Assessing the effects of meadow restoration on bird populations in the greater Sierra Nevada: report for the 2012 field season

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EXECUTIVE SUMMARY

During 2009-2010, The Institute for Bird Populations partnered with the National Fish and Wildlife Foundation to develop a monitoring protocol for assessing how bird populations respond to meadow restoration in the Sierra Nevada. During summer 2010 we field-tested the protocol by conducting pre-restoration bird surveys at 28 meadows proposed for restoration and 32 reference meadows. In 2012, we conducted repeat surveys at 18 of the original pre-restoration meadows and at 10 new pre-restoration meadows, as well as at 31 paired reference meadows. Prior to the 2012 field season, restoration projects were implemented at five of the sites we surveyed in 2010, allowing us to conduct the first year of post-restoration surveys at those meadows. Study sites were identified in collaboration with partners at National Forests, National Parks, and California State lands, as well as private landowners. Monitoring visits included point count surveys, area searches, and vegetation assessments. This report describes results of the pre- and post-restoration monitoring completed at 59 meadows (including restoration and reference meadows) during 2012.

We surveyed meadows twice during the 2012 breeding season, conducting a total of 1219 point counts and 612 vegetation plots, and over 203 person-hours of area searching. We were able to evaluate preliminary effects of restoration projects on bird populations at five meadows where restoration was implemented between our 2010 and 2012 surveys. At the remaining 54 meadows, results of pre-restoration surveys will provide baseline information for assessing the effects of future restoration activities on bird populations.

Analysis of pre- and post-restoration results at the five completed restoration projects did not yield statistically significant findings of focal bird species responding to restoration efforts, though at many sites there were non-significant increases in meadow focal species. This lack of statistically significant change was not surprising at this juncture, as our sample size, with just 5 of our study sites having been restored before the 2012 field season, was relatively small. Perhaps even more importantly, ecological response to restoration takes time. Open water and emergent vegetation can appear rapidly after restoration, but herbaceous vegetation may take a few years to fully respond, and changes in the abundance and composition of riparian shrubs may take even longer. Nonetheless, we documented almost immediate post-restoration colonization and/or increases in numbers by waterfowl, wading birds, and other species that utilize open water and emergent graminoid vegetation (e.g., Wood Duck, Sandhill Crane, Sora, and others) at meadows where restoration yielded newly ponded water and wetlands. Documenting similar success stories for willow-nesting songbirds and other meadow focal species will likely require additional time and monitoring effort.

INTRODUCTION

Montane meadows in the Sierra Nevada form ecological islands within the surrounding forest matrix (Ratliff 1985, Fites-Kaufman et al. 2007). They provide abundant water, food, and cover for birds and other wildlife, and are among the most important breeding and foraging habitats for birds in the Sierra Nevada (Grinnell and Miller 1944, Orr and Moffit 1971, Gaines 1992, Graber 1996, Heath and Ballard 2003). However, at many Sierra meadows human activities and historic management practices have altered meadow hydrology, which in turn has changed the characteristics of meadow plant communities, and often diminished the value of meadow habitat for native bird populations (Klebenow and Oakleaf 1984, Allen-Diaz 1991, Kattlemann and Embury 1996, Cicero 1997, Siegel et al. 2008).

Throughout the Sierra Nevada, many public and private land managers are seeking win-win solutions for humans and wildlife by restoring or enhancing meadow habitats, in many cases addressing the historical legacy of hydrological impacts that have led to poorly watered meadows (Rood and Mahoney 1990, Loheide and Gorelick 2006, Skidmore et al. 2009). Restoring meadow hydrology is often a critical first step in restoring the full complement of native biodiversity to a meadow (Poff et al. 1997, Dwire et al. 2006).

One way to assess the success of meadow restoration is to monitor the responses of bird populations that inhabit the meadow. Birds can respond rapidly and dramatically to meadow restoration efforts, with populations of meadow-associated bird species increasing in or even colonizing meadows within as little as one year after restoration efforts are implemented (Taylor and Littlefield 1986, Larison et al. 2001, Stanley and Knopf 2002, McCreedy and Heath 2004, Heltzel and Earnst 2006, Borgmann 2010).

Each of the meadow-associated bird species that utilizes montane meadows in the Sierra Nevada has its own particular habitat needs, and the presence or absence of those specific habitat components largely predicts which species utilize a particular meadow (Wiens 1985). When meadow habitats are degraded the number of individual birds and the number of bird species occupying them tends to decline.

The primary objective of this project in 2012 was to collect post-restoration data at sites that had been restored since our first visits in 2010, and to collect pre-restoration data on bird populations at meadows where future restoration projects are planned (and at associated reference sites),. These data will allow assessment of the response of bird populations to restoration activities. Such assessments are valuable both for documenting successes of restoration activities and for facilitating improvement of restoration techniques in an adaptive management context.

We assessed bird populations at meadows using a bird survey protocol (Loffland et al. 2011) developed with funding from the National Fish and Wildlife Foundation specifically for pre- and post-restoration bird monitoring at meadow restoration sites. The protocol integrates

multiple multi-species survey techniques including point counts and area searches, and also incorporates vegetation characterization plots.

The use of a standardized survey protocol will help managers and researchers to glean important lessons from restoration monitoring efforts—lessons that cannot be learned from monitoring at any single site. Standardized data from diverse sites that undergo a variety of restoration measures will facilitate comparison of bird responses across sites and projects. Such comparisons will lead to an improved understanding of which restoration efforts most effectively produce high-quality bird habitat, and will allow future meadow restoration efforts to incorporate those findings.

METHODS

All of our methods adhered to Loffland et al.'s (2011) *Avian Monitoring Protocol for Sierra Nevada Meadows.* Here we provide a cursory summary of methods, but readers seeking more detail or a discussion of the merits and limitations of particular methods should refer to the protocol itself.

Monitoring Framework

Loffland et al. (2011) suggest a BACI (Before, After, Control, Impact) monitoring framework, in which all monitoring sites where restoration activities are planned are paired with one or more reference sites with similar hydrology and vegetation, but where no restoration activities are imminent. All monitoring activities are then conducted at both the restoration and reference sites in at least one year prior to restoration and at least one year after restoration. This design yields an improved capacity to separate local population changes that are the result of restoration from regional changes that may be due to annual weather variation or other factors. Comparing change in bird populations at the restoration site with the reference site will allow managers to see how individual bird species and suites of species respond to restoration activities, and how the response varies by type of restoration activity, locality, and, if multiple years of post-restoration monitoring are conducted, time since restoration activity (Smucker et al. 2005, Ward et al. 2010).

Site Selection and Study Areas

During early spring of 2012 we consulted with personnel at multiple National Forests, National Parks, and state agencies, as well as private landowners to identify appropriate monitoring sites. We placed a higher priority on revisiting sites where restoration had occurred since our first visits in 2010, and on restoration projects that were already in the planning stage, but also included some sites that were identified as needing restoration, but for which the NEPA/CEQA process or other planning had not yet begun. In some cases we conducted an additional year of pre-restoration monitoring at sites already visited in 2010 if plans for these projects were moving forward and project completion seemed likely within the next 5 years. Alternately, we did not revisit some of the 2010 project sites where plans for those restoration

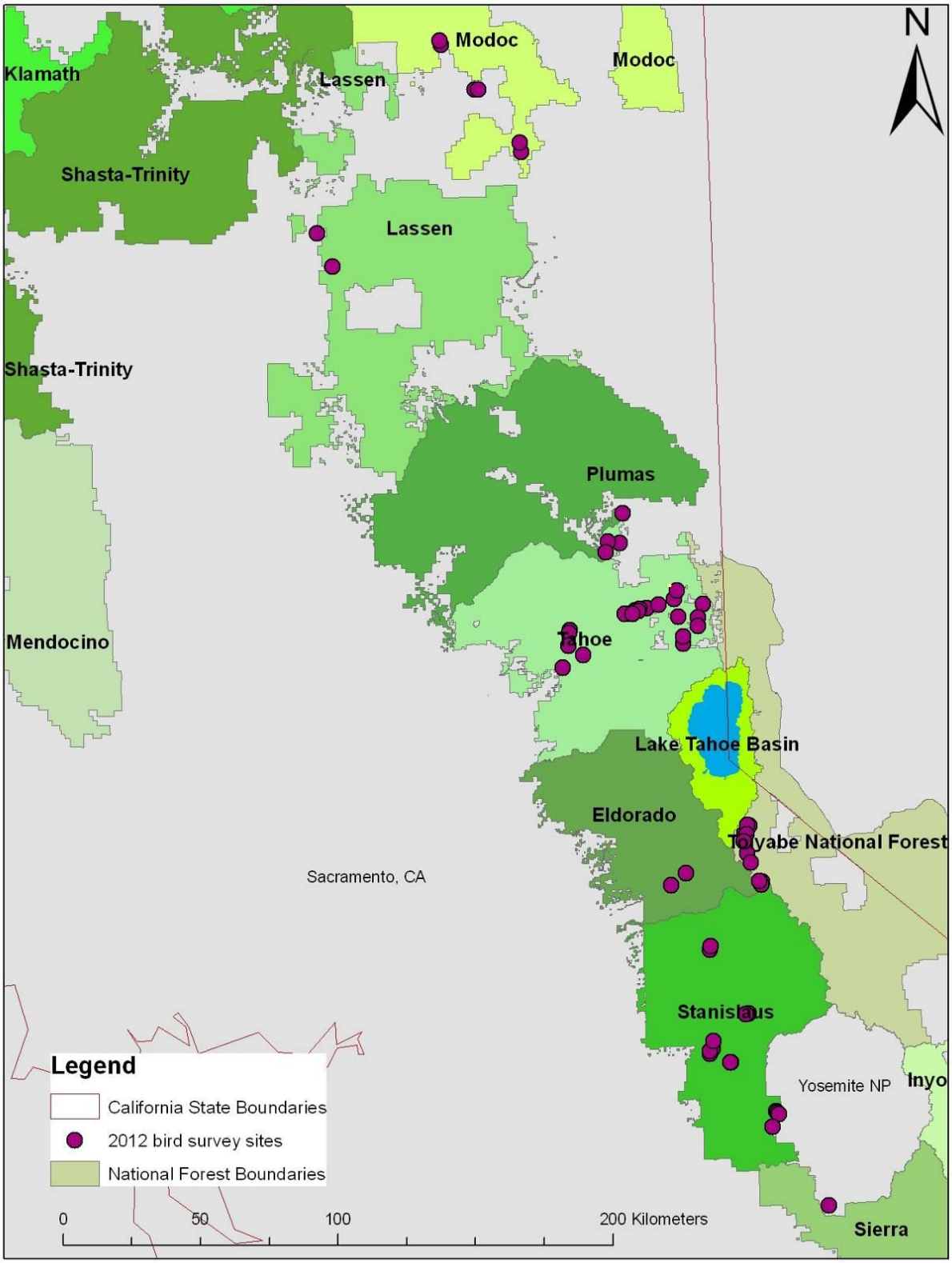
projects had been abandoned, or moved to a lower priority by local land managers. We also made restoration projects with a hydrologic component a higher priority than projects that only modified vegetation or other landscape features without attempting to restore hydrologic processes. The resulting 28 restoration projects surveyed in 2012 were distributed across 6 National Forests, 1 National Park, 2 California State Wildlife Areas, and 5 private parcels. After identifying the restoration projects, we worked with local contacts to identify suitable reference sites to pair with each restoration site. These collaborations yielded 31 reference sites based on advice of local experts and through review of aerial photography. In a few instances multiple small sites were paired with a single restoration site (Table 1, Figure 1, and Appendix A). For ease of interpretation, we have grouped these sites into 4 geographic subregions to facilitate reporting in this document. These 4 subregions are: South-central Sierra Nevada, North-central Sierra Nevada, North Sierra Nevada, and Cascades.

Table 1. Restoration and associated reference sites where bird surveys were conducted in 2012. Sites that received their first post-restoration survey are indicated by bold text.

Restoration Site	Paired Reference Site(s)
CASCADES SUBREGION	
Burney Garden	Big Lake
Lower Ash Creek	Upper Ash Creek
McBride Springs/Willow Creek	Smith Flat
Rose Creek	Upper Rose Creek
NORTH SIERRA NEVADA SUBREGION	
Bear Valley PG&E	Pierce Meadow
Carmen Valley Phase 2 - Folchi	Ross Ranch Meadow
Carmen Valley Phase 2 - West Carman Creek	McNair Meadow
Davies Creek - Site 1	Trossi Canyon
Deer Meadow	Snowflower Mine
Hoke Valley	Donner Picnic Area
Lacey Valley	LT Independence
Loney Meadow	Austin Meadow
Perazzo Lower Meadow	LT Below Stampede
Perazzo Middle Meadow	LT Above Stampede
Perazzo Terrace Meadow	LT West
Perazzo Upper Meadow[1]	
Russell Valley - Dry Creek	Hobart Mills
NORTH-CENTRAL SIERRA NEVADA SUBREGION	
Blue Lakes Road/Hwy88	Burnside Road
Foster Meadow	Sand Shed
Hope Valley Lower	Red Lake Creek
Hope Valley Upper	Upper Charity Valley, Faith Valley
Indian Valley	Little Indian Valley, Indian Valley West Wilderness
SOUTH-CENTRAL SIERRA NEVADA SUBREGION	
2N55 Meadow	Faust Cabin
Ackerson Meadow	Ackerson South, 1S25 Meadow
Fahey Meadow Complex	Fahey Cabin
Round Meadow	Lower Bell Meadow
Seagales Meadow	Big Prather East
Wawona Meadow	Hodgdon Meadow
Wolfin Meadow Complex	Reed Wolfin Tributary

[1] Because pre-restoration data were collected using another methodology by another researcher, detailed discussions of post restoration results at this site will not be included in this report.

Figure 1. Locations of restoration and reference meadows where bird surveys were conducted in 2012.



Cascades Subregion

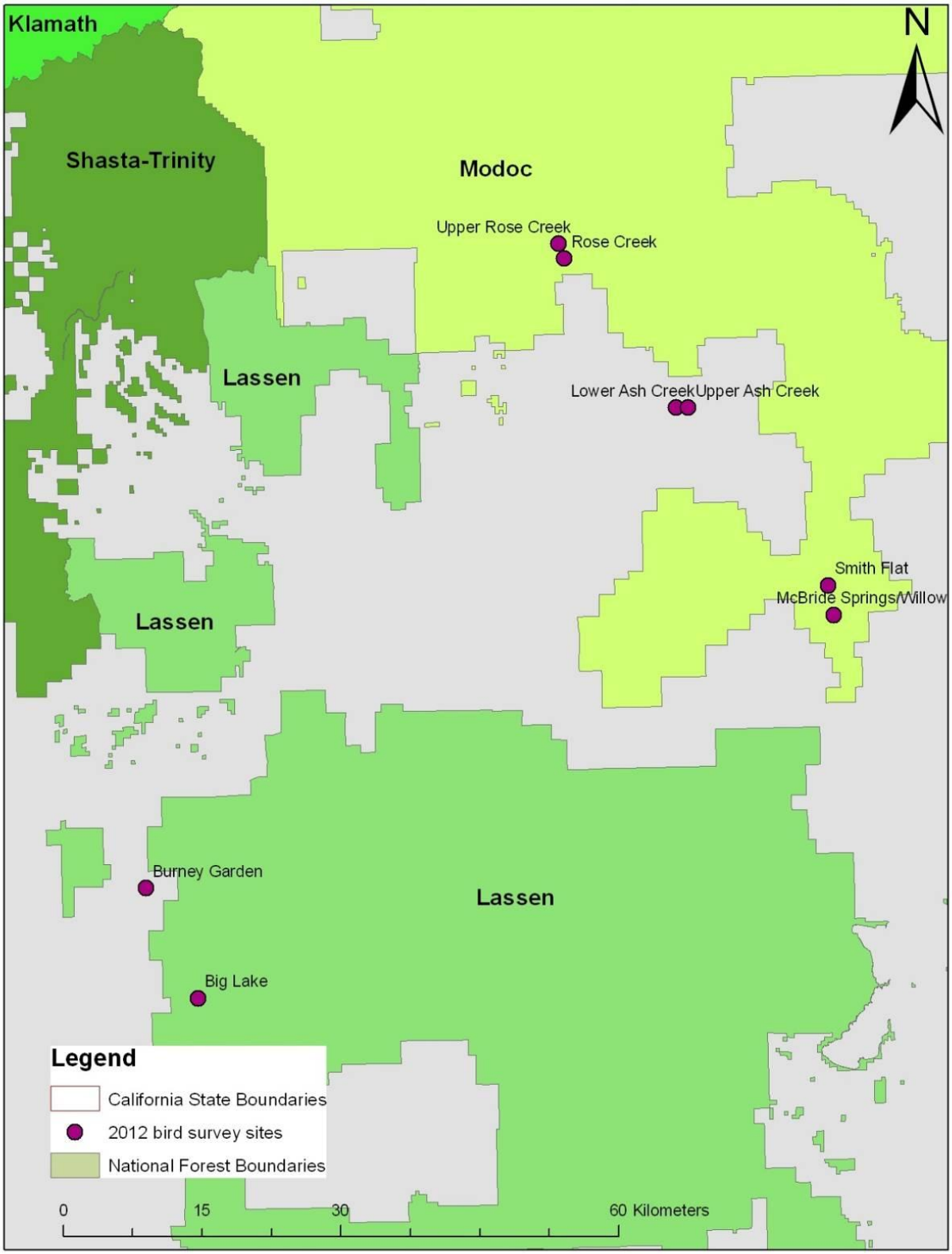
At the time of our 2012 surveys, two restoration projects where we had conducted pre-restoration surveys in the Cascades region had already been completed and one was completed subsequent to our surveys in late summer 2012. The fourth project has initial planning and design underway. Restoration efforts at Rose Creek were completed after our surveys during 2010, and restoration of McBride Springs/Willow Creek and Lower Ash Creek were completed in fall of 2011 and 2012, respectively. The Burney Garden project has a grant in place to begin planning, assessment, and monitoring (Table 1; Figure 2).

All 8 sites (including restoration sites and reference sites) in the Cascades subregion are at relatively low elevations - between 4100 ft. (1250 m) and 5800 ft. (1768 m). Large meadows at this elevation are relatively rare and most are privately owned. These sites have a historical legacy of mining, logging, agriculture, and/or grazing use. The Upper and Lower Ash Creek sites are bordered by intensively managed upland grazing and agricultural areas on three sides, and Big Swamp and the Pit River on the fourth side. The other restoration sites have a mix of pine/oak woodland and sagebrush chaparral at the meadow edges. Areas of volcanic rock outcrop make up a portion of the surrounding upland areas.

The Lower Ash Creek restoration project and its reference site along Upper Ash Creek are unique within the set of meadows visited in 2012. This site is a large and complex system of meadows, marshes, and agricultural lands. Because of its long history of grazing and agricultural uses, it is braided with water diversion canals, and contains numerous historic borrow pits, roadways, and structures. The reference site is quite similar due to its location directly upstream of the restoration site, however the proportion of current marsh area is lower, and the amount of riparian hardwood forest is greater. In contrast to most of our other survey sites where riparian shrubs dominant, the woody riparian vegetation is composed of riparian trees: oak, cottonwood and box elder, with only a small amount of shrubby willow and hawthorn patches.

The Burney Garden property consists of multiple parcels owned by various private entities, with grazing, timber, and electric generation and transmission as their focus. This meadow system sits at approximately 4900 ft. (1494 m) and during recent decades a great deal of this originally expansive system of stringer meadows has been encroached upon by conifers and much of it is now fully forested. The planned project will include both substantial conifer removal and some hydrologic restoration. The reference site at Big Lake (5850 ft.) was chosen due to its public ownership, and because it has a similar volcanic substrate and upland plant community.

Figure 2. Restoration and reference meadows surveyed in the Cascades subregion during 2012.



