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CREP Effectiveness Monitoring Report Final




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Cover photos: Clockwise from top left: Crews compared treated sites with control locations such as this one in Morrow County; crews measured vegetation cover, structural complexity, weed cover, and bank erosion to gather information on the condition of the riparian vegetation and channel across Oregon, including Benton County (shown here); a site in eastern Oregon where treatments consisted of fencing to keep cattle out of the riparian area, riparian plantings, and herbicide application; sites ranged from small intermittent streams to larger rivers such as the Grande Ronde River (shown here) in Union County.

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EXECUTIVE SUMMARY

Stillwater Sciences (Stillwater) was contracted by the Oregon Watershed Enhancement Board (OWEB) to develop and implement an effectiveness monitoring study of the Conservation Reserve Enhancement Program (CREP) contracts implemented in Oregon, focusing on two of the most common conservation practices used in the program: Riparian Buffer (CP 22) and Marginal Pastureland Wildlife Buffer (CP 29). The overall intent of this extensive, post-treatment, statewide study is to assess the effectiveness of the CREP program restoration actions on improving riparian conditions . It was not designed to evaluate individual counties or sites. Stillwater adapted regional sampling protocols to select sample site locations and collect relevant field data, and subcontracted with Sitka Technology Group to tailor an existing data-gathering and management program for this project, and with Cascade Environmental Group to provide input on survey approaches and to assist with field data collection. This report provides a summary and assessment of the findings.

The sampling framework was created by stratifying the state by ecoregion and conservation practice, resulting in three sampling strata. The full set of existing CREP contracts within each stratum was filtered based on several criteria to ensure that restoration had been implemented at selected sites, and the sites were of sufficient size. CREP technicians and local NRCS representatives coordinated landowner access and provided critical information on contracted sites. This information was reviewed by United States Department of Agriculture (USDA) Farm Services Agency (FSA) staff prior to providing it to OWEB, in accordance with the data-sharing agreement between FSA and OWEB. Sites were selected based on random draws from each stratum, and were ultimately visited if landowner permission for access was provided, and appropriate and accessible control sites were available. In order to determine the appropriate sampling number and to test and refine field methods, field sampling was implemented in two phases. Eighteen sites were sampled in June 2016 during Phase 1 and minor refinements were made to the field protocol. Twenty-two additional sites were sampled in September 2016 during Phase 2, for a total of 40 sites, including 25 treatment sites and 15 controls.

The CREP program treatments are intended to improve the quality of riparian site conditions to benefit fish, wildlife, and water quality. Some of the most important treatment effectiveness indicators relate to percent vegetation cover both along the channel and more than 10 m back from the edge of the riparian vegetation, on the floodplain and terrace area. These were found to be significantly higher in treated compared with control sites in the Riparian Buffer conservation practice (CP-22) and the Marginal Pastureland Wildlife Buffer conservation practice (CP-29) sites east of the Cascades, indicating that these goals are being achieved through the program. Differences in streamside native vegetation between untreated controls and treated CREP sites west of the Cascades were not significant, suggesting a need for different strategies or practices for increasing native streamside vegetation cover in this area. CREP sites treated with CP-22 both east and west of the Cascades were found to have significantly higher percent cover of native woody vegetation sampled more than 10 m from the edge of the riparian vegetation, on the floodplain and terrace area, compared with untreated controls. This overall finding indicates that in these areas, the CREP actions are achieving the goal of increasing native woody cover within the riparian corridor. Bank stability was found to be greater in two of the three strata: west side CP-22 and east side CP-29, indicating that bank erosion is being addressed through these practices in these regions but that planting and livestock exclosure practices are not addressing bank erosion effectively in the east-side CP-22 stratum. These results may point to other geomorphic processes driving bank erosion east of the Cascades that cannot be fully addressed by the CREP-eligible conservation practices alone. Finally, while livestock fencing was intact in

over half of the sites visited and evidence of livestock presence within the exclosures was reported for less than one-third of the sites, both absence of livestock indicators AND intact fencing was only found at under half of the CREP treatment sites that included exclosure fencing in their contracts.

Based on these data and field observations, we offer several recommendations for the CREP program that might improve effectiveness of the conservation practices in improving riparian conditions to benefit fish, wildlife, and water quality. However, it is important to note that this study monitored CREP projects that were implemented over seven years ago, so has not captured many of the effects of adaptive measures that have been applied in recent years. In fact, many of the recommendations that are made in this report have already been adopted by the CREP technicians to improve the success and effectiveness of riparian buffers. Thus, findings of this study reinforce the importance of such adaptive management strategies in implementing a successful CREP Program across Oregon

1 INTRODUCTION

1.1 Project Background

The Oregon Conservation Reserve Enhancement Program (CREP) is a cooperative venture between the Oregon Watershed Enhancement Board (OWEB), the United States Department of Agriculture (USDA) Farm Services Agency (FSA), and other partners, in which enrolled landowners receive annual payments for conducting voluntary riparian restoration, livestock exclusion, and other conservation measures on their lands. The purpose of the program is to restore, maintain, and enhance streamside areas on agricultural lands to benefit fish, wildlife, and water quality. Landowners enrolled in CREP receive annual rental, incentive, and cost-share payments to implement conservation measures such as planting trees and shrubs, installing fencing and livestock watering facilities, and other approved conservation measures. Currently, approximately 41,000 acres of land are being conserved as a result of the nearly 1,600 contracts enacted since the program's inception in 1999. Given the overall investment in the program and the ongoing efforts to enroll additional landowners in CREP, it is critical to evaluate the effectiveness of the CREP program restoration actions on improving quality of riparian vegetation and stream channel conditions.

1.2 Project Goals and Objectives

Stillwater Sciences (Stillwater) was contracted to develop and implement the CREP Effectiveness Monitoring Project to evaluate the statewide effect of conservation measures on riparian areas. This is an extensive, post-treatment study that reflects a broad range of randomly sampled ecological conditions and land use practices. The two most common CREP conservation practices applied in Oregon are the focus of this effort: CP 22 Riparian Buffer and CP 29 Marginal Pastureland Wildlife Buffers (see full descriptions in Appendix A). The results of this project evaluation will provide guidance on the development and implementation of future CREP contracts. The project includes development of a sampling methodology and field methods, development of a monitoring database, a two-phase data collection effort at treatment (restored) and control (comparable unrestored) sites, an evaluation of the program effectiveness to date, and recommendations regarding the development and implementation of future CREP contracts. Methods for selecting the treatment sites (those enrolled in the CREP program) and methods for selecting associated control sites were reviewed and approved by the Advisory Group prior to initiation of site selection and field sampling and are described in *Technical Memorandum 1: CREP Effectiveness Monitoring Sampling Design* (Stillwater Sciences 2016a). Methods for the field study are described in *Technical Memorandum 2: OWEB CREP Effectiveness Monitoring Field Methods and Analyses* (Stillwater 2016b). Minor refinements in field methods, such as use of percent cover categories rather than direct percent cover numbers, were made between Phase 1 and Phase 2 field efforts in summer 2016 (Stillwater Sciences. 2016c). The role of the Advisory Group and its membership are described in Section 3 of Stillwater Sciences (2016a).

The over-arching questions addressed through this monitoring effort are:

- Is the CREP program positively affecting riparian site conditions as compared with control sites?
- What are the most important factors affecting successful riparian restoration?

