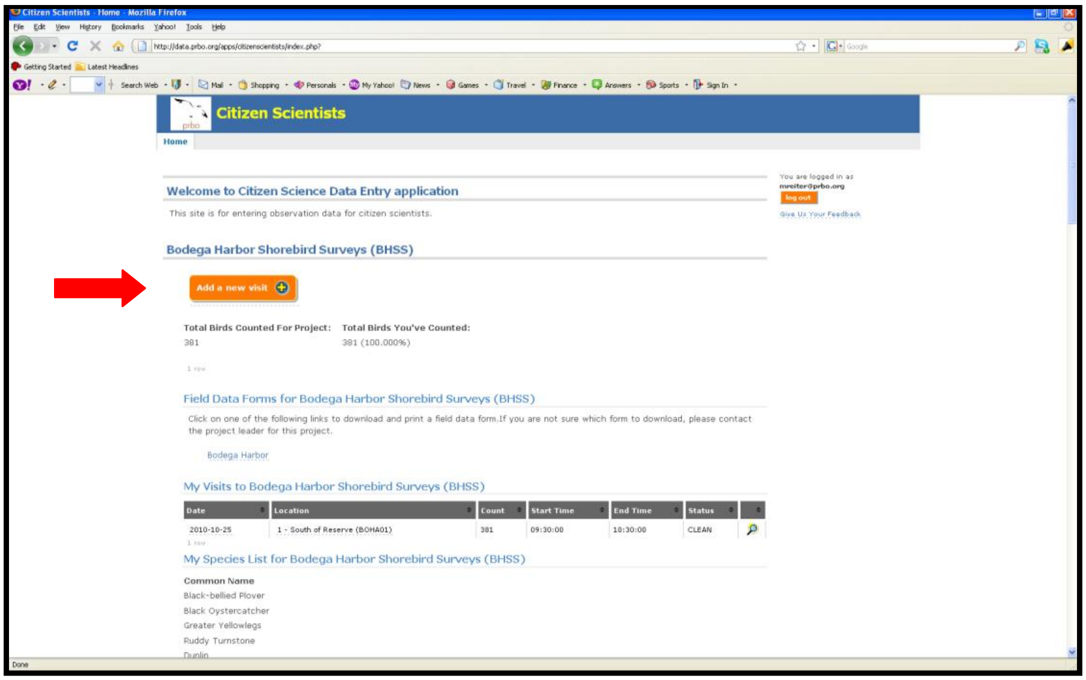
1. Go to www.prbo.org/cadc
2. Click on the blue "**Go**" button in the red box in the upper right hand part of the page (see below).



3. Next page, click on the link that says I want to log into MyCADC account
4. Next page, click on the link that says Citizen Scientists
5. Next page, enter email address and press enter
6. Next page, enter your password and press Log On

B. Select Project

Once you are logged-on, all the projects that you are associated with will show-up on the screen (see below.)



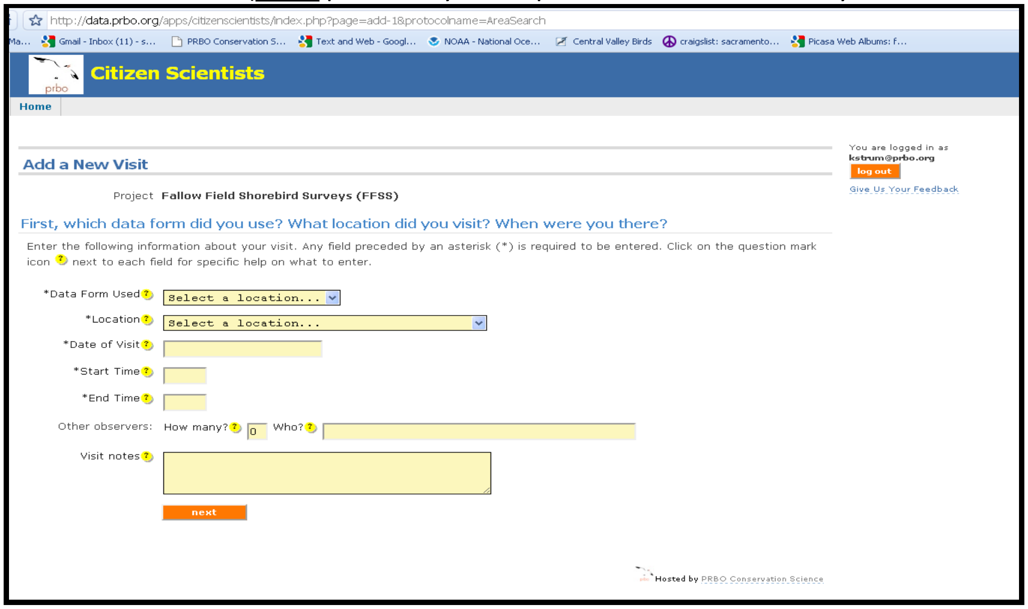
To enter new data click on the "**Add a new visit**" button (in orange above) that is associated with the project for which you want to enter data.

