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Using birds to inform meadow restoration at Faith Valley

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Above: Lincoln's Sparrow (inset); sheet flow across the southern portion of Faith Valley,

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Introduction

This report summarizes the results of 4 years of pre-restoration multi-species bird monitoring at Faith Valley. Also included are the results of broadcast surveys for Willow Flycatcher at Faith Valley. In 2010, 2012, 2017 and 2018 The Institute for Bird Populations (IBP) utilized two distinct bird survey and monitoring protocols within the Faith Valley project area to provide pre-restoration baseline data. These protocols included *A Willow Flycatcher Survey Protocol for California* (Bombay et al. 2003a) and *Avian monitoring protocol for Sierra Nevada meadows: a tool for assessing the effects of meadow restoration on birds* (Loffland et al. 2011a). The first is a targeted single-species survey protocol used to determine the presence/absence of Willow Flycatchers and the approximate number of territories and their locations. The second protocol is used to assess and describe the larger bird community and to detect population-level changes in meadow-associated bird species in response to restoration activities.

Methods

Multi-species Bird Monitoring

Multi-species monitoring (all bird species) in the restoration and reference meadows of the Faith Valley project followed Loffland et al. (2011a), and consisted of two primary methods: point counts and area searches. Point counts were conducted at survey stations spaced 250 m apart, and all individuals of all species seen or heard were counted during a 7-minute period. Area searches consisted of tallying all additional bird species detected incidentally outside of point count surveys, or during targeted searches of the sites.

Surveys were completed in 2010 and 2012 (Loffland et al. 2011a, 2011b), and in 2017 and 2018. By collecting data in multiple years prior to restoration, we are improving our ability to detect and interpret any population changes that occur as a result of future restoration activities. This monitoring protocol uses a Before, After, Control, Impact (B.A.C.I.) design requiring that nearby reference sites not undergoing 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 Upper Charity Valley, although those results are not reported in this document.

Willow Flycatcher Surveys

Willow flycatcher surveys were completed in Faith Valley in 2016 and 2017 as part of another research project, but are described here to help inform restoration planning. To survey for the presence of Willow Flycatchers, Bombay et al. (2003) requires survey visits be completed during the mandatory survey period 2 (June 15 to July 1) (Table 1). This mandatory period coincides with the time when Willow Flycatchers are most likely to be in the reproductive stage when singing rates, and therefore detection probabilities, are highest. Typically another survey visit occurs either before or after survey period 2 depending on the elevation and phenology of the site. During 2016 we completed 2 surveys, and during 2017 we completed a single survey

visit. Because we utilized expert birders who had extensive experience and familiarity with Willow Flycatchers for all our bird monitoring during 2017, and also due to our continued multi-species bird monitoring at the sites during the weeks before and after the Willow Flycatcher surveys, we felt confident that a single broadcast survey was sufficient.

Table 1. Willow Flycatcher survey periods (following Bombay et al. 2003a).

Survey Period 1	Survey Period 2 Mandatory	Survey Period 3
June 1 – June 14	June 15 – June 25	June 26 – July 15

Willow Flycatcher survey stations were delineated within the meadow along transects that parallel the stream channel or areas of shrubby riparian vegetation. Stations were placed 50 m apart, and located only in the areas where riparian shrubs (usually willow) occur. Faith Valley is large, but with a few exceptions riparian shrubs occur primarily along stream channels.

Almost all stations occur along transects paralleling the West Fork of the Carson River and the associated tributaries. There are a few areas where willows are absent or very sparsely scattered. These areas did not receive Willow Flycatcher survey stations because the willow coverage was not adequate to provide habitat for Willow Flycatchers.

Survey activities at each station during each visit included a 6-minute period of broadcasting pre-recorded Willow Flycatcher vocalizations, and listening for a response (Figure 1). If Willow Flycatchers were detected at a survey station the location of the bird was documented, and nearby survey stations were eliminated during the same visit to avoid excessive disturbance to individual birds



Figure 1. IBP volunteer broadcasting Willow Flycatcher vocalizations during surveys

Vegetation Monitoring

In 2010, 2012, and 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 Monitoring

In 2010, 2012 and 2017 we surveyed 15 multi-species point count survey stations in Faith Valley (Figure 2) and 8 stations at the reference site at Charity Valley. In 2018 we surveyed only Faith Valley. All visits to these meadows occurred between late May and early July (Table 2).

Table 2. Dates for multi-species bird monitoring in the Faith Valley area in 2010, 2012, 2017, and 2018.

Site	2010		2012		2017	2018
	Visit 1	Visit 2	Visit 1	Visit 2	Visit 1	Visit 1
Faith Valley	6/6/2010	6/18/2010	6/10/2012	7/3/2012	6/26/2017	6/11/2018
Charity Valley	6/17/2010	6/30/2010	6/9/2012	7/4/2012	7/11/2017	