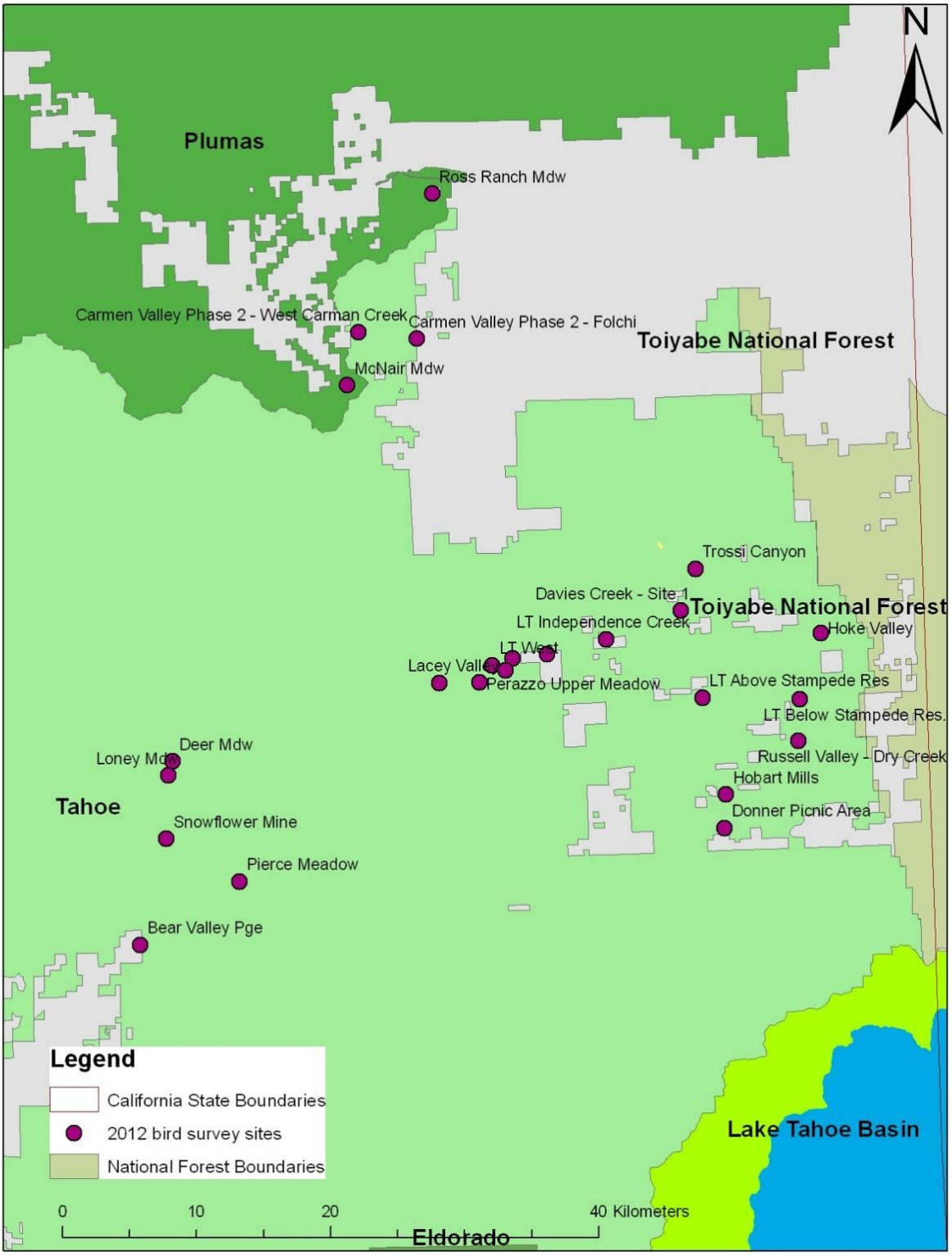
The two remaining restoration sites at Rose Creek and McBride Springs/Willow Creek (Table 1) are located on privately owned land and Lassen National Forest, respectively. Both projects were completed shortly after our initial surveys in 2010. These sites and their nearby reference sites occur at elevations below 5200 ft. (1585 m), but lack the large meadow/marshland component of Burney Garden and Ash Creek. These sites are smaller and geologically restricted to the recent floodplain immediately adjacent to the stream. Stream channels are generally incised with a dominant dry meadow plant community, and uplands are sagebrush steppe, grading into open eastside pine.

North Sierra Nevada Subregion

The two Carman Valley sites, Folchi and West Carman Creek, are both part of a larger restoration program in the Carman Valley area that began in the early 2000's with the Knuthson meadow restoration. Their reference sites at Ross Ranch Meadow and McNair Meadow are both nearby meadows just a few kilometers north and west of the restoration sites. These 4 sites occur at approximately 5000 ft. (1524 m) in elevation and drain into the southern portion of the Feather River watershed on the western edge of the Sierra Valley. These meadows have similar historic use patterns as important grazing lands for cattle and sheep. The Carman Valley area has many historic railroad grades, borrow pits and roads bisecting it. Publicly owned large meadows at this elevation are relatively rare – sites like this were generally not incorporated into national forests when their boundaries were delineated, but were instead retained in private land ownership as base ranches for grazing allotments (Allen-Diaz et al. 1999). Areas such as this surrounding Sierra Valley were (and still are) important agricultural areas for alfalfa hay production. These two project sites represent the final remaining sites within the Carman restoration project complex. Planning is complete at this time, but restoration dates are uncertain.

The Davies Creek – Site 1 meadow is one of a number of completed restoration projects within a much larger restoration plan for the Davies Creek drainage in the northeastern part of the Little Truckee River watershed (Figure 3). Davies Creek Site 1 and its reference meadow at Trossi Canyon occur farther east at slightly higher elevations between 6600 ft. (1980 m) and 7300 ft. (2286 m). Davies Creek – Site 1 is a stringer meadow that is somewhat restricted to the stream course by the geology of the drainage. Because so much of Davies Creek has already undergone restoration, finding a nearby reference site was challenging. Trossi Canyon is less riparian in nature, with a wider, dry meadow type. Although situated only a few kilometers to the north of the restoration site, this meadow drains into the Feather River instead of the Little Truckee River. These 2 sites have both been influenced by a number of wildfires during the last 50 years. Restoration at Davies Creek - Site 1 was completed in 2011, with the first post-restoration bird surveys conducted in 2012.

Figure 3. Restoration and reference meadows surveyed in the North Sierra Nevada subregion during 2012.



Perazzo Upper Meadow, Perazzo Middle Meadow, Perazzo Lower Meadow, Perazzo Terrace, Lacey Valley and the reference sites at LT West, LT Independence, LT above Stampede and LT below Stampede all occur within the vast floodplain meadow system of the Little Truckee River. These sites are on the east slope of the Sierra Nevada crest between approximately 5700 ft. (1737 m) and 6800 ft. (2073 m). This region has a long history as an intensively used travel corridor across the Sierra Nevada Crest and as an important livestock grazing area. In addition, water diversions occur to provide additional water into the Sierra Valley to the North. We originally identified and mapped survey stations for the restoration site at Perazzo Lower Meadow, but due to a scheduling error, this site was not surveyed in 2010. However a survey visit was completed during the summer of 2011. The result of that visit is reported here with the results from the 2012 surveys.

Plans for restoration at Perazzo Lower Meadow have been put on hold due to legal challenges, but surveys were completed nonetheless because inclusion of these sites paints a more complete picture of the system. If not ultimately restored, this site allows for adjustment in the study design if areas we designated as reference meadows are ultimately slated for restoration. Lacey Valley is an extremely large meadow at the Webber Lake Ranch that has a controlled dam which affects downstream flows at the remaining sites. The property is currently undergoing an assessment for purchase, and transfer to a land trust and ultimately restoration of Webber Creek above the lake within Lacey Valley Meadow. Through a subcontract with Balance Hydrologics funded by the Truckee River Watershed Council, we were able to include both Lacey Valley and a reference site in our multi-site NFWF restoration assessment effort. The reference site for this project is downstream at the confluence of Independence Creek and the Little Truckee River. This property was recently transferred into Nature Conservancy management, and as such livestock have been excluded in recent years. Restoration actions at Peruzzi Upper Meadow were completed in late 2009 so we did not originally include the site in our project because no pre-restoration data were collected. In 2012 we determined that point counts were completed in the early 2000s at the site by a local graduate student (Amy Amones), so we decided to include the site in visits conducted during 2012. Even if we had not identified potentially useful pre-restoration data, this site is expected to yield lessons on how bird populations respond over time to hydrologic and vegetative changes from restoration. Pre- and post-restoration comparisons for Perazzo Upper Meadow are not included in this document as the data from the pre-restoration visits in the early 2000s will require additional review prior to comparison and analysis. Perazzo Middle Meadow was restored shortly after our first visits in 2010, and received the first round of post-restoration visits in 2012. Perazzo Terrace was restored after our visits in 2012.

In 2012 we also added two large project areas to the east and southeast of the Little Truckee System. Russell Valley – Dry Creek (5650 ft./1722 m) and Hoke Valley (6000 ft./ 1829 m) are both large floodplain meadow systems with a historic and current use as grazing pasture within the dry sagebrush and eastside-pine uplands that dominate the area. Ownership of both sites is mixed between private grazing lands and public lands. Planning meetings between all parties within the Russell Valley watershed are currently underway to strategize how to best restore the stream channels in these areas, and retain more water (and therefore forage) on

the meadows longer into the summer. Conceptual restoration plans are under development as well. Hoke Valley is at the very beginning of scoping and early planning. Reference sites at Donner Picnic Area (5750 ft./1753 m) and Hobart Mills (5800ft./1768 m) have similar ownership and use patterns. At this time survey stations are only delineated on public lands, but as planning and use agreements progress we hope to add additional bird monitoring stations in other privately owned portions of these valleys.

All of the east-slope sites described above are surrounded by east-side pine, with stands of lodgepole pine and occasionally quaking aspen along meadow edges. Sagebrush chaparral makes up a portion of the surrounding upland areas at many sites.

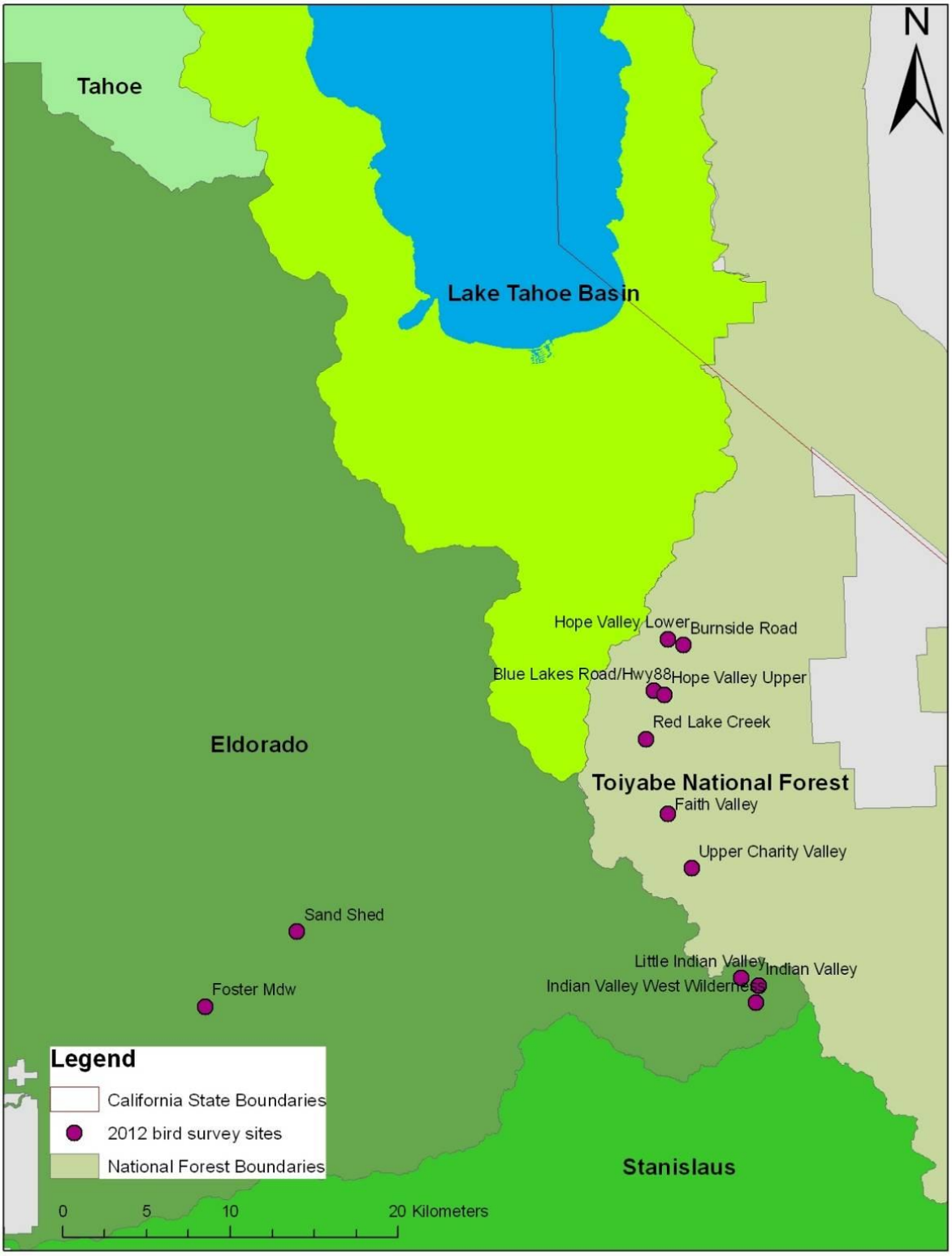
The North Sierra Nevada subregion also included 3 west-slope restoration projects and their reference sites. Bear Valley PG&E is a large privately owned meadow occurring just above 4550 ft. (1387 m) in elevation. Some restoration has occurred on public lands at the upstream end of the valley and planning for an extensive hydrologic restoration project in the main meadow is completed and awaiting final permitting and funding. Identifying an appropriate reference site for this site was a challenge due to private access issues at other nearby sites. We selected Pierce Meadow (only recently under FS management) despite its slightly higher elevation.

Loney Meadow and Deer Meadow are two restoration sites in close proximity to one another at approximately 6000 ft. (1829 m). Loney has planning underway for a number of restoration efforts related to the stream channel, road crossing, and conifer encroachment. Deer meadow has also been identified as being in need of restoration, but planning is only in the early stages of garnering support. Reference sites are Austin Meadow to the North and Snowflower Mine to the South. Austin Meadow is well suited as a reference site but its location makes it difficult to access in some years. Snowflower Mine is a somewhat drier riparian area with a large component of fire-succession vegetation including *Ceanothus* spp.

North-central Sierra Nevada Subregion

Twelve meadows within the North-central Sierra Nevada subregion were surveyed in 2012 (Figure 4).

Figure 4. Restoration and reference meadows in the surveyed in the North-central Sierra Nevada subregion during 2012.



Foster Meadow and Sand Shed are west of the Sierra crest in the Cosumnes and Mokelumne River watersheds, respectively, at elevations of 6500 (1980 m) and 7500 ft. (2286 m) (Figure 4). These two sites have similar meadow vegetation, but dissimilar hydrologic sources (stream-fed vs. spring-fed). We choose Sand Shed as the reference site for Foster Meadow despite its hydrologic dissimilarity, due to a lack of nearby reference sites with similar meadow vegetation under public management. Foster meadow has had many historic attempts at restoration with varying degrees of success. It is currently a high priority for restoration on the Eldorado National Forest. While hydrologic plans have not been prepared to date, removal of encroaching conifers is set to begin in 2013.

The remaining sites are all in relatively close proximity to one another and to the Sierra Crest in Alpine County. Indian Valley, and its reference sites at Indian Valley West Wilderness and Little Indian Valley, are within the upper reaches of the west slope Mokelumne River watershed, although the north end of Indian Valley drains east into the Carson River due to historic ditching that diverted water to the Carson Valley. These sites are all between 7500 ft. (2286 m) and 8500 ft. (2590 m) in elevation and are situated very close to the Sierra Crest. Due to the large size of Indian Valley we selected 2 reference sites (Indian Valley West Wilderness, and Little Indian Valley) to increase the number of survey stations for purposes of comparison. Restoration on the southern half of Indian Valley was completed during fall of 2012. It is currently uncertain whether the northern half of Indian Valley will be restored or whether restoration plans will shift to Little Indian Valley.

Upper Hope Valley, Lower Hope Valley, and Blue Lakes Road/Hwy 88 all occur within the vast floodplain of the west fork of the Carson River. These sites are on the east side of the Sierra Nevada crest between approximately 7000 ft. (2133 m) to 8000 ft. (2438 m). This region has a long history as an intensively used travel corridor (both before and after European colonization) and grazing area. Upper Hope Valley required two reference sites (Upper Charity Valley and Faith Valley) due to its large size and the uncertainty surrounding which areas would ultimately be slated for restoration. The extra reference site allows for adjustment in the study design if areas we designated as references ultimately fall within the restoration area. Lower Hope Valley was paired with Red Lake Creek, a nearby tributary with similar use and vegetation. It now appears that Lower Hope Valley may not be restored beyond the ongoing willow planting efforts of “Friends of Hope Valley”. We continue to survey this site because there is also the possibility that we can use point count data collected here in the early 2000s as reference data for the Perazzo Upper Meadow project discussed above. Both areas were surveyed at that time and provide the only consistent pre-restoration surveys for both sites (Amy Amones, *pers. comm.,* Amones 2008).

Upper Hope Valley has a completed technical restoration plan and is slated to begin the NEPA compliance process in 2013/2014. The technical plan uses a variety of prescriptions to reduce erosion and incision of the main channel and tributaries. Actions to increase, improve and create willow riparian habitat and standing water within the current floodplain were added to the project design in response to concerns we expressed about the needs of meadow birds. Through subcontract from American Rivers that was ultimately funded by a Sierra Nevada

Conservancy (SNC) grant, we were able to provide detailed recommendations to integrate bird habitat into the planning for hydrologic restoration at this site (Loffland and Siegel 2011, Loffland and Siegel 2012).

