

**Upper Deschutes Watershed Council
Technical Report**

2018 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 2018 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. Data from 2018 represent Year 6 post-project, with 2012, the year project implementation was completed, being Year 0. Parameters monitored in 2018 included:

- Groundwater
- Continuous temperature
- Channel morphology (Reaches 1 and 2)
- Riparian vegetation (Reaches 1 and 2)
- Invasive weeds; and
- Fish populations (juvenile density, *O. mykiss* redds)

Channel morphology analysis from 2018 is ongoing and results are not included in this report. Although not monitored in 2018, 2016 stream habitat and 2017 macroinvertebrate results are retained in this report for the purpose of compiling the most recent information for all Camp Polk parameters in one report.

2018 monitoring activities and findings are summarized below.

Groundwater

We sampled groundwater wells monthly from April through October 2018 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 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 2016-2018 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 $\sim 1''$ /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 2.85' in 2018, a dry year. The 2018 mean growing season groundwater depth increased by 0.38' from 2017, a wet year, but remained within 3.00' of the surface.

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 2.9' depending on water year, 0.2' – 0.9' below the revised project objective of 2' depth to groundwater and within 0.6' of the original objective calculated from the seven-well 2008 baseline depth. 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 almost a foot (0.9') 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). Percent cover data from 2018 showing native facultative or obligate wet species representing 62% of total cover, and preliminary results of a riparian vegetation change analysis for Camp Polk showing a 46-acre increase in riparian vegetation as of 2017, suggest 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) and establishment of a minimum of 35 acres of wetland and riparian communities (Objective 4). Higher groundwater levels may also be contributing cold water inputs through groundwater recharge during summer low flows to help meet Oregon's state temperature standards (Goal 5), although the average rate of change in stream temperature per mile through Camp Polk has consistently been higher post-project than pre-project (Table 2). 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 2010-2018 (www.upperdeschuteswatershedcouncil.org).

Table 1. Individual well and overall growing season mean groundwater depths at Camp Polk Meadow from 2007-2018

		Growing Season Mean Groundwater Depths (ft)						Overall mean growing season depth
	Project Hydrologic Events	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7	
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
2018		2.92	2.38	3.95	2.22	2.23	3.64	2.85

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, which is the dramatic reduction in streamflow resulting from diversions for irrigation (*2017 Whychus Creek Water Quality Status, Temperature Trends, and Stream Flow Restoration Targets*, UDWC, 2018). Regression analysis of stream flow and stream temperature in Whychus Creek indicate that streamflow accounts for approximately 80% of variation in July stream temperature.

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 2018. 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). Whereas until 2018 the pre-project maximum July average rate of stream temperature change per mile had remained higher than the post-project maximum July average (at a far lower flow than in post-project years), in 2018 the July average rate of change per mile (2.1°C) surpassed the maximum pre-project average (1.7°C). 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 median flows. The high 2018 rate of warming through the length of the

project was likely exacerbated by multiple occurrences of low flows (e.g. 11.5 to 14.5 cfs average daily flow and as low as 8 cfs instantaneous flow) over consecutive days in July.

Groundwater data from the project showing an increase in the average July median depth from 5.5' pre-project to 3.0' in 2018 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 in July 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, particularly measured as the average rate of change per mile, 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 (2012-2018).

	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
2018	2.1	19
Post-project max temp/ min flow	2.1	19
Post-project median	1.25	39

Stream Habitat

ODFW AIP surveys were last conducted at Camp Polk in 2016; pre-project baseline data were collected in 2008. 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 17.3x higher in 2016 than in 2008 (Table 3). Total channel length in 2016 was 2.9x 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	Difference
Side/off-channel length (km)	0.26	4.5	17.3x
Total length (km)	2.3	6.6	2.9x
Total area (m ²)	17530	40414	2.3x
Number of habitat units	63	226	3.6x
Number of riffles	19	90	4.7x
Number of pools	23	94	4.1x
Average pool depth (m)	0.52	0.42	0.8x
Average percent sand	17	39	2.3x
Average percent gravel	39	51	1.3x
Average percent cobble	31	7	0.2x
Total pieces of wood	19	464	24.4x

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.)

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 used traditional aerial interpretation and heads-up digitization to manually delineate cover classes, including riparian vegetation, from the 2017 imagery and from 2005, pre-project imagery, and compared acres of riparian vegetation cover in 2017 to acres of riparian cover in 2005. Preliminary analysis results show a three-fold increase in the number of acres of riparian vegetation cover at Camp Polk, from 22.92 acres in 2005 to 69.36 acres in 2017. A report summarizing results of the analysis will be available on the UDWC website in December 2019.

In 2018, UDWC collaborated with recent graduates and affiliates from the University of Nottingham to survey four vegetation transects using a point-intercept method in Camp Polk Reaches 1 and 2. Data analysis is ongoing. Preliminary analysis shows 55 species detected in Camp Polk Reaches 1 and 2 in 2018, of which 37 (67%) were native, 17 (30%) were non-native, and 30 (55%) were riparian, wet meadow or wetland species (facultative, facultative wetland, or obligate wetland indicator status). Native species accounted for 79% cover, of which planted species accounted for 38% cover; and non-native species accounted for 56% cover. Total vegetation cover on the four transects averaged 133%; total cover exceeds 100% because more than one species could be detected per point.

Although preliminary, results from the 2017 riparian vegetation cover analysis and from 2018 transect data from Reaches 1 and 2 suggest the riparian vegetation community at Camp Polk is attaining Project Goal 3), restoration and enhancement of high quality riparian wetland habitat along the stream corridor, and meeting Objective 4, establishment of a minimum of 35 acres of wetland and riparian communities. 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.

As in 2015, management actions in 2016 included 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 2018, 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 September 2018, meadow areas with known Canada thistle populations within the restoration area were surveyed and again treated with Opensight herbicide where necessary. Canada thistle and common teasel populations in the Hindman Springs area of Camp Polk are also being treated to lessen the spread of this weed from that upstream area. Hand pulling efforts of common teasel in wet / difficult to reach portions of the Hindman Springs area support the herbicide applications. Populations of these species continue to decline and, subsequently, use of herbicide in this area is declining although

still necessary. We are researching the potential use of a host specific rust fungus (*Puccinia punctiformis*) as a biocontrol for Canada thistle that could be very helpful in treating difficult areas such as water's edge, saturated soil and difficult-to-reach areas which harbor this weed and make elimination difficult. Hand pulling of common mullein and spotted knapweed in the restoration area continues to keep these species in check. We are planning to map and treat reed canarygrass in the restoration area in summer 2019 as funding allows.

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. No RCG monitoring or management occurred in 2018. DLT will map and treat RCG in the the restoration area in summer 2019 as funding allows.

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. In 2018 UDWC prioritized collecting samples from two more recent restoration projects, Whychus Floodplain (2014) and Whychus Canyon (2016), to allow for collection of more samples from side- and off-channel habitats using a proportional multi-habitat sampling protocol; macroinvertebrates will be sampled at Camp Polk in 2019.

Samples from 2005-2017 were collected at the temperature monitoring locations upstream and downstream of Camp Polk (WC 19.5 and WC 18.25). 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.

