Looking Downstream

2011-2012 Update

Physical and Ecological Responses to River Flow Downstream of Hetch Hetchy Reservoir, Yosemite National Park

January 10, 2014

By Greg Stock, Ph.D., James Roche, Monica Buhler, Sarah Stock, David Wolfson,

and Lindsay Cline

National Park Service, Resources Management and Science, Yosemite National Park

Acknowledgements

We appreciate valuable discussions with, field assistance from, and data sharing with scientists from McBain & Trush, Inc. We also thank Bill Sears, Bruce McGurk, Adam Mazurkiewicz, and Mike Horvath of the San Francisco Public Utilities Commission (SFPUC) for discussions, data, review, and support of this project. Dr. Joe Szewczak provided training to use bat detection and recording software and equipment and analyze and interpret bat echolocation calls. This work was funded by the SFPUC.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Summary

The Looking Downstream project is an interdisciplinary study designed to better understand the physical processes and ecology of the mainstem Tuolumne River corridor between O'Shaughnessy Dam and the western boundary of Yosemite National Park. The project consists of hydrology, vegetation, and wildlife (bird, bat, and benthic macroinvertebrate) study components. An overarching goal of the Looking Downstream project is to provide information that water managers can use to manage environmental water releases from O'Shaughnessy Dam in ways that will more closely replicate natural physical processes and benefit dependent ecosystems downstream of the dam.

This status report details findings from the 2011-2012 field seasons in Poopenaut Valley. The 2011 and 2012 water years were respectively one of the 10 wettest and 10 driest water years on record, based on 1 April snowpack records. Hydrology studies in spring 2011 focused on refining flow estimates necessary for various levels of wetland inundation. Low water conditions in 2012 limited the high flows necessary for water to spill into the seasonal pond.

Remapping of wetlands in 2012 did not show substantial change as compared to the original delineation in 2007. However, the shift of the boundary between Wetlands 6 and 7 and the slight expansion of Wetland 5 may indicate possible responses to modified water releases from O'Shaughnessy Dam. Vegetation monitoring between 2008 and 2011 indicates that while there is no significant change in wetland or upland plant frequency, there is a significant increase in both relative and total cover of wetland plants. Whereas wetlands plants may not be spreading, already established plants appear to have more vigor and provide more cover. The majority of plant species present in frequency plots are native (73 to 82%) and no significant change in frequency between years was detected. However both relative and total cover of native species increased significantly between 2008 and 2011. This suggests that while native plant presence not increasing with respect to non-native plants, those established native plants are increasing in cover and vigor. This change could be due to widely variable precipitation amounts during the period of study, modified water releases from the dam, or a combination of both. If future monitoring shows a continuation of this trend, we may be more confident that modified water releases are exerting an influence on native plant species cover. No significant change in individual plant species was detected in our analyses.

Breeding bird studies in Poopenaut Valley improves our understanding of how the timing of water releases from O'Shaughnessy Dam affects birds' productivity. It appears that earlier water releases might discourage birds from nesting and later releases might flood active nests. Song Sparrows are year-round residents in Poopenaut Valley and concentrate their activity along the river's edge. Because Song Sparrows are understory nesters that build their nests on or near the ground, flooding poses a concern to their productivity. The other focal species, Black-headed Grosbeak, Warbling Vireo, and Yellow Warbler are not as vulnerable to flooding. Spot-map surveys provide spatial information about how birds in Poopenaut Valley use the available habitat. We analyzed territory sizes for Black-headed Grosbeak, Song Sparrow, Warbling Vireo, and Yellow Warbler. Long-term data on accurate territory sizes will provide useful information on numbers of breeding pairs and probable nest locations.

Acoustic detection of bats has identified a high diversity of bat species inhabiting Poopenaut Valley, with at least one species, the Mexican free-tailed bat, present year-round. We documented four special status species, two of which were the first (spotted bat) and third (western mastiff bat) most frequently detected species overall. The shift in spotted bat detections from the south site in spring and summer 2011 to the north site in summer 2012 requires further study; however, prey abundance and water level in the seasonal pond may be factors that influence the frequency of detection. Holmquist and Schmidt-Gengenbach, (2012) found that benthic macro-invertebrate fauna in the seasonal pond north of the Tuolumne River adds considerably to the total biodiversity of the Poopenaut Valley ecosystem.

Chapter 1. Introduction

The primary goals of the Looking Downstream project are 1) to fill in first-order information gaps by collecting baseline information on the hydrology, vegetation, birds, and bats. and benthic macroinvertebrates tied to river flow downstream of O'Shaughnessy Dam, 2) provide a general characterization of the river reach, and 3) assess its overall hydrological and ecological condition. An important overarching goal of these studies is to work collaboratively to produce science-based information and recommendations that the San Francisco Public Utilities Commission (SFPUC) can use to design environmental water releases that will be most beneficial to maintaining and enhancing ecosystems downstream of the dam.

Poopenaut Valley, a broad, low gradient valley located approximately 5.5 km (3.5 miles) downstream of O'Shaughnessy Dam, is one of the most ecologically diverse and productive areas in the river reach between the dam and the Yosemite National Park boundary. As a result, we consider Poopenaut Valley to be the location most sensitive to habitat disruption resulting from an altered hydrologic regime (National Park Service, 2009). For these reasons, we have focused our research efforts primarily in Poopenaut Valley, specifically on the meadow, wetland, and riparian ecosystems found there.

Our 2011-2012 research in Poopenaut Valley consisted of four main subject areas: (1) surface and ground water hydrology, (2) upland, meadow, wetland, and riparian vegetation, (3) riparian-dependent bird species and bats, and (4) benthic macroinvertebrate assemblages. Results from benthic macroinverterbrate research are reported separately by researcher Jeff Holmquist of the University of California White Mountain Research Station (Holmquist and Schmidt-Gengenbach, 2012). This report presents the other subjects in Chapters 2-4.

Chapter 2. 2011-2012 Hydrology Studies in Poopenaut Valley

2.1 Introduction

Hydrology studies in 2011 and 2012 primarily consisted of continued monitoring of water levels in the Tuolumne River, tributary streams, Poopenaut Valley seasonal pond, and groundwater within the meadows adjacent to the river. This report covers the period between the end of the 2010 flow experiment (27 July 2010) and the end of the spring water releases in 2012 (20 June 2012). This period marked a transition from prior process-specific experiments (see National Park Service, 2009-2012) to long-term monitoring and operational “test drives” of water release thresholds designed to achieve specific inundation objectives in Poopenaut Valley. Hydrology studies in spring 2011 focused on refining flow estimates necessary for various levels of wetland inundation. Low water conditions in 2012 limited the high flows necessary for water to spill into the seasonal pond.

2.2 Overview of the 2011 and 2012 water years

The 2011 and 2012 water years were respectively one of the 10 wettest and 10 driest water years on record based on 1 April snowpack records. Precipitation totals at O’Shaughnessy Dam for water year 2011 and water year 2012 were 61.75 and 22.31 inches (156.8 cm and 56.7 cm), respectively. A similar result for snowpack accumulation in the upper Tuolumne River watershed is shown in Table 2-1. The onset of spring runoff differed by one month between water year 2011 and water year 2012: Spring runoff onset was 17 April in water year 2011 and 17 March in water year 2012, as determined using the maximum negative cumulative deviation from annual average flows at the USGS gage in the Grand Canyon of the Tuolumne River upstream of Hetch Hetchy Reservoir. Spring runoff peaks upstream of Hetch Hetchy reservoir differed by two months between water year 2011 and water year 2012: The spring runoff peaks occurred on 23 June 2011 and 23 April 2012, respectively. The seasonal pond in Poopenaut Valley at least partially filled in the winter and spring of both years, containing some water at the time of the controlled floods each year.

Table 2-1. Summary snow water content for snow courses in the Tuolumne River watershed upstream of Hetch Hetchy Reservoir, 2011 and 2012.

Snow Course	Course #	Elevation (m)	Apr 1st Average (cm)	April 1 2011 (cm)	May 1 2011 (cm)	April 1 2012 (cm)	May 1 2012 (cm)
Dana	157	2987	79	119	120	38	30
Rafferty	158	2865	83	151	149	59	49
New Grace	368	2713	122	145	--	37	--
Tuolumne	161	2621	58	99	90	21	0
Wilma	163	2438	110	177	169	52	34
Paradise	167	2332	101	144	160	45	18
Vernon	169	2042	57	119	101	20	4
Beehive	171	1981	60	108	79	28	5
Lower Kibbie	173	2042	66	134	101	26	0
% April 1st Average				163%	148%	44%	22%

2.2.1 Water Year 2011

We continued monitoring a complete set of groundwater monitoring wells and river and pond stage recorders during water year 2011 (Table 2-2 and Figure 2-1). Figure 2-2 depicts Tuolumne River flows as measured below the reservoir at the USGS gage. Figures 2-3 and 2-4 show water levels in groundwater monitoring wells, in the seasonal pond, and at the upstream and downstream river stage monitoring locations for the reporting period. Photographic documentation of inundation took place from the Hetch Hetchy Road on several occasions during high river flows in May and June (Figure 2-5), and from the floor of Poopenaut Valley on 22 June and 30 June at 6,230 and 1,700 cfs (176 and 48 cms), respectively (Figure 2-6).

2.2.2 Water Year 2012

To conform to National Park Service regulations regarding scientific infrastructure in wilderness areas, groundwater monitoring wells 4, 5, 6, 7, 9, 12, 14, 17, and 18 were removed in October 2011 (Figure 2-1). All other wells and stage recorders except well 13 operated through the reporting period at a one-hour interval. Very low flow conditions existed in the fall and winter due to unusually low precipitation during this period; this resulted in wells 15 and 19 going dry (Figure 2-3). The downstream river stage recorder experienced some freezing conditions as indicated by numerous periods of spurious results in January 2012, which have been removed from analysis (Figure 2-3).

The Poopenaut Valley pond appeared to partially fill from rainfall beginning in mid-March 2012, after having been dry throughout the fall and winter of water year 2012. The pond continued to fill from rainfall to a surface elevation of 1012.54 meters (a depth of about 0.7 meters) before the peak flood on 2 May 2012. The flood resulted in an additional 10-12 cm added to the pond depth, bringing the surface elevation to 1012.66 meters. SFPUC contractors McBain & Trush have completed a detailed topographic survey of the pond spillway, and determined that a flow of 4,100 cfs should provide 1 foot of freeboard over the pond outlet elevation of 1013.50 meter (W. Sears, pers. Comm. January 2014). According to these calculations, the pond should fill after about 4hrs at 4,100 cfs. Peak river stage at the upstream stage recorder on 2 May 2012 was 1013.82 meters, which is about 30 cm above the elevation of the pond outlet (1013.50 meters). However, this stage was only attained for approximately 2 hours, which is likely why the pond stage was only raised by about 10 cm.

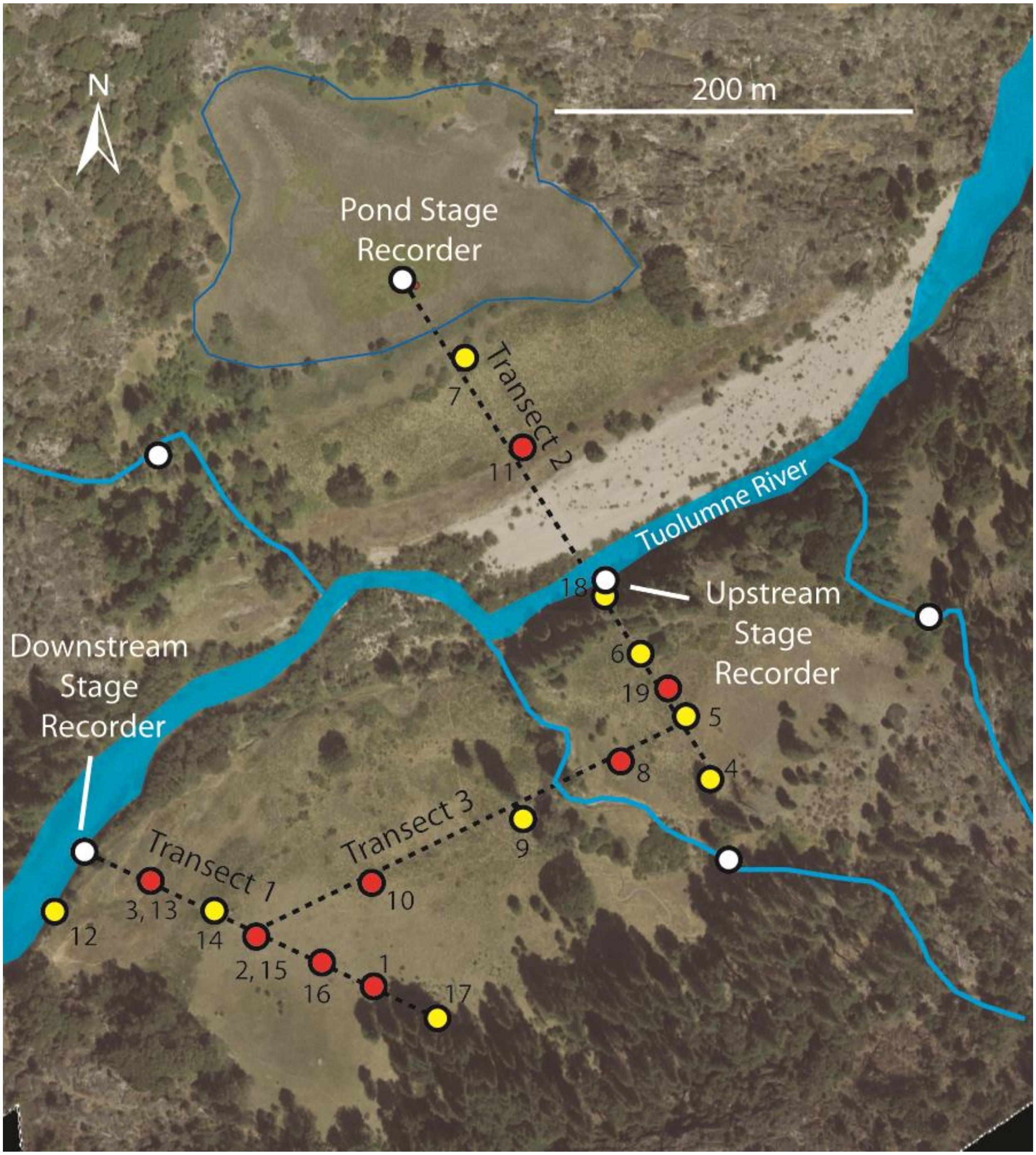

Figure 2-1. Poopenaut Valley water level monitoring locations. White dots indicate stage recorders in surface waters. Red dots indicate existing monitoring wells. Yellow dots indicate former monitoring wells removed in October 2011.

Table 2-2. Poopenaut Valley groundwater monitoring well depth and elevations

Well Number	Elevation TOC (m)	Stickup (m)	Ground Elevation (m)	Total well depth below ground surface (m)
1	1014.29	0.167	1014.124	3.730
2	1013.95	0.171	1013.783	3.960
3	1012.35	0.109	1012.241	3.540
4	1015.43	0.220	1015.210	2.930
5	1015.38	0.185	1015.191	3.970
6	1015.99	0.190	1015.798	3.800
7	1014.36	0.182	1014.173	3.510
8	1014.27	0.215	1014.057	2.720
9	1015.50	0.150	1015.344	3.800
10	1014.74	0.185	1014.554	3.770
11	1013.19	0.205	1012.985	3.650
12	1012.24	0.569	1011.671	2.833
13	1012.69	0.285	1012.399	3.099
14	1014.25	0.404	1013.850	4.396
15	1014.23	0.466	1013.768	4.863
16	1014.23	0.364	1013.859	4.898
17	1015.05	0.433	1014.618	4.828
18	1011.69	0.537	1011.147	1.609
19	1016.16	0.385	1015.780	5.789
Upstream recorder	1009.54	-	-	-
Downstream recorder	1009.60	-	-	-
Pond recorder	1012.48	-	-	-
SW Tributary	1013.46	-	-	-
SE Tributary	1012.99	-	-	-
North Tributary	1011.65	-	-	-

Grey shaded entries indicate wells that were removed in October 2011.

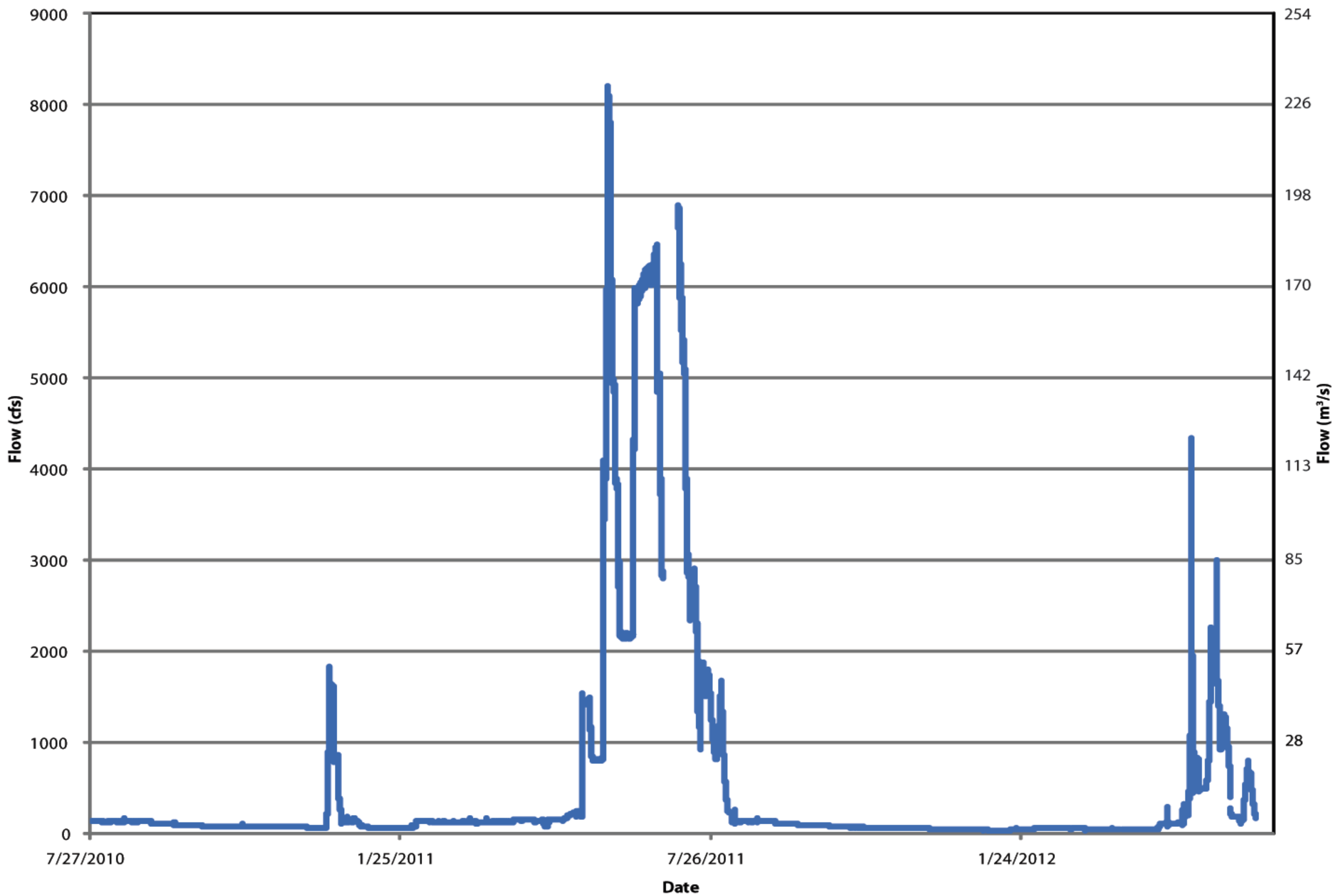

Figure 2-2. Tuolumne River discharge at USGS gage 11-276500 below Hetch Hetchy Reservoir from 27 June 2010 through 20 June 2012.

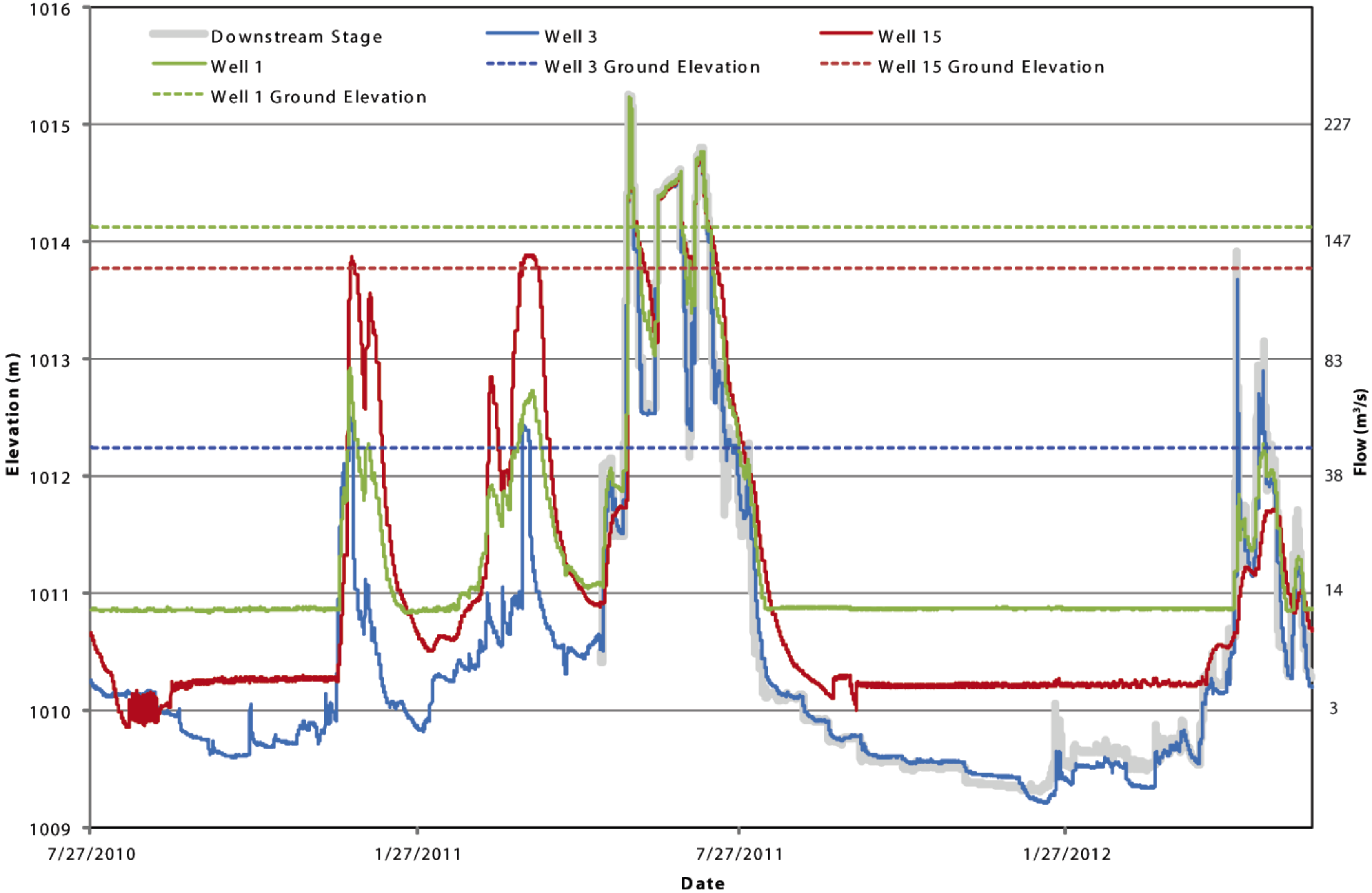

Figure 2-3. Groundwater monitoring well response along Transect 1 (downstream, see Figure 2-1) from 27 June 2010 through 20 June 2012. Periods of record that are nearly flat for wells 1 and 15 indicate no groundwater in the well.

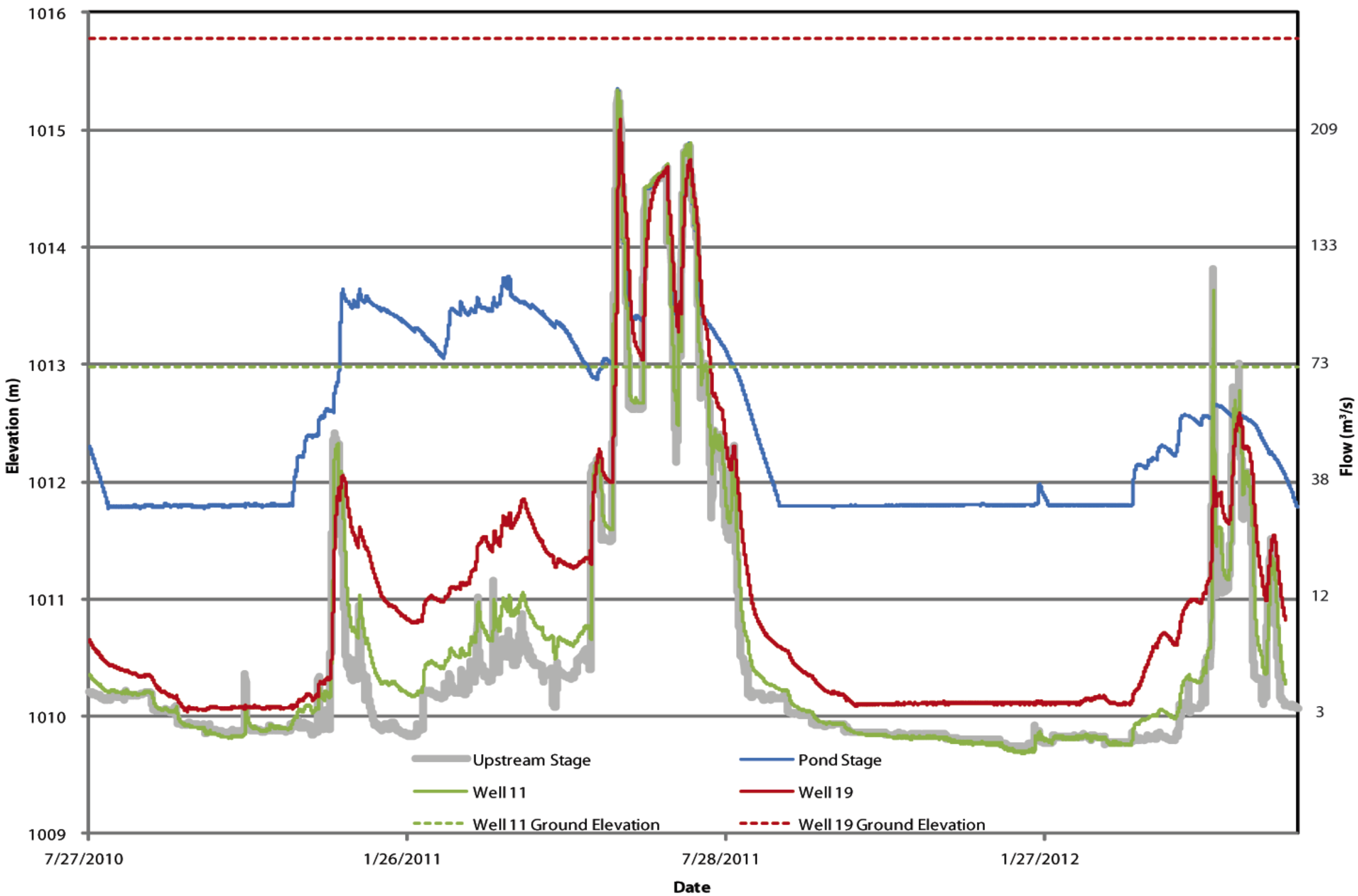

Figure 2-4. Groundwater monitoring well response along Transect 2 (upstream, see Figure 2-1) from 27 June 2010 through 20 June 2012. Transect includes river stage, pond stage, and groundwater levels in two monitoring wells. Periods of record that are nearly flat for well 19 and the pond indicate no water.

