Using birds to inform meadow restoration at Hope Valley West Meadow

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Hope Valley West Meadow Photo: Bob Wilkerson; Lincoln's Sparrow (inset) Brian Henderson

Introduction

This report summarizes the results of pre-restoration multi-species bird monitoring at Hope Valley West Meadow. In 2018, The Institute for Bird Populations (IBP) utilized a standard point count protocol to monitor bird species within the Hope Valley West Meadow area to provide pre-restoration baseline data (Loffland et al. 2011a). This protocol is used to assess and describe the larger bird community and to detect population-level changes in meadow bird species in response to restoration activities. Hope Valley West Meadow was identified as a priority site in the *Restoring Carson Meadows: Assessment and Prioritization* (Fair et al. 2018) and was one of twenty three sites surveyed in 2018 by IBP as part of multiple meadow restoration monitoring projects funded by The Truckee River Watershed Council and by the Desert Terminal Lake NFWF initiative. Results from all study sites are combined in the discussion to provide regional context.

Methods

Multi-species Bird Monitoring

In 2018, Multi-species monitoring (all bird species) in Hope Valley West Meadow followed Loffland et al. (2011a). Point counts were conducted at survey stations spaced 200 - 250 m apart, with all individuals of all species seen or heard counted during a 7-minute period.

Vegetation Monitoring

In 2018 we assessed vegetation, bare ground, surface water, and numerous other biotic and abiotic factors within 50 m of all multi-species point count stations, following Loffland et al. (2011a).

Cover classes were averaged across four quadrants of a 50-m radius circle centered at each point count station, and then averaged across all points within a meadow. These metrics are intended to serve as a point of reference for bird counts but are not intended to replace vegetation monitoring specific to meadow restoration. Habitat characteristics including water cover and riparian shrub cover were estimated because they are known to be particularly important to focal bird species. Additionally, measures of sagebrush and bare ground were recorded because they may provide a rough index of the extent of severely disturbed area within a meadow.

Results

Multi-species Bird Monitoring

In 2018 we surveyed 11 multi-species point count survey stations in Hope Valley West Meadow (Figure 1). All visits occurred between late May and early July (Table 1).

Table 1. Dates for multi-species bird monitoring in the Hope Valley West Meadow in 2018.

Site	2018 Visit 1
Hope Valley West	6/21/2018

Figure 1. Multispecies avian point count station locations in Hope Valley West Meadow.

During Sierra-wide baseline surveys in 2010 and 2012 we selected focal species for analysis based on Loffland et al (2011a), which identifies 18 focal bird species expected to respond positively to meadow restoration, or have other conservation implications making them especially worthy targets of monitoring at meadow restoration sites. In 2013 we worked collaboratively with researchers at Point Blue to refine this list to a smaller subset of focal species (Table 2) most appropriate for analysis based on expected distribution, sample size, and predicted direction of change with restoration (Campos et al. 2014). The observation status for these species and their typical habitat preferences are also indicated in Table 2. In 2018, 24 bird species were detected during point counts at Hope Valley West Meadow, including 7 of the focal species (Table 2; Appendix A).

Table 2. Focal bird species observation status during surveys of Hope Valley West Meadow in 2018.

Species	Usual habitat within meadows[1]	Observed in study area?
Wilson's Snipe	E	no
Red-breasted Sapsucker	S,A	**yes**
Calliope Hummingbird	M,S,A	**yes**
Willow Flycatcher	S,E	no
Swainson's Thrush	S,A	no
Warbling Vireo	S,A	**yes**
Yellow Warbler	S	no
MacGillivray's Warbler	S,A	no
Wilson's Warbler	S,A	**yes**
Song Sparrow	M	**yes**
Lincoln's Sparrow	M	**yes**
White-crowned Sparrow	S,M	**yes**
Black-headed Grosbeak	S,A	no

[1] A= Aspen, cottonwood; E = emergent vegetation and surface water; G = gravel bars and streamside zone; M = open meadow; S = riparian deciduous shrubs

For the purpose of assessing change in these sites over time and in response to future restoration we typically limit our analyses to birds detected within 50 meters of survey stations, in an effort to account for reductions in detection probability that occur with increasing distance from an observer. The following results are based only on detections within 50 m of survey stations unless otherwise noted.

The most common birds included generalist and forest species such as Dark-eyed Junco, Green-tailed Towhee, Mountain Chickadee, and Dusky Flycatcher and riparian associates such as Wilson's Warbler, Lincoln's Sparrow and White-crowned Sparrow. Of particular interest are the meadow focal species (Loffland et al. 2011a, Campos et al. 2014). These species are meadow or riparian associates and are typically found in areas with a mix of shrubby and herbaceous vegetation. During our surveys in 2018 we detected 7 of the focal species at Hope

Valley West Meadow, but only 6 of those were detected within 50m of survey stations (Tables 2 and 3).

Table 3. Total count[1] and index of relative abundance[2] for each focal species detected at Hope Valley West Meadow during 2018.

Bird species	Total Count (any distance)	Index of abundance (within 50m) Avg #/acre
Calliope Hummingbird	2	0.09
Red-breasted Sapsucker	1	--
Warbling Vireo	4	0.09
Wilson's Warbler	7	0.23
Song Sparrow	5	0.05
Lincoln's Sparrow	5	0.19
White-crowned Sparrow	8	0.14

[1]Total count is the sum of all individuals detected at any distance from any point count station

[2]Index of relative abundance calculated as number of individuals detected within 50 m of all point count stations averaged across the number of point count stations per meadow.