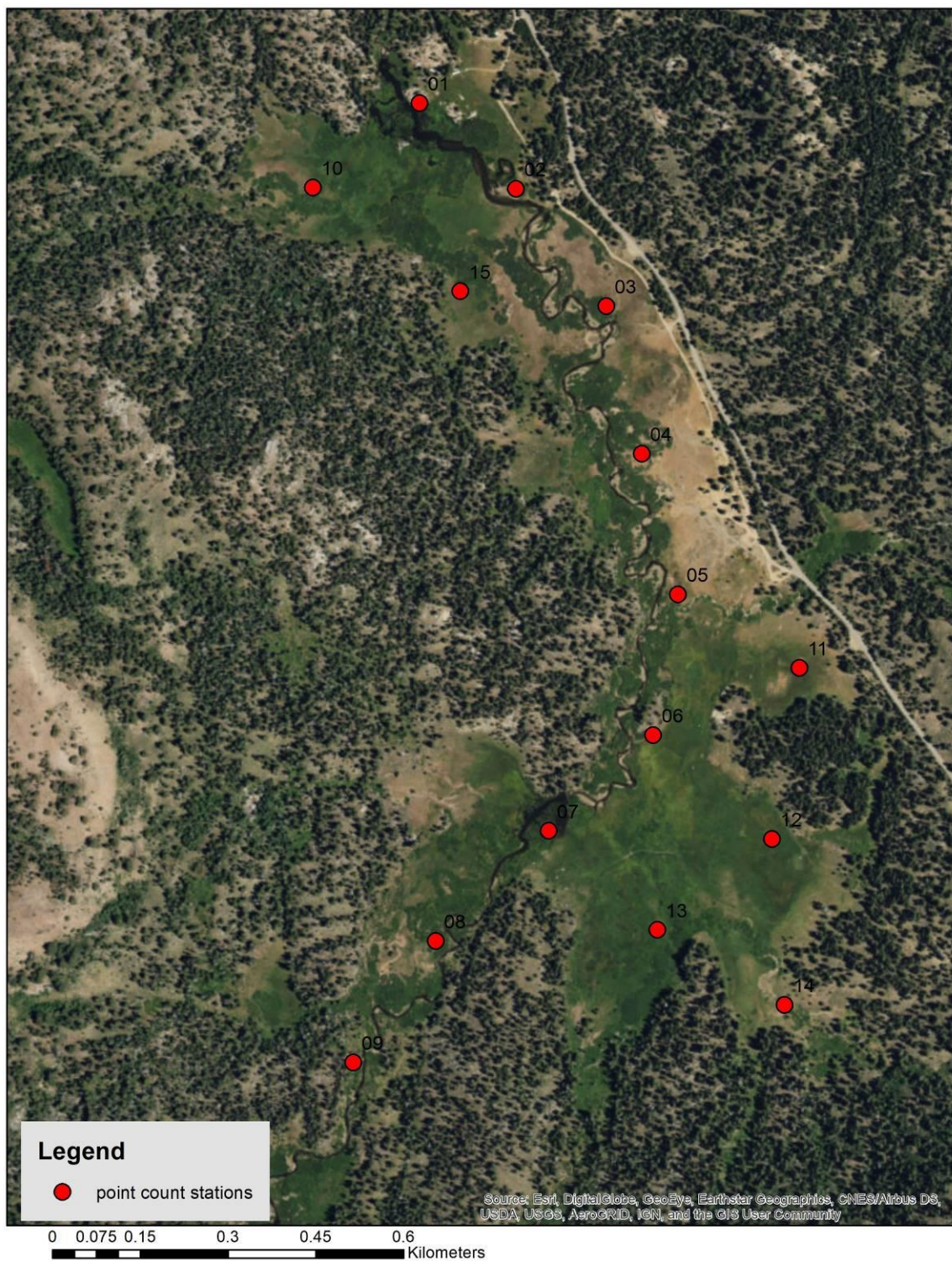


Figure 2. Multi-species point count station locations in Faith Valley.

For 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 in the case of Brown-headed Cowbird, have other conservation implications making them especially worthy targets of monitoring at meadow restoration sites. In 2013 we worked collaboratively with other researchers to refine this list to a smaller subset of focal species (Table 3) 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 indicated in Table 4. In all years combined, 56 bird species were detected during point counts at Faith Valley, including 10 of the focal species (Table 3; Appendix A).

Table 3. Focal bird species observation status during surveys of Faith Valley in 2010, 2012, 2017 and 2018.

Species	Usual habitat within meadows ¹	Observed in study area?
Wilson's Phalarope	<i>E</i>	<i>Not detected</i>
Wilson's Snipe	<i>E</i>	<i>Point count</i>
Red-breasted Sapsucker	<i>S,A</i>	<i>Point count</i>
Calliope Hummingbird	<i>M,S,A</i>	<i>Point count</i>
Willow Flycatcher	<i>S,E</i>	<i>WIFL survey</i>
Swainson's Thrush	<i>S,A</i>	<i>Not detected</i>
Warbling Vireo	<i>S,A</i>	<i>Point count</i>
Yellow Warbler	<i>S</i>	<i>Point count</i>
MacGillivray's Warbler	<i>S,A</i>	<i>Point count</i>
Wilson's Warbler	<i>S,A</i>	<i>Point count</i>
Song Sparrow	<i>M</i>	<i>Point count</i>
Lincoln's Sparrow	<i>M</i>	<i>Point count</i>
White-crowned Sparrow	<i>S,M</i>	<i>Point count</i>
Black-headed Grosbeak	<i>S,A</i>	<i>Not detected</i>

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 only those birds detected within 50 meters of survey stations, in an effort to account for changes 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.

Species' relative abundance was indexed by the number of individuals detected divided by the number of survey stations (Appendix B). Those species with the highest values for this index included generalist species such as American Robin and Brewer's Blackbird, as well as riparian associates including Song Sparrow and White-crowned Sparrow. Of particular interest are the latter two species which are 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 we detected 9 of the focal species at Faith Valley, but some (Calliope Hummingbird, Warbling Vireo, and MacGillivray's Warbler) in only one or two of the four years (Table 4, Figure 3).

Table 4. Index of relative abundance¹ for each focal species detected within 50 meters of point count stations at Faith Valley during 2010, 2012, 2017 and 2018.

Bird species	2010	2012	2017	2018	AVG
Wilson's Snipe	0.18	0.04	0.07	0.07	0.09
Calliope Hummingbird	0	0	0.20	0.07	0.07
Warbling Vireo	0	0	0.07	0.07	0.03
Yellow Warbler	0.41	0.25	0.27	0.50	0.36
MacGillivray's Warbler	0	0	0.20	0	0.05
Wilson's Warbler	0.14	0	0.53	0.36	0.26
Song Sparrow	0.32	0.32	0.67	0.86	0.54
Lincoln's Sparrow	0	0.07	0.27	0.07	0.10
White-crowned Sparrow	0.55	0.68	0.67	0.64	0.63

¹Index: number of individuals detected within 50 m of all point count stations averaged across 2 visits and then divided by the number of point count stations per meadow.



Figure 3. Portion of Faith Valley with sheet flow of water across meadow surface and (inset) Wilson's Snipe, a species we encountered frequently there.

Song Sparrow and White-crowned Sparrow were by far the most abundant focal species present, followed by Yellow Warbler and Wilson's Warbler. Of our focal species, Song and White-crowned Sparrows have the least restrictive habitat needs and will occur in both wet and dry meadows with small amounts of riparian or other shrub cover. Yellow Warblers require abundant riparian shrub (usually willow) cover in both wet and mesic meadow settings, while Wilson's Warblers are usually associated with willow thickets along forest edges and near streams. The remaining focal species (Table 4) were detected less frequently within the study site, likely because they are typically associated with conditions that occur only in relatively small portions of Faith Valley. These conditions include: saturated or flooded conditions (Lincoln's Sparrow, Wilson's Snipe), or dense and tall riparian shrubs mixed with riparian deciduous trees (MacGillivray's Warbler, Red-breasted Sapsucker, Warbling Vireo)(Figure 4; Ray 1903, Grinnell and Miller 1944, Orr and Moffit 1971, Stewart et al. 1977, Heath and Ballard 2003). Those meadow focal species not detected at all are either associated with marsh or continuously flooded meadow habitat (Wilson's Phalarope) or flooded meadow/riparian habitat in combination with dense shrub cover (Willow Flycatcher, Swainson's Thrush).



Figure 4. Red-breasted Sapsucker - a focal species for Faith Valley -creating sap wells in willow.

In addition to monitoring how individual focal species respond to restoration we measure an additional metric of restoration success known as “focal species richness” (Campos et al 2014). This metric assesses the number of focal species detected at a station, or averaged across stations for the entire site. Table 5 displays focal species richness for each station and year combination. The average value for all years and stations pooled at Faith Valley was 2.22 focal species detected per station.

Table 5. Focal species richness (number of focal species detected) by station and year.

Station number	2010	2012	2017	2018	Average
01	1.5	2	1	0	1.125
02	1	1	3	2	1.75
03	2.5	1	4	2	2.375
04	3	3	3	2	2.75
05	2.5	1	3	2	2.125
06	1	1	3	5	2.5
07	2	3	3	3	2.75
08		1	3.5	4	2.83
09		2	0	4	2
10	3	2.5	6	5	4.125
11	1	0	0	0	0.25
12	1	0	0	0	0.25
13	1.5	3	4	4	3.125
14	2.5	2.5	4		3
15			3	4	3.5
	1.875	1.64	2.7	2.64	2.22

Willow Flycatcher Surveys

In 2016 and again in 2017 we completed surveys for Willow Flycatcher following Bombay et al (2003a) at Faith Valley (Table 6; Figure 5).

Table 6. Dates for Willow Flycatcher surveys in Faith Valley in 2016 and 2017.