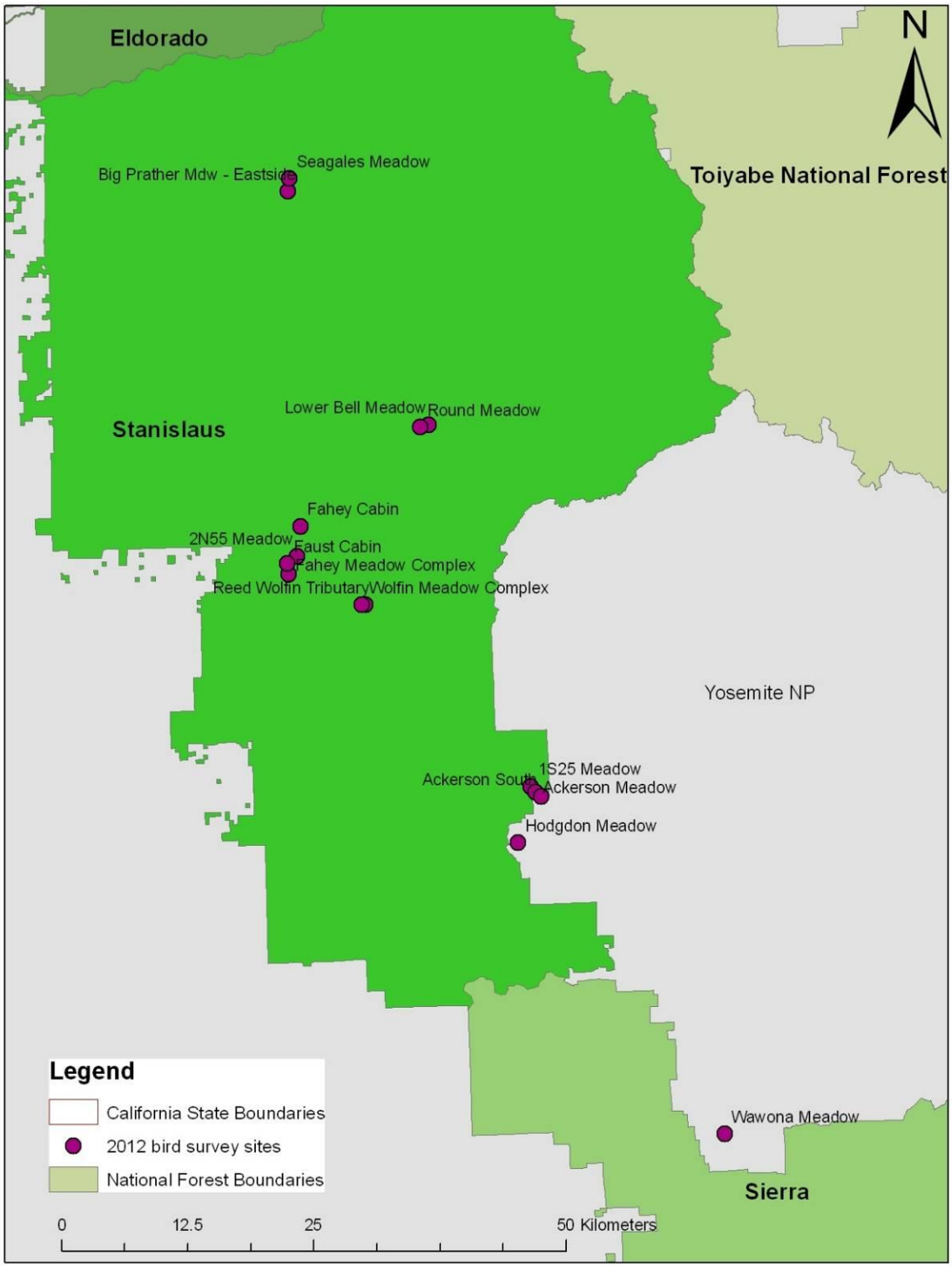
The Blue Lakes Road/Hwy 88 site is more adequately described as a part of the larger Upper Hope Valley project, but was treated separately from the larger area in the project design, so is treated separately in this document. Blue Lakes Road/Hwy 88 is a project where a dispersed parking/camping area has been improved to stop expanding recreational vehicle use of the meadow surface. Although some portions of the site were converted to pavement and bathrooms, much of the site was ripped and reseeded. What was a large dispersed RV camping area now has limited day use parking in designated locations. Although not a typical restoration project, the site should ultimately see improvement due to more controlled use. We paired it with a similar location downstream along the Hwy 88 corridor at Burnside Lake Road, but at this time we are not analyzing it as a meadow restoration project due to its unusual project type.

All project sites in the North-central Sierra Nevada subregion are mainly surrounded by coniferous forest. Lodgepole pine often occurs at the meadow edges and Sierra mixed conifer or red fir dominates the more upland areas, depending on elevation. Occasionally areas of granite outcrop, sagebrush scrub, or aspen make up a portion of the surrounding upland areas in the Hope Valley and Indian Valley project areas.

South-central Sierra Nevada Subregion

We surveyed one restoration project in Yosemite National Park in 2012 (Figure 5). Wawona Meadow had restoration completed in the fall of 2011, and received its pre-restoration visits in 2010 and its first two post-restoration bird monitoring visits in 2012. Wawona Meadow is a relatively large, low-elevation (4200 ft. /1280 m) meadow on the west slope of the Sierra Nevada. Large meadows at this elevation on the west side of the Sierra crest are relatively rare and most are privately owned – sites like this were generally not incorporated into national forests when their boundaries were delineated, but were instead retained in private land ownership as base ranches for grazing allotments (Allen-Diaz et al. 1999). Additionally, many meadows of this type were popular with developers of residential and recreational areas. Likewise, even within the national parks, development of facilities often historically occurred in close proximity to meadows (including Wawona Meadow). Ideally, we would have selected a reference site for Wawona that was closer than Hodgdon Meadow. Because of the difficulties in locating publicly owned reference sites at low elevation (as described above) we opted to relax our requirement of selecting nearby reference sites and chose to include Hodgdon Meadow because of its similar elevation and vegetation.

Figure 5. Restoration and reference meadows surveyed in the South-central Sierra Nevada subregion during 2012.



The remainder of the South-central Sierra Nevada restoration sites are located on the Stanislaus National Forest or adjacent private lands (Table 1; Figure 5). With the exception of Ackerson Meadow, all occur at higher elevations, between 5000 and 7000 ft. (1829 and 2134 m). All restoration and reference sites outside of Yosemite occur in active grazing allotments with similar management. Round Meadow and its associated reference site, Lower Bell Meadow, occur on tributaries of Bell Creek within approximately 1 km of each other. Round Meadow has a complex restoration plan to stabilize and repair the hydrology of the meadow, and planning is near completion. Lower Bell Meadow is a site historically occupied by Willow Flycatcher, a California Endangered Species, but surveys have not detected the species in over 10 years. Subsequent to our surveys a singing male Willow Flycatcher was detected just south of Round Meadow in a nearby meadow.

Restoration sites at 2N55 Meadow, Fahey Meadow Complex, and Wolfin Meadow Complex are part of large restoration effort called the Twomile Watershed Restoration Project. Grant agreements between the Forest Service and Sierra Nevada Conservancy are funding planning, permitting and multi-year pre-restoration monitoring of vegetation and hydrology. Our NFWF grant is allowing us to add bird restoration to the existing monitoring suite for this project. All three of these restoration sites are between 5000 and 6000 ft. (1524 and 1829 m) in elevation and have experienced relatively heavy historical grazing and agricultural pressure, with roads bisecting meadows, and dams and ponds created along and adjacent to the stream channel.

All 7 restoration and 8 reference sites within this management area have a historical legacy of extensive logging and/or grazing use. Wawona Meadow and Ackerson South lie within Yosemite National Park boundaries, so these 2 sites have a differing management history in recent decades compared to the remainder of the sites in the subregion. Sites at the lowest elevations also experienced heavy alteration in streamside areas as a result of historical mining activities. Most sites border upland forest dominated by Sierra Mixed Conifer, while the higher elevation sites have lodgepole pine dominant at the meadow edges and white or red fir in the upland areas. Occasionally areas of granite outcrop make up a portion of the surrounding upland.

Crew Training and Certification

All data were collected by full-time crew members working or volunteering for The Institute for Bird Populations. At the beginning of the 2012 field season, crew members underwent an intensive 3-week training session that followed the guidelines in Loffland et al. (2011) for ensuring surveyors are fully competent and qualified to collect reliable bird count data. At the end of the training session all crew members passed a rigorous bird identification exam that tested the skills necessary to conduct point counts and area searches.

Data Collection

Establishing Survey Stations

At restoration and reference meadows we established survey stations 200 to 250 m apart along transects that followed the general course of stream channels within meadows, as well as in areas of meadows with no adjacent stream. We used 200 m spacing only in smaller meadows where sample sizes were deemed inadequate using the larger station spacing. Where possible, survey stations were placed at least 25 m from streams that were large enough to cause substantial noise interference during surveys – this will also help ensure that if stream restoration results in inundation or widening of the channel, survey stations do not end up under water in future years. In narrow meadows (<100 m wide), stations were placed every 200 to 250 m along a transect that traveled along the center of the meadow, regardless of where the stream channel was located. In most cases survey stations were delineated prior to the first field visit using digital aerial photos (DOQQs) and ArcMap software. Site maps with survey station locations are provided in Appendix B and geographic coordinates of individual survey stations are provided in Appendix C. In a few instances intended station locations were inaccessible. For those stations that could not be reasonably relocated to a more accessible area nearby, surveys were not completed in 2012. Nonetheless, their coordinates remain in Appendix C, and the points should be surveyed if possible during future monitoring visits.

Survey Schedule

All sites were surveyed within the May 20-July 15 temporal window specified by the Loffland et al. (2011) protocol. At most meadows we were able to complete two full survey visits (excluding the vegetation plots which we completed only once per season, in accordance with the survey protocol).

Point Counts

We conducted 7-minute point counts, divided into three smaller time intervals to facilitate estimating detection probability and modeling occupancy rates (MacKenzie et al. 2002) in the future, if desired. All birds were classified as being either ≤50 m from the survey station at first detection, or at a distance >50 m.

Area Searches

When all of the point count surveys were completed, surveyors remained at the meadow and began the area search portion of the survey. The amount of time spent area searching was dependent on the size of the meadow; surveyors spent at least 10 minutes area-searching for every survey station the meadow accommodated. One of the objectives of the areas search was to increase the likelihood of detecting rarer or more secretive species that were present at the site, particularly species that may have been missed during the point count portion of the survey. When conducting the area search, surveyors moved through the meadow slowly and quietly, counting all birds detected at the site. Special attention was paid to areas

along stream channels or other flooded or ponded areas, and locations where restoration activities were planned. Additionally, areas of the meadow where sight and sound were obstructed by dense vegetation were observed carefully. We tallied individual birds based on their location at the time of first detection, either within the meadow, or within the surrounding forest or other upland vegetation community.

Vegetation Plots

After completing bird surveys we assessed the vegetation structure and community type at each survey station to characterize the meadow and provide context for bird survey results. We recorded relative cover and vegetation height for a variety of vegetative and surface water components in each of the four quadrants formed by four 50-m transects extending away from the station in each of the cardinal directions (N, S, E, W). For each quadrant (NW, NE, SE, SW), we recorded cover for each vegetation type after first walking the quadrant to observe the entire area. Cover was estimated as if one was looking down on the site from above. Totals of all cover types combined sometimes exceeded 100% because values were combined over multiple overlapping levels of the canopy: herbaceous, shrub, and tree.

Data Analysis

Because only one to two seasons of monitoring have been completed, with most sites still in the pre-restoration phase, analysis is for the most part limited to summary statistics.

Point Counts

From point count results at each meadow, we tabulated the number of species detected, the number of individuals of each species detected, and the number of individuals of all species pooled detected per point. Results are provided separately for birds detected within 50 m of the survey station, and birds detected at any distance from the survey station. From our entire set of all survey meadows we also identified those meadows with the greatest number of meadow focal species (Loffland et al. 2011) and individuals of focal species, to help managers understand which values might provide reasonable estimates for post restoration targets. Bivariate Correlation analyses were used to assess how three distinct focal species metrics co-varied, and to assess how point-specific abundances of focal species co-varied with abundance of other bird species. There are 5 restoration sites that received the first year of post-restoration monitoring in 2012. For those sites we now have preliminary before and after results. We completed a Multivariate Analysis of Variance (MANOVA) for the index of relative abundance of focal species, with “year” (pre-restoration/2010 versus post-restoration/2012) and “site type” (restoration versus reference) as factors. We also assessed qualitatively whether waterfowl and other wading birds appeared to increase at those projects that resulted in ponds or other surface water. We recommend using caution when interpreting results based on only a single year of post-restoration response, as many habitat elements and species responses will not be observed until more time has elapsed since restoration.

Area Searches

We tallied the number of individuals of each species (within the meadow, outside the meadow, and combined) detected during area searches. We also compared total number of species and number of focal species across meadows and subregions.

Vegetation Plots

Mean vegetation cover measurements are aggregated across points and reported at the meadow scale, with the intention of characterizing the areas of the meadows where we conducted point counts.

RESULTS

With the exception of a few difficult to access sites, we were able to visit all monitoring sites twice within our survey window of May 20 through July 15 (Table 2). Loffland et al. (2011) encourage two visits, but the second visit is considered optional. One restoration site, and three reference sites received only one visit during 2012 breeding season, while the remaining sites received two visits. We surveyed 612 point count stations at the 59 study sites (Table 2, Appendices A, B, C).

Table 2. Number of stations surveyed and survey dates for meadows visited in 2012. Sites are listed by region with restoration sites immediately followed by their associated reference site(s).

Meadow	Monitoring Category	Number of Stations	Date of Visit No. 1	Date of Visit No. 2
CASCADES SUBREGION				
Burney Garden	**Restore**	**25**	**14-Jun-12**	**12-Jul-12**
Big Lake	Reference	8	14-Jun-12	12-Jul-12
Lower Ash Creek	**Restore**	**27**	**13-Jun-12**	**11-Jul-12**
Upper Ash Creek	Reference	15	13-Jun-12	11-Jul-12
McBride Springs/Willow Creek	**Restore**	**6**	**11-Jun-12**	**08-Jul-12**
Smith Flat	Reference	4	11-Jun-12	
Rose Creek	**Restore**	**5**	**12-Jun-12**	**10-Jul-12**
Upper Rose Creek	Reference	5	12-Jun-12	10-Jul-12
NORTH SIERRA NEVADA SUBREGION				
Bear Valley PG&E	**Restore**	**24**	**21-May-12**	**23-Jun-12**
Pierce Meadow	Reference	6	24-Jun-12	08-Jul-12
Carmen Valley Phase 2 - Folchi	**Restore**	**16**	**23-May-12**	**21-Jun-12**
Ross Ranch Meadow	Reference	10	21-Jun-12	09-Jul-12
Carmen Valley Phase 2 - West Carman Creek	**Restore**	**9**	**23-May-12**	**21-Jun-12**
McNair Meadow	Reference	6	22-May-12	21-Jun-12
Davies Creek - Site 1	**Restore**	**5**	**24-May-12**	**09-Jul-12**
Trossi Canyon	Reference	5	24-May-12	10-Jul-12
Deer Meadow	**Restore**	**10**	**11-Jun-12**	**24-Jun-12**
Snowflower Mine	Reference	9	11-Jun-12	24-Jun-12
Hoke Valley	**Restore**	**11**	**25-May-12**	**28-Jun-12**
Donner Picnic Area	Reference	9	24-May-12	12-Jun-12
Lacey Valley	**Restore**	**25**	**20-Jun-12**	**28-Jun-12**
LT Independence	Reference	17	08-Jun-12	19-Jun-12
Loney Meadow	**Restore**	**7**	**11-Jun-12**	**24-Jun-12**
Perazzo Lower Meadow	**Restore**	**5**	**22-May-12**	**19-Jun-12**
LT Below Stampede	Reference	14	25-May-12	22-Jun-12
Perazzo Middle Meadow	**Restore**	**16**	**22-May-12**	**19-Jun-12**
LT Above Stampede	Reference	4	18-Jun-12	26-Jun-12
Perazzo Terrace Meadow	**Restore**	**6**	**22-May-12**	**19-Jun-12**
LT West	Reference	5	22-May-12	19-Jun-12
Perazzo Upper Meadow	**Restore**	**21**	**03-Jun-12**	**20-Jun-12**
Russell Valley - Dry Creek	**Restore**	**36**	**20-May-12**	**22-Jun-12**
Hobart Mills	Reference	18	24-May-12	12-Jun-12
NORTH-CENTRAL SIERRA NEVADA SUBREGION				
Blue Lakes Road/Hwy88	**Restore**	**6**	**30-May-12**	**04-Jul-12**

Meadow	Monitoring Category	Number of Stations	Date of Visit No. 1	Date of Visit No. 2
Burnside Road	Reference	3	31-May-12	03-Jul-12
Foster Meadow	**Restore**	**6**	**07-Jun-12**	**20-Jul-12**
Sand Shed	Reference	5	21-Jun-12	
Hope Valley Lower	**Restore**	**24**	**31-May-12**	**03-Jul-12**
Red Lake Creek	Reference	20	10-Jun-12	02-Jul-12
Hope Valley Upper	**Restore**	**29**	**30-May-12**	**04-Jul-12**
Faith Valley	Reference	11	10-Jun-12	03-Jul-12
Upper Charity Valley	Reference	8	09-Jun-12	04-Jul-12
Indian Valley	**Restore**	**13**	**09-Jun-12**	**01-Jul-12**
Indian Valley West Wilderness	Reference	3	09-Jun-12	01-Jul-12
Little Indian Valley	Reference	4	09-Jun-12	01-Jul-12
SOUTH-CENTRAL SIERRA NEVADA SUBREGION				
2N55 Meadow	**Restore**	**2**	**02-Jun-12**	**29-Jun-12**
Faust Cabin	Reference	4	02-Jun-12	29-Jun-12
Ackerson Meadow	**Restore**	**14**	**03-Jun-12**	**30-Jun-12**
1S25 Meadow	Reference	3	03-Jun-12	30-Jun-12
Ackerson South	Reference	6	02-Jun-12	29-Jun-12
Fahey Meadow Complex	**Restore**	**10**	**02-Jun-12**	**29-Jun-12**
Fahey Cabin	Reference	7	02-Jun-12	29-Jun-12
Round Meadow	**Restore**	**5**	**01-Jun-12**	**30-Jun-12**
Lower Bell Meadow	Reference	5	01-Jun-12	30-Jun-12
Seagales Meadow	**Restore**	**5**	**31-May-12**	
Big Prather East	Reference	7	31-May-12	
Wawona Meadow	**Restore**	**8**	**01-Jun-12**	**01-Jul-12**
Hodgdon Meadow	Reference	5	02-Jun-12	29-Jun-12
Wolfin Meadow Complex	**Restore**	**5**	**04-Jun-12**	**02-Jul-12**
Reed Wolfin Tributary	Reference	5	04-Jun-12	02-Jul-12

Point Counts

Summing across all bird species detected (included non-meadow species along meadow edges) the average number of individuals detected per point count station was 3.8 (SD=1.41) within 50 meters of stations, and 20.0 (SD=3.80) when birds at all distances were included (Figure 6 and 7, Appendix D).

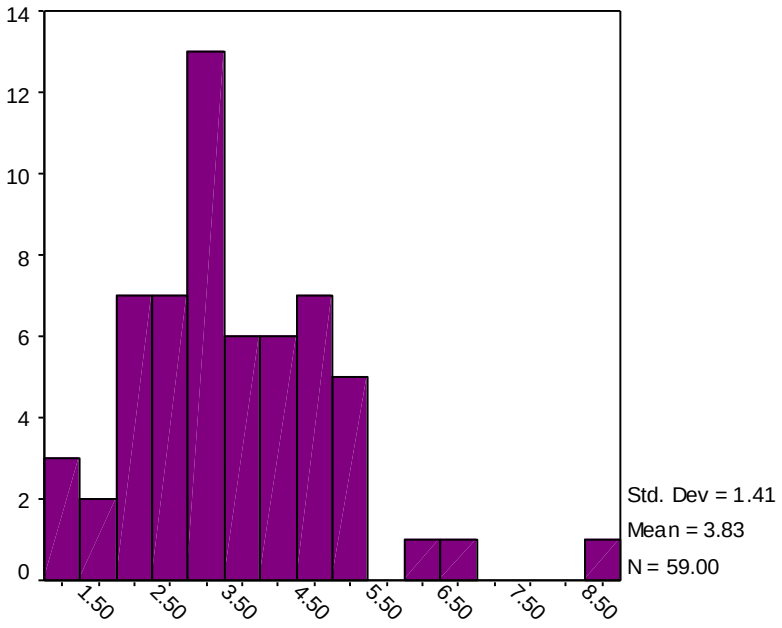


Figure 6. Average number of individual birds detected within 50 m of survey stations.

