Point Blue Report

Monitoring Bird Response to Childs Meadow Restoration


2017 Annual Report to The Nature Conservancy

DECEMBER 2017

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Cover photos: *Foggy morning (left) and Warbling Vireo nestlings (right) at Childs Meadow. Photos by Max Baber (left) and Kelly Franson (right).*

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SUMMARY

The Nature Conservancy and its partners are studying the efficacy of using beaver-dam analogs and other restoration actions to increase carbon storage, improve water storage capacity, and increase populations of meadow birds and Cascades frog in Childs Meadow. The primary objective of Point Blue's research within this project is to measure the response of meadow birds to the restoration. In this report we summarize our activities from 2015–2017 and synthesize of our findings to-date. Our third year of monitoring was the first breeding season following BDA construction, and the second season since willow planting and riparian fencing. We have yet to record any effects of the restoration efforts on the bird community, as expected.

Among the five study reaches, the highest territory densities of meadow focal bird species were in the US Forest Service reach with 6.7 territories per ha, followed by 4.0 territories per ha on the Positive Control A/B reach. The Negative Control, Riparian Fence, and BDA treatment reaches had very low densities or no territories in all years.

We found 229 focal species nests in 2015–2017. The proportion of nests resulting in at least one fledged young was higher in USFS reach (0.69) than the Positive Control A/B reach (0.56), both of which are quite high relative to other riparian habitats in California. Sample sizes of nests in the other three reaches were too low to make any inference.

Results from habitat assessments at these nests and random locations in each study reach demonstrate a strong selection for high shrub cover, and low to moderate amounts of water cover within 5 m of the nest site. This combination of habitat attributes remained generally unavailable to birds in the Negative Control and the two treatment reaches in all three years, though the BDAs did provide water cover equivalent those of the highest quality habitat in the US Forest Service reach.

The Positive Control A/B and US Forest Service reaches illustrate the large potential of the upstream reaches to support bird habitat in a restored condition and the role of ponded water and shrubs in creating those conditions. Our first three years of data provide a strong foundation from which to evaluate whether the treated reaches achieve that potential.

ACTIVITIES

2015

- Point Blue initiated a study of bird response to riparian fencing and beaver-dam analog restoration of Childs Meadow along five reaches of Gurnsey Creek.
- Two interns and one field supervisor censused birds using spot-mapping, nest monitoring, and point count methods from May – July 2015.
- We completed habitat assessments at 64 nest locations and 138 random locations within the 5 study reaches in July – August 2015.
- We helped design and implement initial willow planting in October 2015.

2016

- We planted an additional ca. 245 willows in May 2016 with a crew of 8 people.
- Two interns and one field supervisor censused birds using spot-mapping, nest monitoring, and point count methods from May – July 2016.
- We completed a willow survival survey in June 2016 of all willows planted to date.
- We completed habitat assessments at 90 nest locations and 140 random locations within the 5 study reaches in July – August 2016.
- Three Point Blue staff members assisted in beaver-dam analog construction in October 2016.

2017

- Two interns and one field supervisor censused birds using spot-mapping, nest monitoring, and point count methods from May – July 2017.
- We completed a willow survival survey in June 2017 of all willows planted to date.
- We completed habitat assessments at 73 nest locations and 140 random locations within the 5 study reaches in July – August 2017.

INTRODUCTION

Restoration practitioners are increasingly using beaver to accomplish stream, wetland, and floodplain restoration (Pollock et al. 2015). The activity of beaver, or creating structures that mimic their behavior, impounds water and retains sediment, thereby substantially altering the physical, chemical, and biological characteristics of the surrounding riparian ecosystem, providing benefits to plants, fish, wildlife, and people. There are several mechanisms by which this occurs. Beaver dams increase the vertical and lateral connectivity of rivers and create heterogeneous habitat for riparian birds and frogs. For example, in a study of beaver-modified streams in Wyoming, McKinstry et al. (2001) found that the riparian width in streams with beaver ponds averaged 111 feet, in contrast to 35 feet in streams without beaver. Beaver dams also increase surface and groundwater storage, store sediment and organic material, and increase the frequency of overbank flow. The dams attenuate moderate and small flood flows and increase late-season flows, sometimes converting intermittent streams into perennial ones (Naiman et al 1998). By raising the water table with dams, beaver increase the productivity of riparian and aquatic vegetation that they rely on for forage, which in turn increases carbon storage and habitat value to riparian- and meadow-dependent species.

Intensive livestock grazing and widespread removal of beaver and willows, along with other land uses, have transformed many of the Sierra Nevada's riparian meadows from multi-thread channels with seasonally active floodplains into single-thread, incised channels that store less carbon and are lower in habitat quality for a diverse suite of meadow-dependent wildlife. Compared to upland habitats, cattle congregate and forage more intensively in riparian areas where vegetation is most productive. Beaver populations, where they have been reintroduced or survived naturally, have failed to recover in riparian areas that are heavily grazed by cattle or ungulates like elk. This, combined with active and persistent removal of willows from meadow systems by landowners, has limited beaver populations and other ecosystem processes (Ripple and Beschta 2004, Baker et al. 2005, Beschta and Ripple 2011). As a result of these broad-scale changes to meadow function, their capacity to serve as natural sinks for carbon, to store and release water during the summer months, and to provide habitat for meadow-dependent wildlife have been severely compromised across the Sierra Nevada mountain range.

The Nature Conservancy and its partners in this research are in the process of restoring Childs Meadow using beaver-dam analogs among other restorative actions, to increase carbon storage, improve water storage capacity, and increase populations of meadow birds, amphibians, and other sensitive meadow-dependent species. Childs Meadow is a 290-acre meadow near Lassen National Park that is typical of many Sierra Nevada and southern Cascades meadows, having been recently grazed at levels common to other meadows, yet it has also been colonized by beavers in two reaches in the lower section of the meadow. The Childs Meadow project is using a modified Before-After Control-Impact design to test the effects of Beaver Dam Analog restoration treatments on carbon sequestration, hydrology, and sensitive species (Figure 1). Point Blue is one of the primary collaborators in the research, with the responsibility of measuring the response of meadow-dependent birds to the restoration. More specifically, we are testing the hypothesis that removing livestock grazing from the riparian area, planting willows, and building and maintaining beaver-dam analog structures will create habitat for meadow-dependent bird species comparable to reference areas.

METHODS

Sampling Design

Childs Meadow is located 10 miles from the south entrance to Lassen National Park. It is 7.5 miles northwest of the intersection of highways 36 and 32. The 290-acre meadow runs northwest-southeast along Gurnsey Creek, which flows into Deer Creek about 4 miles downstream. The restoration project includes two treatment reaches—referred to as Riparian Fence and BDA (beaver-dam analog)—and three control reaches—Negative Control, Positive Control A/B, and USFS (USDA Forest Service). The Negative Control reach is just upstream of the two treatment reaches; willows were planted, but cattle have access to the riparian zone. The two restoration treatments are in the central section of Childs Meadow. The Riparian Fence reach included willow planting and the exclusion of cattle from the riparian zone using an electric fence. The BDA reach includes a combination of willow planting, cattle exclusion from the riparian zone via an electric fence, and beaver-dam analogs (BDAs). Five BDAs were installed in October 2016. Willows were planted in October of 2015 and April 2016 at equal densities and similar configurations across the negative control, riparian fence, and BDA reaches. Willow stakes were planted in pods. Pods consisted of three clusters of 15 willow stakes. Within a cluster, 0.5 – 1.5-inch willow stakes were planted 1 – 2 m apart. Stakes were planted approximately 2 – 3 feet deep with a goal of getting them deep enough to intercept the dry season water table. Clusters within a pod were 15 m apart such that each pod spanned approximately 50 m. Each pod was spaced 45 m apart. We then planted willow stakes every 5 meters along the stream channel between each pod. This resulted in approximately 261 willow stakes planted per reach, or approximately 65 willows per hectare. Willows were not planted in the Positive Control A/B or USFS reaches. The electric fence was erected in October 2015 following all 2015 data collection. Cattle occasionally breached the electric fence, but widespread grazing within the reach was limited, expect for October of 2017, after our data collection had ended for the year. The Positive Control A/B reach was grazed up until July 2015 when a cross fence was erected ca. 1 km upstream that excluded all grazing. This reach has had beaver activity since at least 2011 when we first visited (probably longer) and, until 2017, was characterized by multiple dams and ponds. All dams blew out during the winter of 2016 – 2017 when three high-flow events occurred. Light beaver herbivory was noted during the 2017 season, but no sign of dam reconstruction was observed. The USFS reach has had beaver activity for 10 (downstream) to over 20 years (upstream) and has been ungrazed for over 20 years; there is a large pond and a beaver lodge. Many beaver dams of varying size blew out during the winter of 2016/2017, greatly reducing the amount of standing water and saturated ground in this reach. A new beaver dam was constructed over the course of the 2017 season in the upstream portion of this reach. No willows were planted or BDAs installed in either of these reaches. We divided these five reaches into seven study plots (Figure 1), with the two positive control reaches each divided into two plots.

Focal Species

We identified seven focal species to monitor in Childs Meadow based on our local knowledge of the system and our expert knowledge of the Sierra Nevada avifauna (Table 1). Our primary considerations for inclusion were a strong association with meadow or riparian habitat, appropriately surveyed with territory mapping and point count methods, and known to be present and nesting within the Childs Meadow complex. As a sum, these species represent a range of meadow habitat attributes. Throughout this report we refer to the species by their four-letter codes listed in Table 1.

