Upper Deschutes Watershed Council
Technical Report

2017 Camp Polk Monitoring Report

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Introduction

UDWC and restoration partners implemented a suite of monitoring actions at Camp Polk Meadow (CPM) from 2010 through 2017 per the Whychus Creek Restoration Project at Camp Polk Meadow Preserve Monitoring Summary Table (Appendix A) and in accordance with project funding agreements. Restoration partners modified monitoring activities to respond to emerging conditions and needs. 2017 represents Year 5 post-project, with 2012, the year project implementation was completed, being Year 0. Parameters monitored in 2017 included:

- Groundwater
- Continuous temperature
- Riparian vegetation
- Invasive weeds
- Macroinvertebrates; and
- Fish populations *(*juvenile density, *O. mykiss* redds)

Fish habitat was surveyed in 2016 but was not included in the 2016 Camp Polk Project Monitoring Report; we include it here.

2017 monitoring activities and findings are summarized below.

Groundwater

We sampled groundwater wells monthly from April through October 2017 to evaluate depth to groundwater in relation to the project objective of elevating the water table to within 2.0'of the surface. Monitoring was conducted during these months to track groundwater trends during the growing season, when water availability is essential to support riparian vegetation growth and survival, and runoff and snowmelt recharge groundwater. In 2015 we discontinued monitoring at Well 1 after a side channel head-cut back to the well, connecting surface and groundwater at the well site and compromising the integrity of the well casing and function of the well. We recalculated monthly median values for March through October 2008-2015, the 2008 baseline mean growing season depth to groundwater, and the overall mean for each growing season 2009-2015, excluding values from Well 1 to allow comparison between years prior and subsequent to the 2015 failure of Well 1. We calculated all 2016 and 2017 values using data from the remaining 6 wells. We calculated the mean value for each individual well as the mean of the April through October depths for each well. We calculated the mean growing season depth to groundwater as the mean of the median value from the six-well dataset for each month.

Groundwater well monitoring was initiated at Camp Polk in June 2007, resulting in an incomplete dataset for that year. In 2008 groundwater wells were monitored from April through October; the 2008 dataset represents the baseline for the project. Although Whychus Creek wasn't diverted into the constructed meadow channel until 2012, 2008 also represents the only year of true pre-project data given various sources of water introduced into the meadow beginning in 2009, including diversion of 1.5 cfs of water into the new channel beginning in June 2009 and maintained until the creek was diverted in 2012, and irrigation along the constructed channel at a rate of ~ 1"/week from April through October in 2010 and 2011.

The 2008 mean growing season groundwater depth was 4.98' (Table 1). This number decreased (groundwater rose toward the surface) as flows and irrigation were introduced into the meadow from

2009 through 2011, to 3.6’ in 2011. The groundwater response following the February 2012 diversion of Whychus Creek into the constructed meadow channel was immediate and sustained: mean growing season depth in 2012, notably an exceptionally high water year, was 2.17’. Mean growing season groundwater depth since 2012 has fluctuated within approximately 0.6’, between 2.18’ in 2014, also a high water year, and 2.82’ in 2013, a drought year. The 2017 mean growing season groundwater depth was 2.47’.

The project objective for groundwater was to raise groundwater a minimum of three feet from the pre-project mean growing season depth to within approximately 2’ of the surface, to 2.3’ from the original seven-well 5.3’ baseline depth or to 2’ from the six-well pre-project mean growing season depth of 4.98’. Since diversion of Whychus Creek into the constructed channel at Camp Polk, the mean growing season depth to groundwater has remained relatively stable between 2.2’ and 2.8’ depending on water year, 0.2’ – 0.8’ below the revised project objective of 2’ depth to groundwater and within 0.5’ of the original objective. As importantly, riparian vegetation is thriving in the meadow, indicating sufficient hydrologic conditions for the obligate and facultative wet species planted across the floodplain. Median depth to groundwater in August, when groundwater is historically lowest, has ranged from 1.9’-3.5’ since 2012, between 2’ and 4.6’ shallower than in 2007 and 2008, the two years before flows were introduced into the meadow. Despite mean growing season groundwater depth stabilizing up to 0.8’ below the revised project objective, the persistence of an elevated water table throughout the growing season, the pre-project to post-project difference in August, and the success of riparian vegetation in the meadow suggest a meaningful degree of success in restoring meadow hydrology and floodplain connectivity and increasing the groundwater table and summer base flow (Project Goal 2). The observed increase in groundwater level is also contributing to restoration and enhancement of high quality riparian wetland habitat along the stream corridor (Goal 3), establishment of a minimum of 35 acres of wetland and riparian communities (Objective 4), and is very likely cooling summer stream temperatures to help meet Oregon’s state temperature standards (Goal 5). Restoration partners expect groundwater levels at Camp Polk Meadow to continue to fluctuate from year to year as a result of inter-annual climatic differences in snowpack, runoff, precipitation, and air temperature. Groundwater levels may also continue to change in relation to ongoing channel evolution and increasing water demands of more abundant riparian vegetation. Groundwater monitoring results are presented in annual reports spanning 2010-2017 (www.upperdeschuteswatershedcouncil.org).

Table 1. Individual well and overall growing season mean groundwater depths at Camp Polk Meadow from 2007-2017

	Growing Season Mean Groundwater Depths (ft)							
	Project Hydrologic Events	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7	Overall mean growing season depth
2007		5.33	5.33	7.95	6.05	6.51	7.75	6.22
2008		5.02	5.08	7.29	4.34	4.55	5.07	4.98
2009	June: 1.5 cfs first diverted into new channel	4.27	5.20	7.14	3.75	3.97	5.25	4.69
2010	Irrigation (1”/wk) installed along new channel	3.71	4.94	6.87	3.31	2.95	4.49	4.03
2011	April-October: Irrigation along new channel	3.51	4.78	6.69	3.28	2.45	3.52	3.61
2012	February: Whychus diverted into new channel	1.91	2.81	3.83	2.13	1.35	2.36	2.17
2013		2.23	2.98	4.66	2.74	1.85	3.26	2.82
2014		2.23	1.53	3.41	2.16	1.85	3.10	2.18
2015		2.59	1.86	3.66	2.44	2.36	3.68	2.77
2016		2.72	2.00	3.52	2.30	2.17	3.47	2.73
2017		2.65	1.98	3.62	1.91	1.86	2.98	2.47

Continuous Temperature

Recovery plans for Mid-Columbia summer steelhead cite reduced floodplain connectivity and function, degraded channel structure and complexity, and altered hydrologic processes as limiting factors for steelhead in Whychus. These factors each play a role in stream temperature. With reduced floodplain connectivity, the floodplain is not inundated by spring runoff and groundwater recharge and storage is eliminated, consequently eliminating groundwater discharge and its dual effects of cooling stream temperatures locally and increasing flow in mid- to late- summer. Degraded channel structure and complexity and altered hydrologic processes together reduce or eliminate hyporheic flow, a function which also reduces stream temperature locally.