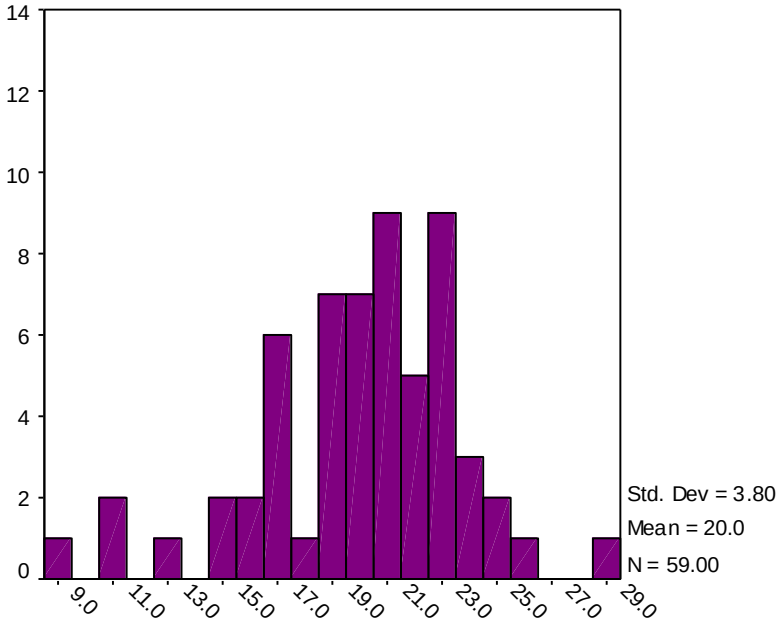


Figure 7. Average number of individual birds detected within an unlimited distance of survey stations.

When examining the number of *species* detected, mean indices of abundance were 3.20 (SD=1.05) species/station within 50 m, and 11.69 (SD=1.85) species/station at all distances

(Figures 8 and 9). Meadows with greatest numbers of individuals and species varied by metric, but, Wawona Meadow, Upper Ash Creek and the Perazzo Meadow sites were frequently in the top 5. These are sizable meadows associated with the large streams and/or diverse vegetation communities.

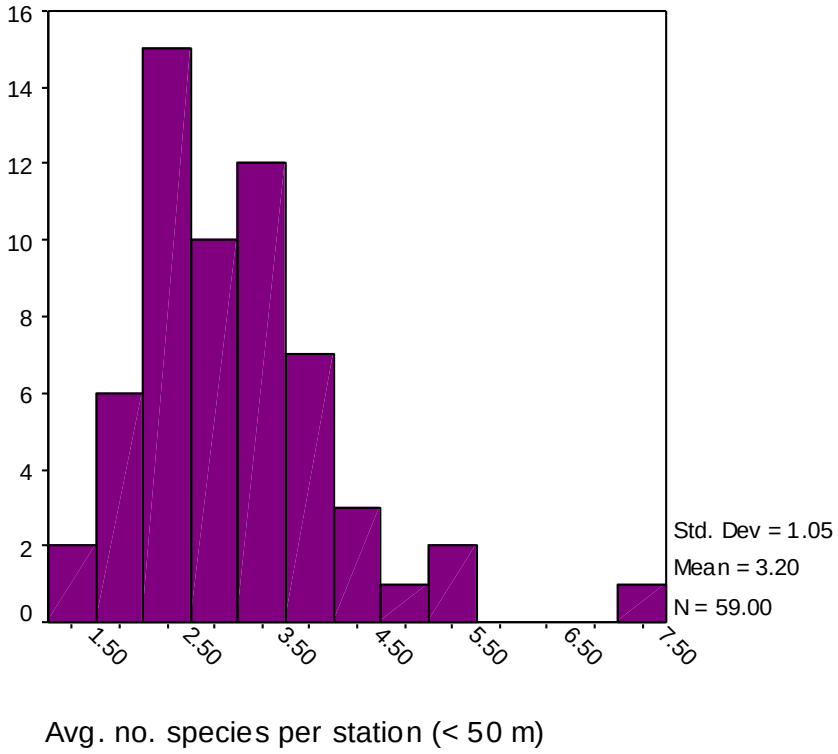


Figure 8. Average number of bird species detected within 50 m of survey stations.

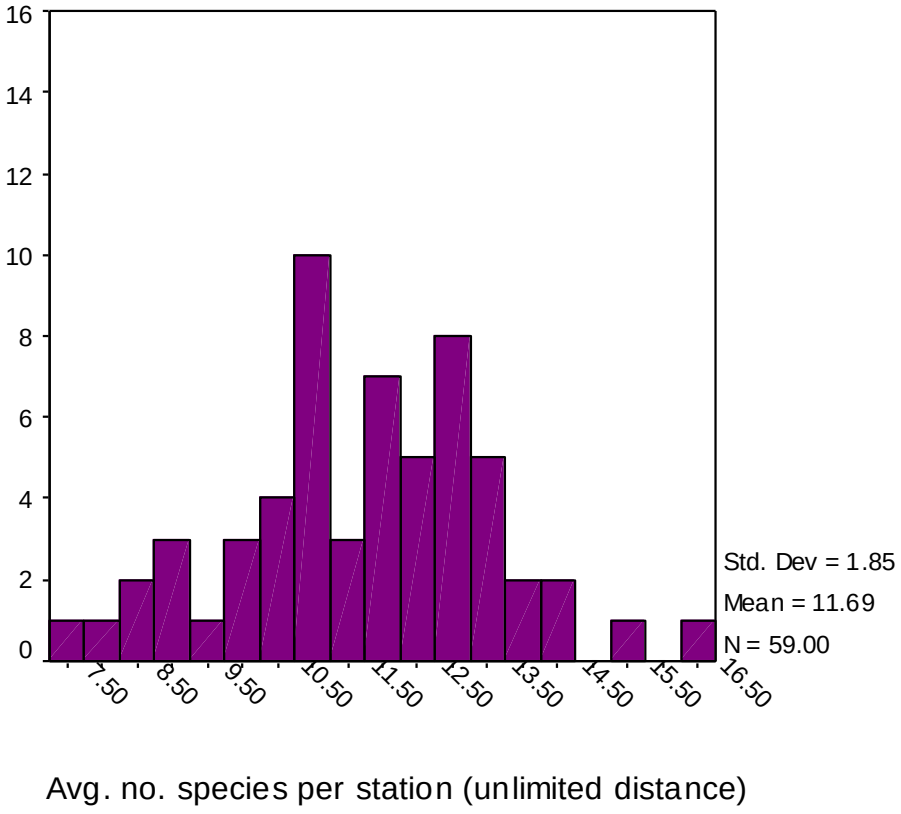


Figure 9. Average number of bird species detected within an unlimited distance of survey stations.

Perhaps a more meaningful set of metrics include those associated with the number of individual birds and number species detected from the suite of 18 meadow "focal" species described by Loffland et al.(2011). These species were selected because of their affinity to meadow and riparian communities, and based on the expectation that their numbers would increase if meadow restoration efforts improved the quantity or quality of habitat components important to them. One exception is the Brown-headed Cowbird. While often found in meadows, this species also uses many other open or disturbed habitats with human or livestock use. Brown-headed Cowbirds were selected by Loffland et al. (2011) as a focal species because of the role they play as nest parasites of other meadow-associated birds, and the association between their relative abundance and human disturbance.

When examining only focal species results, the number of individual focal birds detected within 50 m of stations and at unlimited distances were 0.94 (SD=0.8) and 3.91 SD=2.75) , respectively (Figures 10 and 11). The average number of focal *species* per station recorded within these two distance parameters were 0.7 (SD=0.53) and 2.3 (SD=1.4), respectively (Figures 12 and 13). One potential use for this information is to create an understanding of regional or subregional averages for numbers of focal species that might be expected at a site. The average values plus one standard deviation could be a starting point for setting post-restoration targets. Using our 2012 results, the mean plus one standard deviation would

suggest targets of 1.74 and 6.72 focal individuals at the 50m and unlimited radius distances, respectively. Similarly, 1.24 and 3.70 focal species per station at these two distances. Caution should be used, when developing these sorts of targets, and efforts should be made to identify targets based on results from only those sites with similar size, hydrology, elevation, and vegetation characteristics, to avoid identifying targets that are unreasonable for individual sites.

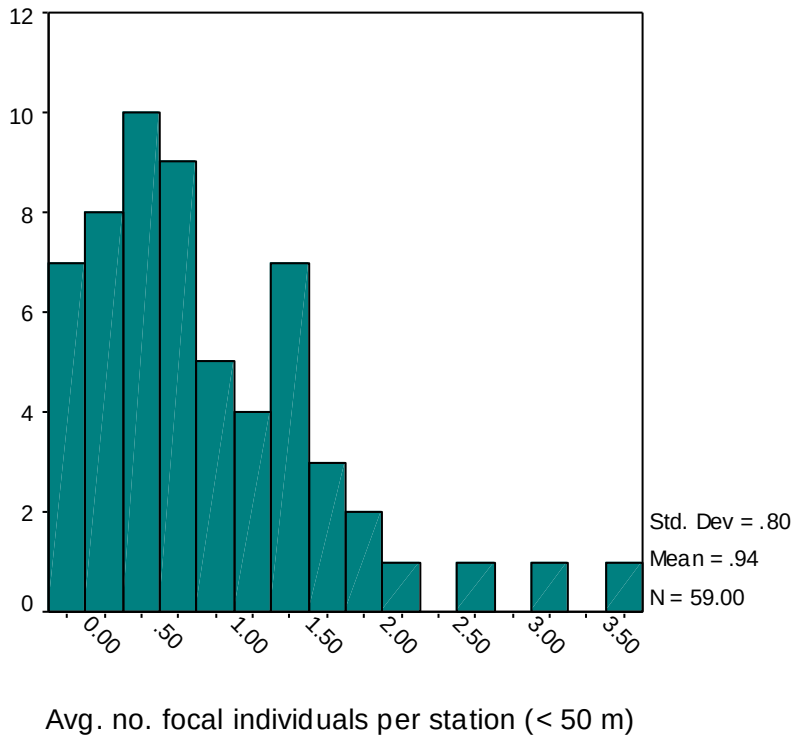


Figure 10. Average number of individuals of 18 focal species detected within 50 m of survey stations.

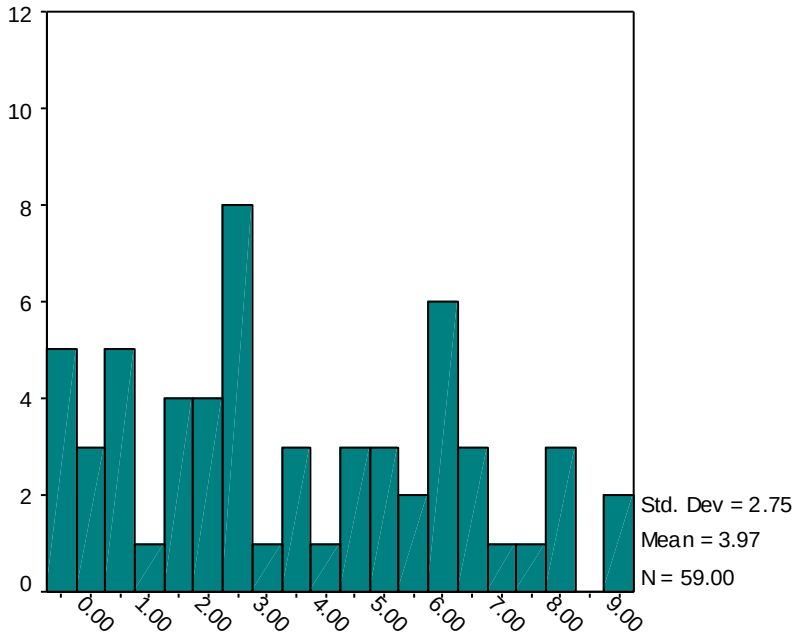


Figure 11. Average number of individuals of 18 focal species detected at unlimited distances of survey stations.

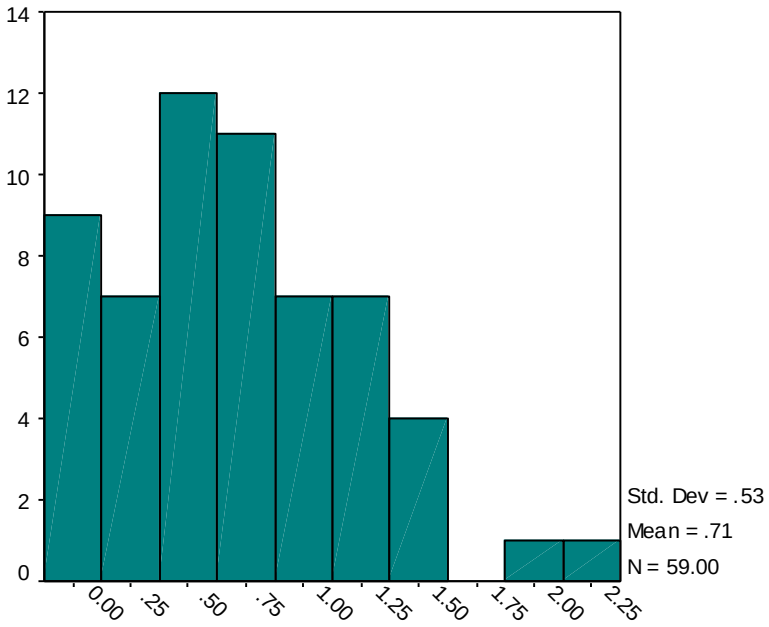


Figure 12. Average number of focal species detected within 50 m of survey stations.

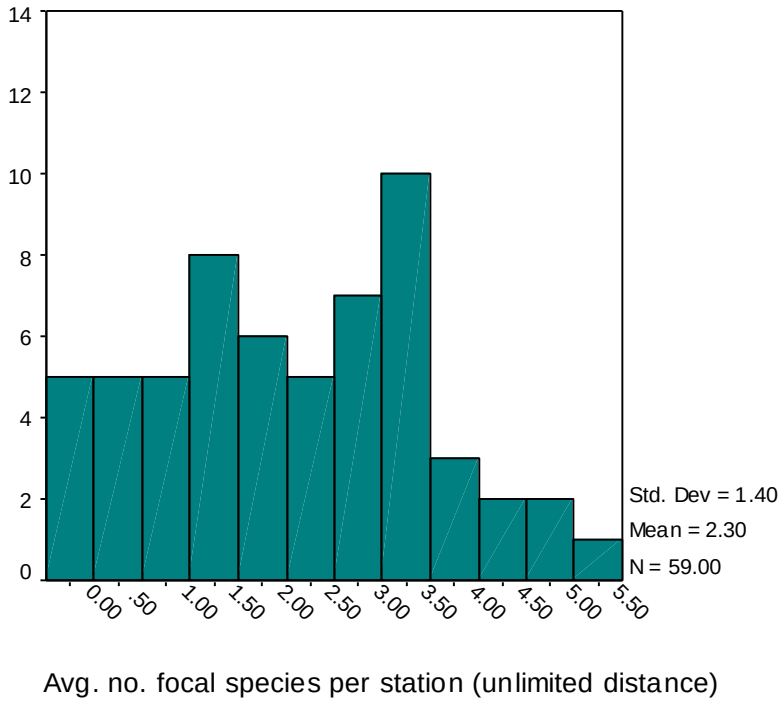


Figure 13. Average number of focal species detected at unlimited distances of survey stations.

Using the indices described above allows us to divide total numbers of birds detected by the number of survey stations and thereby account for variability that is the result of meadow size. Nonetheless, it can still be useful to examine the total number of focal species at a site to gain insight into regional averages for montane meadows. At our suite of meadows, some had no focal species present and one site had 14 focal species (Table 3). The average number of focal species detected during point counts was 5.86 (SD=3.07). Sites in the North Sierra Nevada sub-region in general and the Perazzo Meadows and Little Truckee (LT) areas specifically had values that were almost all greater than the mean Sierra Nevada value (Table 3).

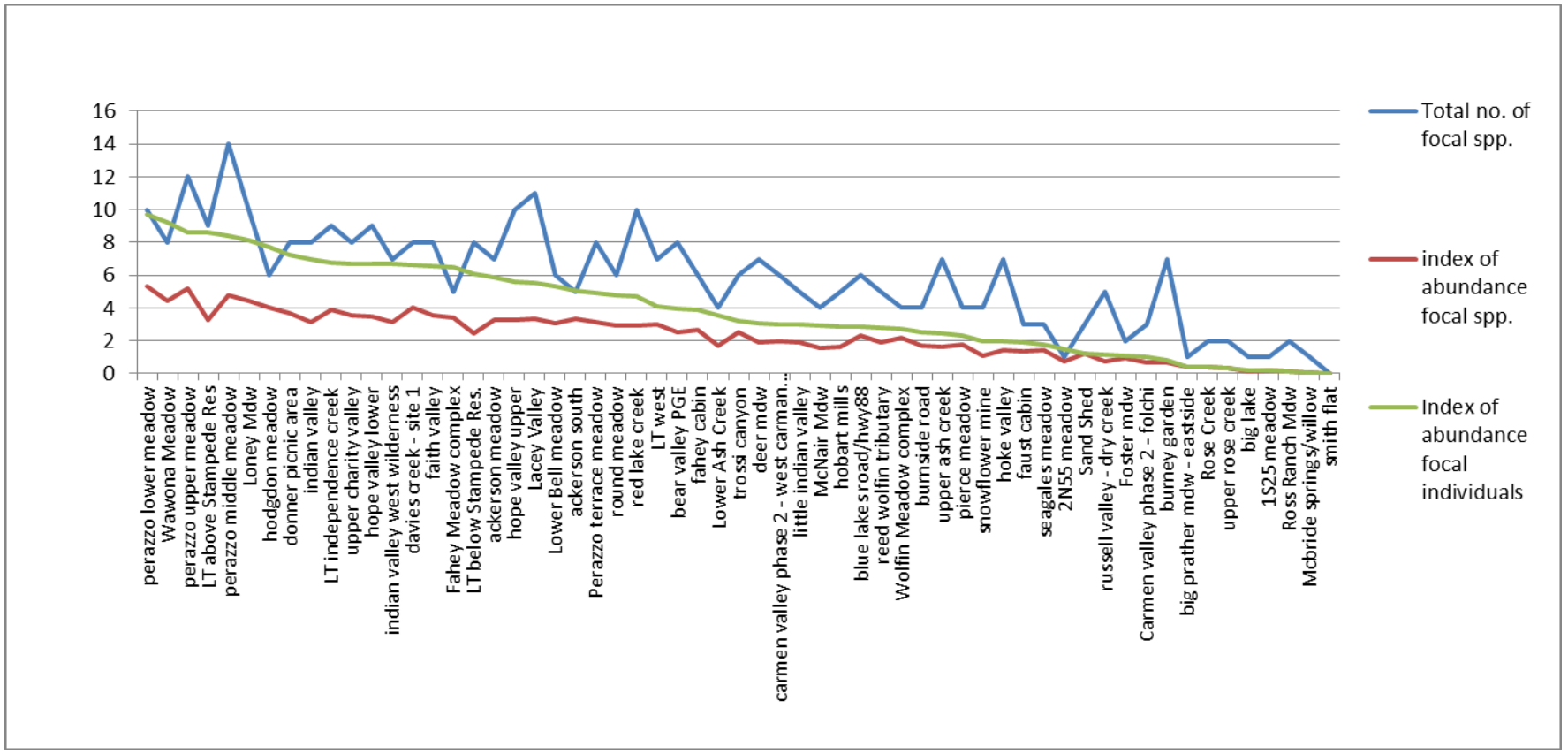
Table 3. Total number of focal species by site. Values are reported in descending order by subregion.