Territory Mapping and Densities

Territory mapping is an intensive census method used for determining the density of bird territories in an established area or plot. The density of territories can be used as an indicator of habitat quality, especially when combined with results from nest monitoring (Johnson 2007). We mapped the breeding territories for all focal species on each of the seven study plots from 2015 – 2017. Within each year, the same observer censused each plot at least eight times during peak activity hours during the breeding season. The observers' supervisor also assisted in plot censusing. Observers changed between years. Singing, conspecific aggression, or any other territorial behavior was noted and marked on an aerial photo of the plot. Two preliminary maps of territories for each species were made one-third and two-thirds of the way through the breeding season. A final territory map for each species was made at the end of the breeding season. Supervisors assisted each observer in developing all maps. Final territory polygons were digitized with Google Earth software. To calculate territory densities for each plot, first we (the authors) assigned a proportion area for each territory that intersected each plot. Each territory was given a value from 0 to 1 based on the proportion of the territory polygon that was within the plot boundary. The territory values for each species were summed to yield the number of territories per plot. We standardized the number of territories per plot as a density of the number of territories per hectare to compare between study plots of different size. We present territory density for each of seven focal species by reach and year and average densities per plot across all years combined. Data from the two USFS control plots were combined in the analysis. The two plots in the Positive Control A/B reach—positive control A and positive control B—were kept separate in the territory analysis because only positive control A overlaps the study area of the other projects taking place in the system.

Nest Monitoring and Nest Success

Nest monitoring can provide detailed information on productivity, nest parasitism rates, and nesting habitat selection. Productivity and parasitism rates are direct measures of population health, and provide additional insight into habitat quality beyond metrics of species density.

Nest finding and monitoring followed the guidelines outlined in Martin and Geupel (1993). Nests were located at all stages: construction, egg-laying, incubation, and nestling. Observers searched for nests of all focal species territories that overlapped each study plot. Nests located outside of study plot boundaries are included in analysis. See the Appendix for results from nests located exclusively within plot boundaries. Nests were checked in a way to minimize human disturbance, including keeping visits brief, minimizing disturbance to the area around a nest, and avoiding nest sites when predators were detected nearby. Each nest found was monitored at least every four days (often more frequently) until the nest either fledged young or failed. Observers attempted to confirm the presence of fledged young with repeated visits to each territory.

Nest searching effort was commensurate with focal species densities. The Positive Control A/B and USFS reaches were each divided into two plots, such that they received much more effort than the BDA, Riparian Fence, or Negative Control plots due to the lack of focal species detected on the latter plots. We searched for nests on the Positive Control A/B and USFS plots 2 – 4 days per week from May 15 – July 10. Nest searches began around 0600 and lasted 4 – 6 hours. The BDA, Riparian Fence, and Negative Control plots were searched 1 – 2 days per week and nest searches lasted circa 2 hours.

In this report we use proportional nest success as the metric of nest success. Proportional nest success was calculated by dividing the number of nests that fledged at least one of their own young (fledging only cowbirds was considered unsuccessful) by the total number of nests with known outcomes. It is important to note that estimates of nest success from proportional calculations are likely biased high because nests failing early in the nesting cycle may be missed by observers. In the future, we will use methods for calculating nest success that take into consideration the amount of time a nest was exposed to predation and other causes of failure (Mayfield 1975 and Johnson 1979). These methods require large sample sizes to provide meaningful estimates of nest survival. With one more year of data at the USFS and Positive Control A/B study plots we hope to be able to use these methods for about half of our focal species. The proportional success we present here should be comparable within a species across study plots.

Habitat Assessments

We measured the vegetation and various habitat conditions associated with each nest and a set of random locations in each plot in each year. We selected 20 random locations within each study plot using a random point generator in ArcMap version 10.3, yielding 20 points in the three upstream reaches and 40 points in each of the Positive Control A/B and USFS reaches. We sampled the habitat conditions at each nest and random location using a slightly modified version of the Breeding Biology Research and Monitoring Database protocol for vegetation measurements (Martin et al. 1997). Herbaceous and shrub vegetation were sampled in a 5-m radius plot, and trees on an 11.3-m radius plot, centered on the nest or random location. We made visual estimates of vegetation cover and height in the three vegetation layers: herbaceous, shrub, and tree. We estimated relative cover of each species for the tree and shrub layers and the relative cover of forb, grass, and sedge/rush species in the herbaceous layer. We also estimated the percent of the 5-m radius plot covered by standing water, logs, and bare ground, and measured the depth of herbaceous thatch at 10 random locations. We limit the bulk of our inference to the two habitat metrics we believe to be most influential to nest site selection in the context of this restoration project: riparian shrub cover and standing water.

Finally, we used weighted logistic regression to investigate our study species' selection of water cover, shrub cover, and herbaceous cover for their nest sites relative to random locations at the 5-m radius scale described above. We ran a separate model for each focal species, excluding Lincoln Sparrow and Willow Flycatcher for lack of sample size, using the 'glm' function in Program R (R Core Team 2015). Nest and random locations were coded 1 and 0, respectively, and water cover, shrub cover, and herbaceous cover were included as additive fixed effects. For Song Sparrow, we included a quadratic effect of water cover based on a visual inspection of the data. In each model, we set the weight for each nest location to 1 and the weight for each random location to the number of nest locations divided by the number of random locations (the ratio of nest locations to random locations), thereby giving equal influence in the model to nest and random locations.

RESULTS

Territory Densities

Territory densities varied greatly among the five study reaches (Table 2). The highest combined focal species territory densities were in the USFS reach with an average over all years of 6.7 total territories per ha, followed by the Positive Control A plot with 4.6 total territories per ha and Positive Control B plot with 3.5 total territories per ha. The Negative Control reach and BDA reach contained very low densities of focal birds at 0.6 and 0.04 total territories per ha, respectively. The Riparian Fence reach had no focal species territories. Annual variation in territory densities within reaches were apparent within and across species, but this variation was minimal relative to variation among reaches (Table 3 and 4).

Song Sparrow was the most abundant species in the study area, averaging 1.4 territories per hectare across all reaches and years with a maximum density in the USFS reach of 3.15 territories per ha (Table 2 and 3). The next most abundant species was MacGillivray's Warbler with a maximum of 1.4 territories per ha and an average of 0.33 across all plots. Yellow Warbler had a maximum of 0.87 territories per ha and an average of 0.31. Willow Flycatcher was the least abundant, averaging 0.01 territories per ha across all reaches and years, a result of only one territory on the Positive Control A/B reach in 2015. Territory densities for five of the seven focal species were highest on the USFS reach. Lincoln's Sparrow and Willow Flycatcher reached their highest densities on the Positive Control A/B.

Nest Success

We found 229 nests from 2015 – 2017 (Appendix 1-3), for which we could determine the fate for 208. The proportion of nests resulting in at least one fledged young was higher in USFS reach (0.69) than the Positive Control A/B reach (0.56; Figure 2). The higher nest success, combined with the higher territory densities, provides evidence that the USFS reach has higher quality meadow bird habitat than the Positive Control A/B. Although there were more nests found in and around the Positive Control A/B reach (n=123) than the USFS reach (n=79), the positive control reach is twice the size of the USFS reach. Our inference of habitat quality from nest success in the Negative Control and treatment reaches is limited due to lack of territorial meadow focal species in these three reaches.

Nest success rates were relatively high (≥ 0.50) for all but the two least abundant focal species, Willow Flycatcher and Lincoln's Sparrow, for which sample sizes were small (Figure 2). Cowbird parasitism rates were notably low, which may help explain the high success rates for many of these species relative to other riparian habitats in California. Song Sparrow nest success increased markedly from 2015 – 2017, while the three warbler species each had highest nest success in 2016 (Figure 3). Sample sizes were insufficient to discern annual variation in nest success for the three other species.

Habitat Assessments

Data from the habitat assessments demonstrate that the habitat the focal bird species used for nesting was generally unavailable in the Negative Control, Riparian Fence, and

BDA reaches. Of the habitat variables we investigated, shrub cover had the largest and most consistent discrepancies between nest and random locations in these reaches (Figure 4). Median values of shrub cover at nest locations were higher for all focal species than shrub cover values at >99% of random locations in three upstream reaches (Figure 4). Willow Flycatcher, Song Sparrow, and Lincoln's Sparrow showed a fairly consistent pattern of having nest locations with higher water cover than was generally available on the fenced reaches in 2015-2017, the negative control reach in 2015 and 2017, and the BDA reach in 2015-2016 (Figure 5). The Negative Control reach had substantial wet ground for these species in 2016, but not in other years, based on our random sampling. The installation of dams in the BDA reach covered the meadow surface in water (in July) at percent cover values that were similar to the USFS reach in 2016—a normal water year—which is the reach-year combination with our highest densities of nesting focal species.