Restoration partners designed the Camp Polk Meadow restoration project to restore floodplain connectivity and function and in doing so restore groundwater discharge in mid- to late- summer when flows are low and stream temperatures are high. The project was designed to restore channel structure and complexity which was anticipated to also restore hyporheic flow. These changes were hypothesized to result in cooler stream temperatures as documented at similar restoration projects in California (Loheide and Gorelick 2006). Based on these anticipated outcomes, UDWC identified reducing stream temperature as a project goal and identified continuous stream temperature upstream and downstream of the project as a monitoring indicator.

Although local changes in stream temperature were anticipated to result from the restoration project, the project was not designed to address the primary factor contributing to altered hydrologic processes and the primary driver of high stream temperatures in Whychus Creek, the dramatic reduction in streamflow resulting from diversions for irrigation (*2015 Whychus Creek Monitoring Report*, UDWC, 2016). Regression analysis of stream flow and stream temperature in Whychus Creek indicate that streamflow accounts for 83% of the water temperature condition (*2015 Whychus Creek Monitoring Report*, UDWC, 2016).

UDWC monitors continuous temperature at eleven locations along Whychus Creek from April through October, including at sites approximately 250 m upstream and downstream of the restored channel. We analyzed pre- and post-project data for July, limiting the analysis to a 30-day period to reduce the effects of inter-annual seasonal variation, and selected July as the month during which the hottest water day occurred most often between 2005 and 2017. To evaluate stream temperature in the project reach pre- and post-project we compared the average rate of change in temperature per mile between the upstream and downstream sites. “Pre-project” and “post-project” intervals refer to data collected prior and subsequent to diversion of Whychus Creek into the constructed meadow channel at Camp Polk in February 2012. We incorporated all available pre-project and post-project July temperature data for the two sites in our analysis.

Pre-project and post-project average rates of change in stream temperature per mile suggest stream temperature is warming more quickly through the Camp Polk Meadow restoration reach post-project than it did pre-project, even at higher flows (Table 2). The pre-project maximum July average rate of stream temperature change per mile remains higher than the post-project maximum July average, but at a far lower flow. The pre-project median of average rates of change per mile for all pre-project July data available is approximately half the post-project median, at similar flows.

Groundwater data from the project showing an increase in the average August median depth from 5’ pre-project to 2.8’ post-project suggest groundwater is available in late summer to augment flow and locally cool stream temperature. However, any local cooling effect of groundwater recharge that may be occurring at Camp Polk appears to be negated by warming of surface water, likely through a combination of increased residence time in a sinuous channel, flow already limited by significant diversions for irrigation allocated to multiple channels, and reduced riparian shading as planted trees and shrubs continue to mature. Over the long term, restoration partners expect planted riparian species including alder, willow, and cottonwood to shade the meadow channel at Camp Polk. Despite the potential reductions in stream temperature that might be achieved through groundwater recharge, hyporheic flow, and shading, we now recognize the relatively limited degree to which stream or floodplain restoration can achieve significant reductions in stream temperature given the primary role of stream flow in determining stream temperature. Significant reductions in stream temperature will most effectively be achieved through substantial increases in stream flow.

Table 2. July average rate of change per mile and average July flow at Sisters, maximum average July temperature and minimum average July flow, median average rate of change per mile and median average July flow, pre-project (2003-2011) and post-project (2012-2017).

	Average rate of change/ mi	Average July flow at Sisters
Pre-project		
2003	1.5	6.2
2005	1.7	7.5
2006	0.2	74.2
2007	1	16
2008	0.3	64
2009	0.7	27
2010	0.6	35
2011	0.2	119
Pre-project max temp/ min flow	1.7	6.2
Pre-project median	0.65	31
Post-project		
2012	0.5	118
2013	1.1	23
2014	1.4	49
2015	1.5	23
2016	1.4	29
2017	0.6	77
Post-project max temp/ min flow	1.5	23
Post-project median	1.25	39

Stream Habitat

ODFW AIP surveys were conducted at Camp Polk in 2008 and 2016. Key parameters from these surveys provide information about the quantity and quality of stream habitat pre- and post- project.

Length of side channels and off-channel habitat including isolated and backwater pools and alcoves was 17.6x higher in 2016 than in 2008 (Table 3). Total channel length in 2016 was 2.8x the 2008 total length and wetted area was 2.3x the 2008 wetted area. The number of habitat units, corresponding to both diversity and frequency of unit types and habitat complexity resulting from deposition and storage of sediment and wood, was 3.6x higher in 2016 than in 2008, with 4.7x the number of riffles and 4.1x the number of pools. Average pool depth in 2016 was 81% of the 2008 average. Substrate distribution (from ocular estimates of percent cover in each habitat unit) was characterized by a higher proportion of smaller substrate sizes in 2016 than in 2008, indicating lower stream velocities. The number of pieces of wood was 24.4x higher in 2016 than in 2008. While much of the wood counted in 2016 was placed during project implementation, the persistence of this amount of wood indicates wood storage capacity in the project reach. Together these parameters describe a 2016 stream system characterized by multiple channels, high channel complexity, and high wetted area; high diversity of habitat units corresponding to bedforms; and increased storage of smaller substrate sizes and wood. They describe a 2008 pre-project stream system characterized by 0.26 km of side channel and off channel features to 2.1 km of primary and single channel, representing a simplified channel network with limited side channel length and off-channel features, low channel complexity, and relatively lower wetted area; lower diversity and abundance of habitat units; and lower storage of smaller substrate sizes and wood.

Table 3. ODFW AIP Stream Habitat Survey parameters, corresponding SEM physical attributes, 2008 and 2016 values, and percent change.

Survey parameter	2008	2016	Percent change
Side/off-channel length (km)	0.26	4.5	1764%
Total length (km)	2.3	6.6	282%
Total area (m^2)	17530	40414	231%
Number of habitat units	63	226	359%
Number of riffles	19	90	474%
Number of pools	23	94	409%
Average pool depth (m)	0.52	0.42	81%
Average percent sand	17	39	229%
Average percent gravel	39	51	131%
Average percent cobble	31	7	23%
Total pieces of wood	19	464	2442%

Riparian Vegetation

UDWC began monitoring riparian vegetation at Camp Polk in 2010, the first growing season following riparian plantings in Fall 2009. We measured riparian plant survival including tree and shrub survival, one of several vegetation parameters identified in the Camp Polk monitoring plan, in 2010 and 2011 to assess establishment and need for re-planting. Survival approached 100% in both years and by 2011 differentiating between original planted individuals and new growth and detecting dead individuals was sufficiently difficult to bring into question the accuracy of results. However, the successful establishment of riparian vegetation was evident. From 2012-2014 we used a percent cover sampling methodology to quantify total cover and abundance of planted species.

Total vegetative cover within 100 ft of the main channel averaged 73% in 2014. Although 11% lower than the 84% reported for 2013, this difference is likely a result of sampling error associated with a relatively small sample (n=14), inclusion of two transects from Reach 1 where planting occurred two years later than on the rest of the project, and the patchiness and heterogeneity characteristic of plant communities. Planted riparian species cover averaged 29%, a small gain over the 27% reported for both 2012 and 2013. Cover of other species, both native and non-native, averaged 60% (compared to 76% in 2013), while priority weed species, namely cheatgrass (1.5%), accounted for only 1.8% of total vegetation. (Both planted species and other species could be detected and recorded on the same point, hence percentages for these two groups summed to more than the 73% total vegetative cover.)