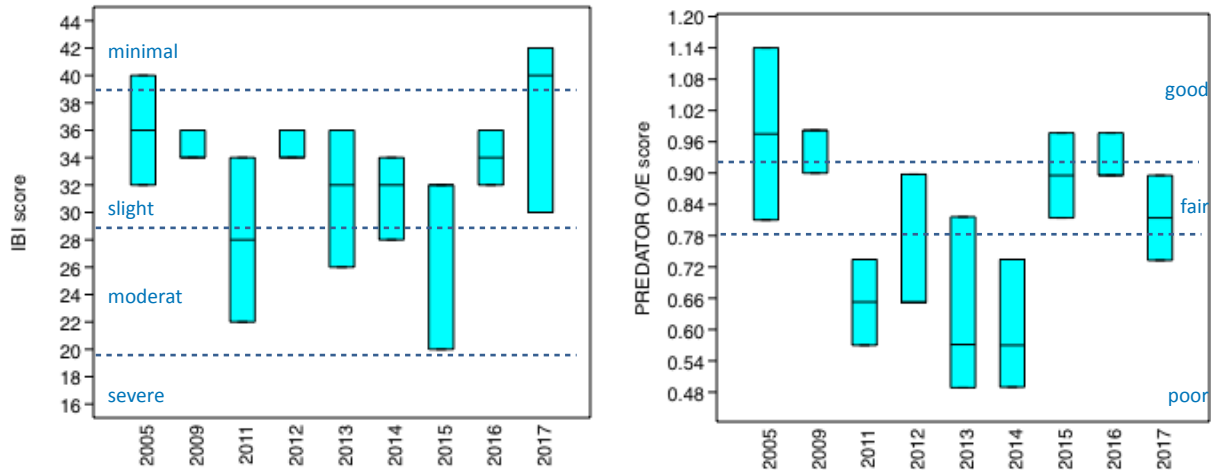
Mean Index of Biological Integrity (IBI) scores, PREDATOR scores, and means for six additional community metrics from the three downstream Camp Polk sites suggest stream conditions declined between 2011 and 2015 but improved from 2015 (in some cases 2014) to 2017. For many metrics, 2017 represented the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

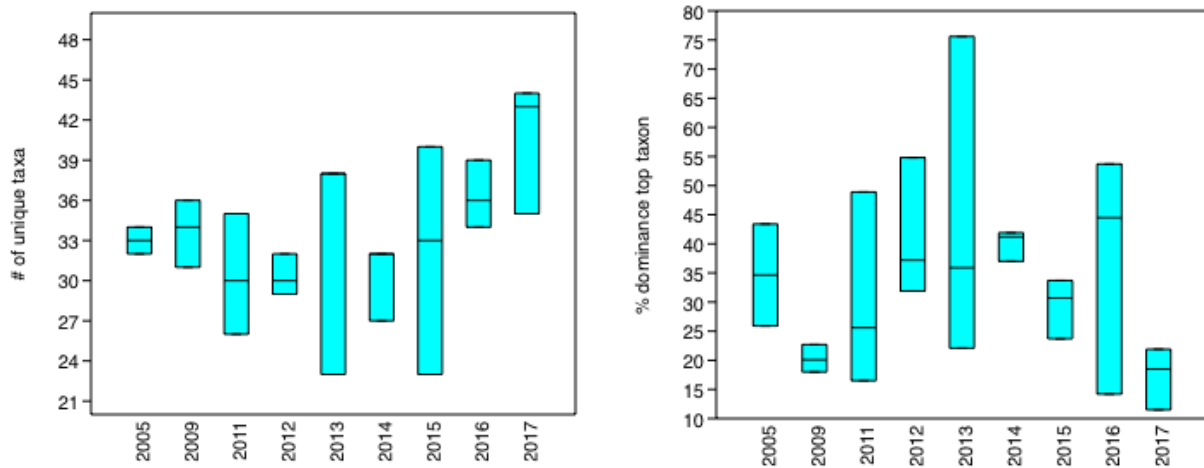
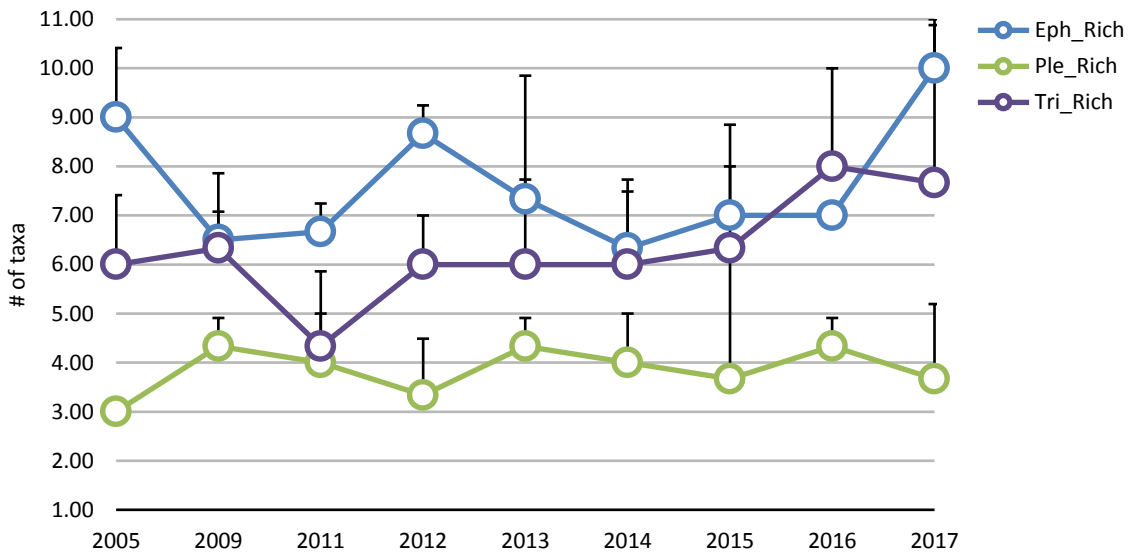
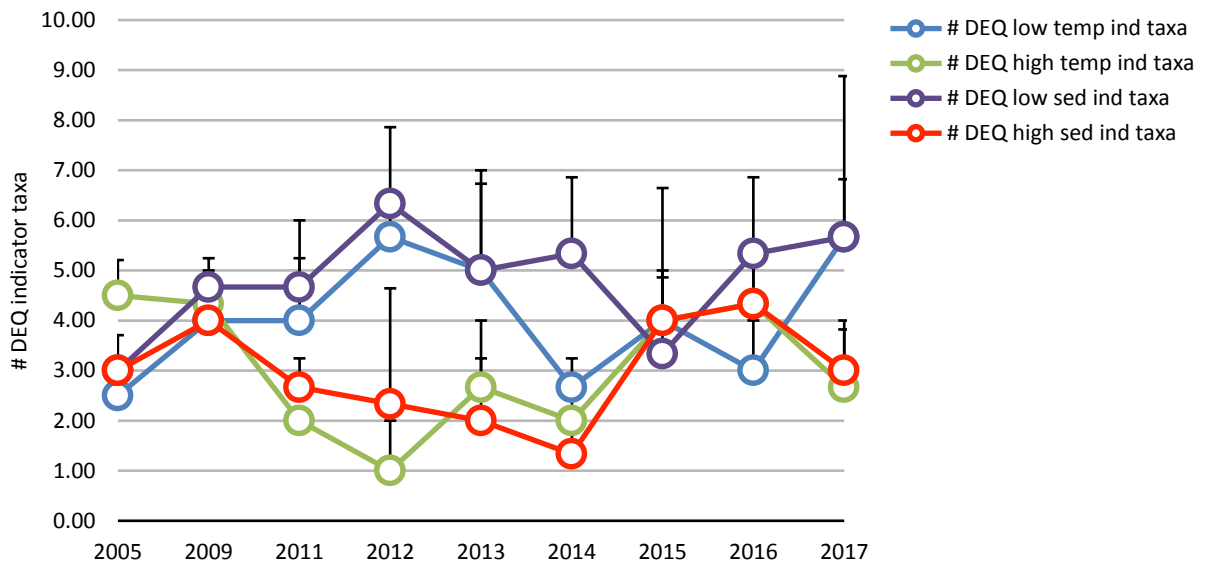