Figure 2-5. Poopenaut Valley inundation at 6,230 cfs (176 cms) on 22 June 2011 (top) and at 1,700 cfs (48 cms) on 30 June 2011 (bottom).

Figure 2-6. View upstream of Poopenaut Valley downstream constriction at 6,230 cfs (176 cms) on 22 June 2011 (left) and at 1,700 cfs (48 cms) on 30 June 2011 (right).

Chapter 3. 2011 - 2012 Vegetation Studies in Poopenaut Valley

3. 1 Introduction

The vegetation in Poopenaut Valley is primarily comprised of herbaceous wetlands and upland meadows intermixed with dense riparian trees and shrubs. Maintaining and enhancing the ecological integrity of these communities requires magnitude, timing, frequency and duration of river flows sufficient to inundate wetlands and maintain the water table and soil moisture required for plants to establish and persist. The minimum hydrologic requirements for a jurisdictional wetland in the western mountain region is defined by the US Army Corps of Engineers to have soil saturation within 30 cm (12 inches) of the ground surface for a period of 14 consecutive days during the growing season 5 out of every 10 years (USACOE 2008).

Through several years of hydrologic assessments and modeling, we have a quantitative understanding of the physical response of Poopenaut Valley wetland soils (e.g. soil saturation, water table level, soil moisture retention) to different flow magnitudes and durations. However, measuring the biological response requires a longer time period and is more complex. For example, Russo et al. (2012) suggests that surface soil inundation is the most effective method of saturating wetland soils, and that a pulsed inundation and sub-inundation (saturating) hydrograph is most efficient in terms of minimizing the volume of flow needed to saturate soils and support wetland hydrology, but notes that the effects of a pulsed flow regime on wetland plants is unknown and will require ongoing monitoring to understand. Also, while the wetland delineation and description of existing vegetation types in Poopenaut Valley, completed in 2007 (National Park Service, 2009) and refined in 2008 and 2009, provides a baseline of the composition and spatial distribution of plant communities and wetlands, vegetation dominance, frequency, abundance and distribution vary widely between years due to fluctuations in annual temperature and precipitation. Therefore, detection of a plant community response to altered flows is likely to take many years of monitoring. In order to refine these assessments, additional vegetation work continued in the 2011 and 2012 seasons, including vegetation monitoring and a re-delineation of the wetlands. In addition, we continued to identify additional plant species occurring in Poopenaut Valley (bringing the total observed to 212) and invasive plant survey and treatment.

3.2 Methods

3.2.1 Wetland Delineation

Wetlands delineated in 2007 (Figure 3-1) followed jurisdictional wetland criteria and wetland delineation methodologies defined by the United States Army Corp of Engineers (Environmental Laboratory 1987) but also included areas defined as wetlands according to the Cowardin system (Cowardin et al., 1979). In 2008, the USACE released supplements to the 1987 handbook, including one specifically for Western Mountains (USACE 2008). We confirmed that wetland delineation parameters had not changed based on this supplement and that the current delineation would not change.

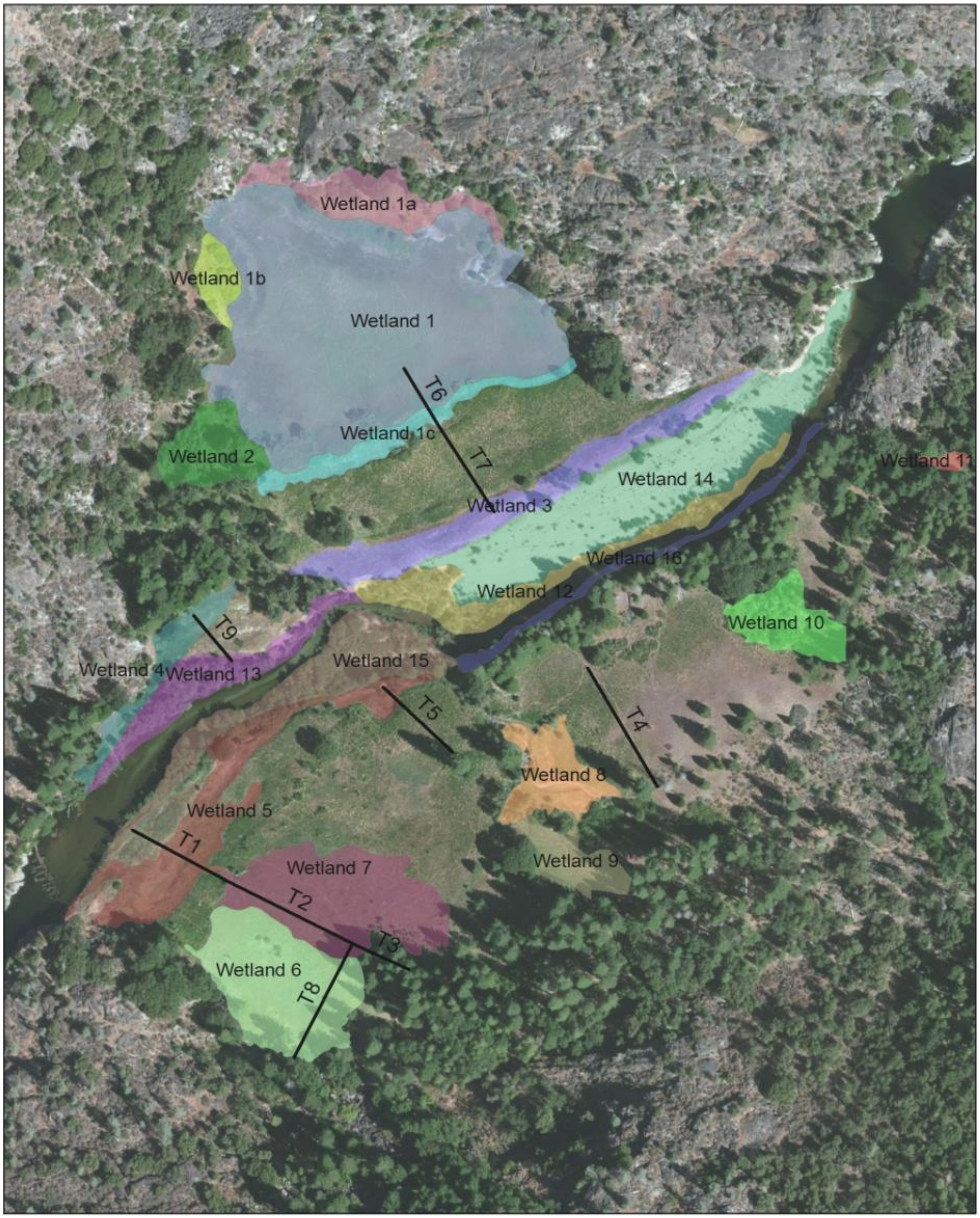

Figure 3-1. Vegetation monitoring transects and wetlands (2007) in Poopenaut Valley, Yosemite National Park.

To determine if wetland boundaries have shifted substantially, wetlands were re-delineated in August with GPS in 2012. Field remapping focused on vegetation rather than hydrology or soils as hydrologic conditions are available through modeling and soils are unlikely to have changed in this timeframe. There is a margin of error due to the inaccuracies of the GPS unit (average +/- 1 m) and observer error. To minimize observer error, biologists completing the 2007 wetland delineation carefully documented which plant species they used to determine wetland boundaries. These same species were utilized in the 2012 delineation.

We also revisited vegetation plots used to determine dominate species for wetlands and uplands during the delineation. These plots are not monumented and were relocated based on GPS coordinates. Total vegetation cover is estimated in a one meter area and a dominance test is conducted to determine if hydrophytic (wetland) vegetation dominates.

3.2.2 Vegetation Monitoring

To better assess changes in vegetation, we established nine transects along and perpendicular to three established cross sections, recording 600 point intercept data points and 50 nested frequency quadrats in 2008. Most transect ends used established rebar (for the cross sections) and vary in length depending on the location of those rebar.

Cross Section 1 is broken up into 3 transects (to improve the repeatability in subsequent surveys), Cross Section 2 has one transect and Cross Section 3 is broken up into 3 transects (1 on the south side of the river and 2 on the north side). We also installed one additional transect perpendicular to Cross Section 1 to better monitor Wetland 6 and a final transect north of the river at the west end (see Figure 3-1).

Data collected on each transect includes a point intercept reading every meter (on the whole number) and a varying number of nested frequency plots randomly placed along the transects. For each point intercept, we measured and recorded the height and species of the tallest plant intercepted and recorded any other plant species below. Each plant species is only counted once. Point intercept methodology gives us cover (often expressed as relative cover), frequency and composition (although less common species are often underrepresented). This method is simple and easy to use, and is appropriate for large areas and monitoring dominant vegetation (Elzinga et al., 2006). Measurements are repeatable but observer error is quite high as the tendency is to overestimate the number of “hits.” The same observer (M. Buhler) completed monitoring in all surveys, lessening some of this inherent disadvantage.

For nested frequency quadrats, the nest sizes include: 0.25 meters (read the corner closest to the beginning point). 0.5 meters (the half perpendicular to the transect) and the full meter. In 2011, an additional nest of 0.1 meters was added to better monitor very common species. Beginning in the smallest quadrat we recorded all species observed. Each species is recorded only once in the smallest nest in which it occurs.

Frequency is one of the easiest and fastest methods available for monitoring vegetation. Frequency describes the abundance and distribution of species and is useful to detect changes in a plant community over time (Elzinga et al., 2006). However, because frequency data are non-absolute (presence/absence), they only indicate a change is occurring and which species are changing, but the nature of those changes cannot be established. For example, a change in frequency does not necessarily relate directly to more concrete parameters such as density, cover, weight, height, volume or any criteria related to the amount of a species present at a location.

Good sensitivity to change is obtained for frequency values between 20 percent and 80 percent (Despain et al., 1991). Frequency values between 10 percent and 90 percent are still useful, but values outside this range only indicate species presence and do not detect change (Despain et al., 1991). Because frequency values are measured separately for each species, an optimum size quadrat for one species may be less than optimum or even inappropriate for another; this is partially resolved by using nested quadrats of different sizes.

3.3 Results

3.3.1 Wetland Delineation

In general, little change in wetland boundaries was observed, particularly in areas where topography defines wetland boundaries. Where GPS error is the likely reason for boundary shifts (by 1-5 m), the 2007 boundaries still represent the delineation (Figure 3-1). For wetlands where boundaries differed more than 5 meters or we detected errors in boundaries, the 2012 remapping (Figure 3-2) will replace the 2007 delineation. These changes are further described below.

For reference, plants classified as upland and facultative upland occur in wetlands 0-33% of the time, facultative plant species occur in wetlands 50% of the time and obligate or facultative wet (FACW) occur 66-100% of the time in wetlands (NRCS 2006).

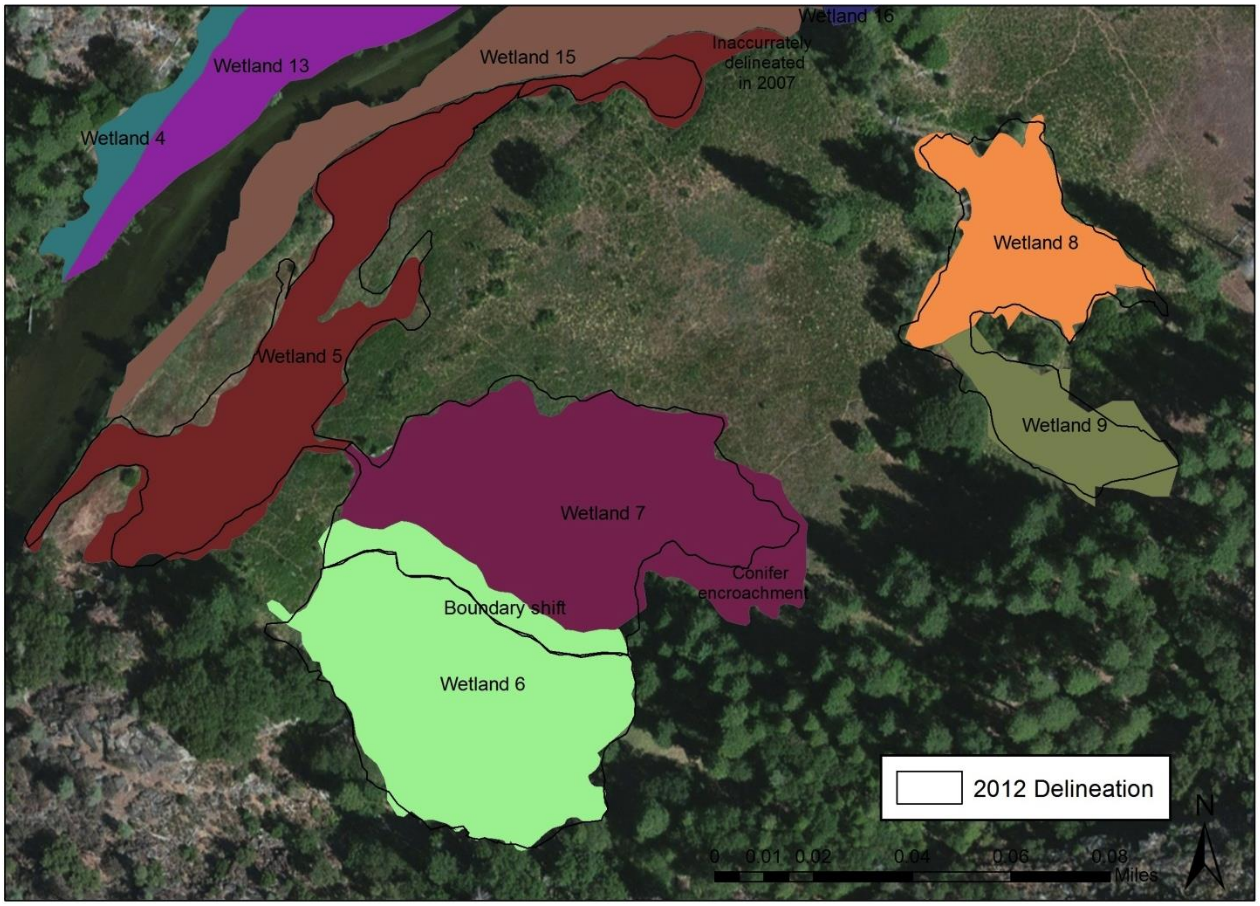

Figure 3-2. Wetland delineation in 2007 (colored polygons) overlain with 2012 wetland boundaries (black lines).

The northeastern most section of Wetland 5 was likely inaccurately mapped in 2007 as this area was visually confirmed as upland (cheat grass occurs here) and has not changed in the last five years. Remapping indicates that there may be a slight expansion of wetland in the lower lying areas in the middle portion of the wetland in a small depression. The 2012 mapping shows this wetland more accurately (Figure 3-2).

The 2007 boundaries of Wetland 9 seem inaccurate and likely reflect GPS error, as it is unlikely that actual wetland boundaries changed based on the topography of the area. The 2012 mapping shows this wetland more accurately (Figure 3-2).

The most substantial change observed in wetland boundaries was between Wetland 6 and Wetland 7, where the boundary shifted an average of 10 meters to the south. The 2007 wetland delineation describes Wetland 7 as transitional; meaning that most dominant vegetation is facultative but very few obligate species occur. Kentucky bluegrass *(Poa pratensis),* a non-native, facultative perennial grass, dominates this wetland with some occurrence of sedges *(Carex ssp.)* and bearded wildrye *(Leymus triticoides)*; in general wetland 7 is not very diverse. In contrast, a high diversity of obligate plants and sedges occur in Wetland 6, with Kentucky bluegrass having substantially less cover. It was for these reasons that the area was split into two separate wetlands in 2007. Following an obligate wetland plant, goldenrod *(Euthamia occidentalis,)* that defined the boundary between the two wetlands in 2007, it appeared that the boundary shifted to the south between 7 and 15 meters, decreasing the size of Wetland 6 and increasing Wetland 7 (Figure 3-2). Though not clearly apparent in the photographs (Figure 3-3 and 3-4), goldenrod was more robust and flowering in 2007 as compared to 2012. In 2007, the conifer encroachment on the southern edge of Wetland 7 was included in the delineation. We determined that this area should be excluded from the wetland boundary, reflected in the 2012 mapping.

Figure 3-3. Wetlands 6 and 7 in 2007.

Figure 3-4. Wetlands 6 and 7 in 2012.

3.3.2 Vegetation Monitoring Results

We installed vegetation monitoring transects in late July of 2008 and resurveyed them in late April 2010, late July 2010 and late July 2011. Many analyses can be completed for the transect data including establishing the relationship between plant communities and water table utilizing hydrologic models along the cross sections, plant community level analyses, as well as comparative analyses between years. Following are preliminary comparative analyses between years for eight of the nine transects (due to errors on the 9th transect it was excluded). The large differences in conditions measured in April as compared to all other surveys do not represent a change in ecological condition but are a factor of the time of year. Therefore, these comparisons are not represented as a change but as an indication of what species occur prior to any inundation or saturation from higher river flows. Most analyses focus on changes between 2008 and 2011.

Nested Frequency

Following are data summaries for general frequency by lifeform, native status and wetland indicator status in the largest quadrat (1 m) across all transects in Poopenaut Valley. In 2008, 50 species were present in the plots, 44 in April of 2010, 62 in July of 2010 and 55 in 2011. Quadrats are treated as sampling units (n = 50) and chi-square tests and McNemar's tests for paired samples were conducted. Basic statistics (chi-square and McNemar's) did not indicate significant change in the frequency of specific plant species (e.g., Kentucky bluegrass or Carex ssp.) between years. Further analysis is needed to test changes in frequency by differing nest sizes.

Point intercept

Cover data from point intercept measurements are summarized by percent relative cover (always equals 100%) and percent total cover (includes layered vegetation and can equal over 100%). Both relative and total cover includes substrate (litter, bare, water, rock etc.) as a proportion of the cover. In 2008, vegetation relative cover was 80%, 43% in April 2010, 94% in July of 2010 and 93% in 2011. Total vegetation cover was 106% in 2008, 47% in April 2010, 155% in July of 2010 and 164% in 2011. The increases in both relative and total vegetative cover is significant between 2008 and 2011(p = 0.006) and between 2008 and July 2010 (p = 0.001) but not significant between July 2010 and 2011.

Using transects as the sampling unit (n =8) we applied paired t tests to detect change in cover by lifeform, native status and wetland indicator status between measurements. Paired t tests did not indicate significant change in cover of specific plant species (e.g., Kentucky bluegrass or Carex ssp.) between years. Because transects sample less than 5% of the population, a finite population correction factor was not applied.

Lifeform

Lifeform of plants is based on physiological and morphological groupings and can provide a general picture of a plant community. For this analysis, plants are classified as a fern/ally, forb (herbaceous flowering plants), graminoid (grasses, sedges and rushes) or shrub. Grasses are further divided into annual vs. perennial, as there are large differences in functionality and cover between the two.

When comparing percent frequency of all plants by lifeform between 2008 and 2011, we see a slight decrease in annual grasses (not significant), little change in ferns/allys (not significant), an increase in forbs (p = 0.007), varying presence of perennial grasses (not significant) and a slight decrease in sedges (p = 0.07), (Figure 3-5). In April 2010, forbs and annual grasses were more frequent, likely because perennial grasses such as Kentucky bluegrass germinate early in the spring while sedges and ferns germinate later.

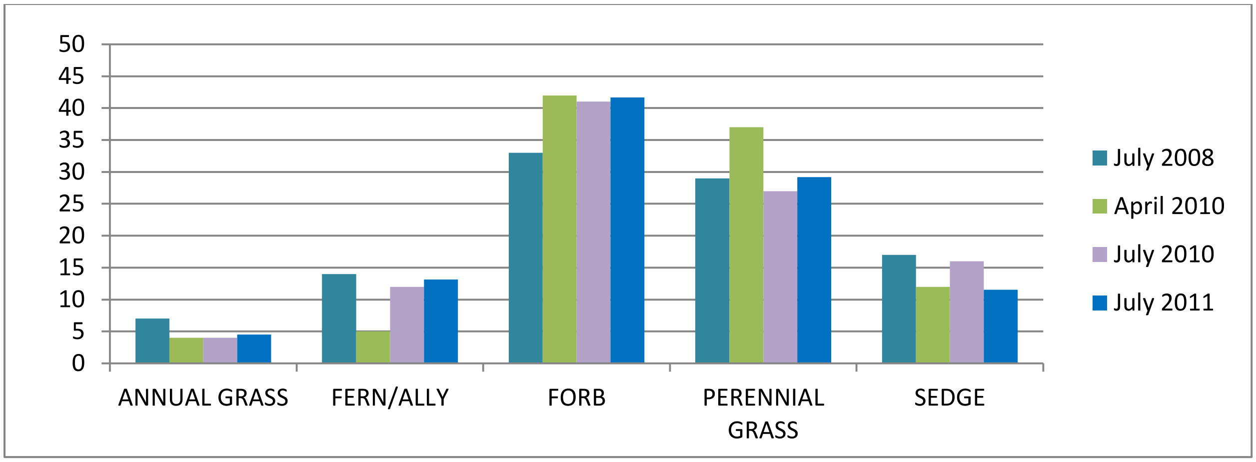

Figure 3-5. Frequency by lifeform

When we evaluate relative cover by lifeform, perennial grasses have the highest cover in all years (Figure 3-6). Changes in relative cover between 2008 and 2012 include a decrease in annual grass (not significant), a slight increase in fern/ally (not significant), an increase in forbs (p = 0.005), little change in perennial grass and an increase in sedges (not significant). As expected, relative plant cover was the lowest in April of 2010 due to the high cover of litter (substrate) and lower in 2008 when compared to July of 2010 and 2011.

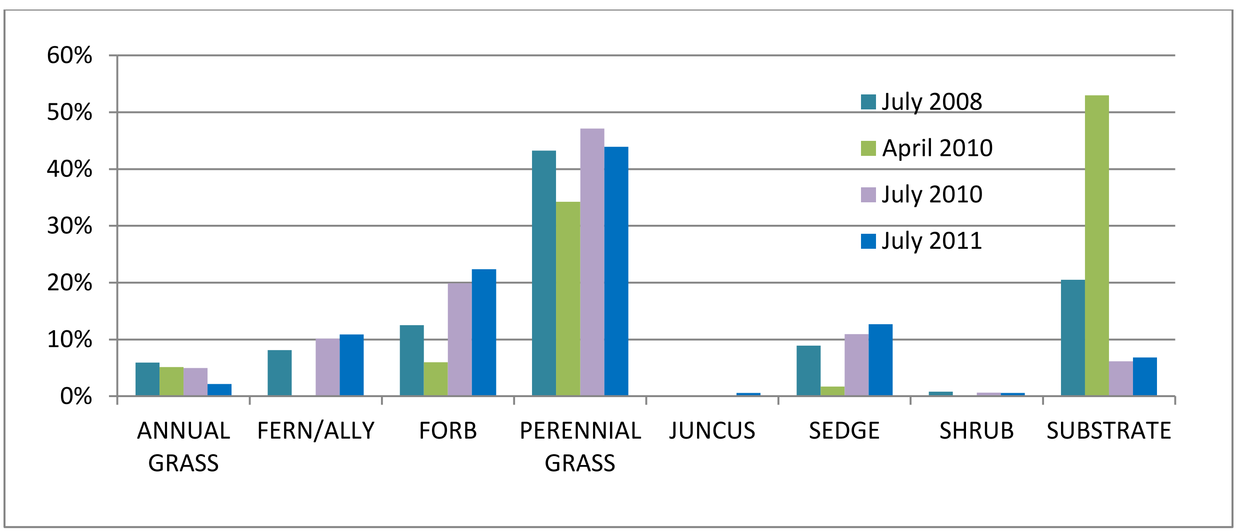

Figure 3-6. Relative Cover by lifeform

Total cover shows a similar pattern to relative cover with perennial grasses dominating (Figure 3-7). Comparing 2008 and 2011, the decrease in cover of annual grass (p = 0.3) was not significant, while increases in fern/ally (p = 0.09), forbs (p = 0.01), perennial grass (p = 0.008) and sedges (p = 0.05) were significant. Again, substrate cover was highest in April 2010 and slightly higher in 2008 as compared to 2010 and 2011. When compared to frequency data, although the presence of sedges decreased slightly in 2011, both relative and total cover increased.

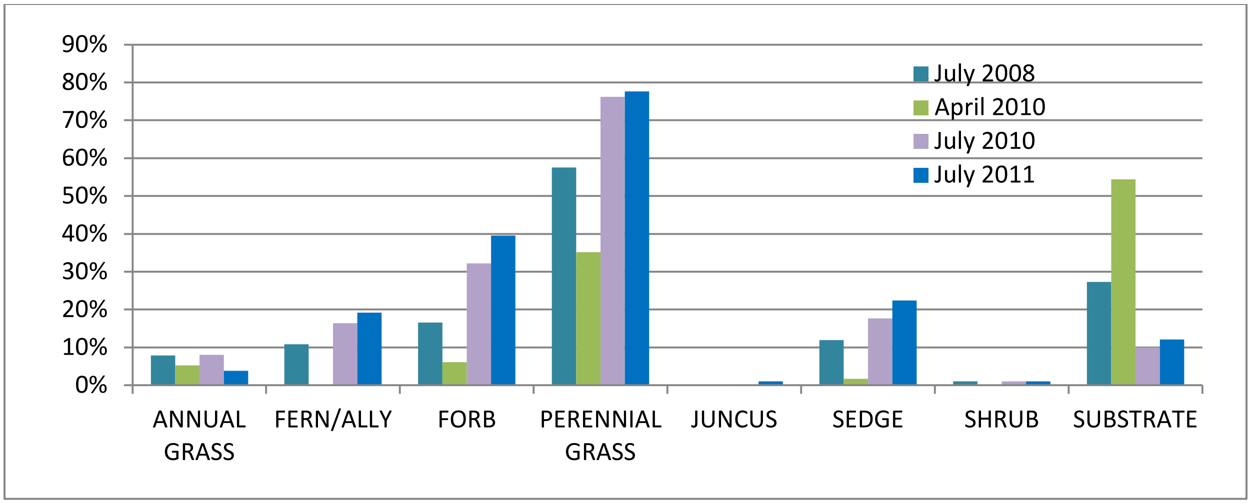

Figure 3-7. Total cover by lifeform

Wetland indicator

The National Wetland Indicator (NWI) status of plant species helps to determine the likelihood that a particular plant would or would not occur in a wetland (NRCS 2006). Not all plant species have ratings, particularly those that do not typically occur in wetlands, and in these cases, local knowledge of those plants was used to determine NWI status. Again, plants classified as upland (UPL) and facultative upland (FACU) occur in wetlands 0-33% of the time, facultative (FAC) plant species occur in wetlands 50% of the time and obligate (OBL) or facultative wet (FACW) occur 66-100% of the time in wetlands (NRCS 2006). To present the data, UPL and FACU plants are combined (Upland), and FACW and OBL (Wetland) are combined. When completing vegetation dominance tests for wetland delineations, FAC species are typically considered wetland but are kept separate for this data summary to demonstrate how the majority of species occurring in Poopenaut Valley can occur in both wetlands and uplands. FAC+ plants (more than 50% in wetlands) are included in wetland and FAC (less than 50%) in uplands.