Despite the lower measured abundance of total vegetation and the small increase in planted vegetation from 2013-2014, riparian vegetation monitoring from 2010 through 2014 showed the seeded and planted riparian community at Camp Polk Meadow to be increasingly well-established and abundant, characterized by a strong native component and low abundance of invasive weeds, consistent with achieving project goals. Along some reaches of the main stream channel, the riparian community has changed from a knee- to shoulder-high scattering of shrubs to a dense overhead canopy of willow and alder. Whereas the point-intercept sampling protocol implemented in 2012 was ideally suited for measuring percent cover (i.e. lateral growth) of a shorter herbaceous and shrub community, as the bigger species at Camp Polk Meadow have accelerated in vertical growth, the point-intercept protocol became both less well-suited for measuring plants that are overhead and more difficult to implement. 2015 vegetation monitoring efforts focused on mapping reed canarygrass, a highly invasive species that has altered wetland and stream ecosystems throughout the Pacific Northwest and which had been observed at increased abundance in the meadow, and no vegetation monitoring occurred in 2016.

In 2017, UDWC worked with Earth Design Consultants, Inc. (EDC) to fly aerial imagery along 16.5 miles of Whychus Creek, including the Camp Polk project. EDC digitized land cover classes, including riparian vegetation, from the 2017 imagery. Digitization of land cover classes from pre-project aerial imagery is ongoing. When completed, the resulting GIS shapefiles will allow us to calculate increase in acres of riparian vegetation and display extent and location of pre- and post-project riparian vegetation at Camp Polk. UDWC and Deschutes Land Trust (DLT) will continue to evaluate vegetation (riparian community and invasive weed) monitoring needs at Camp Polk and tailor monitoring metrics and methods accordingly.

Invasive Weeds

The Deschutes Land Trust has inventoried, mapped, and actively managed invasive plant species at Camp Polk Meadow Preserve since 2000. During the summer of 2006, prior to beginning construction at Camp Polk, weeds were inventoried and distribution maps and infestation levels were updated for priority weed species. The *Camp Polk Meadow Weed Management Plan,* developed in 2002 and revised every year starting in 2009, was updated to respond to these baseline conditions.

The spread of non-native, invasive plants in disturbed areas was anticipated to occur in the first few years following restoration construction. Pre- and post- construction weed treatments (chemical application and manual control) and weed population monitoring were planned according to the *Camp Polk Meadow Weed Management Plan* to maximize successful establishment of native plants. DLT has monitored priority weed species and implemented treatments annually between April and October since 2009. Changes in species density and distribution are recorded and mapped. Monitoring data are used in an adaptive management approach to plan monitoring and treatments for the following year.

By 2013 weed populations had been controlled to the extent that 2014 weed monitoring was reduced to once a month during June, July, and August. 2014 surveys detected spotted knapweed, common mullein, and bull and scotch thistle at lower abundances than in previous years; mustard, nightshade, and fiddleneck (a weedy native) populations were also much reduced. The expansion of reed canarygrass observed within and along the main channel in reach 2 in 2014 prompted an intensive reed canarygrass mapping effort in 2015, summarized in the Reed Canarygrass section of this report.

In addition to reed canarygrass mapping, weeds were surveyed and mapped in 2015 over four visits to the meadow, once per month from May through August (Appendix B; Appendix C). Species that continued to present a management concern as of 2015 included spotted knapweed, bull and Canada thistle, common mullein, and reed canarygrass. Spotted knapweed and bull thistle were found in sandbars, flood deposits, and dry side channels, suggesting that flood flows are likely introducing seeds of these species into the meadow. Common mullein also remained abundant throughout the restoration area. Volunteer crews hand-pulled (mullein) or clipped (knapweed and thistle) these species throughout the summer. Canada thistle continued to expand in the meadow despite sustained efforts to control it through clipping. In September 2015, DLT staff treated all major Canada thistle and co-occurring common teasel populations that could be safely treated with the herbicide Opensight (aminopyralid and metsulfuron methyl); additional treatments were anticipated to be needed in 2016 to control Canada thistle and teasel to the point where they can be controlled without the use of herbicides.

Management actions in 2016 continued to include hand-pulling and clipping of spotted knapweed, mullein, and bull thistle. The Canada thistle and common teasel populations treated in 2015 demonstrated improvements. One small, isolated population of Canada thistle to the west of the main populations exhibited very little re-emergence in 2016 and therefore was not re-treated. Canada thistle and teasel continued to flourish in areas of saturated soils and near water where DLT had not treated in 2015 due to restrictions specific to the herbicide used. Accordingly, in 2016 DLT treated dry areas with Opensight as in 2015, and treated populations growing in saturated soils with an aquatic version of 2,4-D (Appendix D).

In 2017, the Land Trust continued to concentrate weed management efforts on hand-pulling of mullein and spotted knapweed in the restoration area. Canada thistle and teasel were treated with herbicides in the Preserve adjacent to the restoration area. Similar to 2016, DLT treated dry soil areas with Opensight and treated populations growing in saturated soils with an aquatic version of 2,4-D. A formal survey of weed populations was not conducted in 2017 but observations during staff visits and volunteer weed pulling efforts did not reveal any new species of concern or major changes to weed populations.

As of 2017, weed populations at Camp Polk appear to be remaining static or diminishing but not expanding under the weed management regime implemented in the project area since restoration. In 2018 DLT staff will continue to observe populations of mullein, spotted knapweed, Canada thistle and teasel and apply the same treatments as in 2017 as needed and given staff capacity.

Reed Canarygrass

In fall 2014, the project team noticed a marked increase in reed canarygrass (RCG), a rhizomatous grass that has invaded wetlands throughout the continental US, in Camp Polk Meadow. RCG was known to occur in the meadow and had been actively controlled through manual and herbicide treatments and closely monitored from 2009 through 2012. By 2012, abundance of RCG in established populations had decreased, populations detected in the new meadow channel in 2011 were absent following diversion of Whychus Creek into the channel, and no new populations had been observed subsequent to 2011 treatments. Riparian vegetation monitoring and field observations showed native species to be increasing in abundance and successfully competing with weeds. Weed populations responded so positively to 2012 and 2013 control measures that in 2014 weed monitoring was reduced to once per month.

To evaluate the scope and severity of RCG expansion and identify management alternatives for controlling RCG, in 2015 UDWC and DLT staff mapped reed canarygrass in the meadow, reviewed available literature on reed canarygrass ecology and management, and developed a preliminary plan for controlling reed canarygrass at Camp Polk. Sampling efforts were focused in the upstream reaches of the project (Reaches 1 & 2) and along the main channel and side channels (Appendix C). RCG was found at relatively low abundance (<25% cover) throughout areas sampled. It was consistently found in riparian areas and side channels where the stream accesses the floodplain during high flow events, leaving soil moisture high, and in stream channels where sediment and woody material collect. We did not find reed canarygrass in drier areas above elevations typically flooded by high flows.