Figure 3. Mean diversity of mayflies (Eph_Rich), stoneflies (Ple_Rich) and caddisflies (Tri_Rich) at sites WC1825-WC1900. Vertical bars show standard deviation.



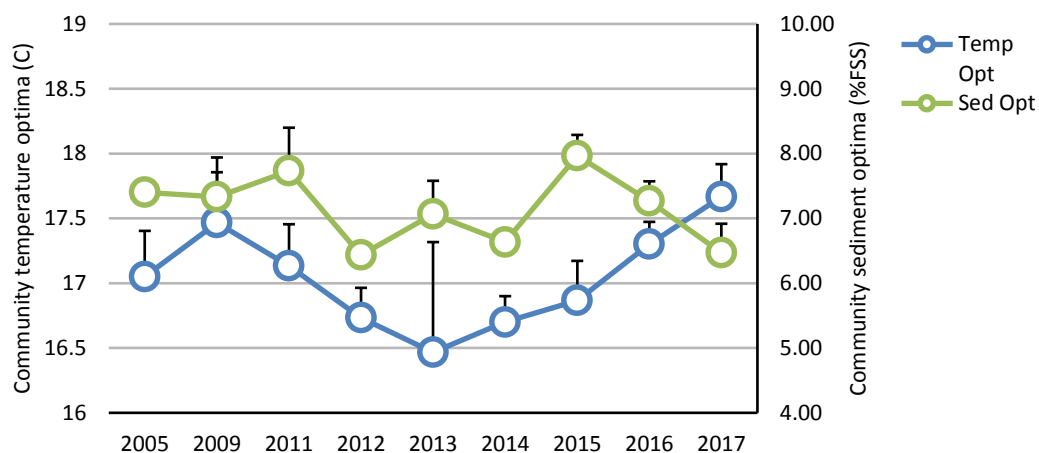
The mean number of DEQ low temperature indicator taxa and low sediment indicator taxa generally tracked each other, increasing through 2012, decreasing between 2014 and 2016, and increasing to match 2012 numbers in 2017 (low sediment indicator taxa decreased only in 2015) (Figure 4). This pattern also 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

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



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.

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 in 2006, 2017, and 2018 (Table 4). Fish density per 100m² was 5x higher in Reach 4 in 2018 and 8x higher in Reach 2 in 2017 than the pre-project average density; density per 100m was 4x higher in Reach 4 in 2018 and 12x higher in Reach 2 in 2017 than pre-project. These results likely reflect in part increases in numbers of *O. mykiss* in Whychus Creek as a result of releases of millions of *O. mykiss* fry under the reintroduction program since 2007; as importantly, they also suggest the post-project stream in Reaches 2 and 4 is providing suitable rearing habitat where juvenile fish are able to find velocity refuges and an adequate food supply.

Table 4. Camp Polk juvenile *O. mykiss* densities in 2006, 2017, and 2018

Year and Reach	Treatment	Fish/100m ²		Fish/100m	
		Density	CI 95%	Density	CI 95%
2006	Before	4.1	2	31.0	15.7
2006	Before	5	1	34.0	23.7
2006	Before	4.2	2	38.0	15.3
2017-R2	After	33	9	410.4	113.0
2018-R4	After	20.9	3.6	132.4	22.8

USFS or PGE surveyed *O. mykiss* redds at Camp Polk (RKM 25, PGE Reach 25) in every year from 2006-2018, in the ditched, pre-restoration channel from 2006 to 2011 and in the restored meadow channel from 2012-2018. In 2018 surveyors found four redds at Camp Polk during the course of four surveys between April 10 and June 28. In 2018 (10.8%) and over all years sampled (16%) Camp Polk accounted for the second-highest percentage of redds at a site after the Alder Springs area (PGE Reaches 2, 2a, and 2b), which accounted for 67.6% of redds in 2018 and 74% of total redds observed since 2006 (Madden and Bennett 2019). The average, minimum, and maximum number of redds detected at Camp Polk since project completion are slightly lower than those observed pre-project (Table 5); however, this is consistent with the trend observed for the same years from Reach 2, suggesting lower redd numbers since 2012 at Camp Polk as well as Alder Springs may reflect a response to regional climate conditions rather than a decline in spawning conditions at Camp Polk.

Table 5. Average, median, minimum and maximum numbers of redds observed from 2006-2011 and from 2012-2018 at Camp Polk (PGE Reach 25) and at Alder Springs (PGE Reach 2)

	Camp Polk (Reach 25)		Alder Springs (Reach 2)	
	2006-2011	2012-2018	2006-2011	2012-2018
Average	6.8	4.0	22.0	16.4
Median	6.5	4.0	19.0	15.0
Min	4.0	2.0	16.0	2.0
Max	11.0	7.0	40.0	29.0

Photopoints and Aerial imagery

Photographic monitoring was conducted in 2018 per the Camp Polk monitoring plan. A select portfolio from photo monitoring comparing photopoints from 2008/2009 and 2018 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 low-elevation (sub-5 cm) aerial imagery of Camp Polk Reaches 1 and 2 was flown by Wolf Water Resources, LLC in 2018; the imagery products including georeferenced orthomosaics 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. Preliminary analysis shows that before the implementation of restoration in May 2009, the surveyors observed a total of 133 species. During the construction phase, 131 species were observed. Since the stream was rerouted, 154 species were observed. Several more years of observations were included in the 'after' period than in the two previous, so adjustments to the analysis will need to be made to correct for this but preliminary results suggest species richness increased post restoration. Data analysis is ongoing and is anticipated to be completed in 2020. 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 & Technology* Vol 40, No 10.

Madden R and M Bennett. 2019. Native Fish Monitoring: Biological Component 2018 Annual Report and 2019 Work Plan. Portland General Electric Company and The Confederated Tribes of the Warm Springs Reservation of Oregon. Warm Springs, Oregon. 49 p.