Evaluating frequency by NWI rating shows that a slightly larger proportion of plants observed are classified as wetland as opposed to upland (Figure 3-8). The largest difference was observed in April and is likely due to the absence of inundation or high groundwater levels, conditions favored by upland plant species. Statistical tests did not indicate significant change between measurements.

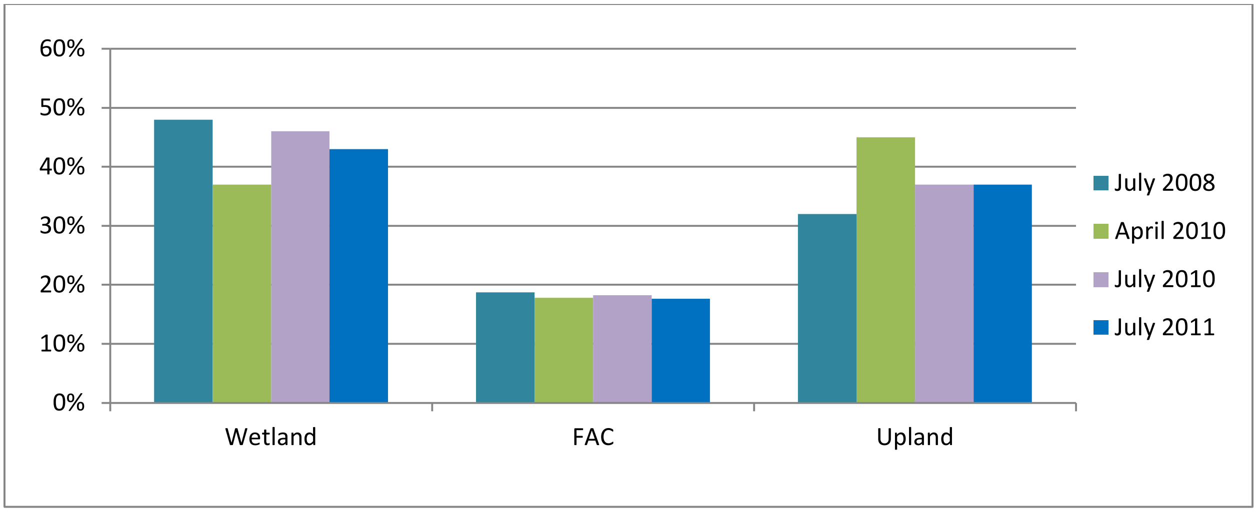

Figure 3-8. Frequency by wetland indicator

Relative cover of wetland plants increased (not significant) in July of 2010 and 2011 as compared to April 2010 and 2008 (Figure 3-9). Wetland plant frequency decreased (not significant) between July 2010 and 2011. Again, April 2010 shows less total cover of vegetation and both wetland and upland species provide much less cover. FAC species relative cover remains generally the same for all surveys.

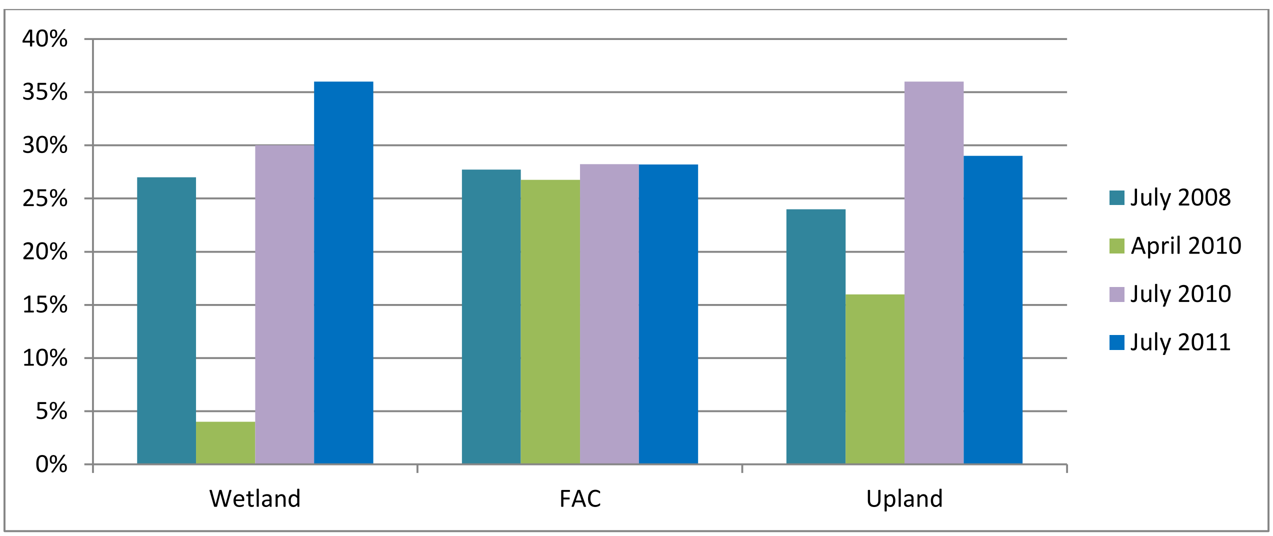

Figure 3-9. Relative cover by wetland indicator

Total cover follows a similar pattern; although cover of FAC species in April of 2010 is lower (Figure 3-10). This is likely due to the lower vegetation cover in general and the absence of several layers of vegetation that are present later in the season. The increase in frequency of wetland species between 2008 and 2011 is significant (p = 0.02) while the change in upland species is not.

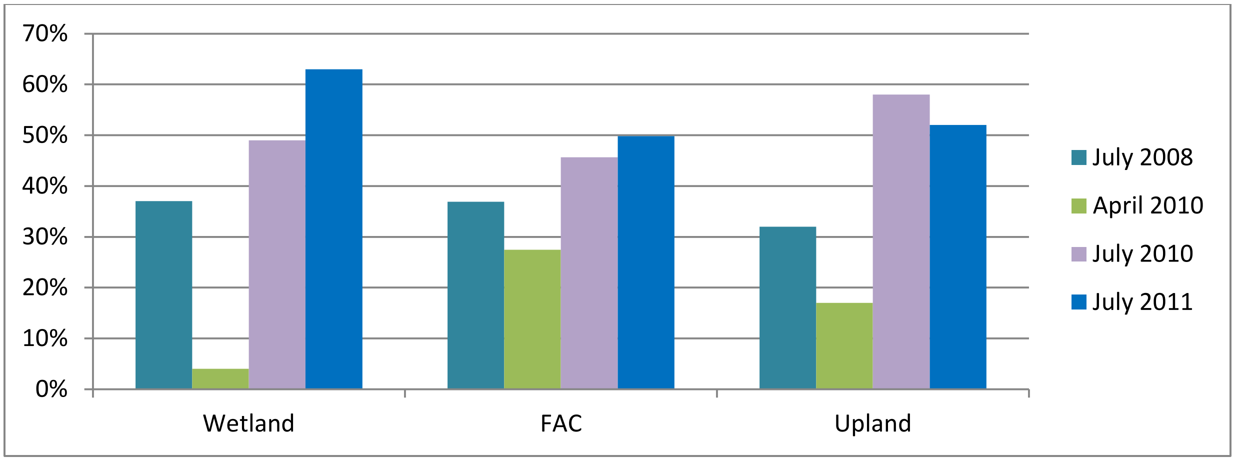

Figure 3-10. Total cover by wetland indicator

Native Status

The majority of plant species present in frequency plots are native (between 73-82%) and no significant change in frequency between years was detected (Figure 3-11). Non-native plant presence was higher as compared to other surveys in April 2010 largely because Kentucky bluegrass and cheat grass germinate and begin growth earlier than many native species, particularly sedges.

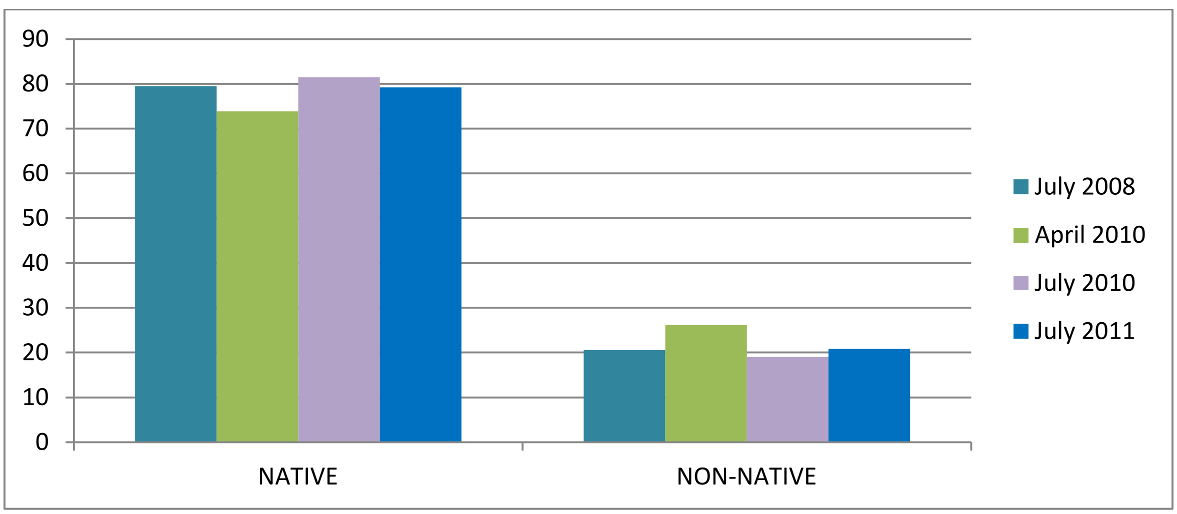

Figure 3-11. Frequency by native status

Relative and total cover of native species increased significantly (p = 0.005) between 2008 and 2011 (Figures 3-12 and 3-13). The large differences between April 2010 and other surveys are likely due to the prevalence of Kentucky bluegrass and cheat grass early in the season.

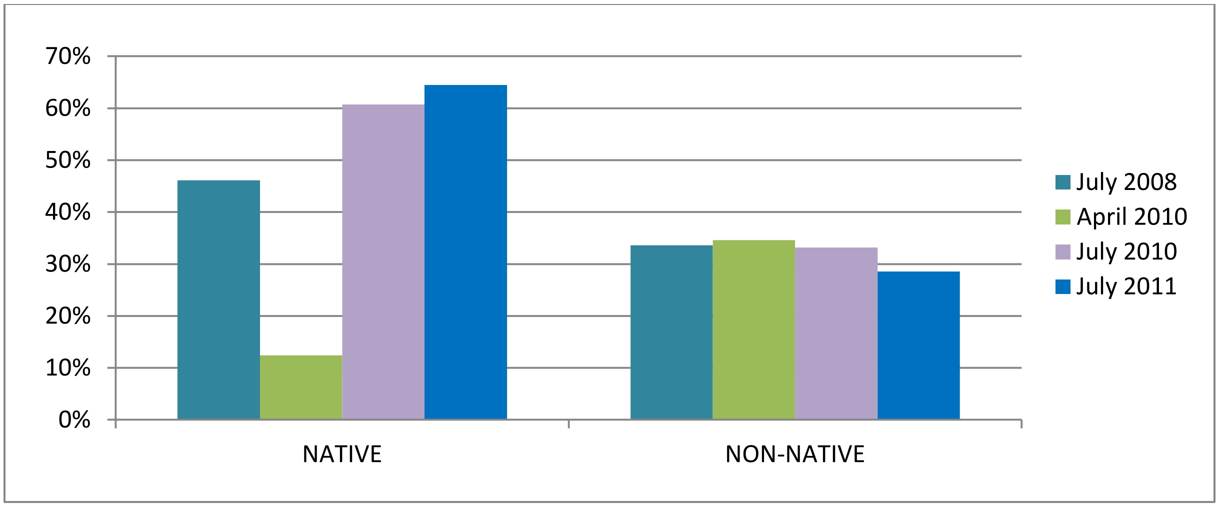

Figure 3-12. Relative cover by native status

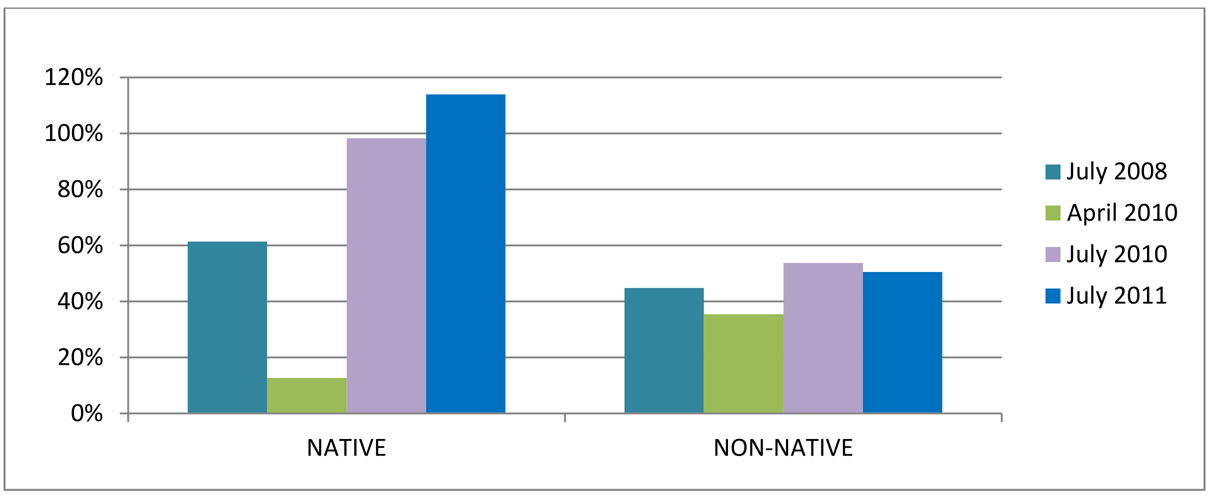

Figure 3-13. Total cover by native status

3.4 Invasive Plant Species Removal

Although still funded by the Looking Downstream project in 2011 and 2012, invasive plant survey and treatment are summarized in separate National Park Service project status reports (see “Blackberry Below the Dam” status reports). With the completion of the Yosemite Invasive Plant Management Plan, additional survey and herbicide treatment of Himalayan blackberry (*Rubus discolor)* occurred, resulting in treatment of 4.75 canopy acres below the O’Shaughnessy Dam, including all known populations in Poopenaut Valley. Funding for invasive plant treatments is now separate from the Looking Downstream project.

3.5 Discussion

Most plant communities and wetlands in Poopenaut Valley are defined by topography. For example, bracken fern occupies higher benches that remain above the inundation and saturation level even when flows are adequate to flood the pond and lower lying areas (such as Wetland 6 and 7). Even during the highest flow in 2011 (Figure 3-14), groundwater levels measured at Well 19 remained 1 m below the ground surface (see Figure 2-4) in the bracken fern and annual grassland plant communities (Figure 3-15). Therefore, vegetation changes resulting from modified water releases from O'Shaughnessy Dam are not likely to occur in these plant communities; accordingly, plant communities in depressions or lower lying areas that are more frequently inundated (particularly Wetlands 5, 6, and 7) will be the focus of subsequent analyses and future monitoring.

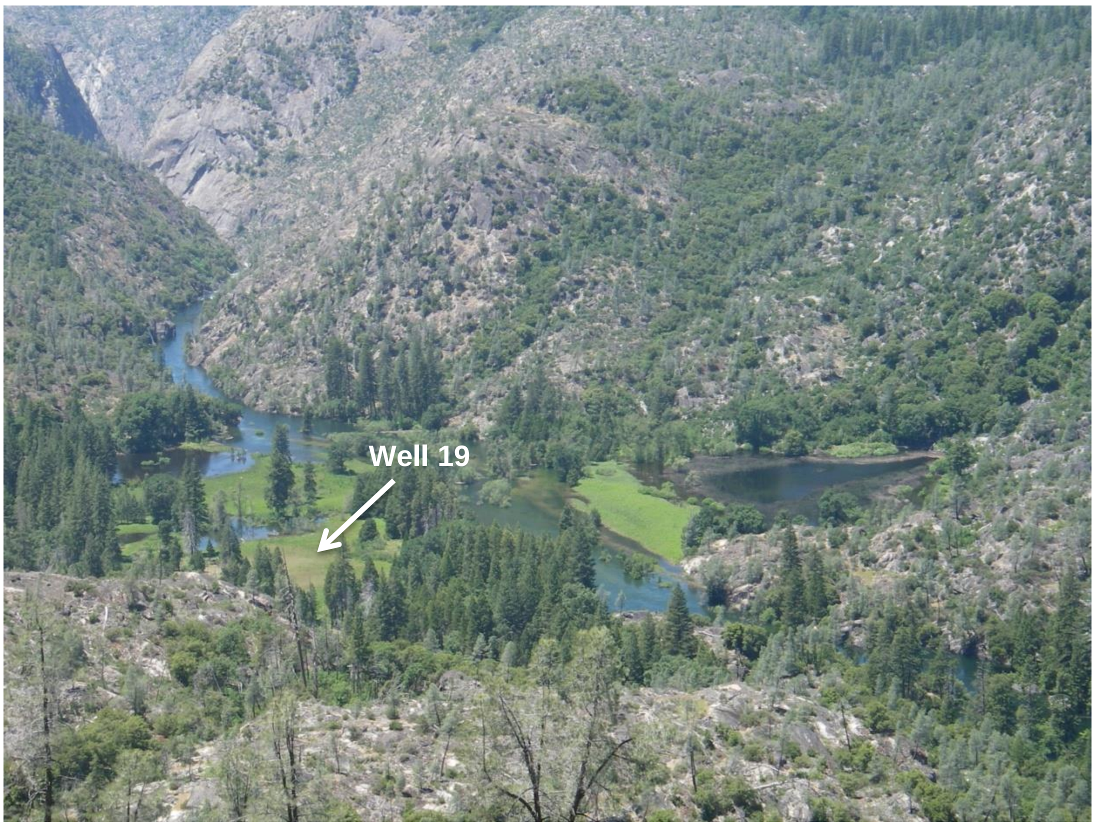

Figure 3-14. 6,230 cfs flow in Poopenaut Valley, June 2011. Groundwater monitoring well 19 is shown for reference.

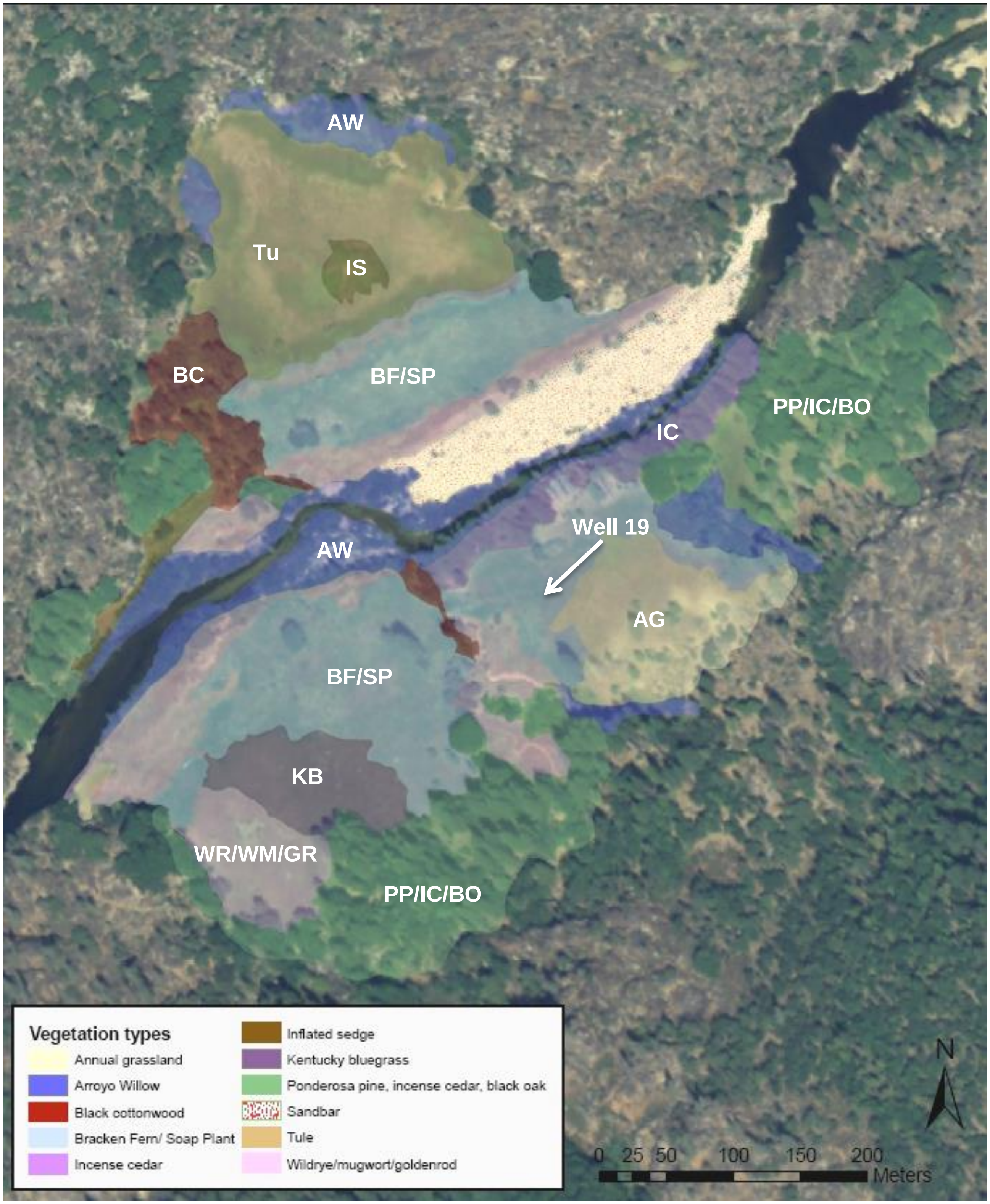

Figure 3-15. Vegetation types in Poopenaut Valley. Labeled polygons refer to vegetation types in the legend; AG – Annual grassland; AW – Arroyo Willow; BC – Black cottonwood; BF/SP – Bracken Fern/Soap Plant; IC – Incense cedar; IS – Inflated sedge; KB – Kentucky bluegrass; PP/IC/BO – Ponderosa Pine, incense cedar, black oak; Tu – Tule; WR/MW/GR – Wildrye/mugwort/goldenrod. Groundwater monitoring well 19 is shown for reference.

It is difficult to attribute changes in vegetation patterns to a particular cause because numerous factors can contribute to these changes. The timing, amount, and duration of precipitation, as well as temperatures at the onset of the growing season, strongly influence plants at both the individual and community level. The 2011 and 2012 water years were respectively one of the 10 largest and 10 smallest on record based on April 1st snowpack records. Precipitation totals at O'Shaughnessy Dam (running average = 90.60 cm [35.67 inches]) for water year 2011 and water year 2012 were 156.8 cm and 56.7 cm (61.75 and 22.31 inches), respectively. Water year 2007 and water year 2008 were below average (53.95 cm [21.24 inches] and 77.04 cm [30.33 inches], respectively). Water year 2010 was above average (144.30 cm [56.81 inches]) (WRCC, accessed 2012). This wide variation in precipitation amounts not only influences plant health directly, but also can have lasting effects on spatial patterns, cover and reproduction.

3.5.1 Wetland Delineation

In general, wetland delineations provide approximate wetland boundaries due to GPS and observer error. Therefore, the remapping of wetlands is likely to only detect large changes, not subtle shifts of less than five meters. Considering this large margin of error, the remapping of wetlands in 2012 did not show a substantial change as compared to 2007. However, the shift of the boundary between Wetlands 6 and 7 and the slight expansion of Wetland 5 may indicate a trend, although it could be exaggerated due to these inaccuracies.

Both 2007, when the initial delineation was completed, and 2012 had below average annual precipitation. However, the resulting effects on vegetation are not necessarily the same due to differences in temperature and the timing of precipitation. It is possible that conditions in 2012 reduced vigor, cover and frequency of goldenrod (the species distribution that defined the boundary between Wetlands 6 and 7) while those in 2007, although equally dry, did not. We did observe stunted growth and little flowering in those plants present in 2012. The observed boundary shift between Wetlands 6 and 7 does not indicate a change in overall wetland size but in the type of wetland. Further investigations of microtopography, groundwater levels and other plant species may provide more information about this shift. Wetland 5 is located in a depression where modified water releases may be providing wetter conditions that benefit wetland species.

3.5.2 Vegetation Monitoring

The objective of our vegetation monitoring is to measure changes in plant frequency and cover, and to determine if modified water releases from O'Shaughnessy Dam are influencing these parameters. From preliminary analyses, we do see measurable change betweenut continued monitoring is needed to evaluate whether these changes are demonstrably related to modified water releases or are instead due to interannual variation in precipitation and other environmental factors.

Measuring vegetation transects in April provided information on which plants are germinating when conditions are relatively dry (prior to mainstem inundation or saturation) and moisture availability is completely dependent on precipitation. As expected, non-native species, annual species and C3 grasses (early germinators) such as Kentucky bluegrass dominate. In wetlands with natural hydrologic regimes, conditions are wet in late April when sedges and other native species may begin germination and this dry period prior to water release may give Kentucky bluegrass an competitive advantage.

Monitoring data indicates that both relative and total plant cover was significantly higher in 2010 and 2011 as compared to 2008. This is likely due to the above average precipitation in both years. However, if future monitoring shows continued high or increased plant cover as compared to 2008, independent of precipitation amounts, then we may have increased confidence that modified water releases are having a stronger influence on plant cover.

As water availability increases, we hypothesize that sedges will increase in both frequency and cover as compared to perennial grasses, Kentucky bluegrass in particular. Relationship studies of Kentucky bluegrass and associated groundwater levels indicate that prolonged inundation and saturation provides an opportunity for sedges to outcompete this non-native grass (Allen-Diaz 1991). Preliminary data summaries of our transect data show that sedge presence significantly decreased by 5% between 2008 and 2011 while both relative and total cover significantly increased. This may indicate that while some sedge species may be less frequent, others are increasing in vigor and cover.

A significant increase in cover of forbs and ferns/allys was detected between 2008 and 2011. Optimal moisture conditions may allow forbs to establish and compete with graminoids and increase fern vigor and cover. Again, this change could be due to the wide variation in water years, modified flows, or more likely a combination of both. If ongoing monitoring shows a continuation of this trend, we may be more confident that modified flows are having a stronger influence.

Monitoring indicates that while there is no significant change in wetland or upland plant frequency, there is a significant increase in both relative and total cover of wetland plants. While wetlands plants may not be spreading, already established plants appear to have more vigor and provide more cover.