Results from the logistic regression models show selection for nest sites with high shrub cover, and, depending on the species, low to moderate water cover. All five of the focal species we analyzed selected for increasing shrub cover, meaning they had significantly higher likelihood of nesting in areas with locally (<5m from their nest) high shrub cover (Table 5). Water cover appears to be important for a smaller subset of species. Willow Flycatcher, Song Sparrow, and Lincoln's Sparrow all had nest locations with higher water cover than the other focal species (Figure 5), but of these three species we were only able to model Song Sparrow due to sample size constraints. Of the five species we modeled, Song Sparrow was the only species that had statistically significant relationship with water cover in our logistic regression models (Table 5), with highest probabilities of nest use at values 25-30% percent cover within a 5m radius plot. While we did not detect a significant effect for water cover for the other species, the signs of the coefficient estimates were all negative, suggesting a general avoidance of areas with higher water cover among these species (Table 5).

DISCUSSION

Our third year of monitoring was the first breeding season following BDA construction, and the second season since willow planting and riparian fencing. We have yet to record any effects of the restoration efforts on the bird community. The Riparian Fence treatment reach was devoid of meadow birds from 2015 – 2017 and the BDA treatment reach contained a very low density of focal species (0.04/ha) in 2017 following none in

2015 and 2016. The Negative Control reach, which received willow planting, contained some territories at very low densities in all years. These territories are likely the result of the three tall, remnant small willow clumps—not because of the willow planting, which has had far lower survival in this reach. As evidenced by the lack of bird response in the BDA reach after substantially wetting the meadow surface, shrub cover is the major limiting factor for nesting habitat of the focal species on the three upper reaches. It will probably be five years post-restoration before the planted willows grow large enough to be suitable for any meadow birds, and a decade or more before the benefits of restoration to meadow birds are fully realized, as data from other meadow re-watering methods suggests (Burnett and Campos 2015).

The two positive control reaches illustrate the potential of the upstream plots to support bird habitat in a restored condition. Even though both of the positive control reaches had substantially higher densities than the three upstream reaches, habitat quality on the USFS Positive Control reach appears greater than the Positive Control A/B reach, as measured by territory densities and nest success. This suggests very dense clumps of willows provide high-quality habitat, and riparian shrub cover may be a limiting factor on the Positive Control A/B reach. The lower shrub cover here is likely a result of a combination of long-term grazing (ceased in 2015) and the current beaver population regulating shrub growth. Shrub cover on the USFS reach may provide an ideal target for the treatment reaches to maximize meadow bird density and nest success. Because most of the willows planted in the treatment reaches were in pods at 1-m spacing, these pods should provide some of the dense willow cover the birds are selecting. However, creating habitat that can support the densities of meadow birds in the USFS reach will require substantial willow recruitment, or planting well beyond what has already been implemented. The planned additional willow planting in the treatment reaches should both expedite colonization by focal meadow birds, including Willow Flycatcher, as well as increase future territory densities.

Though a strong association with riparian shrubs continues to be the most evident nesting habitat association of the focal species, some focal species also appear to be selecting for areas with more water cover than was available in the treatment reaches. As beaver activity has done in the Positive Control A/B and USFS reaches, the beaver-dam analogs created some of this habitat in 2017. Song Sparrow's selection for higher water cover than many of the other focal species may explain the overall reduced density of Song Sparrow territories in 2017, following the loss of most beaver dams on both the Positive Control A/B and USFS reaches.

Compared to other riparian habitats in California, nest success was high on the Positive Control A/B and USFS reaches, but similar to what has been reported from the USFS reach from 1997–1999 (King et al. 2001). Mid-elevation montane habitats provide higher nest success than lower-elevation habitats for Warbling Vireo in the Sierra Nevada (Purcell 2006), and the same may be the case with other species in this study. The high nest success may also be attributable to low cowbird parasitism rates for most species. However, it is important to note that cowbirds were not absent. We suspect a few Yellow Warbler nests were abandoned just after nest building completion because they were parasitized. Also, one of the Willow Flycatcher nests abandoned in 2015 may have been due to cowbirds.

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TABLES

Table 1. Bird focal species for Childs Meadow restoration monitoring, listed in taxonomic order, with their four-letter codes and conservation status.

Common Name	Species Name	Code	Conservation Status
Willow Flycatcher[‡, CPF]	*Empidonax traillii*	WIFL	State Endangered, USFS Sensitive
Warbling Vireo[‡, CPF]	*Vireo gilvus*	WAVI	Declining locally in CA[1]
Yellow Warbler[‡, CPF]	*Setophaga petechia*	YEWA	CA Species of Special Concern
MacGillivray's Warbler[‡]	*Geothlypis tolmiei*	MGWA	none
Wilson's Warbler[‡, CPF]	*Cardellina pusilla*	WIWA	Declining in the Sierra Nevada[2]
Song Sparrow[CPF]	*Melospiza melodia*	SOSP	none
Lincon's Sparrow[‡]	*Melospiza lincolnii*	LISP	none

[‡] Nearctic-Neotropical Migratory Bird; [CPF] California Partners in Flight Riparian Focal Species (RHJV 2004);
[1] Gardalli et al. 2000; [2] Sauer et al. 2008

Table 2. Average focal species territory density per hectare on five study reaches in Childs Meadow from 2015-2017. All plots were between 3.65 and 4.32 hectares.

Species	Negative Control	Riparian Fence	BDA	Positive Control A/B: Positive Control A	Positive Control A/B: Positive Control B	USFS Positive Control	All
LISP	0.09	0	0.04	0.33	0.25	0	0.12
MGWA	0	0	0	0.49	0.10	1.40	0.33
SOSP	0.51	0	0	2.65	2.12	3.15	1.40
WAVI	0.04	0	0	0.41	0.34	0.84	0.27
WIFL	0	0	0	0	0.07	0	0.01
WIWA	0	0	0	0.36	0.09	0.46	0.15
YEWA	0.07	0	0	0.43	0.52	0.87	0.31
ALL	0.71	0	0.04	4.66	3.48	6.71	2.60

Table 3. Focal species territory density per hectare in each year from 2015-2017 on three upper study reaches in Childs Meadow. Plots were between 3.8 and 4.13 hectares.

	Negative Control			Riparian Fence			BDA		
Species	2015	2016	2017	2015	2016	2017	2015	2016	2017
LISP	0	0.26	0	0	0	0	0	0	0.13
MGWA	0	0	0	0	0	0	0	0	0
SOSP	0.52	0.26	0.74	0	0	0	0	0	0
WAVI	0	0	0.13	0	0	0	0	0	0
WIFL	0	0	0	0	0	0	0	0	0
WIWA	0	0	0	0	0	0	0	0	0
YEWA	0	0.20	0	0	0	0	0	0	0

Table 4. Focal species territory density per hectare in each year from 2015-2017 positive control reaches in Childs Meadow. Plots were between 3.65 and 4.32 hectares.

	Positive Control A/B								
	Positive Control A			Positive Control B			USFS Positive Control		
Species	2015	2016	2017	2015	2016	2017	2015	2016	2017
LISP	0.38	0.13	0.47	0.55	0.14	0.07	0	0	0
MGWA	0.38	0.44	0.63	0.07	0.14	0.10	1.79	1.33	1.08
SOSP	2.99	3.11	1.85	2.67	1.85	1.84	4.14	3.01	2.29
WAVI	0.44	0.38	0.39	0.48	0.34	0.21	0.81	0.87	0.83
WIFL	0	0	0	0.21	0	0	0	0	0
WIWA	0.44	0.32	0.32	0.21	0.04	0.01	0.58	0.38	0.41
YEWA	0.44	0.44	0.41	0.82	0.55	0.18	1.09	0.83	0.70

Table 5. Parameter estimates and statistics from weighted logistic regression models for the 5 bird focal species with adequate sample sizes to attempt modeling.

Variable	**Species**	**Estimate**	**SE**	**Z**	**P**
Intercept	Song Sparrow	-1.549	0.761	-2.037	0.042
shrub cover		0.033	0.006	5.693	0.000
herbaceous cover		0.003	0.008	0.352	0.725
water cover		0.094	0.026	3.697	0.000
water cover^2		-0.002	0.001	-3.136	0.002
Intercept	Yellow Warbler	-2.064	2.031	-1.016	0.309
shrub cover		0.066	0.018	3.640	0.000
herbaceous cover		-0.006	0.021	-0.263	0.792
water cover		-0.072	0.055	-1.301	0.193
Intercept	MacGillivray's Warbler	-2.232	2.406	-0.928	0.354
shrub cover		0.066	0.018	3.739	0.000
herbaceous cover		-0.013	0.024	-0.549	0.583
water cover		-0.061	0.061	-0.998	0.318
Intercept	Warbling Vireo	1.965	1.361	1.444	0.149
shrub cover		0.033	0.015	2.210	0.027
herbaceous cover		-0.035	0.017	-2.085	0.037
water cover		-0.091	0.065	-1.410	0.158
Intercept	Willow Flycatcher	0.113	3.740	0.030	0.976
shrub cover		0.059	0.029	2.041	0.041
herbaceous cover		-0.028	0.041	-0.692	0.489
water cover		-0.215	0.200	-1.076	0.282

FIGURES

Figure 1. Overview map of the Childs Meadow complex and study reaches.

