Produced by The Institute for Bird Populations'
Sierra Nevada Bird Observatory

Monitoring bird response to restoration at Indian Valley

September 25, 2015

Helen Loffland and Rodney B. Siegel

The Institute for Bird Populations
P.O. Box 1346
Point Reyes Station, CA 94956

www.birdpop.org

Above: Mallard nest in Indian Valley area.

Table of Contents

Introduction

This report summarizes the results of pre and post-restoration multi-species bird monitoring completed between 2010 and 2014 at Indian Valley South and at reference sites at Indian Valley North, Indian Valley West Wilderness, and Little Indian Valley (Figure 1).

During the summers of 2010 through 2014 The Institute for Bird Populations (IBP) utilized a standardized bird survey and monitoring protocol within the Indian Valley project area to provide pre-restoration baseline data for the area, and post-restoration bird response to restoration activities. We utilized the Loffland et al. (2011a) protocol entitled *Avian monitoring protocol for Sierra Nevada meadows: a tool for assessing the effects of meadow restoration on birds*. This protocol is designed to assess and describe the larger bird community and to detect population level changes in meadow-associated bird species in response to restoration activities.

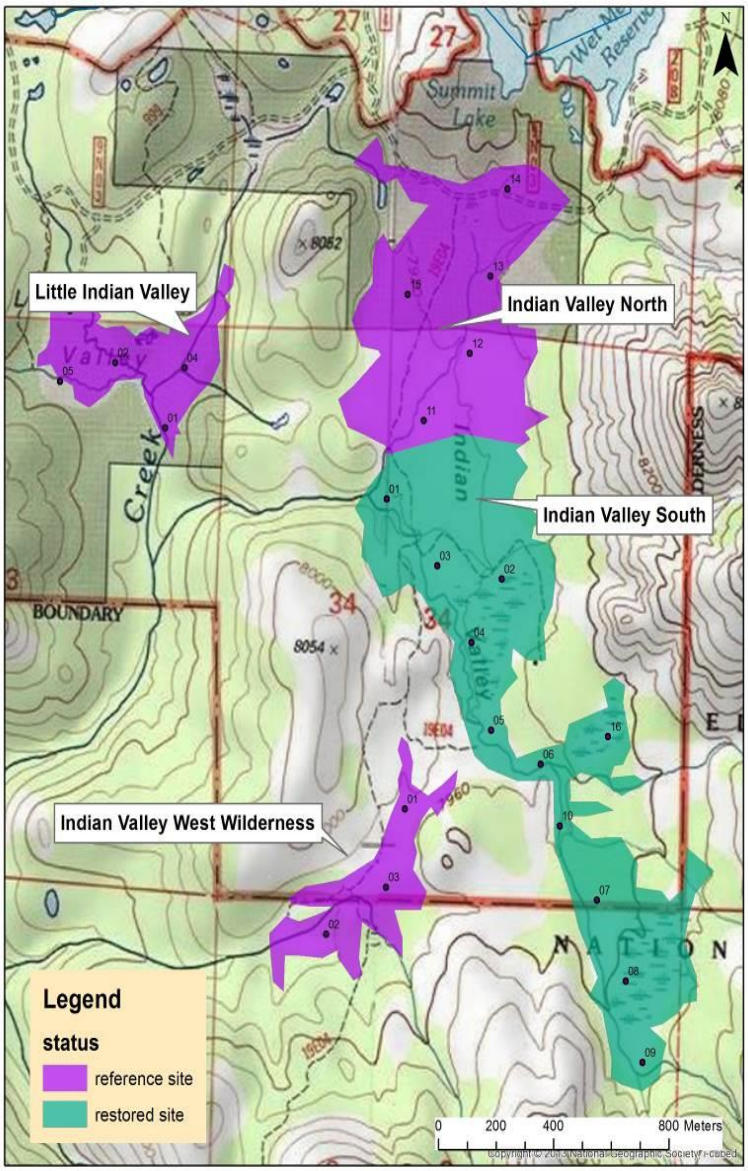

Figure 1. Indian Valley South and 3 reference meadows surveyed for birds: 2010-2014.

METHODS

We identified the portion of this large meadow system that was likely to be enhanced by restoration activities and designated this region, Indian Valley South, as the "restoration site" for monitoring purposes. Within this area we monitored 10 multi-species survey stations which included 5 stations within or directly adjacent to the restored stream course and 5 stations in areas upstream and on elevated hanging meadows to the east of the restoration zone. Although some of these stations fall outside of the area where construction took place, we nonetheless expect some change in water holding capacity or stream channel changes over time and therefore consider this area "restored" as well. At our reference sites at Indian Valley North, Indian Valley West Wilderness, and Little Indian Valley we monitored 5, 3 and 5 multi-species survey stations, respectively, resulting in a total of 13 reference stations (Figures 2 and 3). In earlier reports (Loffland et al 2011b, 2013) we reported the station results from Indian Valley North in combination with the restoration stations in Indian Valley South because the site is a large contiguous meadow system. We later decided to split the site and treat the stations in Indian Valley North as reference stations because that portion of Indian Valley is unaffected by the restoration efforts on Deer Creek. The hydrology of the two areas is discreetly separate from one another. Indian Valley North only flows into Deer Creek at the outflow point in the meadow, and otherwise drains entirely along a different unnamed tributary that flows from the north. This portion of the meadow is an ideal reference because it has deeply incised channels and an extensive remnant willow population that is very similar to the pre-restoration conditions found in the restored area in Indian Valley North.

Multi-Species Bird Monitoring

Multi-species monitoring (all bird species) in the meadows of Indian Valley South and its reference sites followed Loffland et al. (2011a), and consisted of two primary methods: point counts and area searches. Point counts were conducted at survey stations spaced 250m apart, and all individuals of all species seen or heard were counted during a 7-minute period. Area searches consisted of slowly walking through the entire meadow tallying all birds by species. In addition to bird monitoring, basic habitat assessments were completed at each point count survey station.

Surveys were completed in 2010 and 2012 prior to restoration. After restoration was completed during fall of 2012, post-restoration monitoring visits were completed in 2013 and 2014 (Loffland et al 2011a, 2011b). By collecting data in multiple pre-restoration and post-restoration years we are improving our ability to detect and interpret any population changes that occur as a result of restoration activities. This monitoring protocol uses a Before, After, Control, Impact (B.A.C.I.) design requiring that nearby reference sites not scheduled for restoration also be monitored. By collecting data at reference sites we hope to distinguish bird population changes that occur as a result of restoration, from those occurring across the local population due to other factors not related to restoration efforts. Therefore, the same multi-species monitoring protocol was applied at Indian Valley North, Indian Valley West Wilderness and Little Indian Valley.