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

Whychus Creek Restoration Project at Camp Polk
Monitoring Plan Summary
June-18

Monitoring Parameter	Goals ¹	Protocol/Citation	Reporting	Location	Season	Frequency	Duration	Years													Lead	Annual Budget	Baseline	Notes							
								2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017					2018	2019	2020	2021	2022		
								Project Year																							
								0 1 2 3 4 5 6 7 8 9 10																							
								B = Baseline; I = Implementation; PP = Post Project																							
Priority 1²																															
I. Hydrology																															
Groundwater	2, 3, 5	Groundwater well measurements. S:\UDWC\Projects\M etolius & Whychus\Camp Polk\Monitoring\Groundwater\Data\Monitoring Well Protocol	Annual groundwater monitoring report written by UDWC intern	2 x-sections of 5 and 2 wells	Thaw and growing season, March - October	Monthly March - October	2007 - 2017. Installed in 2007.																				UDWC	Installation (2007), maintenance, data management	2008	Assistance from UDWC intern, UDWC or DLT volunteer. Pelton grant req: continue 5-10 years as indicated by findings	
Temperature Heterogeneity	1,5	2010 Temperature Heterogeneity at Rimrock Ranch and Camp Polk Meadow; Benawah Creek Model Watershed Effectiveness Monitoring 2009	UDWC Intern or Monitoring Coordinator	Pools and downstream riffles within existing channel reach (pre project) and new channel (post project)	July (hottest days of the year)	Once, post phase II construction.	2013. Additional monitoring will depend on results from 2013.																				UDWC	Labor for field work and write up.	2010	Discontinued post-2013 monitoring. Summary of 2013 findings included in 2013 Pelton Camp Polk Monitoring Report. Baseline study conducted at Rimrock Ranch and Camp Polk by an OSU student.	
II. Water Quality																															
Continuous Temperature	1, 2, 5	Data collected with Vemco temperature dataloggers. UDWC QAPP 2008, SOP 2008.	Written evaluation of temperature at monitoring sites upstream and downstream of Camp Polk by Monitoring Coordinator	Above new channel (RM 19.50); Below new channel (RM 18.25).	April - October	Annually	2007 - 2017. Begun in 2007.																					UDWC	Deployment, audits, maintenance, data management	Upstream data from 1998, 2000-2012; Downstream data 2001, 2003-2012 (UDWC)	Camp Polk sites are a subset of the Whychus Creek Model Watershed Monitoring
III. Geomorphology																															
Channel dimension, pattern and profile	3,4, 5	Full Channel survey/ total station survey with cross-sections and 2009 Lidar data	Paul Powers, Fisheries Biologist, and Cari Press, Hydrologist, Deschutes National Forest	16 cross sections; entire project reach	Summer or fall	2009: Reaches 2-5; 2013: As-built for Reaches 1-6, cross sections for Reach 1 and 6.	Evaluate need for additional surveys after 2013 pending further changes to system																					UDWC w/ field work conducted by USFS	Labor for field work and write-up	Lidar data was collected in 2009 post Phase I construction	
IV. Biological Parameters																															
Riparian Vegetation - Transects	1, 2, 3, 4	Percent cover monitoring. 2012 Camp Polk Vegetation Monitoring Report	Annual vegetation monitoring report written by UDWC intern	Twelve stratified randomly located transects in riparian beltwidth	First week of August	Annually	2012 - 2017																					UDWC	Labor for field work and write-up (Monitoring Coordinator, Intern). Consulting contract with Karen Allen.	2012	Replaces Riparian Plant Survival. UDWC Intern, Monitoring Coordinator, Karen Allen (contracted). Repeated in Reaches 1-2 in 2018.
Riparian Vegetation - Grids	1, 2, 3, 4	Percent cover monitoring. 2010 U of O CPM Vegetation Monitoring Report.	OSU Field Course Reports (Formerly U of O)	Five transects and grids along monitoring well cross sections	Summer	Annually 2007-2010; evaluate frequency in 2013.	Resume in 2013 or later depending on vegetation conditions.																					Karen Allen, Matt Orr (OSU).	In-kind from UofO field ecology course.	2007 (Grid #1), 2008 (Grids #2,3), 2009 (Grids #4,5), 2010 (Grids #1,2,3)	Discontinued after 2014 due to change of U of O faculty priorities. Independent UofO work not coordinated by UDWC or DLT.
Riparian Plant Survival	1, 2, 3, 4	Belt transects perpendicular to channel. 2010 Camp Polk Vegetation Monitoring Report.	2010 and 2011 Camp Polk Vegetation Monitoring Reports written by UDWC intern	Twelve stratified randomly located transects in riparian beltwidth	Summer	Annually	2010 - 2011																					UDWC	Labor for field work and write-up; Contract with Karen Allen (2010 and 2011)	2010	Discontinued in 2012 due to abundance of vegetation and inability to distinguish planted individuals and detect dead plants.
Invasive Weeds	3	Direct observation focusing on targeted species. 2006 Weed Monitoring and Evaluation	Annual DLT report summarizing Weed Management Plan, Weekly Weed Monitoring Reports and Monthly Accomplishments	Restoration project area delineated by implementation boundary on implementation schematics (2009)	Spring, Summer, Fall	Annually	Funding through 2013. Should continue as long as possible																					DLT	Labor for weed removal including manual and herbicide applications, materials and reporting.	DLT 2006	Annual Weed Management Plans
Macroinvertebrate sampling	1, 5	Level 2 Benthic Macroinvertebrate survey. 2009 Whychus Creek Monitoring Technical Report.	Excerpted from annual Whychus Creek Monitoring Technical Report by Monitoring Coordinator.	Two original sites (UDWC 2009); two sites in new channel established in 2012 (UDWC 2012)	Third week of August	2005, 2009, 2011 - present; Annually depending on status, trends and funding	2011-2017																					UDWC	Labor for write-up and/or in-kind.	UDWC 2005	Camp Polk sites are a subset of the Whychus Creek Model Watershed Monitoring
Fish Habitat	1	Refer to Camp Polk Restoration Plan Appendix B and E	Excerpted from Whychus Creek Monitoring Technical Report by Monitoring Coordinator.	Within project reach, as determined by PGE, ODFW and UDWC	Summer	1997; 2008-2009; TBD	Assess ongoing changes to system and collaborate with PGE to determine post-2011 survey																					PGE, ODFW, UDWC	Labor for field work and write-up	ODFW 2008-2009	Camp Polk sites are a subset of the Whychus Creek Model Watershed Monitoring