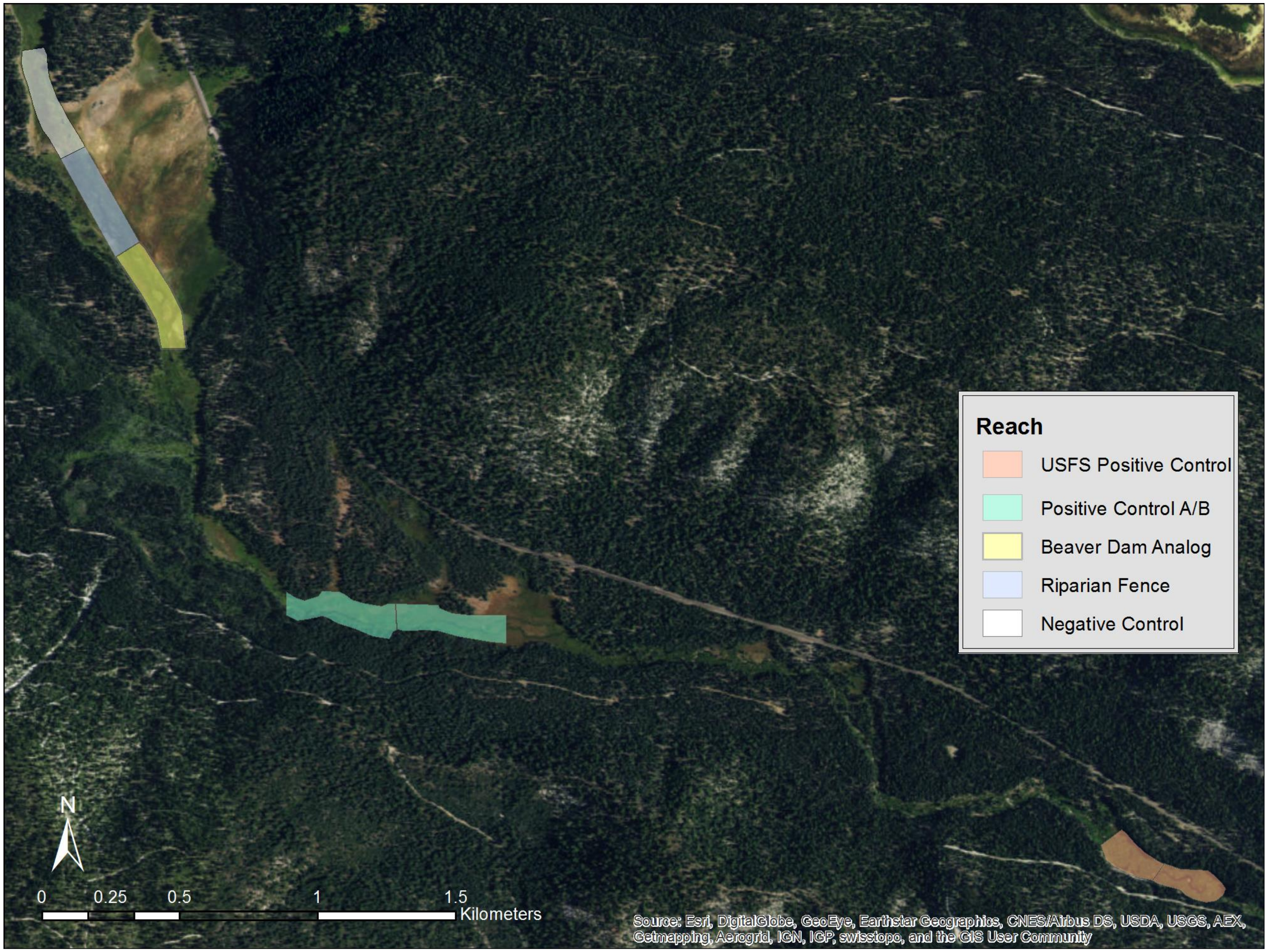


Figure 2. The proportion of nests that fledged at least one young for 208 nests found from 2015-2017, by reach and by species.

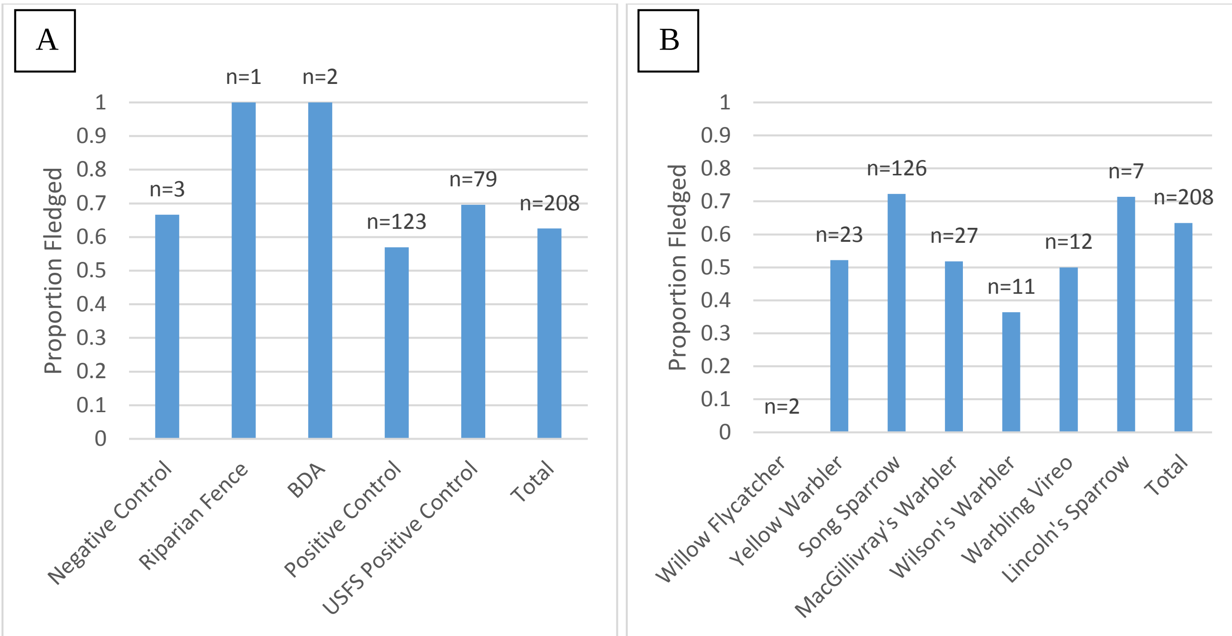


Figure 3. The proportion of nests that fledged at least one young for 208 nests found from 2015-2017, by species and year.

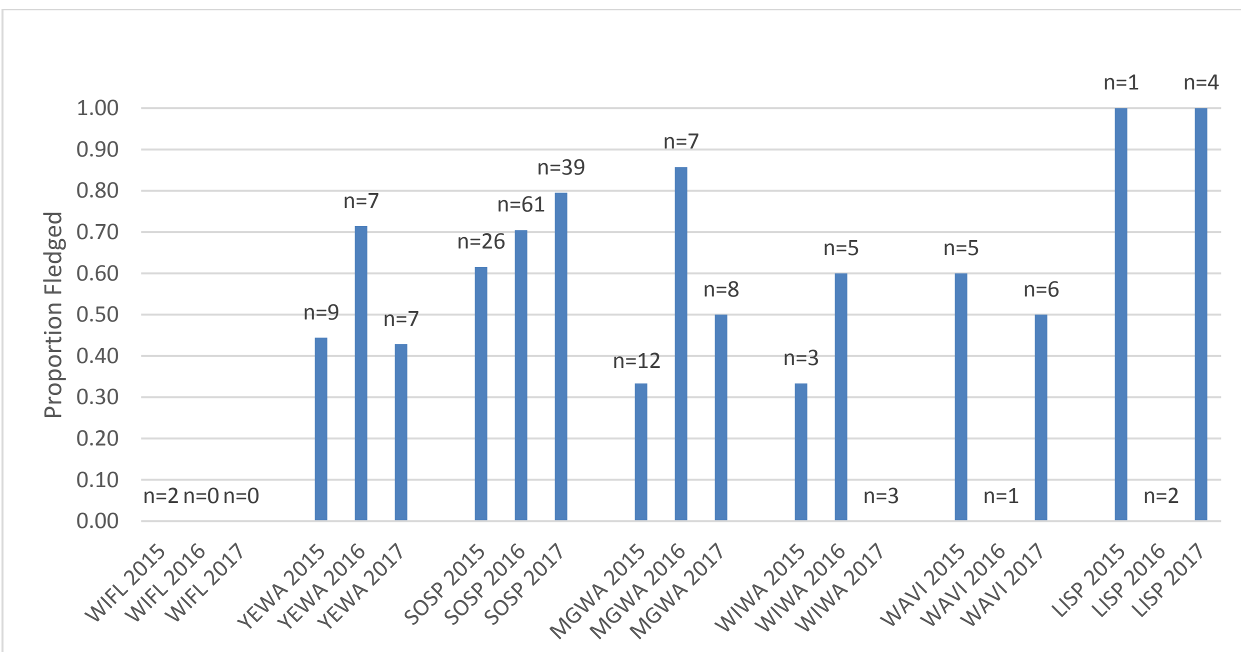


Figure 4. The percentage of shrub cover within a 5-m radius at random and nest locations for the 5 reaches and 7 bird species in the Childs Meadow bird study for 2015-2017 combined.