1.3 Program Area

Oregon can be divided into six geographic areas: the Coast Range, the Willamette Lowland, the Klamath Mountains, and the Cascade Mountains in western Oregon, and the Columbia Plateau, and Basin and Range Region in eastern Oregon. The >10,000-ft peaks along the crest of the Cascade Mountains and associated atmospheric pressure gradients effectively block eastern Oregon from the ample rain and snow that soak western Oregon. Thus, while the region west of the Cascade crest supports dense mountain forests of fir, spruce, and pine and rich valley croplands, very low annual precipitation yields east-side vegetation types dominated by dry grassland, high desert shrubs, and mountain forests dominated by pine. Thus, the Cascades Range coarsely divides Oregon into two regions: a wetter western region with abundant vegetation cover and growth rates that support valley row-crop agriculture, and a drier eastern region, with sparser vegetation cover and a greater expanse of dry shrub and grassland vegetation types used as pasture rather than row-crop agriculture.

1.4 Assumptions and Limitations

The study was designed to evaluate state-wide trends in the effectiveness of CREP conservation measures. The sample size and site stratification were explicitly conducted with this perspective in mind. Although data are collected at the site scale, analysis and conclusions are most appropriately conducted at the scale of a particular strata. Described below are the key assumptions and limitations associated with this study:

- The study design is an extensive, post-treatment, statewide analysis of the effectiveness of CREP practices. It was not designed to evaluate results for an individual county or site.
- The random selection of sites within a strata was conducted to preserve statistical rigor with the intent of collecting a representative sample from the broader population of all available CREP sites.
- Three other categories of conservation practices are used in Oregon CREP (Filter Strips CP 21, Wetland Restoration CP 23, and Wetland Buffer CP30) but are not included in this study because the use of these conservation practices are limited to a small number of sites.
- The study was not designed to identify site- nor region-specific variables (e.g., aspect, slope, elevation, topography, soil type, stream type, wetland status, sunlight, temperature regimes, precipitation, wind, etc.) that may affect site conditions.
- The study was limited to projects that were seven years and older to ensure that sufficient time had elapsed since restoration actions were implemented to result in detectable responses (changes) in the riparian corridor. Any improvements to implementation practices developed since 2009 are not reflected by this study.
- Many landowners (approximately 100) were not willing to participate, including one county with 49 non-willing landowners out of 50 potential sampling sites. Therefore, it is possible that the results of this study do not represent those non-participating areas.
- The number of contracts per county vary, so those counties that administer hundreds of contracts were more likely to be selected from the random list of potential treatment sites to be assessed for sampling.
- All treatment sites, though assigned a random number and assessed for sampling potential sequentially based on the random number, came from 10 counties that were grouped in two geographic areas (the Willamette basin and northern central-eastern Oregon), which may mean that the results do not represent the CREP program statewide.

- The study does not evaluate sites that were implemented under Enhanced CREP (or equivalent) programs.
- A statewide study, limited by funding and time, that requires sampling of more than one site per day necessitates efficient logistics. Therefore, sites selected randomly that required an all-terrain vehicle or a long hike (more than one hour), were removed from the final list of sampling sites.
- Since many CREP sites are initially selected for the program because they are among or the most degraded reaches in their area, findings of no significant difference between a control site (that was not selected as among the most degraded reaches) and CREP contract site does not mean that the CREP contract has not improved from its original baseline conditions.

The findings of this study highlight the need for adaptive management when implementing a successful CREP Program across Oregon. As such, it is noteworthy that many of the recommendations made in this report, based on sites seven years and older, have already been incorporated by the CREP technicians to improve the success and effectiveness of riparian buffers.

1.5 Methods

1.5.1 Sampling Units and Site Selection

Sampling units and site selection methods were explicitly developed to reflect ecological variability and support statistical rigor for a statewide analysis. Methods for selecting the treatment sites (those enrolled in the CREP program) and methods for selecting associated control sites are detailed in Stillwater Sciences (2016a). For convenience, a summary of these methods is provided below. The term ‘site’ is adopted to describe the sampling unit surveyed in the field; this includes control ‘sites’, and treatment ‘sites’ that were associated with a CREP tract and single or set of CREP contract(s) with a particular landowner (see Stillwater Sciences 2016a for more detail).

1.5.2 Stratification

Given the wide variability in ecological conditions across the state, stratification was deemed a necessary component of the sampling design. Stratification of a population is achieved by clustering sites that are expected to exhibit similar conditions into mutually exclusive groups that can then be independently sampled. Such clustering serves to reduce site-to-site variability that might otherwise overshadow our ability to detect a response to CREP practices (i.e., a difference between treatment and control sites). Due to the distinctive differences between eastern and western Oregon climates and ecosystems, CREP sites were first stratified by ecoregion, delineated based on a coarse-scale representation of mean annual precipitation (Figure 1). As illustrated in Figure 1, there is a small subset of wet areas found east of the Cascades, as well as dry conditions west of the Cascades. However, the actual CREP site locations tended to fall within a simple east/west differentiation, in that sites do not occur in wet areas of the east, or dry areas of the west. In addition to reviewing site locations on a precipitation map, we also explored the site locations on a map of evapotranspiration rates (Figure 14 in Sanford and Selnick 2013), and found that the spatial distribution of precipitation and evapotranspiration are generally well-aligned for the CREP sites along this east/west division. The east/west division is also simpler to consider from a management standpoint. As such, for the purpose of this study and anticipated resource management considerations, the east/west stratification was selected to stratify by ecoregion.

Though shown in Figure 1, this analysis and the stratification described below do not include the sites in the Klamath Basin. These sites were removed from the sample pool because of their likely different ecological conditions from those farther away in the northeastern part of the state, the existence of few representative sites in the basin, and because of discrepancies in GIS data that would not allow contributing watershed area to be calculated.