Monitoring Parameter	Goals ¹	Protocol/Citation	Reporting	Location	Season	Frequency	Duration	Years														Lead	Annual Budget	Baseline	Notes					
								2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018					2019	2020	2021	2022	
								Project Year																		0	1	2	3	4
								B = Baseline; I = Implementation; PP = Post Project																						
Fish Populations	1	Refer to Camp Polk Restoration Plan Appendix B and E	Results of Camp Polk fish surveys reported by PGE, USFS or ODFW	Within project reach, as determined by PGE, ODFW, USFS, and UDWC	Spring, Summer	Annually as part of PGE reintroduction monitoring or by ODFW/USFS	Continue through 2017			B															PGE, ODFW, UDWC	Labor for field work and write-up	USFS 2006	Redd counts are conducted annually by PGE, ODFW, and USFS. Electrofishing surveys occur on a year-by-year basis.		
V. Photographic Monitoring																														
Photopoints	1, 2, 3, 4	Established photopoints using DLT protocol.	Annual photo management by DLT; Photopoint binders (2008 pre-implementation photos, 2009 and 2010 Phase I implementation photos)	Various points throughout Camp Polk Meadow Preserve that are good vantage points of the restoration project area.	Summer	Set up in 2008 (year 1); repeated in 2009 immediately following construction (Year 2); 2010-2015 (Years 3-8)	Continue through 2017				B	I	I	I	PP	PP	PP	PP	PP							DLT	Labor for field work and write-up	2008 and/or 2009	Photo points were established in 2008 and modified after phase 1 construction. After phase II, we will reassess if all photopoints should be monitored in the future.	
Aerial photos	1, 2, 3, 4	Aerial imagery is accessed online from USDA Imagery: http://gis.apfo.usda.gov/gisviewer/ .	Track and report most recent year for which imagery is available.	Whole site	Summer	Annually as available	Continue as long as possible				B	I	I	I	PP	PP	PP	PP	PP							UDWC	Labor - Deb, Lauren - NAIP transfer, management	2008 NAIP		
Priority 2²																														
VI. Supplemental Monitoring																														
Bird surveys – presence and breeding data	3	Spring/fall migration counts, Christmas Bird counts, Breeding bird atlas surveys	DLT, intern, or volunteer	Throughout meadow and existing & new riparian corridor	Spring, summer, fall, winter	2000 (pre-implementation); Annually 2008-2017	2008-2017					I	I	I	I	PP	PP	PP	PP	PP	DISCONTINUED						DLT	In-Kind	DLT 2000	
Vegetation Community Mapping	2, 3	USACE Wetland Delineation or GPS mapping of wetland areas and communities.	Whychus Creek Restoration Project: Vegetation Monitoring Report 2010	Throughout meadow, as in 2007	Spring, early summer	Once, post phase II construction.	Evaluate - 2020?				B															UDWC	Labor for field work and write-up. Contract with Karen Allen.	Wetland Delineation (2007)	Complete mapping as long as possible after Phase II construction.	

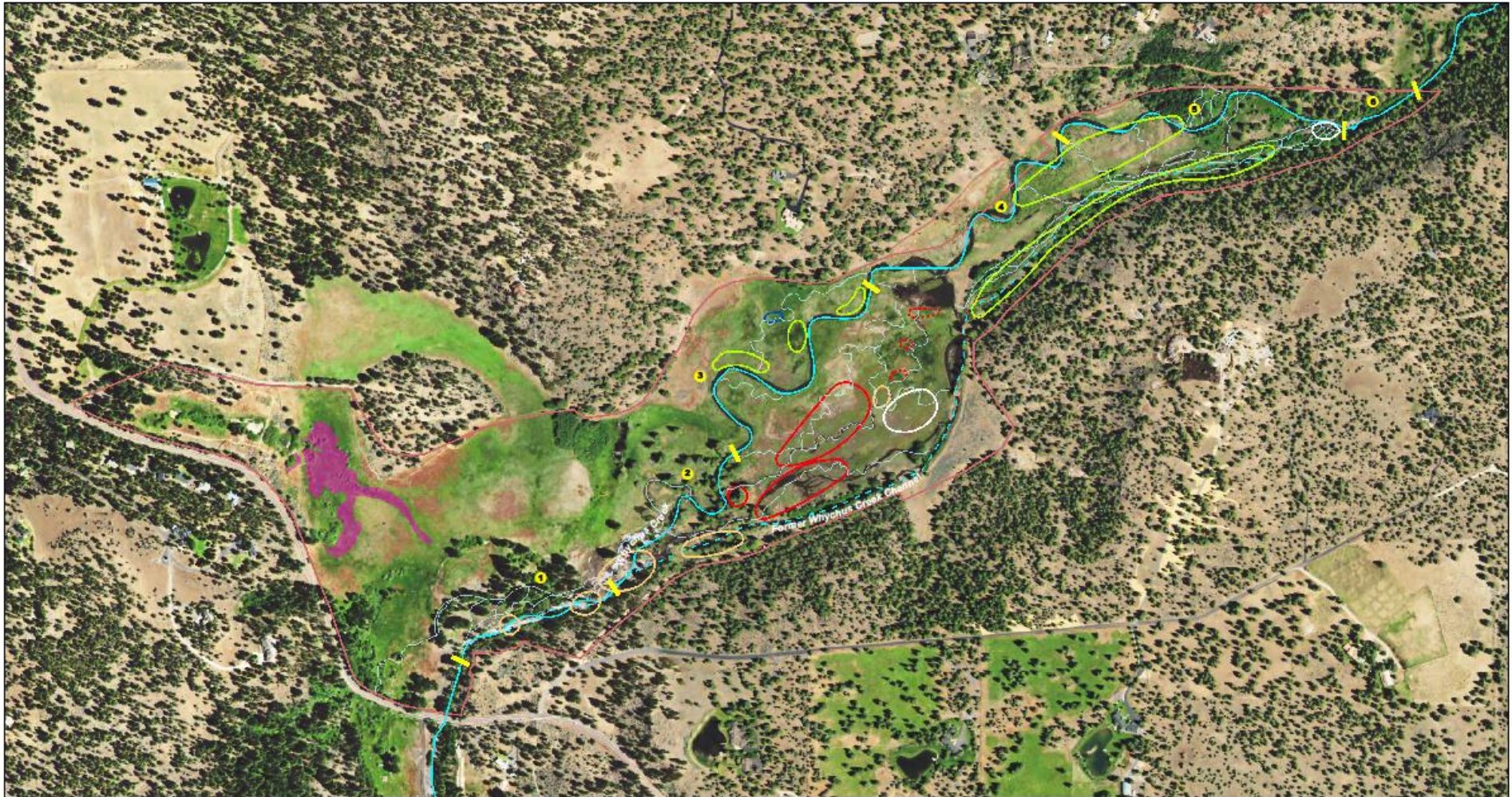
#1: Project Goals:

1. Provide 1.7 miles of high quality redband trout, chinook and steelhead spawning and rearing habitat.
2. Restore functioning meadow hydrology, including floodplain connectivity, an increase in the groundwater table and enhanced summer base flow.
3. Restore and enhance high quality riparian wetland habitat along the stream corridor.
4. Provide natural channel stability, including dimension, pattern and profile that meets reference conditions.
5. Decrease stream temperatures to help meet Oregon's State Temperature Standards.

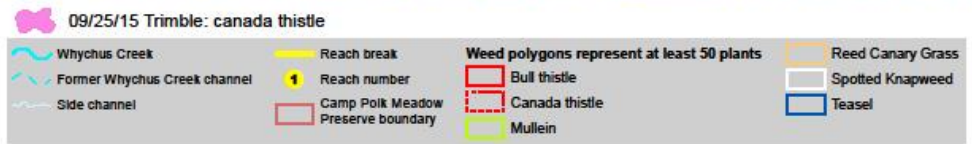
#2: Monitoring Priorities. Priority 1 monitoring is that which helps define project success and for which funding will be prioritized. Priority 2 monitoring is above and beyond that suggested to evaluate the success of the project, but which would provide valuable data if resources are available.