Wilson's Warbler was the most abundant focal species, followed by Lincoln's Sparrow and White-crowned Sparrow. We detected four other focal species, Song Sparrow, Warbling Vireo, Calliope Hummingbird, and Red-breasted sapsucker (although the last of these was not detected within 50m of survey stations). Of our focal species, White-crowned Sparrows and Song Sparrows have the least restrictive habitat needs and will occur in both wet and dry meadows with varying amounts of riparian or other shrub cover. In this case, White-crowned sparrow is more abundant than Song Sparrow. Like White-crowned sparrows, Lincoln's Sparrows tend to be more abundant at higher elevations, but they differ in that they are more strongly associated with mesic meadow conditions and tall, dense herbaceous vegetation, especially where springs or small streams result in sheet flow across the meadow surface. Wilson's Warblers are also more abundant at higher elevations and in meadows with dense willow or other riparian shrub cover and mixed tree cover in more closed stringer-meadow settings. Warbling Vireo and Red-breasted Sapsucker are found along edges where conifers meet the meadows edge, and are especially abundant where there are dense and tall riparian shrubs mixed with riparian deciduous trees. Calliope Hummingbirds require spatially and temporally diverse stands of flowering plants often with a willow mosaic. The remaining focal species (Table 2) were not detected at all within the study site, likely because they are typically associated with conditions that occur only in relatively small portions of Hope Valley West Meadow. These conditions include: flooded areas that include shallow emergent wetland vegetation (Wilson's Snipe), abundant and tall riparian shrub (usually willow) cover in both wet and mesic meadow settings (Yellow Warbler), or dense thickets of riparian shrubs mixed with riparian deciduous trees (MacGillivray's Warbler; Ray 1903, Grinnell and Miller 1944, Orr and Moffit 1971, Stewart et al. 1977, Heath and Ballard 2003). Two declining species associated with perennially flooded meadow and riparian habitat in combination with dense shrub cover (Willow Flycatcher, Swainson's Thrush) were also not detected.

In addition to monitoring how individual focal species respond to restoration, we measured an additional metric of restoration success known as "focal species richness" (Campos et al 2014). This metric assesses the number of the13 target focal species detected at a station, or averaged across stations for the entire site. By monitoring a standard suite of species we can then compare results at Hope Valley West Meadow against other sites within the region. The mean in 2018 at Hope Valley West Meadow was 1.27 focal species per station (0.66 focal species/acre).

Discussion

Hydrology is a primary factor restricting habitat quantity and quality for meadow focal bird species. All rely on lush herbaceous and woody vegetation, and the insect food resources (Erman 1984, 1996) associated with saturated or seasonally flooded areas in meadows. Flooded conditions also may provide protection from nest predation, as some mammalian predators avoid surface water (Cain et al 2003, Borgmann 2010, Cocimano et al. 2012). Similarly, many riparian focal species require dense riparian shrubs or trees (aspen, alder, dogwood) that will germinate and grow only with consistent water within the root zone. Although willow requires consistent moisture for germination, mature willow will often persist at a site after meadow hydrology is altered, if roots are deep enough to remain in contact with the water table, despite its lowered elevation. Another factor significantly related to Willow Flycatcher occupancy specifically, and riparian birds generally, is the presence of beaver (Bombay 1999, Cooke and Zack 2008), due to the impoundments beavers create and the subsequent willow germination and recruitment associated with new sediment capture and inundation. Although beaver are present very nearby in the West Carson River and Red Lake Creek, in Hope Valley West Meadow signs of beaver activity were not noted during point count visits.

Habitat needs of individual meadow-associated bird species are diverse. We believe effective restoration efforts are best informed by considering the needs of the particular species that are being targeted with the restoration efforts. The following discussion is therefore organized around individual meadow focal species or groups of focal species.

Figure 2. Willow Flycatchers are still occasionally found in a few locations in the Carson River watershed.

Willow Flycatcher

The California-endangered Willow Flycatcher is the bird species in the region that is most strictly linked to wet meadows dominated by mature stands of willow (Figure 2). Most Willow Flycatcher breeding sites are found in meadows or riparian areas with season-long saturated soils and surface water (Harris et al. 1987, Bombay 1999, Bombay et al. 2003a, b, Mathewson et al. 2012). These conditions may occur in association with oxbows and ponds within a floodplain meadow community or in areas

where perennial springs spread water across a variable-gradient meadow surface (Weixelman et al. 2011). Deciduous riparian shrubs, particularly willows, are a critical habitat component for Willow Flycatcher. Most Willow Flycatcher territories contain 50% or more willow cover, typically across a 1- 3 acre area (Bombay 1999). Although Willow Flycatchers are not currently breeding in Hope Valley West Meadow, its close proximity to current/recent breeding sites at Red Lake Peak, Red Lake, and Hope Valley make future colonization of restored habitat in Hope Valley West Meadow a possibility, and the opportunity to build a large complex of restored habitat within the Hope Valley and Faith Valley region make this site a high priority for this species (Mathewson et al. 2011, Loffland et al. 2014, Schofield et al. 2018). This is because even smaller meadows like Hope Valley West that are within close proximity to nearby occupied sites can act as satellite breeding sites and be maintained over time if enough breeding territories occur nearby. Sites within already occupied watersheds are of highest priority for restoration for this declining species (Schofield et al. in prep). A restoration project that successfully brings overbank flows in contact with a significantly larger portion of the historic floodplain, creates ponded water settings, and results in 3 or more large willow patches (1+ acre in size) could provide suitable habitat for this species. These factors in combination with the presence of beaver nearby suggest that targeted efforts could create habitat for 2 or more Willow Flycatcher territories over the next 10-20 years, if significant wetted areas are created willow establishes within the first 5 years. Sites that support this many territories when close to larger breeding areas (with the potential to support 10 or more territories such as Faith Valley, Hope Valley, and Red Lake complex) are more likely to be self-sustaining breeding sites over time, especially if nearby meadow restoration projects at Faith Valley and Hope Valley are implemented.

Yellow Warbler

Yellow Warbler, a California Species of Special Concern is, like Willow Flycatcher, strongly linked to dense willow stands. This species is therefore an excellent indicator of the quality of willow habitat in the absence of Willow Flycatchers. However it is not as limited to extremely wet conditions (Heath 2008). Yellow Warblers do, however, occur in their greatest densities at sites with these characteristics. While relatively common nearby in the appropriate portions of Red Lake and Hope Valley Lower Meadow, where tall willow in denser patches is present, Yellow Warblers are absent from Hope Valley West Meadow where willow is more restricted to the immediate streamside zone and tends to be shorter in stature. Campos et al. (2014) recommend a habitat management target of 1.04 Yellow Warblers per station (0.54 Yellow Warblers per acre; Figure 3). The primary channel Hope Valley West Meadow is incised below the historic floodplain, so seed deposition, and moist conditions necessary for new willow recruitment and establishment only exists in the stream bottom and near springs. If restoration reconnects the water table with the historic floodplain and natural recruitment or willow plantings are successful, new willow stands could mature in 10 to 15 years and existing willow mature and thrive then both could provide habitat for Yellow Warbler. Because Yellow Warblers are present at many nearby meadows it is likely they could quickly colonize newly created habitat when new and existing willow stands become larger, taller, and denser.