Note: Each survey point or survey area should be recorded on a separate data sheet and should be entered separately as a new visit.

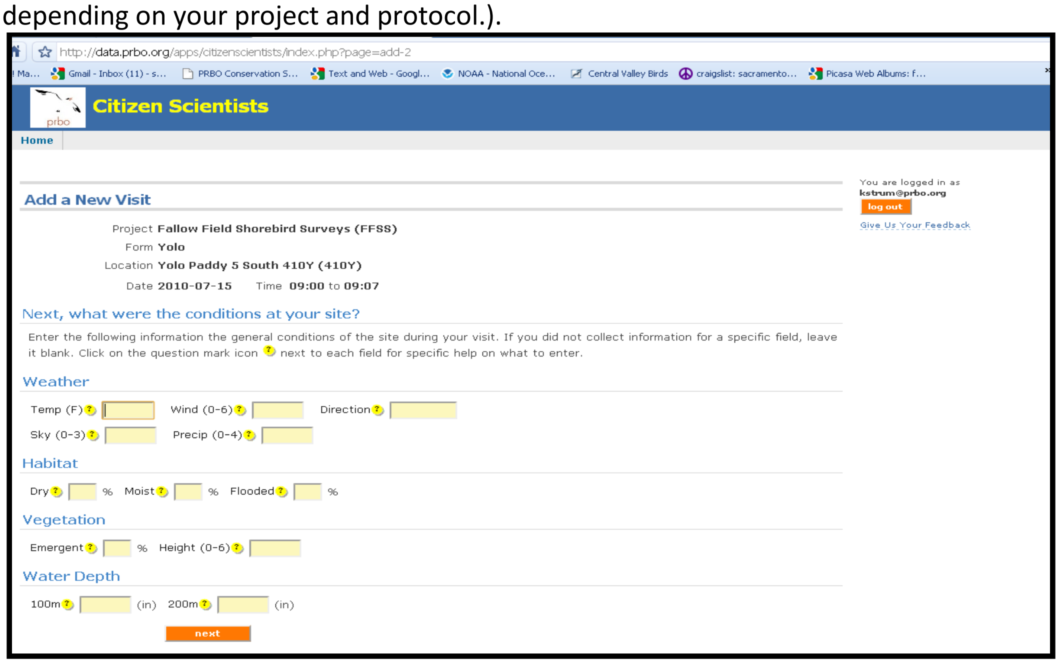
C. Enter Data

There are 3 data entry screens for getting PFSS data into CADC.

1. "Where did you survey? When did you survey? Who did the survey?" screen. The fields on this screen should match the fields on your data form. After filling in the fields press "**next"** at the bottom of the screen (**note:** press the yellow question marks next to any field to obtain help).