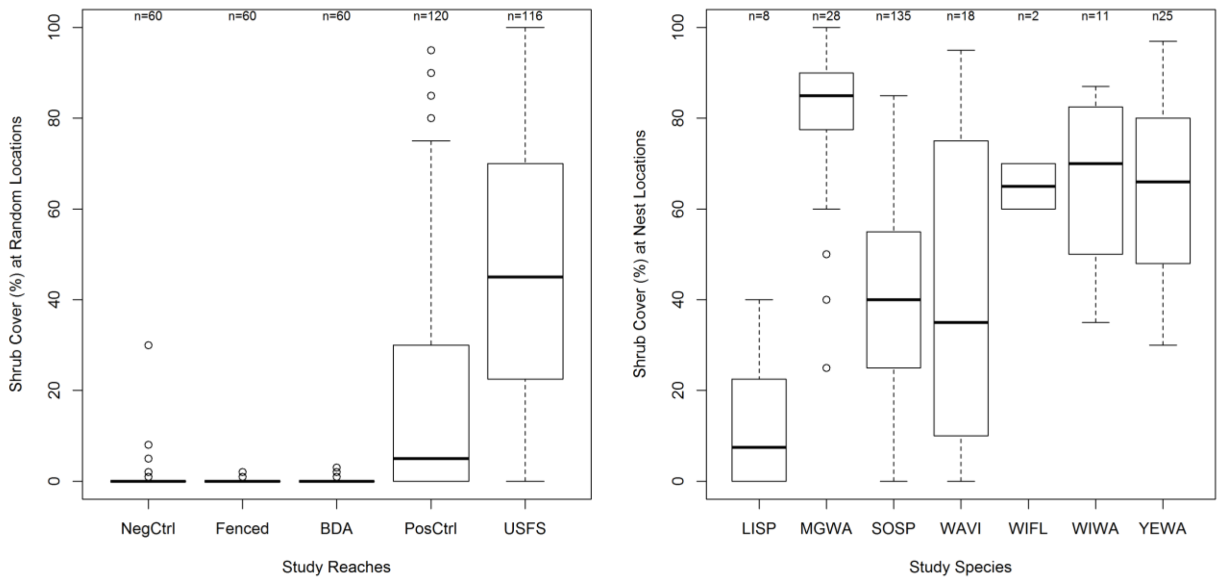
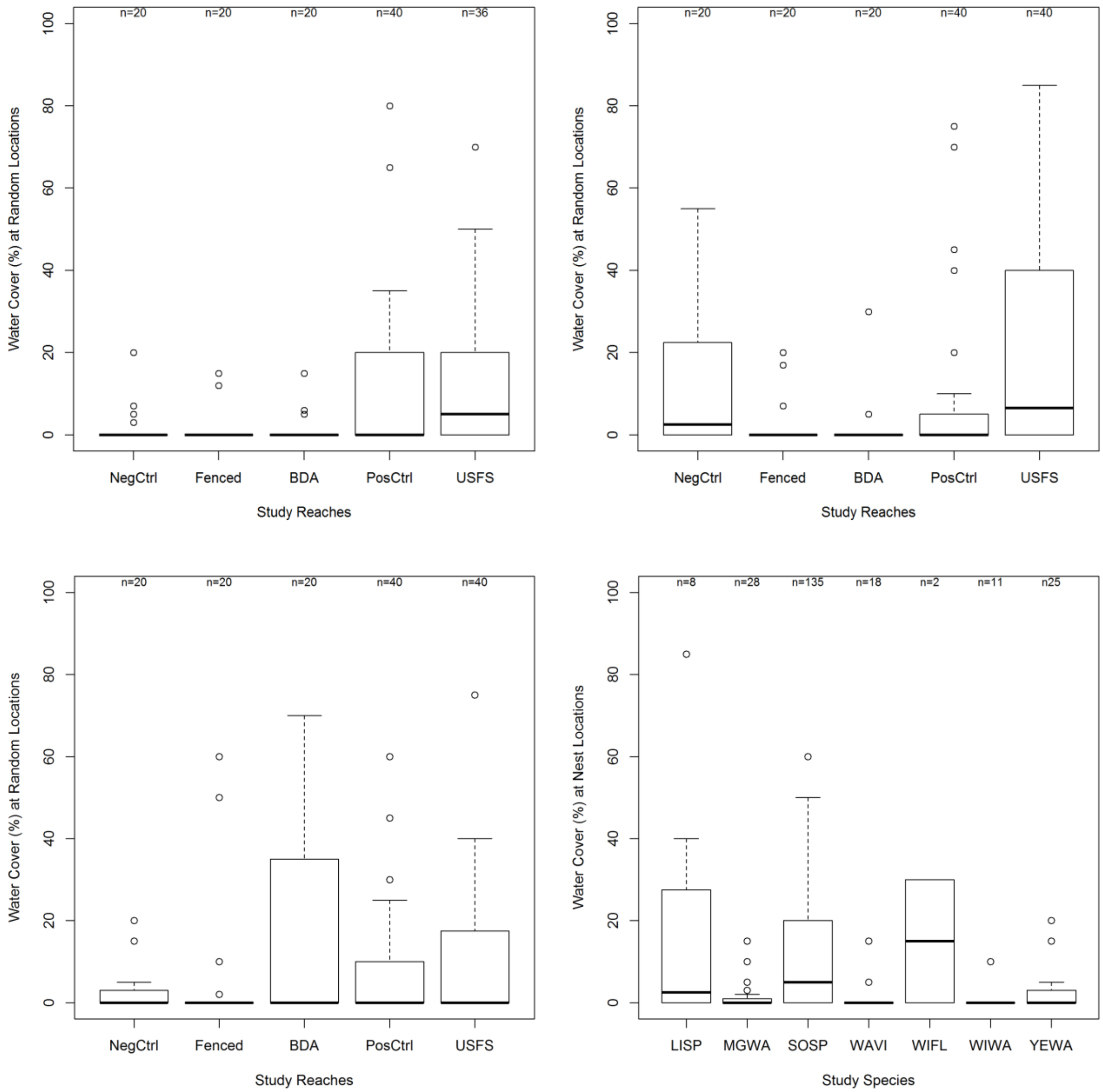


Figure 5. The percentage of meadow surface covered by water within a 5-m radius sampling plot at random and nest locations for the 5 reaches and the 7 bird species in the Childs Meadow bird study. Data from random locations in each reach are displayed for every year—2015 (top left panel), 2016 (top right panel), and 2017 (bottom left panel)—to show inter-annual variation. Data from nest locations are displayed for 2015-2017 combined (bottom right panel).



APPENDIX

Figure A1. Map of nests of bird study species located in the negative control, riparian fence, and beaver-dam analog reaches of the Childs Meadow study from 2015-2017.

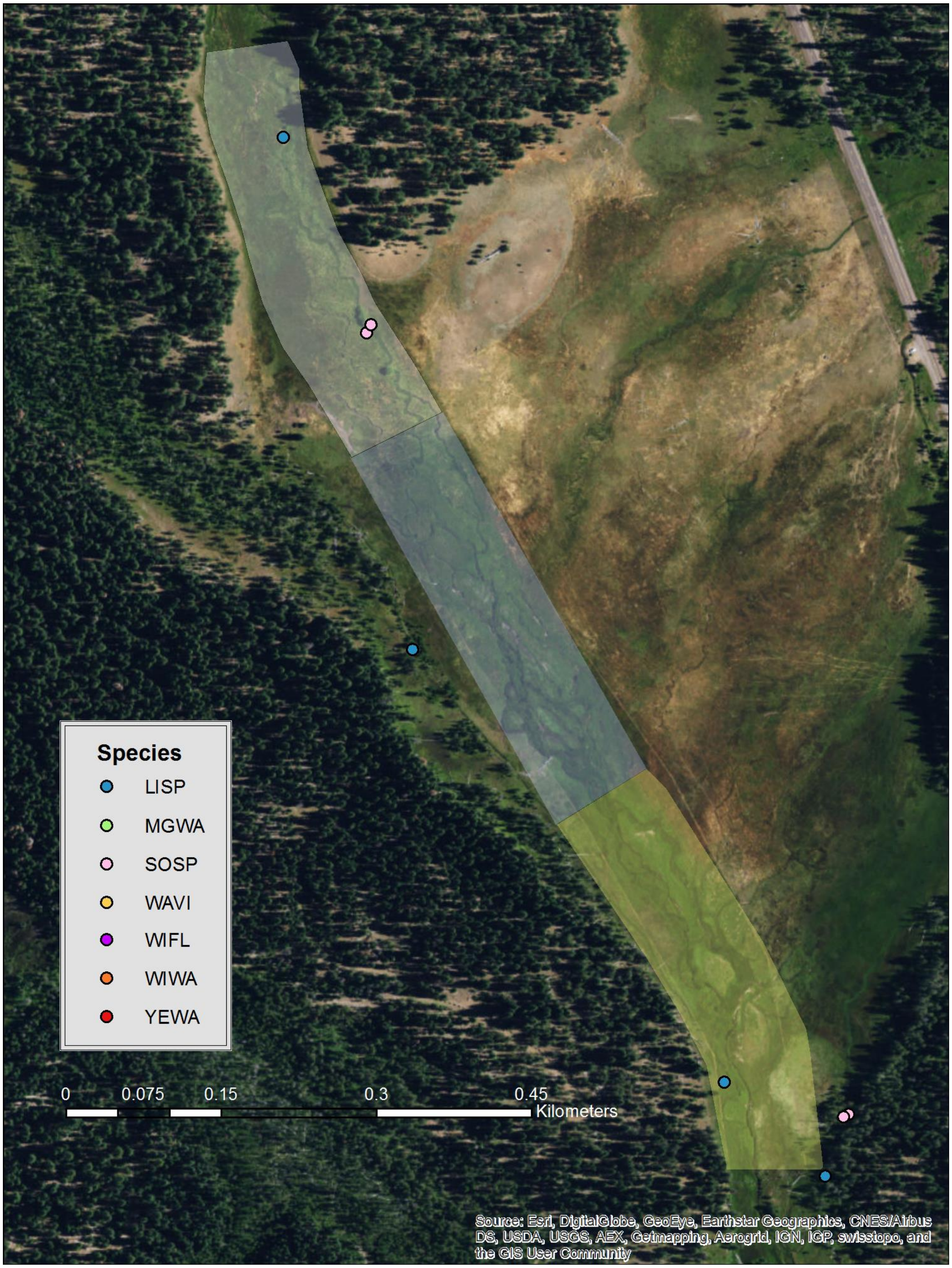


Figure A2. Map of nests of bird study species located in the Positive Control A/B reach of the Childs Meadow study from 2015-2017.