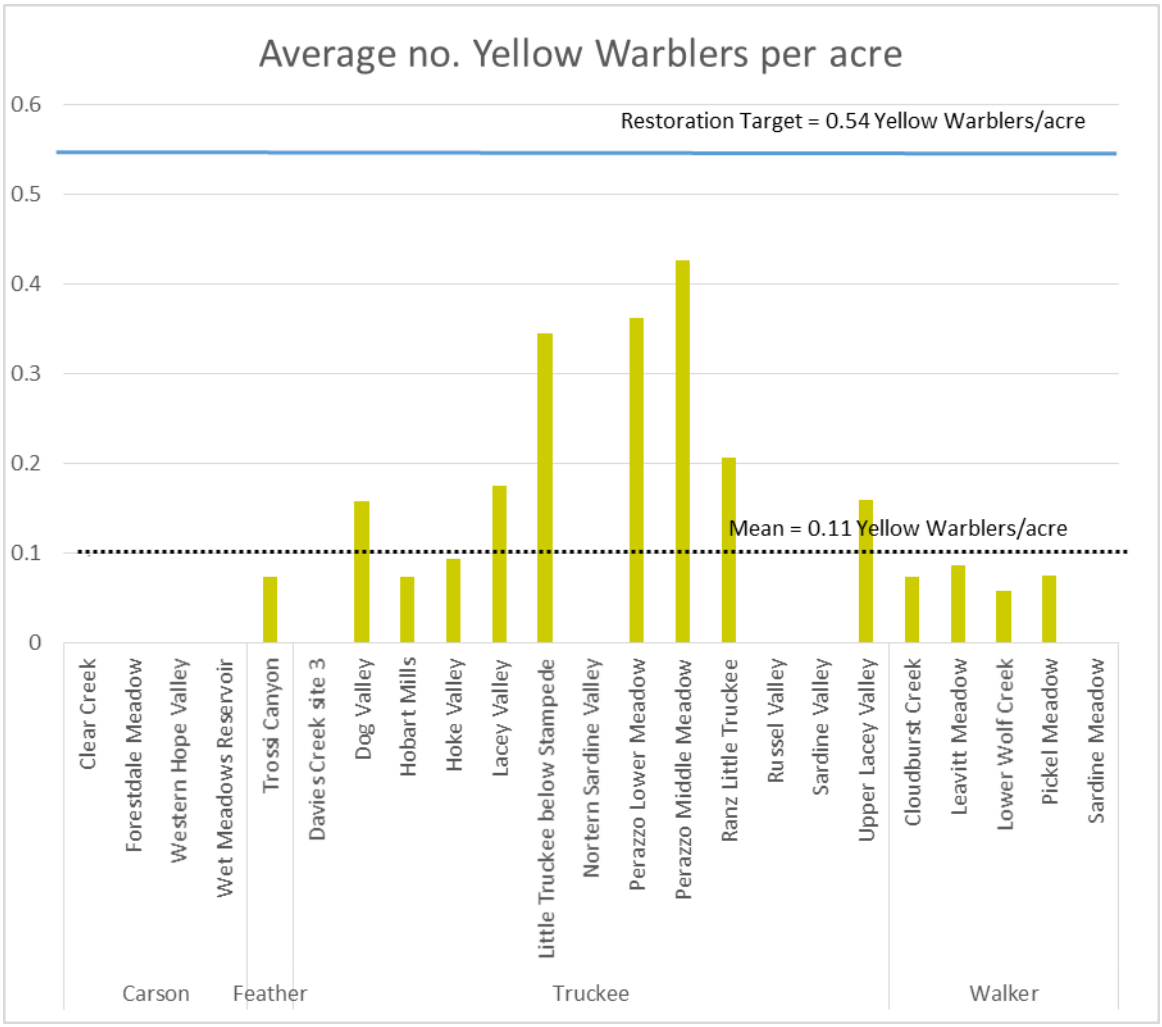

Figure 3. Average number of Yellow Warblers detected per acre at all 2018 survey sites, including Hope Valley West Meadow, relative to regional target and regional mean.

Song Sparrow, White-crowned Sparrow

White-crowned Sparrows are somewhat common in the upstream end of Hope Valley West Meadow where willow (or a mix of sagebrush, and conifers) provide cover (mean relative abundance of 0.14/station or 0.07/acre; Figure 4). The species will likely respond positively to restoration that expands willow and dense herb communities into some of drier regions, especially those currently dominated by sagebrush. Although not strictly necessary, willow is a preferred component of White-crowned and Song Sparrow habitat. Song Sparrow was also detected in Hope Valley West Meadow in areas with willow cover (mean relative abundance of 0.05/station or 0.03/acre; Figure 5). If willow cover was expanded and the meadow becomes wetter overall, it is possible that the Song Sparrow population would also expand at the site. These two sparrow species are important for restoration monitoring because their typically larger sample sizes and less restrictive habitat requirements allow for more robust analyses as post-

restoration monitoring occurs. We also recommend monitoring an additional sparrow species at this site. Savannah Sparrows are common in nearby Hope Valley Lower Meadow and would be expected to expand into this site as tall dense herbaceous vegetation expands with higher water tables and displaces sagebrush.

Figure 4. Point count stations where White-crowned Sparrows were detected. Size of circle indicates number detected (within 50m).

Figure 5. Point count stations where Song Sparrows were detected. Size of circle indicates number detected (within 50m).

Lincoln's Sparrow

Like the Song Sparrow and White-crowned Sparrow, Lincoln's Sparrow requires open meadow habitat with dense herbaceous cover and, ideally, some scattered shrubs. This species, however, is typically linked to meadow areas that are wetter and have more continuous sedge cover than are other sparrow species. They also sometimes utilize stands of corn lily for nesting. Lincoln's Sparrows were relatively common and detected in multiple portions of Hope Valley West Meadow, primarily in areas where springs fed the meadow and where herbaceous cover was more expansive, rather than in areas near the incised stream channel (figure 6).This species is often found at sites with intact tributary hydrology conditions that result in sheet flow. If restoration restores the water table and channel function for the primary channel and more of the meadow is consistently wetted, this species would likely almost immediately occupy newly created habitat because they do not need to wait for willow cover to become established, and because they are already quite common here, making colonization of new habitat likely.