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

2015 Weeds at Camp Polk Meadow Preserve

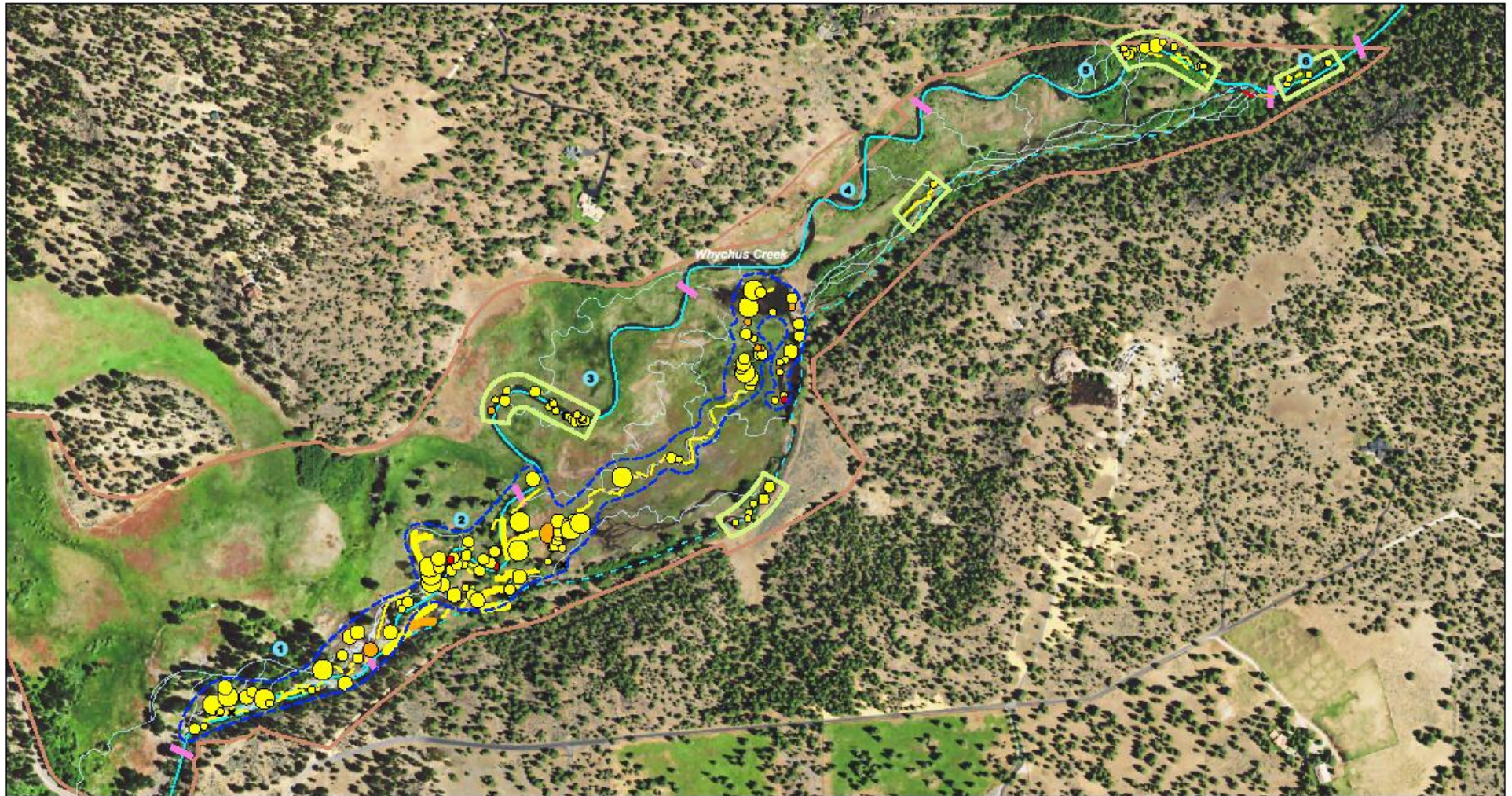


Source:
2014 NAIP aerial imagery
B. Mitchell field observations 2015
11x17_cpm_aerial_weeds_2015.mxd
09/30/15



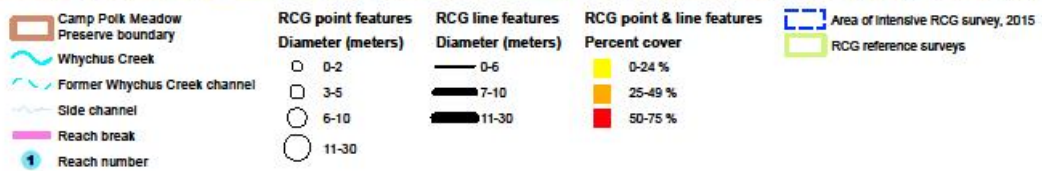
APPENDIX C. 2015 distribution of reed canarygrass at Camp Polk Meadow