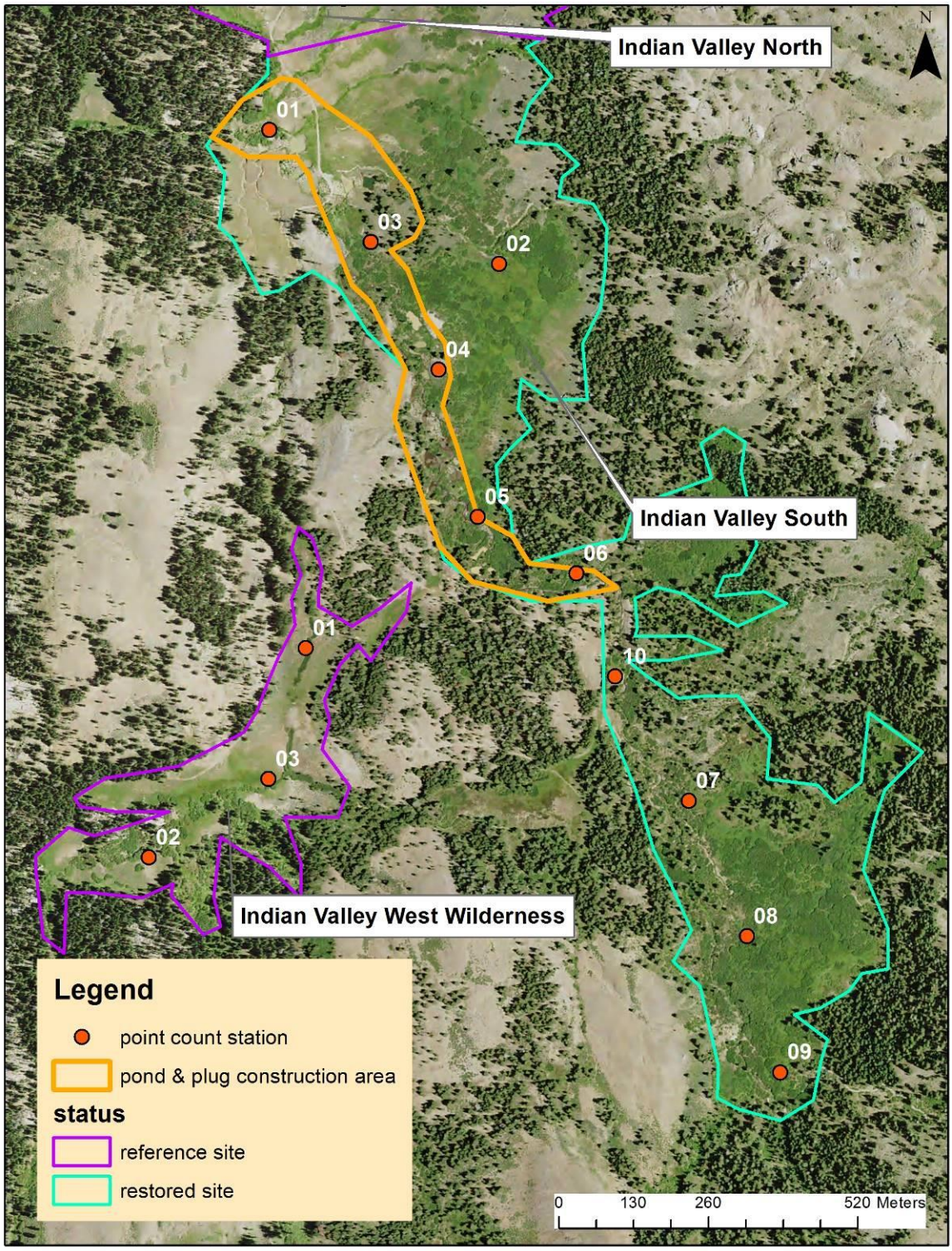

Figure 2. Multi-species point count station locations in Lower Hope Valley and northern Upper Hope Valley.

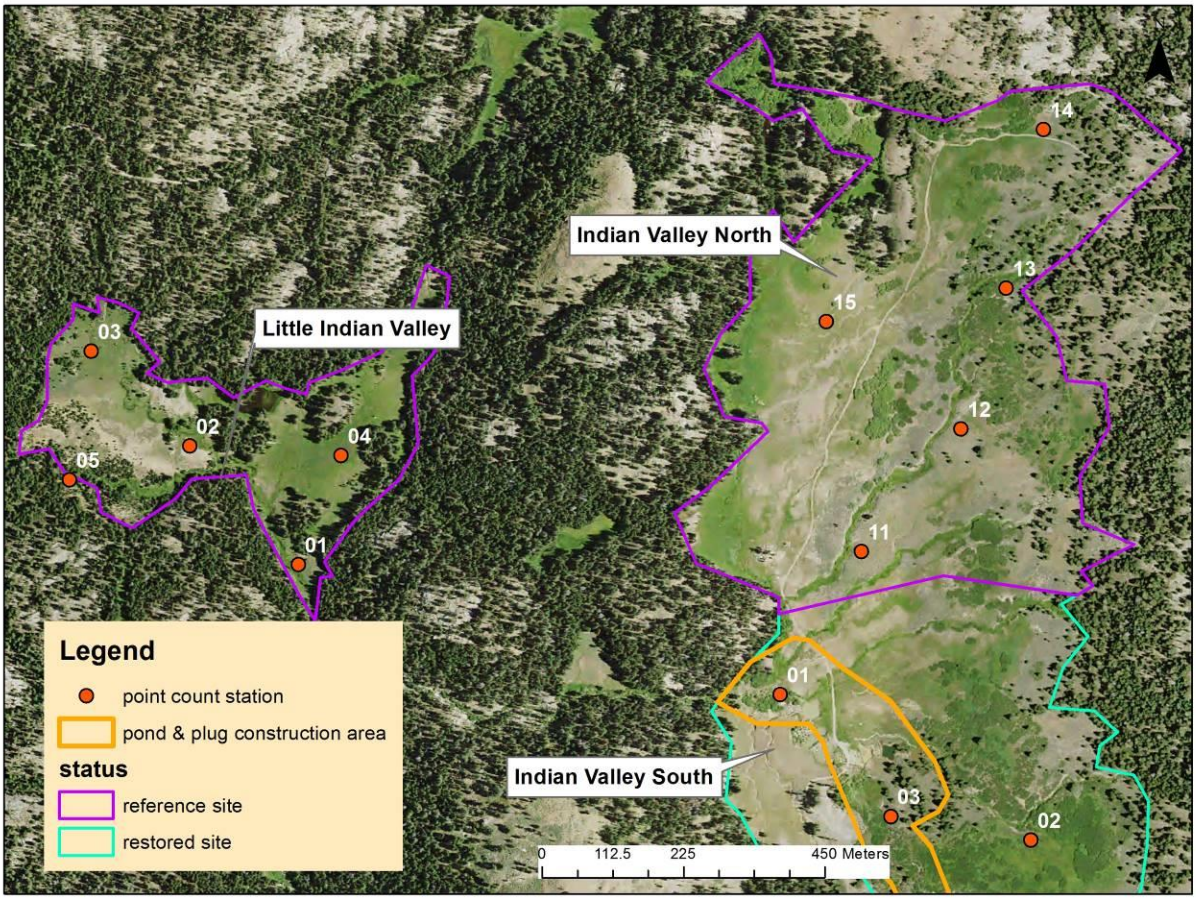

Figure 3. Multi-species point count station locations in Little Indian Valley and Indian Valley North.

Habitat Monitoring

We estimated vegetation, bare ground, water within 50m of all multi-species point count stations following Loffland et al. (2011a). Cover classes were averaged across four 50-m diameter quadrants 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 species counts and indices but are not intended to replace vegetation monitoring specific to meadow restoration. General habitat characteristics that are important to focal bird species, riparian shrub cover and water cover, were quantified by ocular estimation. Similarly, sagebrush cover and the amount of bare ground were estimated to provide a rough index of the extent of severely disturbed area within a meadow. Because our methods are ocular estimates that have considerable error, they are not suitable for measuring or detecting habitat change over the short time periods we have observed so far. For this reason only changes in water cover (created by plug and pond construction) are reported herein.

Incidental Sightings

During monitoring visits we also occasionally surveyed for Willow Flycatchers using the basic broadcast technique described in Bombay et al. (2003) and recorded observations of mammals,

amphibians and bumble bees. Additionally during the 2nd monitoring visit in 2013 we collected a sample of representative plaster casts for mammal tracks found within the mud margins of the restoration ponds.