Figure 6. Point count stations where Lincoln's Sparrows were detected. Size of circle indicates number detected (within 50m).

Red-breasted Sapsucker, Warbling Vireo, Wilson's Warbler, MacGillivray's Warbler

Wilson's Warbler was the focal species with the highest index of relative abundance at Hope Valley West Meadow. Wilson's Warbler was detected in willow stands wherever they occurred within the meadow (mean relative abundance of 0.23/station or 0.12/acre; Table 2, Figure 7). Warbling Vireo were detected in a few different locations, likely due to the tree cover interspersed with willow (mean relative abundance of 0.09/station or 0.05/acre; Table 2, Figure 8). MacGillivray's Warbler were absent, likely due to the lower density and height of willow. It was somewhat surprising that we did not detect more than one Red-breasted sapsucker (and none within 50m of stations), given that tree cover was interspersed and the meadow had a high edge to interior ratio. This may be due to the lower of willow and sparseness of aspen. All members of this suite of species will likely respond positively to any increases in willow or alder cover that occur with a more natural overbank flooding regime, as a result of active planting, or as a result of other land management changes that improve germination and recruitment to mature life stages of riparian shrubs and deciduous trees. Restoration activities may extend the length of growing season when the areas further from the streambed are saturated, and may expand some

slow-water areas within the area immediately adjacent to the channel. This may allow establishment of aspen stands particularly along tributaries and meadow edges. If overall riparian deciduous shrub heterogeneity and aspen cover increase due to natural regeneration and/or plantings, these bird species could increase substantially, but it may take 10-15 years to establish the needed dense heterogeneous woody stands in some parts of this meadow.

Figure 7. Point count stations where Wilson's Warblers were detected. Size of circle indicates number detected (within 50m).

Figure 8. Point count stations where Warbling Vireos were detected. Size of circle indicates number detected (within 50m).

Wilson's Snipe

In the Sierra Nevada, this species is found only in marshy emergent vegetation in large meadows (or other wetlands) with flooded oxbows, beaver ponds, or sites with sheet flow occurring across the meadow surface. Wilson's Snipe are relatively easy to detect and are therefore excellent for monitoring changes to this habitat type after restoration. Wilson's Snipe were not detected in Hope Valley West Meadow. If restoration restores overbank flows, results in sheet flow along other incised springs, and creates ponded areas that mimic oxbows or beaver impoundments, the sedge-dominated nesting cover and the mud/peat foraging requirements of snipe are likely to increase dramatically and could result in colonization by snipe. Wilson's Snipe are abundant in nearby Hope Valley Lower and Upper, and Red Lake area, so habitat improvements and newly created habitat would likely be quickly colonized.

Calliope Hummingbird

Calliope Hummingbirds were found near willow thickets in multiple locations at this site (mean relative abundance of 0.09/station or 0.05/acre; Table 2, Figure 9). They often benefit

from wetter meadows with abundant willows. These conditions usually result in more diverse microclimates and longer growing season for the diverse floral resources they require.

Figure 9. Point count stations where Calliope Hummingbirds were detected. Size of circle indicates number detected (within 50m).

Brown-headed Cowbird

Brown-headed cowbirds are nest parasites that may negatively affect meadow focal species where they are abundant. During our surveys brown-headed cowbirds were absent from Hope Valley West Meadow, but occur relatively nearby in the Hope Valley and Red Lake areas. We recommend that the monitoring of this species continues because population increases may unravel restoration related gains for riparian focal species in some instances.

Multi-species Results

Campos et al. (2014) recommended that management and restoration activities should strive to meet a species richness target of 1.99 focal species per station (or 1.04 focal species per acre). Our current species richness measurement for Hope Valley West Meadow is 1.27 focal species/station (0.66 focal species/acre), so meeting that target at the meadow scale will require

almost a doubling in value. Hope Valley West Meadow is already has a focal species richness that is slightly higher than the average value of 0.56 focal species/acre as measured across all the restoration monitoring sites visited by IBP in 2018 (Figure 11). Closer inspection of data from individual stations reveals that 9% of stations had four focal species (within 50m), 9% had three focal species, 18% had 2 focal species and 27% had a single focal species. Stations where we detected more than one focal species occurred within the portions of the meadow with both willow thickets and wet soils. (Figure 10).