Treatment priorities and methods identified for Camp Polk respond to the flooding regime and plant community that characterize the meadow. Frequent flooding promotes RCG establishment by depositing sediment, RCG rhizomes and seeds onto the floodplain, particularly in Reaches 1 & 2; the planted native riparian community is well-established, diverse and abundant; invasive weeds other than RCG represent a small proportion of the community. Treatment recommendations are summarized as follows:

- Prioritize upstream reaches, the mainstem channel, dense monocultures, and new shoots (“starts”) for treatment. Beginning treatment in the upper reaches of a focal area, addressing vectors, and eliminating small source populations are approaches that have been shown to significantly control RCG in wetland settings.
- Hand-pull starts and in-stream mats and dig up all roots.
- Backpack-spray logjams and well-established, high-density areas with glyphosate herbicide during late summer low flows. A USFS study on the Metolius River found backpack spraying to more effectively control ribbongrass, another *Phalaris* species, than wand application. RCG was consistently found at relatively higher abundances on logjams in the main and side channels at CPM.

- Experimentally solarize dense monocultures above high water. Although solarization has been shown to be effective in controlling dense stands of RCG, restoration partners are wary of floodwaters degrading plastic and introducing plastic fragments into the stream environment.
- Monitor but defer treatment of RCG sparsely interspersed with native riparian vegetation.

Deschutes Land Trust incorporated these recommendations to identify a RCG treatment plan for 2016 that included application of an aquatic glyphosate herbicide in priority treatment areas to prevent reed canarygrass from forming monocultures, choking side channels, and out-competing natives.

DLT prioritized 2016 RCG treatment areas into 3 categories. Treatment of the main new channel through the restored area was highest priority for treatment due to the low infestation of RCG and greatest chance of successfully limiting its spread in this area. Treatment of the smaller connecting and side channels was a secondary priority. Treatment of the old channel was lowest priority due to the density of infestation, density of surrounding native vegetation and access difficulty. Use of solarization and hand-pulling / digging was not deemed an economical or effective strategy at this time. Treatment with an aquatic glyphosate product mixed with an aquatic surfactant was completed via backpack sprayer by a licensed herbicide applicator. All three categorized areas mentioned above were successfully treated in August and September 2016 (Appendix D). Several weeks later, die-off of RCG stands was evident. These stands were checked again in spring and summer 2017 and no new growth was observed. DLT will map RCG in the new channels again in summer 2018 and update their RCG treatment plan to respond to 2018 conditions.

Ultimately DLT aims to reduce the RCG population to the extent that it can be controlled in the future exclusively through hand-pulling. Active prevention of RCG establishment at future projects will be facilitated by intensifying RCG management efforts at the time when the stream is reconnected to the floodplain, and by strategically developing funding and allocation of resources for RCG control.

Macroinvertebrates

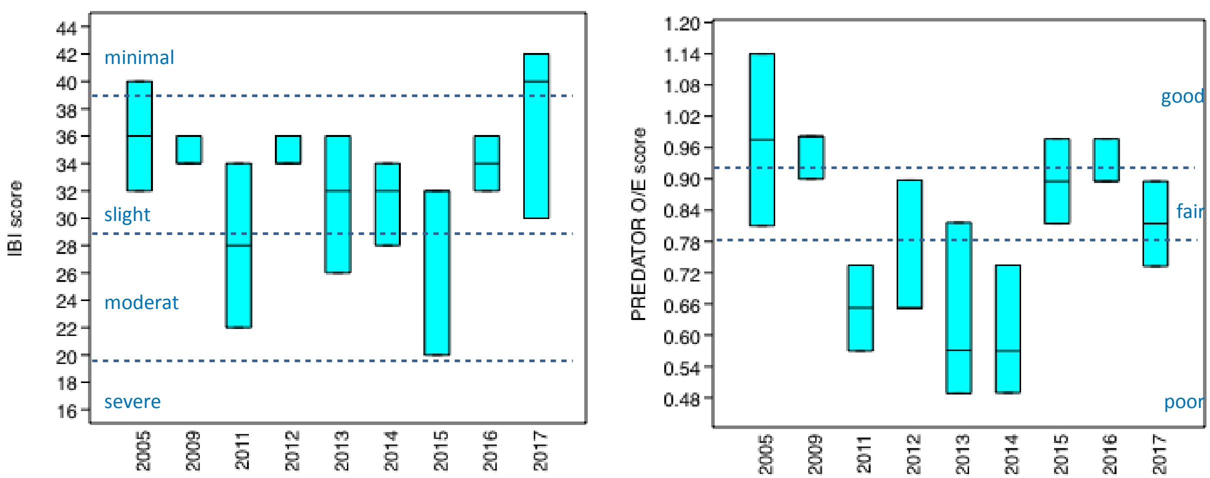
Macroinvertebrates were sampled at Camp Polk in 2005, 2009, and 2011-2017. Samples were collected at the temperature monitoring locations upstream and downstream of Camp Polk (WC 19.5 and WC 18.25) in all nine years. Two additional sites, WC 18.50 and WC 19.00, were sampled in 2005, 2009, and 2011 in the old, straightened channel, re-located to the new channel following diversion of the stream in 2012, and sampled in the new channel from 2012-2017. We evaluated mean scores for the three downstream sites where the stream restoration project was anticipated to have the most direct effect.

Mean Index of Biological Integrity (IBI)scores, PREDATOR scores, and means for six additional community metrics from the three downstream Camp Polk sites suggest stream conditions declined between 2011 and 2015 but improved from 2015 (in some cases 2014) to 2017. For many metrics, 2017 represented the best conditions observed of the nine years of sampling data.

Mean IBI scores among the three downstream sites suggest reduced biological integrity from 2011 to 2015 (lower scores) and recovery in 2016 and 2017. Mean scores for the three sites were not significantly different between years, and scores dropped from slight to moderate disturbance only in 2011 and 2015. Notably, 2011 was a high water year, and samples from this year were collected from the pre-project channel and represent pre-project conditions; 2015 was the worst water year in the last decade. The mean IBI score for the three downstream sites was higher in 2017 than in any other year and is just below the threshold between slightly and minimally disturbed conditions, with minimally disturbed representing the highest scores and highest biological integrity.

Mean PREDATOR scores tracked mean IBI scores (Figure 1). Lower mean scores from 2011-2014 suggested poor biological conditions; mean scores from 2015 to 2017 corresponded to fair, and, in 2016, good biological conditions. Mean scores were significantly different for some years; the 2014 mean score indicating poor conditions was significantly lower than 2005 and 2009 means indicating good conditions, and the 2013 mean score was significantly lower than the 2005 mean score and close to significantly lower than the 2009 mean score. While predictive models such as PREDATOR are often considered more sensitive and accurate than IBIs, on Whychus PREDATOR scores correlate poorly with IBI scores (Pearson's r = 0.203), bringing into question how well the parameters of this model describe the Whychus system. While we continue to use the PREDATOR model as one method to evaluate macroinvertebrate community data, we place greater confidence in metrics that more directly reflect a biological response to stream conditions.

Figure 1. IBI and PREDATOR scores at sites WC1825-WC1900. Horizontal line in each box indicates median value; filled box shows interquartile ranges; whiskers depict data range. Dotted lines show transitions points for biological condition scores.