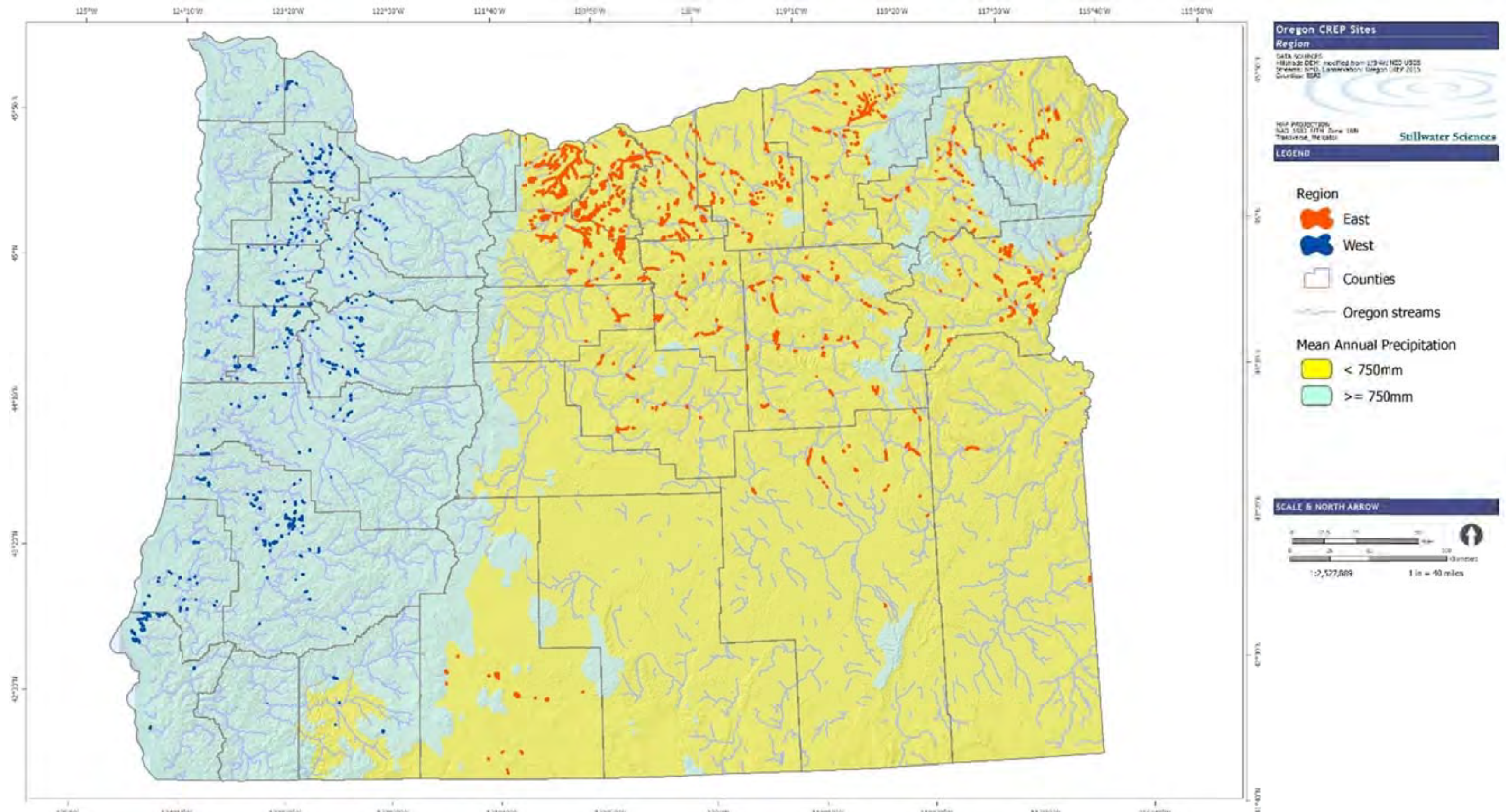

Figure 1. CREP project sites stratified by ecoregion (east or west of the Cascade Range) also show general alignment with differences in mean annual precipitation (> or < 750 mm).

The sites were further stratified by Conservation Practice (CP)— Riparian Buffer (CP 22) vs. Marginal Pastureland Wildlife Buffer (CP 29), as described in Stillwater Sciences (2016a) and in Appendix A of this report. Initially, sites were also stratified by large vs. small contributing watershed area. Thus, the original variables for stratification were:

- Ecoregion—east of the Cascades and west of the Cascades;
- Contributing watershed area—small (<200 km^2) and large (>200 km^2); and
- Conservation Practice (CP)— Riparian Buffer (CP 22) and Marginal Pastureland Wildlife Buffer (CP 29).

This initial stratification applied to the existing CREP contracts in the state resulted in a widely variable distribution among strata, as presented in Table 1.

Table 1. Number of sites per initial stratum, by ecoregion, contributing watershed area, and conservation practice.

Stratum No.	Ecoregion	Contributing watershed area	Conservation practice	No. of Sites (tracts)
1	west	small	22	324
2		large	22	116
3	east	small	22	479
4		large	22	216
5		small	29	133
6		large	29	14
Total				**1,282**

This stratification was based on the assumption (hypothesis) that this framework would reduce variation within the strata and therefore increase the power of the statistical tests described below. As an initial step, this assumption was tested using two measurements collected during a Phase 1 field effort: one that is representative of riparian conditions (mid-channel densiometer readings of canopy cover) and a second that is representative of conditions within the planting area (percent cover of woody species). Significant differences in mean values among strata for these two measurements were tested using analysis of variance (ANOVA). Findings from Phase 1 indicated that the stratification by contributing watershed area was less successful in differentiating results than ecoregion and conservation practice and as a result, the contributing watershed area was shifted from a stratification variable to a covariate for this study (see Section 2.5.1 Methods Validation for more detail on Phase 1 assessment of this initial stratification).

After this adjustment, the following variables were used to stratify the CREP sites into similar groups:

- Ecoregion—east of the Cascades and west of the Cascades; and
- Conservation Practice (CP)— Riparian Buffer (CP 22) and Marginal Pastureland Wildlife Buffer (CP 29).

Classification of the CREP sites by these stratification variables resulted in three distinct strata since very few sites with CP 29 occurred west of the Cascades; each CREP site considered for evaluation was placed into one of these strata (Table 2).

Table 2. Number of sites per stratum, by ecoregion and conservation practice.

Stratum no.	Ecoregion	Conservation practice	No. of sites
1-2	West	22	440
3-4	East	22	695
5-6		29	147
Total			**1,282**

The distribution of these sites in each stratum is presented in Figure 2.