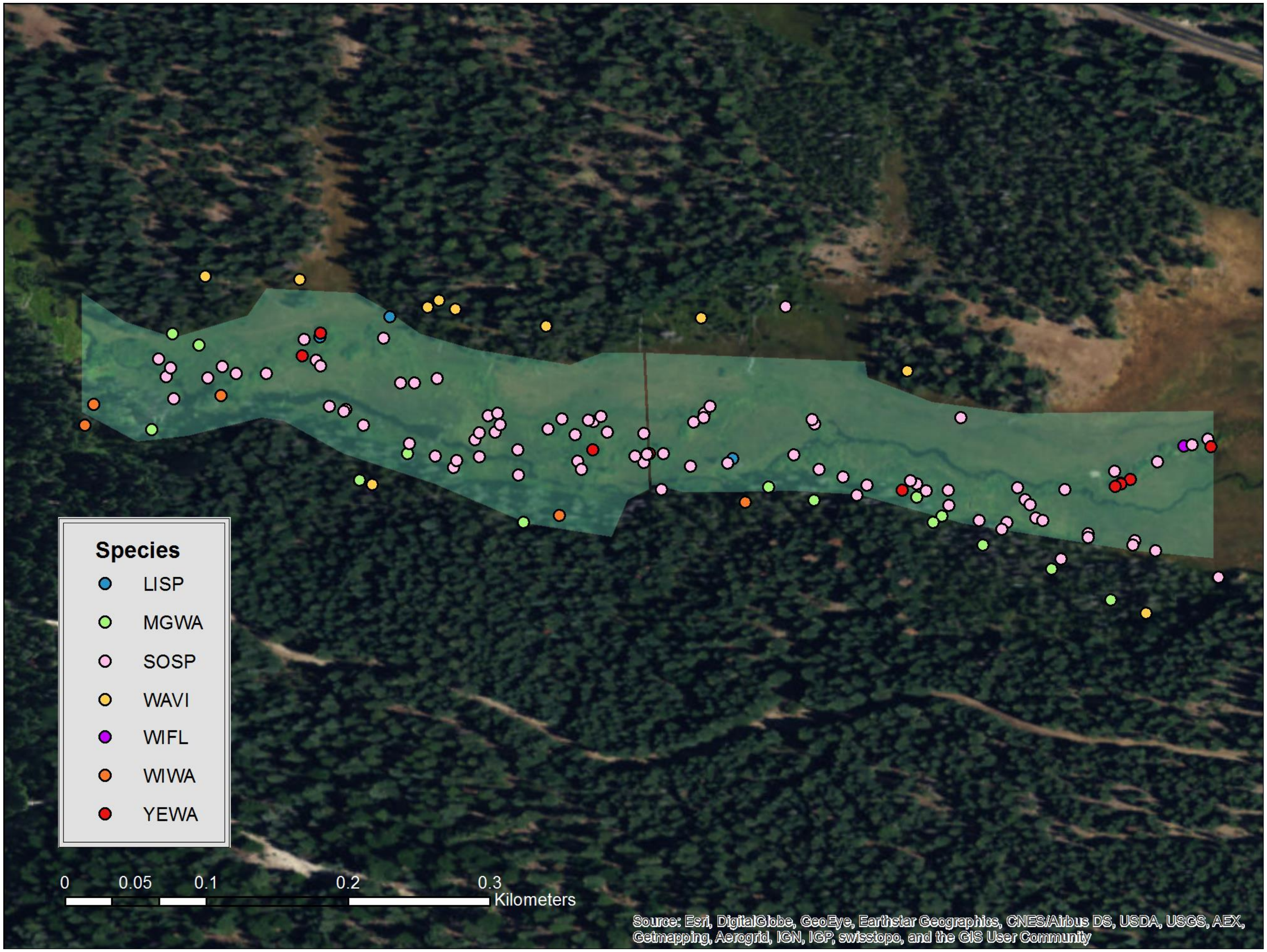


Figure A3. Map of nests of bird study species located in the US Forest Service Positive Control reach of the Childs Meadow study from 2015-2017.

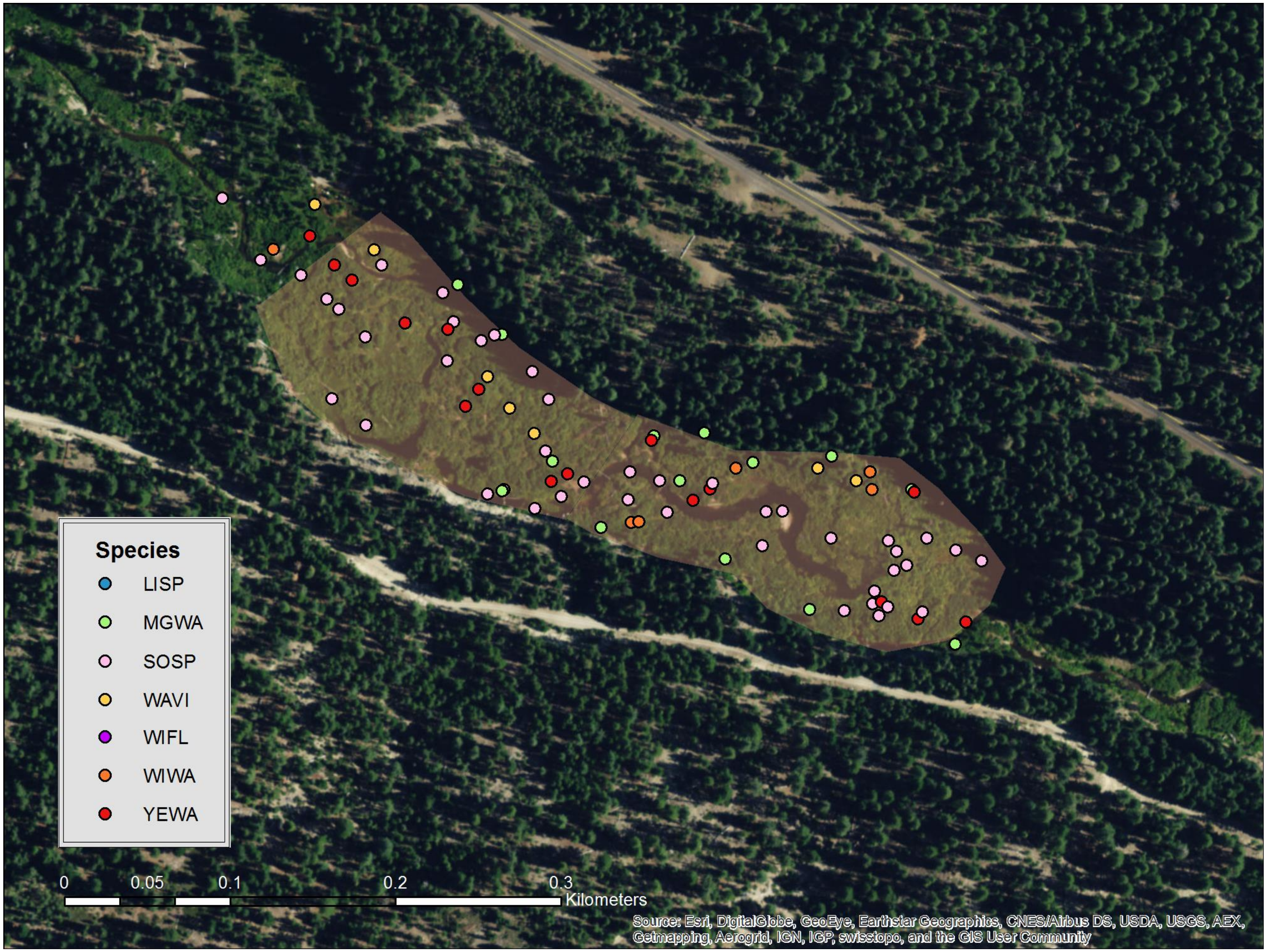


Figure A4. The proportion of nests that fledged at least one young for 189 nests found within study plot boundaries from 2015-2017 by reach (A) and species (B).