2015 Reed Canarygrass at Camp Polk Meadow Preserve



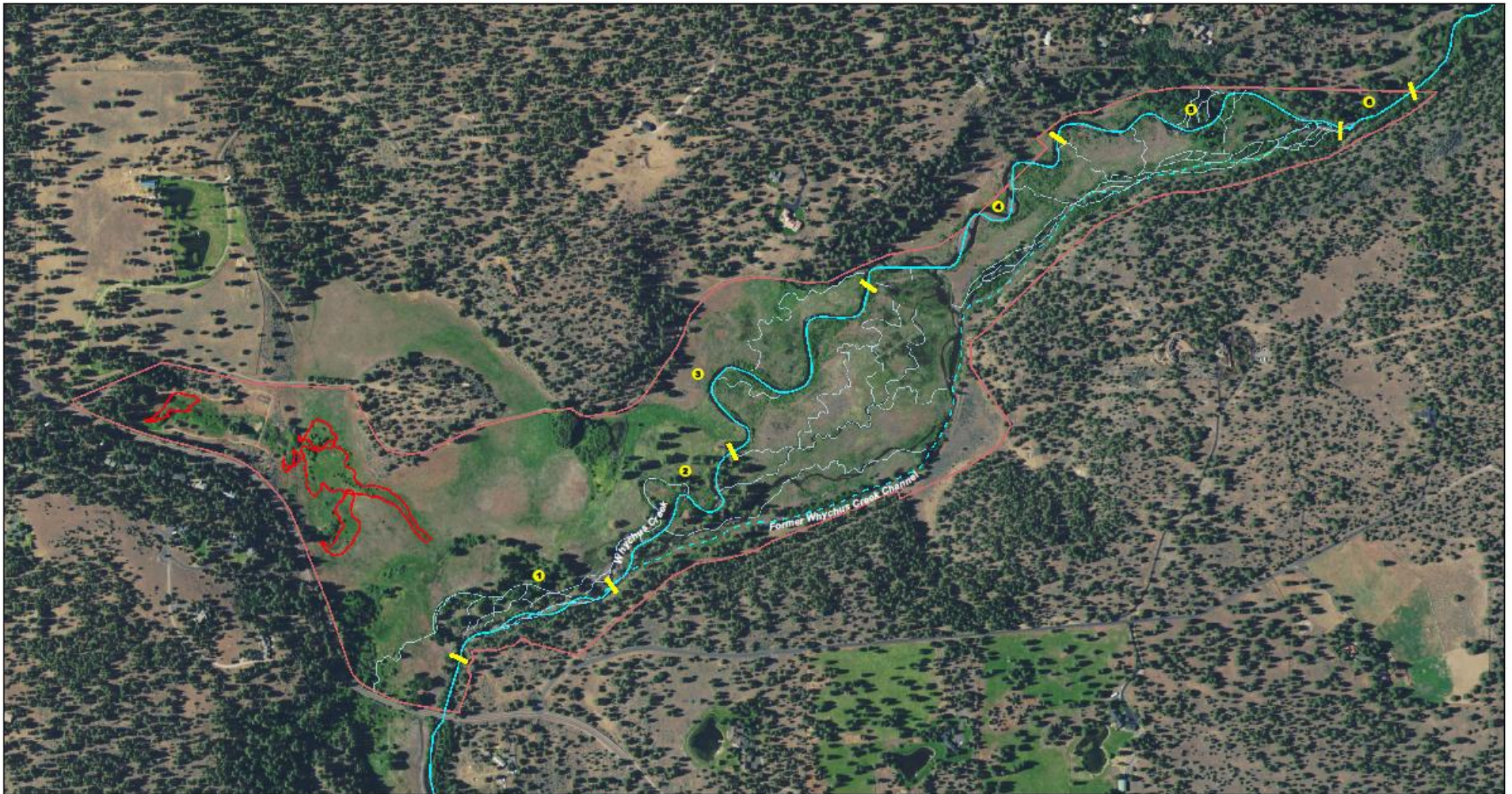
Source:
2014 NAIP aerial imagery

11x17_cpm_aerial_RCGweeds_2015.mxd
11/12/15



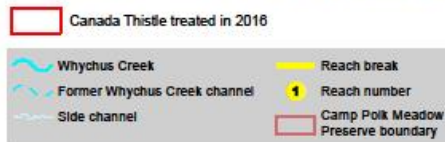
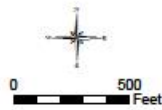
APPENDIX D. 2016 weed treatments at Camp Polk Meadow

Camp Polk Meadow: Canada Thistle treated in 2016

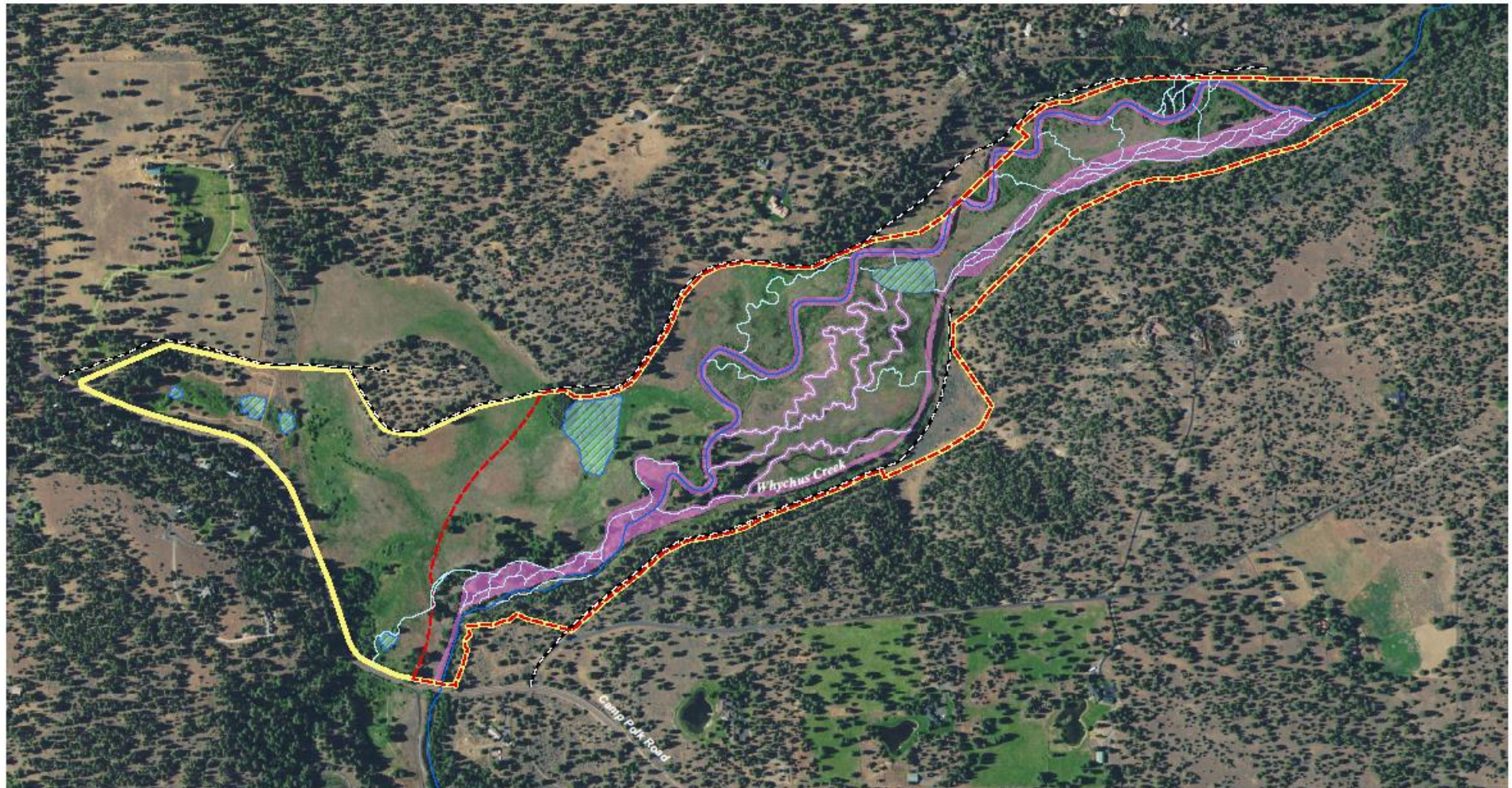


Source:
ESRI Imagery

11x17_cpm_aerial_canthistle_treatment_2016.mxd
02/23/16



Camp Polk Meadow: Reed Canarygrass Treatment 2016



Source:
ESRI aerial imagery
Deschutes County GIS

11x17_rpm_aerial_RCG_treatment_2016.mxd
D. Quinlan, 02/23/17

- Reed Canarygrass treated in 2016
- Whychus Creek restoration project area
- Camp Polk Meadow Preserve Boundary
- Whychus Creek, restored meadow channel
- Side channels
- Springs / wetlands
- Driveway



APPENDIX E. Selected 2008/2009, 2016, and 2018 photopoint photos from Camp Polk Meadow