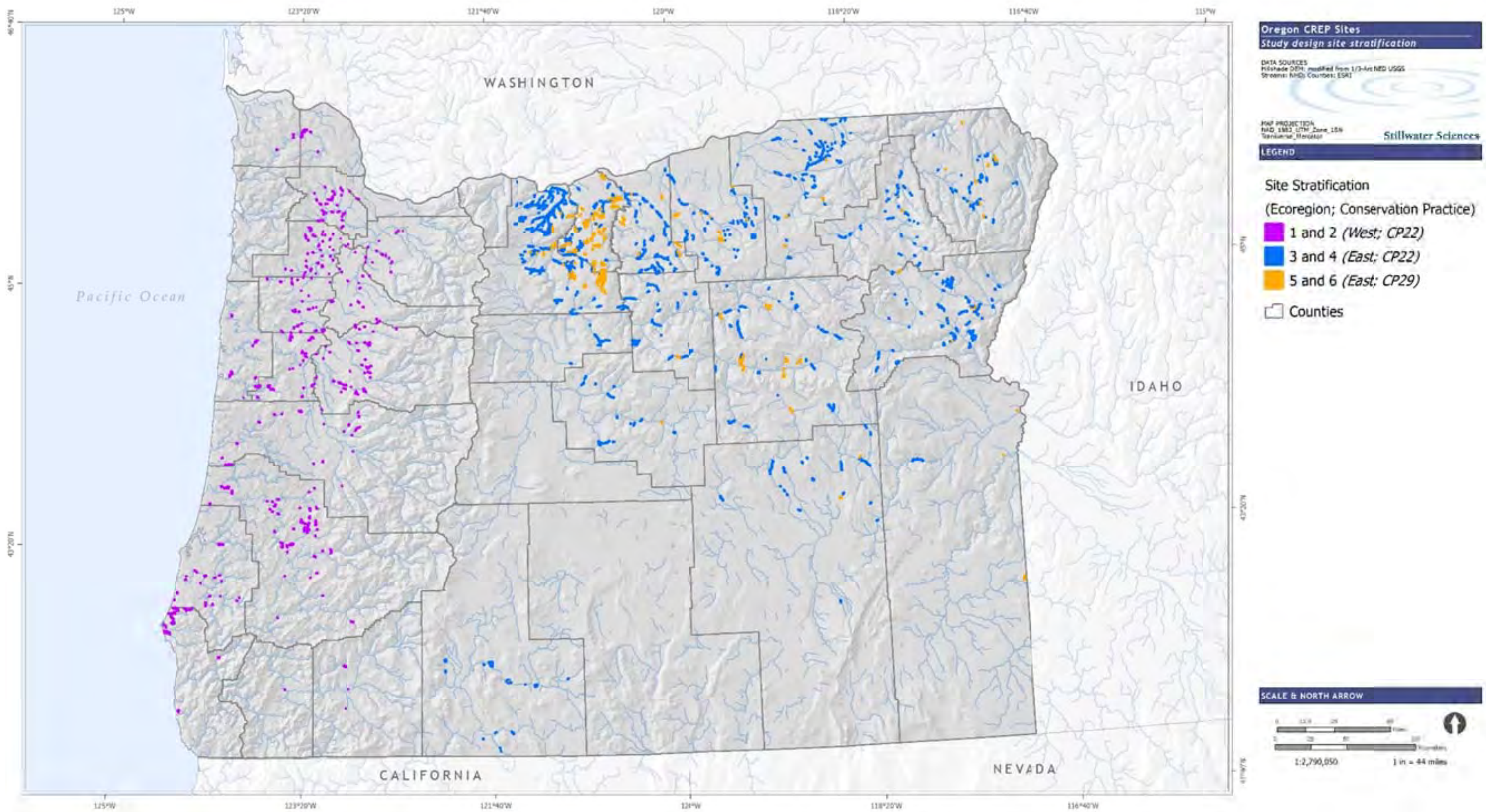

Figure 2. Site stratification based on Region (east or west of the Cascades) and Conservation Practice (CP 22 or CP 29).

1.5.3 Selecting treatment sites

Methods for selecting treatment sites are detailed in Stillwater (2016b) and are summarized as follows.

Following stratification, sites were sequentially ranked based on random selection to avoid bias and then were further assessed in a sequential manner for monitoring suitability based on the following criteria:

- Contract status (active or not).
- Contract age (project age ≥ seven years to ensure sufficient time for site response to the implemented conservation practice).
- Site size (applying a minimum stream length to the applicable area potentially available for surveying within the tract). Since site sampling reach lengths can vary from 120 to 600 m depending on channel width, a size filter for small watershed areas was set at 120 m and for large watershed areas at 250 m.
- Likely level of landowner cooperation (e.g., excellent, good, poor, unwilling).
- The presence of a suitable control site (as defined in below in Section 1.5.4).
- Sites enrolled in the "Enhanced CREP" program were excluded from the analysis in order to avoid study bias (as Enhanced CREP sites have much more intensive treatments, such as higher planting densities). This applied to CREP sites in the Tualatin, Luckiamute, North and South Santiam, Calapooia, Long Tom, Mary's River, and Middle Fork Willamette watersheds.

The criteria listed above were identified in order to select treatment sites within each stratum that would meet the study objectives and also be representative of the range of CREP sites within a large and diverse landscape. Given the size of the state relative to the number of samples, the random selection process, and the site selection criteria, some areas of the state did not include sample sites. Nevertheless, that stratification and power analysis were intentionally designed to maximize the representative nature of sites within a stratum. Input from the local CREP technicians was critical for reviewing sites for several of these criteria, such as the likely level of landowner cooperation and the contract history. Site visualization using GIS and aerial imagery (e.g., Google Earth) were also crucial for evaluating factors such as site size, adjacency, access, and the viability of nearby controls. Sites that did not meet the above criteria were rejected and removed from further consideration. Sites further down the rank order list were then evaluated in turn.

Data collection for this study occurred in two phases during spring and summer 2016. Phase 1 sampling determined statistical variability within and among sites. The resulting information was then used to conduct a statistical power analysis for tailoring the Phase 2 monitoring design. During Phase 1, 18 sites (control plus treatment) were surveyed and data from the CREP contract files were used to inform interpretation of study results. Lessons learned during the Phase 1 monitoring also addressed appropriate modifications to the field survey protocols to make the second phase of sampling more accurate, feasible, and efficient.

1.5.4 Selecting control sites

Control sites represent sites with conditions similar to those of treatment sites, but where CREP conservation practices (or equivalent) have not been applied. They also had to be accessible, have landowner approval, and meet the minimum size criteria established for treatment sites. Suitable and accessible control sites were commonly located upstream of treatment sites at a distance sufficient to isolate any confounding effects. Input from the local CREP technicians was critical for identifying possible control sites and cooperative landowners.

Potential control sites were initially identified by CREP technicians and these were each examined using Google Earth imagery, with an overlaid GIS layer showing ownership boundaries to inform us on where accessible potential control sites began and ended. Access to land similar to the treatment sites was very limited, particularly when participating CREP landowners did not have similar but untreated property. Information from the CREP technicians, Google Earth imagery, and land ownership maps was used to identify control sites that appeared to be subject to similar climatic and ecological conditions and management histories. Because of these challenges in access to comparable but privately owned potential control sites, one control site was sometimes paired with one or up to four treatment sites.

1.6 Field Methods

Methods for the field study are described in Stillwater (2016b) and are adapted from the *Protocol for Monitoring Effectiveness of Riparian Planting Projects, MC-3* (Crawford 2011a), the *Protocol for Monitoring Effectiveness of Riparian Livestock Exclusion Projects, MC-4* (Crawford 2011b), *BPA-MBACI Protocol for Monitoring Effectiveness of Livestock Fencing Projects* (O'Neal and Scranton 2014), *Natural Restabilization of Stream Channels in Urban Watersheds* (Henshaw and Booth 2000), and the *OWEB Guide to Photo Point Monitoring* (Shaff et al. 2007), and are consistent with the *Tier 2 Assessment of the Study Design* (Fetcho 2015). A summary of the objectives for this monitoring effort as stated in Fetcho (2015), along with associated attributes and metrics for assessing these attributes in the field per this protocol, is provided in Table 3. (Additional detail for individual metrics is provided in Table 13 below.)

Table 3. Objectives as stated in Fetcho (2015), along with associated metric, metric ID, and field measurements to be made in treatment and control sites.