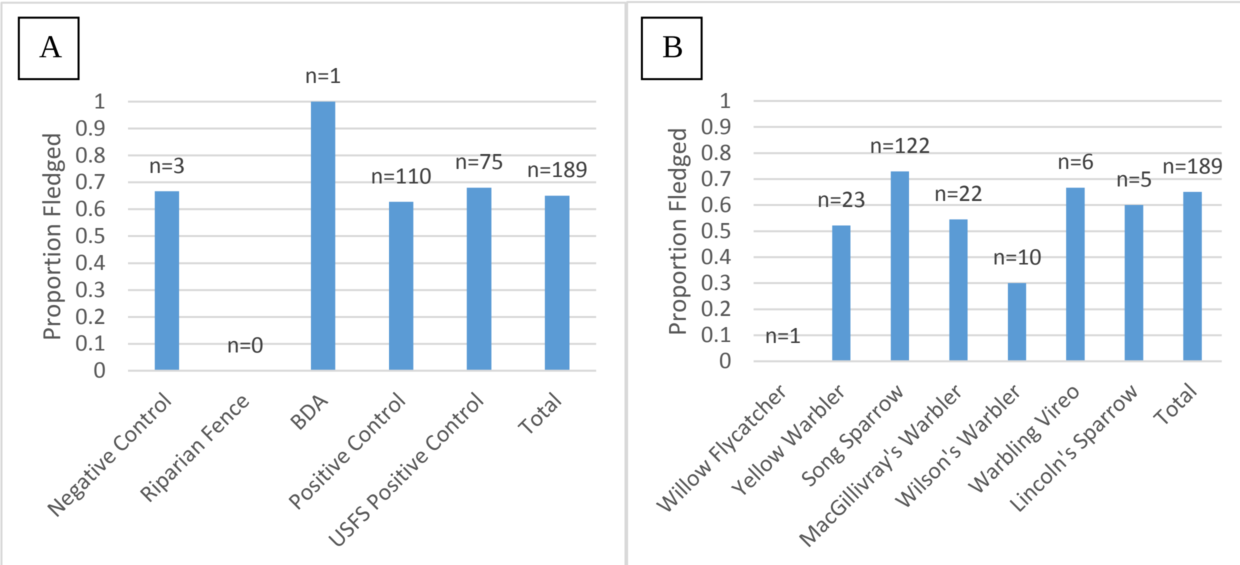


Figure A5. The proportion of nests that fledged at least one young for 189 nests found within study plot boundaries from 2015-2017, by species and year.

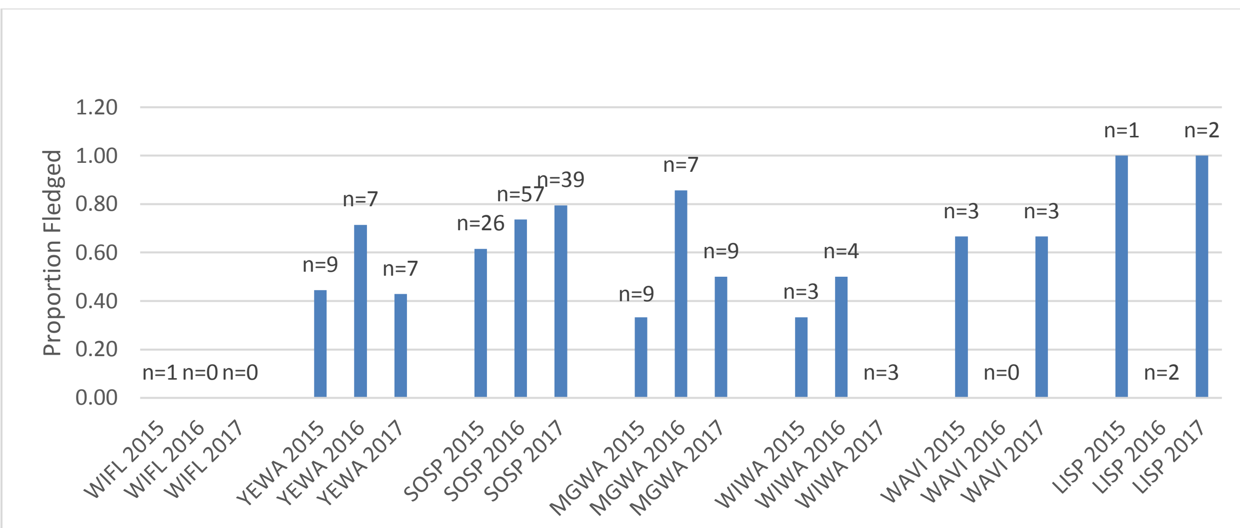


Figure A6. Maps of Song Sparrow territories on Positive Control A/B reach in 2016 (A) and 2017 (B).

Figure A7. Maximum shrub height (top panels) and shrub species richness (bottom panels) within a 5-m radius at random and nest locations for the 5 reaches and 7 bird species in the Childs Meadow bird study for 2015-2017 combined.

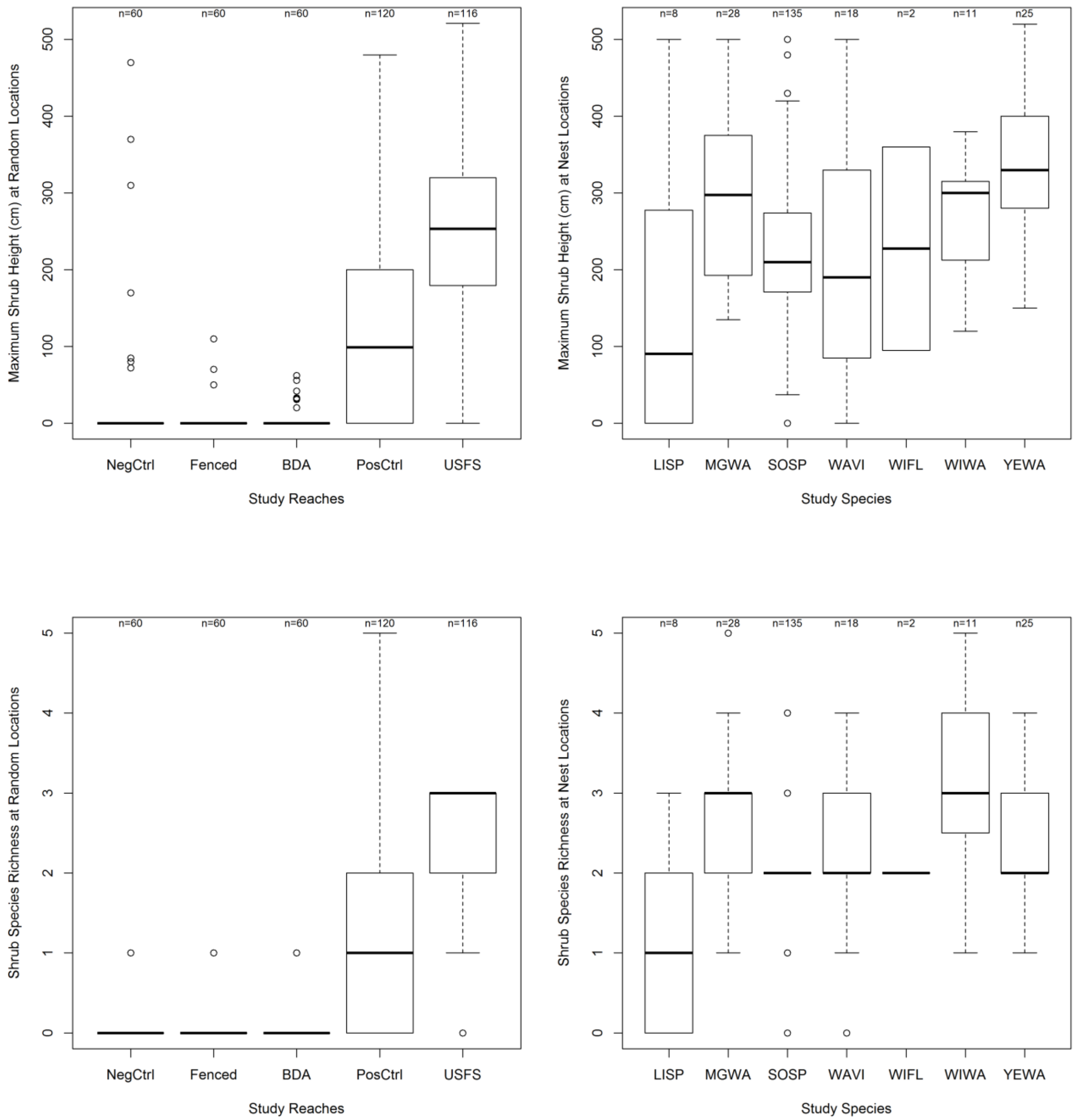


Figure A8. The percentage of herbaceous cover within a 5-m radius at random and nest locations for the 5 reaches and 7 bird species in the Childs Meadow bird study for 2015-2017 combined.