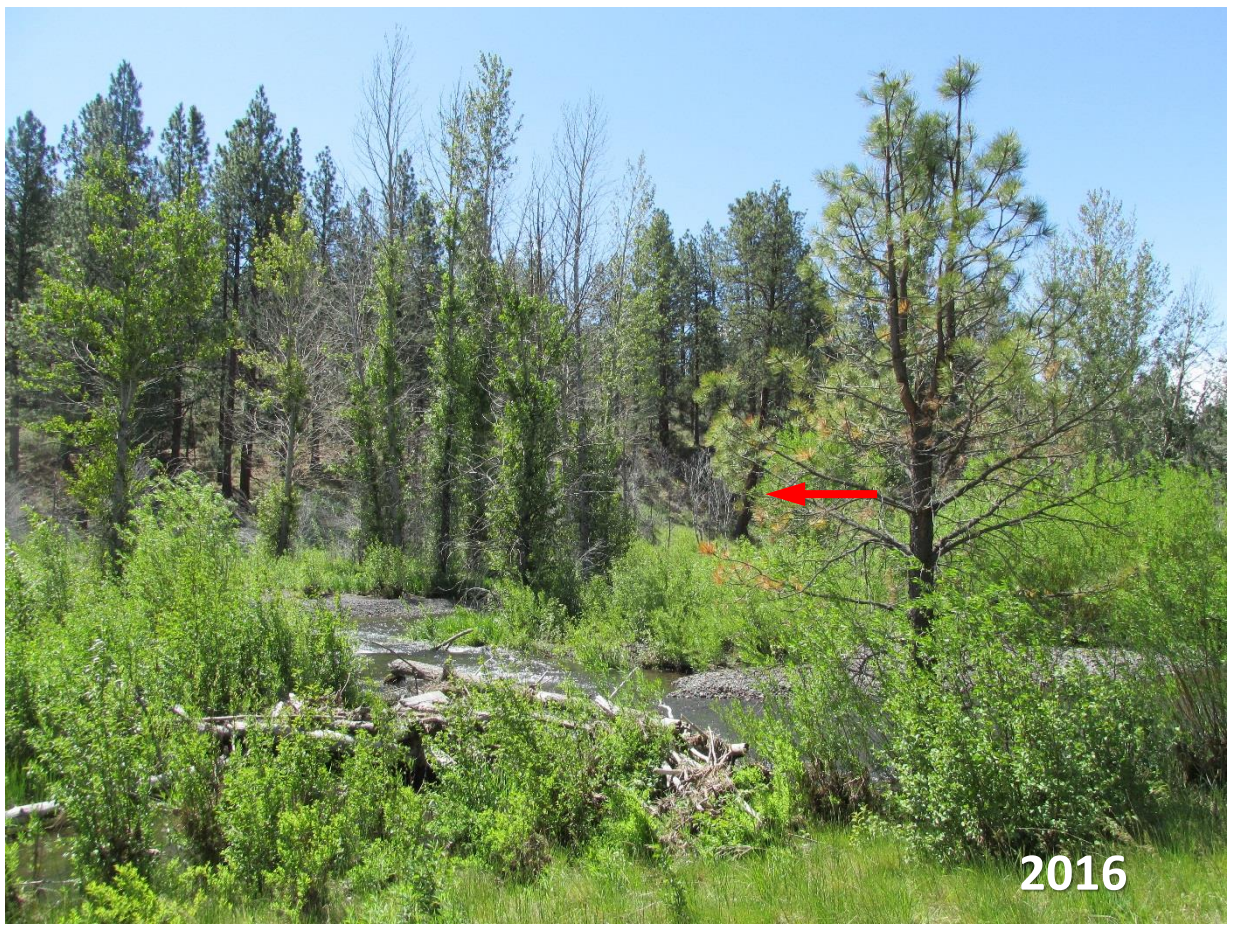




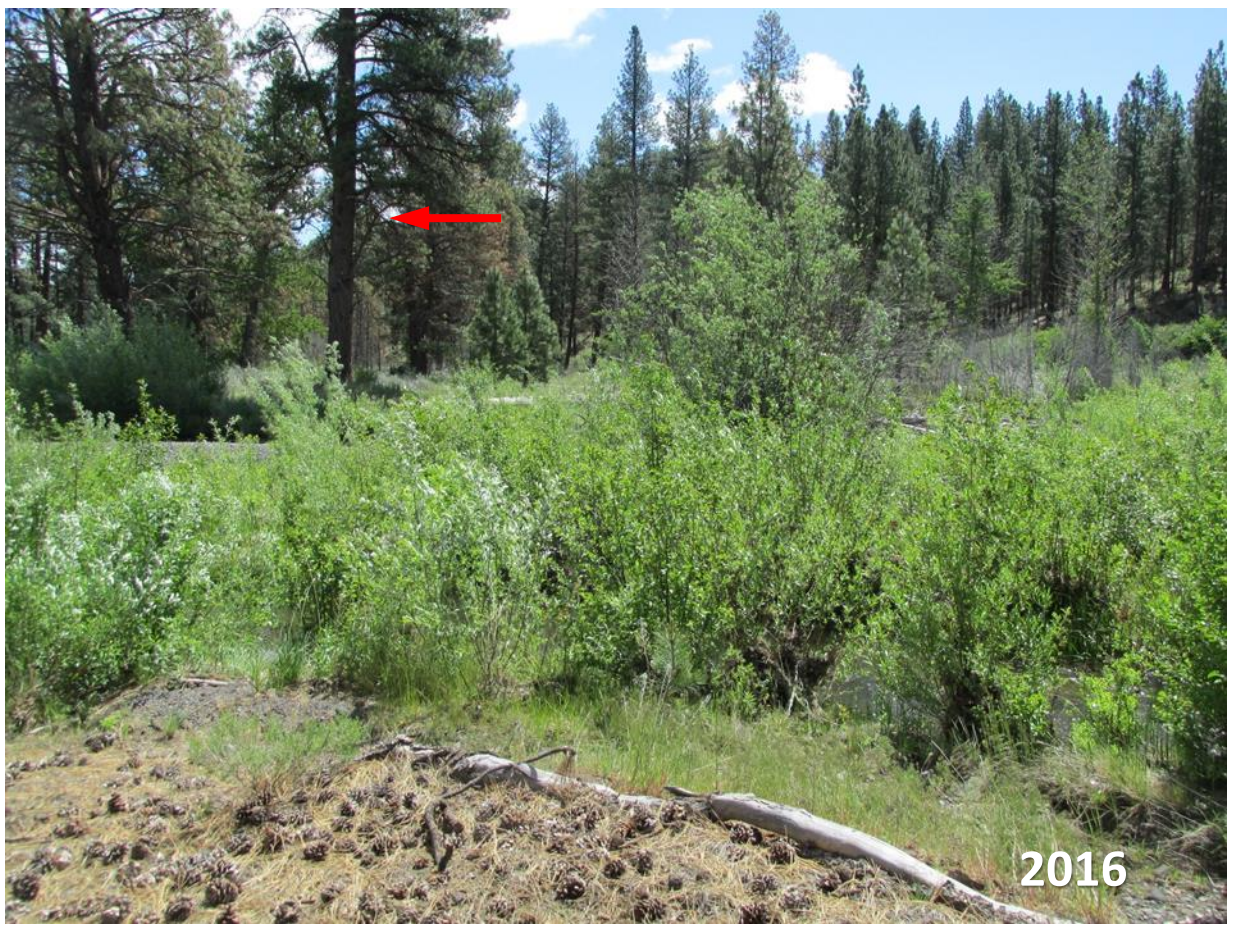


















2009



2018



2016



2018