The majority of plant species present in frequency plots are native (between 73-82%) and no significant change in frequency between years was detected. However both relative and total cover of native species increased significantly ($p = 0.005$) between 2008 and 2011. This suggests that while native plant presence is not increasing with respect to non-native plants, those established native plants are increasing in cover and vigor. This change could be due to the wide variation in precipitation during the period of study, modified water releases from O'Shaughnessy Dam, or a combination of both. It is unlikely that ongoing non-native plant treatment would have such an effect on native plant populations, as most treatment areas are relatively small and isolated. If future monitoring shows a continuation of this trend, we may be more confident that modified water releases are exerting an influence on native plant species cover.

No significant change in individual plant species was detected in our analyses. Further analyses, described below, may provide a more complete picture. Overall, our monitoring is detecting changes but we must continue this monitoring and identify indicator species to confidently attribute causes for these changes.

3.6 Future work

To further reduce the amount of observer error in remapping wetlands, we will develop more specific descriptions of wetland boundaries, set up photo points and identify reference features. Wetlands will be remapped every five years to attempt to detect if wetland boundaries are being maintained or enhanced by modified water releases from O'Shaughnessy Dam.

Transects will continue to be monitored every other year. Utilizing our preliminary analyses as a guide, we will focus monitoring on key indicator species that are most likely to respond to a modified flow regime. We will continue to measure a smaller nested quadrat added in 2011 to better monitor very common species. We will also investigate ways to correlate soil moisture gradients and plant community spatial distribution. Monitoring could also be expanded to look more closely at plant physiological response (root growth, vegetative growth, reproduction) in an environment where soils are very dry with low groundwater levels at the start of the growing season, are inundated or saturated during flooding, and return to drought conditions rather abruptly (as compared to an unimpaired hydrograph) again when flows decrease. By evaluating plant response, we can identify those species that benefit from these conditions as well as those that decline, and monitor these species as indicator species. For example, Goslee et al. (1997) found that plants can be used as indicators of water source, primarily groundwater vs. surface water, and the associated water chemistry and hydroperiod.

The difficulty of vegetation monitoring is to determine if any changes are ecologically important and if vegetation is responding to a particular factor such as river and groundwater levels rather than a suite of environmental influences. More detailed investigation of relationships between wildlife and vegetation, groundwater levels and vegetation and individual plants physiological response will help to refine what influences plant cover and frequency and identify changes we expect to detect.

Chapter 4. 2011 - 2012 Bird and Bat Studies in Poopenaut Valley

4.1 Introduction

The sensitivity of bird populations to changes in the ecosystem makes them an important indicator of overall habitat quality (Marzluff and Sallabanks, 1998). Long-term monitoring of birds, particularly during the breeding season, can be used to effectively assess habitat health (Ralph et al., 1993). Bird population dynamics have been used as scientifically viable surrogates for evaluation of ecosystem condition because (1) birds are conspicuous, easily observable, and monitoring and analysis are cost effective; (2) as secondary consumers (i.e. insectivores), birds are sensitive indicators of environmental change; and (3) knowledge of the natural history of many bird species has a rich basis in literature. In human-altered riparian areas, bird monitoring can be a valuable tool for assessing changes in habitat quality incurred from restoration efforts, river diversion and channelization projects, water impoundment, and flooding events.

Bats are also recognized as important bio-indicators (Jones et al., 2009). Bats are essential in maintaining ecosystem health by controlling insect populations through nighttime foraging. Most bat species forage either directly over water or within the adjacent riparian zone, where plant and insect productivity is higher than in seasonally dry upslope areas. The riparian zone of Poopenaut Valley in Yosemite National Park represents important foraging habitat for bat populations. There are 17 bat species known to occur within Yosemite National Park (Pierson et al., 2001), five of which are special status species that have experienced state-wide declines (Table 4-1). While population declines are based largely on issues that affect these species outside park boundaries, they serve to highlight the importance of park land as a potential refuge, and signal a potentially heightened sensitivity of these species to management activities within the park.

Bat populations in Poopenaut Valley may also serve as an ecological indicator of habitat health by providing information for further refining flow recommendations for the Tuolumne River, particularly the timing of when water should be released from O'Shaughnessy Dam. Past studies suggest that the highest bat species diversity, detection rates, and degree of foraging activity occur in the park's lower elevations (Pierson et al., 2001; Pierson et al., 2006; Pierson and Rainey, 2009; Rainey et al., 2009). Most bat species in Yosemite forage for insects over ponds, rivers, meadows, and among riparian vegetation, which are all affected either directly or indirectly by stream flow. Bat species richness and foraging activity can be linked to prey availability which appears to respond to fluctuations in stream flow.

To understand potential effects of altered hydrology below O'Shaughnessy Dam on wildlife in Poopenaut Valley we have accomplished the following objectives: (1) modeled predicted occurrence of vertebrate species between O'Shaughnessy Dam and the park boundary and in Poopenaut Valley using California Wildlife Habitat Relationships (CWHR) system models and validation tools (National Park Service, 2007); (2) characterized breeding bird and bat communities in Poopenaut Valley (National Park Service, 2007, 2008, 2009, 2010).

In 2010 we began a more in-depth investigation into the breeding ecology of five riparian bird focal species (RHJV, 2004), and initiated a bat study to gather baseline data toward relating seasonal population trends to water availability in Poopenaut Valley. Our research objectives in 2011-2012 for birds were to determine breeding characteristics (arrival time, number of breeding pairs, nesting success, and territory size and distribution) of four riparian focal species (RHJV, 2004) that breed in Poopenaut Valley: Black-headed Grosbeak (*Pheucticus melanocephalus*), Song Sparrow (*Melospiza melodia*), Warbling Vireo (*Vireo gilvus*), and Yellow Warbler (*Setophaga petechia*). Our research objectives for bats were to: (1) characterize the bat community in Poopenaut Valley and determine seasonal patterns of bat species presence in Poopenaut Valley. This information on breeding birds and seasonal bat populations will enable us to provide informed recommendations to the San Francisco Public Utilities Commission on timing water releases from O'Shaughnessy Dam in order to benefit focal bat and bird species.

Table 4-1. Names and codes of the seventeen bat species known to occur in Yosemite National Park. Species in bold indicate California species of special concern. Code names are used in all result tables and figures.

Code	Common Name	*Genus species*
Anpa	**Pallid bat**	***Antrozous pallidus***
Coto	**Townsend's big-eared bat**	***Corynorhinus townsendii***
Epfu	Big brown bat	*Eptesicus fuscus*
Euma	**Spotted bat**	***Euderma maculatum***
Eupe	**Western mastiff bat**	***Eumops perotis***
Labl	**Western red bat**	***Lasiurus blossevillii***
Laci	Hoary bat	*Lasiurus cinereus*
Lano	Silver-haired bat	*Lasionycteris noctivagans*
Myca	California myotis	*Myotis californicus*
Myci	Small-footed myotis	*Myotis ciliolabrum*
Myev	Long-eared myotis	*Myotis evotis*
Mylu	Little brown bat	*Myotis lucifugus*
Myth	Fringed myotis	*Myotis thysanodes*
Myvo	Long-legged myotis	*Myotis volans*
Myyu	Yuma myotis	*Myotis yumanensis*
Pahe	Canyon bat	*Parastrellus hesperus*
Tabr	Mexican free-tailed bat	*Tadarida brasiliensis*

4.2 Methods

4.2.1 Bird Area Search and Point Count Surveys

We conducted the sixth year of standardized area search surveys (2007-2012) and the fifth year of point count surveys (2008-2012) to estimate bird community species abundance, composition, and habitat use in Poopenaut Valley wet meadow and montane riparian habitats. We conducted area searches in five distinct areas, each comprising approximately 0.03 km^2 (3 hectares) (Figure 4-1); see the 2007 Looking Downstream Report (National Park Service, 2009) for a thorough description of protocols and search areas.

In 2008 we established two point count locations, one on either side of the river in Poopenaut Valley at locations intersecting Areas 1 and 2; and Areas 3 and 4 (Figure 4-1). We used the standardized point count protocol for monitoring landbirds (Ralph et al., 1993, Nur et al., 1999), including the use of a standardized datasheet. Use of standardized methods will allow data to be compared among point count survey results in subsequent years, as well as in areas outside of Poopenaut Valley. Each set of surveys were spaced at least 10 days apart and were completed by 10 am. Point counts were conducted for 5-minutes each, during each of the three visits, following the area searches. For both survey methods, the observer recorded observed species, method of detection (visual, song, or call), and indications of breeding status, such as copulation, courtship or territorial display, food carrying, and any observed fledglings. Data analysis of area searches and point counts included relative abundance, species richness, species diversity index, evenness, and dissimilarity (see 2007 Report for description of data analysis methods and examples of standardized datasheets).

4.2.2 Bird Spot Map Surveys

We conducted spot map surveys in the same avian search areas (Areas 1-5) as the area searches (Figure 4-1). We completed 8 visits in 2011 and 9 visits in 2012. Because of difficulty crossing the river during high flows, we only surveyed Areas 1 and 2 on the north side of the river when river flow allowed safe crossing. During a single visit, we spent between 40 to 90 minutes spot mapping each area, and finished by 12 pm. We adapted spot mapping methods from the standardized spot mapping protocol described by Bibby et al., (1992) and Ralph et al., (1993). The observer walked the area slowly, stopping for as long as necessary to mark every bird detected in its exact location on a map of the area. We recorded birds inside each area, and within 10 meters outside the area boundary, unless the boundary was the dividing line between areas. The observer distinguished males from females if possible, and marked their locations on the map using a different symbol. The observer also noted if males were singing (denoted by circling the male), recorded any and all territorial behavior including chasing or counter-singing (denoted by drawing dotted lines between individuals), and noted the direction of movement of individuals using arrows. During each visit, the observer recorded data on a new map.

At the end of the season, we prepared cumulative maps for the four focal species: Black-headed Grosbeak, Song Sparrow, Warbling Vireo, and Yellow Warbler in order to determine number of breeding pairs and territory sizes and distribution. We digitized these maps and analyzed the detection data using geographic information system software (GIS). We mapped locations of individuals, pairs, and territorial behavior such as counter-singing and chasing. Measuring the size of bird territories has been done using various methods in the past (Hayne, 1949; Odun and Kuenzler, 1955; Suthers, 1960; Wiens et al., 1985). Traditionally, bird detections were marked on a map, and then clusters of detections were grouped into the smallest polygon in which no internal angle exceeded 180 degrees (Burgman and Fox, 2003). This method is known as minimum convex polygons (Mohr, 1947). Without the aid of computer analysis, minimum convex polygons remain the best choice because of their simplicity (Burgman and Fox, 2003). While this method provides useful insight into potential territories, it is susceptible to significant observer bias (Laver and Kelly, 2008; Nilsen et al., 2008; Worton, 1995). For each species, we plotted each pair's territory location and size using kernel density estimation which has been argued to be a more rigorous method of mapping home ranges (Borger et al., 2006; Naef-Daenzer, 1993; Seaman and Powell, 1996) and the minimum convex polygon method (Mohr, 1947; Silverman, 1986). The kernel density estimation produced a raster layer depicting detection densities. This layer estimated a probability density for the entire study area. To identify each territory belonging to a pair of birds, we used the kernel raster layer as a visual guide for creating a convex hull around groups of points. We used minimum registration number guidelines from I.B.C.C., (1970) to avoid selecting clusters with not enough detections. Each resulting convex hull represented an independent territory.

4.2.3 Bird Nest Search Surveys

We conducted nest search surveys simultaneously with spot map surveys, and used a standardized nest searching protocol (PRBO, 2001). Birds exhibiting probable or confirmed breeding activity such as foraging in pairs, carrying nesting material, or carrying food were followed as closely as possible in order to find nests, and their movements and behaviors were mapped onto the spot maps. For each nest, we recorded the nest location using a GPS unit and recorded information about the status and location of the nest onto a nest card. During every subsequent site visit, we checked each nest and recorded the observed nest activity onto the nest card. At the end of the season, we transferred nest card information onto a nest record sheet and coded nest results.

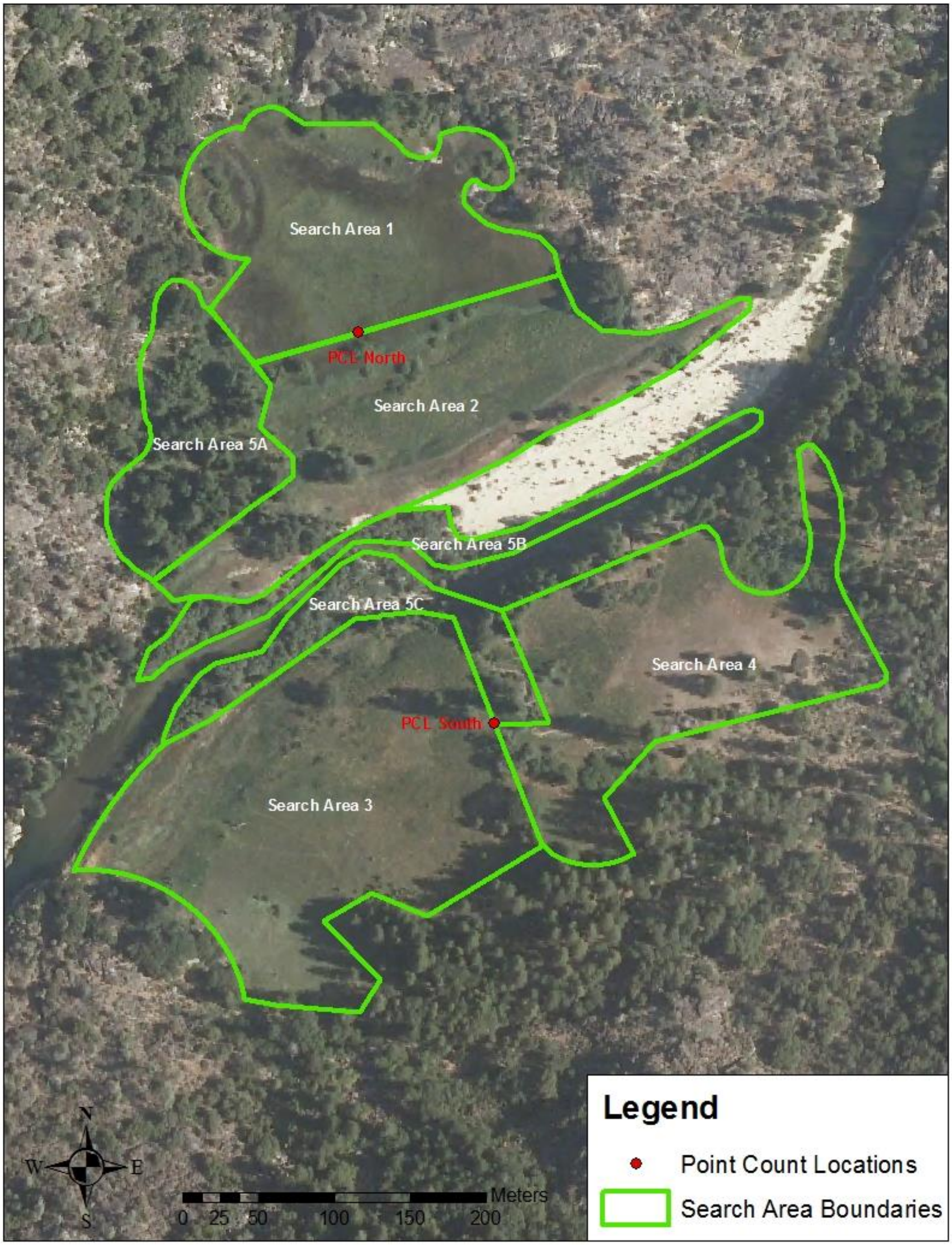

Figure 4-1. Bird search areas (same as spot map and nest search areas) and point count locations (PCL) in Poopenaut Valley.

4.2.4 Bat Acoustic Surveys

We conducted acoustic bat surveys at two sites in Poopenaut Valley to determine species presence and activity level. We deployed one bat detector on the south side of the Tuolumne River and operated it on a year-round basis in order to determine seasonal bat patterns in relation to stream flow. We deployed a second bat detector on the north side of the Tuolumne River adjacent to the seasonal pond and, when accessible, operated it to determine the relationship between bat foraging activity and water levels and insect availability in the adjacent seasonal pond (Figure 4-2).

At each site, we secured one detector and external battery in a locked metal box at the base of a 6.1 m (20 ft.) tall metal pole (Figure 4-3). At the top of the metal pole, we mounted an external microphone in a weather-proof metal casing and positioned it horizontally to face the meadow opening (south site) and seasonal pond (north site) in order to increase the detection probability of foraging bats. We powered each detector with a 9-volt external battery, which we secured in the locked metal box. Each detector recorded sound in the high frequency range continuously during each night between 1900 and 0700 during the first month of survey. For the remaining time period, each detector recorded sound in the high frequency range each night at two different time periods: (1) 1900 - 2300 and (2) 0300 - 0700. Acoustic surveys at the south site occurred from 14 April 2011 to 19 August 2012. Acoustic surveys at the north site occurred from 19 April 2011 to 15 August 2012. Detectors were scheduled to be checked on a monthly basis. Due to erratic equipment failure (both sites) and accessibility issues (north site only), continuous monitoring was not possible. Total seasonal monitoring effort for each site is shown in Table 4-2.

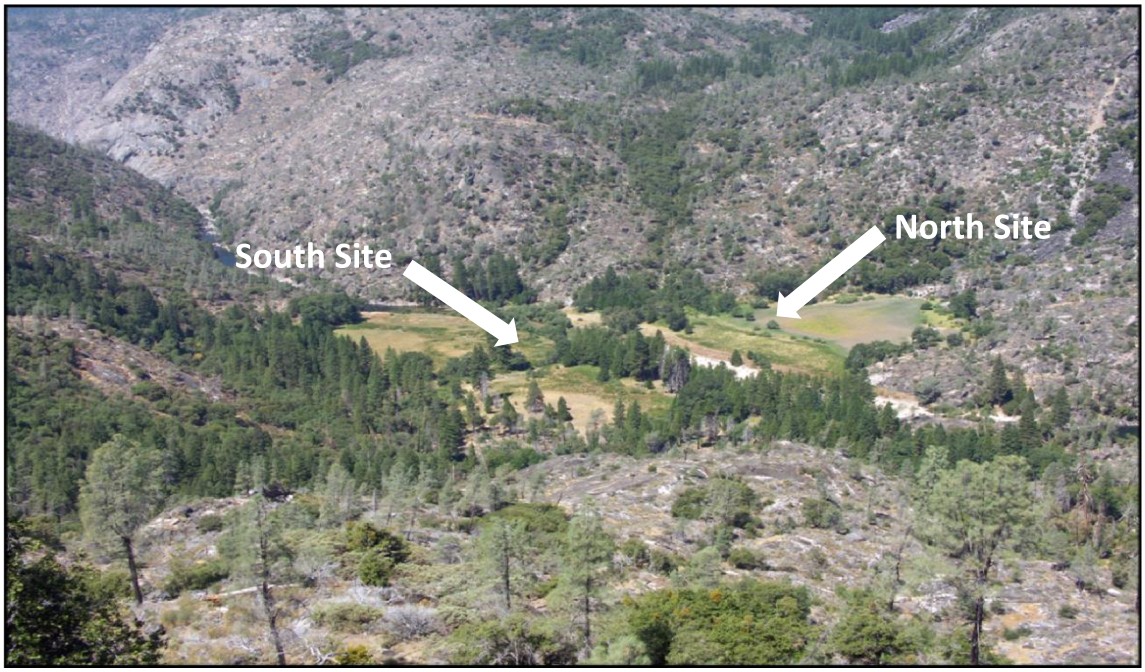

Figure 4-2. Acoustic monitoring sites in Poopenaut Valley, Yosemite National Park. Monitoring occurred between April 2011 and August 2012 at two sites: (1) north of the Tuolumne River adjacent to the seasonal pond and (2) south of the Tuolumne River.


Figure 4-3. Acoustic bat detector set-up (left) north of the Tuolumne River adjacent to the seasonal pond and (right) in the meadow south of the Tuolumne River.

Table 4-2. Total seasonal monitoring effort from acoustic bat detectors at two sites in Poopenaut Valley, Yosemite National Park from 14 April 2011 to 19 August 2012. For each season and site, the first number indicates total number of days that the detector operated; the second number in parentheses indicates the percentage of time that the detector operated.

	Spring 2011 (Mar-May)	Summer 2011 (Jun-Aug)	Fall 2011 (Sep-Nov)	Winter 2011/2012 (Dec-Feb)	Spring 2012 (Mar-May)	Summer 2012 (Jun-Aug)
North	42 (46%)	5 (5%)	48 (53%)	70 (78%)	92 (100%)	76 (83%)
South	14 (15%)	18 (20%)	82 (90%)	90 (100%)	90 (98%)	80 (87%)

Dr. Joe Szewczak, creator of SonoBat™, provided specialized hands-on training the week of 28 June 2010 to instruct Yosemite Wildlife Biologists to use bat detection and recording software and equipment and analyze and interpret bat echolocation calls. We used Pettersson D500x ultrasound recording units coupled with SonoBat™ software for full-spectrum acoustic monitoring and bat echolocation call identification. The Pettersson D500x hardware is built specifically for long-term passive monitoring. SonoBat™ software provides a comprehensive tool for analyzing and comparing high-resolution full-spectrum sonograms of bat echolocation calls. SonoBat™ uses a decision engine based on the quantitative analysis of approximately 10,000 species-known recordings from across North America. The software automatically recognizes and sorts calls, then processes the calls to extract six dozen parameters that describe the time-frequency and time-amplitude trends of a call.

SonoBat's call trending algorithm recognizes the end of calls buried in echo and noise as well as establishes trends through noise and from low power signals. SonoBat™ generates high resolution continuous trends of time-frequency and time-amplitude content that enable robust parameter extraction. Inclusion of amplitude parameters increases classification performance above that achieved by using time-frequency parameters alone. We analyzed echolocation call data from each site using the batch process option in SonoBat™. The discriminant probability threshold for each echolocation call was set at 0.90 and the acceptable call quality was set at 0.80. Species were identified by consensus only.

Because we have only completed 1.5 years of acoustic monitoring for this study, we feel that any comparison to water levels, stream flow, and insect availability would be premature until more data is collected. Thus, our results and the ensuing discussion focus on seasonal patterns of bat species present in Poopenaut Valley.

4.3 Results

4.3.1 2011 Bird Area Searches

The fifth consecutive year of area search surveys in Poopenaut Valley took place during summer 2011 and comprised three separate visits (19 May 2011, 31 May 2011, and 10 June 2011). During all three visits, the north side of the river (Areas 1, 2, 5A, and 5B) was inaccessible due to high water, and those Search Areas and the Point Count Location were omitted from analyses accordingly. During the three visits, flow was approximately 23 cms (805 cfs), 120 cms (4,240 cfs) and 100 cms (3,540 cfs), respectively.

For area searches, a total of 279 individuals of 40 species was observed in Poopenaut Valley. Accounting for possible duplicate observations among visits, we estimated relative abundance to be 174 individuals (Table 4-3). The five most frequently encountered species were: Black-headed Grosbeak (29 individuals), Warbling Vireo (27 individuals), Yellow Warbler (21 individuals), Western Wood-Pewee (*Contopus sordidulus)* (18 individuals), and Spotted Towhee (*Pipilo maculatus*) (16 individuals).

Table 4-3. Bird species detected from area search surveys and their relative abundance in Poopenaut Valley, Yosemite National Park, in May - June 2011.

		Areas			
English Name	**Status**	**3**	**4**	**5**	**Totals**
Acorn Woodpecker		2	3		5
American Robin		2	2	1	5
Anna's Hummingbird		1		1	2
Blue-gray Gnatcatcher				1	1
Brown-headed Cowbird		2	2	2	6
Black-headed Grosbeak	RFS	3	7	3	13
Brewer's Blackbird				1	1
Black-throated Gray Warbler		1			1
Bullock's Oriole		2		3	5
Cassin's Vireo		2	1	3	6
Chipping Sparrow		3	2	2	7
Dark-eyed Junco		2			2
Dusky Flycatcher			1		1
Gray Flycatcher			1		1
Hairy Woodpecker				1	1
House Wren		2			2
Lazuli Bunting		1	3	1	5
Lesser Goldfinch		4	2	1	7
Mallard		2	2	3	7
MacGillivray's Warbler			1	1	2
Mountain Quail			1		1
Nashville Warbler		2	1		3
Northern Flicker		1	1		2
Nuttall's Woodpecker				1	1
Pine Siskin			1		1
Pacific-slope Flycatcher		1			1
Purple Finch		1	3	1	5
Red-breasted Nuthatch		1		1	2
Red-winged Blackbird				4	4
Song Sparrow	RFS	1	2	5	8
Spotted Sandpiper		1		3	4
Spotted Towhee		2	3	2	7
Steller's Jay		4	2		6
Violet-green Swallow				2	2
Warbling Vireo	RFS	3	6	4	13
Western Tanager		2	3		5
Western Wood-Pewee		3	1	6	10
Wilson's Warbler			1		1
Yellow-rumped Warbler		1	4	1	6
Yellow Warbler	CSC, SSC, RFS	3	3	6	12
Total		**55**	**59**	**60**	**174**

CSC = California species of special concern; SSC = CDFG Bird Species of Special Concern; RFS = California Partners in Flight Riparian Focal Species

Bird indices from the wet meadow habitat in Search Area 3 had the highest number of species richness (28 species), diversity index (*H* = 3.23), and relatively high evenness (*J* = 0.97). The wet meadow areas averaged 57 detections (relative abundance) of 27 species (Table 4-4), which were similar compared to the indices for the montane riparian area (60 detections of 26 species). Of all five search areas, Search Area 5 had the most number of detections (60 individuals).

Table 4-4. Bird species richness (number of species), abundance, diversity, and evenness from area searches, by study area in Poopenaut Valley, Yosemite National Park, May - June 2011.

Search Area	Species Richness	Abundance Estimate*	Species Diversity Index*	Evenness*
Search Area 3 Wet Meadow	28	55	3.229	0.969
Search Area 4 Wet Meadow	26	59	3.071	0.943
Search Area 5 Montane Riparian	26	60	3.050	0.936

*For each species in a given area, the highest number of individuals detected in the three visits is reported.

Analysis of area search survey data from Search Areas 3, 4, and 5C using the Bray-Curtis Dissimilarity Measure revealed that Areas 4 and 5 differed the most in community assemblage (I_{BC} = 0.333, Table 4-5), meaning they shared the least number of species in common. Areas 3 and 5 shared the highest degree of community similarity (I_{BC} = 0.244, Table 4-5), meaning they had similar species composition.

Table 4-5. Bray-Curtis Dissimilarity Matrix for bird assemblages by search area in Poopenaut Valley, Yosemite National Park, May - June 2011. Numbers enclosed in boxes indicate the least and most similar sites.

	Area 3	*Area 4*	*Area 5*
Area 3	0		
Area 4	0.277	0	
Area 5	0.244	0.333	0

4.3.2 2011 Bird Point Counts

The fourth year of point counts in Poopenaut Valley took place during 2011 and comprised three separate visits (19 May 2011, 31 May 2011, and 10 June 2011). Because the river was too high to cross during every visit, we were only able to survey Point 2 (PCL South). To account for differences in effort, we report relative abundance as the average number of individuals per visit. We detected an average of 27 individuals of 22 species (Table 4-6).

Table 4-6. Total number of individuals, species relative abundance, and species richness by point using 2011 point count data in Poopenaut Valley, Yosemite National Park. Data include all detections, excluding flyovers.