Objective	Target metric	ID No.	Field measurements
1a. Compare the overall riparian vegetation cover layers within the treatment to a control area that has not been treated.	Vegetation structure	1-4	Percent cover for each of three vegetation layers (canopy, understory, ground cover) present in 100-m^2 (1,076-ft^2) square plots on river left and on river right for each **channel** transect; distinctions recorded for hardwood vs. conifer dominated vegetation layers.
1b. Compare the overall riparian canopy cover density within the treatment area to a control area that has not been treated.	Vegetation overhang over channel	5	Channel edge and mid-channel densiometer readings for each **channel** transect.
2a. Compare the percent woody cover for the specific Conservation Practice implemented within the treatment area to a control area that has not been treated.	Woody cover	6, 16	Total percent cover of woody species present in 18.7-m^2 (200-ft^2) circular plots
2b. Compare the potential vegetation for the specific Conservation Practice implemented within the treatment area to a control area that has not been treated.	Herbaceous cover	9, 15	Total percent cover of herbaceous species present in 18.7-m^2 (200-ft^2) circular plots

Objective	Target metric	ID No.	Field measurements
3. Compare the overall proportion of stream bank that is not actively eroding within the treatment area to a control area that has not been treated.	Bank stability	12	Reach length without actively eroding bank on river right and river left between each set of **channel** transects.
4. Determine the extent of livestock use in CREP buffers.	Livestock exclusion	13, 14	Exclusion fencing is intact in sample reach, absence of livestock evidence in exclosure area.
5. Compare the percent cover of weed plant species, including noxious species within the treatment area to a control area that has not been treated on floodplain and terrace.	Weed plant species cover	10-11	Total percent cover of woody and herbaceous weeds (one value for herbaceous weeds, another for woody) using Oregon Department of Agriculture weeds lists per county present in 100-m^2 (1076-ft^2) square plots on river left and on river right for each **channel** transect.
6. Compare the percent cover of weed plant species, including noxious species within the treatment area to a control area that has not been treated on floodplain and terrace.	Weed plant species cover	17-18	Total percent cover of woody and herbaceous weeds (one value for herbaceous weeds, another for woody weeds) in 18.7-m^2 (200-ft^2) **circular plots** using Oregon Department of Agriculture weeds lists per county.

1.7 Compilation of Data from CREP Contract Files

Information available from the CREP contract files was compiled for the set of sites selected for field sampling, as detailed in Stillwater (2016b) and summarized here. Information requested included important facts about site pre-project land use, initial restoration actions, and follow-up maintenance activities performed under the CREP contract. Combined with the field data, this information was intended to provide a basis for assessing the effectiveness of CREP actions on improving riparian and channel conditions.

Information compiled by CREP technicians from the CREP contracts that was gathered into the database include:

- **Exclosure fencing boundaries:** The planned location of livestock exclosure fencing was used to assess whether or not the fencing had been installed and maintained according to the CREP contract.
- **Planting density:** Information on the number of plants or cuttings, combined with project acreage, was converted to planting density for herbaceous and woody species.
- **Replanting density:** Information on replanting numbers (stems, cuttings, pounds of seed) was considered in overall planting density.
- **Site preparation practices:** Site preparation practices and methods included irrigation, mowing, and/or spraying for weed management.
- **Site maintenance practices**: Contract maintenance practices for riparian buffer maintenance included irrigation, mowing, and/or spraying.
- **Prior land use:** Land use at the site prior to project initiation included agricultural field, cropland, fallow woodland, or open range.
- **Recent catastrophic events:** CREP technician flagged sites where natural disasters had occurred and influenced the vegetation, streambanks, and/or fencing to the extent that the

site would not be comparable to a control site. These sites were removed from further consideration.

The ability to compile complete and accurate information on the CREP contracts varied widely, depending on the county where the contract was located, due to varying capacity of the agency and level of agency involvement in contract administration. Also, the quality and timeliness of information received from the agency and landowner varied depending on the relationship between the agency and the landowner, as well as on the agency and landowner's overall level of willingness and responsiveness to participate in the study. Some counties, such as Sherman County, had landowners that were not willing to participate in the study at all, thereby reducing potential study sites in Stratum 3-4 by 12 and in Stratum 5-6 by 37. These numbers represent potential study sites in Sherman County and do not necessarily mean that once assessed, the sites would have been eligible for inclusion in the study. However not including these sites in the initial assessment and dataset affected the overall distribution of the sample set across a diverse geographic landscape.

1.8 Statistical Analysis

Statistical tests follow recommendations provided in Section 4 and Appendix E of Stillwater (2016b). Data collected during Phase 1 and Phase 2 sampling were compiled and used to address the primary study question: *Are conditions in treatment (restored) sites significantly improved compared with those at control sites within a stratum?* To answer the question, 12 target metrics were evaluated:

1. Vegetation structure along channel bank – all layers, canopy, cover, ground story
2. Vegetation overhang over channel – woody, conifer, broadleaf
3. Woody cover along channel
4. Herbaceous cover along channel
5. Cover of woody weeds along channel
6. Cover of herbaceous weeds along channel
7. Bank stability
8. Livestock exclusion
9. Herbaceous cover for riparian buffers within floodplain and terrace area
10. Woody cover for riparian buffers within floodplain and terrace area
11. Cover of herbaceous weeds within floodplain and terrace area
12. Cover of woody weeds within floodplain and terrace area

Three primary statistical analyses were conducted – t-tests for each metric at the site scale, linear models for each metric at the stratum scale, and an exploratory analysis of potential covariates. The first analysis explored the difference in mean values between treatment and control sites using simple, pairwise t-tests of one unit against another. In all cases, a treatment site was compared with a "matched" control site. The tests are all one-sided (testing for "treatment > control") and heteroscedastic. Although the study design is tailored for stratum-level analysis and not individual sites, the t-test results provide detail on individual sites that was examined for *systematic* trends between treatment and control sites within a stratum.

The second and focal analysis for this study is a linear model used to compare individual metrics at treatment sites vs control sites within a given stratum. The sample sites were assigned to "groups", each containing one control site and one or more matched treatment sites, and each test consisted of fitting a model of the form:

(metric) = (group effect) + (treatment effect) + error

The statistics of interest are the coefficient of the "treatment effect", which in most cases is a positive ecological response if the metric is larger at treatment sites than control sites, and its associated p-value (e.g. woody cover for riparian buffers as measured by percent cover of woody species along floodplain and terrace circular plots). For a few metrics, a larger coefficient for the "treatment effect" reflects a negative ecological condition (i.e. bank stability as measured by the reach length without actively eroding bank on river right and river left between each set of channel transects). Significant results were highlighted at the following levels *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; • $p < 0.10$.

In addition to the t-tests and linear models, a third analysis was conducted to address the question *Are there any important co-variates influencing the difference among the treatment (restored) sites within a stratum?* This analysis was exploratory in nature and much like the t-tests, it aids the interpretation of linear model results. Covariates derived from field and CREP contract information included: (1) planting density, (2) planting year, (3) site preparation irrigation, (4) site preparation spraying, (5) site preparation mowing, (6) maintenance irrigation, (7) maintenance spraying, (8) maintenance mowing, and (9) contributing watershed area. The potential effects of covariates were explored using ANOVA for a singular covariate and the adjusted Akaike's Information Criteria (AIC) for multiple covariates (Akaike 1973). AIC is a measure of goodness-of-fit which takes the number of fitted parameters into account. It can be thought of as an ANOVA for multiple covariates. The resulting AIC score points to the preferred model (lower AIC value), which is the model with the fewest parameters that still provides the best fit to the data:

(metric) = a + m*(covariate) + error

2 RESULTS

2.1 Phase 1 Field Data Collection

From the original 324 sites available from Stratum 1 (prior to combining with Stratum 2 during Phase 2[1]), additional information was requested from the CREP technicians on 79 sites, drawn randomly from the full set of Stratum 1, and received information on 76 of those sites. From the original 133 sites in Stratum 5 (prior to combining with Stratum 6 during Phase 2), information was requested on 80 randomly drawn sites and received additional information on a little over half (43 sites). The sites for which information was received were screened according to the criteria described above in Section 1.5.3 and resulted in 20 candidate sites for Stratum 1 and eight candidate sites for Stratum 5 (Table 4).