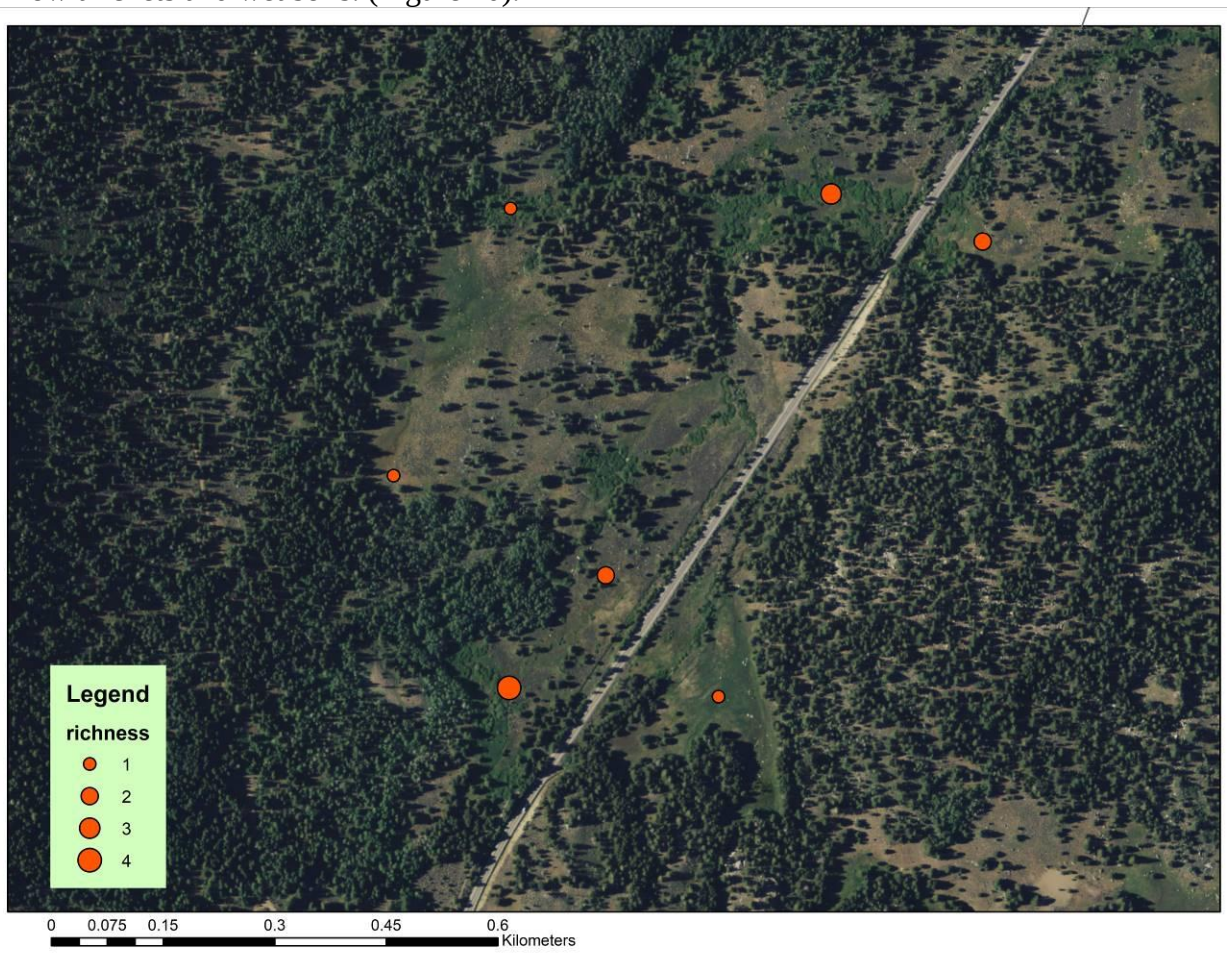

Figure 10. Locations within Hope Valley West Meadow where one or more focal species were detected within 50m of survey stations. The size of the peach circle indicates number of focal species detected.

Based on assessment of focal species richness values from other sites within the watershed and elsewhere (Figure 11), we suggest that the most reliable way to boost focal species richness is to use restoration techniques that re-wet the drier portions of the meadow and create areas of season-long ponded water, and especially through creating conditions necessary for germination and recruitment of native woody vegetation (and subsequently protecting it from browsing while it becomes established). Where there is a shortage of riparian shrubs we recommend planting at least a few large patches in an attempt to jump start this habitat component. Similarly, through

planting of aspen along meadow edges or within the stream channels where hydrology is appropriate, additional bird species are likely to respond positively over the next 10+ years.

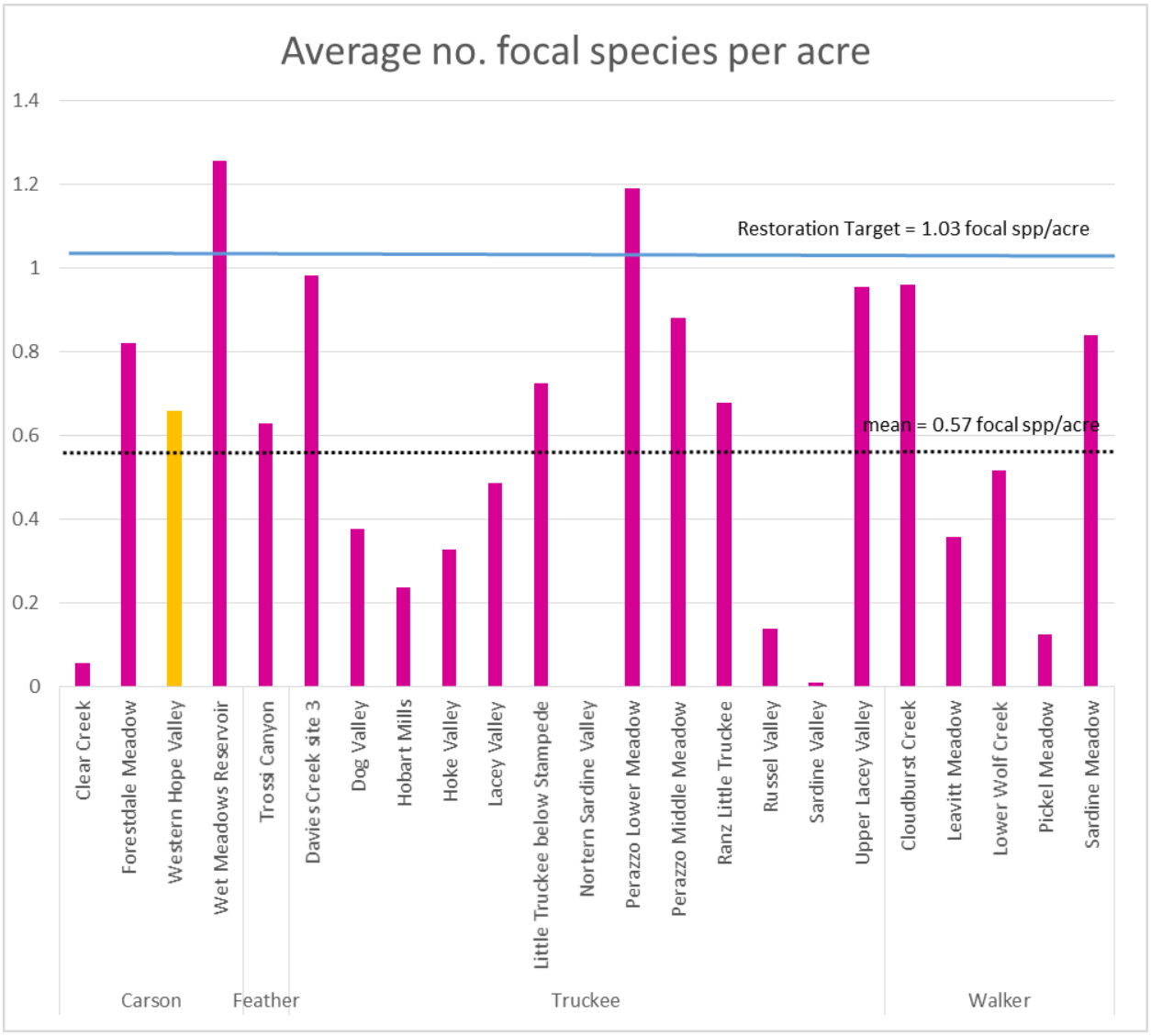

Figure 11. Average riparian focal species richness per acre at all 2018 survey sites, including Hope Valley West Meadow (yellow bar), relative to regional target and regional mean.