Data Analysis

Analyses compared results of pre-restoration and post-restoration bird monitoring at the station scale, where all stations within the restored area, Indian Valley South, are compared to the results of the 3 reference sites pooled together (Indian Valley North, Indian Valley West Wilderness, and Little Indian Valley). Exceptions include the site-specific species lists in which we reported the average values for each individual reference site (rather than pooling all reference sites). Unless otherwise noted all point count results are reported using only the birds detected within 50m of point count stations. Using a 50-m radius cutoff allows for more consistent detection probability between years, sites, stations, and observers. Additionally, at this restoration site in particular it makes sense to use this observation distance in analyses because the restored stream system still sits at an elevation lower than the surrounding landscape of hanging meadows, volcanic lahar, and red fir forest. In this setting the hydrologic effects of restoration are likely to have the greatest effect near the stream (rather than spreading across a floodplain landscape as they would in other locales). Birds detected farther away may not be responding to restoration induced changes as much as those birds detected closer to the construction zone (Figure 2).

Loffland et al (2011a) identified 18 focal bird species that are expected to respond positively to meadow restoration, or in the case of Brown-headed Cowbird, have other conservation implications making them especially worthy targets of monitoring at project sites. In 2014 Campos et al. used this species list in combination with baseline results at over 100 meadows during 2010 and 2012 to determine which of these target focal species would be likely to occur in sample sizes that lend themselves to analysis. Most of the species not included in the refined focal list were rails and other secretive or rare species (Sora, Virginia rail, Willow Flycatcher, and Sandhill Crane). Because we were interested in both statistically significant results needed for monitoring purposes, and biologically significant colonization by rare species, we report results for all focal species used by Loffland et al. (2011a) and Campos et al. (2014).

We developed an index of relative abundance that reports the number of focal species, and focal individuals detected around survey stations. These values are then averaged between visits within each year, and the resulting station level values were compared between years using Repeated Measure ANOVA, where each year's station average is the dependent variable, measured against the independent "treatment" variable that denoted whether that station was in a restored or unrestored area. Limited sample sizes preclude taking the next step of including the before/after restoration variable, but presumably restoration effects on bird populations are occurring gradually over the years since restoration, so assessing change as it is today relative to the starting point is still valid.

In addition to assessing results at the focal multi-species scale we evaluated response of individual focal species using the same methods described above. We also qualitatively describe bird species' responses that we observed at levels that were not statistically measureable, particularly the colonization by single individuals (or family groups) of wetland associated

species. To generate post-restoration species lists we combined all area search and point count results to create the most comprehensive bird species list for each site.

RESULTS

Multi-species Monitoring

All stations were received either one or two visits, annually. In 2010 and 2014, sites were monitored once, while in 2012 and 2013 sites received 2 visits. In years with two visits, the first visit occurred in early June, and the second during mid-June or early July (Table 1).

Table 1. Dates for multi-species bird monitoring in the Indian Valley area in 2010 through 2014. Text with background shading denotes restoration site.

Site	2010	2012	2013	2014
Indian Valley South	7/7/2010	6/9/2012, 7/1/2012	6/14/2013, 6/29/2013	7/1/2014
Indian Valley North	7/7/2010	6/9/2012, 7/1/2012	6/14/2013, 6/29/2013	7/1/2014
Indian Valley West Wilderness	7/8/2010	6/9/2012, 7/1/2012	6/14/2013, 6/27/2013	7/1/2014
Little Indian Valley	7/8/2010	6/9/2012, 7/1/2012	6/15/2013, 6/28/2013	7/1/2014

Construction of the plug and pond restoration occurred in October of 2012. Since that time 53 bird species were detected during post-restoration point counts and area searching in Indian Valley South (Table 2). The number of species detected at reference sites at Indian Valley North, Indian Valley West Wilderness and Little Indian Valley were, 35, 31, and 27 respectively. When all reference sites were pooled, a total of 45 species were detected during the post-restoration period. Eight focal species were detected overall, with 6 of them at the restored Indian Valley South site. Other notable wetland species that occur in the restored Indian Valley South are Red-winged Blackbird, Mallard, and Green-winged Teal (Table 2).

Figure 4. Green-winged teal

Table 2. Species and years with detections during the post restoration period (2013, 2014) at Indian Valley South and reference sites.

Bird Species	Indian Valley South (restored)	Indian Valley North (reference)	Indian Valley West Wilderness (reference)	Little Indian Valley (reference)
Mallard[a]	2013 & 2014			
Green-winged Teal[a]	2013			
Mountain Quail	2013 & 2014	2013 & 2014	2013	2013
Red-tailed Hawk	2014	2013 & 2014		
Killdeer	2014			
Spotted Sandpiper[a]	2013 & 2014			
Great Horned Owl	2013 & 2014			
Calliope Hummingbird[b]	2013 & 2014			
Rufous Hummingbird	2014			
Williamson's Sapsucker	2013 & 2014	2013 & 2014	2013	2013 & 2014
Red-breasted Sapsucker[b]	2013 & 2014			
Northern Flicker	2013 & 2014	2013	2013 & 2014	
Olive-sided Flycatcher	2014			
Western Wood-Pewee	2014		2014	2014
Hammond's Flycatcher		2013		2013
Dusky Flycatcher	2013 & 2014	2013 & 2014	2013 & 2014	2013 & 2014
Warbling Vireo[b]	2013 & 2014	2013 & 2014	2014	
Steller's Jay	2013 & 2014	2013 & 2014	2014	2014
Clark's Nutcracker	2013 & 2014	2013 & 2014	2013 & 2014	2013 & 2014
Common Raven	2013 & 2014	2013 & 2014		
Tree Swallow	2014			2014
Violet-green Swallow	2014			
Cliff Swallow	2014			
Mountain Chickadee	2013 & 2014	2013 & 2014	2013 & 2014	2013 & 2014
Red-breasted Nuthatch	2014	2013		2013 & 2014
Pygmy Nuthatch			2013	
Brown Creeper	2014		2014	2013 & 2014
Ruby-crowned Kinglet	2014			2014
Mountain Bluebird	2013 & 2014	2013	2014	
Townsend's Solitaire	2013			2013
Hermit Thrush	2013 & 2014	2013	2013	2013 & 2014
American Robin	2013 & 2014	2013 & 2014	2013 & 2014	2013 & 2014

Bird Species	Indian Valley South (restored)	Indian Valley North (reference)	Indian Valley West Wilderness (reference)	Little Indian Valley (reference)
Orange-crowned Warbler	2013	2013		
Yellow Warbler[b]	2013 & 2014	2013		
Yellow-rumped Warbler	2013 & 2014	2013	2013 & 2014	2013 & 2014
Hermit Warbler	2013 & 2014			
MacGillivray's Warbler[b]	2013 & 2014	2013 & 2014	2013	
Wilson's Warbler[b]	2013 & 2014	2013	2013 & 2014	
Western Tanager	2013 & 2014		2013 & 2014	2014
Green-tailed Towhee	2013 & 2014	2013 & 2014	2013	
Chipping Sparrow	2013 & 2014	2013	2013 & 2014	2013 & 2014
Brewer's Sparrow	2013 & 2014	2013 & 2014	2013 & 2014	
Fox Sparrow	2014	2013 & 2014		2013
Song Sparrow[b]	2013 & 2014	2014	2014	
Lincoln's Sparrow[b]	2013 & 2014	2013 & 2014	2013 & 2014	2013 & 2014
White-crowned Sparrow[b]	2013 & 2014	2013 & 2014	2013 & 2014	2013 & 2014
Dark-eyed Junco	2013 & 2014	2013 & 2014	2013 & 2014	2013 & 2014
Lazuli Bunting	2013 & 2014	2013 & 2014	2013 & 2014	2013
Red-winged Blackbird	2014	2014		
Brewer's Blackbird	2014	2014		2013
Brown-headed Cowbird[c]	2013		2014	
Pine Grosbeak	2013 & 2014	2014	2013	
Cassin's Finch	2013 & 2014	2013 & 2014	2013 & 2014	2013 & 2014
Red Crossbill	2013 & 2014			
Pine Siskin	2013 & 2014	2013 & 2014	2013 & 2014	2013

[a] Waterfowl or wading species
[b] Meadow focal species
[c] Not included in indices of restoration success.