Meadow	Total No. Focal Species Detected
CASCADES SUBREGION	
Burney Garden	7
Upper Ash Creek	7
Lower Ash Creek	4
Rose Creek	2
Upper Rose Creek	2
Big Lake	1
McBride Springs/Willow Creek	1
Smith Flat	0
NORTH SIERRA NEVADA SUBREGION	
Perazzo Middle Meadow	14
Perazzo Upper Meadow	12
Lacey Valley	11
Loney Meadow	10
Perazzo Lower Meadow	10
LT Above Stampede	9
LT Independence	9
Bear Valley PG&E	8
Davies Creek - Site 1	8
Donner Picnic Area	8
LT Below Stampede	8
Perazzo Terrace Meadow	8
Deer Meadow	7
Hoke Valley	7
LT West	7
Carmen Valley Phase 2 - West Carman Creek	6
Trossi Canyon	6
Hobart Mills	5
Russell Valley - Dry Creek	5
McNair Meadow	4
Pierce Meadow	4
Snowflower Mine	4
Carmen Valley Phase 2 - Folchi	3
Ross Ranch Meadow	2
NORTH-CENTRAL SIERRA NEVADA SUBREGION	
Hope Valley Upper	10

Meadow	Total No. Focal Species Detected
Red Lake Creek	10
Hope Valley Lower	9
Faith Valley	8
Indian Valley	8
Upper Charity Valley	8
Indian Valley West Wilderness	7
Blue Lakes Road/Hwy88	6
Little Indian Valley	5
Burnside Road	4
Sand Shed	3
Foster Meadow	2
SOUTH-CENTRAL SIERRA NEVADA SUBREGION	
Wawona Meadow	8
Ackerson Meadow	7
Fahey Cabin	6
Hodgdon Meadow	6
Lower Bell Meadow	6
Round Meadow	6
Ackerson South	5
Fahey Meadow Complex	5
Reed Wolfin Tributary	5
Wolfin Meadow Complex	4
Faust Cabin	3
Seagales Meadow	3
1s25 Meadow	1
2n55 Meadow	1
Big Prather East	1

Not surprisingly the three focal species metrics described above were highly correlated with R^2 values that were $\geq$0.98 for each bivariate correlation; and significant with p values $\leq$0.001 in all instances. The two indices of abundance for focal individuals and focal species (unlimited distance) tracked each other very well, but although still significantly correlated, the total number of focal species at a site did not co-vary as closely (Figure 14).

Figure 14. Comparison of total number of focal species detected, index of abundance of focal species (average number of focal species detected per station), and index of abundance of focal individuals (average number of individuals of focal species detected per station) across all restoration and reference sites.



We assessed the bivariate correlation between all possible pairs of the 18 focal species detected during 2012, to examine how these species varied as a group and if any were so well correlated that they might stand as surrogates for one another and reduce the need to track populations of so many focal species (Table 4). Although all focal species except Swainson's Thrush were significantly correlated with at least one other focal species, most had very low Pearson's correlation coefficients (R). Only Yellow Warbler and Song Sparrow had an R value greater than 0.5 ($R=0.519$, $p<0.0001$). Even in this case the $R^2=0.27$, suggested that only approximately one quarter of the variation in the index of abundance for Yellow Warbler could be explained by the variation in Song Sparrow abundance. Six other species pairs had correlation coefficients at or slightly above 0.25 ($R^2=0.063$) including:

- Warbling Vireo * Lincoln's Sparrow
- Spotted Sandpiper * Willow Flycatcher
- Virginia Rail *Common Yellowthroat and Willow Flycatcher
- Willow Flycatcher * Yellow Warbler
- Wilson's Warbler * White-crowned Sparrow

These correlations have R^2 values explaining only 7% of the variation in each bivariate relationship. Some of these species are only rarely detected or have ranges that do not overlap the entire Sierra Nevada, so these results do not warrant eliminating focal species. Rather, these results indicate that that species vary substantially in individual habitat requirements, with no single species or even small group of species able to serve as an effective indicator for the entire assemblage of meadow-dependent birds.

Table 4. Bivariate correlations for detections of 18 focal species in 2012.

		Brown-headed Cowbird	Common Yellowthroat	Lincoln's Sparrow	MacGillivrays' Warbler	Red-breasted Sapsucker	Sandhill Crane	Sora	Song Sparrow	Spotted Sandpiper	Swainson's THrush	Virginia Rail	Warbling Vireo	White-crowned Sparrow	Willow Flycatcher	Wilson's Snipe	Wilson's Warbler	Yellow – breasted Chat	Yellow Warbler
Brown-headed Cowbird	**Pearson R**	**1.000**	**0.006**	**-0.153**	**-0.112**	**-0.060**	**0.016**	**-0.003**	**0.008**	**0.034**	**-0.017**	**0.026**	**-0.158**	**-0.112**	**-0.008**	**-0.019**	**-0.010**	**0.020**	**0.021**
	p	.	0.858	0.000	0.000	0.058	0.609	0.912	0.807	0.281	0.596	0.417	0.000	0.000	0.813	0.546	0.748	0.522	0.517
Common Yellowthroat	**Pearson R**	**0.006**	**1.000**	**-0.021**	**-0.015**	**-0.011**	**-0.006**	**-0.003**	**-0.014**	**-0.015**	**-0.001**	**0.256**	**-0.021**	**-0.021**	**-0.005**	**0.022**	**-0.011**	**-0.002**	**-0.020**
	p	0.858	.	0.510	0.633	0.735	0.839	0.928	0.671	0.637	0.968	0.000	0.508	0.504	0.870	0.483	0.726	0.952	0.539
Lincoln's Sparrow	**Pearson R**	**-0.153**	**-0.021**	**1.000**	**0.136**	**0.027**	**-0.121**	**-0.049**	**-0.054**	**-0.106**	**-0.014**	**0.044**	**0.270**	**0.182**	**-0.023**	**-0.093**	**0.140**	**-0.040**	**-0.025**
	p	0.000	0.510	.	0.000	0.387	0.000	0.121	0.088	0.001	0.665	0.162	0.000	0.000	0.476	0.003	0.000	0.212	0.424
MacGillivray's Warbler	**Pearson R**	**-0.112**	**-0.015**	**0.136**	**1.000**	**0.051**	**-0.091**	**-0.043**	**0.043**	**-0.135**	**0.004**	**-0.023**	**0.165**	**-0.016**	**-0.026**	**-0.140**	**0.056**	**-0.029**	**0.077**
	p	0.000	0.633	0.000	.	0.107	0.004	0.173	0.176	0.000	0.909	0.467	0.000	0.616	0.419	0.000	0.075	0.366	0.015
Red-breasted Sapsucker	**Pearson R**	**-0.060**	**-0.011**	**0.027**	**0.051**	**1.000**	**-0.049**	**-0.031**	**-0.026**	**-0.086**	**-0.014**	**0.030**	**0.045**	**-0.095**	**-0.047**	**-0.078**	**-0.011**	**0.004**	**0.007**
	p	0.058	0.735	0.387	0.107	.	0.122	0.335	0.412	0.007	0.669	0.349	0.153	0.003	0.140	0.013	0.738	0.907	0.819
Sandhill Crane	**Pearson R**	**0.016**	**-0.006**	**-0.121**	**-0.091**	**-0.049**	**1.000**	**0.062**	**-0.072**	**-0.075**	**-0.008**	**-0.010**	**-0.129**	**-0.131**	**-0.027**	**0.210**	**-0.057**	**-0.012**	**-0.093**
	p	0.609	0.839	0.000	0.004	0.122	.	0.052	0.023	0.019	0.798	0.746	0.000	0.000	0.390	0.000	0.071	0.701	0.003
Sora	**Pearson R**	**-0.003**	**-0.003**	**-0.049**	**-0.043**	**-0.031**	**0.062**	**1.000**	**0.035**	**0.164**	**-0.004**	**0.125**	**-0.047**	**-0.015**	**0.122**	**0.120**	**-0.014**	**-0.005**	**0.052**
	p	0.912	0.928	0.121	0.173	0.335	0.052	.	0.275	0.000	0.909	0.000	0.139	0.628	0.000	0.000	0.666	0.864	0.098
Song Sparrow	**Pearson R**	**0.008**	**-0.014**	**-0.054**	**0.043**	**-0.026**	**-0.072**	**0.035**	**1.000**	**0.208**	**-0.031**	**0.062**	**-0.008**	**0.019**	**0.158**	**0.089**	**0.020**	**0.003**	**0.520**
	p	0.807	0.671	0.088	0.176	0.412	0.023	0.275	.	0.000	0.326	0.049	0.800	0.545	0.000	0.005	0.521	0.935	0.000
Spotted Sandpiper	**Pearson R**	**0.034**	**-0.015**	**-0.106**	**-0.135**	**-0.086**	**-0.075**	**0.164**	**0.208**	**1.000**	**-0.019**	**0.181**	**-0.150**	**0.143**	**0.266**	**0.174**	**0.022**	**-0.028**	**0.230**
	p	0.281	0.637	0.001	0.000	0.007	0.019	0.000	0.000	.	0.551	0.000	0.000	0.000	0.000	0.000	0.497	0.372	0.000
Swainson's Thrush	**Pearson R**	**-0.017**	**-0.001**	**-0.014**	**0.004**	**-0.014**	**-0.008**	**-0.004**	**-0.031**	**-0.019**	**1.000**	**-0.004**	**-0.003**	**-0.018**	**-0.007**	**-0.018**	**0.008**	**-0.002**	**-0.025**
	p	0.596	0.968	0.665	0.909	0.669	0.798	0.909	0.326	0.551	.	0.892	0.927	0.578	0.837	0.569	0.803	0.939	0.437
Virginia Rail	**Pearson R**	**0.026**	**0.256**	**0.044**	**-0.023**	**0.030**	**-0.010**	**0.125**	**0.062**	**0.181**	**-0.004**	**1.000**	**-0.013**	**-0.008**	**0.257**	**0.217**	**0.044**	**-0.006**	**0.193**
	p	0.417	0.000	0.162	0.467	0.349	0.746	0.000	0.049	0.000	0.892	.	0.692	0.811	0.000	0.000	0.169	0.840	0.000
Warbling Vireo	**Pearson R**	**-0.158**	**-0.021**	**0.270**	**0.165**	**0.045**	**-0.129**	**-0.047**	**-0.008**	**-0.150**	**-0.003**	**-0.013**	**1.000**	**-0.002**	**0.017**	**-0.166**	**0.194**	**0.074**	**0.057**
	p	0.000	0.508	0.000	0.000	0.153	0.000	0.139	0.800	0.000	0.927	0.692	.	0.938	0.592	0.000	0.000	0.020	0.075
White-crowned Sparrow	**Pearson R**	**-0.112**	**-0.021**	**0.182**	**-0.016**	**-0.095**	**-0.131**	**-0.015**	**0.019**	**0.143**	**-0.018**	**-0.008**	**-0.002**	**1.000**	**0.027**	**-0.001**	**0.252**	**-0.040**	**0.004**
	p	0.000	0.504	0.000	0.616	0.003	0.000	0.628	0.545	0.000	0.578	0.811	0.938	.	0.400	0.986	0.000	0.206	0.893

		Brown-headed Cowbird	Common Yellowthroat	Lincoln's Sparrow	MacGillivrays' Warbler	Red-breasted Sapsucker	Sandhill Crane	Sora	Song Sparrow	Spotted Sandpiper	Swainson's THrush	Virginia Rail	Warbling Vireo	White-crowned Sparrow	Willow Flycatcher	Wilson's Snipe	Wilson's Warbler	Yellow – breasted Chat	Yellow Warbler
Willow Flycatcher	**Pearson R**	**-0.008**	**-0.005**	**-0.023**	**-0.026**	**-0.047**	**-0.027**	**0.122**	**0.158**	**0.266**	**-0.007**	**0.257**	**0.017**	**0.027**	**1.000**	**0.167**	**0.039**	**-0.010**	**0.273**
	p	0.813	0.870	0.476	0.419	0.140	0.390	0.000	0.000	0.000	0.837	0.000	0.592	0.400	.	0.000	0.219	0.758	0.000
Wilson's Snipe	**Pearson R**	**-0.019**	**0.022**	**-0.093**	**-0.140**	**-0.078**	**0.210**	**0.120**	**0.089**	**0.174**	**-0.018**	**0.217**	**-0.166**	**-0.001**	**0.167**	**1.000**	**-0.065**	**-0.027**	**0.087**
	p	0.546	0.483	0.003	0.000	0.013	0.000	0.000	0.005	0.000	0.569	0.000	0.000	0.986	0.000	.	0.039	0.394	0.006
Wilson's Warbler	**Pearson R**	**-0.010**	**-0.011**	**0.140**	**0.056**	**-0.011**	**-0.057**	**-0.014**	**0.020**	**0.022**	**0.008**	**0.044**	**0.194**	**0.252**	**0.039**	**-0.065**	**1.000**	**-0.021**	**0.040**
	p	0.748	0.726	0.000	0.075	0.738	0.071	0.666	0.521	0.497	0.803	0.169	0.000	0.000	0.219	0.039	.	0.507	0.202
Yellow-breasted Chat	**Pearson R**	**0.020**	**-0.002**	**-0.040**	**-0.029**	**0.004**	**-0.012**	**-0.005**	**0.003**	**-0.028**	**-0.002**	**-0.006**	**0.074**	**-0.040**	**-0.010**	**-0.027**	**-0.021**	**1.000**	**0.052**
	p	0.522	0.952	0.212	0.366	0.907	0.701	0.864	0.935	0.372	0.939	0.840	0.020	0.206	0.758	0.394	0.507	.	0.099
Yellow Warbler	**Pearson R**	**0.021**	**-0.020**	**-0.025**	**0.077**	**0.007**	**-0.093**	**0.052**	**0.520**	**0.230**	**-0.025**	**0.193**	**0.057**	**0.004**	**0.273**	**0.087**	**0.040**	**0.052**	**1.000**
	p	0.517	0.539	0.424	0.015	0.819	0.003	0.098	0.000	0.000	0.437	0.000	0.075	0.893	0.000	0.006	0.202	0.099	.

Mean indices of abundance for each focal species at each site are shown in Table 5 and for all species in Appendix E. Some species are clearly quite rare in some or all of the four subregions (Willow Flycatcher, Sandhill Crane, Sora, Virginia Rail, Swainson's Thrush, Common Yellowthroat, Yellow-breasted Chat). Other species are found in most sites and subregions (MacGillivray's Warbler, Yellow Warbler, Warbling Vireo, Song Sparrow, Lincoln's Sparrow and Red-breasted Sapsucker). Wilson's Warbler and White-crowned Sparrow were detected at many sites in the 3 northern-most subregions, but only occurred at one site each in the South-central Sierra Nevada subregion. Although not desirable, Brown-headed cowbird was detected at most sites in all subregions. Of all the focal species the three that occurred most often and at the greatest mean abundance were, Lincoln's Sparrow (0.53 birds/station; SE=0.62), Song Sparrow (0.88 indiv./station; SE=0.91), and Yellow Warbler (0.52: SE=0.73).

Table 5. Index of relative abundance[a] of meadow-associated focal bird species at each meadow. Greatest recorded abundance for each species is indicated with blue shading.

Meadow	Sandhill Crane	Virginia Rail	Sora	Spotted Sandpiper	Wilson's Snipe	Red-breasted Sapsucker	Willow Flycatcher	Swanson's Thrush	Warbling Vireo	Yellow Warbler	MacGillivray's Warbler	Common Yellowthroat	Wilson's Warbler	Yellow-breasted Chat	Song Sparrow	Lincoln's Sparrow	White-crowned Sparrow	Brown-headed cowbird
CASCADES SUBREGION																		
Big Lake	0	0	0	0	0	0.19	0	0	0	0	0	0	0	0	0	0	0	0
Burney Garden	0.12	0	0	0	0.02	0.02	0	0	0.3	0	0.2	0	0.04	0	0.1	0	0	0.34
Lower Ash Creek	2.04	0	0.06	0	0.91	0	0	0	0	0	0	0	0	0	0.56	0	0	0.57
McBride Springs/Willow Creek	0	0	0	0	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0.42
Rose Creek	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0.1	0	0	2.2
Smith Flat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
Upper Ash Creek	0.37	0	0	0.17	0.37	0	0	0	0	0.27	0	0	0.13	0	0.97	0.2	0	1.2
Upper Rose Creek	0	0	0	0	0	0.2	0	0	0	0.1	0	0	0	0	0	0	0	0.4
NORTH SIERRA NEVADA SUBREGION																		
Bear Valley PG&E	0	0	0	0	0.4	0.06	0	0	0.4	0.74	0.34	0	0.06	0	1.91	0.02	0	0.19
Carmen Valley Phase 2 - Folchi	0.13	0	0	0	0.31	0	0	0	0	0	0	0	0	0	0.56	0	0	0.06
Carmen Valley Phase 2 - West Carman Creek	0	0	0	0	0	0.06	0	0	0.44	0.22	0	0	0	0	1.17	1	0.11	1.06
Davies Creek - Site 1	0	0	0	0.4	0	0.4	0	0	0.4	1	0.8	0	0	0	1.9	0.1	1.6	0.9
Deer Meadow	0	0	0	0	0	0.05	0	0	0.7	0.2	0.6	0	0.65	0	0.05	0.85	0	0
Donner Picnic Area	0	0	0	0.17	1.17	0	0	0	0	1.72	0.06	0	0.11	0	3	0.33	0.67	0.17
Hobart Mills	0	0	0	0	0	0	0	0	0.03	0.58	0	0	0	0	0.89	0.44	0.94	0.42
Hoke Valley	0	0	0	0.09	0	0.09	0	0	0.23	0.23	0.05	0	0	0	1	0	0.27	0.14
Lacey Valley	0.02	0	0	0.8	0.42	0.16	0.18	0	0.54	0.86	0	0	0.32	0	0.64	0.16	1.4	0.22
Loney Meadow	0	0	0	0.36	0.14	0.21	0.14	0	1.71	0.79	0.21	0	0.43	0	1.36	2.79	0	0

Meadow	Sandhill Crane	Virginia Rail	Sora	Spotted Sandpiper	Wilson's Snipe	Red-breasted Sapsucker	Willow Flycatcher	Swanson's Thrush	Warbling Vireo	Yellow Warbler	MacGillivray's Warbler	Common Yellowthroat	Wilson's Warbler	Yellow-breasted Chat	Song Sparrow	Lincoln's Sparrow	White-crowned Sparrow	Brown-headed cowbird
LT Above Stampede	0	0	0	2.5	0	0.08	0.17	0	0.25	2.33	0.08	0	0	0	2.75	0.08	0.33	0.42
LT Below Stampede	0	0	0	0.27	0	0	0	0	0.13	1.77	0.07	0	0.03	0	3.17	0.07	0.57	0.8
LT Independence	0	0	0	0.61	0	0.06	0	0	0.53	1.78	0.58	0	0.22	0	1.92	0.19	0.89	0.28
LT West	0	0	0	0.63	0	0	0	0	0.5	0.63	0.63	0	0.63	0	0.88	0	0.25	0.5
Mcnair Meadow	0	0	0	0	0	0.08	0	0	0.5	0	0.08	0	0	0	0	2.25	0	0.25
Perazzo Lower Meadow	0	0	0	1.1	0.1	0.1	0	0	0.7	2.1	0.5	0	0.90	0	1.8	0.4	2	0.5
Perazzo Middle Meadow	0.12	0.15	0.03	1.65	0.82	0.09	0.26	0	0.26	1.85	0.06	0	0.26	0	2	0.21	0.62	0.44
Perazzo Terrace Meadow	0	0	0	0	0.25	0	0	0	0.58	0.83	0.08	0	0.25	0	0.33	1.33	1.25	0.42
Perazzo Upper Meadow	0	0.12	0.07	0.85	0.63	0	0.22	0	0.8	1.32	0.22	0	0.41	0	1.41	1.44	1.1	0.39
Pierce Meadow	0	0	0	0	0	0	0	0	1.33	0	0.25	0	0	0	0.5	0.25	0	0
Ross Ranch Meadow	0	0	0	0	0	0	0	0	0	0.05	0	0	0	0	0.1	0	0	0.62
Russell Valley - Dry Creek	0	0	0	0	0.2	0	0	0	0	0.04	0	0	0	0	0.75	0.03	0.11	0.25
Snowflower Mine	0	0	0	0	0	0.44	0	0	0.67	0	0.11	0	0.78	0	0	0	0	0
Trossi Canyon	0	0	0	0	0	0.6	0	0	0.6	0	0.1	0	0	0	0.3	1.1	0.5	0.2
NORTH-CENTRAL SIERRA NEVADA SUBREGION																		
Blue Lakes Road/Hwy88	0	0	0	0.77	0.54	0	0	0	0.08	0.15	0	0	0	0	0.46	0	0.85	0.31
Burnside Road	0	0	0	0	0	0	0	0	1	0	0.33	0	0	0	0.83	0.33	0	0.67
Faith Valley	0	0	0	0.64	0.32	0	0	0	0.14	0.89	0	0	0.04	0	1.57	0.46	2.5	0.61
Foster Meadow	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0.92	0	0
Hope Valley Lower	0	0	0	0.44	0.44	0	0	0	0.33	0.6	0.02	0	0.08	0	2.15	0.58	2.04	0.38
Hope Valley Upper	0	0	0	1.21	0.12	0.11	0	0	0.19	0.35	0.05	0	0.14	0	1.72	0.23	1.47	0.3
Indian Valley	0	0	0	0.07	0	0	0	0	0.53	0.07	0.53	0	0.90	0	0.43	1	3.47	0.23
Indian Valley West Wilderness	0	0	0	0	0	0	0	0	0.67	0.33	0.17	0	0.50	0	0.17	0.67	4.17	0