Vegetation Surveys

Western Hope Valley has similar water cover values when compared to all sites visited in 2018, but generally higher values for shrub, sagebrush, and tree cover (Table 4). Higher values for riparian shrub are positive, but tree and sagebrush values indicate a lowered water table.

Table 4. Average cover values in percentage of vegetation and hydrology habitat components at all sites visited in 2018

		Avg. percent cover by type %					
Watershed	Site name	Riparian shrub	Sagebrush	Flowing water	Standing water	Tree	Aspen or cottonwood present?
Carson	Clear Creek	1.5	5.7	2.1	0.4	6.8	yes
Carson	Forestdale Creek	33.3	0.0	2.5	13.8	0.5	
Carson	Hope Valley West Meadow	20.9	20.2	0.8	5.1	13.2	yes
Carson	Wet Meadows Reservoir	42.1	7.3	0.5	1.5	11.4	yes
Feather	Trossi Canyon	15.5	28.8	1.5	5.5	26.2	yes
Truckee	Davies Creek	21.3	19.7	1.5	5.4	7.8	
Truckee	Dog Valley	5.5	19.8	1.2	0.8	0.9	yes
Truckee	Hobart Mills	4.4	16.7	2.5	4.2	2.5	
Truckee	Hoke Valley	8.0	27.8	2.1	7.0	15.0	yes
Truckee	Lacey Valley Lower	10.0	0.0	3.3	4.3	1.6	
Truckee	Little Truckee Below Stampede	15.8	23.6	3.0	2.6	6.2	yes
Truckee	North Sardine Valley	0.6	5.2	0.4	25.3	0.6	
Truckee	Perazzo Lower	26.2	11.8	8.3	0.1	5.8	
Truckee	Perazzo Middle	31.2	10.4	6.9	25.1	8.7	
Truckee	Ranz Little Truckee	20.4	16.2	5.7	1.1	17.1	yes
Truckee	Russel Valley	1.8	19.8	2.2	3.3	1.5	
Truckee	Sardine Valley	0.1	49.2	1.8	1.2	0.0	
Truckee	Upper Lacey Valley	25.7	0.0	1.1	7.5	16.2	
Walker	Cloudburst Creek	11.9	7.8	2.3	9.3	30.5	yes
Walker	Leavitt Meadow	15.4	15.7	2.9	0.8	2.5	yes
Walker	Lower Wolf Creek Meadow	10.9	12.0	4.6	1.3	22.3	yes
Walker	Pickel Meadow	10.4	11.6	4.3	9.0	0.5	yes
Walker	Sardine Meadow	17.5	25.0	5.9	0.6	29.6	
	Mean across all sites	11.7	17.2	2.9	4.6	6.4	

Recommendations

Meadow restoration is a complex and challenging process that is not completed in one season. If restoration actions are undertaken at Hope Valley West Meadow they may take many years to create habitat conditions needed for some focal bird species. We recommend continued monitoring efforts at these and other restoration sites so that future practitioners can better understand the complex and temporally dynamic responses of bird populations to restoration of this sort and identify those practices that create the best outcomes for birds, fish, plants, hydrologic systems, recreation, and downstream water users. Long-term monitoring is necessary to generate science-based best management practices.

The primary issue constraining bird habitat quality at Hope Valley West Meadow is a lowered water table caused by incision of the primary channel and a de-watering ditch running along the west side of the highway (Figure 12). These conditions have resulted in the middle of the meadow being quite dry, and a lack of new riparian shrub recruitment. Restoration to fully restore the primary channel and ditch through use of techniques such as beaver dam analogs, complete channel fill, or pond and plug could provide improved hydrology to the primary and small tributary channels and springs. Techniques such as these could improve hydrology and vegetative communities in the shortest time frame and most benefit the region's rapidly declining Willow Flycatcher population at a temporal scale best matching the species' rate of decline. Beaver have not colonized the area, likely due to a lack of hiding cover in the form of deep ponded water. It would be informative to assess whether beaver populations are being actively controlled at the site (or nearby), and how management of beaver could be used to improve conditions. Similarly, although the Hope Valley allotment is currently vacant, prior to issuance of future permits, season of use and intensity of use by livestock could be assessed and modified to incorporate or increase rest rotation (or other actions) in the meadow to improve woody vegetation recruitment in areas wet enough to support it. Any culverts under highway 88 should also be assessed for possible improvements to natural flow regime if feasible.

Highway 88 runs north/south through Hope Valley West Meadow (Figure 12) Highway construction is likely the source of the incised channel and deep ditch on the west side of the highway. Sagebrush has encroached across much of the open areas in the middle of the meadow that are not fed by springs near the edges. It is possible that prior to road construction, development, and historic mining and grazing pressure altered hydrology, there was sheet flow of water across more of the meadow surface. If stream restoration techniques are applied to the ditch, the primary channel and tributaries, more of the meadow could again have a mesic nature more suitable to riparian birds. Overbank flows might encourage new willow establishment, but active willow planting could also improve the size and continuity of stands within the more uniformly saturated parts of the meadow (especially within natural or artificially constructed oxbows), regardless of restoration techniques used.

Despite the dryness and sagebrush and lodgepole pine encroachment in some parts of the meadow, the presence of springs and a new inset floodplain allow the site to support some smaller areas of standing water and willow thickets. The primary habitat components that are missing in the area away from the stream channel are woody riparian shrubs, sedge mats, and deciduous trees. Typically areas that are both wet for most of the season and have dense riparian

woody vegetation support a rich insect community and provide hiding and nesting cover. Hope Valley West Meadow could benefit from additional riparian shrub plantings (1 acre patches with subsequent fencing to protect against browse if needed). Hope Valley West Meadow is also a good candidate area for aspen planting along the meadow edges (or efforts to release any existing aspen stands).

Figure 12. Hope Valley West Meadow showing stream and ditch locations.

Recommended Restoration Actions

1. Treat the primary channel, tributaries (via complete fill, pond and plug, beaver dam analogs, etc.) to reduce incision and increase soil saturation, standing water and sheet flow on the existing elevated floodplain (with subsequent willow, alder, or aspen planting as feasible).

2. Treat the ditch along the west side of highway 88, to push flow back into historical channel if feasible (via complete fill, pond and plug, beaver dam analogs, etc.)