Post-restoration species' indices of relative abundance ranged from almost zero (when a species was only detected once) to values greater than 1.5 (Table 3). Those species with values approaching or exceeding 1.0 individuals per station included generalist species such as, Dusky Flycatcher, Pine Siskin, and Dark-eyed Junco, as well as riparian associates including White-crowned Sparrow and Wilson's Warbler. Of particular interest are the latter two species which are meadow

Figure 5. Dusky Flycatcher nest at Indian Valley South

focal species (Loffland et al. 2011a, Campos et al. 2014a).

Table 3. Post-restoration (2014) index of relative abundance within 50m of point count stations for focal bird species.

			Index of relative abundance			
Common Name	**Latin Name**	**Usual Habitat within Meadows[c]**	**Indian Valley South**	**Indian Valley North**	**Indian Valley West Wilderness**	**Little Indian Valley**
Sandhill Crane[a]	*Grus canadensis*	*M, E*	--	--	--	--
Virginia Rail[a]	*Rallus limicola*	*E*	--	--	--	--
Sora[a]	*Porzana carolina*	*E*	--	--	--	--
Spotted Sandpiper[a,b]	*Actitis macularius*	*G*	*0.10*	--	--	--
Wilson's Snipe[a]	*Gallinago gallinago*	*E*				
Great Gray Owl[a]	*Strix nebulosa*	*M*	--	--	--	--
Calliope Hummingbird[b]	*Stellula calliope*	*S,A,M*	*0.20*	--	--	--
Red-breasted Sapsucker[a,b]	*Sphyrapicus ruber*	*S,A*	--	--	--	--
Willow Flycatcher[a,b]	*Empidonax traillii*	*S,E*	--	--	--	--
Swainson's Thrush[a,b]	*Catharus ustulatus*	*S,A*	--	--	--	--
Warbling Vireo[a,b]	*Vireo gilvus*	*S,A*	*0.3*	--	--	--
Yellow Warbler[a,b]	*Dendroica petechia*	*S*	--	--	--	--
MacGillivray's Warbler[a,b]	*Oporornis tolmiei*	*S,A*	-	*0.2*	--	--
Common Yellowthroat[a]	*Geothlypis trichas*	*S,E*	--	--	--	--
Wilson's Warbler[a,b]	*Wilsonia pusilla*	*S,A*	*1.2*	--	*0.67*	--
Yellow-breasted Chat[a]	*Icteria virens*	*S*	--	--	--	--
Song Sparrow[a,b]	*Melospiza melodia*	*M*	--	*0.2*	--	--
Lincoln's Sparrow[a,b]	*Melospiza lincolnii*	*M*	*0.6*	*0.2*	*0.33*	*0.2*
Brown-headed cowbird[a]	*Molothrus ater*	*all*	--	--	--	--
Sandhill Crane[a]	*Grus canadensis*	*M, E*	--	--	--	--

[a] Focal species identified in Loffland et al 2011
[b] Focal species identified in Campos et al 2014
[c] A= Aspen; E = emergent vegetation and surface water; G = gravel bars and streamside zone; M = open meadow; S = riparian deciduous shrubs

All 4 restoration and reference sites support Lincoln's Sparrows and White-crowned Sparrows. The White-crowned Sparrow index of abundance indicates at least one bird per station at both the restored site and Indian Valley West Wilderness. These values are twice as high as the remaining 2 reference areas. Lincoln's Sparrow relative abundance indicated at least one detected per every 2 stations at the restored site, which is twice the abundance at the other reference areas. MacGillivray's Warblers and Song Sparrows were detected at single stations at 2 reference areas (but not the restored site). Wilson's Warblers were twice as abundant at the restored area than the reference site at Indian Valley West Wilderness. The remaining 3 focal species were only detected at in the restored area (Indian Valley South).

When indices of abundance were analyzed with Repeated Measure ANOVA we were able to assess how restored and unrestored stations tracked over time. As expected, prior to restoration most bird metrics where quite similar between the treatment groups (and most differences were easily explained by pre-existing differences in habitat). We first examined how the average number of focal species reacted to treatment group (restored, unrestored) and time. Figure 6 shows that during the pre-restoration period the index of abundance measuring the number of focal species per station for both treatment groups tracked together in parallel, but after restoration the values diverged. After restoration, the number of focal species at restored stations increased in both 2013 and 2014, while the values at the reference stations increased slightly in 2013 and then declined in 2014. The effect of year was significant across both treatments ($F=4.361$; $\alpha=0.02$), but the interaction of year and treatment was not ($F=1.383$; $\alpha=0.284$). We then assessed the between-treatments effect alone which was significant ($F=5.334$; $\alpha=0.033$). This implies that although the two treatment groups were different from one another they both varied somewhat in parallel to one another.

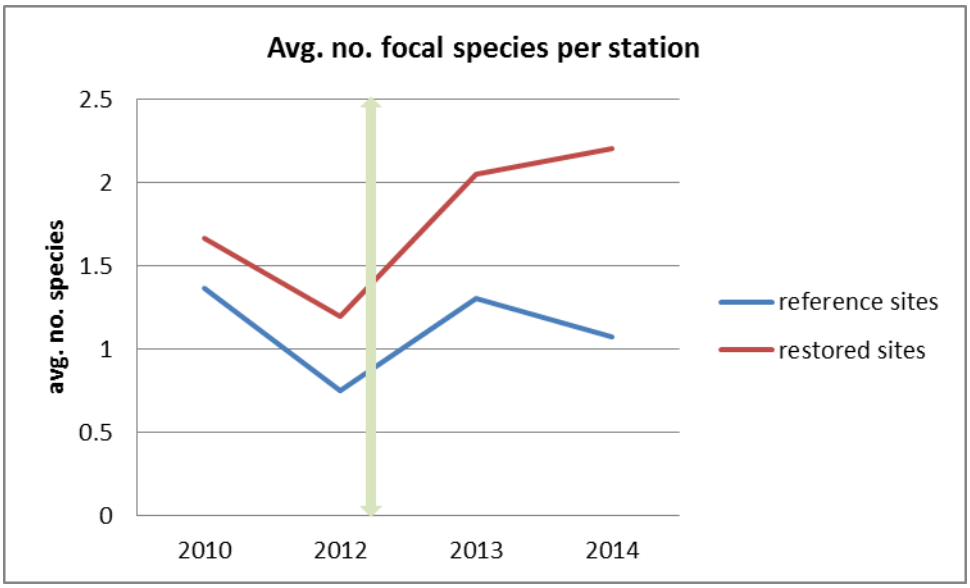

Figure 6. Index of abundance for total number of focal species per station (50m) in each year, grouped by restored and unrestored areas. Green arrow denotes point in time when restoration occurred.

We examined the same relationships for the total number of individuals of all focal species detected, averaged across visits for each station. In this instance the pre-restoration pattern is almost identical to the previous test of focal species numbers, but the post-restoration response at restored stations is even more pronounced. Multivariate outcomes are still limited by sample size, but the univariate response of the within-subject effect of year is nearly significant ($F=2.720$, $\alpha=0.053$). The between subject effect of restoration treatment was however significant ($F=5.475$, $\alpha=0.031$) showing that restoration had a measurable effect on the number of focal birds detected (Figure 7).