Meadow	Sandhill Crane	Virginia Rail	Sora	Spotted Sandpiper	Wilson's Snipe	Red-breasted Sapsucker	Willow Flycatcher	Swanson's Thrush	Warbling Vireo	Yellow Warbler	MacGillivray's Warbler	Common Yellowthroat	Wilson's Warbler	Yellow-breasted Chat	Song Sparrow	Lincoln's Sparrow	White-crowned Sparrow	Brown-headed cowbird
Little Indian Valley	0	0	0	0	0	0.13	0	0	0.13	0	0.13	0	0	0	0	0.88	1.75	0
Red Lake Creek	0	0	0	0.7	0.25	0.08	0	0	0.23	0.4	0.05	0	0.08	0	1.3	0.68	0.98	0.45
Sand Shed	0	0	0	0	0	0	0	0	0.6	0	0.4	0	0	0	0	0.2	0	0
Upper Charity Valley	0	0	0	0.25	0.19	0	0	0	0.69	0.06	0	0	0.63	0	0.19	1.25	3.44	0.06
SOUTH-CENTRAL SIERRA NEVADA SUBREGION																		
1S25 Meadow	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0
2N55 Meadow	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0
Ackerson Meadow	0	0	0	0	0	0.36	0.04	0	0.82	1.21	0.61	0	0	0	2.46	0.39	0	0.5
Ackerson South	0	0	0	0	0	0.08	0	0	1	0	0.92	0	0	0	1.42	1.67	0	0
Big Prather East	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.43	0	0
Fahey Cabin	0	0	0	0	0	0.21	0	0	0.29	0.14	1.29	0	0	0	1.14	0.79	0	0.07
Fahey Meadow Complex	0	0	0	0	0	0	0	0	0.95	2.35	1	0	0	0	1.05	1.15	0	0.5
Faust Cabin	0	0	0	0	0	0	0	0	0.25	0.25	1.38	0	0	0	0	0	0	0
Hodgdon Meadow	0	0	0	0	0	1.2	0	0	0.8	0.2	1.3	0	0	0	2.2	2	0	0.4
Lower Bell Meadow	0	0	0	0	0	0.1	0	0	2.3	0.7	0.4	0	0	0	0.7	1.1	0	0
Reed Wolfin Tributary	0	0	0	0	0	0.4	0	0	0.2	0.4	1.5	0	0	0	0	0.3	0	0
Round Meadow	0	0	0	0	0	0.2	0	0	2	0.4	0.1	0	0	0	1.2	0.9	0	0.3
Seagales Meadow	0	0	0	0	0	0	0	0	1.4	0	0.2	0	0	0	0	0.2	0	0
Wawona Meadow	0	0	0	0	0	0.5	0	0	1.06	2.94	0.69	0	0.06	0	2.81	1.13	0.06	0.19
Wolfin Meadow Complex	0	0	0	0	0	0.2	0	0	1.1	0	0.9	0	0	0	0	0.5	0	0
Mean of all site means	**0.05**	**0.00**	**0.00**	**0.23**	**0.13**	**0.12**	**0.02**	**0.00**	**0.48**	**0.52**	**0.31**	**0.00**	**0.13**	**0.00**	**0.88**	**0.53**	**0.57**	**0.31**
Standard Error of site means	**0.27**	**0.02**	**0.01**	**0.47**	**0.25**	**0.20**	**0.06**	**0.00**	**0.52**	**0.73**	**0.43**	**0.00**	**0.24**	**0.00**	**0.91**	**0.62**	**0.97**	**0.38**

[a]Number of individuals of each species divided by the number of visits and number of survey stations, based on all detections at unlimited distances.

Post-restoration Results for Completed Restoration Projects

We used multivariate analysis of variance (MANOVA) to test for effects of restoration on focal bird species abundance at sites where restoration was completed prior to our 2012 surveys. Detectable restoration effects on focal bird species appear as significant increases in focal species at the restoration sites in excess of any increases at the reference sites (or bird populations at the restoration sites holding steady while populations at the reference sites continued to decline) that might be due to annual weather variation or other factors unrelated to the restoration projects. MANOVAs comparing the suite of focal species with site type (restoration vs. reference) and year (before vs. after restoration) status as factors did not result in any significant relationships for the intercept of these two factors, however some individual species did show significant responses as described below.

Perazzo Middle Meadow

In the MANOVA analysis for Perazzo Middle Meadow and LT Above Stampede with site type and year as factors, site type*year had no significant effect on focal species indices of abundance ($F=1.17$; $p=0.322$). Interestingly, this study design allowed us to see that the obvious increase in Song Sparrow between years (Fig. 15) was not the result of restoration but rather a regional phenomenon that occurred at the reference site as well. It should be noted that the restoration site did exhibit increases in this species at a greater magnitude than the reference site, but not significantly so.

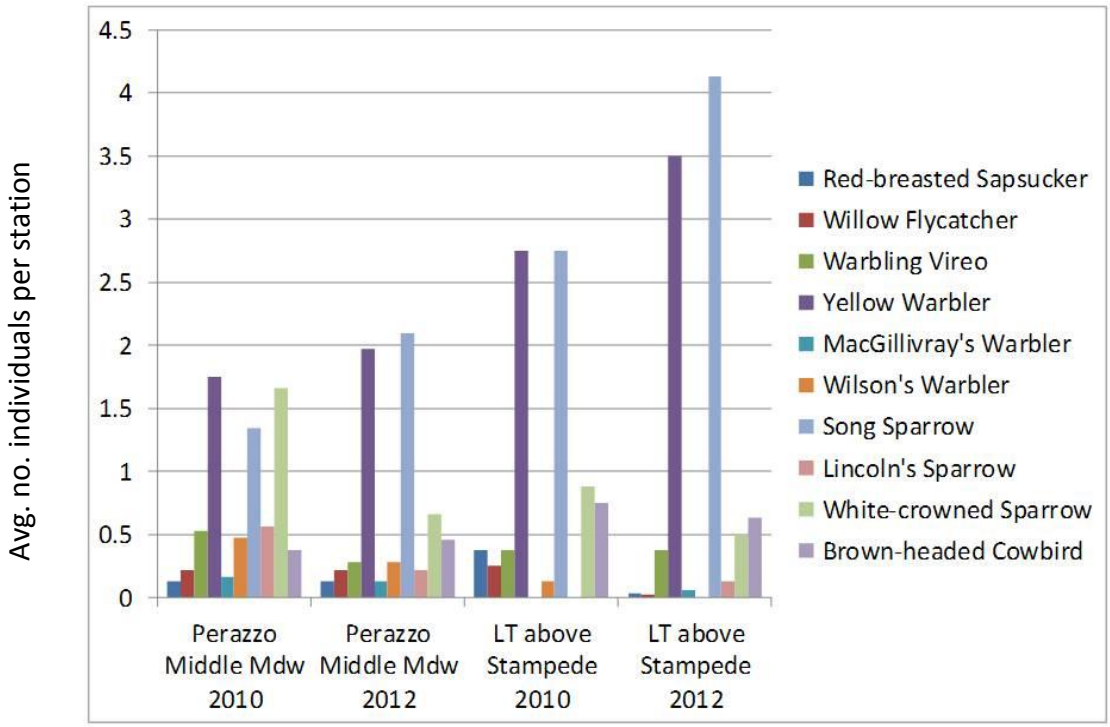


Figure 15. Meadow focal species indices of abundance for Perazzo Middle Meadow and LT above Stampede.

Also of note was the non-significant (F=0.854; p=0.559) but still noteworthy appearance of (or increase in) 8 waterfowl or wading bird species associated with wetlands and wet meadows (Figure 16). These increases are a peek at what could likely become a significant increase at sites like Perazzo Middle Meadow, where large ponded areas were created by the restoration treatment (Figures 17 and 18). Because of their secretive and often naturally low densities, increases in some of these wetland birds may be difficult to detect with significance until more years of results are accumulated.

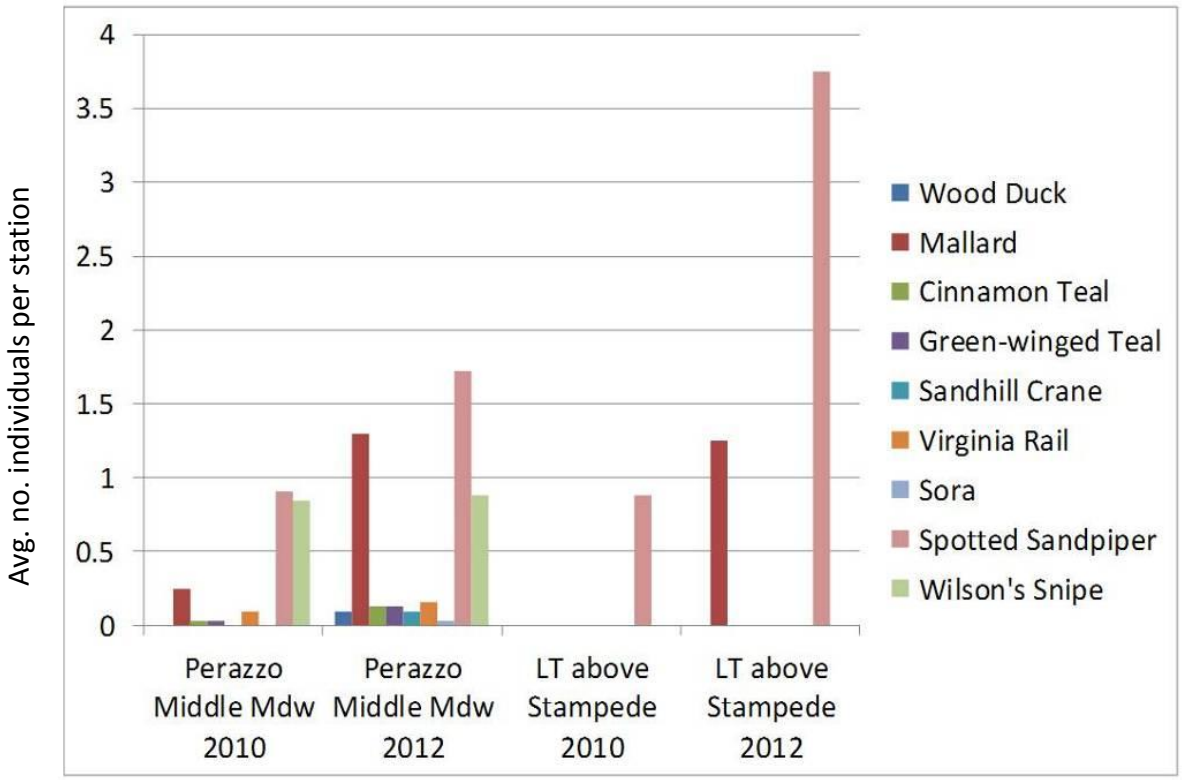


Figure 16. Waterfowl, wading bird and shorebird focal species indices of abundance for the restoration site at Perazzo Middle Meadow and the reference site at LT Above Stampede.

Figure 17. Perazzo Middle Meadow 1 year pre-restoration. The stream was largely restricted to the channel bed, with little standing water even during late spring.

Figure 18. Perazzo Middle Meadow 1 year post-restoration. The restored channel holds large areas of standing water even during late summer.

Davies Creek - Site 1

At Davies Creek - Site 1, populations of Yellow Warbler, MacGillivray's Warbler, White-crowned Sparrow, Song Sparrow and Lincoln's Sparrow appear qualitatively to have increased after restoration (Figure 19). When these five species were included in a MANOVA with site type and year as factors, there was a significant response for site type*year ($F=3.48$; $p=0.013$). Examined individually, the Song Sparrow population at increased significantly at the restoration site when compared to the reference site ($F=1.60$; $p=0.020$), whereas Lincoln's Sparrow detections increased at the reference site relative to the restoration site ($F=4.23$; $p=0.018$). Nonetheless given that some meadow focal species (e.g., Yellow Warbler) were rare or absent at the reference site, it may be worth conducting further analysis after another year of monitoring and determining if another of our nearby reference sites might provide a better reference for this site. Also notable is the appearance at the restoration site of Gadwall, Mallard, Green-winged Teal, Red-winged Blackbird and Spotted Sandpiper, all species that likely arrived because of the appearance of surface water and persistence of water longer into the breeding season (Figure 20 and 21). Because of the small sample size, these increases were not significant at the 0.05 level.

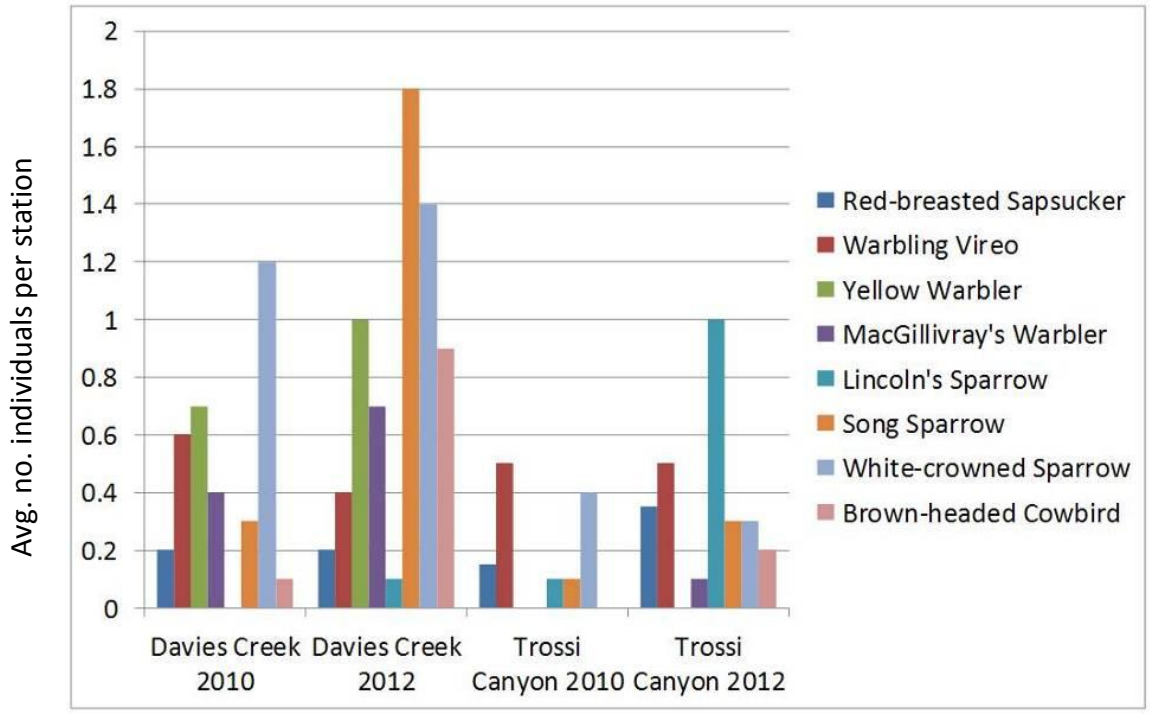


Figure 19. Indices of abundance for focal species at the restoration site at Davies Creek – Site 1 and the reference site at Trossi Canyon.

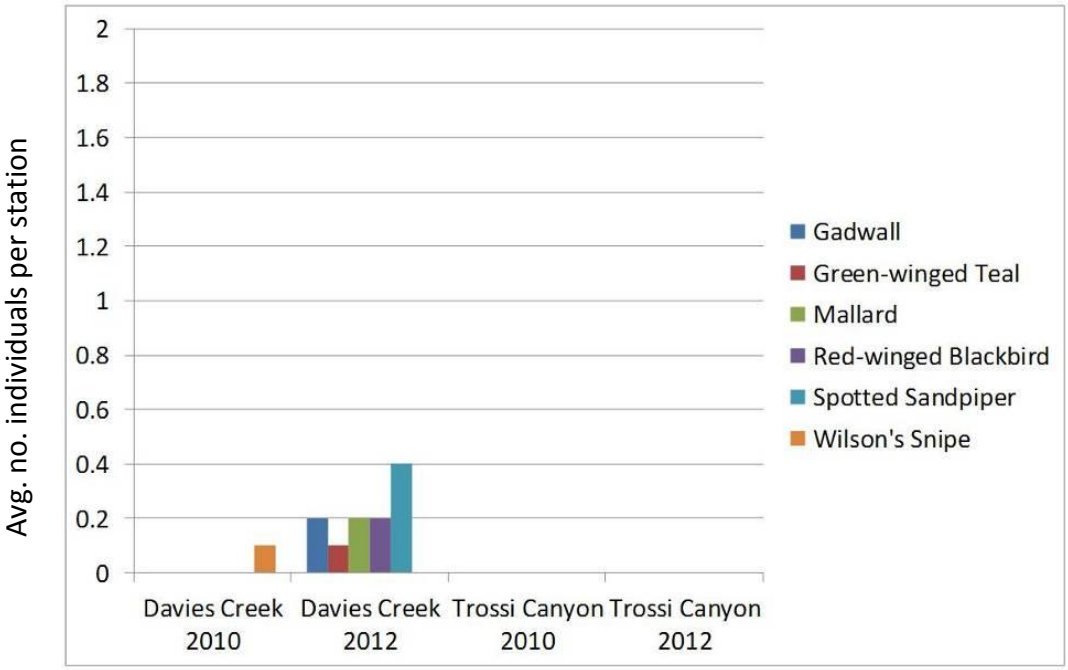


Figure 20. Indices of abundance for waterfowl and wading birds at the restoration site at Davies Creek – Site 1 and the reference site at Trossi Canyon.

Figure 21. Newly created ponded water along Davies Creek – Site 1.

Rose Creek

Qualitative inspection of results for Rose Creek suggested the number of detections of Gadwall and Red-breasted Sapsucker appear to have increased and Yellow Warbler decreased after restoration at Rose Creek while Brown-headed Cowbird and Song Sparrow held steady (Figure 22). When these species were included in a MANOVA with site type and year as factors, there was not a significant response for site type*year ($F=0.904$; $p=0.505$). Examined individually, none of these species had significant changes when compared to the reference site at the 0.05 significance level. It is possible that disturbance to willow stands during construction may have temporarily decreased suitable habitat for Yellow Warbler, which could explain the observed decline for that species. Another possibility is that only a single year of baseline pre-restoration data and post-restoration data is inadequate to screen out the 'noise' of normal population fluctuations. Probably more notable is the appearance of Gadwall after restoration (even if the increase was not significant). Gadwall nest along the edges of and forage in ponds and would not have had suitable habitat at this site before restoration. The construction of in-stream ponds during restoration creates habitat that can be almost immediately discovered and occupied by waterfowl such as these (Fig 23).