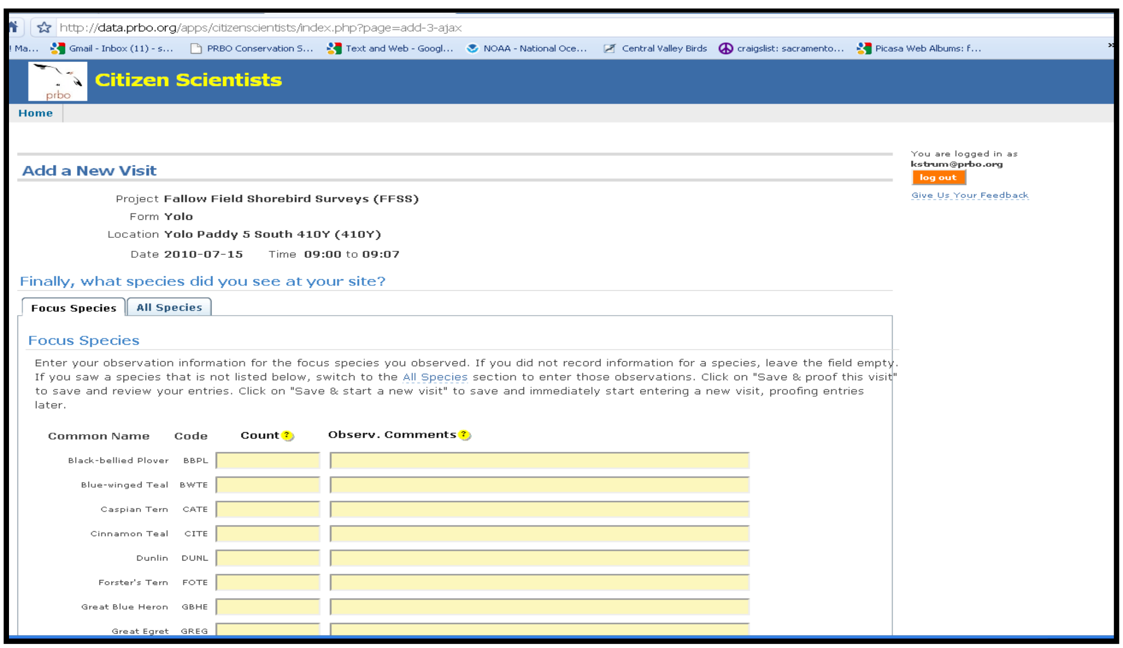


2. "What were the conditions at your site?" screen (below). The fields on this screen should match the fields on your data form and be described in the survey protocol. After filling in the fields press "**next"** at the bottom of the screen (**note:** fields may different than the example below depending on your project and protocol.).



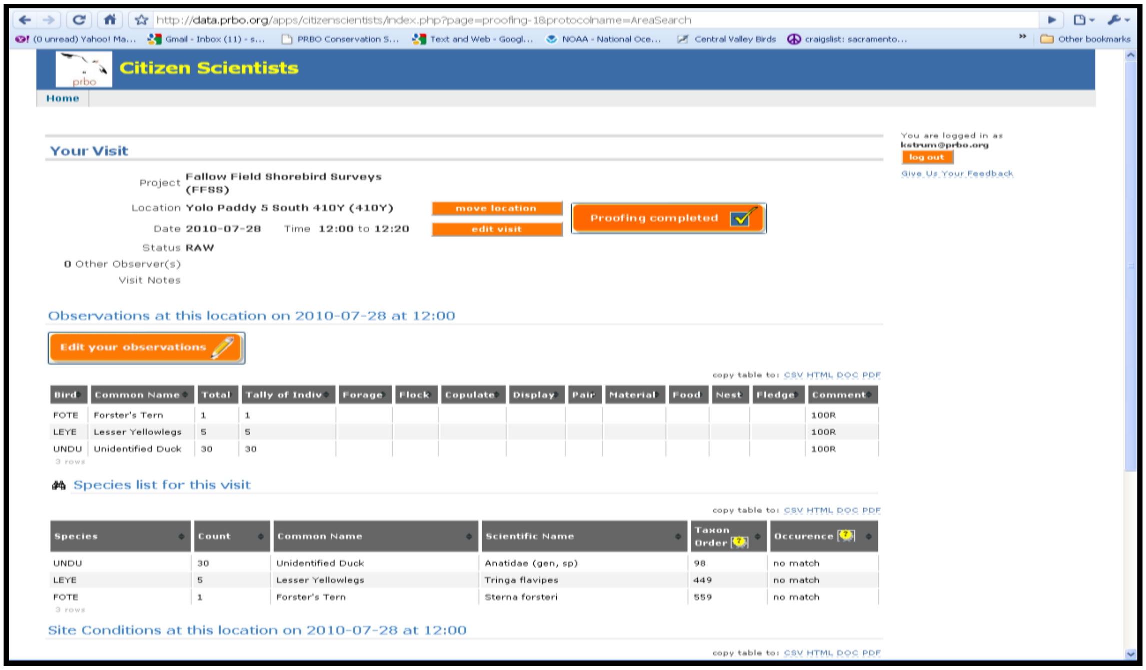
3. "Finally, what species did you see at your site?" screen (below).