Point	**South Poopenaut[1] 3 Visits**	
Species	**Number of Individuals**	**Relative Abundance[2]**
American Robin	6	2.00
Brown-headed Cowbird	2	0.67
Black-headed Grosbeak	6	2.00
Bullock's Oriole	5	1.67
Cassin's Vireo	2	0.67
Chipping Sparrow	5	1.67
Gray Flycatcher	1	0.33
Hairy Woodpecker	1	0.33
Lazuli Bunting	1	0.33
Lesser Goldfinch	3	1.00
Lincoln's Sparrow	1	0.33
MacGillivray's Warbler	1	0.33
Mountain Quail	2	0.67
Northern Flicker	4	1.33
Purple Finch	4	1.33
Red-winged Blackbird	2	0.67
Song Sparrow	4	1.33
Spotted Towhee	4	1.33
Steller's Jay	5	1.67
Warbling Vireo	7	2.33
Western Wood-Pewee	7	2.33
Yellow Warbler	8	2.67
Total Individuals	**81**	**27.00**
Species Richness	**22**	**16**

[1]North Poopenaut was not visited due to high flows; South Poopenaut was visited all three times

[2]Average number of individuals per visit

4.3.3 2011 Bird Spot Mapping

In 2011 we conducted the third consecutive year of spot mapping in Poopenaut Valley. We conducted eight separate spot mapping visits: 27 April 2011, 28 April 2011, 3 May 2011, 4 May 2011, 5 May 2011, 11 May 2011, 12 May 2011, and 13 May 2011. We were unable to map Areas 1 and 2 on 12 May 2011 and 13 May 2011 because of high water. We detected a cumulative total of 870 birds of 72 species in all five areas over eight visits. To account for possible duplicate observations among visits, we estimated relative abundance to be 376 individuals (Table 4-7).

Table 4-7. Species richness and relative abundance using 2011 spot mapping data in Poopenaut Valley, Yosemite National Park.

	Area 1	*Area 2*	*Area 3*	*Area 4*	*Area 5*	*Total*
Number of Visits	6	6	8	8	8	
Species Richness	35	27	40	35	45	72
Relative Abundance	86	46	76	74	94	376

In addition to species richness and relative abundance, spot mapping also yielded detailed results for the four riparian focal species: Black-headed Grosbeak, Song Sparrow, Warbling Vireo, and Yellow Warbler.

Black-headed Grosbeak. We first detected Black-headed Grosbeaks in Poopenaut Valley on 28 April 2011. A large influx was noted on 2 May 2011, and territorial behavior was noted soon after. Between 5 May 2011 and 19 May 2011, we identified six territories in the study area. Territories included riparian habitat and mixed oak-conifer forest. Although we never located any nests, we confirmed breeding activity by a female carrying prey items. We observed males engaged in counter-singing and territory defense throughout the survey period. We did not detect juveniles, though this may be attributed to the survey period ending before chicks fledged.

Song Sparrow. Song Sparrows are resident in Poopenaut Valley. Territoriality had started by the time the survey period commenced. We located four territories, all in riparian habitat along the Tuolumne River. Although we frequently observed nesting behavior, we did not locate any nests. We also did not observe any juveniles the duration of the study period, but this may be attributed to fluctuating water levels which may have discouraged nesting attempts. In addition to resident birds, we observed three individuals along the edge of the pond on the north side of the study area. One of these birds was clearly different from the resident individuals, and was probably a migrant from farther north; the other two could have been either transient birds or migrants.

Warbling Vireo. Warbling Vireo is the most common of the four riparian focal species at Poopenaut Valley. We found seven territories. We detected two singing males at the beginning of the study period on 27 April 2011, but by 11 May 2011, all territories were occupied. Like Black-headed Grosbeak, Warbling Vireos occupied territories in both willow-dominated riparian habitat, as well as mixed oak-conifer forest. Pairs aggressively defended territories from both conspecifics as well as other species. We observed females carrying food numerous times, though we located no nests.

Yellow Warbler. Yellow Warblers were the last of the four focal species to initiate breeding. Singing males were present by 3 May 2011 and were defending territory by 5 May 2011. We located two territories during the Spot Mapping phase of the study period. However, during the latter half of May and into June at least two other territories were known to be active within the study area. All territories, including those that were found later in the season, were established in willow-dominated riparian habitat, both along the main Tuolumne River and the north tributary stream. On 12 May 2011, we observed a female bringing nesting material to a partially completed nest in a Black Cottonwood (*Populus trichocarpa*) along the Tuolumne River. On subsequent days, we observed the same female collecting food items, though we did not observe a nest or nestlings.

We mapped breeding territories of Black-headed Grosbeak, Song Sparrow, Warbling Vireo, and Yellow Warbler; Figure 4-4). Within the Poopenaut Valley study area we confirmed five Black-headed Grosbeak territories (Figure 4-5), four Song Sparrow territories (Figure 4-6), eight Warbling Vireo territories (Figure 4-7), and three Yellow Warbler territories (Figure 4-8). Black-headed Grosbeak territories were the largest on average, while Yellow Warbler territories were the smallest.

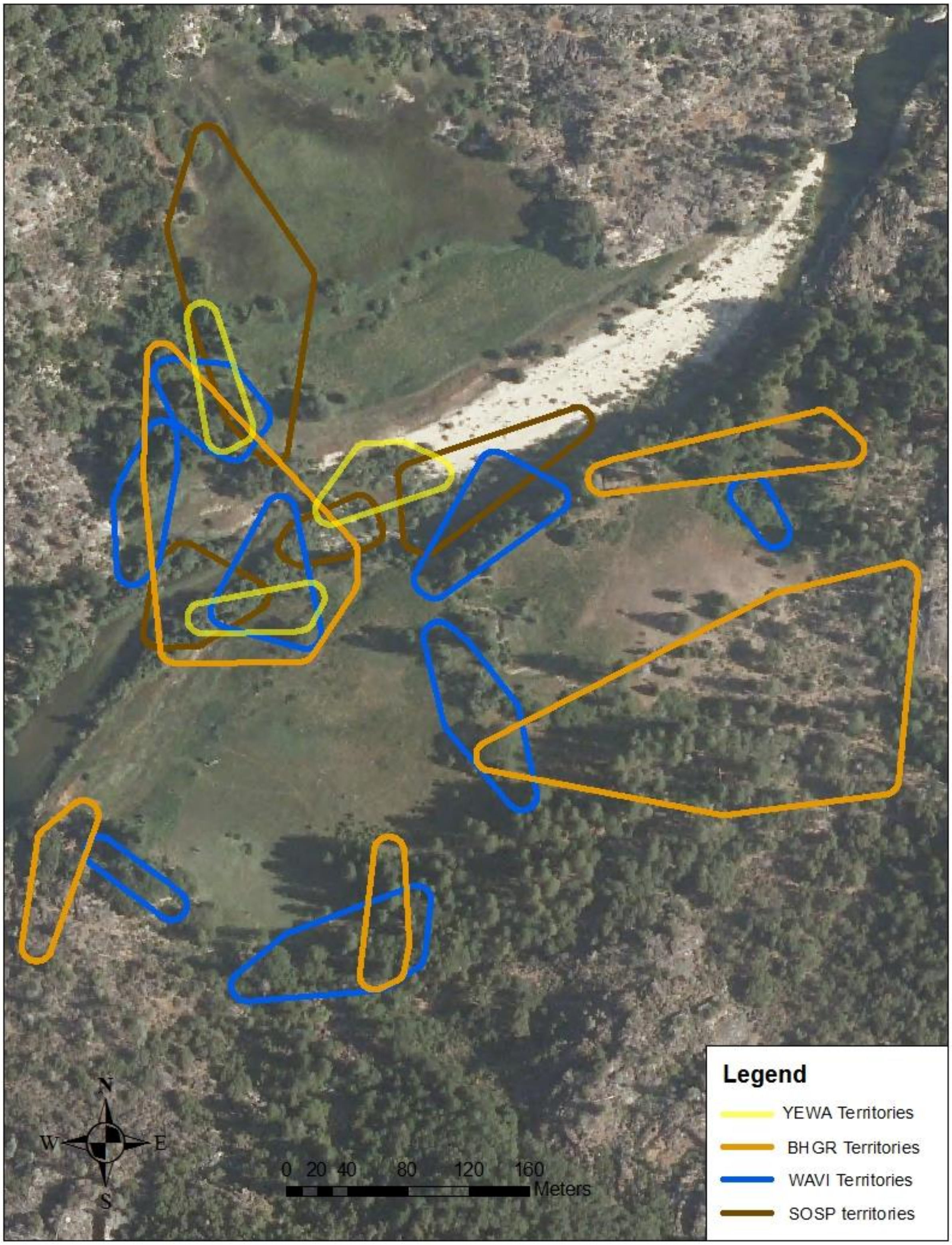

Figure 4-4. Yellow Warbler (YEWA), Black-headed Grosbeak (BHGR), Warbling Vireo (WAVI), and Song Sparrow (SOSP) breeding territories in Poopenaut Valley, 2011.

Figure 4-5. Black-headed Grosbeak (BHGR) breeding territories (with individual detections shown) based on spot map surveys in Poopenaut Valley, 2011.

Figure 4-6. Song Sparrow (SOSP) breeding territories (with individual detections shown) based on spot map surveys in Poopenaut Valley, 2011.

Figure 4-7. Warbling Vireo (WAVI) breeding territories (with individual detections shown) based on spot map surveys in Poopenaut Valley, 2011.

Figure 4-8. Yellow Warbler (YEWA) breeding territories (with individual detections shown) based on spot map surveys in Poopenaut Valley, 2011.

4.3.4 2011 Bird Nest Searching

In 2011 we conducted the third consecutive year of nest searching in Poopenaut Valley. We conducted eight separate nest searching visits: 27 April 2011, 28 April 2011, 3 May 2011, 4 May 2011, 5 May 2011, 11 May 2011, 12 May 2011, and 13 May 2011. We were unable to conduct nest searching in Areas 1 and 2 on 12 May 2011 and 13 May 2011 because of high water. We documented nine nests of eight species (Table 4-8) and plotted their locations (Figure 4-9).

Table 4-8. Nests confirmed during 2011 nest searching in Poopenaut Valley, Yosemite National Park.

Species	Nests located
Acorn Woodpecker	1
American Robin	2
Bullock's Oriole	1
Cassin's Vireo	1
House Wren	1
Lesser Goldfinch	1
Spotted Towhee	1
Yellow Warbler[1]	1

[1] Riparian Focal Species

In 2011 all nine nests were discovered between 5 May and 10 June. The second week of May was the most productive time period for locating nests. Below we describe the results from nest searching.

House Wren (Troglodytes aedon). Found 5 May 2011 when one adult entered the nesting cavity. Cavity was in a California black oak (*Quercus kelloggii*) snag on the edge of the meadow; cavity was formed from a broken-off branch. No further detections were noted. 11S 251955 4200443

Acorn Woodpecker (Melanerpes formicivorus). Found 11 May 2011 when we observed both adults entering the cavity. Cavity was approximately 6 m above the ground in a large gray pine (*Pinus sabiniana*) on the north side of the seasonal pond. No follow up was possible due to flooded river. 11S 252050 4200950

Cassin's Vireo (Vireo cassinii). Found 12 May 2011 when we observed the female carrying nesting material while the male sang nearby. We observed the female in incubation posture on 19 May 2011. Nest was approximately 5 m above the ground in a black oak on the east side of the tree. The tree was near the small stream at the edge of the meadow, on the boundary between areas 3 and 4. 11S 252191 4200474

Yellow Warbler. Found 12 May 2011 when we observed the female carrying material to nest several times. Nest was approximately 12 m above the surface of the river in a large willow (*Salix* spp) growing on a sandbar in the river. No further activity at the nest was observed, but we observed the female foraging and gathering food on later dates. 11S 252079 4200615

Spotted Towhee. Found 12 May 2011 when female flushed off the nest. Nest was on the ground under some willows. One egg was in the nest, but on 19 May 2011 the nest was empty. The nest was in thick riparian vegetation next to the stream in Area 4. 11S 252360 4200649

Bullock's Oriole (Icterus bullockii). Found 13 May 2011 when female was observed attending half-built nest. Nest was approximately 7 m above the ground in a willow along the flooded river. No further detections were made, due to the inaccessibility of the location after the river continued to flood. 11S 251975 4200546

American Robin (Turdus migratorius). Nest 1: Found 19 May 2011 when Western Scrub-Jay (*Aphelocoma californica*) raided the nest. Nest was in nestling stage, but the scrub-jay ate all (3+) of the nestlings. Nest was in a dense stand of willows on a sandbar along the river. 11S 252092 4200633

American Robin. Nest 2: Found 10 June 2011. Nest was adjacent to the south side Bat detector, located low in a small cottonwood. On 30 June 2011 the nest was empty. 11S 252198 4200579

Lesser Goldfinch (Spinus psaltria). Found 10 June 2011 when female flushed from the nest. Nest was approximately 1.5 m above the ground on the north side of a small willow on a slight rise, near a large, distinctive black oak in Area 3. There were four eggs in the nest. 11S 252040 4200600

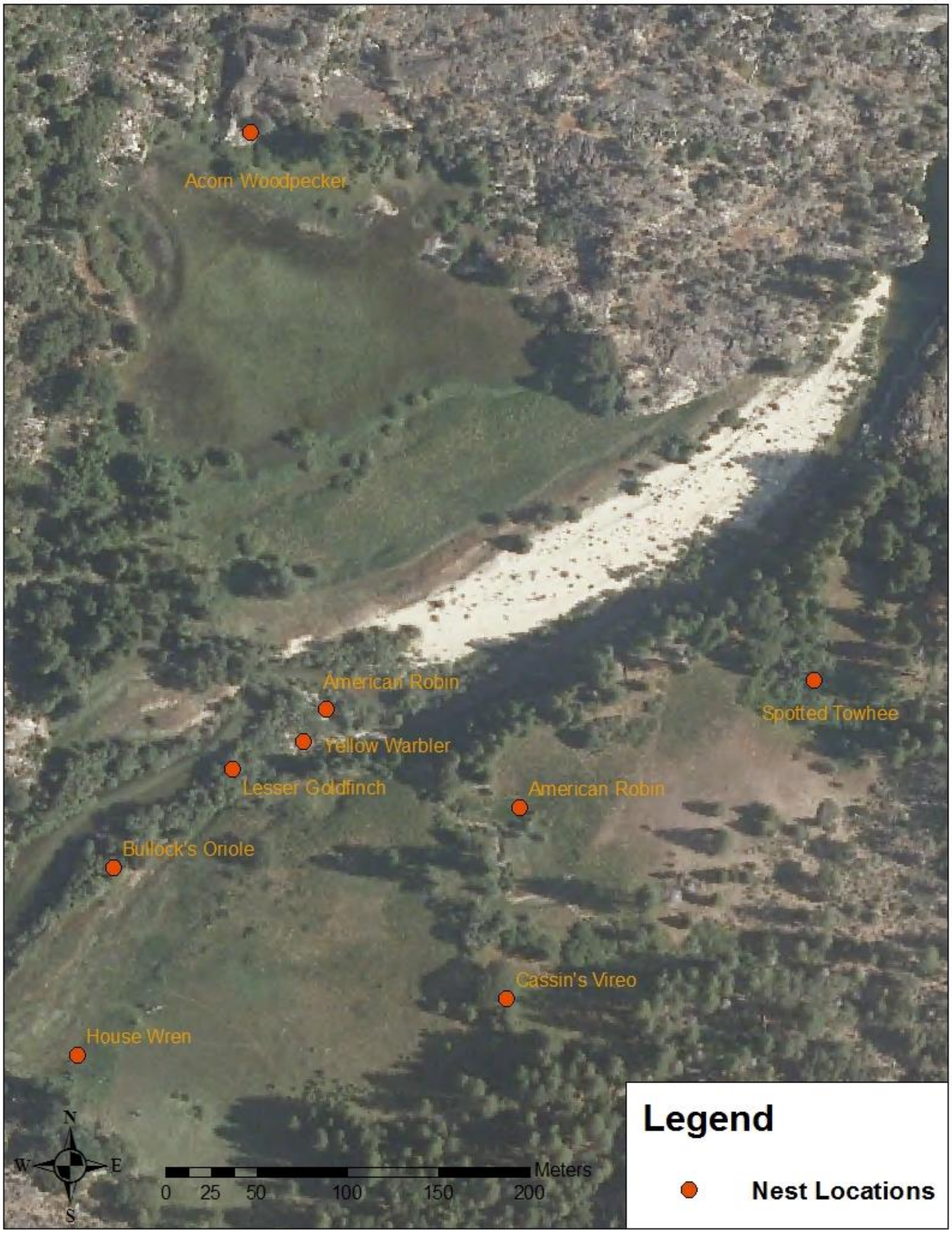

Figure 4-9. Locations of bird nests in Poopenaut Valley, 2011.

4.3.5 2012 Bird Area Searches

The sixth consecutive year of area search surveys in Poopenaut Valley took place during summer 2012 and comprised three separate visits (21 May 2012, 6 June 2012, and 22 June 2012). During the first two visits, the north side of the river (Areas 1, 2, 5A, and 5B) was inaccessible due to high water, and those Search Areas and the Point Count Location were omitted from analyses accordingly. During the three visits, flow was approximately 35 cms (1230 cfs), 18 cms (619 cfs) and 3 cms (116 cfs), respectively.

For area searches, a total of 231 individuals of 38 species were observed in Poopenaut Valley. Accounting for possible duplicate observations among visits, we estimated relative abundance to be 153 individuals (Table 4-9). The five most frequently encountered species were: Western Wood-Pewee (20 individuals), Warbling Vireo (18 individuals), Bullock's Oriole (18 individuals), Spotted Towhee (16 individuals), and Western Tanager (*Piranga ludoviciana*) (16 individuals).

Table 4-9. Bird species detected from area searches and their relative abundance in Poopenaut Valley, Yosemite National Park, in May – June 2012.

		Areas					
Species	**Status**	**Area 1**	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Totals**
Acorn Woodpecker		1	1	1	1		4
American Robin		1		1	2	1	5
Anna's Hummingbird					1		1
Belted Kingfisher			1			1	2
Blue-gray Gnatcatcher		2				1	3
Brown-headed Cowbird			2	2	1	1	6
Black-headed Grosbeak	RFS	1	1	2	1	1	6
Brown Creeper				1			1
Band-tailed Pigeon					1		1
Black-throated Gray Warbler				1	1		2
Bullock's Oriole			2	5	1	2	10
Bushtit					1		1
Canada Goose				2			2
Cassin's Vireo			1	3	1	1	6
Chipping Sparrow					1		1
Hairy Woodpecker					1		1
House Wren		1		3			4
Lazuli Bunting			1	1	1		3
Lesser Goldfinch			1	1	4	2	8
Mallard		1		2	2		5
Mountain Quail				1			1
Nashville Warbler				1			1
Northern Flicker				1	1		2
Northern Rough-winged Swallow				1			1

Nuttall's Woodpecker				1			1
Pacific-slope Flycatcher				1			1
Purple Finch				1			1
Red-winged Blackbird		4	8			3	15
Song Sparrow	RFS					2	2
Spotted Towhee		1		2	4	2	9
Steller's Jay				2	2	1	5
Warbling Vireo	RFS	1	1	3	2	2	9
Western Scrub-Jay		1					1
Western Tanager		2	2	3	2		9
Western Wood-Pewee		1	1	2	2	4	10
Wrentit		1					1
White-throated Swift		3	2				5
Yellow Warbler	CSC, SSC, RFS	1	2	1	1	2	7
Total		**22**	**26**	**45**	**34**	**26**	**153**

CSC = California species of special concern; SSC = CDFG Bird Species of Special Concern; RFS = California Partners in Flight Riparian Focal Species

Bird indices from the wet meadow habitat in Search Area 3 had the highest number of species richness (26 species), diversity index (H = 3.12), and relatively high evenness (J = 0.96). The wet meadow areas averaged 32 detections (relative abundance) of 19 species (Table 4-10), which was much greater compared to the indices for the montane riparian area (26 detections of 15 species). Of all five search areas, Search Area 3 had the most number of detections (45 individuals).

Table 4-10. Species richness, abundance, bird diversity, and evenness from area searches, by study area in Poopenaut Valley, Yosemite National Park, May - June 2012.

Search Area	Species Richness	Abundance Estimate*	Species Diversity Index*	Evenness*
Search Area 1 Wet Meadow	15	22	2.563	0.946
Search Area 2 Wet Meadow	14	26	2.352	0.891
Search Area 3 Wet Meadow	26	45	3.119	0.957
Search Area 4 Wet Meadow	22	34	2.956	0.956
Search Area 5 Montane Riparian	15	26	2.598	0.959

*For each species in a given area, the highest number of individuals detected in the three visits is reported.

Analysis of area search survey data from Search Areas 1, 2, 3, 4, and 5C using the Bray-Curtis Dissimilarity Measure revealed that Areas 1 and 5 differed the most in community assemblage (I_{BC} = 0.429, Table 4-11), meaning they shared the least number of species in common. Areas 1 and 2 shared the highest degree of community similarity (I_{BC} = 0.091, Table 4-9), meaning they had similar species composition.

Table 4-11. Bray-Curtis Dissimilarity Matrix for bird assemblages by search area in Poopenaut Valley, Yosemite National Park, May - June 2012. Numbers enclosed in boxes indicate the least and most similar sites.

	Area 1	*Area 2*	*Area 3*	*Area 4*	*Area 5*
Area 1	0				
Area 2	0.091	0			
Area 3	0.286	0.333	0		
Area 4	0.167	0.231	0.125	0	
Area 5	0.429	0.333	0.333	0.250	0

4.3.6 2012 Bird Point Counts

The fifth year of point count surveys in Poopenaut Valley took place during 2012 and comprised three separate visits (21 May 2012, 6 June 2012, and 22 June 2012). Because the river was too high to cross until the third visit, we were not able to conduct surveys on the north side during visits 1 and 2. Results from the south side were averaged per visit to account for differences in effort. At North Poopenaut, we detected 16 individuals of 13 species; at South Poopenaut, we detected an average of 15.33 individuals of 17 species (Table 4-12).

Table 4-12. Total number of individuals, species relative abundance, and species richness by point using 2012 point count data in Poopenaut Valley, Yosemite National Park. Data include all detections, excluding flyovers.

Point	**North Poopenaut 1 Visit[1]**		**South Poopenaut 3 Visits[1]**	
Species	**Number of Individuals**	**Relative Abundance[2]**	**Number of Individuals**	**Relative Abundance[2]**
Acorn Woodpecker	1	NA	0	0
American Robin	1	NA	2	0.67
Belted Kingfisher	1	NA	0	0
Black-headed Grosbeak	0	NA	1	0.33
Brown-headed Cowbird	1	NA	0	0
Bullock's Oriole	1	NA	3	1
Cassin's Vireo	2	NA	2	0.67
House Wren	1	NA	1	0.33
Lazuli Bunting	1	NA	2	0.67
Lesser Goldfinch	1	NA	1	0.33
Mountain Quail	0	NA	2	0.67
Northern Flicker	0	NA	1	0.33
Red-winged Blackbird	0	NA	2	0.67
Song Sparrow	0	NA	2	0.67
Spotted Towhee	0	NA	4	1.33
Steller's Jay	0	NA	5	1.33
Warbling Vireo	1	NA	6	2
Western Tanager	2	NA	5	1.67
Western Wood-Pewee	2	NA	4	1.33
Yellow Warbler	1	NA	3	1
Total Individuals	**16**	NA	**46**	**15.33**
Species Richness	**13**	NA	**17**	**11.67**

[1]North Poopenaut was visited only once due to high flows; South Poopenaut was visited all three times
[2]Average number of individuals per visit
NA = Not applicable because only one visit was conducted

4.3.7 2012 Bird Spot Mapping

In 2012 we conducted the third consecutive year of spot mapping and nest searching in Poopenaut Valley. We conducted nine spot mapping visits: 27 April 2012, 3 May 2012, 4 May 2012, 7 May 2012, 11 May 2012, 22 May 2012, 30 May 2012, 7 June 2012, and 21 June 2012. Areas 1 & 2 were mapped only on 27 April 2012, 30 May 2012, and 21 June 2012. During the other spot map surveys these areas were inaccessible due to high water in the river. A cumulative total of 773 birds of 51 species were detected in all five areas over all nine visits. To account for possible duplicate observations among visits, we estimated relative abundance to be 327 individuals (Table 4-13).

Table 4-13. Species richness and relative abundance by search area using 2012 spot mapping data in Poopenaut Valley, Yosemite National Park. Data include all detections, excluding flyovers.

	*Area 1**	*Area 2**	*Area 3*	*Area 4*+	*Area 5*	*Total*
Number of Visits	3	3	9	8	9	
Species Richness	24	24	30	33	33	51
Relative Abundance	34	45	92	84	72	327

In addition to species richness and relative abundance, spot mapping also yielded detailed results for the four riparian focal species: Black-headed Grosbeak, Song Sparrow, Warbling Vireo, and Yellow Warbler.

Black-headed Grosbeak. We first detected Black-headed Grosbeaks in Poopenaut Valley during the first survey on 27 April 2012. We did not detect any females until 3 May 2012. On this date, we observed many pairs together, and males engaged in territorial behavior such as chasing and counter-singing. Most of the birds we observed were along the forest edge using riparian and mixed oak-conifer habitats. We found one nest on 11 May 2012 on the north side of the river and on 30 May 2012 we observed a female carrying nesting material at the west end of area 5B, but could not locate the nest. We identified six territories in the areas 3, 4, and 5.

Song Sparrow. We first detected Song Sparrows during the first survey on 27 April 2012. Their abundance remained stable from that date throughout the remainder of the field season. We observed this species most frequently within the riparian habitat along areas 5B and 5C, where we confirmed four territories. An unconfirmed territory was located in area 4 and consisted of two detections from the first survey visit on 27 April 2012 and no subsequent detections. Interestingly, this territory appeared to have been occupied in 2010 but not in 2011. On 27 April 2012, we observed a bird gathering nesting material along the river’s edge, but a nest was never located. Despite prevalent counter-singing during most survey visits, there were no confirmed nests.

Warbling Vireo. We first detected Warbling Vireos during the first survey on 27 April 2012. On this date, males had already begun establishing territories (chasing, counter-singing) and forming pair bonds with females. During surveys, we observed more pairs and detected more nests of Warbling Vireo than any other focal species. We found one nest on 11 May 2012 and two nests on 21 May 2012. We identified eight territories in the areas 2, 3, 4, and 5, mostly located in riparian and forest edge habitats.

Yellow Warbler. Yellow Warblers arrived later in Poopenaut Valley than the other focal species, which corresponds with observations from 2011. We detected two males on 3 May 2012, but only one male on subsequent surveys on 4 May 2012 and 7 May 2012. We observed more individuals on 11 May 2012 (six individuals) and 12 May 2012 (4 individuals), including the first female on 12 May 2012. Spot-mapping suggested that territories were not firmly established until the end of May. We identified six territories, however it is likely that one or more of these may be the result of outlier detections rather than established territories. Territories were in a range of different habitat types including riparian, forest edge, and meadow. We observed copulation on 21 May 2012, however we observed no other breeding behavior nor did we detect any nests.