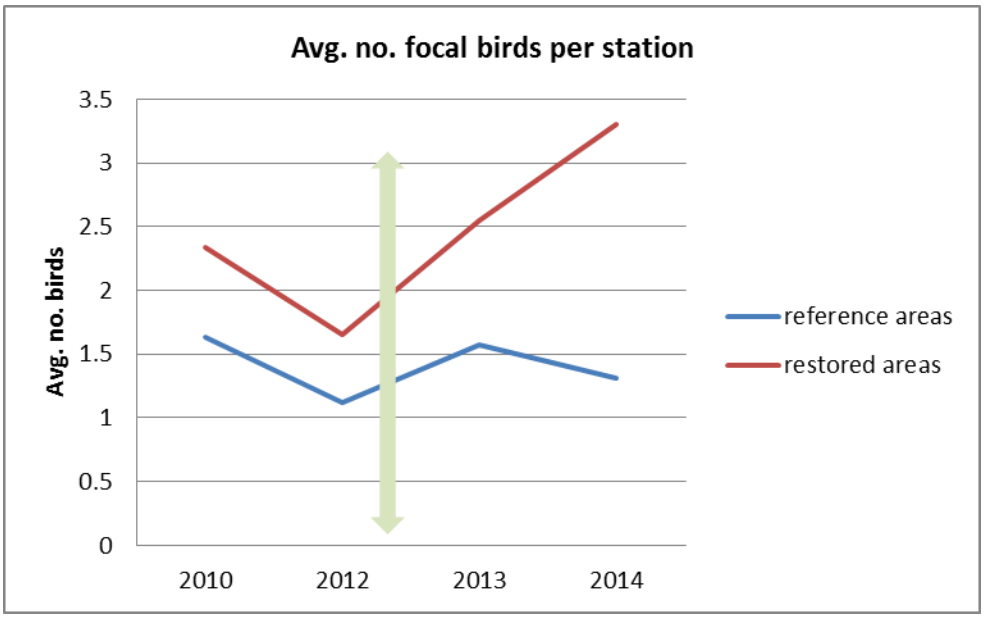

Figure 7. Index of abundance for total number birds of all focal species pooled per station (50m) in each year, grouped by restored and unrestored areas. Green arrow denotes point in time when restoration occurred.

We examined results for individual focal species that appeared to respond to habitat changes in the restored area and that were detected often enough to provide adequate data for analysis. Both Lincoln's Sparrow and Warbling Vireo showed similar patterns of increase in relative abundance after restoration occurred (Figures 8 and 9), but year and treatment effects were not significant at 0.05 level (all $\alpha > 0.07$).

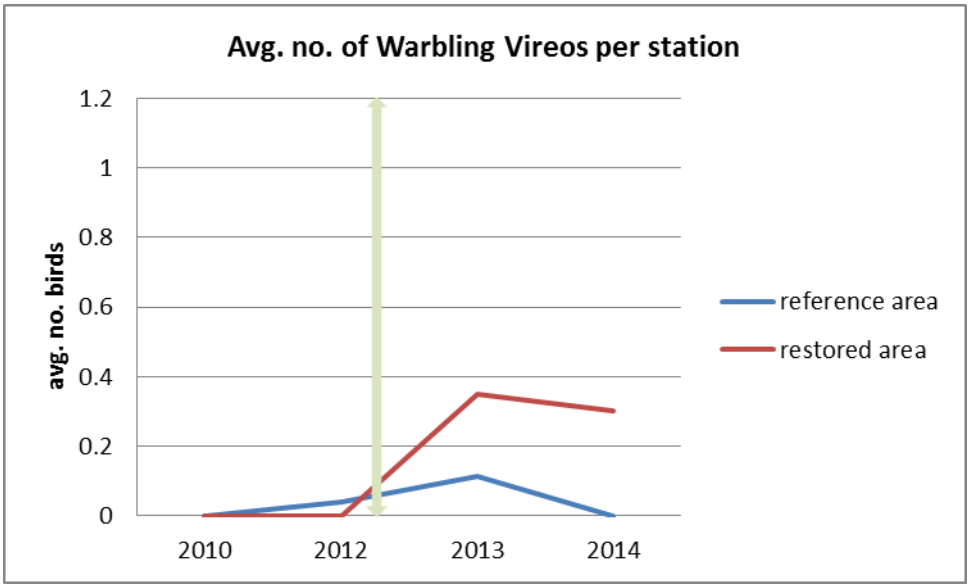

Figure 8. Index of abundance for total number of Warbling Vireos per station (50m) in each year, grouped by restored and unrestored areas. Green arrow denotes point in time when restoration occurred.

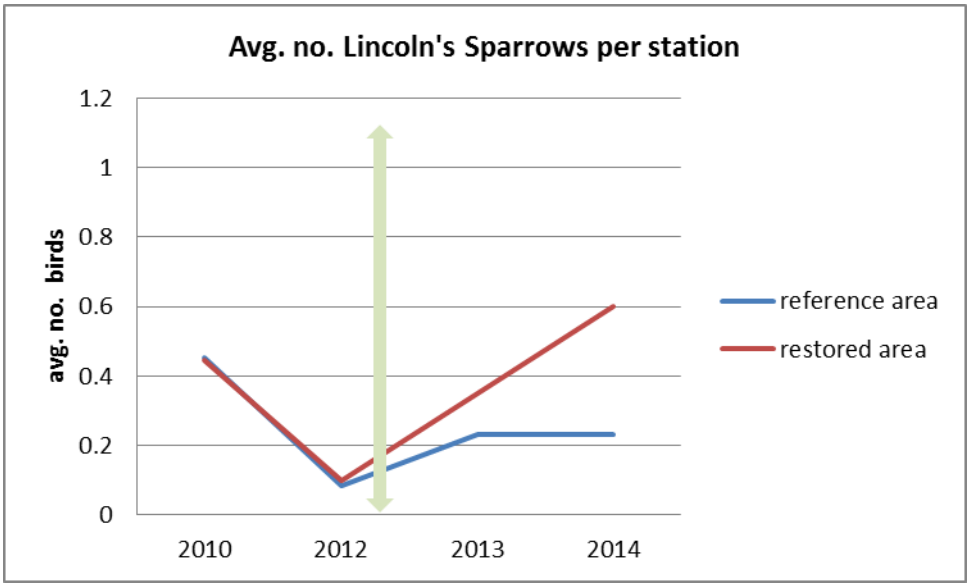

Figure 9. Index of abundance for total number of Lincoln's Sparrow per station (50m) in each year, grouped by restored and unrestored areas. Green arrow denotes point in time when restoration occurred.

During the post-restoration period, the Wilson's Warbler index of relative abundance tripled at the restored stations from less than 0.5 to greater than 1.2 individuals per station, while simultaneously declining at the reference stations. In this case the the year and year*treatment effects were significant ($F=3.565$, $\alpha=0.020$, $F=3.430$, $\alpha=0.023$). The between treatment effect was also significant ($F=7.439$; $\alpha<0.001$)(Figure 10 and 11).

Figure 10. Wilson's Warbler foraging in mountain alder.