Site	2016		2017	
	Visit 1	Visit 2	Visit 1	Follow-up
Faith Valley	6/21/2016	7/12/2016	6/16/2017	6/17/2017 6/26/2017

Although the site is known to have supported Willow Flycatchers in the 1980s and early 2000s, no Willow Flycatchers were detected in Faith Valley in 2016. However a single singing male was detected early in 2017 during surveys related to another Willow Flycatcher research project. This flycatcher was detected approximately 500 m south of the river (near Willow Flycatcher survey station 65) in a patch of willow associated with hillslope springs (Figure 5). We conducted multiple follow-up visits to this location and additional survey visits but never detected the flycatcher again, suggesting that this bird was a late migrant using the site as a stopover during northward migration, but not breeding there.

In addition to surveying Faith Valley, we also used other research projects to obtain information about other nearby Willow Flycatcher breeding sites (Loffland et al. 2014, Schofield et al. 2018). These occurrence data from other nearby sites are relevant to the Faith Valley restoration project as they provide information on the relative likelihood that Willow Flycatchers will find and colonize newly created habitat in the years after restoration occurs. As part of other research efforts, we visited nearby historic Willow Flycatcher breeding sites (Red Lake Peak,

Red Lake Creek, Red Lake 1, Red Lake 2, and Hope Valley) intermittently between 2010 and 2017 to determine if those sites were occupied by Willow Flycatchers. One Willow Flycatcher was detected at Red Lake Peak in 2010 but not in 2015 or 2016, and one was detected at Red Lake Creek in 2016, but detections only occurred on a single visit despite repeated follow-ups (Figure 6). None were detected at the other nearby historically occupied sites. Although a sizable and consistent nearby breeding population would be more favorable, the occasional presence of the species in the vicinity of Faith Valley indicates that recolonization is possible if the population should

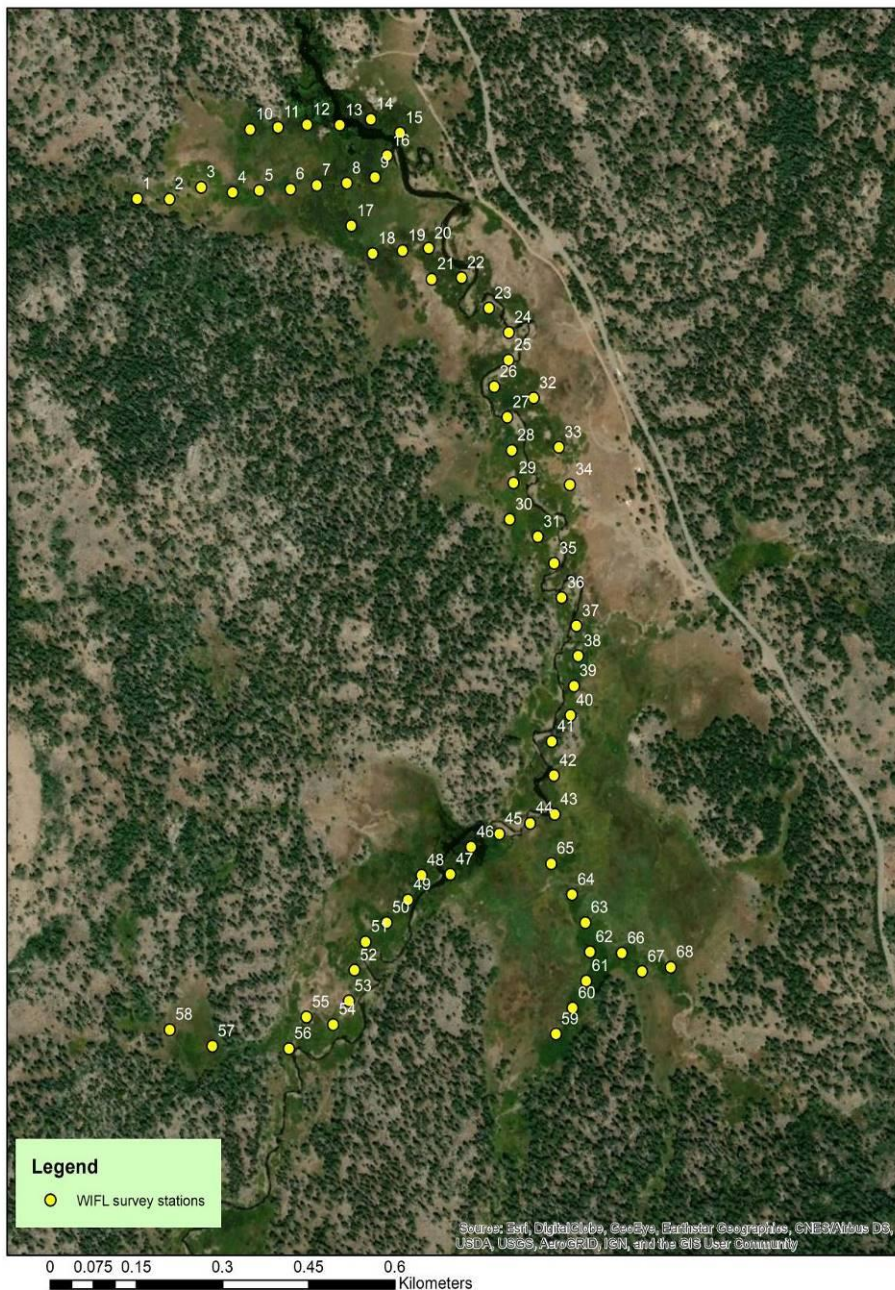


Figure 5. Willow Flycatcher survey stations at Faith Valley.

expand. Faith Valley is consequently identified as high priority for restoration based on its location relative to recent detections and its history of supporting the species in the past (Loffland et al. 2014).