We mapped breeding territories of Black-headed Grosbeak, Song Sparrow, Warbling Vireo, and Yellow Warbler; Figure 4-10). Most of the territories were located along meadow edges, especially where willows were present (Figure 4-10). We confirmed 6 Black-headed Grosbeak territories (Figure 4-11), 4 Song Sparrow territories (Figure 4-12), 8 Warbling Vireo territories (Figure 4-13), and 4 Yellow Warbler territories (Figure 4-14). Warbling Vireo territories were the largest on average, while Song Sparrow territories were the smallest.

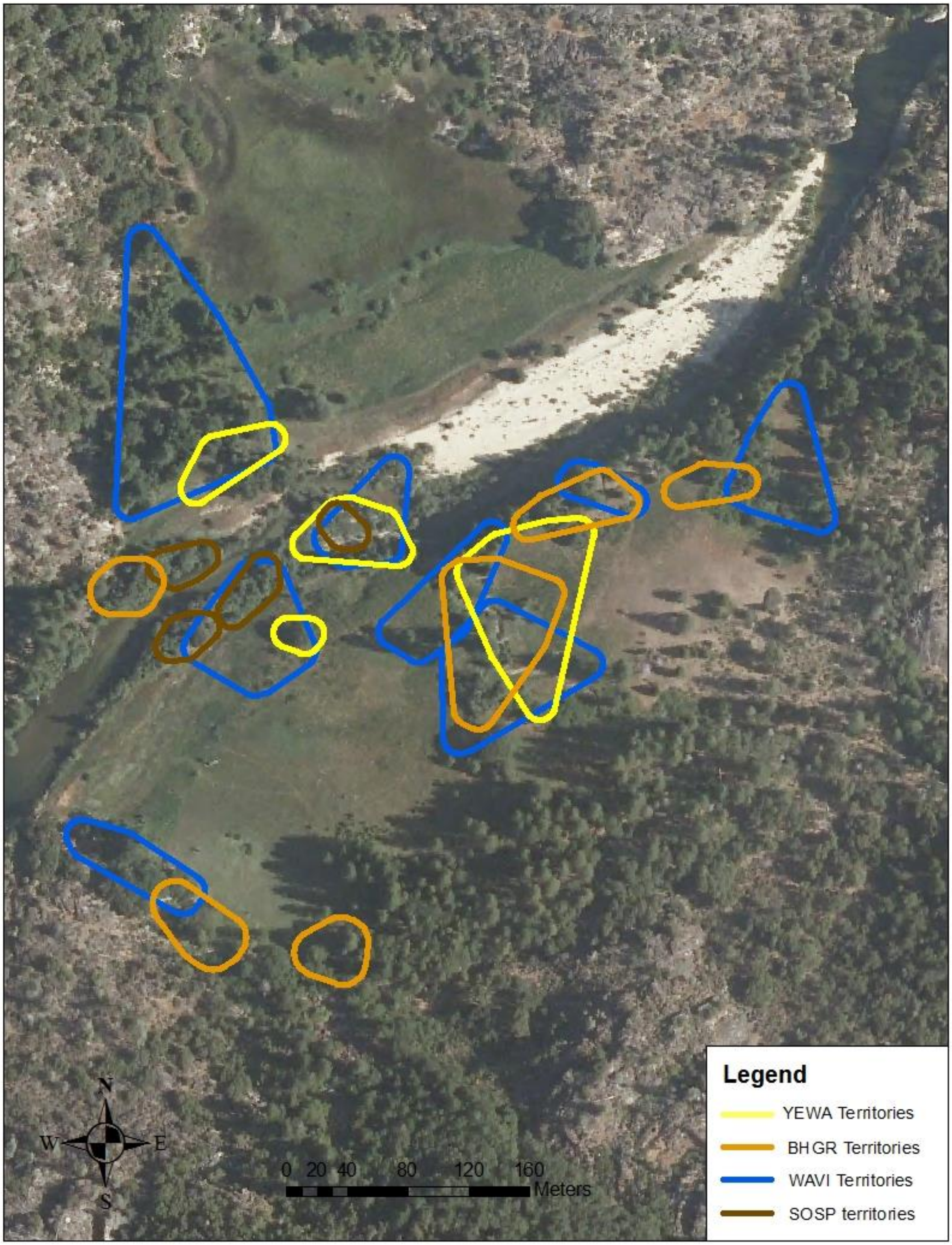

Figure 4-10. Yellow Warbler (YEWA), Black-headed Grosbeak (BHGR), Warbling Vireo, (WAVI) and Song Sparrow (SOSP) breeding territories in Poopenaut Valley, 2012.

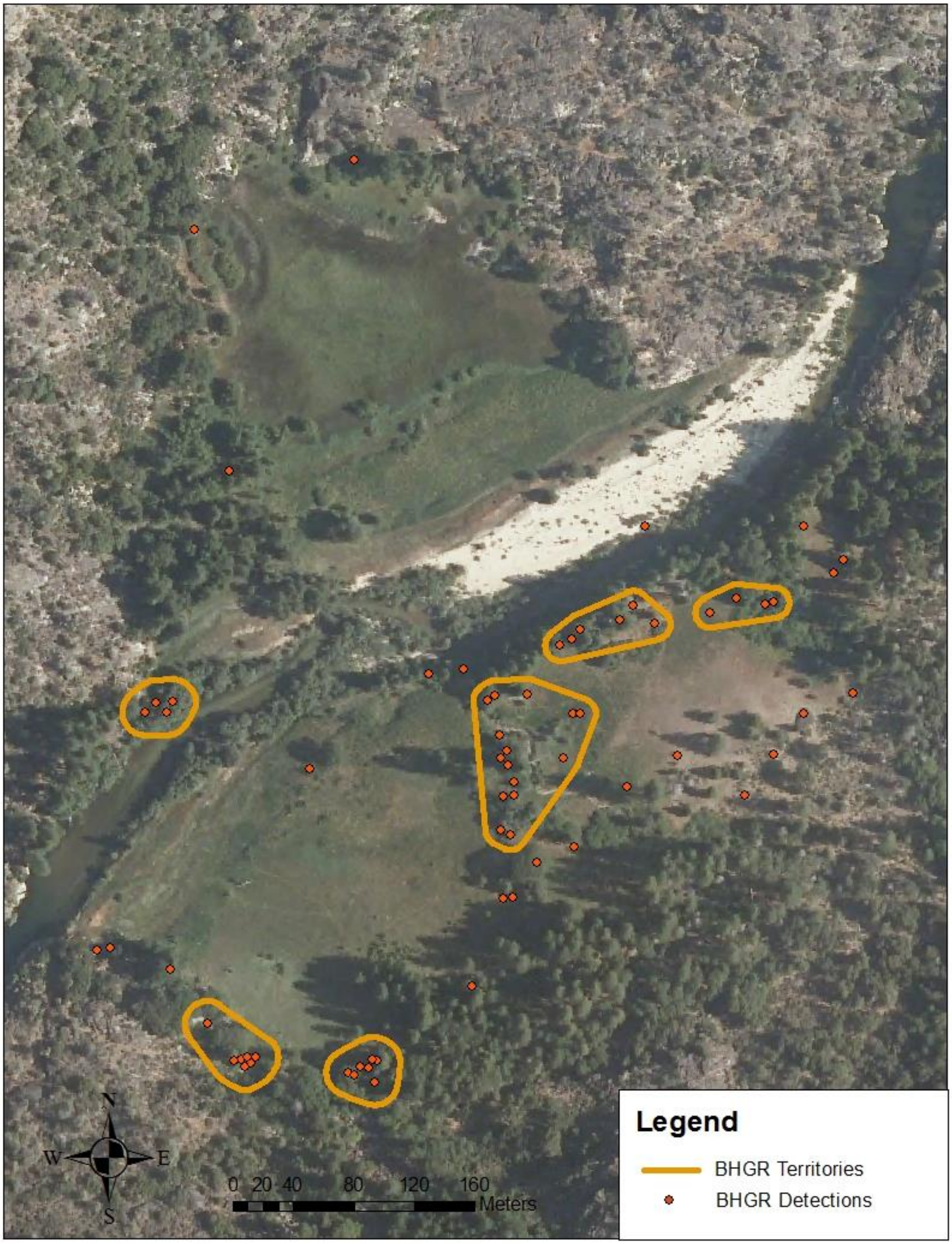

Figure 4-11. Black-headed Grosbeak (BHGR) breeding territories (with individual detections shown) based on spot map surveys in Poopenaut Valley, 2012.

Figure 4-12. Song Sparrow (SOSP) breeding territories (with individual detections shown) based on spot map surveys in Poopenaut Valley, 2012.

Figure 4-13. Warbling Vireo (WAVI) breeding territories (with individual detections shown) based on spot map surveys in Poopenaut Valley, 2012.

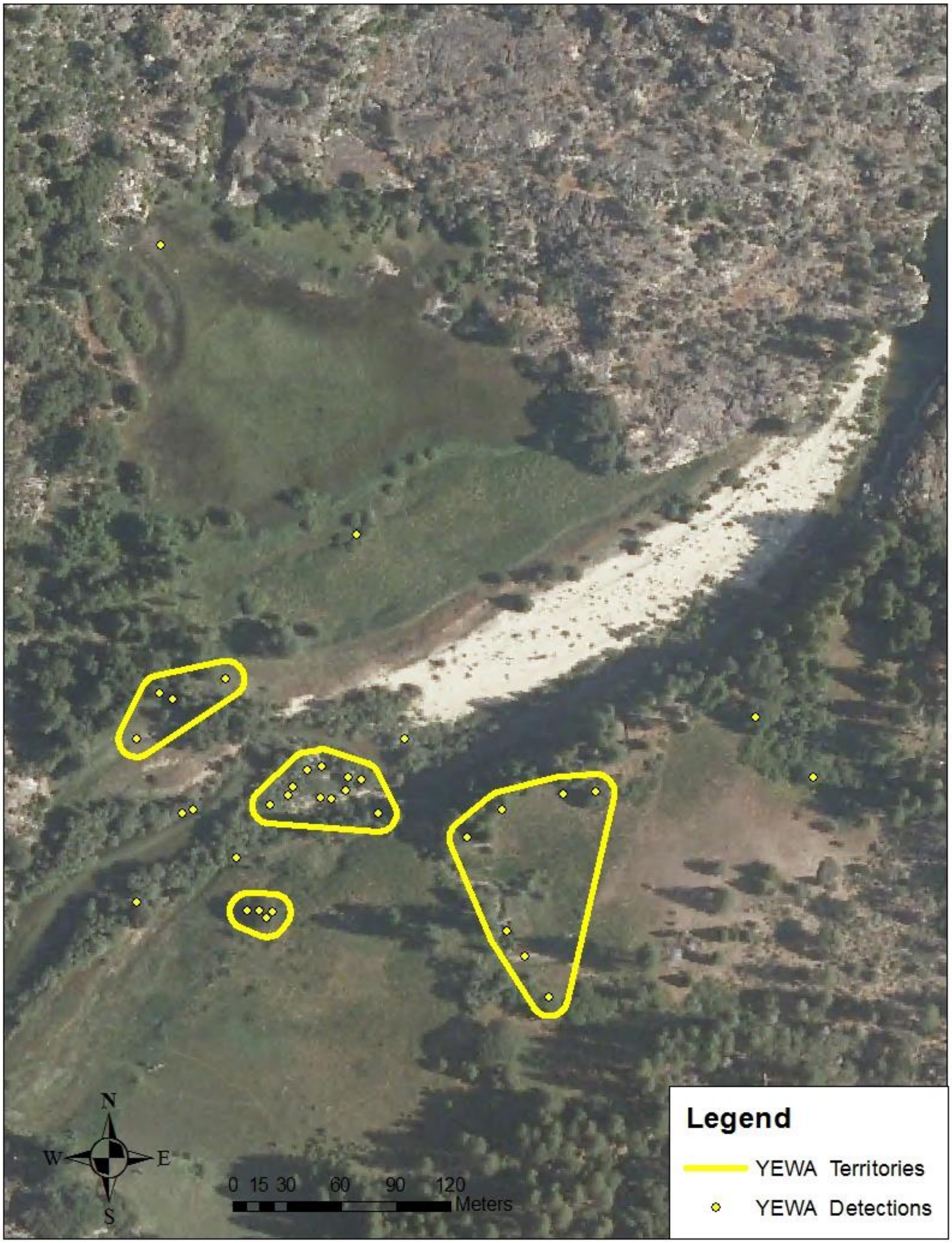

Figure 4-14. Yellow Warbler (YEWA) breeding territories (with individual detections shown) based on spot map surveys in Poopenaut Valley, 2012.

4.3.8 2012 Bird Nest Searching

In 2012 we conducted the third consecutive year of nest searching in Poopenaut Valley. We conducted nine nest searching visits: 27 April 2012, 3 May 2012, 4 May 2012, 7 May 2012, 11 May 2012, 22 May 2012, 30 May 2012, 7 June 2012, 21 June 2012. We conducted nest searching in Areas 1 and 2 only on 27 April 2012, 30 May 2012, and 22 June 2012. During the other survey dates these areas were inaccessible due to high water in the river.

In 2012 we located nine nests of six species (Table 4-14) and plotted their locations (Figure 4-15). We located four nests belonging to focal species: three of Warbling Vireo and one of Black-headed Grosbeak. We observed nesting behavior of a Song Sparrow and Lesser Goldfinch but could not locate their nests.

Table 4-14. Nests confirmed during 2012 nest searching in Poopenaut Valley, Yosemite National Park.

Species	Nests located	Nests confirmed but not located
Acorn Woodpecker	1	
Black-headed Grosbeak[1]	1	
Bullock's Oriole	2	
Cassin's Vireo	1	
Lesser Goldfinch		1
Mallard	1	
Song Sparrow[1]		1
Warbling Vireo[1]	3	

[1] Riparian Focal Species

In 2012 all nine nests were discovered between 11 May and 22 June. The third week of May was the most productive time period for locating nests. Below we describe the results from nest searching.

Warbling Vireo. Nest 1: Found 11 May 2012 during initial stages of nest building. We observed the female make over 10 trips bringing material to the nest. Nest cup was approximately 7 m above the ground toward the end of a cottonwood branch over the gully that divided areas 3, 4, and 5C. The nest was abandoned fewer than 10 days later, but we discovered another Warbling Vireo nest less than 20 m away, presumably belonging to the same birds. 11S 252181 4200559.

Warbling Vireo. Nest 2: Found 21 May 2012 across the gully from where the previous Warbling Vireo nest had been abandoned. The nest was near the top of a 7.6 m (25 ft) tall black cottonwood tree in the open meadow of area 4. We observed an adult incubating the nest over the course of four visits spanning 16 days, so it is presumed that the nest was successful. 11S 252194 4200566.

Warbling Vireo. Nest 3: Found 21 May 2012 in the branch of a large black oak that hangs over the gully in area 5C. We discovered the nest when nest construction was underway. We later observed the adult incubating, however the final outcome of nesting success is unknown. 11S 252153 4200598.

Black-headed Grosbeak. Found 11 May 2012 on the north side of the river across from area 4. The nest was approximately 8 m above the ground in a tall clump of willows growing along the riparian corridor of the river. The nest was obscured in foliage and difficult to observe, thus we could not determine the final outcome of the nest. 11S 252196 4200645.

Cassin's Vireo. Found 21 May 2012 when we observed the female carrying material to the nest multiple times. We later observed the female sitting on the nest over the span of two weeks. On later inspection, we discovered that a Brown-headed Cowbird (*Molothrus ater*) had parasitized the nest; there was one cowbird nestling and no vireo nestlings (see photo). 11S 252176 4200616.

Brown-headed Cowbird chick in Cassin's Vireo nest

Mallard (Anas platyrhynchos). Found 21 May 2012 when we accidentally flushed the female off the nest. The nest was on the ground by the same black oak containing the Warbling Vireo nest in 5C. The nest contained nine eggs, which the female incubated until successful hatching between 9 and 16 days later. 11S 252151 4200601.

Bullock's Oriole. Nest 1: Found 22 May 2012 in the upper branches of a cottonwood in the flooded area of 5C. Female was still building nest upon first observation. Nest was presumed to be abandoned because there was no activity observed on three subsequent nest checks. 11S 252102 4200607.

Bullock's Oriole. Nest 2: Found 30 May 2012 when adults were observed making multiple trips carrying food to nestlings. Nest was in a tall willow in area 5C. Adults were also observed bringing food to nestling on later nest checks. Nest was considered successful because in the last check when there was no activity at the nest, the adults were seen foraging in the area with at least two fledgling birds.

Acorn Woodpecker. Found 22 June 2012 in the cavity of a snag on the north side of area 1. The cavity was about 10 m above the ground. We observed the adult entering and leaving the nest, but did not see any nestlings. 11S 252017 4200954.

On two occasions, we detected breeding behavior but could not locate the nests. On 27 April 2012 we observed a Song Sparrow taking nesting material to the north side of the river in area 5B, but high water prevented thorough searching of this area. We observed a pair of Lesser Goldfinches making multiple trips to a single spot high up in a conifer in area 4, but visibility was blocked by branches.

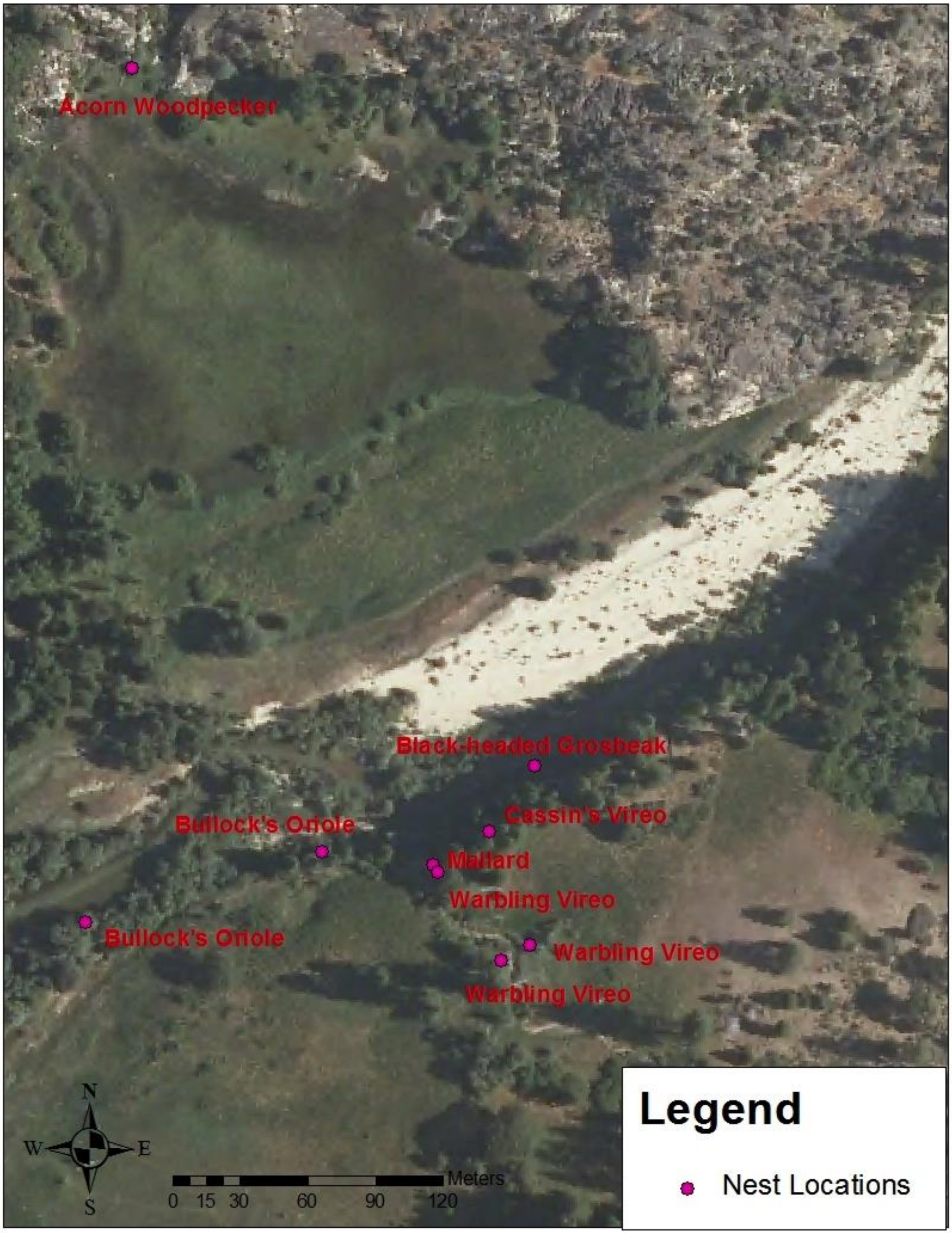

Figure 4-15. Locations of bird nests in Poopenaut Valley, 2012.

4.3.9 2011-2012 Breeding Bird Summaries

Data collected during spot mapping and nest searching in 2011-2012 were used to calculate dates pertaining to arrival on the breeding ground, initiation of breeding, and fledging young for Riparian Focal Species (Table 4-15). These data show that several species initiate breeding in late April or early May, when water levels are still artificially low.

Table 4-15. Preliminary life history breeding schedules for four Riparian Focal Species in Poopenaut Valley, Yosemite National Park, 2011-2012.

YELLOW WARBLER		
Resident/Migratory	Migratory	
Site fidelity	High	
Feeding type/food source	Insect and other arthropods, gleaning, sallying, hovering	
Nesting strata	Often contain heavy brush understory for nesting and tall trees for foraging and singing	
Nesting location	0.60 to 4.90 m above ground in shrub or deciduous sapling	
Capable of two clutches?	One brood (3-6 eggs) normally reared; second broods rarely attempted	
	2011	**2012**
Males arrive	2 May	3 May
Females arrive	5 May	12 May
Males define territories	4 May	12 May
Females begin nesting	12 May[1]	-
Fledglings leave nest	3 June to 10 June	-

[1]Active nest 12 May 2011

SONG SPARROW		
Resident/Migratory	Resident	
Site fidelity	High	
Feeding type/food source	During breeding, primarily insects and other small invertebrates; some seeds and fruit	
Nesting strata	Nests commonly 0–4 m, mostly on ground under grass tuft or shrub; wet meadows and margins of ponds, lake and slow-moving streams	
Nesting location	Ground cover, low in grass and shrubs	
Capable of two clutches?	Yes	
	2011	**2012**
Males arrive	28 April	27 April
Females arrive	28 April	27 April
Males define territories	28 April	27 April
Females begin nesting	-	27 April[1]
Fledglings leave nest	-	20 May to 26 May

[1]Nest materials carried on 27 April 2012

BLACK HEADED GROSBEAK		
Resident/Migratory	Migratory	
Site fidelity	Unknown	
Feeding type/food source	Gleans animal matter, primarily insects and spiders, and vegetable matter, including cultivated fruit and weed seeds. Most forage on foliage, twigs, branches, and in the air	
Nesting strata	In outer branches of deciduous trees, cottonwoods, willows, and other hardwoods that margin rivers and streams, also in oak-conifer forest. Occupies diverse habitats	
Nesting location	Shrub, canopy, favors meadows, clearings, and extensive edge	
Capable of two clutches?	No; clutch 2-5 eggs	
	2011	**2012**
Males Arrive	28 April	27 April
Females Arrive	5 May	3 May
Males define territories	28 April	3 May
Females begin nesting	-	11 May[1]
Fledglings leave nest	-	4 June to 13 June

[1]Active nest 11 May 2012

WARBLING VIREO		
Resident/Migratory	Migratory	
Site fidelity	Unknown	
Feeding type/food source	Highly plastic, primarily glean from twigs in broad leaf tree-tops for insects throughout the year, some fruit in winter	
Nesting strata	In forked lateral limbs of tree periphery, prefer cottonwood, alders, and aspens that line streams	
Nesting location	Canopy, tall, primarily coniferous trees, 7m or higher	
Capable of two clutches?	Yes, two considered normal; clutch 3-5 eggs	
	2011	**2012**
Males Arrive	28 April	27 April
Females Arrive	28 April	27 April
Males define territories	28 April	27 April
Females begin nesting	-	11 May[1]
Fledglings leave nest	-	6 June to 18 June

[1]Active nest 11 May 2012, two more on 21 May 2012

4.3.10 2007-2012 Cumulative Breeding Bird Summaries

Out of 85 species detected during 2007-2012 area searches, 2008-2012 point counts, and 2010-2012 spot mapping and nest searching, we confirmed 18 breeding species, detected 41 probable breeding species, 11 possible breeding species, and 15 unlikely breeding species in all study areas and points combined. Of these, 7 are riparian focal species (Black-headed Grosbeak, Song Sparrow, Spotted Sandpiper (*Actitis macularia*) Warbling Vireo, Wilson's Warbler (*Wilsonia pusilla)*, Yellow-breasted Chat (*Icteria virens)*, and Yellow Warbler (RHJV, 2004); 2 are California Species of Concern (Yellow Warbler and Yellow-breasted Chat); 2 are nest predators [Steller's Jay (*Cyanocitta stelleri)* and Western Scrub-Jay], and 1 is an invasive brood-parasite, Brown-headed Cowbird (Table 4-16).

Table 4-16. List of 85 bird species detected and their breeding status from area search (AS), point count (PC), and spot map (SM) surveys in Poopenaut Valley, Yosemite National Park, in April – June, 2007 to 2012.