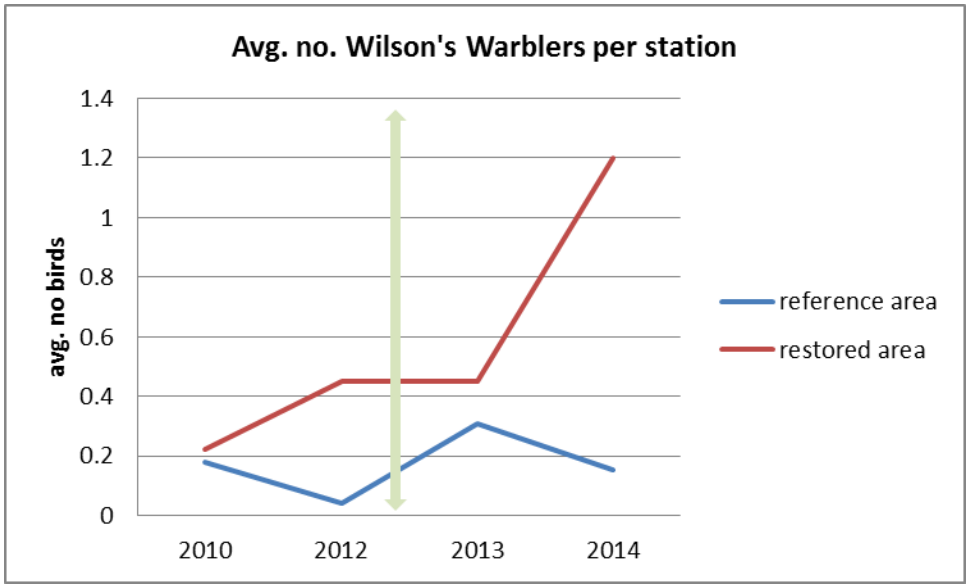

Figure 11. Index of abundance for total number of Wilson's Warblers per station (50m) in each year, grouped by restored and unrestored areas. Green arrow denotes point in time when restoration occurred.

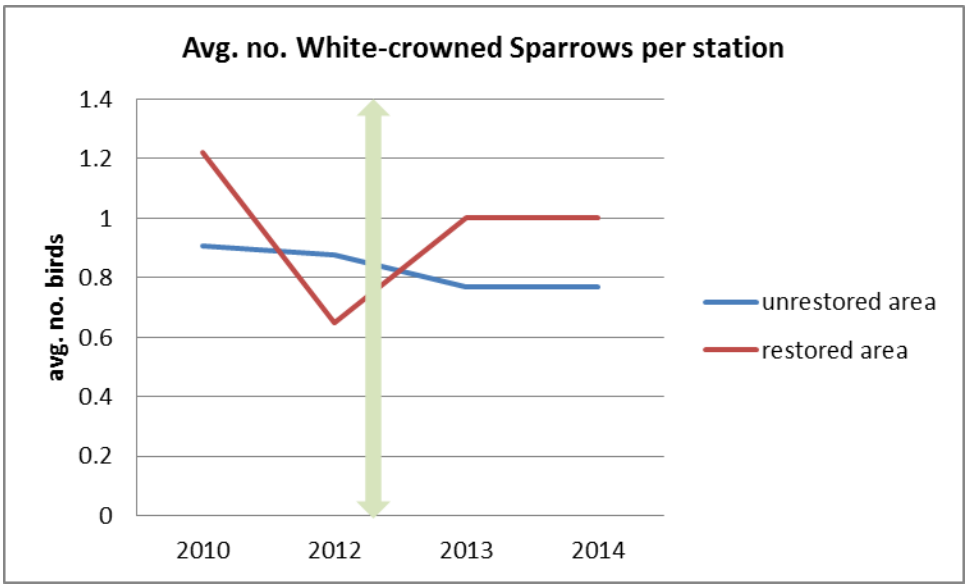

Figure 12. Index of abundance for total number of White-crowned Sparrows per station (50m) in each year, grouped by restored and unrestored areas. Green arrow denotes point in time when restoration occurred.

The response of White-crowned Sparrow to restoration at Indian Valley is harder to interpret. Analysis of time and treatment did not result in significant responses or interaction effects. The restored site experienced large declines in White-crowned Sparrow abundance between the 2 pre-restoration years, but then increased again to the pre-restoration levels after restoration. During the same time period the reference areas declined slightly (Figure 12).

Habitat Monitoring

Prior to restoration the index of water cover within 50m of point count stations was almost identical between restoration and reference areas. Post-restoration however there were increases in water cover in the restored area relative to the reference areas despite drought effects experienced at all sites in 2013 and 2014. In this case the within-subject year effect was significant ($F=4.362$, $\alpha=0.035$) but the year*treatment was not ($F=2.810$, $\alpha=0.094$). The between treatment effect was also not significant ($F=3.406$; $\alpha=0.082$)(Figure 13).

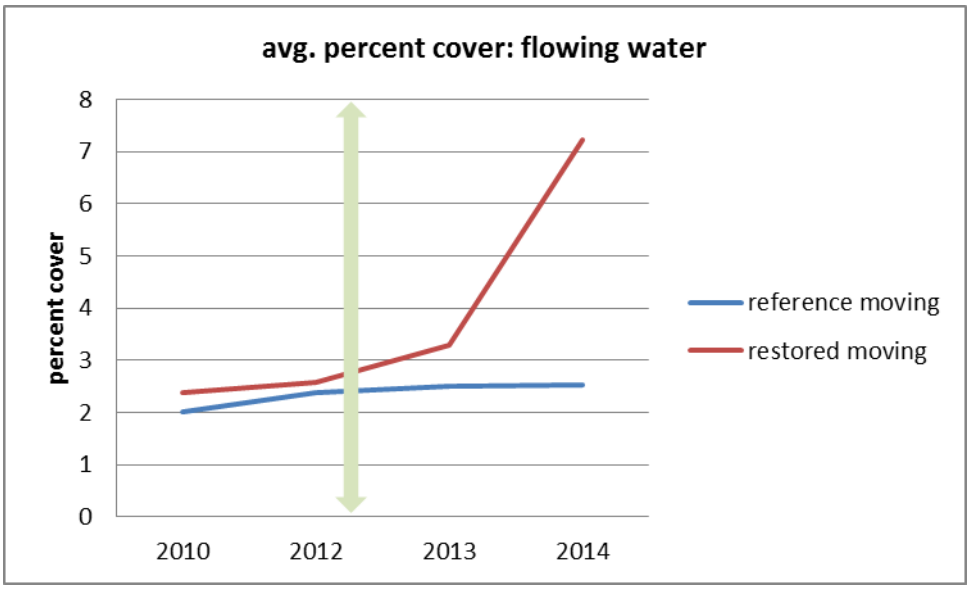

Figure 13. Index of cover from flowing water at survey stations (50m) in each year, grouped by restored and unrestored areas. Green arrow denotes point in time when restoration occurred.

Incidental Sightings

During monitoring visits and site visits associated with public education we recorded opportunistic observations of many other species not monitored by our bird monitoring protocol.

Figure 14. *Bombus bifarius*

Bumble Bees

Although we have not undertaken a standardized bumble bee survey at Indian Valley, during 2014 and 2015 we observed at least 3 species of bumble bee. We observed both males and workers of *Bombus bifarius* (figure 14), worker *Bombus vandykii*, and a queen of *Bombus appositus*. Bumble bees rely on a wide variety of plant species for foraging purposes, and species diversity increases with

elevation. With restoration there is greater assurance that water is available for meadow forbs later in the summer so that the largest variety of floral resources over a longer time period.

Mammals

Indian Valley has a diverse mammalian community. We commonly observed Mule Deer, Coyotes, Gray Squirrel, Belding's Ground Squirrel, Douglas Squirrel. In addition we observed meadow species like Badger, Jumping Mouse and Short-tailed Weasel. In 2013 we happened to be at the restoration site after a summer thunderstorm created fresh mud and sand in the perfect condition for recording tracks. We used plaster of Paris to make casts of a sampling of tracks in the sand/mud around the restored ponds. The species we detected were: Mountain Lion, Black Bear, Coyote, Mule Deer. Habitat at this meadow is also potentially quite good for Sierra Nevada Red Fox, currently extirpated from much of its former range but still occurring just to the South near Ebbetts Pass.