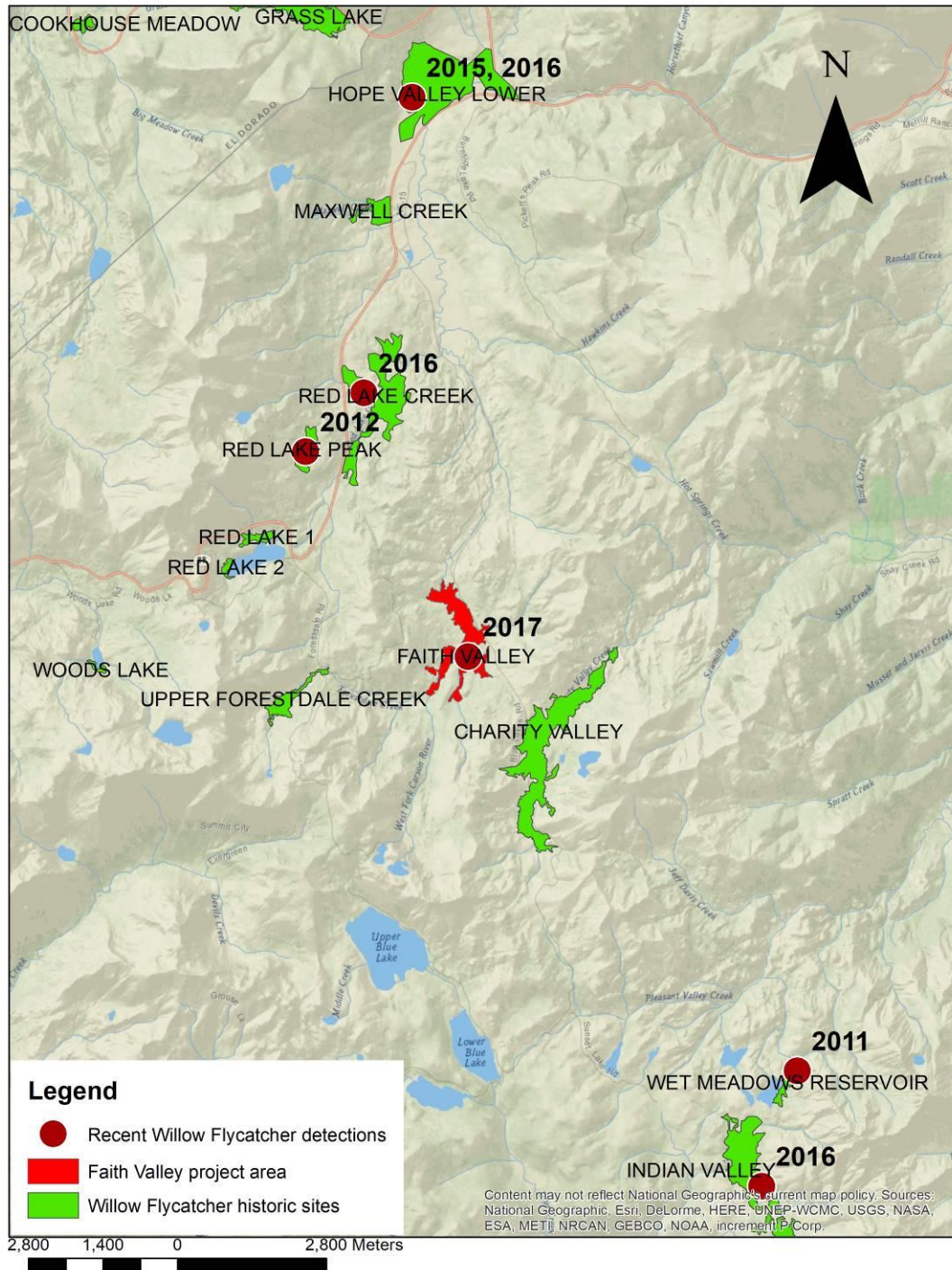


Figure 6. Recent Willow Flycatcher detections in the vicinity of Faith Valley

Discussion

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 protection from nest predation, as some mammalian predators avoid surface water (Cain et al 2003, Borgmann 2010). 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 is the presence of beaver at the site (Bombay 1999), due to the impoundments they create and the subsequent willow germination and recruitment associated with new sediment capture and inundation. In Faith Valley beaver are a dominant factor affecting meadow wetness. During drought years beaver were able to build and maintain dams across the primary channel (West Carson River) and maintain them continuously year after year because spring flood events were relatively minor. During that period portions of the meadow near stations 1, 2, and 15, and upstream near 7, 8, and 9 were consistently flooded such that large ponds and multiple dams and lodges were dominant features on the landscape. At the end of the drought when extreme precipitation events and heavy spring run-off occurred in 2017, beaver dams that had been anchored to boulders and constructed all the way across the West Carson near stations 1 upstream and 8 downstream (Figure 2) were completely blown out and washed away, and smaller dams on tributaries and oxbows were at least partially breeched. During the summer of 2017 and 2018 the previously flooded areas were much drier with little or no standing water (Figure 7 and 8). In 2018, a few smaller tributary dams had been rebuilt by beavers (Figure 9).



Figure 7. Beaver pond while inundated (left) and after dam was blown out during 2017 floods (right). Ponded water is gone in 2018, but saturated sheet flow area with beaked sedge can still be seen outside of dam in far right.



Figure 8. Beaver lodges left exposed above water line after 2017 dam blow outs. Photos were taken downstream near station 2 (left) and upstream near station 8 (right).



Figure 9. Willow vegetation adjacent to a small beaver impoundment on a tributary in Faith Valley in 2018.

In addition to portions of the meadow inundated by beaver activity, the northwestern and southern parts of Faith Valley support relatively intact system of tributaries and springs whose flow during spring and throughout the summer spread out across the meadow surface and slowly seep downhill towards the Carson River channel. This sheet flow results in dense, almost monotypic, stands of beaked sedge with large willow patches towards the meadow edges (Figure 10). These consistently wet areas and dense vegetation provide wet meadow conditions off the main channel even when beaver activity is reduced by floods breaching dams. In addition to creating high quality habitat, beaver activity in many cases protects the hydrologic integrity of tributaries by stopping or repairing head cutting activity that would otherwise migrate up channel and dewater the portions of the meadow with intact sheet flow.



Figure 10. Sheet flow spreading across meadow surface and flowing towards primary channel in background near conifers.

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 that we detected in Faith Valley.

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 11). 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 (across a 1- 3 acre area)(Bombay

1999). Although Willow Flycatchers are not currently breeding in Faith Valley, the presence of a migrant here in 2017 (between stations 13, 6 and 7: Figure 2), and known territory holders in the early 2000s (between stations 1 and 10), and their continued persistence (at least on an occasional basis) at nearby meadows, make future colonization of restored habitat in Faith Valley a strong possibility (Mathewson et al. 2011, Loffland et al. 2014, Schofield et al. 2018). A restoration project that successfully brings the existing mature willow stands- in the drier middle section of the meadow where the main channel and tributaries are incised (Figure 12 and 13) in contact with overbank flows would greatly improve habitat here. These factors in combination with the presence of beaver within the meadow that already have created smaller ponded areas (Figures 12, 13, 14) suggest that targeted efforts could create additional habitat for this species over the next 5-10 years.



Figure 11. Willow Flycatchers are still occasionally found in and around Faith Valley.

Yellow Warbler

Yellow Warbler, a California Species of Special Concern is, like Willow Flycatcher, strongly linked to dense willow stands. 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 not extremely abundant in Faith Valley, Yellow Warblers are present in adequate numbers to quickly colonize newly created habitat when new willow stands reach maturity, or where increased soil saturation improves existing willow habitat. In recent years Faith Valley has had an average index of abundance of 0.36 Yellow Warblers per point count station. Campos et al. (2014) recommend a target of 1.04 Yellow Warblers per station (or 0.54 Yellow Warblers per acre). This target value is three times greater than the current value. The middle portion of Faith Valley is well above the current floodplain and unlikely to experience overbank flows, seed deposition, and moist conditions necessary for new willow recruitment and establishment (Figure 12 and 13). Because of the elevation of the site, establishing new willow stands could take some time (as much as 10 to 15 years). Nonetheless, mature stands at the site

are relatively abundant so increases in soil moisture and flood frequency alone could dramatically improve the habitat for this species almost immediately. This species is also an excellent indicator of the quality of willow habitat in the absence of Willow Flycatchers.

Song Sparrow, White-crowned Sparrow

Although already common in Faith Valley with indices of relative abundance of 0.65 and 0.53 for White-crowned and Song sparrows, respectively, these two sparrow species should respond positively and quickly to restoration of hydrology in drier willow communities, and if willow expands further into the dryer eastern portions of the meadow. Although not strictly necessary, willow is a preferred component of White-crowned and Song Sparrow habitat. Although relatively common at the restoration site, these species are important for restoration monitoring because their larger sample sizes will allow for more robust analyses as post-restoration monitoring occurs.