Species	Unlikely	Possible	Probable	Confirmed	Survey
Acorn Woodpecker				ON, T	SM, AS, PC
American Coot	X				SM
American Crow	X				SM
American Dipper			S		SM
American Robin				ON, T, CF, S	SM, AS, PC
Anna's Hummingbird				CN, T	SM, AS, PC
Ash-throated Flycatcher		X			SM, AS
Bald Eagle	X				SM
Band-tailed Pigeon		X			SM, AS
Belted Kingfisher			S		SM, AS
Bewick's Wren			S		SM, AS
Black Phoebe			S		SM, AS, PC
Black-headed Grosbeak				CF, P, T, CN, F	SM, AS, PC
Black-throated Gray Warbler			S, P, T		SM, AS
Blue-gray Gnatcatcher			S		SM, AS
Brewer's Blackbird			S, P		SM, AS
Brown Creeper			S		SM, AS
Brown-headed Cowbird			S		SM, AS, PC
Bullock's Oriole				ON, CN, S, P, F, CF	SM, AS, PC
Bushtit			P		SM, AS
California Towhee			S, P		SM, AS
Calliope Hummingbird			T, P		AS
Canada Goose			S, P		SM
Canyon Wren			S, P, T		SM
Cassin's Finch	X				SM
Cassin's Vireo				ON, T, S, P	SM, AS, PC
Chipping Sparrow				S, CN, P, T	SM, AS, PC
Cliff Swallow	X				SM
Common Merganser			P		SM, AS
Common Yellowthroat	X				SM
Dark-eyed Junco			S, P		SM, AS
Downy Woodpecker		X			SM, AS
Dusky Flycatcher			S, P		SM, AS, PC
Evening Grosbeak	X				AS
Golden-crowned Kinglet			S		SM
Gray Flycatcher	X				SM, AS, PC
Great Egret	X				SM
Hairy Woodpecker			P, D		SM, AS, PC
Hammond's Flycatcher			S		SM

House Wren				ON, T, S, P	SM, AS
Hutton's Vireo		X			AS
Lark Sparrow	X				SM
Lazuli Bunting			S, P, T		SM, AS, PC
Lesser Goldfinch				ON, S, P	SM, AS, PC
Lincoln's Sparrow				CN	PC, AS
MacGillivray's Warbler			S		SM, PC, AS
Mallard				F, ON, P	SM, AS, PC
Marsh Wren	X				SM
Mountain Chickadee			S		SM
Mountain Quail			S		SM, AS, PC
Mourning Dove			P		SM, AS
Nashville Warbler			S, P, T		SM, AS, PC
Northern Flicker			P, D		SM, AS, PC
Northern Rough-winged Swallow			S, P		SM, AS
Nuttall's Woodpecker			S, D		SM, AS
Oak Titmouse		X			SM, PC
Orange-crowned Warbler			S		SM, PC
Pacific-slope Flycatcher			S		SM, AS
Pine Siskin		X			SM, AS
Purple Finch				CN, S, P	SM, AS, PC
Red-breasted Nuthatch			S		SM, AS, PC
Red-winged Blackbird			S, P, T,C		SM, AS, PC
Ruby-crowned Kinglet	X				SM
Savannah Sparrow	X				SM, AS
Song Sparrow				CN, CF, F, T, S, P, C	SM, AS, PC
Spotted Sandpiper			P		SM
Spotted Towhee				ON, S, P, CF, F	SM, AS, PC
Steller's Jay			P, F		SM, AS, PC
Townsend's Warbler	X				SM
Tree Swallow		X			SM
Violet-green Swallow				F	SM, AS, PC
Virginia Rail		X			SM
Warbling Vireo				CF, T, S, P, CN, F, ON	SM, AS, PC
Western Bluebird		X			SM
Western Scrub-Jay			P		SM, AS, PC
Western Tanager			P, S, T		SM, AS, PC
Western Wood-Pewee				ON, S, P, CN	SM, AS, PC
White-breasted Nuthatch	X				PC
White-throated Swift			P, C		SM, AS
Wilson's Warbler		X			SM, AS
Wood Duck			P		SM
Wrentit			S		SM, PC
Yellow Warbler				ON, CN S, P, T, CF, C	SM, AS, PC
Yellow-breasted Chat		S			SM, AS, PC
Yellow-rumped Warbler			S		SM, AS, PC

Breeding status for each species reported as unlikely, possible, probable, and confirmed (see National Park Service, 2007) at Poopenaut Valley, summers 2007-2012. Unlikely species represent those species considered transient in Poopenaut Valley. Codes indicating breeding status are: X = detected in study area during the breeding season; P = pair observed during the breeding season; S = more than one singing male in study area or male bird singing during at least 3 visits; D = drumming woodpecker heard; C = courtship behavior or copulation observed; T = Territorial behavior; CN = bird observed carrying nest material or nest building; CF = bird observed carrying food for young; F = recently fledged or downy young observed; ON = occupied nest observed. Partners in Flight riparian focal species indicated by **bold** print.

4.3.12 Bat Acoustic Surveys

We documented a high diversity of bat species in Poopenaut Valley from spring 2011 through summer 2012. Of the 17 bat species known to occur in Yosemite National Park (Pierson et al., 2001), we detected 16 species in Poopenaut Valley, four of which have special status (pallid bat, spotted bat, western mastiff bat, and Townsend's big-eared bat) (Tables 4-17, 4-18). Western red bat was not detected at either site.

Preliminary results show that spotted bat had over three times as many detections overall as the next most frequently detected species, the Mexican free-tailed bat (Tables 4-17, 4-18). The western mastiff bat was the third most frequently detected species (Tables 4-17, 4-18). Habitat requirements and arrival/departure dates of the eight most frequently detected bat species in Poopenaut Valley are described in Table 4-19.

Accessibility issues at the north site and equipment failure at both sites prevented continuous monitoring over the 1.5 year survey period, which had negative effects on the detection probability of each species. For example, at the north site during summer 2011, the detector operated only five days during June, July, and August (Table 4-2). As a result, seasonal comparisons between years and sites are not entirely possible until more data is collected over the coming years. However, preliminary results at this time suggest that detection totals for each species vary by site, year, and season.

During 2011, the Mexican free-tailed bat was the most frequently detected species at both the north and south sites; during 2012, spotted bat detections increased considerably at the north site only, making it the most frequently detected species. Although detection totals for Mexican free-tailed bat increased from 2011 levels at the south site, it was the second most frequently detected species in 2012 (Figures 4-16, 4-17; Tables 4-17, 4-18).

Seasonal bat use of Poopenaut Valley varied between species, with Mexican free-tailed bat the only species that was detected year-round at both sites (Figures 4-19 and 4-21). During spring and summer 2011, spotted bat and western mastiff bat were detected in high frequency at the south site, but had mostly disappeared from the south site during spring and summer 2012. However, these two species were detected in high (western mastiff bat) and very high (spotted bat) frequency at the north site during spring and summer 2012 (Figures 4-19 and 4-21). Mexican free-tailed bat had the highest total detections during winter 2011/2012 at both sites (Figures 4-19 and 4-21). Other species detected during winter 2011/2012 at both sites include silver-haired bat, California myotis, hoary bat, western mastiff bat, and Yuma myotis.

During spring and fall 2011 at the north site, several species including Yuma myotis, hoary bat, California myotis, canyon bat, and silver-haired bat had similar detection levels that peaked and declined at the same time period (Figure 4-18). During spring and summer 2012 at the north site, Yuma myotis, hoary bat, and California myotis had similar detection levels, although slightly lower than during spring and fall 2011. During spring and summer 2011 at the south site, Yuma myotis, silver-haired bat, and hoary bat had similar detection levels, although they peaked during different months (Figure 4-20). During fall 2011 at the south site, detection levels of Yuma myotis and hoary bat peaked. During spring and summer 2012 at the south site, detection levels of hoary bat, and to a lesser extent, silver-haired bat and canyon bat, peaked (Figure 4-18).

Table 4-17. Total detections of 16 bat species north of the Tuolumne River in Poopenaut Valley from 14 April 2011 to 15 August 2012. Anpa = Pallid bat, Coto = Townsend's big-eared bat, Epfu = Big brown bat, Euma = Spotted bat, Eupe = Western mastiff bat, Labl = Western red bat, Laci = Hoary bat, Lano = Silver-haired bat, Myca = California myotis, Myci = Small-footed myotis, Myev = Long-eared myotis, Mylu = Little brown bat, Myth = Fringed myotis, Myvo = Long-legged myotis, Myyu = Yuma myotis, Pahe = Canyon bat, Tabr = Mexican free-tailed bat.

NORTH

Date	Anpa	Coto	Epfu	Euma	Eupe	Laci	Lano	Myca	Myci	Myev	Mylu	Myth	Myvo	Myyu	Pahe	Tabr
Apr-11				8	6	2		3						10	1	1
May-11		2	10	62	22	78	36	64	4	8	1	4	1	90	19	44
Jun-11		1		4	1	56	2	1		2				18	1	7
Jul-11																
Aug-11																
Sep-11		4	3	2	63	69	6	100	2	6	1	7		109	87	682
Oct-11			1		1	15	5	35		2		1		21	23	123
Nov-11			1				1									2
Dec-11							2									20
2011 Total	**0**	**7**	**15**	**76**	**93**	**220**	**52**	**203**	**6**	**18**	**2**	**12**	**1**	**248**	**131**	**879**
Jan-12					1		1	1								15
Feb-12						1		3						1		24
Mar-12						3	1	7				1		4	2	25
Apr-12			1			2	15	49	2	1	1	5		28	14	14
May-12			2	2	4	14	15	57	2	4	1	3		79	11	14
Jun-12			4	1163	61	58	12	26	3	8	1	4		28	2	56
Jul-12	1		6	1892	639	12	8	22	5	6		3		23	19	240
Aug-12			4	1240	246	5	4	33	3	2		3	1	24	12	160
Sep-12																
2012 Total	**1**	**0**	**17**	**4297**	**951**	**95**	**56**	**198**	**15**	**21**	**3**	**19**	**1**	**187**	**60**	**548**

Table 4-18. Total detections of 16 bat species south of the Tuolumne River in Poopenaut Valley from 14 April 2011 to 19 August 2012. Anpa = Pallid bat, Coto = Townsend's big-eared bat, Epfu = Big brown bat, Euma = Spotted bat, Eupe = Western mastiff bat, Labl = Western red bat, Laci = Hoary bat, Lano = Silver-haired bat, Myca = California myotis, Myci = Small-footed myotis, Myev = Long-eared myotis, Mylu = Little brown bat, Myth = Fringed myotis, Myvo = Long-legged myotis, Myyu = Yuma myotis, Pahe = Canyon bat, Tabr = Mexican free-tailed bat.

SOUTH

Date	Anpa	Coto	Epfu	Euma	Eupe	Laci	Lano	Myca	Myci	Myev	Mylu	Myth	Myvo	Myyu	Pahe	Tabr
Apr-11				34	33	4	6	12		4		6		60	9	6
May-11	1		6	281	168	4	28	6						2	7	11
Jun-11			4	144	124	28	56	7						6	1	12
Jul-11		1	2	26	21	24	4	1				1		2		128
Aug-11																
Sep-11			2	4	90	42		1		2	1	4		5	83	714
Oct-11					5	17	3	3		1		1			3	161
Nov-11						2	1	1						5		42
Dec-11							2							1		28
2011 Total	**1**	**1**	**14**	**489**	**441**	**121**	**100**	**31**	**0**	**7**	**1**	**12**	**0**	**81**	**103**	**1102**
Jan-12							1	1								34
Feb-12																12
Mar-12																22
Apr-12			1		1	1	5								8	10
May-12			4	1	1	11	28	2		1				4	8	14
Jun-12			5		3	129	8	1		1				5		153
Jul-12		1	10		4	18	19	1	1			1		4	16	787
Aug-12		1	1	3	5	2	4	4	1	1		1		5	24	521
Sep-12																
2012 Total	**0**	**2**	**21**	**4**	**14**	**161**	**65**	**9**	**2**	**3**	**0**	**2**	**0**	**18**	**56**	**1553**

Table 4-19. Occurrence, habitat requirements, and arrival/departure dates of the eight most frequently detected bat species in Poopenaut Valley from 14 April 2011 and 19 August 2012. Note that Acoustic bat detectors were not operating continuously during this time period. Refer to Table 4-2 for total seasonal monitoring effort.

SPOTTED BAT		
Occurrence/habitat	Widely distributed throughout Sierra Nevada, with records > 3000 m. Occurs in habitats ranging from desert scrub to montane coniferous forests	
Feeding type/food source	Forages in a wide variety of habitats,5-15 m off the ground, primarily for moths	
Roosting structure	Uses crevices in rock faces for roosting and reproduction	
Seasonal movements	Makes local movements in some areas, from high elevations in summer to lower elevations in fall. Little is known about the California populations; may be yearlong residents, or migratory.	
	NORTH	**SOUTH**
2011		
Arrival	19 April	15 April
Departure	18 September	16 September
2012		
Arrival	21 May	27 May
Departure	15 August	15 August

WESTERN MASTIFF BAT		
Occurrence/habitat	Found in a variety of habitats to > 3000 m in elevation. From desert scrub to chaparral to oak woodland and into the ponderosa pine belt.	
Feeding type/food source	Detected most often over meadows and other open areas, but will also feed above forest canopy; sometimes to high altitudes (1,000 feet)	
Roosting structure	Roosts primarily in crevices in cliff faces and occasionally trees	
Seasonal movements	Unknown	
	NORTH	**SOUTH**
2011		
Arrival	19 April	14 April
Departure	4 October	17 October
2012		
Arrival	1 January	30 April
Departure	15 August	17 August

MEXICAN FREE-TAILED BAT		
Occurrence/habitat	Uncommon in high Sierra Nevada but found throughout California. Found in all habitats including mixed conifer forest, but open habitats such as woodlands, shrublands, and grasslands preferred.	
Feeding type/food source	Forages high, 30 m above ground.	
Roosting structure	Roosts in caves, mine tunnels, crevices, and buildings.	
Seasonal movements	In California, makes local movements to and from hibernacula or short migrations attitudinally.	
	NORTH	**SOUTH**
2011		
Arrival	21 April	14 April
Departure	31 December	31 December
2012		
Arrival	2 January	1 January
Departure	15 August	19 August

CANYON BAT		
Occurrence/habitat	Wide range including desert, grassland, woodland, and mixed conifer forests. Yearlong resident in California	
Feeding type/food source	Feeds at low to moderate heights over water, rocky canyons, and along cliff faces.	
Roosting structure	Roosts in rock crevices, mines, caves, and buildings.	
Seasonal movements	Yearlong resident in California. May make local movements.	
	NORTH	**SOUTH**
2011		
Arrival	19 April	15 April
Departure	2 October	2 October
2012		
Arrival	5 March	23 April
Departure	15 August	18 August

CALIFORNIA MYOTIS		
Occurrence/habitat	Broad distribution over western North America, most abundant at mid-elevations. Found in almost every habitat.	
Feeding type/food source	Forages in canopy and along riparian corridors on insects and moths.	
Roosting structure	Uses crevices in wide variety of natural and anthropogenic structures.	
Seasonal movements	Individuals can be active in winter, even in below freezing temperatures.	
	NORTH	**SOUTH**
2011		
Arrival	19 April	15 April
Departure	18 October	14 November
2012		
Arrival	13 January	31 January
Departure	15 August	10 August

SILVER-HAIRED BAT		
Occurrence/habitat	Broad distribution concentrated in northern part of California.	
Feeding type/food source	Forages above canopy, in forest clearings, and in riparian zone along water courses for wide variety of insects and moths	
Roosting structure	Roosts in trees	
Seasonal movements	Migratory	
	NORTH	**SOUTH**
2011		
Arrival	2 May	15 April
Departure	27 December	24 December
2012		
Arrival	19 January	1 January
Departure	15 August	12 August

HOARY BAT		
Occurrence/habitat Feeding type/food source Roosting structure Seasonal movements	The hoary bat is the most widespread North American bat. Habitats include cottonwood riparian habitat, forested areas, and woodlands. Feeds primarily on moths. Roosts in dense foliage of medium to large-size trees Migrates between summer and winter ranges, probably over long distances. During spring and fall, large groups are encountered, occasionally in unusual locations. Females precede males in the northward spring migration, which occurs from February - May. Fall migration occurs September - November.	
	NORTH	**SOUTH**
2011		
Arrival	21 April	16 April
Departure	18 October	14 November
2012		
Arrival	17 February	24 April
Departure	13 August	9 August

YUMA MYOTIS		
Occurrence/habitat Feeding type/food source Roosting structure Seasonal movements	Usually occurs below 8,000 feet in elevation. Optimal habitats are open forests and woodlands with sources of water over which to feed. More highly associated with water than any other species. Forages over open, still, or slow-moving water and above low vegetation in meadows for emergent insects (midges, mayflies, caddis flies) and moths. Roosts in buildings, caves, or crevices. Probably makes local or short migrations to suitable hibernacula. Individuals that spend summer at high elevations probably move downslope.	
	NORTH	**SOUTH**
2011		
Arrival	21 April	14 April
Departure	18 October	27 December
2012		
Arrival	25 February	3 May
Departure	15 August	17 August

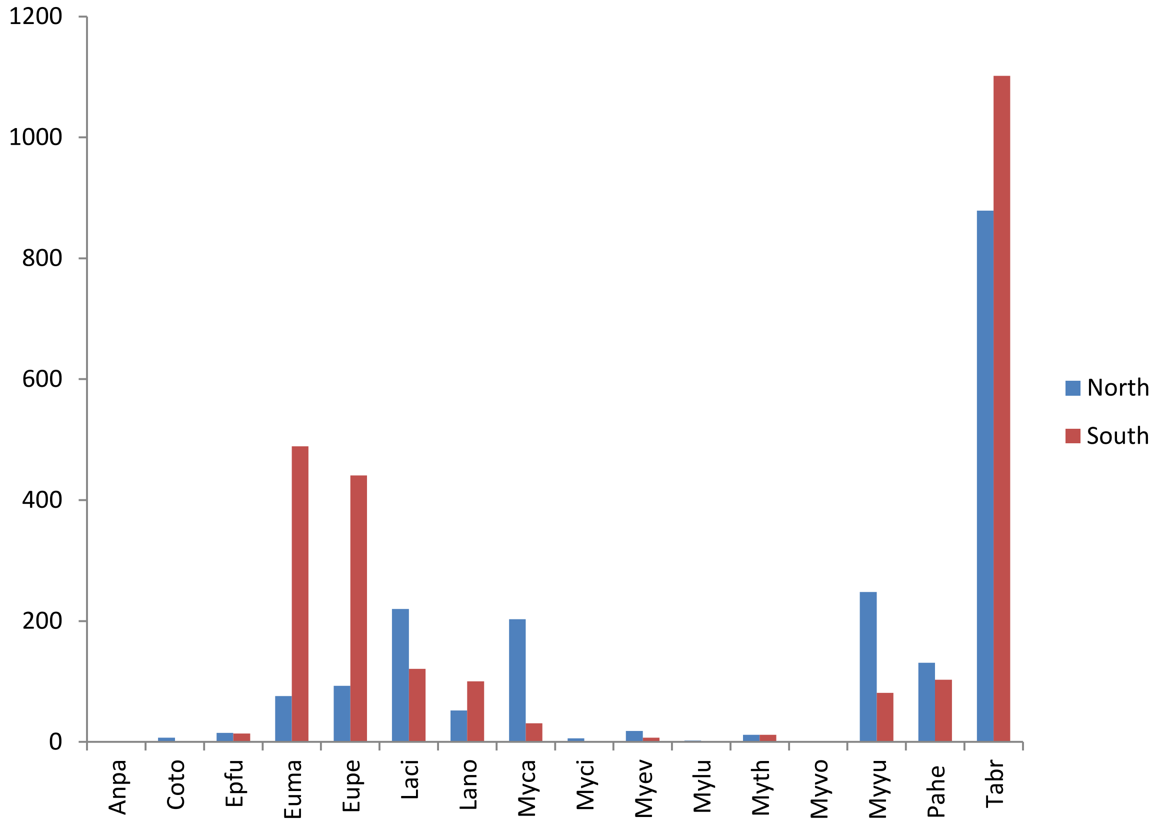

Figure 4-16. Total bat detections in Poopenaut Valley by site between 14 April 2011 and 31 December 2011. A total of 16 bat species were detected. Anpa = Pallid bat, Coto = Townsend's big-eared bat, Epfu = Big brown bat, Euma = Spotted bat, Eupe = Western mastiff bat, Labl = Western red bat, Laci = Hoary bat, Lano = Silver-haired bat, Myca = California myotis, Myci = Small-footed myotis, Myev = Long-eared myotis, Mylu = Little brown bat, Myth = Fringed myotis, Myvo = Long-legged myotis, Myyu = Yuma myotis, Pahe = Canyon bat, Tabr = Mexican free-tailed bat.

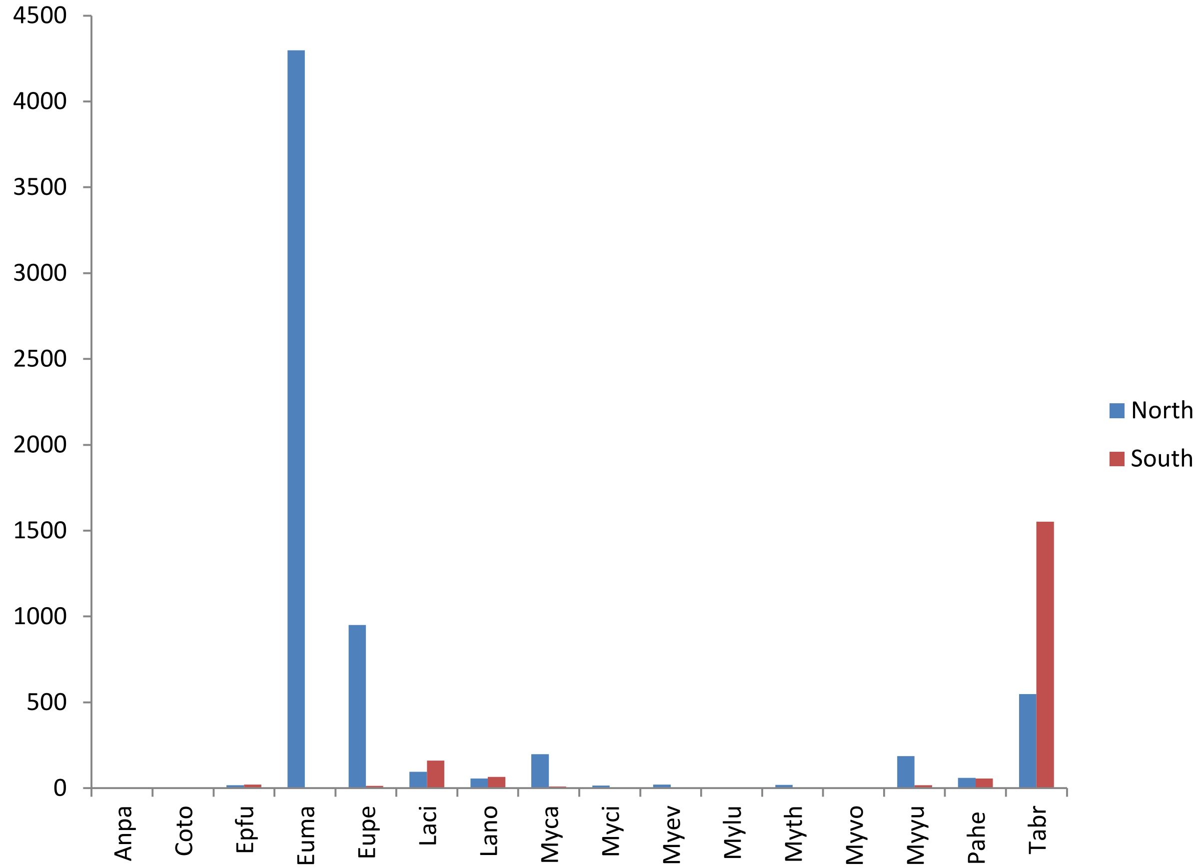

Figure 4-17. Total bat detections in Poopenaut Valley by site between 1 January 2012 and 19 August 2012. A total of 16 bat species were detected. Anpa = Pallid bat, Coto = Townsend's big-eared bat, Epfu = Big brown bat, Euma = Spotted bat, Eupe = Western mastiff bat, Labl = Western red bat, Laci = Hoary bat, Lano = Silver-haired bat, Myca = California myotis, Myci = Small-footed myotis, Myev = Long-eared myotis, Mylu = Little brown bat, Myth = Fringed myotis, Myvo = Long-legged myotis, Myyu = Yuma myotis, Pahe = Canyon bat, Tabr = Mexican free-tailed bat.

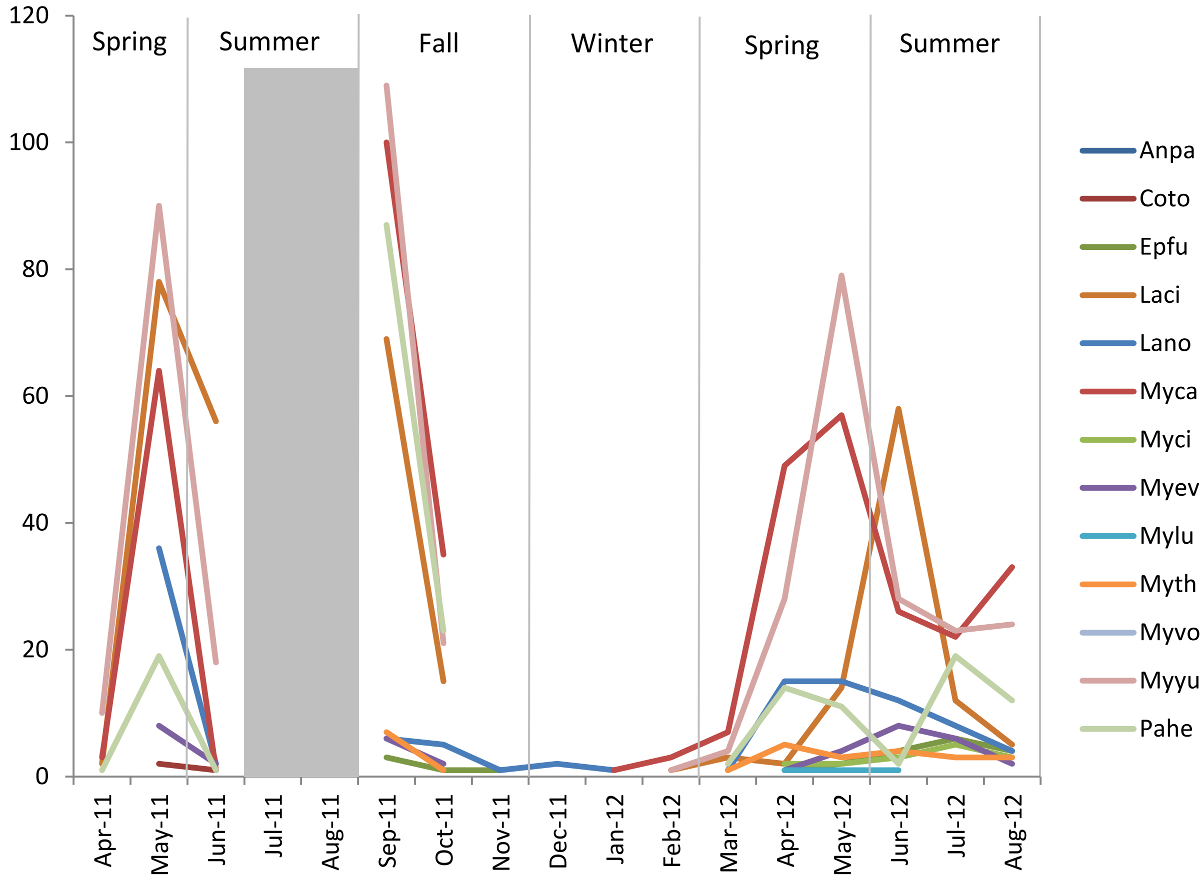

Figure 4-18. Total detections of 13 bat species north of the Tuolumne River in Poopenaut Valley on a monthly basis from 14 April 2011 to 15 August 2012. No data was collected between July and August 2011 (gray bar). Anpa = Pallid bat, Coto = Townsend's big-eared bat, Epfu = Big brown bat, Euma = Spotted bat, Eupe = Western mastiff bat, Labl = Western red bat, Laci = Hoary bat, Lano = Silver-haired bat, Myca = California myotis, Myci = Small-footed myotis, Myev = Long-eared myotis, Mylu = Little brown bat, Myth = Fringed myotis, Myvo = Long-legged myotis, Myyu = Yuma myotis, Pahe = Canyon bat, Tabr = Mexican free-tailed bat.