Figure 15. Jumping Mouse drinking at a restored pond in Indian Valley South.

Figure 16. Mountain Lion and Black Bear Tracks collected in Indian Valley South.

Discussion

Specific habitat needs of individual meadow-associated focal bird species are diverse. We believe effective restoration and restoration monitoring 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 that we detected in Indian Valley South, or that have the potential to be detected in Indian Valley South as subtle habitat changes occur over time in response to the 2012 restoration activities.

Song Sparrow, White-crowned Sparrow

Although not strictly necessary, willow is a preferred component of White-crowned and Song Sparrow habitat. Willow is abundant throughout the restoration site at Indian Valley South, and reference areas at Indian Valley North and Indian Valley West Wilderness. Willow should continue to increase along the ponds and plugs constructed here, but because it is was already almost ubiquitous along this reach of stream it is possible we will not see large changes in White-crowned sparrow population here. White-crowned Sparrows consistently had a relatively high index of abundance at all sites monitored.

Figure 17. White-crowned sparrow nest, and adult (inset).

Song Sparrows were uncommon or absent at all sites despite ample willow cover. The elevation at these sites may be near the upper elevational limit for Song Sparrows. Because of these elevational effects restoration may have little if any impact on Song Sparrow. We may however see increases over time if climate change results in habitat shifts upslope in the Sierra Nevada.

Lincoln's Sparrow

Like White-crowned Sparrows, Lincoln's Sparrows require open meadow habitat with dense herbaceous cover and, ideally, some scattered shrubs. This species, however, is associated with sites that are wetter and have more continuous sedge cover that are other sparrow species. They also sometimes utilize stands of corn lily for nesting. They appear to be less tolerant of

disturbance and grazing pressure than many other bird species inhabiting meadows (Cicero 1997). Lincoln's Sparrows were detected at a rate of almost 0.60 birds/station at the spring fed and restored portions of Indian Valley South where the meadow habitat was most saturated. Lincoln's Sparrows did increase in the restored area after restoration, however the restoration effect was not statistically significant. This increase in abundance was likely a response to grassy understory developing on plugs and along pond margins as sedimentation occurred. As the ponds continue to fill over time and more sedge cover develops we expect to see a continued increase in the index of abundance for this species (especially if climate change or drought results in continued meadow drying in the unrestored reference areas).

Figure 18. Lincoln Sparrow

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

These species are often found in mature willow stands that have a component of aspen, alder, or lodgepole pine, in typically more shady settings. With restoration this suite of species is expected to respond to increases in willow or aspen cover. In the case of Indian Valley South, although willow and aspen should increase along plugs with time, there was an abundant mature willow component even before restoration. We believe that the modest increases for Warbling Vireo and significant increases for Wilson's Warblers resulted from the improved herbaceous understory and saturated soils, and ponded water within the plug and pond areas. These conditions likely caused more individuals to settle in the restoration zone to take advantage of increased insect prey that result from lush herbaceous vegetation and wet soil conditions.

Figure 19. Warbling Vireo

Although Wilson's Warbler occurred at almost every station within the restored zone, we were surprised that McGillivray's Warblers only occurred at rates < 0.2 birds/station or not at all. Elevation may be a limiting factor for this species. Warbling Vireos have similar habitat needs but will utilize more coniferous areas along meadows and creeks, and therefore were found more frequently in the Indian Valley South area

where willow, aspen and lodgepole pine co-occur extensively. Despite the existing habitat, Red-breasted Sapsuckers were uncommon or not detected at all. This may be in part a result of competition with Williamson's Sapsuckers which are relatively common in this area (although not as tied to riparian vegetation). We did not detect Swainson's Thrush, however this species is only rarely (or historically) found in the Sierra Nevada at latitudes as far south as Indian Valley.

Figure 20. Red-breasted Sapsucker foraging in willow.

Yellow Warbler, Yellow-breasted Chat, Common Yellowthroat

Yellow Warbler, a California Species of Special Concern, is strongly linked to dense willow stands. Yellow Warblers, however, are often restricted to elevations below 7,000 ft (Heath 2008, Heath and Ballard 2003). We occasionally detected a single Yellow Warbler in the Indian Valley area, but unless climate change or drought pushes the species range to higher elevations we are unlikely to have a consistent population at the restored site, despite excellent habitat conditions. Yellow-breasted Chats are unlikely to occur here due to elevation and Common Yellowthroat are typically restricted to large lower elevation marsh areas with emergent cattails, tules, or willow (Grinnell and Miller 1944, Gaines 1992, Ivey and Herzinger 2001).

Spotted Sandpiper

Spotted Sandpipers occur where there are open gravel bars (either actively forming, or abandoned by the stream on upper terraces). This species is usually most abundant along larger streams or rivers that support annual sedimentation and deposition. Spotted Sandpipers occur in modest numbers (both pre and post restoration) along the restored portion of Deer Creek in Indian Valley South, and upstream. The species has only occasionally been detected at reference sites, where the channels are either deeply incised or the streams are so small and low gradient that there is little gravel bar habitat.

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. 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., in press). 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 (across a 1- 3 acre area) (Bombay 1999). Although Willow Flycatchers have been detected in Indian Valley south from time to time, there are no confirmed records of breeding at the site and we suspect most detections were of migrants or post-breeding floaters. Willow Flycatchers were detected at this site in 2003, 2004, and briefly in 2009. Follow-up broadcast surveys in 2009, 2010, and 2013 have not resulted in detections.

This species is known to breed at least occasionally at Wet Meadows Reservoir (just north of Indian Valley North). Although extensive spring fed meadow habitat already exists on the hanging meadows along the east edge of the construction zone in Indian Valley South, with the increase in open standing water and emergent vegetation created by restoration future colonization of restored habitat in Indian Valley South a distinct possibility (Mathewson et al. 2011). To that end, in 2016 we will include Indian Valley South in an effort to attract breeding Willow Flycatchers to colonize the restored area. This will be done using conspecific attraction: the practice of attracting a bird species to settle in a meadow by broadcasting territorial vocalizations during the period of northward migration in the spring.

Sora, Virginia Rail, Wilson's Snipe, Sandhill Crane, Wilson's Phalarope

In the Sierra Nevada, these species are found only in marshy emergent vegetation in large meadows (or other wetlands) with flooded oxbows, beaver ponds, or other impoundments. Wilson's Snipe are relatively easy to detect and are therefore excellent for monitoring improvements in this habitat type with restoration. Although more secretive, the two rail species are still common enough in the Sierra to respond if adequate wetlands are created during restoration. Despite increased standing water as a result of restoration these focal species have not been detected within the Indian Valley area, and were likely absent because they are typically associated with conditions that do not occur or occur only in relatively small amounts in Indian Valley. Wilson's Snipe nest and forage in spring-fed or otherwise water-covered areas with mud or peat and dense sedge cover. Despite their presence in similar meadow habitat elsewhere in Alpine County (Hope Valley, Red Lake) this species is not found in the boggy spring fed areas just east of the restoration work. With time the new flooded habitat and emergent vegetation around the constructed ponds may attract the species as well as Sora and/or Virginia Rail. It is unlikely this site will support Sandhill Crane or Wilson's Phalarope, two species associated with vast open expanses of wet meadow/marsh.

Figure 21. Wilson's Snipe foraging in shallow water habitat.