Mean richness (number of unique taxa) and mean dominance of the most abundant taxon for the three sites both support the trend indicated by IBI and PREDATOR scores (Figure 2). Mean richness decreased slightly from 2005 to 2014 and increased from 2015-2017, with 2017 characterized by the highest number of taxa observed at the three sites to date. Mean dominance of the most abundant taxon, a negative metric (higher scores indicate worse conditions), increased from 2011 through 2014 and decreased from 2014 through 2017. Means were not significantly different among years for either metric. The number of caddisfly taxa increased from 2005 through 2017, and the number of mayfly taxa increased significantly from 2014 to 2017 (Figure 3).

Figure 2. Diversity and % dominance of the most abundant taxon at sites WC1825-WC1900. Horizontal line in each box indicates the median value; filled box shows interquartile ranges; whiskers depict data range.

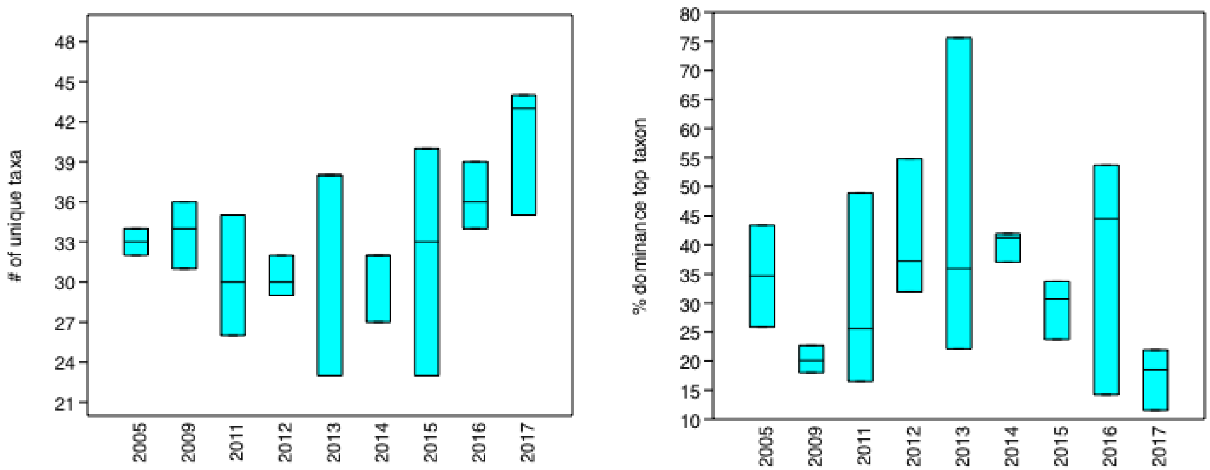
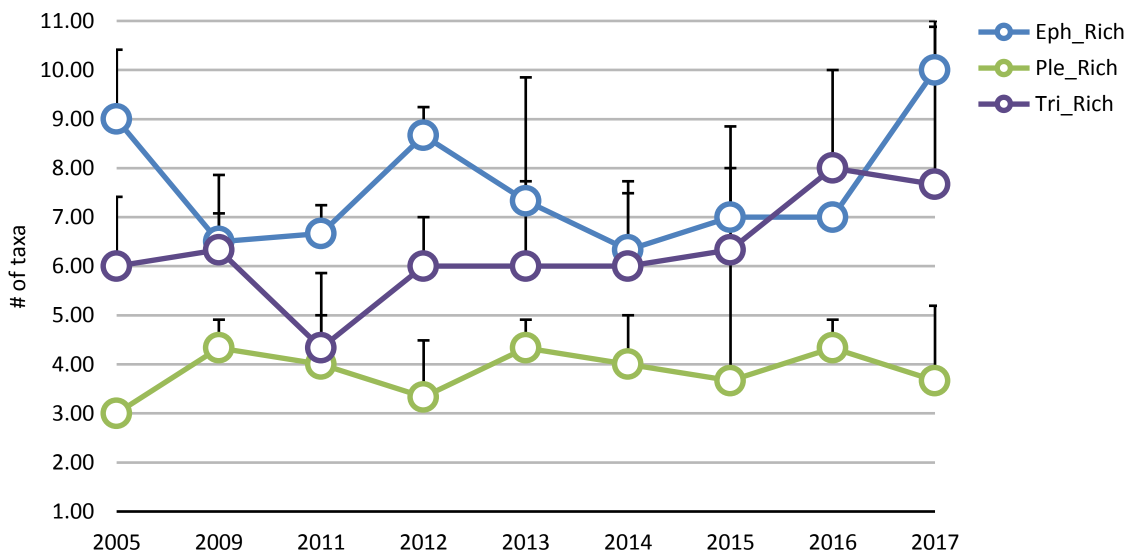
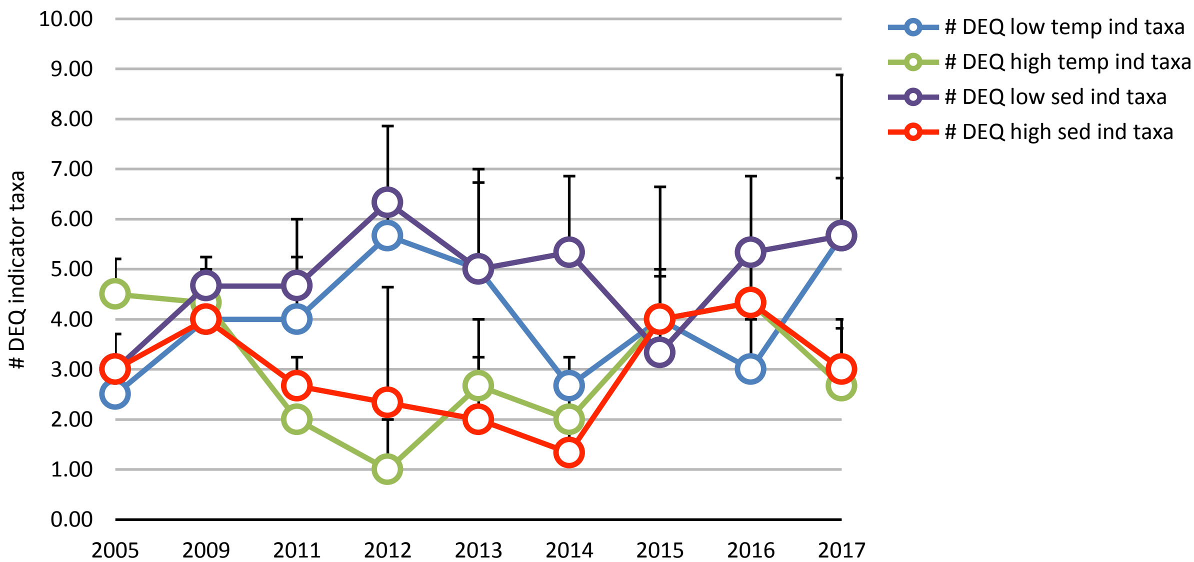


Figure 3. Mean diversity of mayflies (Eph_Rich), stoneflies (Ple_Rich) and caddisflies (Tri_Rich) at sites WC1825-WC1900. Vertical bars show standard deviation.