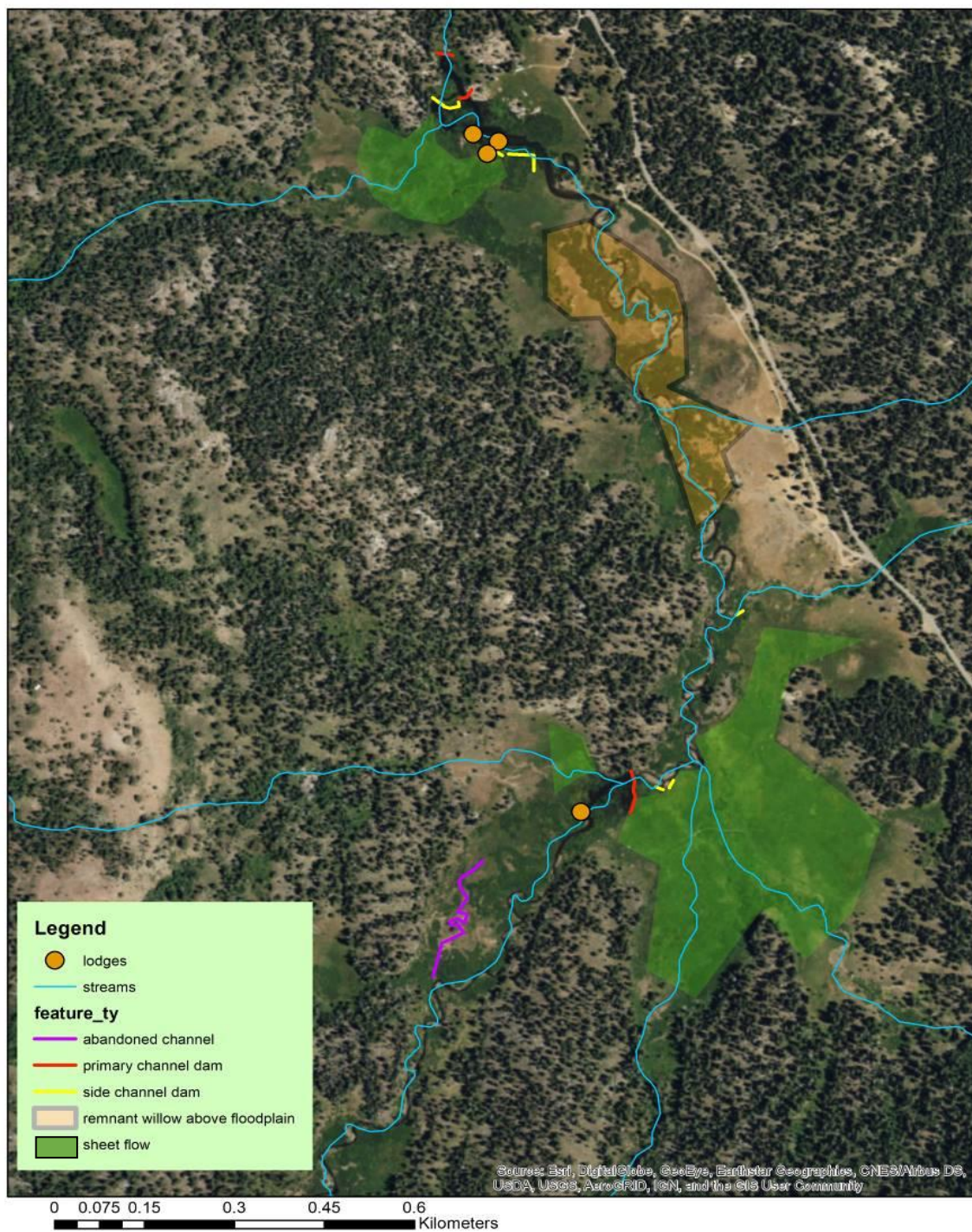


Figure 12. Overview of Faith Valley showing beaver structures (orange dots, red and yellow lines), sheet flow (green polygons) and de-watered areas (orange polygon).

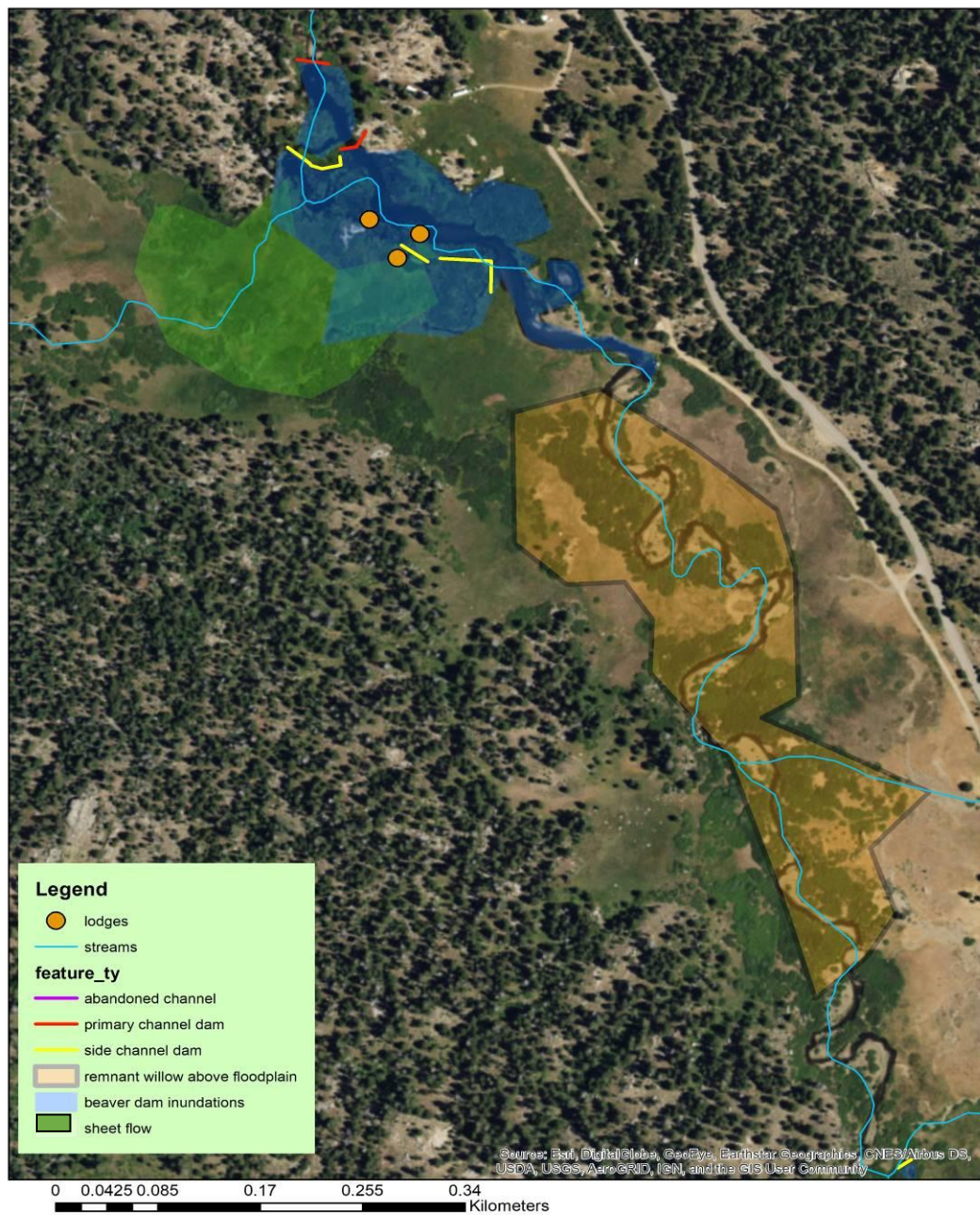


Figure 13. North end of Faith Valley with beaver structures (orange dots, red and yellow lines), sheet flow (green polygon), Remnant willow on incised historic floodplain (orange polygon), and areas frequently inundated by beaver dams (blue polygons)