3. Plant and protect willow and other riparian deciduous shrubs in areas where existing or restored hydrology provides necessary flooding and/or soil saturation levels. Plant patches at least 1 acre in size if possible.

4. Plant aspen along meadow edge or treat existing aspen stands to stimulate new growth as feasible.

5. Assess future grazing plans for the Hope Valley allotment as needed to support hydrologic stability, riparian vegetation recruitment, and restoration goals.

Climate-Smart context

We are already experiencing the effects of climate change in the Sierra Nevada. Projections suggest that the region is likely to continue to experience profound changes through the end of the 21st century. Rising temperatures, reduced snowpack, changing hydrological conditions, and increased frequency and intensity of extreme events threaten Sierra meadows and meadow-associated species. Restoring Sierra meadows in the context of historical conditions and the range of historic variability is unlikely to be adequate to ensure that desired meadow restoration outcomes, such as hydrological processes and habitat for diverse species, are able to persist under future climate change. In order to retain our investment in meadow restoration, it is necessary to design and implement climate-smart meadow restoration projects in the context of a changing climate and associated uncertainty about future conditions (Veloz et al. 2013), in a manner that makes them resilient to the consequences of climate change. Below we summarize the projections for the Sierra Nevada and outline some climate-smart actions that may increase the likelihood of success. For more information, please see "A guide to climate-smart meadow restoration in the Sierra Nevada and southern Cascades" (Vernon et al. 2019).

Climate Projections**.** The Sierra Nevada is projected to experience large changes in climate and hydrology by the mid-21st century relative to conditions observed in the 20th century. Below is a summary of projections for the Northern Sierra Nevada from a CA-wide water balance model (Flint et al. 2014) and the Assessment of Climate Change in the Southwest US (Garfin et al. 2013):

- Large reductions in April 1st snowpack
- Higher maximum and minimum daily temperatures throughout the year
- Increased evapotranspiration rates (water demand) by plants in meadows
- Higher proportion of winter precipitation falling as rain instead of snow, including rain on snow
- Larger, longer ,and more frequent heavy rain events that cause large floods
- Hotter, longer and more frequent droughts and heat waves
- Increased probability of high severity fire

Potential Climate-Smart Actions

- Promote beaver occupancy (e.g. by managing for sufficient willow cover) to maintain hydrologic function and increase habitat complexity. In general, Sierra Nevada riparian

meadows historically had a high capacity for beaver dams. Beaver dams prolong floodplain activation and hold more water in the meadow during droughts.

- Plant a diversity of riparian shrubs that occur in the vicinity to increase the duration fruits and flowers are available to wildlife to compensate for divergences in plant and animal phenology. Plant along the channel, meadow edges, and other moisture gradients, and consider sourcing material from drier areas and lower elevations that may be more tolerant of the future climate.
- Identify and plant more drought-tolerant species and phenotypes. Source species for plantings from areas lower in the watershed that are warmer and drier. Plant large numbers of willows cuttings from all willow species in the meadow to increase the likelihood of survival of some individuals following severe drought.
- Provide thermal refugia (shade, shelter, water, and food) for wildlife species by planting willows and other shrub species to promote large clumps of dense foliage with diverse plant understories near and over water. Shrubs and sedges along the stream channel promote complex instream habitat and may reduce stream temperatures by shading.
- If the meadow is grazed, maintain riparian fencing to protect streamside vegetation and adaptively manage grazing pressure to achieve desired objectives, especially during drought years or following major disturbance (e.g. large flood).
- Monitor the restoration project to inform agile and adaptive management, and provide context for understanding climate-related impacts and vulnerabilities.

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Literature Cited

Bombay, H. L. 1999. Scale perspectives in habitat selection and reproductive success for Willow Flycatchers (*Empidonax traillii*) in the central Sierra Nevada, California. Thesis, California State University, Sacramento, California.

Bombay, H. L, T. M. Benson, B. E. Valentine, and R. A. Stefani. 2003a. *A willow flycatcher survey protocol for California*. USDA Forest Service, Pacific Southwest Region, Vallejo, CA.

Bombay, H. L., M. L. Morrison, and L. S. Hall. 2003b. Scale perspectives in habitat selection and animal performance for Willow Flycatchers (*Empidonax traillii*) in the central Sierra Nevada, California. *Studies in Avian Biology* 26:60-72.

Borgmann, K. L. 2010. *Mechanisms underlying intra-seasonal variation in the risk of avian nest predation: implications for breeding phenology*. Ph.D. Dissertation. University of Arizona, Tucson, AZ.

Cain, J. W., III, Morrison, M. L., and Bombay, H. L. 2003. Predator activity and nest success of Willow Flycatchers and Yellow Warblers. Journal of Wildlife Management 67:600-610.

Campos, B.R., R.D. Burnett, H.L. Loffland, and R.B. Siegel. 2014. Evaluating meadow restoration in the Sierra Nevada using birds and their habitat associations. Report to The National Fish And Wildlife Foundation. Point Blue Conservation Science, Petaluma, CA.

Cicero, C. 1997. Boggy meadows, livestock grazing, and interspecific interactions: influences on the insular distribution of montane Lincoln's Sparrows (*Melospiza lincolnii alticola*). *Great Basin Naturalist* 57(2):104-115.

Cocimano, M.C., Morrison, M.L., Mathewson, H.A. and Vormwald, L.M., 2011. The influence of meadow moisture levels on activity of small mammal nest predators in the Sierra Nevada, California. *Northwestern Naturalist*, *92*(1), pp.50-57.

Cooke, H.A. and Zack, S., 2008. Influence of beaver dam density on riparian areas and riparian birds in shrubsteppe of Wyoming. *Western North American Naturalist*, *68*:365-374.

Erman, N. 1984. The use of riparian systems by aquatic insects. Pp. 177-1982 *in* R. E. Warner and K. Hendrix (eds.), *California riparian systems: ecology, conservation, and productive management*. University of California Press, Berkeley, CA.

Erman, N. A. 1996. Status of aquatic invertebrates. Chapter 35, pp. 987–1008 *in*, D. C. Erman (ed.), *Sierra Nevada Ecosystem Project: final report to Congress, vol. II, assessments and scientific basis for management options*. Centers for Water and Wildland Resources. University of California, Davis.