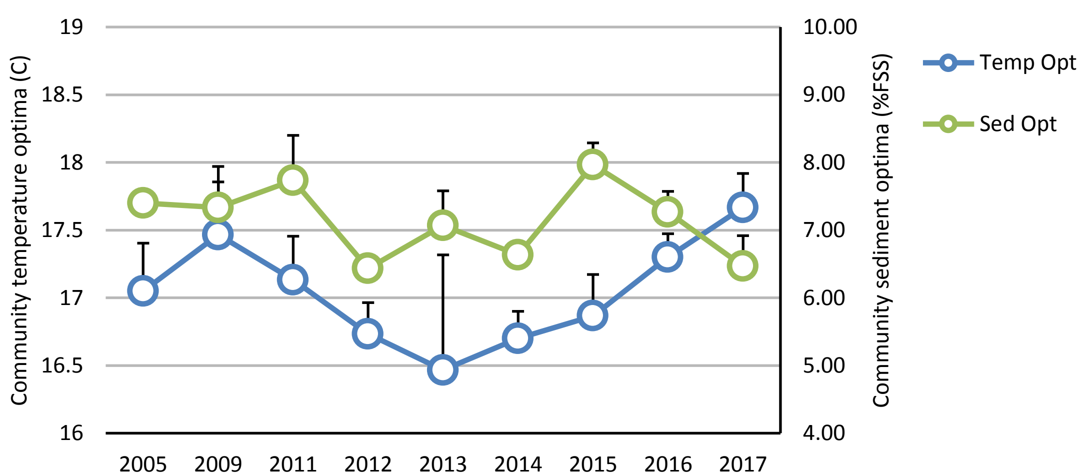
The mean number of DEQ low temperature indicator taxa and low sediment indicator taxa generally tracked each other, increasing through 2012, decreasing between 2014 and 2016, and increasing to match 2012 numbers in 2017 (low sediment indicator taxa decreased only in 2015) (Figure 4). This pattern also follows the trend observed from other metrics indicating improving conditions through 2012, declining from 2012 to 2014 or 2015, and improving between 2015 and 2017. The decrease in low temperature indicator taxa in particular corresponds to a 2014-2016 increase in high temperature and sediment indicator taxa (both fell to or below 2005 numbers in 2017). The mean number of low temperature indicator taxa was significantly higher in 2017 than in 2005 and 2014.

Figure 4. Mean numbers of DEQ temperature and sediment indicator taxa at WC1825-WC1900. Vertical bars show standard deviation.



Unlike other community metrics, community temperature optima decreased through 2013, but has steadily increased since 2013 (Figure 5). This trend, consistent across all Whychus Creek macroinvertebrate sampling sites and more pronounced at mid-stream and upstream sites, may signal a response to larger climate stressors.

Figure 5. Mean community temperature and sediment optima at WC1825-WC1900. Vertical bars show standard deviation.



Overall, the 2017 Camp Polk macroinvertebrate community indicates recovery, after an initial post-project decline, to the best stream conditions observed in the reach to date. It is worth noting that the assemblage of macroinvertebrate species in the new channel is entirely a product of colonization following diversion of the stream, signaling conditions in the new channel at Camp Polk are sufficient to support a robust and species-rich macroinvertebrate community. The 2017 macroinvertebrate report, *Effectiveness Monitoring in Whychus Creek; Benthic Macroinvertebrate Communities in 2005, 2009, and 2011-2017*, will be available on the UDWC website at www.upperdeschuteswatershedcouncil.org in June 2018 following final revisions.

Fish Populations

PGE discontinued juvenile density surveys at Camp Polk following diversion of Whychus Creek into the new channel in 2012. ODFW and USFS conducted fish density surveys in Camp Polk Reach 2 in September 2017; the data are in preparation. USFS or PGE surveyed O. mykiss redds at Camp Polk (RKM 25, PGE Reach 5) in every year from 2007-2017, in the ditched, pre-restoration channel from 2007 to 2011 and in the restored meadow channel from 2012-2017 (PGE Reach 5). Redd data from 2017 surveys will be available in the PGE Native Fish Monitoring Biological Report in June 2018. In 2016 surveyors found seven redds at Camp Polk during the course of five surveys between April 8 and June 17, more than three times the two redds found in this reach in 2015. Redd numbers at Camp Polk have fluctuated between two and eight redds since 2006; notably some of the highest numbers of redds in the reach were found in post-project years, seven in 2016 and six in 2012. More redds have been detected at Camp Polk than at any other site except below Alder Springs since 2012.

Photopoints and Aerial imagery

Photographic monitoring was not conducted in 2017 per the Camp Polk monitoring plan. A select portfolio from photo monitoring comparing photopoints from 2008/2009, 2015, and 2016 is presented as Appendix F. We included 2008, pre-construction photopoints where available; where 2008 photos were not available we used 2009 photos for the pre-project comparison.

New aerial imagery was flown by USFS and Earth Design Consultants in 2017; the orthorectified photomosaic files are stored on the UDWC server.

Bird Surveys

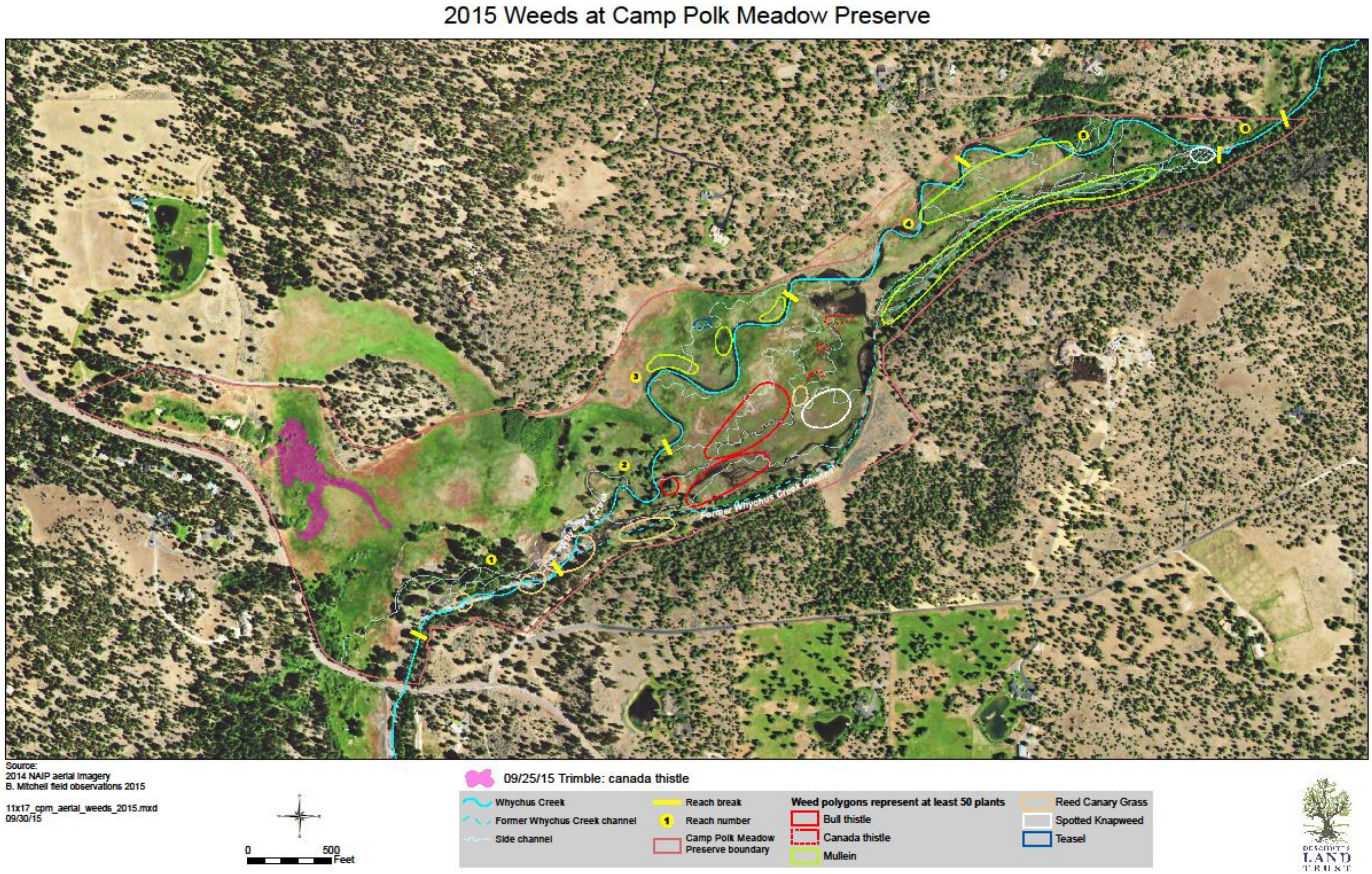
Since 2006, volunteers from Deschutes Land Trust, Central Oregon Birder's Association, and the East Cascades Audubon Society have conducted presence/absence bird surveys year-round throughout Camp Polk Meadow. The survey protocol was designed to support analysis of changes in the number, composition, and frequency of species detected over time, and specifically before and after the diversion of Whychus Creek to the new channel in 2012. 2016 marked the final year of surveys under this protocol; 169 species were observed since the incepton of the survey program. Data analysis is ongoing and is anticipated to be completed in 2018. Raw data are available upon request.