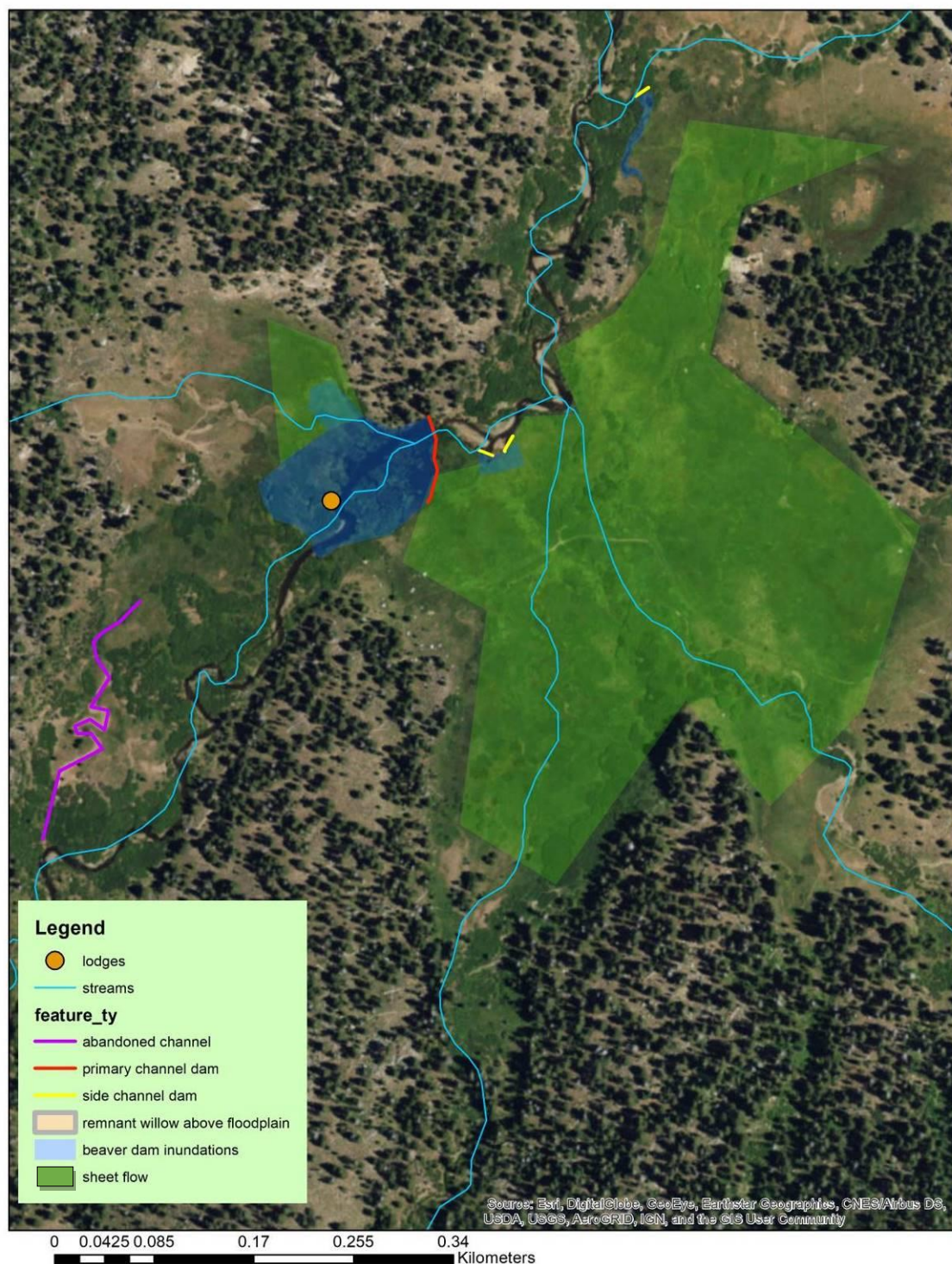


Figure 14. South end of Faith Valley with beaver structures (orange dots, red and yellow lines), sheet flow (green polygon), and areas frequently inundated by beaver dams (blue polygons)

Lincoln's Sparrow

Like the more common 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 linked to sites 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 Sparrow currently occurs in low numbers in only the wettest portions of the meadow where intact tributary hydrology result in sheet flow, and in areas adjacent to beaver impounded water near survey stations 6-8, 12, and 13 (areas with green and blue shading in figure 13 and 14). If consistently wetted areas expand along the middle incised section of the river, or along the west flowing tributaries adjacent to this section, this species would likely increase dramatically and almost immediately occupy newly created habitat as we witnessed in Indian Valley after restoration (Loffland and Siegel 2015).

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

This suite of species, all of which are at least present and in some cases relatively common at Faith Valley, should respond to any increases in willow or alder cover. Restoration activities may expand some slow-water moist areas and may allow establishment or expansion of aspen stands particularly along the upstream end of the meadow. Aspen is currently absent or rare along most of Faith Valley. If overall riparian deciduous shrub heterogeneity and aspen cover increase due to natural regeneration and/or plantings, these species could increase substantially over the next 10-20 years.

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 other impoundments. Wilson's Snipe are relatively easy to detect and are therefore excellent for monitoring changes to this habitat type after restoration. Currently snipe are only found in the areas where sheet flow through dense sedge-dominated meadow flow into areas where beaver have inundated the primary floodplain (Figures 12-14). The combination of sheet flow and beaver impoundments creates the lush season-long wet conditions necessary for sedge-dominated nesting cover and the mud/peat foraging requirements of snipe. Re-wetting of historic floodplains and/or restoration of sheet flows along the west flowing tributaries in the middle section of meadow would greatly extend available habitat for this species.

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 Faith Valley is 2.22 focal species per station, so meeting that target at the meadow scale has already been achieved. Closer inspection of data from individual stations reveals that those stations that fall below the target (in all or most years) have either no willow cover within 50 m, or are occurring on the drier east side of the main

meadow. Those stations with the highest focal species richness (stations 8, 10, and 13-15) are in areas where there is ample willow cover and water cover from either beaver impoundments, sheet flow or both (Figure 15). Because the restoration site has extensive stands of remnant willow even in drier areas 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. Similarly, through planting of aspen along meadow edges where hydrology is appropriate, additional bird species are likely to respond positively over the next 10+ years.