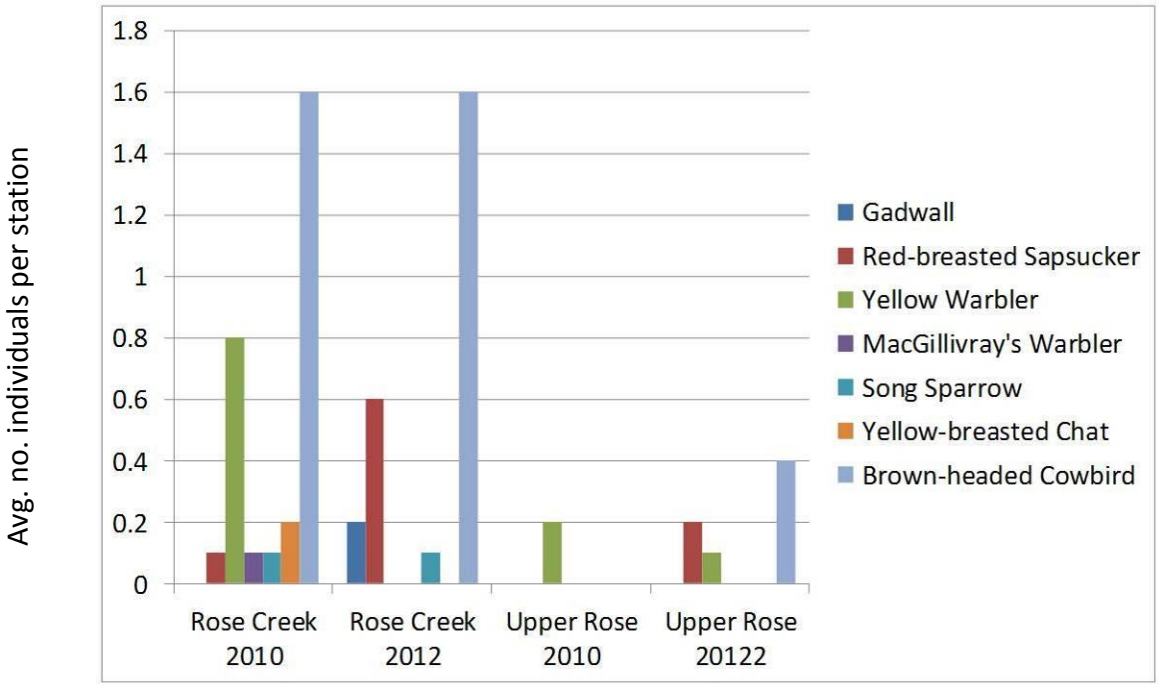


Figure 22. Indices of abundance for waterfowl and focal species at Rose Creek restoration site and the reference site at Upper Rose Creek.

Fig 23. Rose Creek restoration area, with small ponded water areas and small patches of replanted willows after restoration.

McBride Springs/Willow Creek

At McBride Springs/Willow Creek only three focal species have been detected: Warbling Vireo, White-crowned Sparrow, and Brown-headed Cowbird (Figure 24). When these species were included in a MANOVA with site type and year as factors, there was not a significant response for site type*year (F=0.523; p=0.670). Examined individually, none of these species had significant changes when compared to the reference site at the 0.05 significance level. Brown-headed Cowbird was the most abundant of these at 0.4 individuals detected per station (almost one per every two stations). Warbling Vireo was detected at one station after restoration and although the increase was not significant, the appearance of a focal species in previously dry sagebrush dominated disturbed riparian area is biologically notable. One non-focal species that responded significantly to restoration was Tree Swallow (F=4.923; p=0.034). While Tree swallow detections dropped by a third at the reference site (possibly in response to the much drier year in 2012), numbers held steady at the McBride Restoration site. This species nests in snags and feeds on emerging aquatic insects over open water. It is possible that the open water habitat created during plug and pond restoration held water much longer during this drier year than the degraded channel at the reference site (Fig 25), however caution should be used in interpreting results as this species tends to occur in flocks which can confound statistical results.

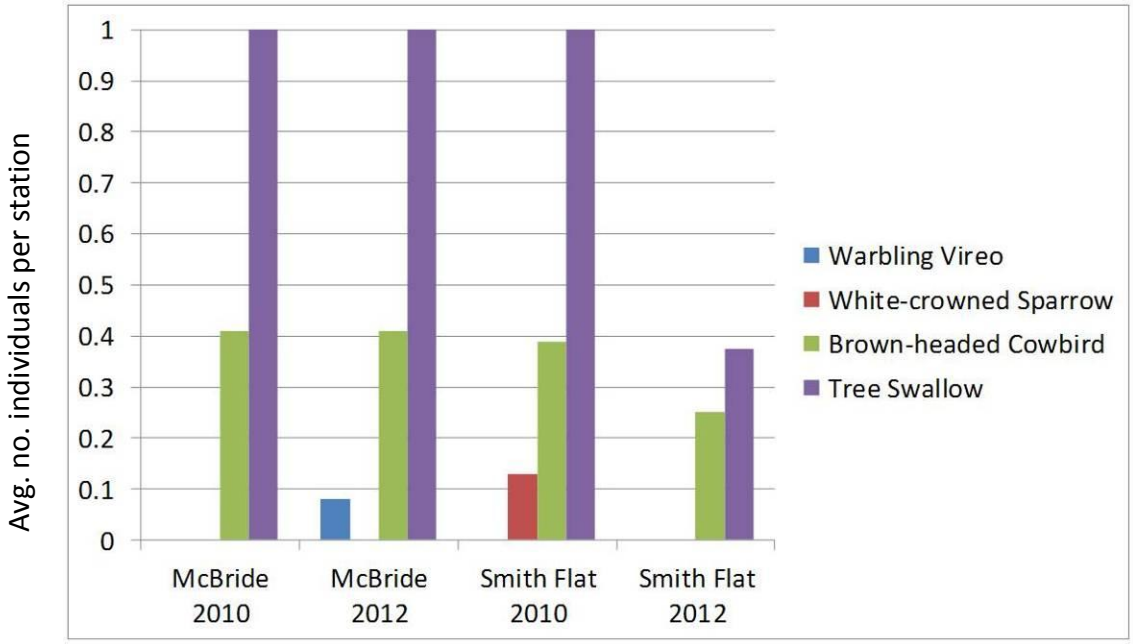


Figure 24. Indices of abundance for focal and other species at the restoration site at McBride Springs/Willow Creek and its reference site at Smith Flat.

Figure 25. Open water in a recently constructed pond on McBride Springs, with new herbaceous vegetation.

Wawona Meadow

Wawona Meadow is an interesting example of restoration occurring not so much to restore a highly degraded site, but rather restoration to restore a still highly functioning (but presumably degraded from previous condition) system with an active stream incision. As a result bird response might be more subtle at this site due to the already good condition, but alternately habitat improvements in expanded shallow wetlands and shrub recruitment can be expected to happen quickly (Fig 26). At Wawona ten focal species were detected (Figure 27). When these species were included in a MANOVA with site type and year as factors, there was not a significant response for site type*year ($F=1.469$; $p=0.188$). Examined individually, none of these species had significant changes when compared to the reference site at the 0.05 significance level.

Figure 26. Inundated vegetation 6 months after restoration of an incised channel was completed at Wawona Meadow.

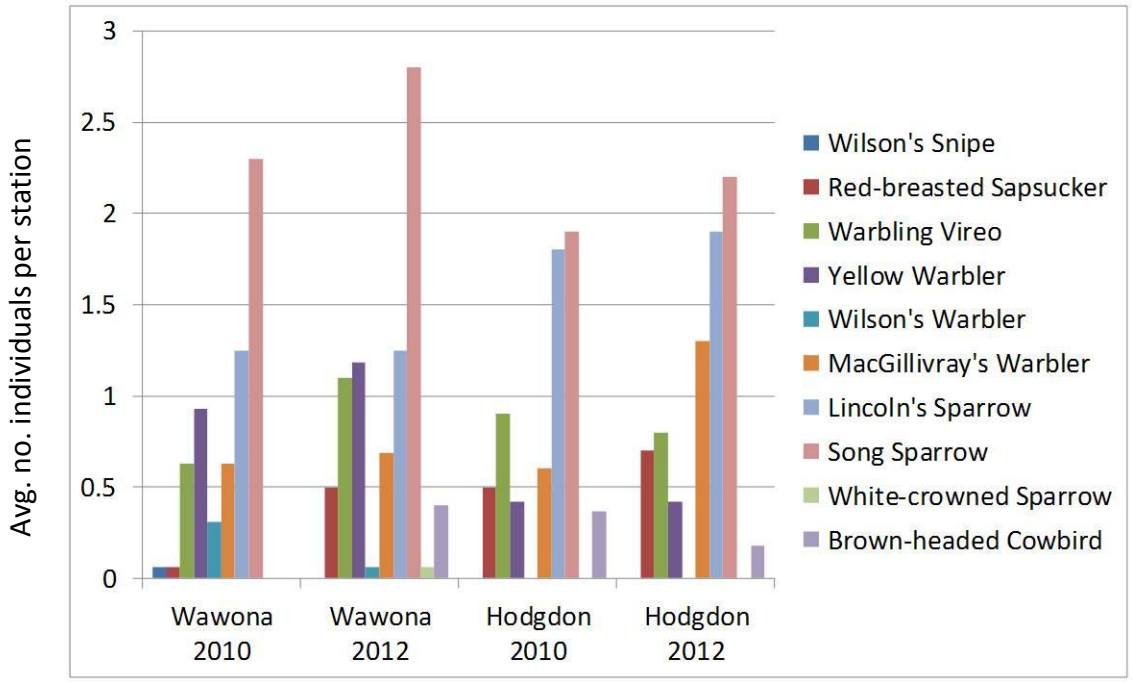


Figure 27. Focal bird abundance indices at Wawona Meadow and its reference site, Hodgdon Meadow.

All restored sites pooled

In a final analysis we pooled data from all restored sites and all associated reference sites, respectively, and conducted a pooled MANOVA on focal species indices with site type and year as factors. The resulting model did not have a significant relationship between site type and year ($F=0.881$, $p=0.592$). None of the individual species had a significant response either in the pooled data set. What shows most markedly is that fluctuations in some populations (e.g., Red-breasted Sapsucker) between years and across sites would be difficult to separate from treatment effects if we were not using a paired sampling strategy (Figure 28).

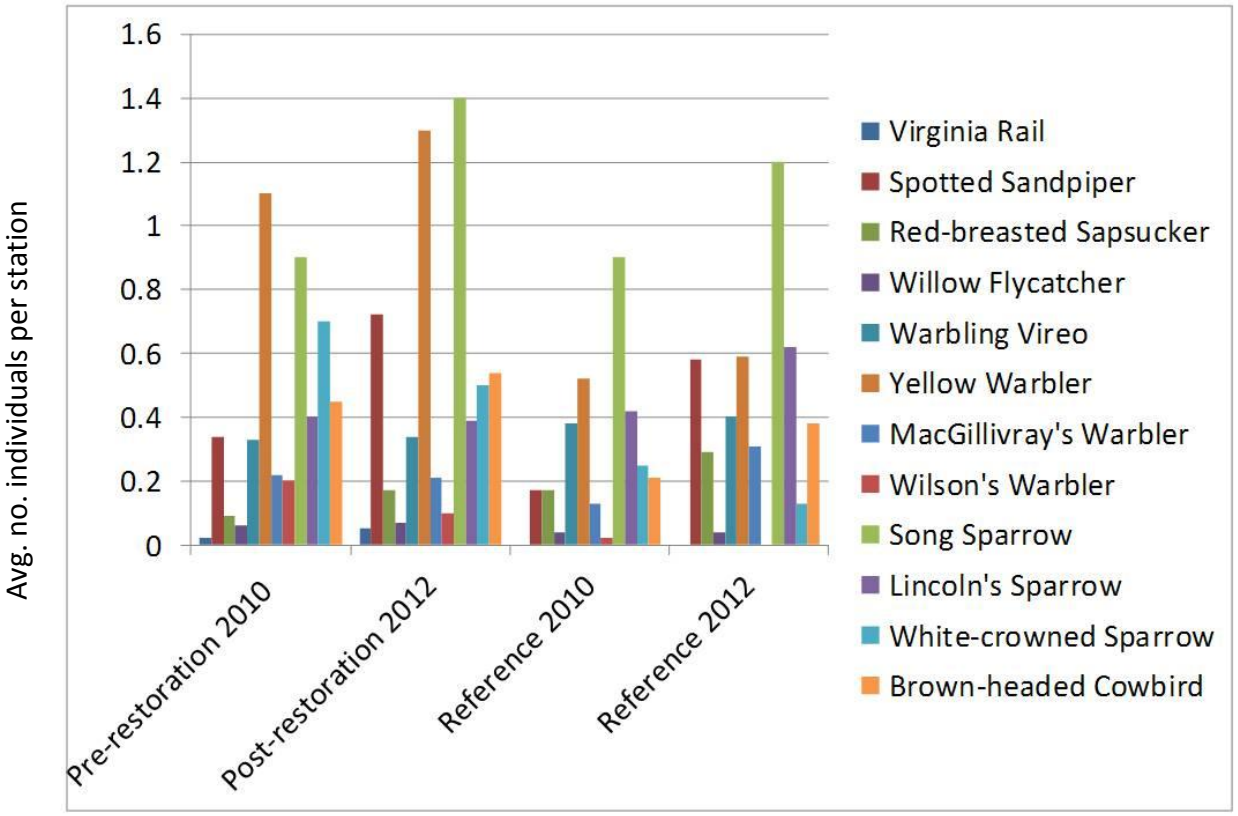


Figure 28. Focal species indices of abundance with all restored sites pooled and associated reference sites pooled.

Area Searches

Total number of species and number of focal species detected per site during area searches are indicated in Table 6. Species-specific area search results for each site are provided in Appendix F. Large meadows consistently supported more total species than small meadows, but in some cases many focal species were detected at relatively small meadows.

Table 6. Size of meadow, number of survey stations, number of total bird species, and number of focal species detected during area search surveys during 2012. Meadows are listed alphabetically by subregion.

Meadow	Size (Ha)	No. Stations	No. of Species Detected	No. of Focal Species Detected
CASCADES SUBREGION				
Big Lake	26	8	24	0
Burney Garden	193	25	53	9
Lower Ash Creek	1051	27	63	9
McBride Springs/Willow Creek	55	6	36	4
Rose Creek	12	5	46	4
Smith Flat	45	4	17	0
Upper Ash Creek	306	15	47	6
Upper Rose Creek	11	5	31	0
NORTH SIERRA NEVADA SUBREGION				
Bear Valley C	142	24	57	9
Carmen Valley Phase 2 - Folchi	140	16	46	4
Carmen Valley Phase 2 - West Carman Creek	22	9	38	7
Davies Creek - Site 1	10	5	44	9
Deer Meadow	24	10	37	6
Donner Picnic Area	50	9	54	8
Hobart Mills	69	18	57	7
Hoke Valley	102	11	48	10
Lacey Valley	171	25	59	12
Loney Meadow	57	7	41	10
LT Above Stampede	32	4	41	10
LT Below Stampede	128	14	42	9
LT Independence	103	17	50	10
LT West	28	5	33	8
McNair Meadow	17	6	33	3
Perazzo Lower Meadow	23	5	33	9
Perazzo Middle Meadow	98	17	54	15
Perazzo Terrace Meadow	23	6	36	9
Perazzo Upper Meadow	105	21	68	14
Pierce Meadow	28	6	22	4
Ross Ranch Meadow	64	10	47	3

Meadow	Size (Ha)	No. Stations	No. of Species Detected	No. of Focal Species Detected
Russell Valley - Dry Creek	267	36	74	10
Snowflower Mine	22	9	31	4
Trossi Canyon	15	5	36	8
NORTH-CENTRAL SIERRA NEVADA SUBREGION				
Blue Lakes Road/Hwy88	34	6	34	5
Burnside Road	12	3	24	5
Faith Valley	87	14	42	9
Foster Meadow	10	6	18	2
Hope Valley Lower	186	24	49	10
Hope Valley Upper	187	29	58	10
Indian Valley	110	13	46	11
Indian Valley West Wilderness	14	3	26	7
Little Indian Valley	15	4	25	4
Red Lake Creek	114	20	51	11
Sand Shed	4	5	17	4
Upper Charity Valley	38	8	33	9
SOUTH-CENTRAL SIERRA NEVADA SUBREGION				
1S25 Meadow	5	3	19	0
2N55 Meadow	3	2	22	1
Ackerson Meadow	62	14	54	7
Ackerson South	22	6	26	5
Big Prather East	22	7	19	1
Fahey Cabin	12	7	36	6
Fahey Meadow Complex	27	10	42	7
Faust Cabin	4	4	28	2
Hodgdon Meadow	21	5	42	7
Lower Bell Meadow	8	5	35	8
Reed Wolfin Tributary	11	5	37	5
Round Meadow	7	5	37	8
Seagales Meadow	7	5	26	3
Wawona Meadow	63	8	49	8
Wolfin Meadow Complex	7	5	27	3

Vegetation Assessment

Vegetation and water measurements were collected at each survey station for the purpose of assessing the 50-m radius area surrounding each survey station, and to provide

information characterizing the general vegetation communities and hydrologic conditions within the overall meadow. Table 7 provides the average cover values for each meadow, calculated from the means of the four quadrants at each survey station.

Tree and snag cover was greatest at smaller sites (1S25 meadow, Fahey Cabin) where the forest edge regularly fell within 50 m of the survey stations, long linear stringer meadows (Foster Meadow, Carman Creek West), and sites being encroached by conifers (Burney Garden, Big Lake). Tree cover within the meadow can be an indicator of lowered water tables and conifer encroachment. Although meadow-associated birds will utilize trees for foraging and territory advertisement, brown-headed cowbirds and nest predators also use trees within the meadow as hunting perches. Higher elevation sites had the greatest amount of cover from riparian shrubs (generally willows) within the 50-m plots (Indian Valley, Faith Valley), as did sites within broad floodplains (Perazzo Upper, Middle and Lower Meadows). On average, sites had only 9.3% (SD=18.03) riparian shrub cover within 50 m of stations. Extent of shrub cover is particularly important for many shrub-nesting bird species (Yellow Warbler, Willow Flycatcher).

Sagebrush cover, often an indicator of lowered water tables, was rare on the west slope and in the more southern areas, but reached values of greater than 40% at some sites (Trossi Canyon, McBride Springs). Overall, sagebrush cover around survey stations was 9.35% (SD=19.12).

We quantified the amount of flowing and standing water around survey stations to assess habitat quality for bird species that are associated with water or saturated conditions. This is also a measurement expected to change rapidly with restoration activities. Water cover from flowing water averaged 2.75% (SE=7.32), but standing water covered only 2.90% (SE=9.96) of plots (Table 7).

Table 7. Average vegetative and water cover characteristics (mean percent cover, followed by SD of percent cover, for each variable) for 50-m plots surrounding survey stations at each meadow.