[1] During Phase 1, it was assumed that all six strata would be sampled separately. Therefore, to be consistent with this assumption, these strata are discussed as separate strata in this section. As detailed in Section 2.5.1, analysis of Phase 1 data indicated that the six original strata could be collapsed into three strata (Strata 1-2, 3-4, and 5-6). Therefore, the six strata were combined into three for Phase 2 and for the full data analysis. Thus, the strata are presented as only the three combined strata following this section of the document.

Table 4. Numbers of CREP contract sites that made it through the Phase 1 site selection process.

Stratum	Initial information request	Information received	Post-screening candidates	Sampled (treatment and control)
1: west, CP 22	79	76	20	6 and 4
5: east, CP 29	80	43	8	4 and 4
Total	**159**	**119**	**28**	**18**

The large difference between Strata 1 and 5 in sites for which information was received from CREP technicians could be due to either or both the lower number of CREP technicians in the east side counties and/or the greater reluctance for east side landowners to accommodate surveyors on their property. Just prior to field sampling, several of the final candidate sites on both sides dropped out due to various reasons, such as plans to log other parts of the property during the site visit, need for ATV to access area, and re-assessment of the proposed control site.

Ultimately, 18 sites were visited during the week of 12–17 June 2016. For Stratum 1, these included two treatments and two controls from Yamhill County, one treatment from Benton County, and three treatments and two controls from Polk County. For Stratum 5, these included three treatments and three controls from Wasco County, and one treatment and one control from Morrow County.

One day of field training occurred on 12 June 2016 for both field crews led by a senior riparian ecologist; each field crew included one experienced botanist and one technician experienced in stream and river monitoring. Minor refinements in definitions and sequencing field measurements were worked out together at that time. An additional, experimental change to the protocol included recording both the exact percent cover for vegetation cover parameters and recording the category of percent cover as prescribed in Stillwater (2016b). This initial training took place at a Stratum 1-2 site, CP 22 west of the Cascades. The senior ecologist then accompanied one of the field crews to train and refine field methods at two east side CP 29 sites. Field protocols were successfully implemented as described in Stillwater (2016b).

2.2 Adjustments in Data Collection Methods for Phase 2

One of the important goals of the Phase 1 sampling effort was to correct inefficiencies in the data collection process early in the field sampling effort. In this section, we report on successes and challenges met in application of the field methods detailed in Stillwater Sciences (2016b). In addition to the important goal of gaining insight on statistical variability described in the next section, goals in completing Phase 1 of the sampling were six-fold:

- Training for two crews
- Two sites sampled per day per team for five days
- Sample one control site per treatment
- Field metrics make sense in the field
- Field methods are efficient and repeatable
- Data management is smooth and efficient

Two of these goals, training field crews at the onset of the field effort, and ensuring that the field metrics made sense in the field, were achieved without further refinement. For the remaining four, slight variations were made for the approach during Phase 2 in order to increase quality and efficiency in sampling, after presenting the Phase 1 study results to and receiving feedback from the project Advisory Group. These were described in Stillwater Sciences (2016c) and are summarized below.

2.2.1 Site selection and site access

Maintaining a pace of two sites per day for each of the two field crews was hampered when several of the proposed control sites were found to no longer be feasible based on field inspection. For example, one control site was located along a major channel while the proposed paired treatment site was on an adjacent but small tributary; another was found to be planted by the landowner, outside of the CREP program; and another was no longer accessible due to changes in landowner plans. We addressed this situation during Phase 2 in several ways: we more fully screened the proposed control sites via Google Earth at least three weeks prior to initiation of field sampling; and we prepared multiple additional sites per stratum that were ready to access and sample if others fell through. During Phase 1, we maintained a key staff member in the office to act as a liaison between the field crews, CREP technicians, and landowners. This ‘mothership’ approach proved to be an effective and efficient means of supporting field crew that encountered any number of unexpected problems and so was employed during Phase 2 as well.

2.2.2 Field measurements

During Phase 1, field crew were trained and successfully implemented the field methods detailed in Stillwater Sciences (2016a). At each site, the field crew first walked the treatment area and found representative locations for setting up the sample reach (Figure 3). The sample reach length was established as 16 times average bankfull width of the stream. Along the sample reach, field crews established five transects, located four average bankfull widths apart. At each transect, a series of measurements were made on channel canopy cover, vegetation cover by woody vs. herbaceous plant types, by vertical layer, and for weed and bare ground cover. It should be noted that all vegetation was recorded for each layer in the treatment and control sites, regardless of whether or not it was at the site before the treatment began, was planted as part of the treatment, or became established after the restoration treatment was complete.

Field crews also measured bank erosion along the sample reach. Vegetation floodplain and terrace circular plots (2.33 m diameter) were established and sampled for vegetation cover by woody vs. herbaceous plant types, weed and bare ground cover, at random distances from the outer edge of each transect (Figure 3). There were no problems locating representative reaches or setting up and sampling these transects or the vegetation plots.

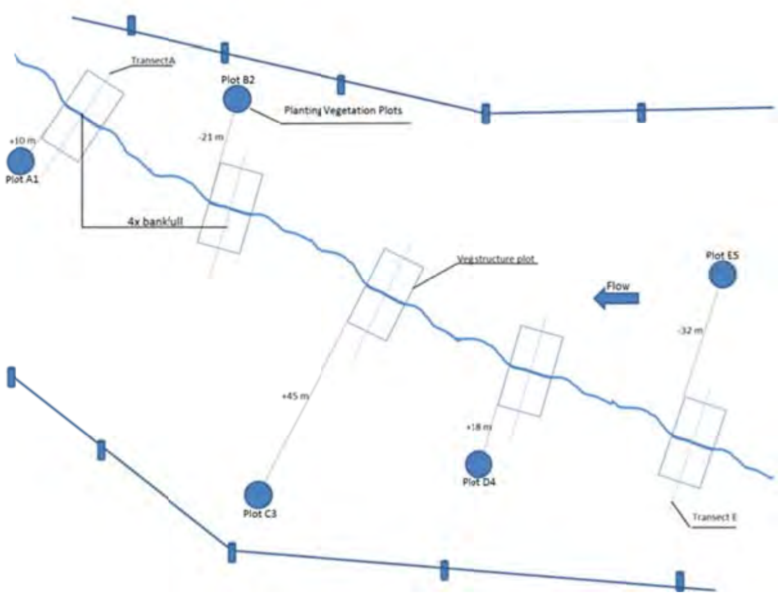

Figure 3. Site sample reach and riparian vegetation structure (squares along river) and riparian vegetation of the floodplain and terrace (blue circles) for Phase 1 and Phase 2 field sampling.

For both Phase 1 and Phase 2 efforts, field crews followed methods modified from O'Neal (2014) to assess the effectiveness of the livestock exclosures, as described below.