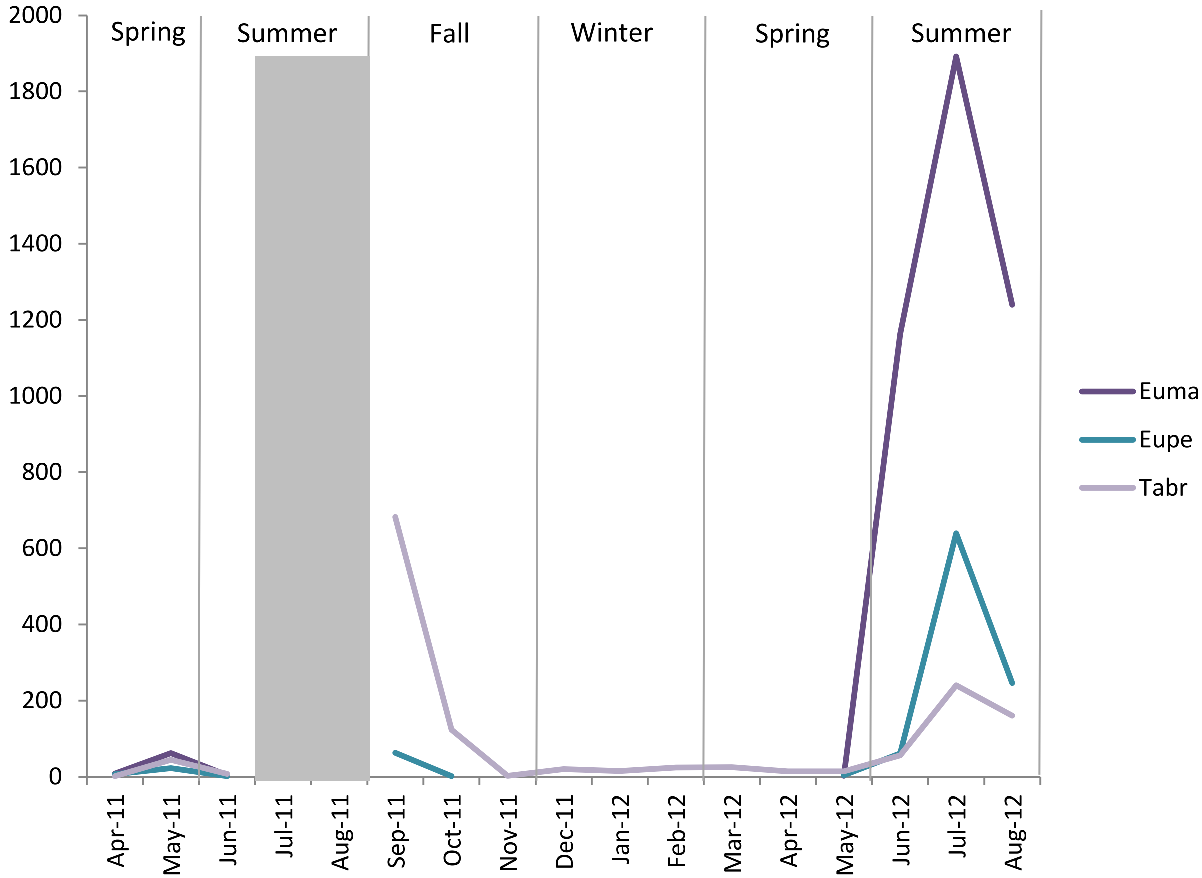

Figure 4-19. Total detections of the three most frequently detected bat species (spotted bat, western mastiff bat, and Mexican free-tailed bat) north of the Tuolumne River in Poopenaut Valley on a monthly basis from 14 April 2011 to 15 Aug 2012. No data was collected between July and August 2011 (gray bar). Euma = Spotted bat, Eupe = Western mastiff bat, Tabr = Mexican free-tailed bat.

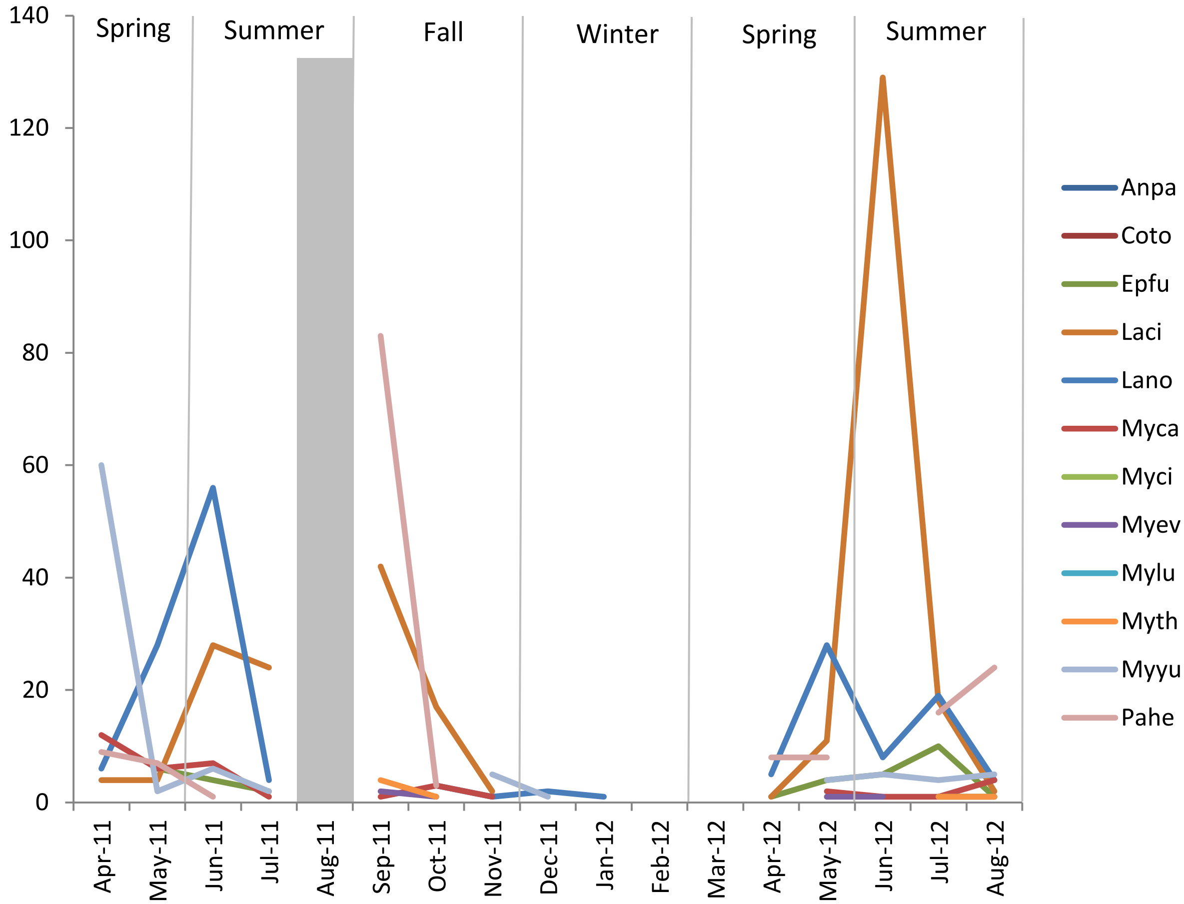

Figure 4-20. Total detections of 12 bat species south of the Tuolumne River in Poopenaut Valley on a monthly basis from 14 April 2011 to 15 August 2012. No data was collected in August 2011 (gray bar). Anpa = Pallid bat, Coto = Townsend's big-eared bat, Epfu = Big brown bat, Euma = Spotted bat, Eupe = Western mastiff bat, Labl = Western red bat, Laci = Hoary bat, Lano = Silver-haired bat, Myca = California myotis, Myci = Small-footed myotis, Myev = Long-eared myotis, Mylu = Little brown bat, Myth = Fringed myotis, Myvo = Long-legged myotis, Myyu = Yuma myotis, Pahe = Canyon bat, Tabr = Mexican free-tailed bat.

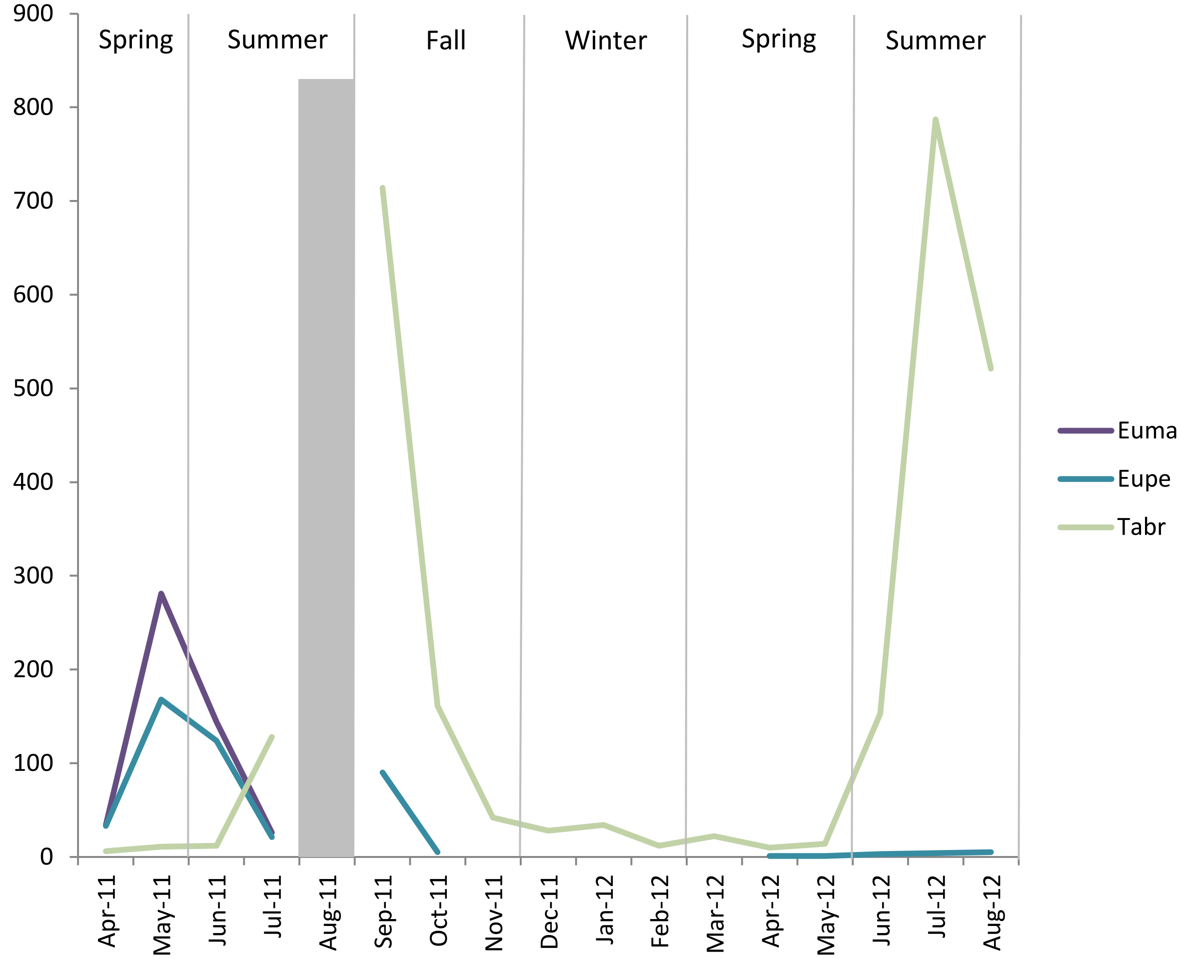

Figure 4-21. Total detections of the three most frequently detected bat species (spotted bat, western mastiff bat, and Mexican free-tailed bat) south of the Tuolumne River in Poopenaut Valley on a monthly basis from 14 April 2011 to 15 August 2012. No data was collected in August 2011 (gray bar). Euma = Spotted bat, Eupe = Western mastiff bat, Tabr = Mexican free-tailed bat.

4.4 Discussion

4.4.1 Birds

Studying breeding birds in Poopenaut Valley is helping us to understand how the timing of water releases from O'Shaughnessy Dam affects birds' productivity. It appears that earlier water releases might discourage birds from nesting and later releases might flood active nests. By quantifying the birds' territories and determining whether or not birds are nesting successfully, we are beginning to understand habitat availability and habitat quality.

Song Sparrows are year-round residents in Poopenaut Valley and concentrate their activity along the river's edge. Because Song Sparrows are understory nesters that build their nests on or near the ground, flooding poses a concern to their productivity. In 2010 an active Song Sparrow nest was destroyed by rising water levels between 8 May and 12 May (National Park Service, 2012). In 2011 and 2012 Song Sparrows did not appear to nest, however in 2012 we observed a Song Sparrow carrying nesting material to the north side of the river. The flow level was still quite low at the point of detection, and it is possible that if a nest was constructed, it could have been subsequently washed out when the river level rose. There is evidence that Song Sparrows may attempt more than one clutch (Nice 1937), thus they may build a second nest after flood waters subside. In 2012, we conducted a late survey on 17 July for Song Sparrows and concluded that no late nesting was occurring. 2012 was a dry year, thus it would be interesting to conduct late-season nest searching in a wetter year when presumably more food resources are available.

The other focal species, Black-headed Grosbeak, Warbling Vireo, and Yellow Warbler are not as vulnerable to flooding as Song Sparrows. In 2012 a Black-headed Grosbeak nest was in a willow along the riparian corridor; however the nest was approximately 5-8 m above the ground, and safe from potential flooding. In 2012 the three Warbling Vireo nests were all located along a side tributary, but they were at least 7 m above the ground and therefore not affected by potential flooding. On 12 May 2011 we observed a female Yellow Warbler carrying material to her nest several times. The nest was approximately 12 m above the surface of the river in a large willow growing on a sandbar in the river. Yellow Warblers typically nest later when spring releases have already begun and they almost always build their nests higher off the ground than Song Sparrows, which make their nests much less prone to flooding.

The spot-map surveys provided valuable spatial information about how birds in Poopenaut Valley used the available habitat. Using GIS we digitized and analyzed territory sizes for Black-headed Grosbeak, Song Sparrow, Warbling Vireo, and Yellow Warbler. Objective and standardized survey methods, including territory mapping from year to year is an important aspect of avian monitoring in Poopenaut Valley. Long-term data on accurate territory sizes will provide useful information on numbers of breeding pairs and probable nest locations. Territory size has been linked to other aspects of the biotic and abiotic community, including avian body size, intraspecific competitive pressure, and resource availability (Peters, 1983; Schoener, 1968; Tompa, 1962; Hixon, 1980). It may be possible to use territory size to develop metrics to study these other variables as an evaluation of the health of bird communities and to gage the relative habitat quality in Poopenaut Valley.

4.4.2 Bats

Studying bats in Poopenaut Valley year-round tells us how many species of bats inhabit Poopenaut Valley and during which times of the year. Eventually, we will be able to relate these population dynamics to seasonal patterns of stream flow in the river, water availability in the seasonal pond, and prey availability.

Preliminary results of this study have identified a high biodiversity of bat species inhabiting Poopenaut Valley, with at least one species, the Mexican free-tailed bat, present year-round. We documented four special status species, two of which were the first (spotted bat) and third (western mastiff bat) most frequently detected species overall. The considerable jump in spotted bat detections from the south site in spring and summer 2011 to the north site in summer 2012 requires further study; however, prey abundance and water level in the seasonal pond may be factors that influence the frequency of detection.

Holmquist and Schmidt-Gengenbach, (2012) found that benthic macro-invertebrate fauna in the seasonal pond north of the Tuolumne River adds considerably to the total biodiversity of the Poopenaut Valley ecosystem. The seasonal pond contributed an additional six orders and 28 families to those identified from the Tuolumne River benthic macro-invertebrates during 2007-2009; two orders and eight families were detected in 2011-12 (Holmquist and Schmidt-Gengenbach, 2012). Macroinvertebrate hatches from the pond are likely an important food source for bats in Poopenaut Valley.

Spotted bats roost in the crevices of cliff faces, which are available in the walls surrounding Poopenaut Valley. While roosting structure availability alone cannot explain the increase in spotted bat detections between 2011 and 2012, it should be taken into consideration in future analyses.

In addition to spotted bat, the Yuma myotis is a riparian specialist that may serve as an ecological indicator of riparian health. The Yuma myotis is more highly associated with water than any other species (Pierson et al., 2006). Riparian habitat also provides important foraging habitat for hoary bat, silver-haired bat, and California myotis. Future analyses will investigate relationships between these riparian-associated species and water availability.

4.5 Future Work

The studies on nesting birds and foraging bats were initiated to investigate how timing of water releases affects productivity of birds and seasonal assemblages of bats. Preliminary results show great promise toward informing timing of water releases from O'Shaughnessy Dam, both in terms of the river discharge and stage and the filling of the seasonal pond.

Full implementation of the bird nesting and bat population studies is further fulfilling our overarching goal of informing water releases from O'Shaughnessy Dam for ecological benefit. We now have evidence that the timing and duration of flood events impact certain bird species' nesting success. Additional years of study are needed to determine approximate arrival and nest initiation dates and specific nesting locations for focal species during years of varying snow pack and flow regimes. Determining the timing for when birds begin nesting and the locations for where they build their nests enable a more accurate assessment for objective recommendations related to river discharge and stage in Poopenaut Valley.

Implementing bat monitoring year-round allows us to characterize seasonal bat population dynamics and helps inform when and how long the seasonal pond needs to be full. We have learned that there is a high diversity of bats in Poopenaut Valley, all of them insectivorous, and most of them dependent on insects associated with the riparian ecosystem.

Working closely with Jeff Holmquist (UC White Mountain Research Station) and his investigations of aquatic invertebrate species richness and diversity associated with the pond will provide a key linkage to bat population dynamics and determining how population dynamics are tied to the seasonal pond. Integrating the aquatic invertebrate and bat species richness information with pond stage and temperature will further develop a picture of ecosystem health for informing spring and summer water releases. Future work will quantify bat foraging activity in relation to stream flow and aid in understanding the ecology of the seasonal pond as related to insect availability and stream flow.

We propose introducing another component to our bird studies in Poopenaut Valley. We are interested in operating a bird banding station (following the Monitoring Avian Productivity and Survivorship [MAPS] protocol) and color-banding Song Sparrows and Yellow Warblers. Yosemite, in collaboration with the Institute for Bird Populations, already operates five long-term MAPS stations that measure productivity and survivorship. By comparing these demographic metrics between Poopenaut and the other stations in the park, we will deduce if Poopenaut Valley is functioning as an ecological source or sink; and specifically if it contains the functional elements necessary for Song Sparrows and Yellow Warblers to successfully reproduce. Gaining a more robust measure of productivity will enable us to better understand how birds will respond to changes in the habitat that may result from varying flow regimes. Better understanding the quality and resilience of habitat in Poopenaut will advance the over-all goal of restoring the integrity of the ecosystem in Poopenaut Valley.

Color-banding will serve two main critical functions in our survey efforts. One major benefit is that it will allow much more sophisticated census efforts as we try to map the relative locations of Song Sparrows and Yellow Warblers in Poopenaut. Positive identification of color-banded individuals will increase the accuracy of territory mapping. As our knowledge of territories becomes more accurate and reliable, this will open the door to the possibility of correlating territory size to other ecological variables.

The other major benefit that integrating MAPS and color-banding provide is an opportunity to measure multiple indices of avian community health. Some of these include population productivity, juvenile survival, and adult survival. Color-banding has also been shown to make tracking breeding status less time-intensive, especially in the case of species that have difficult to locate nests (Anders and Marshall, 2005). Banding birds will also provide more detailed information about unpaired males that are not represented in nest searching attempts (Villard et al., 1993). By combining more comprehensive measures such as banding with more fine-tuned efforts like nest-searching, we will know which species are simply moving through as transients or migrants and which species are successfully breeding and what their population productivity levels are. Incorporating the MAPS protocol and color-banding into the suite of avian survey techniques utilized in Poopenaut Valley will result in a more thorough and comprehensive assessment of the avian community in the region.

References

Allen-Diaz, B. 1991. Water-table and plant species relationships in Sierra Nevada Meadows. American Midland Naturalist, 126:30–43.

Anders, A. D. and Marshall, M. R. 2005. Increasing the Accuracy of Productivity and Survival Estimates in Assessing Landbird Population Status. Conservation Biology, 19: 66-74.

Bibby, C.J., Burgess, N.D., and Hill, D.A., 1992, *Bird Census Techniques*. Academic Press, Toronto, Ontario. 257 pp.

Borger, L., Franconi, N., De Michele, G., Gantz, A. Meshci, F., Manica, A., Lovari, S. and Coulson, T. 2006. Effects of sampling regime on the mean and variance of home range size estimates. Journal of Animal Ecology, 75: 1393-1405.

Brady, W. W. and J.E. Mitchell, C.D. Bonham and J. W. Cook. 1995. Assessing the power of the point-line transect to monitor changes in plant basal cover. Journal of Range Management, 48: 187-190.

Burgman, M.A. and Fox, J.C. 2003. Bias in species range estimates from minimum convex polygons: implications for conservation and options for improved planning. Animal Conservation, 6:19-28.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Fish and Wildlife Service. FWS/OBS-79/31. http://el.erdc.usace.army.mil/emrrp/emris/emrishelp2/cowardin_report.htm

Despain, D.W., P.R. Ogden, and E.L. Smith. 1991. Plant frequency sampling for monitoring rangelands. Some methods for monitoring rangelands and other natural area vegetation. Extension Report 9043. University of Arizona, Tucson, AZ

Elzinga, C.L., D. W. Salzer, and J.W. Willoughby. 2001. Measuring and monitoring plant populations. BLM Technical Reference 1730-1

Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual.Technical Report Y-87-1. Vicksburg, MS: U. S. Army Engineer Waterways Experiment Station.

Goslee, S.C., R.P. Brooks and C.A. Cole. 1997. Plants as indicators of wetland water source. Plant Ecology 131: 199-206.

Hayne, D. W. 1949. Calculation of Size of Home Range. Journal of Mammalogy 30: 1-18.

Hixon, M. A. 1980. Food Production and Competitor Density as the Determinants of Feeding Territory Size. The American Naturalist 115: 510-530.

Holmquist J., and Schmidt-Gengenbach. 2012. The Tuolumne River below Hetch Hetchy Reservoir: Characterization of the benthic macroinvertebrate assemblage in the river, Poopenaut Pond, and ephemeral pools and response of benthos and drift to spring release events. Report to the National Park Service, 20 September 2012, 156 p.

I.B.C.C. (International Bird Census Committee). 1970. Recommendations for an international standard for a mapping method in bird census work. Audubon Field Notes 24:722-726.

Karr, J.R., and Roth, R.R., 1971, Vegetation structure and avian diversity in several New World areas, The American Naturalist, v. 105, p.423-435.

Laver, P. N. and Kelly, M. J. 2008. A Critical Review of Home Range Studies. The Journal of Wildlife Management 72: 290-298.

MacArthur, R.H., and MacArthur, J.W. 1961. On bird species diversity, Ecology, v. 42: 594-598.

Marzluff, J.M., and Sallabanks, R., 1998, *Avian Conservation: Research and Management*. Island Press, Washington, D.C.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. American Midland Naturalist, 37: 223-249.

National Park Service, 2009, Looking Downstream 2007 Report: *Ecological Responses to an Altered Hydrologic Regime Downstream of Hetch Hetchy Reservoir, Yosemite National Park,* 117 pp. (plus appendices).

National Park Service, 2010, Looking Downstream 2008 Update: *Physical and Ecological Responses to an Experimental Pulse Flow Downstream of Hetch Hetchy Reservoir, Yosemite National Park,* 87 pp.

National Park Service, 2011, Looking Downstream 2009 Update: *Physical and Ecological Responses to an Experimental Pulse Flow Downstream of Hetch Hetchy Reservoir, Yosemite National Park*, 110 pp.

National Park Service, 2012, Looking Downstream 2010 Update: *Physical and Ecological Responses to River Flow Downstream of Hetch Hetchy Reservoir, Yosemite National Park*, 43 pp.

Naef-Daenzer, B. 1993. A New Transmitter for Small Animals and Enhanced Methods of Home-Range Analysis. The Journal of Wildlife Management 57: 680-689

Natural Resources Conservation Service (NRCS). 2006. Wetland Indicator Status Plants Database. U. S. Department of Agriculture, Natural Resources Conservation Service, Fort Worth, TX. http://plants.usda.gov/wetland.html

Nice, M. M. 1937. Studies in the life history of the song sparrow. Linnean Society of New York 4:1-247.

Nilsen, E. B., Pedersen, S., and Linnell, J. D. C. 2008. Can minimum convex polygon home ranges be used to draw biologically meaningful conclusions? Ecological Research 23: 635-639.

Nur, N, Jones, S.L., and Geupel, G., 1999, *Statistical guide to data analysis of avian monitoring programs*, U.S. Fish and Wildlife Service, BTP-R6001-1999, Washington, D.C.

Odum, E. P. and Kuenzler, E. J. 1955. Measurement of Territory and Home Range Size in Birds. The Auk 72:128-137.

Peters, R.H. 1983. The ecological implications of body size. Cambridge, England, Cambridge University Press.

Pierson, E.D., Rainey, W.E. and Corben, C.J. 2001. Seasonal patterns of bat distribution along an altitudinal gradient in the Sierra Nevada, Report prepared for California Department of Transportation, California State University at Sacramento Foundation, and Yosemite Fund.

Pierson, E.D., Rainey, W.E. and Chow, L.S. 2006. Bat use of the giant sequoia groves in Yosemite National Park, project report prepared for The Yosemite Fund, Yosemite, California.

Pierson, E.D., and Rainey, W.E. 2009. Bat inventory for Sequoia-Kings Canyon National Parks and Devil's Postpile National Monument, Project Report.

Point Reyes Bird Observatory. 2001. Protocol for PRBO nest data-entry. http://www.prbo.org/cadc/songbird/nest/nestentry.pdf

Partners in Flight, 170 pp., http://www.prbo.org/calpif/pdfs/riparian.v-2.pdf.

Rainey, W.E, Ingersoll, T.I., Corben, C.J., and Pierson, E.D. 2009. Using acoustic sampling of bat assemblages to monitor ecosystem trends. Report prepared for the U.S. Geological Survey Western Ecological Research center. 139 pp.

Ralph, C.J., Geupel, G.R., Pyle, P., Martin, T.E., and DeSante, D.F., 1993, *Handbook of field methods for monitoring landbirds*. General Technical Report PSW-GTR-144-www. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 41 pp.

RHJV (Riparian Habitat Joint Venture), 2004, Version 2.0, *The riparian bird conservation plan: A strategy for reversing the decline of riparian associated birds in California.* California

Russo, T.A., A.T. Fisher and J.W. Roche. 2012. Improving riparian wetland conditions based on infiltration and drainage behavior during and after controlled flooding. Journal of Hydrology 432: 98-111.

Seaman, D. E. and R. A. Powell. 1996. An Evaluation of the Accuracy of Kernel Density Estimators for Home Range Analysis. Ecology 77: 2075-2085.

Suthers, R.A. 1960. Measurement of Some Lake-Shore Territories of the Song Sparrow. The Wilson Bulletin 72:232-237.

Tompa, F. S. 1962. Territorial Behavior: The Main Controlling Factor of a Local Song Sparrow Population. The Auk 79: 687-697.

U.S. Army Corps of Engineers. 2010. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region. http://el.erdc.usace.army.mil/elpubs/pdf/trel10-3.pdf

Villard, M.A, Martin, P. R., and Drummond, C. G. 1993. Habitat Fragmentation and Pairing Success in the Ovenbird (Seiurus aurocapillus) The Auk 110:759-768.

Western Regional Climate Center. Accessed 2012. Summary of Hetch Hetchy NOAA station 043939. http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca3939

Wiens, J. A., Rotenberry, J. T., and Van Horne, B. 1985. Territory Size Variations in Shrubsteppe Birds. The Auk 102:500-505.

Worton, B. J. 1995 A Convex Hull-Based Estimator of Home-Range Size. Biometrics 51:1206-1215.