   a. The "**Focus Species**" table contains the large majority of species that you will see on your surveys.
   b. Enter the "Count" for each species from your data sheet.
   c. You do NOT need to enter "0" for species you did not see.
   d. If you saw no birds at a survey site scroll to the bottom of the species table and press the orange "**No species observed Save & proof this visit**" button.
   e. If a species does not appear in the Focus Species table, use the "**All Species**" tab to enter data for species not listed in the table.
      a. Enter the name of the species in the provided space.
      b. Select the correct four-letter code from those listed and that match those in "PFSS_SpeciesList.pdf"
      c. Enter the "Count" for each species
      d. Press "**next**" before moving on the next species OR before switching back to the "Focus Species" table
   f. You can use the Focus Species and All Species tables interchangeably to enter data. However, please only enter data for species within the guilds listed in the project protocol and the project species list (i.e. do not enter gulls or terns.)
   g. Once you have entered all the species detection data press "**Save and Proof this Visit**"

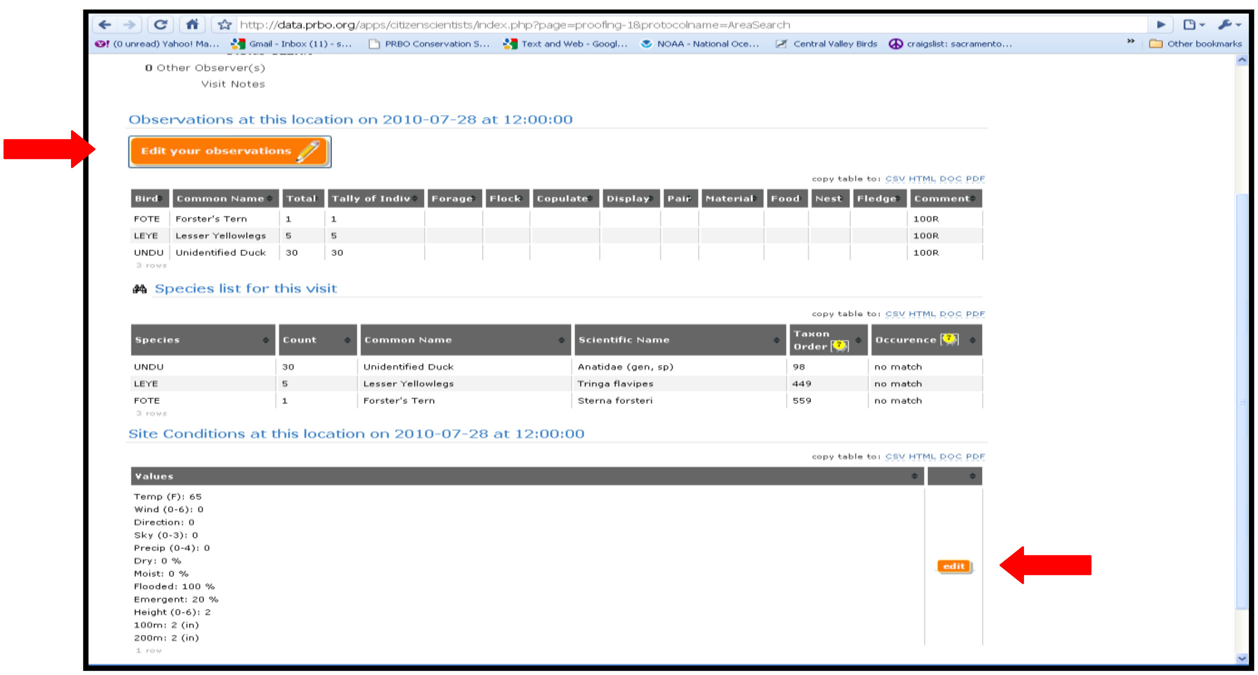


D. Proof Data

After clicking "**Save and Proof this Visit**" you should be taken to the following screen:



You must proof the data you entered in order for it to become part of the database. Look carefully through the data you entered and compare it to the data on your datsheet. If you note inconsistencies between your datasheet and what appers on the screen, follow the steps beginning with Step 1 below in the "Editing Data"section.