Fair, J., L. Hunt, M. Hanley, and J. Dyste. 2018. Restoring Carson Meadows, Assessment and Prioritization. A report by American Rivers submitted to the National Fish and Wildlife Foundation.

Flint, L., A. Flint, J. Thorne, and R. Boynton. 2014. California Basin Characterization Model (BCM) downscaled climate and hydrology. California Climate Commons. Accessible online at http://climate.calcommons.org/dataset/2014-CA-BCM

Garfin, G. A., A. Jardine, R. Merideth, M. Black, and S. LeRoy, eds. 2013. Assessment of climate change in the Southwest United States: A report prepared for the National Climate Assessment. A report by the Southwest Climate Alliance. Washington, D.C.: Island Press.

Grinnell, J. and A. H. Miller. 1944. The distribution of the birds of California. *Pacific Coast Avifauna* 27:1-617.

Harris, J. H., S. D. Sanders, and M. A. Flett. 1987. Willow Flycatcher surveys in the Sierra Nevada. *Western Birds* 18:27–36.

Heath, S. 2008. Yellow Warbler (*Dendroica petechia*). in California Bird Species of Special Concern: a ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California (W. D. Shuford, and Gardali, T., eds) Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento. Pgs 332-339.

Heath, S. K., and G. Ballard. 2003. Patterns of breeding songbird diversity and occurrence in riparian habitats of the eastern Sierra Nevada. Pp. 21-34 *in* P. M. Faber (ed.), *California riparian systems: processes and floodplain management, ecology and restoration*. Riparian Habitat and Floodplains Conference Proceedings, Riparian Habitat Joint Venture, Sacramento, CA.

Loffland, H. L. and R. B. Siegel. 2017. Conspecific attraction and information gap surveys for Willow Flycatchers in the Sierra Nevada during 2016**.** The Institute for Bird Populations, Point Reyes Station, CA.

Loffland, H. L. and R. B. Siegel. 2015. Monitoring bird response to restoration at Indian Valley**.** The Institute for Bird Populations, Point Reyes Station, CA.

Loffland, H.L., Siegel, R.B., Stermer, C., Campos, B.R., Burnett, R.D. and Mark, T., 2014. Assessing Willow Flycatcher population size and distribution to inform meadow restoration in the Sierra Nevada and Southern Cascades. *The Institute for Bird Populations, Point Reyes Station, CA*.

Loffland, H. L, R. B. Siegel, and R. L. Wilkerson. 2011a. Avian Monitoring Protocol for Sierra Nevada Meadows: A tool for assessing the effects of meadow restoration on birds. Version 1.0. The Institute for Bird Populations, Point Reyes Station, CA.

Loffland, H. L, R. B. Siegel, and R. L. Wilkerson. 2011b. Pre-restoration bird surveys at meadows on the Eldorado and Humboldt-Toiyabe National Forests and nearby lands managed by the State of California. The Institute for Bird Populations, Point Reyes Station, CA.

Mathewson, H. A., H. L. Loffland, M. L. Morrison. 2011. *Demographic Analysis for Willow Flycatcher Monitoring in the Central Sierra Nevada, 1997–2010: Final Report.* Texas A & M University.

Mathewson, H.A., Morrison, M.L., Loffland, H.L. and Brussard, P.F., 2012. Ecology of willow flycatchers (Empidonax traillii) in the Sierra Nevada, California: effects of meadow characteristics and weather on demographics. *Ornithological Monographs*, *75*, pp.1-32.

Orr, R. T., and J. Moffitt. 1971. *Birds of the Lake Tahoe Region*. California Academy of Sciences, San Francisco, CA.

Ray, S. M. 1903. Land birds of Lake Valley, CA. *Auk* 20:185.

Schofield, L., Loffland, H., Siegel, R., Stermer, C. and Mathewson, H., 2018. Using conspecific broadcast for Willow Flycatcher restoration. *Avian Conservation and Ecology*, *13*(1).

Stewart, R. M., R. P. Henderson, and K. Darling. 1977. Breeding ecology of Wilson's Warbler in the High Sierra Nevada, California. *Living Bird* 16:83-102.

Veloz, S. D., N. Nur, L. Salas, D. Jongsomjit, J. K. Wood, D. Stralberg, and G. Ballard. 2013. Modeling climate change impacts on tidal marsh birds: Restoration and conservation planning in the face of uncertainty. Ecosphere. 4:49. http://dx.doi.org/10.1890/ES12-00341.1

Vernon, M. E., B. R. Campos, and R. D. Burnett. 2019. A guide to climate-smart meadow restoration in the Sierra Nevada and southern Cascades. Version 1.0. Point Blue Contribution Number 2232

Weixelman, D.A., B. Hill, D. J. Cooper, E. L. Berlow, J. H. Viers, S. E. Purdy, A. G. Merrill, S. E. Gross. 2011. A Field Key to Meadow Hydrogeomorphic Types for the Sierra Nevada and Southern Cascade Ranges in California. Gen. Tech. Rep. R5-TP-034. Vallejo, CA. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, 34pp.

Appendix A. Bird Species detected during point count surveys in Hope Valley West Meadow in 2018, including total number of individuals detected and relative abundance[1]. Tan highlighting indicates meadow focal species.

Bird Species	# detected (all distances)	Index of abundance (within 50m) Avg #/acre
Mountain Quail	6	
Calliope Hummingbird	2	0.09
Red-breasted Sapsucker	1	
Northern Flicker	4	
Western Wood-Pewee	8	0.09
Dusky Flycatcher	10	0.14
Warbling Vireo	4	0.09
Steller's Jay	2	
Clark's Nutcracker	4	
Cliff Swallow	8	0.37
Mountain Chickadee	10	0.14
Red-breasted Nuthatch	6	
White-breasted Nuthatch	1	
House Wren	3	
American Robin	9	0.14
Yellow-rumped Warbler	5	0.09
Wilson's Warbler	7	0.23
Western Tanager	1	
Green-tailed Towhee	14	0.28
Chipping Sparrow	1	
Fox Sparrow	1	
Song Sparrow	5	0.05
Lincoln's Sparrow	5	0.19
White-crowned Sparrow	8	0.14
Dark-eyed Junco	26	1.03
Brewer's Blackbird	4	0.05
Cassin's Finch	1	

[1] number of individuals detected within 50m radius plot around survey stations divided by the number of station visits and multiplied by 0.515 plots per acre.