Meadow	Tree	SD	Snag	SD	Riparian shrub	SD	Sagebrush	SD	Bare soil	SD	Flowing water	SD	Standing water	SD
CASCADES SUBREGION														
Big Lake	**29.25**	23.60	**4.66**	4.53	**0.00**	0.00	**0.00**	0.00	**11.53**	9.72	**0.00**	0.00	**10.03**	18.88
Burney Garden	**21.26**	28.53	**0.60**	1.13	**0.00**	0.00	**0.00**	0.00	**2.86**	4.51	**0.54**	2.11	**4.14**	11.66
Lower Ash Creek	**0.01**	0.10	**0.00**	0.00	**0.00**	0.00	**8.10**	17.76	**4.21**	3.79	**0.19**	1.17	**0.07**	0.35
McBride Springs/Willow Creek	**10.25**	14.06	**0.00**	0.00	**0.00**	0.00	**42.92**	23.36	**19.17**	15.63	**0.00**	0.00	**0.00**	0.00
Rose Creek	**3.55**	4.78	**0.15**	0.49	**10.20**	15.73	**1.20**	2.63	**3.45**	3.00	**0.35**	0.75	**1.60**	3.02
Smith Flat	**1.88**	4.65	**0.00**	0.00	**0.00**	0.00	**2.06**	3.55	**13.56**	6.59	**0.00**	0.00	**0.00**	0.00
Upper Ash Creek	**4.02**	11.60	**0.00**	0.00	**2.93**	9.49	**18.17**	25.59	**4.77**	5.42	**2.60**	5.36	**0.63**	1.82
Upper Rose Creek	**6.60**	8.63	**0.00**	0.00	**3.00**	3.99	**11.65**	17.40	**6.25**	2.36	**0.40**	0.88	**0.60**	1.19
Subregion Total	**9.96**	**20.03**	**0.56**	**1.91**	**1.16**	**5.76**	**8.64**	**18.98**	**5.97**	**7.68**	**0.64**	**2.61**	**2.17**	**8.62**
NORTH SIERRA NEVADA SUBREGION														
Bear Valley PG&E	**9.32**	16.48	**0.16**	0.64	**4.55**	9.76	**4.17**	20.09	**1.91**	6.76	**2.56**	5.46	**5.29**	19.47
Carmen Valley Phase 2 - Folchi	**1.72**	2.96	**0.00**	0.00	**0.00**	0.00	**34.38**	25.74	**17.37**	20.48	**0.00**	0.00	**1.67**	5.57
Carmen Valley Phase 2 - West Carman Creek	**24.67**	19.67	**0.08**	0.50	**4.11**	11.24	**8.58**	10.07	**3.83**	4.78	**1.31**	2.94	**2.31**	4.21
Davies Creek - Site 1	**8.70**	9.41	**0.40**	0.94	**23.90**	16.84	**34.00**	28.59	**5.85**	4.21	**1.80**	2.67	**8.85**	10.84
Deer Meadow	**22.85**	22.10	**1.10**	1.41	**12.30**	26.09	**0.00**	0.00	**5.33**	13.80	**1.30**	1.98	**0.43**	1.20
Donner Picnic Area	**6.00**	11.02	**1.67**	3.81	**6.75**	11.35	**0.69**	2.56	**4.28**	12.68	**5.67**	8.73	**5.78**	10.34
Hobart Mills	**3.60**	7.58	**0.17**	0.65	**3.90**	10.39	**19.47**	22.47	**4.82**	7.70	**0.67**	2.31	**0.78**	1.51
Hoke Valley	**11.86**	21.38	**0.16**	0.53	**7.07**	18.38	**31.05**	29.44	**5.93**	4.23	**3.93**	11.20	**0.05**	0.21
Lacey Valley	**0.48**	1.68	**0.05**	0.30	**7.03**	14.37	**0.00**	0.00	**3.95**	5.58	**1.68**	3.79	**6.31**	18.21
Loney Meadow	**10.00**	13.26	**0.75**	1.40	**15.82**	22.06	**0.00**	0.00	**1.75**	2.07	**2.68**	3.42	**2.50**	3.91
LT Above Stampede	**3.83**	6.23	**0.08**	0.41	**15.92**	20.78	**5.29**	9.24	**13.08**	29.14	**0.71**	2.61	**11.67**	20.97
LT Below Stampede	**3.45**	6.22	**0.00**	0.00	**17.75**	16.97	**25.62**	19.68	**7.60**	11.91	**9.38**	17.33	**0.75**	1.70

Meadow	Tree	SD	Snag	SD	Riparian shrub	SD	Sagebrush	SD	Bare soil	SD	Flowing water	SD	Standing water	SD
LT Independence	**13.32**	16.43	**0.93**	1.92	**22.21**	23.01	**14.24**	19.67	**3.86**	4.52	**2.96**	5.08	**0.21**	0.73
LT West	**4.69**	5.85	**0.38**	0.89	**9.88**	11.58	**24.25**	24.66	**2.25**	3.53	**3.19**	3.56	**0.50**	2.00
Mcnair Meadow	**34.25**	21.47	**1.79**	2.02	**0.42**	1.18	**0.75**	3.10	**7.08**	18.81	**1.33**	3.03	**1.33**	2.08
Perazzo Lower Meadow	**6.70**	7.36	**0.80**	2.35	**26.25**	14.55	**11.75**	15.76	**0.80**	1.64	**17.25**	18.60	**2.05**	3.65
Perazzo Middle Meadow	**6.00**	12.93	**0.72**	1.81	**17.25**	21.62	**12.99**	20.27	**1.71**	3.48	**12.96**	17.86	**11.88**	21.02
Perazzo Terrace Meadow	**6.67**	12.67	**0.71**	1.16	**8.13**	17.34	**28.54**	35.74	**6.08**	7.92	**2.17**	1.71	**0.71**	1.30
Perazzo Upper Meadow	**10.79**	18.30	**0.81**	1.44	**21.99**	22.81	**5.29**	16.06	**1.54**	3.45	**7.75**	16.88	**11.95**	22.69
Pierce Meadow	**35.67**	23.11	**2.33**	2.12	**21.96**	18.84	**0.00**	0.00	**3.88**	3.40	**1.58**	3.27	**4.88**	4.25
Ross Ranch Meadow	**0.61**	1.86	**0.00**	0.00	**0.00**	0.00	**8.84**	19.48	**3.55**	6.15	**0.00**	0.00	**0.00**	0.00
Russell Valley - Dry Creek	**3.39**	11.87	**0.04**	0.42	**1.51**	7.92	**25.75**	22.88	**7.05**	8.98	**2.41**	4.71	**1.00**	2.94
Snowflower Mine	**50.72**	29.25	**0.75**	1.11	**1.08**	6.50	**0.00**	0.00	**27.08**	32.34	**0.92**	2.10	**0.22**	0.64
Trossi Canyon	**11.20**	8.25	**0.00**	0.00	**5.60**	18.39	**46.90**	34.52	**4.10**	8.50	**0.00**	0.00	**0.70**	1.56
Subregion Total	**9.65**	**17.68**	**0.45**	**1.35**	**9.58**	**17.45**	**13.90**	**22.58**	**5.77**	**12.18**	**3.59**	**9.46**	**3.69**	**12.39**
NORTH-CENTRAL SIERRA NEVADA SUBREGION														
Blue Lakes Road/Hwy88	**3.79**	7.04	**0.00**	0.00	**0.71**	1.51	**16.00**	22.97	**7.61**	11.71	**0.00**	0.00	**0.18**	0.94
Burnside Road	**5.25**	5.24	**0.00**	0.00	**6.17**	9.62	**2.17**	3.33	**3.42**	3.55	**0.92**	1.88	**0.92**	1.56
Faith Valley	**4.46**	10.86	**0.29**	0.87	**29.63**	28.29	**2.75**	7.67	**5.13**	5.34	**3.32**	4.99	**2.54**	3.74
Foster Meadow	**26.05**	19.10	**1.40**	1.64	**20.55**	26.61	**0.00**	0.00	**2.70**	3.33	**4.80**	4.67	**4.65**	7.15
Hope Valley Lower	**1.98**	5.08	**0.01**	0.10	**8.56**	11.68	**7.82**	12.43	**4.65**	7.27	**2.76**	5.97	**1.17**	3.30
Hope Valley Upper	**3.01**	7.07	**0.07**	0.37	**11.15**	16.48	**3.76**	7.57	**5.49**	7.36	**4.64**	7.63	**0.71**	2.41
Indian Valley	**5.37**	6.50	**0.00**	0.00	**38.22**	29.49	**12.00**	23.41	**17.08**	13.49	**2.52**	3.39	**1.38**	3.01
Indian Valley West Wilderness	**15.25**	25.66	**0.00**	0.00	**13.67**	12.78	**1.83**	2.86	**9.75**	13.63	**2.58**	2.57	**0.17**	0.58
Little Indian Valley	**17.31**	12.11	**0.19**	0.54	**1.44**	2.58	**0.00**	0.00	**10.75**	20.31	**2.19**	3.54	**0.38**	0.89
Red Lake Creek	**3.33**	7.42	**0.48**	1.52	**9.00**	15.18	**3.08**	8.27	**2.66**	2.99	**4.65**	5.59	**0.51**	1.27
Upper Charity Valley	**5.63**	7.84	**0.25**	0.62	**56.22**	18.01	**0.84**	2.63	**3.97**	3.47	**3.06**	4.12	**5.00**	6.83
Subregion Total	**5.14**	**10.29**	**0.19**	**0.82**	**17.62**	**23.83**	**5.37**	**12.83**	**6.32**	**9.40**	**3.37**	**5.61**	**1.40**	**3.52**

Meadow	Tree	SD	Snag	SD	Riparian shrub	SD	Sagebrush	SD	Bare soil	SD	Flowing water	SD	Standing water	SD
SOUTH-CENTRAL SIERRA NEVADA SUBREGION														
1S25 Meadow	**59.33**	21.59	**1.08**	1.16	**0.08**	0.29	**0.00**	0.00	**12.00**	6.61	**0.00**	0.00	**0.00**	0.00
2N55 Meadow	**40.00**	22.04	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**8.00**	4.60	**0.00**	0.00	**0.00**	0.00
Ackerson Meadow	**7.63**	11.29	**0.09**	0.35	**13.00**	18.32	**0.00**	0.00	**0.95**	1.31	**1.16**	2.70	**0.45**	1.11
Ackerson South	**8.88**	14.48	**1.71**	6.33	**1.29**	3.34	**2.29**	11.23	**0.00**	0.00	**0.67**	1.49	**5.54**	10.17
Big Prather East	**37.61**	29.21	**2.18**	2.34	**0.64**	1.54	**0.00**	0.00	**17.54**	7.54	**2.36**	2.38	**0.64**	0.62
Fahey Cabin	**31.82**	27.18	**0.14**	0.45	**2.14**	3.27	**0.00**	0.00	**7.25**	7.65	**3.21**	4.28	**0.14**	0.45
Fahey Meadow Complex	**8.78**	12.15	**0.18**	0.45	**0.00**	0.00	**0.00**	0.00	**5.63**	7.96	**1.30**	2.21	**10.18**	14.11
Faust Cabin	**22.69**	14.54	**0.88**	2.63	**0.00**	0.00	**0.00**	0.00	**9.75**	10.29	**1.63**	3.52	**0.00**	0.00
Hodgdon Meadow	**8.80**	15.03	**0.15**	0.67	**6.45**	11.22	**0.00**	0.00	**1.35**	1.93	**3.65**	4.66	**7.85**	7.46
Lower Bell Meadow	**24.05**	18.88	**1.45**	2.70	**2.00**	3.39	**0.00**	0.00	**6.10**	6.81	**0.20**	0.89	**0.70**	1.08
Reed Wolfin Tributary	**58.00**	28.12	**0.65**	0.81	**0.25**	1.12	**14.50**	14.77	**1.55**	1.57	**0.20**	0.62	**0.25**	0.79
Round Meadow	**28.70**	30.84	**1.05**	1.67	**14.00**	23.50	**0.00**	0.00	**3.55**	4.50	**0.50**	1.54	**0.05**	0.22
Seagales Meadow	**29.85**	23.03	**2.00**	2.25	**0.00**	0.00	**0.00**	0.00	**2.85**	2.98	**0.60**	1.60	**0.45**	0.94
Wawona Meadow	**0.72**	1.42	**0.00**	0.00	**15.47**	20.75	**0.00**	0.00	**0.06**	0.35	**1.84**	2.62	**12.56**	13.30
Wolfin Meadow Complex	**57.55**	27.83	**1.60**	0.88	**0.30**	1.34	**0.00**	0.00	**3.90**	3.01	**0.15**	0.37	**0.05**	0.22
Subregion Total	**23.33**	**26.95**	**0.78**	**2.19**	**4.93**	**12.73**	**0.95**	**5.52**	**4.74**	**7.07**	**1.32**	**2.69**	**3.23**	**8.17**
Grand Total	**10.77**	**19.34**	**0.46**	**1.53**	**9.30**	**18.03**	**9.35**	**19.12**	**5.76**	**10.36**	**2.75**	**7.32**	**2.90**	**9.96**

For those survey stations with riparian deciduous shrub cover, we also assessed the proportion of shrubs occurring within different height and age classes, as well as taxonomic groups (Table 8). Immature shrubs in the lowest height class are indicative of shrub recruitment, an important factor in maintaining suitable habitat for shrub-nesting birds. Mature shrubs in the shortest height class can indicate certain low-growing species, as well as situations where livestock or native ungulates are regulating growth patterns. These factors, as well as the proportion of the shrub community in the taller height classes, are relevant to certain focal bird species that prefer to nest at heights greater than 1 m above the ground (Willow Flycatcher, Yellow Warbler, Warbling Vireo). For all sites combined, the vast majority of riparian shrubs (83%) were >1m tall, but relatively equally split between the 1-2m and >2m height classes. The North-central Sierra Nevada and South-central Sierra Nevada sites showed an opposite distribution pattern with south-central sites having primarily >2m and north-central sites primarily 1-2m height class. The North Sierra Nevada and Cascades subregions both had height distributions almost evenly split between these height classes. The seedling size class was consistently below 7% of the total shrub cover, and <1m tall mature shrubs consistently accounted for less than 15% of total shrub cover (Table 7). Only a few sites had riparian shrubs other than willows surrounding the survey stations, typically mountain alder (*Alnus tenufolia*).

Table 8. Mean percent of riparian shrubs in each of four height and age classes within 50 m of point count stations.

Subregion	N	Riparian Shrub Height <1m (Seedling)	SE	Riparian Shrub Height <1m (Mature)	SE	Riparian Shrub Height 1-2m	SE	Riparian Shrub Height > 2m	SE
Cascades	3	4.44%	(6.71)	14.06%	(23.22)	40.72%	(35.93)	40.78%	(43.94)
North Sierra Nevada	22	5.20%	(11.85)	10.88%	(18.45)	38.37%	(31.42)	45.38%	(35.01)
North-central Sierra Nevada	9	6.26%	(10.14)	14.99%	(19.28)	52.28%	(30.56)	26.20%	(30.40)
South-central Sierra Nevada	11	2.94%	(6.74)	4.95%	(8.63)	23.47%	(28.79)	68.63%	(33.63)
Grand Total		**5.31**	**(10.75)**	**11.78**	**(18.39)**	**41.68**	**(32.22)**	**41.06**	**(35.99)**

DISCUSSION

Regional and subregional comparison of focal species metrics

When comparing indices of abundance for focal individuals and focal species with total counts of focal species across all subregions, we found an interesting relationship where some sites had many focal species overall, but very few individuals of focal species at each station, on average. This indicates that although the species were present on site they were patchily distributed and not occupying much of the total area available. A few of the intended restoration

sites (Russell Valley – Dry Creek, Hoke Valley, Burney Garden, Upper Ash Creek) displayed this combination of metrics; these sites tended to be quite large and hydrologically degraded. The presence of many focal species suggests a basic suitability of the site (elevation, food resources, climate), as well as the presence of some remnant riparian and meadow areas. It may also indicate the potential for a rapid expansion of these species as habitat improvements occur with restoration.

Also of note when considering these three focal metrics, is the ecological value of clusters of meadows. The Perazzo Upper, Middle, and Lower Meadow sites and Lacey Valley tend to all rank high in most metrics suggesting that modest improvements in that area would be particularly likely to yield positive responses by many target species due to abundant source populations and a certainty of the overall suitability of the watershed for the species in question. Nonetheless caution should be used when interpreting these results. In the more southerly subregions, expansive montane meadow systems are less common than they are in the north, and effective focal species conservation will require conserving and restoring the best possible locations in each subregion, despite some relatively low metric rankings when compared to meadows to the north. An extremely ecologically important site for many species in the southern Sierra Nevada may not appear biologically significant when viewed in comparison to bird abundance metrics for the vast meadow systems of the northern subregions, but may be critical to maintaining habitat connectivity across the Sierra Nevada as a whole.

Rapid responses by waterfowl and wading birds

Analysis of pre- and post-restoration results at the five completed restoration projects did not yield statistically significant findings of focal bird species responding to restoration efforts. This was not surprising as and our sample size, with just 5 our study sites having been restored before the 2012 field season, was relatively small. Perhaps even more importantly, ecological response to restoration takes time. Open water and emergent vegetation can appear rapidly after restoration, but herbaceous vegetation may take a few years to fully respond, and changes in the abundance and composition of riparian shrubs may take even longer. Nonetheless, we documented almost immediate post-restoration colonization and/or increases in numbers by waterfowl, wading birds, and other species that utilize open water and emergent graminoid vegetation (e.g., Wood Duck, Sandhill Crane, Sora, and others) at meadows where restoration yielded newly ponded water and wetlands. Documenting similar success stories for willow-nesting songbirds and other meadow focal species will likely require additional monitoring effort.

Species-specific restoration targets

The focal species identified by Loffland et al (2011) and referenced in this report can be divided into two groups: rare species and relatively common species. Meadow species that are now rare in the Sierra Nevada region, such as Willow Flycatcher, Sandhill Crane, Common Yellowthroat, Virginia Rail, and Wilson's Phalarope are associated with very wet or seasonally flooded meadows, or meadows with dense riparian shrub cover (two characteristics that are often lost when sites are degraded). Creating habitat for rare species is often a goal of restoration because their populations arguably have the most to gain from restored habitat. From a

conservation standpoint restoration targeted on rare species has the opportunity to do the most good for the most at risk. However, because of the rarity of these species, it can be hard to measure success based on statistically significant increases, or to set population targets. We found that at this early stage in monitoring, rare species are not generally detected in great enough frequency to easily establish statistically significant trends in relation to restoration. Some wetland or marsh species are unlikely to ever be abundant in a wet meadow setting, or occur evenly across the entire meadow site, but pockets of emergent vegetation and associated pockets of wetland birds indicate a complex and hydrologically functioning system that can support a wide variety of meadow vegetation types and abundant arthropod prey populations, and therefore a diverse bird community. Thus for some species and some projects, colonization by rare birds, rather than a statistically significant increase in abundance in those birds, should be considered indicative of a successful restoration and a healthy wet meadow bird community. Also examining additional wetland species (Green-winged teal, Gadwall, Yellow-headed Blackbird) on a site-by-site basis may be necessary for individual project assessment. Even if rare species are never attracted, the colonization by other wetland species, especially waterfowl can be a powerful indicator of success. It may also be important to add some additional focal species to individual projects that more closely tier to the activities planned and the expected habitat outcomes.

More common meadow-associated focal species like Yellow Warbler, Lincoln's Sparrow, Song Sparrow, and White-crowned Sparrow may yield more statistically rigorous monitoring results and provide effective quantitative restoration targets. These species were common enough across subregions, meadows (both restoration and reference site types) and individual point count stations to yield statistically reliable results in a shorter timeframe (although we have not yet reached that point). The more widespread presence of these species also means that more realistic population targets can be set for individual restoration projects or groups of projects. One example is the White-crowned Sparrow that utilizes meadows with a substantial willow component. This species exhibited its highest index of abundance at Indian Valley West Wilderness at 4.17 birds per station. The average number of birds per station across all sites was 0.57 (SD=0.97). One method of assigning targets could be the mean plus one standard deviation, or an average of at least 1.54 White-crowned Sparrows per station. A factor to keep in mind is that this species is more common in higher elevations so this target will not be appropriate at lower-elevation sites. Similarly if we know that the species is more abundant at some sites than others it might be more meaningful to adopt as a restoration target the mean value of the top 10 sites, or an average of 2.38 White-crowned Sparrows per station. As an alternate approach, one could assess each site, and determine which individual stations reported the greatest values and calculate targets based on station-specific values rather than meadow averages. We are currently partnering in a new NFWF-sponsored project to determine meaningful restoration targets for several focal species.

We strongly recommend continuing bird monitoring activities at restoration and reference meadows in the Sierra Nevada Region in as many pre- and post-restoration years as feasible. Our ability to document responses from bird populations in a scientifically sound manner will require continued investment in monitoring over multiple years. All meadows are different and all restoration projects are different. After only one post-restoration visit it was difficult to identify statistically significant results that could be accounted for by the restoration activities. To tease

apart the effects of restoration from the effects of annual weather variation will require a great deal of effort for some species. That said, we were already able to document the colonization of newly restored sites by waterfowl within one year of project completion. Species that require open water and emergent graminoid vegetation can respond quickly, but projects that aim to increase willow cover and shrub nesting bird populations may require additional years to reach fruition.

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