- Walk the length of the fence within the sample reach, looking for breaks or evidence that livestock are moving through or under the fence.
- Indicate whether or not the exclusion fence appears intact within the sample reach in the data form (Y/N).
- Examine the exclusion area for signs of livestock, such as tracks/trails, cow patties, livestock hair, or presence of livestock themselves, being careful not to mistake signs of wildlife, such as elk or deer, with signs of livestock.
- Record whether or not there is evidence of livestock present in the exclusion area in the data form.
- If there are signs of livestock within the exclusion area, note potential causes. (Are there breaks in the fences? Can the animals move around/under the fence? Is there a gate that could have allowed entrance?)
- Record apparent source of problem in the data form.
- Record observations of wildlife browsing, including signs of beaver, in the 'notes' field of the data form for Livestock Exclusion.

Browsed vegetation was attributed to wildlife (e.g., deer, elk, and beaver) when scat, prints, gnawed tree trunks, and dams were observed. In all cases, it was clearly apparent when cattle had been present within the riparian zone. Evidence of cattle presence within a treatment or control location included observations of cow patties (fresh and dry) and hoof prints, typically in conjunction with compacted soils and trails. At all locations with evidence of cattle, adjacent land use was used for livestock grazing and the exclusion fence was absent or damaged and recently repaired.

While it was found that the field methods detailed in Stillwater Sciences (2016b) were feasible and resulted in high consistency among users, there were initial concerns about the wide vegetation percent cover categories detailed in the Crawford (2011a) survey protocol for monitoring effectiveness of riparian planting projects. The initial percent cover categories were:

- 0 – absent: 0%,
- 1 – sparse: <10%,
- 2 – moderate: 10%-40%,
- 3 – heavy: 40%-75%, and
- 4 – very heavy: >75%.

In order to test whether or not valuable information was lost by using these wide categories rather than the $\pm$1 % precision allowed with a simple numeric rather than categorical input, both data sets were collected. A Pearson's correlation coefficient was used to compare the site means and standard errors of the two versions of each metric (continuous vs categorical), together with the slope of the regression lines. The comparison demonstrated that the means and standard errors are strongly correlated in most cases. As such, tests and analyses using the categorical variates (percent cover categories) should be as sensitive as using continuous variates (digital values). Based upon these findings, a decision was made to stay with the wider percent cover categories described in Crawford (2011a) since there were no significant differences, at a site scale, between the digital values vs. the much wider percent cover categories.

Finally, field electronic data recorders (iPads) were used to enter field data directly into tailored data entry forms. This was very efficient in some ways; however, several points were identified where changes in the data entry sequencing could importantly improve the efficiency and accuracy of the field methods. Sitka Technology Group, who developed the iPad-based data entry system, made changes in the electronic datasheet format to support more field efficient sequencing in data input and flexibility in using non-iPad cameras in the field. Finally, the database was adjusted to accommodate adding new sites in the field by including 'blank' datasheets.

2.3 Phase 2 Field Data Collection

The number of sites sampled for Phase 2 (15 additional treatment sites plus 7 controls) was decided based on the results of the power analysis of the Phase 1 data set, as described below in Section 2.5.1, which was presented to the Advisory Group prior to initiation of Phase 2 sampling.

During the screening, 227 sites were reviewed, including those already approved from Phase 1 screening but not sampled yet, plus sites from counties that had not previously provided information and from strata not sampled in Phase 1. Of these 227, 59 sites were selected for further review by selecting the sites sequentially using their previously assigned random number. From these 59, 22 sites (15 treatment and 7 control sites) were approved for sampling based on a suitable available control site, verified landowner permission, and accessibility (no all-wheel drive or long-distance hiking necessary). This review was more intensive than that employed during Phase 1 and included use of Google Earth imagery and information on land ownership (county parcel data) to inform likelihood of access to potential controls. As detailed under Section 2.5 below, the six original strata were collapsed into three for the remainder of the monitoring effort. Thus, Strata 1 and 2 became Stratum 1-2, Strata 3 and 4 became Stratum 3-4, and Strata 5 and 6 became Stratum 5-6.

Ultimately, 22 sites were visited during the weeks of September 7–11 and September 13–15 2016, as summarized in Table 5 and Figure 4. For Stratum 1-2, these included one treatment in Lane County, two treatments in Yamhill County, and one treatment and one control in Benton County. For Stratum 3-4, these included two treatments and one control in Morrow County, two treatments in Umatilla County, one treatment and one control in Union County, one treatment in Gilliam County, and four treatments and three controls in Wasco County. In Stratum 5-6, one treatment and one control were sampled in Baker County.

Adjustments to the sampling sites were made just prior to field sampling and also while the crews were in the field when information provided by the landowner or CREP technician was found to be inaccurate. For example, when the field crew visited a previously reviewed and approved control site in Umatilla County, it was found to have been burned and no longer qualified as a viable control. Landscape fabric at the burned site also indicated that the site was part of a planting program and therefore would not have qualified as a control if it had not otherwise been affected by fire. In another case, a previously reviewed and approved control site in Benton County was discovered to have been logged just prior to the field sampling. Having back-up control and treatment sites available and maintaining up-to-date communication with the landowners and CREP technicians were instrumental in facilitating a successful Phase 2 field effort.

Table 5. Number of sites initially reviewed, screened, and ultimately sampled for each stratum during Phase 2.

Stratum	Post-screening candidates	Final candidates	Sampled (treatment and control)
1-2: west, CP 22	69	17	4 and 1
3-4: east, CP 22	139	32	10 and 5
5-6: east, CP 29	19	10	1 and 1

A summary of all of the treatment and control sites visited during Phase 1 and Phase 2 in each of the three final strata is provided in Table 6 below. Locations of sites visited during Phase 1 and Phase 2 are summarized in Table 7 and illustrated in Figure 4 below.

Table 6. Final number of sites sampled as control and treatments during Phases 1 and 2.

Stratum	Ecoregion	Conservation practice	Phase 1		Phase 2		Total Treatment	Total Control
			Treatment	Control	Treatment	Control		
1-2	West of Cascades	CP 22	6	4	4	1	10	5
3-4	East of Cascades	CP 22	0	0	10	5	10	5
5-6	East of Cascades	CP 29	4	4	1	1	5	5
Total			**10**	**8**	**15**	**7**	**25**	**15**

Table 7. Final number of site sampled, by county, as control and treatments during Phases 1 and 2.

County	Phase 1		Phase 2		Total Treatment	Total Control
	Treatment	Control	Treatment	Control		
Baker	-	-	1	1	1	1
Benton	1	-	1	1	2	1
Gilliam	-	-	1	-	1	-
Lane	-	-	1	-	1	-
Morrow	1	1	2	1	3	2
Polk	3	2	-	-	3	2
Umatilla	-	-	2	-	2	-
Union	-	-	1	1	1	1
Wasco*	3	3	4	3	7	6
Yamhill	2	2	2	-	4	2
Total	**10**	**8**	**15**	**7**	**25**	**15**

* 1 control site and 1 treatment site are located in Sherman County but are administered by Wasco County. Therefore these sites have a Wasco ID and are included in Wasco County results.