References

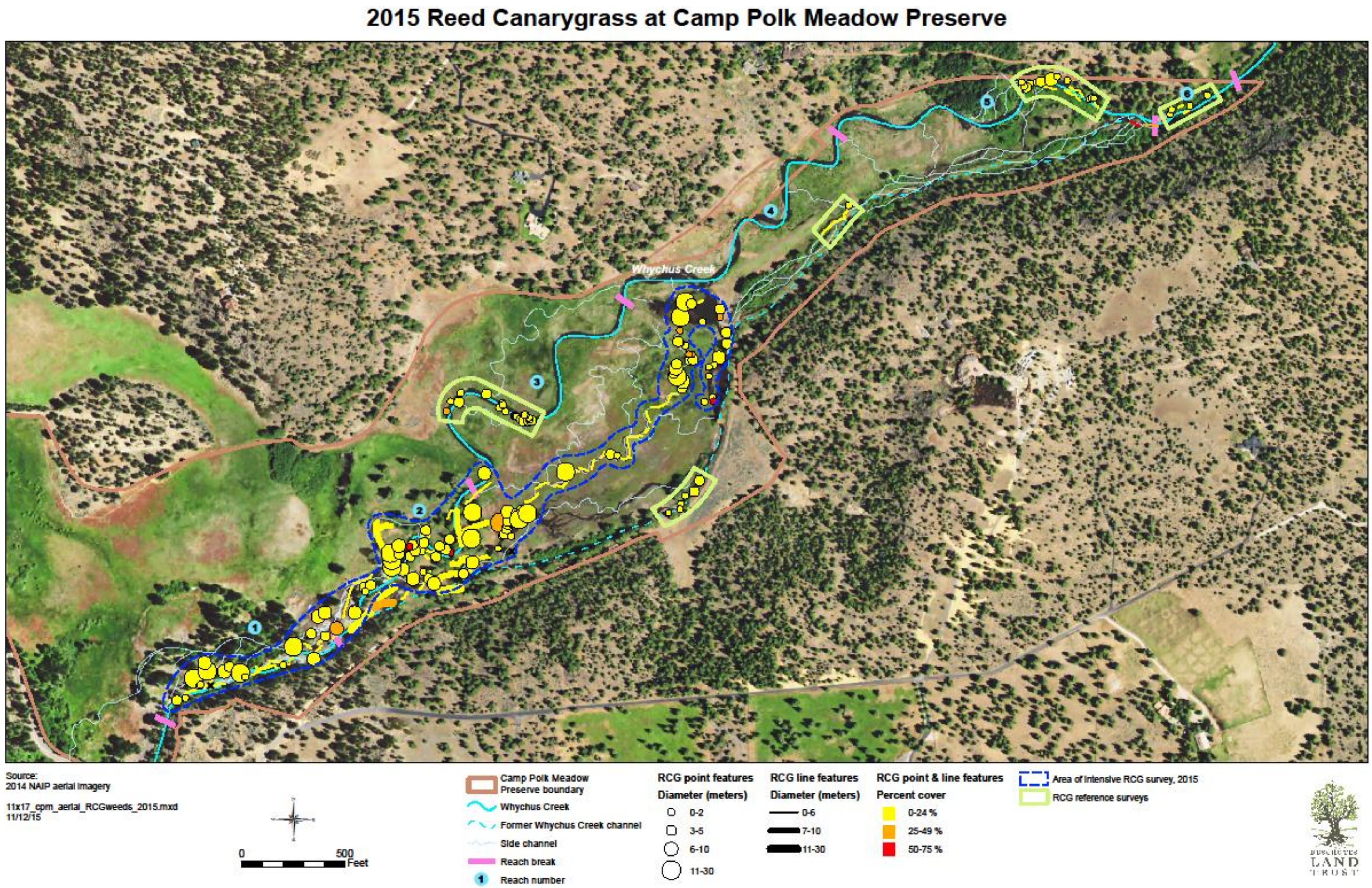
Loheide SP and Gorelick SM. 2006. Quantifying stream-aquifer interactions through the analysis of remotely sensed thermographic profiles and in situ temperature histories. Environmental Science & Techonology Vol 40, No 10.

APPENDIX A. Whychus Creek Restoration Project at Camp Polk Meadow Preserve Monitoring Summary Table