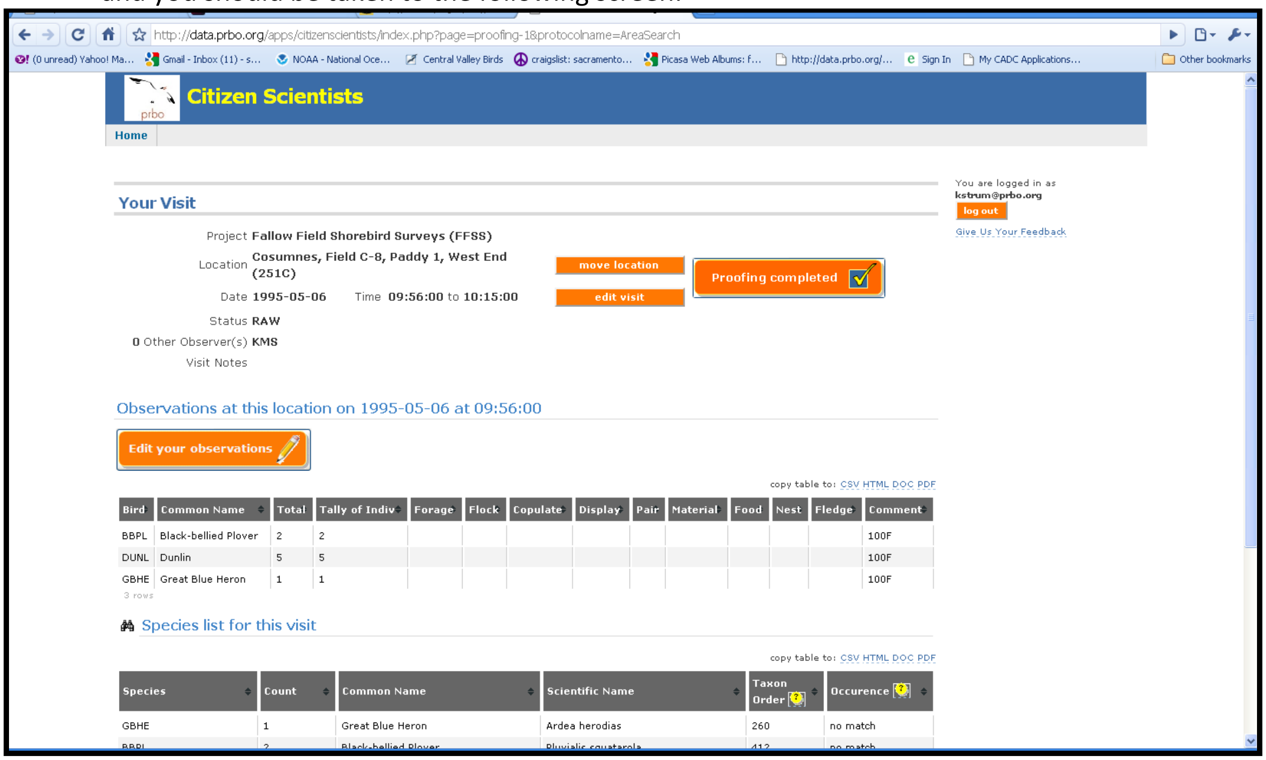
When you are finished proofing make sure to click on "**Proofing completed**" at the top of the page.

<u>Go back and follow each step to enter data for the rest of the survey points or areas.</u>

E. Edit Data

After you enter your data you may be asked to make corrections or you may realize you have entered something incorrectly. Each section of data (site condicitons, dectections, etc.) has a unique place for editing data.

1. To edit your data, log on into CADC (see **A. Log In** above).
2. Click the magnifying glass  next to the observation in the project that you would like to edit and you should be taken to the following screen:



3. To edit the ***Location*** click "**Move Location**". Choose the correct location for the observations and then click "**Move**".

4. To edit the ***Visit Information*** (Date, Start Time, End Time, Observers, Visit Notes) click "**Edit Visit**". <u>Make sure to click "**Save**" when you are finished editing your data.</u>

5. To edit your ***Observations*** (Species, Number, Comments, Add new species) click "**Edit your Observations**". On the following screen, click on the data to activate the table. If you want to add an additional species, enter data in a blank field and click "**Next**". <u>Make sure to click "**Save & Proof this Data**" when you are finished editing your data.</u>

6. To Edit ***Site Conditions*** (e.g. Weather) click "**Edit Site Conditions**". <u>Make sure to click "**Save**" when you are finished editing your data.</u>

7. Finally, when you are finished editing your data click "**Proofing Completed**"