Great Gray Owl

Foraging habitat for Great Gray Owl is abundant along the boundaries of Indian Valley south and all three reference sites, where the species could take advantage of the pocket gopher and vole populations found in the dry and wet portions of the meadows, respectively. Although

Great Gray Owl are known to currently breed at lower west-side locals to the west, and high elevation sites to the south near Yosemite, it has been many years since the species was found in this region (Wu et al. 2014). The most proximal confirmed observation to Indian Valley was a Great Gray Owl detected at Grover Hot Springs over 30 years ago.

Waterfowl and wading birds

Other notable wetland-related species that now occur in the restored portions of Indian Valley South are Red-winged Blackbird, Mallard, and Green-winged Teal. These species nest in flooded margins of ponds along the constructed ponds in Deer Creek. All three of these species have colonized the site and began breeding since restoration occurred, although we only have documented a single pair of each so far. Nesting Mallards and Green-winged Teals were recorded in both 2013 and 2014. These 3 species require open water for nesting and foraging. A single pair of Red-winged Blackbirds immediately established a territory in the willow surrounding the largest pond at the downstream end of the construction zone. During non-monitoring site visits in 2015 we documented the establishment of cattails along the margins of many of the ponds. Cattails will provide denser, taller cover than the aquatic sedges that established immediately after restoration. With the spread of cattails and other aquatic obligate plants we expect to see additional waterfowl, and wading birds take up residence in the restored area over the next few years.

Figure 22. Newly established cattails, mallard family group (inset), and nest (inset).

Recommendations

Hydrology is a primary factor restricting habitat quantity and quality for Willow Flycatcher and other focal bird species associated with meadows. All rely on lush herbaceous and woody vegetation, and the insect food resources (Erman 1984, 1996) associated with saturated wet meadows. Flooded conditions also may provide some degree of protection from nest predation, as some mammalian predators avoid open water (Cain et al 2003, Borgmann 2010). Similarly, many of these focal species require dense riparian shrubs or tress (aspen, alder, and dogwood) that will only germinate and grow with consistent deep water. Although willows require consistent moisture for germination, mature willow will often persist at a site after meadow hydrology is altered when roots are deep enough to remain in contact with the water table, despite its lowered elevation.

In 2012 plug and pond construction at Indian Valley South was completed. Since that time the upper ponds have begun to fill with sediment as designed, and vegetation is establishing on new deposition, and on constructed plugs. Bird habitat has been improved through this project and will continue to improve and evolve over time, with more species expected to colonize the site as the pond habitat matures. We have a few recommendations to support or expand on the success of this project:

1. Use conspecific attraction – the broadcasting of recorded Willow Flycatcher vocalizations – to encourage breeding Willow Flycatchers to colonize the restored meadow (planned for 2016).

2. Protect the hanging meadows to the east of the construction area that are at risk by extending plug and pond activities upstream on the tributary southeast of the current ponds (Figure 23, area B).

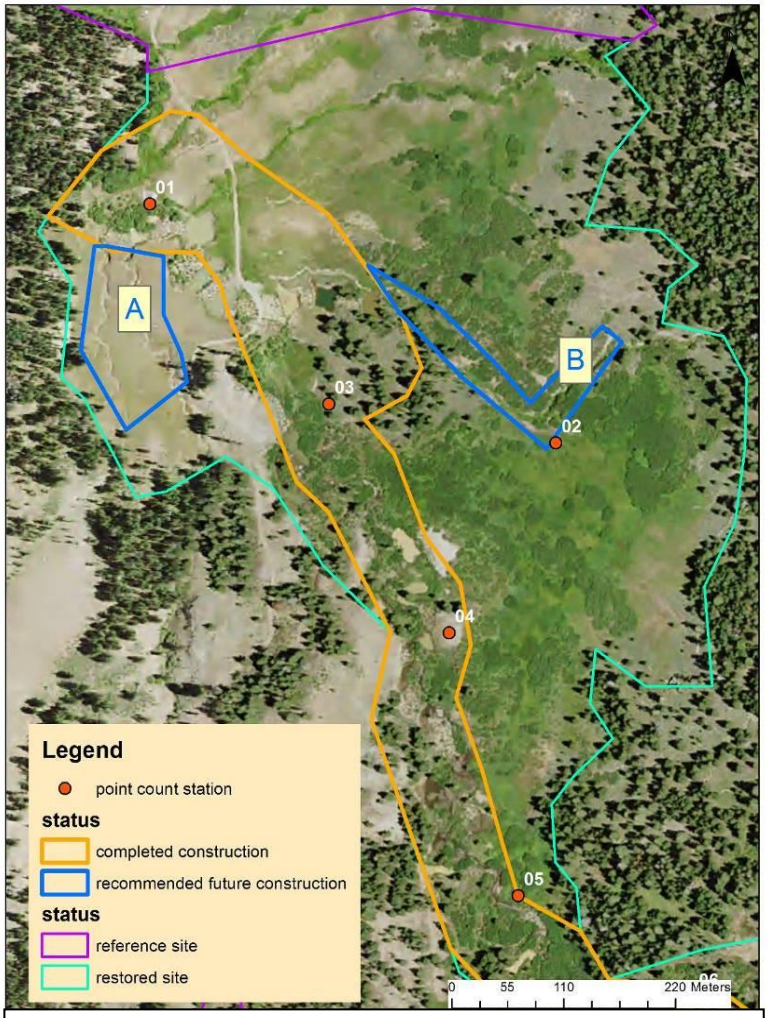

Figure 23. Recommended future restoration.

3. Treat headcuts in the short-hair sedge meadow to the south of the lowest ponds (Figure 23, area A).

4. Use broadcast surveys to monitor for colonization of the site by Virginia Rail or Sora.

5. Complete a bumble bee survey to assess bumble bee diversity and determine important floral resources for bumble bees.

6. Conduct Sierra Nevada Red Fox surveys to determine if the species is utilizing the riparian habitat in Indian Valley South.

Acknowledgments

We thank our partners at American Rivers, The National Fish and Wildlife Foundation, and The Eldorado National Forest for funding, input and historic context for our work. Special thanks to our field crew for their dedicated efforts: Adam Baz, Rob Frye, Katie Hood, Claire Johnson, Cedar Mathers-Winn, Christina Varians, and Bob Wilkerson for training and database management. This project was conducted by The Institute for Bird Populations' Sierra Nevada Bird Observatory. This is Contribution No. 513 of The Institute for Bird Populations.

Literature Cited

Beck, T. W., and J. Winter. 2000. Survey protocol for Great Gray Owl in the Sierra Nevada of California. USDA Forest Service, Pacific Southwest Region, Vallejo, CA.

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.

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.

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.

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.

Gaines, D. 1992. Birds of the Yosemite Sierra. Artemisia Press. Lee Vining, CA.

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 assessement of species, subspecies, and distrinct 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.

Ivey, G. L. and C. P. Herziger. 2001. Distribution of Greater Sandhill Crane Pairs in California 2000. California Department of Fish and Game, Sacramento.

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.

Loffland H. L., R. B. Siegel, and R. L. Wilkerson. 2013. Assessing the effects of meadow restoration on bird populations in the greater Sierra Nevada: report for the 2012 field season. The Institute for Bird Populations, Point Reyes Station, CA.

Mathewson H. A, M. L. Morrison, H. L. Loffland, P. Brussard. 2013. Ecology of Willow Flycatchers in the Sierra Nevada, California: the role of meadow characteristics and weather on demographics. *Ornithological Monographs.*

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.

Wu, J. X., R. B. Siegel, H. L. Loffland, M. W. Tingley, S. L. Stock, K. N. Roberts, J. J. Keane, J. R. Medley, R. Bridgman, C. Stermer. 2015. Diversity of Great Gray Owl Nest Sites and Nesting Habitats in California. Journal of Wildlife Management 79:937-947.