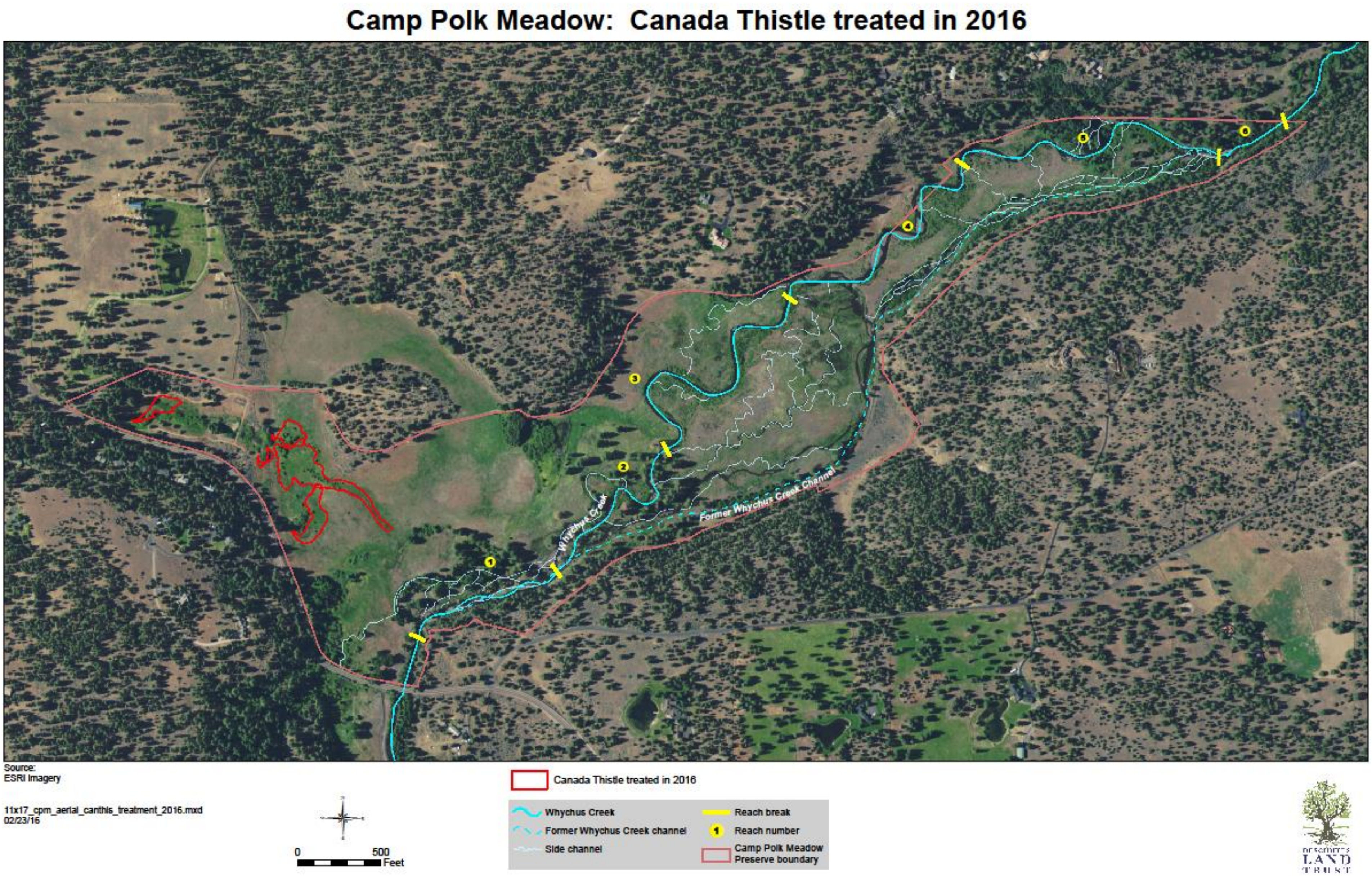
APPENDIX B. 2015 distribution of priority weed species of concern at Camp Polk Meadow.



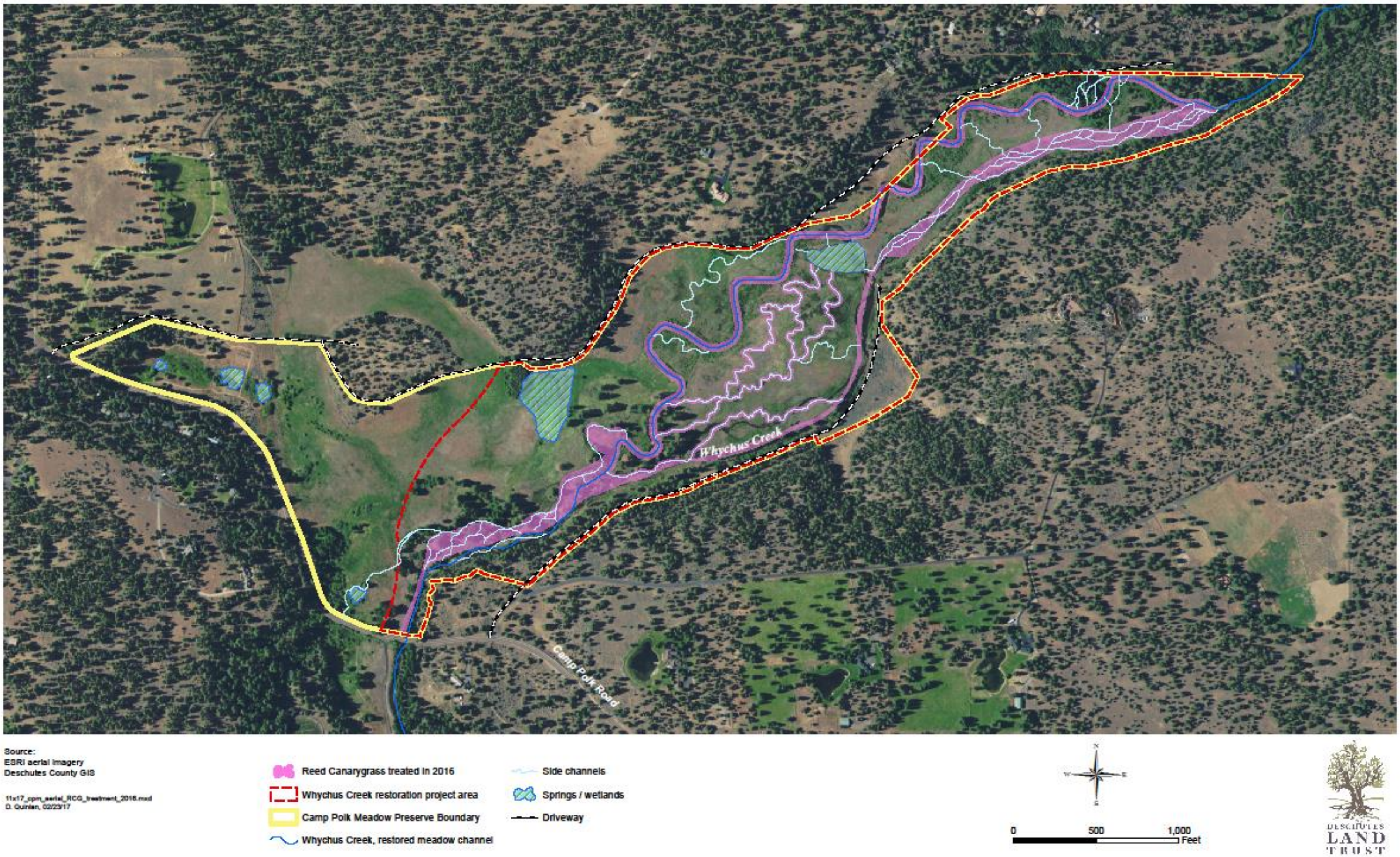
APPENDIX C. 2015 distribution of reed canarygrass at Camp Polk Meadow



APPENDIX D. 2016 weed treatments at Camp Polk Meadow



Camp Polk Meadow: Reed Canarygrass Treatment 2016



APPENDIX E. Selected 2008/2009, 2015, and 2016 photopoint photos from Camp Polk Meadow