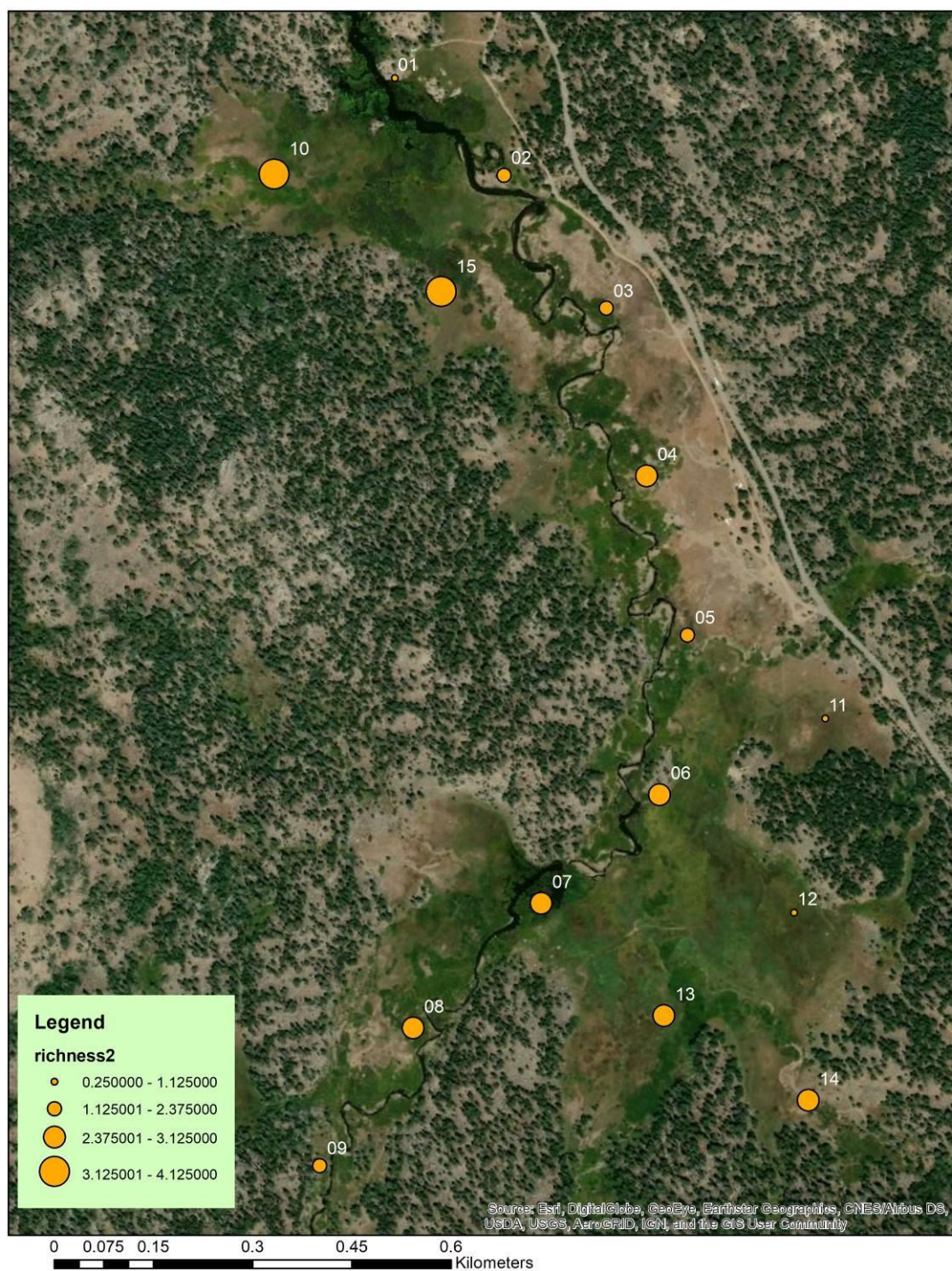


Figure 15. Average annual focal species richness by survey station. Numbers in white are station numbers; average number of focal species detected is indicated by the size of the circle.

Recommendations

Meadow restoration is a complex and challenging process that is not completed in one season. The restoration actions undertaken at Faith Valley 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 Faith Valley is a lowered water table. This is especially noticeable in central and eastern portion of the meadow where neither beaver impoundments nor spring-fed sheet flow ameliorate the effects as they do in the north and south ends of the valley. Restoration to restore the primary channel to its historic floodplain through use of techniques such as beaver dam analogs, complete channel fill, or pond and plug could provide improved hydrology 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. Similar techniques applied to the west-flowing tributaries could provide similar positive effects at a more modest scale, if they restore sheet flow to the central portion of the meadow.

North Meadow

Figure 13 shows details of the north end of the meadow where, despite channelization of the river, beaver have maintained dams that hold back water, provide inundation, and maintain sheet flow on upstream tributaries by keeping headcuts from traveling upstream from the river edge. The area west of the river within the beaver lodge cluster (Figure 13) has contained excellent Willow Flycatcher habitat since at least 2001, when banded young Willow Flycatchers dispersing from Red Lake settled here for a few years. Some oxbows exist in this area and are flooded during years when beaver can maintain dams across the main river channel. If beaver dams (red lines on Figure 13) were maintained across the primary channel year after year (or other restoration techniques applied) the area upstream through the central part of the meadow could begin to regain connectivity with the floodplain and existing mature willow would have saturated conditions nearby. 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 oxbows, regardless of restoration techniques used; Figure 16).



Figure 16. Saturated area within existing floodplain where willow and sod plantings could help anchor the streambank.

Wilson's Snipe. Further east of the willow the meadow surface is extremely dry and extensive bare ground exists. It is possible that prior to building of the Blue Lakes road this area also had sheet flow of water across the meadow surface and wet conditions summer-long. If culverts and dirt access roads are addressed, and stream restoration techniques are applied to the main channel and tributaries, this portion of the meadow could again have a mesic nature more suitable to riparian birds.

South Meadow

The southern portion of Faith Valley contains some of the best riparian bird habitat in Faith Valley at the current time because it is fed by springs that occur along the south and west and flow down to the main channel across the meadow surface. In addition, in this area beaver have had more success in recent years in damming the main channel, resulting in a great deal of standing water and excellent sediment entrapment. Because the main channel is not as deeply incised here, beaver dams are able to inundate a much larger area of the West Carson River (Figure 17). Little is needed to improve this area for Willow Flycatcher with the exception of actions to help anchor main channel beaver dams (via beaver dam analog techniques) to allow persistence over time. In addition if possible, redirecting flow into a historic side channel between stations 8 and 9 (purple line in Figures 12 and 14) would bring water back to the meadow surface further to the west of the current channel and potentially improve aspen

Middle Meadow

The middle area of Faith Valley is the most degraded portion of this meadow. There is no evidence that beaver have had success damming this section of the West Carson, likely because the narrow incised condition results in flows that are too swift, and possibly also because there are few opportunities for beaver to secure or anchor dams to natural formations (e.g., boulders or granite outcrops). The result is an elevated meadow on a bench that is often more than 2 m above the stream level. There is a large stand of mature willow on this bench but no regeneration is occurring and no understory sedge mats that would provide cover for species like Lincoln's Sparrow and

regeneration. This southern end of the meadow is also a good candidate area for aspen planting along the edges (or efforts to release existing aspen).



Figure 17. Beaver pond near station 7 when fully inundated in 2016.

Recommended Restoration Actions

1. Treat small tributaries (via complete fill, pond and plug, beaver dam analogs, etc.) to increase soil saturation, standing water and sheet flow on the existing elevated floodplain, especially along the east side of the middle portion of the meadow.(with subsequent willow planting as feasible).
2. Treat primary channel (via complete fill, pond and plug, beaver dam analogs, etc.) to increase soil saturation and standing water by raising the water table to the historic level, particularly in locations that beaver have historically targeted, and in the more incised area of the middle meadow (with subsequent willow planting as feasible).
3. Use mechanical shaping of existing stream banks to alter flow patterns if action 2 is not possible (with subsequent willow planting within new lower floodplain).
4. Lower oxbow base levels or create artificial oxbows to match the water table in existing primary stream channels (with subsequent willow planting as feasible).