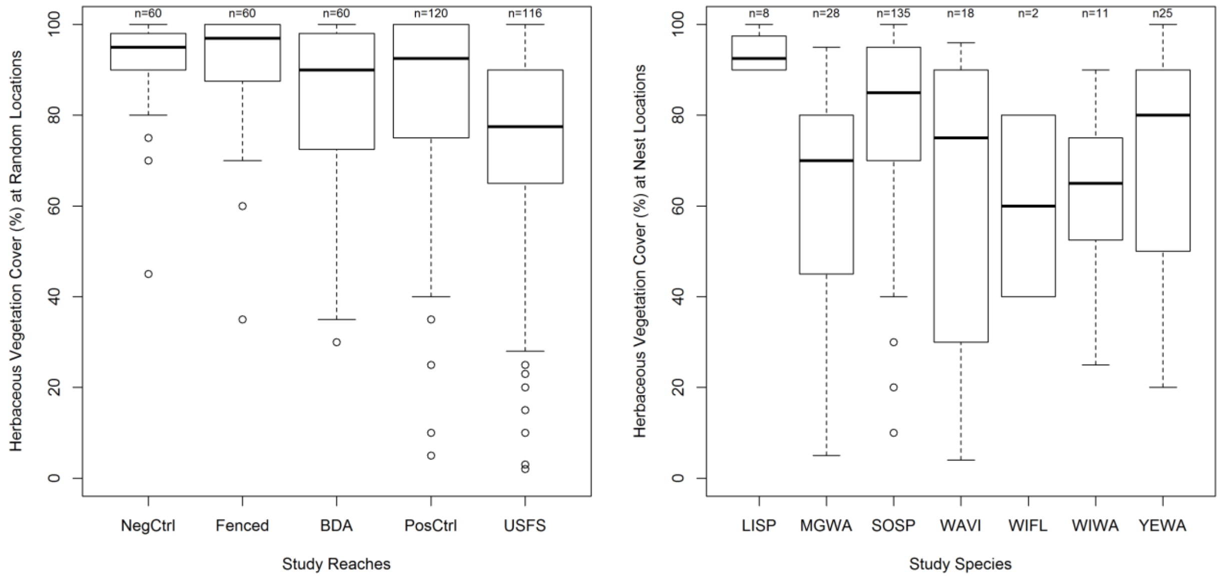


Table A1. The mean percentage of cover (±SE) of vegetation, logs, litter, bare ground, and water at nest and random locations in five study reaches of Childs Meadow in 2015.

Sample Type	Species or Reach	N	Shrub	Herbaceous	Logs	Litter	Bare Ground	Water
Nest	LISP	1	10.0 ± NA	95.0 ± NA	4.0 ± NA	3.0 ± NA	0.0 ± NA	40.0 ± NA
Nest	MGWA	13	80.2 ± 3.0	66.2 ± 6.7	6.4 ± 1.7	81.3 ± 5.3	4.3 ± 1.9	2.7 ± 1.3
Nest	SOSP	31	37.9 ± 3.7	82.3 ± 3.2	1.8 ± 0.4	48.8 ± 6.2	7.6 ± 1.6	14.8 ± 2.6
Nest	WAVI	6	58.8 ± 17.0	43.2 ± 13.5	9.7 ± 4.4	91.3 ± 3.9	7.5 ± 3.4	0.0 ± 0.0
Nest	WIFL	2	65.0 ± 5.0	60.0 ± 20.0	1.0 ± 1.0	62.5 ± 27.5	5.0 ± 5.0	15.0 ± 15.0
Nest	WIWA	3	78.3 ± 4.4	71.7 ± 9.3	20.0 ± 10.4	85.0 ± 7.6	2.3 ± 1.3	0.0 ± 0.0
Nest	YEWA	8	72.2 ± 5.3	58.1 ± 8.8	2.9 ± 1.4	73.4 ± 10.4	3.2 ± 1.2	5.2 ± 3.2
Random	NegCtrl	20	1.9 ± 1.5	93.7 ± 2.8	0.0 ± 0.0	16.1 ± 4.1	7.1 ± 3.1	1.8 ± 1.1
Random	Fenced	20	0.0 ± 0.0	86.2 ± 2.6	0.0 ± 0.0	71.0 ± 5.2	19.3 ± 3.5	1.4 ± 0.9
Random	BDA	20	0.0 ± 0.0	69.2 ± 4.2	0.0 ± 0.0	79.9 ± 3.7	17.3 ± 3.6	1.3 ± 0.8
Random	PosCtrlAB	40	18.7 ± 4.1	84.6 ± 2.5	2.1 ± 0.7	61.3 ± 5.6	6.2 ± 1.1	11.9 ± 3.2
Random	USFS	38	52.9 ± 4.0	76.3 ± 3.0	3.5 ± 0.8	78.3 ± 4.2	3.2 ± 0.8	13.1 ± 3.2

Table A2. The mean percentage of cover (±SE) of vegetation, logs, litter, bare ground, and water at nest and random locations in five study reaches of Childs Meadow in 2016.

Sample Type	Species or Reach	N	Shrub	Herbaceous	Logs	Litter	Bare Ground	Water
Nest	LISP	2	27.5 ± 12.5	95.0 ± 5.0	1.5 ± 1.5	90.0 ± 10.0	0.0 ± 0.0	7.5 ± 7.5
Nest	MGWA	7	91.0 ± 2.6	52.1 ± 11.2	4.0 ± 1.3	90.0 ± 4.3	4.0 ± 2.8	1.4 ± 1.4
Nest	SOSP	63	43.6 ± 2.9	79.2 ± 2.5	0.8 ± 0.2	84.8 ± 2.0	1.4 ± 0.4	10.0 ± 1.8
Nest	WAVI	4	41.5 ± 19.6	63.8 ± 21.2	15.0 ± 6.5	67.5 ± 17.0	20.8 ± 19.8	5.0 ± 3.5
Nest	WIFL	0	--	--	--	--	--	--
Nest	WIWA	5	72.6 ± 7.0	49.0 ± 8.6	3.8 ± 1.0	65.0 ± 10.0	19.4 ± 11.5	2.0 ± 2.0
Nest	YEWA	9	65.4 ± 7.9	64.1 ± 10.1	0.6 ± 0.6	89.4 ± 3.9	1.9 ± 1.1	2.1 ± 1.6
Random	NegCtrl	20	0.8 ± 0.5	94.0 ± 1.6	0.0 ± 0.0	77.0 ± 4.0	3.5 ± 1.5	11.8 ± 3.7
Random	Fenced	20	0.2 ± 0.1	92.2 ± 3.5	0.0 ± 0.0	84.3 ± 5.2	5.7 ± 3.4	2.2 ± 1.3
Random	BDA	20	0.0 ± 0.0	94.0 ± 2.4	0.4 ± 0.3	89.4 ± 3.5	5.3 ± 2.4	1.8 ± 1.5
Random	PosCtrlAB	40	16.6 ± 3.6	85.3 ± 3.7	1.7 ± 0.5	83.2 ± 3.6	1.8 ± 0.8	8.3 ± 3.0
Random	USFS	40	53.0 ± 4.4	73.2 ± 4.0	3.8 ± 0.6	68.2 ± 4.6	5.3 ± 1.6	21.4 ± 4.1

Table A3. The mean percentage of cover (±SE) of vegetation, logs, litter, bare ground, and water at nest and random locations in five study reaches of Childs Meadow in 2017.

Sample Type	Species or Reach	N	Shrub	Herbaceous	Logs	Litter	Bare Ground	Water
Nest	LISP	5	7.0 ± 5.8	93.0 ± 2.0	3.2 ± 1.9	64.0 ± 16.1	3.0 ± 1.8	18.0 ± 16.8
Nest	MGWA	8	68.1 ± 8.5	60.0 ± 9.2	3.6 ± 1.0	85.1 ± 3.4	6.2 ± 2.9	1.2 ± 1.2
Nest	SOSP	41	35.1 ± 3.1	76.2 ± 2.6	1.0 ± 0.5	74.8 ± 2.9	5.6 ± 1.4	13.3 ± 2.6
Nest	WAVI	8	31.9 ± 9.4	73.2 ± 8.2	4.1 ± 1.1	86.0 ± 2.9	3.0 ± 0.7	1.9 ± 1.9
Nest	WIFL	0	--	--	--	--	--	--
Nest	WIWA	3	40.0 ± 5.0	78.3 ± 3.3	8.7 ± 5.2	73.3 ± 7.3	11.7 ± 1.7	0.0 ± 0.0
Nest	YEWA	8	60.0 ± 6.4	86.6 ± 2.6	3.5 ± 2.6	84.4 ± 3.5	3.4 ± 0.7	2.5 ± 0.8
Random	NegCtrl	20	0.1 ± 0.1	89.4 ± 1.8	0.0 ± 0.0	67.3 ± 1.7	11.8 ± 1.6	2.5 ± 1.2
Random	Fenced	20	0.0 ± 0.0	96.2 ± 1.6	0.0 ± 0.0	74.0 ± 5.6	4.2 ± 1.7	6.1 ± 3.8
Random	BDA	20	0.4 ± 0.2	87.8 ± 3.2	2.2 ± 1.5	69.5 ± 6.2	5.6 ± 1.6	16.1 ± 5.8
Random	PosCtrlAB	40	19.8 ± 4.5	83.4 ± 3.6	1.8 ± 0.9	86.0 ± 2.5	4.1 ± 1.6	7.5 ± 2.2
Random	USFS	40	34.4 ± 3.6	67.2 ± 3.9	3.4 ± 0.6	71.2 ± 3.8	10.9 ± 2.8	10.1 ± 2.6