5. Plant willow in areas where hydrology already provides necessary flooding and/or soil saturation levels.
6. Plant aspen along meadow edge or treat existing aspen stands to stimulate new growth as feasible.
7. After restoration is complete attempt using conspecific attraction technique to help Willow Flycatcher reestablish at Faith Valley.

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Appendix A. Total count of individuals for all bird species detected during point count surveys at Faith Valley during 2010¹, 2012¹, 2017 and 2018 (all detection distances included).

Bird Species	2010	2012	2017	2018	AVG
Mallard	1.0	1.0	1.0	1.0	1.0
Green-winged Teal	0.0	0.5	0.0	0.0	0.1
Sooty Grouse	0.0	1.0	0.0	0.0	0.3
Mountain Quail	1.5	5.5	3.0	3.0	3.3
California Quail	0.5	0.0	0.0	0.0	0.1
Red-tailed Hawk	0.0	0.5	0.0	0.0	0.1
Virginia Rail	0.0	0.0	1.0	0.0	0.3
Spotted Sandpiper	12.0	9.0	6.0	10.0	9.3
Wilson's Snipe	4.0	4.5	4.0	4.0	4.1
Mourning Dove	0.0	1.5	0.0	0.0	0.4
Common Nighthawk	0.0	0.0	0.0	1.0	0.3
Calliope Hummingbird	0.0	0.0	3.0	1.0	1.0
Williamson's Sapsucker	0.5	1.0	1.0	0.0	0.6
Red-breasted Sapsucker	0.0	0.0	1.0	0.0	0.3
Northern Flicker	1.0	1.5	0.0	2.0	1.1
Western Wood-Pewee	0.0	1.0	1.0	0.0	0.5
Dusky Flycatcher	13.0	12.0	14.0	12.0	12.8
Warbling Vireo	0.0	2.0	4.0	2.0	2.0
Steller's Jay	0.0	0.0	0.0	1.0	0.3
Clark's Nutcracker	0.0	4.0	4.0	1.0	2.3
Common Raven	0.5	2.5	0.0	2.0	1.3
Tree Swallow	0.5	0.0	2.0	0.0	0.6
Cliff Swallow	0.5	0.0	0.0	0.0	0.1
Mountain Chickadee	12.0	6.5	2.0	5.0	6.4
Red-breasted Nuthatch	0.5	0.5	0.0	1.0	0.5
House Wren	0.0	0.5	0.0	0.0	0.1
Golden-crowned Kinglet	0.0	1.0	0.0	0.0	0.3
Ruby-crowned Kinglet	1.5	1.5	0.0	0.0	0.8
Hermit Thrush	0.5	1.0	0.0	1.0	0.6
American Robin	21.0	12.5	11.0	6.0	12.6
Nashville Warbler	0.0	1.0	0.0	0.0	0.3
Yellow Warbler	11.5	12.0	6.0	9.0	9.6
Yellow-rumped Warbler	4.5	6.0	2.0	3.0	3.9
Hermit Warbler	0.0	0.5	0.0	0.0	0.1
MacGillivray's Warbler	1.0	0.0	3.0	2.0	1.5
Wilson's Warbler	3.0	0.5	11.0	9.0	5.9
Western Tanager	0.0	2.5	0.0	1.0	0.9
Green-tailed Towhee	0.0	1.5	0.0	4.0	1.4

Bird Species	2010	2012	2017	2018	AVG
Chipping Sparrow	2.5	6.5	0.0	1.0	2.5
Vesper Sparrow	0.0	0.0	0.0	2.0	0.5
Savannah Sparrow	4.0	10.5	9.0	6.0	7.4
Fox Sparrow	0.0	0.5	0.0	0.0	0.1
Song Sparrow	10.0	22.0	22.0	19.0	18.3
Lincoln's Sparrow	4.5	5.5	7.0	3.0	5.0
White-crowned Sparrow	15.0	34.0	29.0	20.0	24.5
Dark-eyed Junco	1.0	8.5	3.0	3.0	3.9
Red-winged Blackbird	13.5	28.5	10.0	11.0	15.8
Brewer's Blackbird	7.5	9.0	8.0	5.0	7.4
Brown-headed Cowbird	5.0	8.5	5.0	5.0	5.9
Pine Grosbeak	0.0	0.0	1.0	0.0	0.3
Purple Finch	0.0	0.5	0.0	0.0	0.1
Cassin's Finch	8.0	10.0	4.0	2.0	6.0
Pine Siskin	0.0	2.0	0.0	0.0	0.5
Lesser Goldfinch	0.0	0.5	0.0	0.0	0.1
Evening Grosbeak	1.0	0.0	0.0	0.0	0.3

¹Total count of individuals is averaged between 2 visits.

Appendix B. Index of abundance (average number of individuals detected per station during each visit) for bird species observed within 50 m of stations in Faith Valley in 2010, 2012, 2017 and 2018.

Bird species	2010	2012	2017	2018	AVG
Mallard	0	0.07	0.07	0	0.03
Spotted Sandpiper	0.18	0.11	0.20	0.43	0.23
Wilson's Snipe	0.18	0.04	0.07	0.07	0.09
Common Nighthawk	0	0	0	0.07	0.02
Calliope Hummingbird	0	0	0.20	0.07	0.07
Williamson's Sapsucker	0	0.04	0.07	0	0.03
Dusky Flycatcher	0.41	0	0.47	0.36	0.31
Warbling Vireo	0	0	0.07	0.07	0.03
Common Raven	0.05	0.11	0	0.07	0.06
Tree Swallow	0.05	0	0.07	0	0.03
Cliff Swallow	0.05	0	0	0	0.01
Mountain Chickadee	0	0	0.07	0.07	0.03
House Wren	0	0.04	0	0	0.01
Golden-crowned Kinglet	0	0.07	0	0	0.02
American Robin	0.91	0.07	0.33	0.29	0.40
Nashville Warbler	0	0.04	0	0	0.01
Yellow Warbler	0.41	0.25	0.27	0.50	0.36
Yellow-rumped Warbler	0.05	0.14	0	0.07	0.06
MacGillivray's Warbler	0	0	0.20	0	0.05
Wilson's Warbler	0.14	0	0.53	0.36	0.26
Green-tailed Towhee	0	0	0	0.07	0.02
Chipping Sparrow	0.05	0.11	0	0	0.04
Vesper Sparrow	0	0	0	0.07	0.02
Savannah Sparrow	0.23	0.18	0.27	0.36	0.26
Song Sparrow	0.32	0.32	0.67	0.86	0.54
Lincoln's Sparrow	0	0.07	0.27	0.07	0.10
White-crowned Sparrow	0.55	0.68	0.67	0.64	0.63
Dark-eyed Junco	0.05	0.14	0.13	0.07	0.10
Red-winged Blackbird	0.32	0.29	0.27	0.14	0.25
Brewer's Blackbird	0.41	0.36	0.53	0.29	0.40
Brown-headed Cowbird	0.05	0.07	0.20	0.36	0.17
Cassin's Finch	0.09	0.14	0.07	0	0.08
Pine Siskin	0	0.11	0	0	0.03
Lesser Goldfinch	0	0.04	0	0	0.01