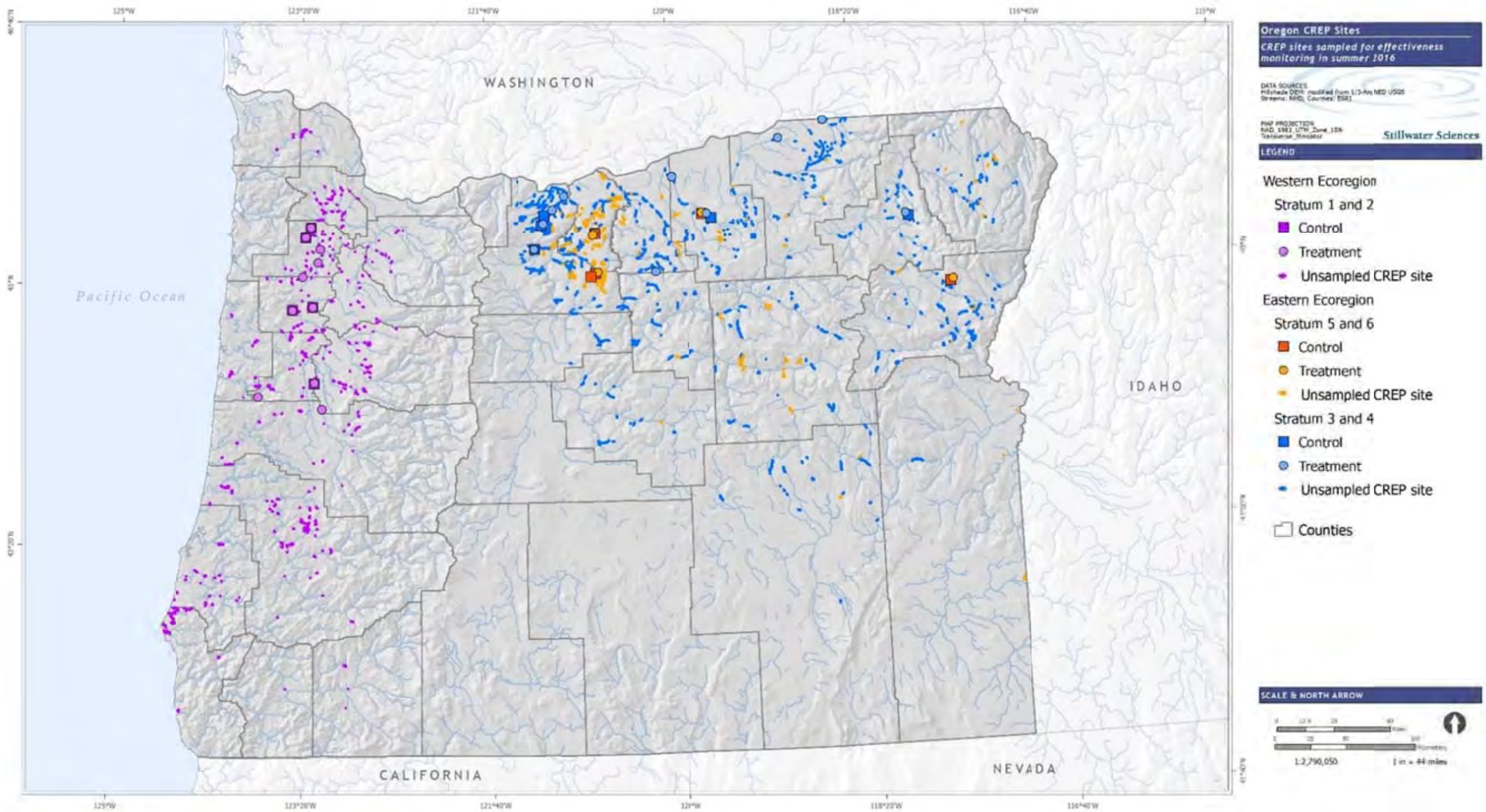

Figure 4. Location of sites visited during effectiveness monitoring survey, Phase 1 and Phase 2, summer 2016.

2.4 Data Management

Sitka Technology Group (Sitka) tailored an existing electronic data collection platform for ecological monitoring (GeoOptix) to fit the needs for the CREP effectiveness monitoring study. Each field crew was provided with a loaded iPad on which they could record all field data. In preparation for both field efforts, Stillwater provided Sitka digital field maps and site locations to load onto the iPads; during Phase 2, Stillwater also included maps and locations for additional back-up site information for when field crews were not able to access a target site or encountered unforeseen issues with the sites selected (e.g., recent history of fire, flood, or in some cases, that control sites had been otherwise restored). Sitka also loaded the county weed lists provided by Stillwater onto the iPads.

The electronic data collection platform had built-in QA/QC functionality in that it, for instance, would not let field crews complete data entry and upload until all relevant data fields had been completed. While field work was ongoing, data were uploaded from the iPads to the "cloud" via a website provided by and maintained by Sitka. Data transfer issues with the web-based database encountered during Phase 1 were resolved before Phase 2 and data transfer from field crews to the web-based database occurred smoothly during Phase 2. The data were also backed up on the iPads themselves and to external hard drives following each day of data collection. After all field data were collected, field crew members and Sitka coordinated during the QA/QC process to ensure overall data integrity. Data were available for review by field crews on the website and as downloaded Microsoft Excel files. After the data were QA/QC'ed for accuracy and completeness, the data were finalized as Excel files and distributed for analysis. For a limited time, the finalized data will be available to approved users on the website and can be accessed with credentials (user name and password) provided by Sitka. Neither the data nor the data collection locations are available via the website except to approved users.

2.5 Statistical Analyses

The overall stratification structure used to implement effectiveness monitoring was tested following Phase 1 field sampling. Findings on this Methods Validation are described below. Field and CREP contract data collected during Phase 1 and Phase 2 were then combined in order to assess the overall effectiveness of the CREP program on site condition; these findings are also described below under Hypothesis Testing and Exploratory Analysis. Statistical results are provided in summary tables below with additional detail presented in Appendices B, C, and D.

2.5.1 Methods validation

An important aspect of the Phase 1 monitoring was to evaluate aspects of the study design that might require refinement. Stratification was one such component. Stratification according to location (east/west) and conservation practice (CP 22/29) worked well given the variation in measured site conditions and the number of candidate monitoring sites (Table 8).

Table 8. Number of sites per stratum (original stratum before strata were combined), by ecoregion, contributing watershed area, and conservation practice.

Stratum No.	Ecoregion	Contributing watershed area	Conservation practice	No. of sites
1	West	Small	22	324
2		Large	22	116
3	East	Small	22	479
4		Large	22	216
5		Small	29	133
6		Large	29	14
Total				**1,282**

However, the stratification by contributing watershed area (large/small) was less successful. Although it was not sampled during Phase 1, Stratum 6 (East, large CP) had only 14 potential monitoring sites (Table 8 above), which was unlikely to result in a sufficient sample size based on prior experience in Strata 1 and 5 for Phase 1 sampling. Moreover, although it was expected for conditions to be different in large vs. small contributing watershed areas, the only proposed metric likely to reflect that difference is canopy cover at mid-channel and it is not a measurement that can safely be collected on the large rivers. So, although there may be a difference in sites with large vs. small contributing watershed areas, it is not one that sampling is likely to reflect. As a result, the contributing watershed area was shifted from a stratification variable to a covariate and as a result reduced the sampling strata from six to three collapsed strata: Stratum 1-2, Stratum 3-4, and Stratum 5-6.

In addition to refining the sampling design stratification, Phase 1 monitoring provided information on variability within and among sites. Figures 5 and 6 show the results for two of the 18 metrics and illustrate the wide range of results within and between sites.

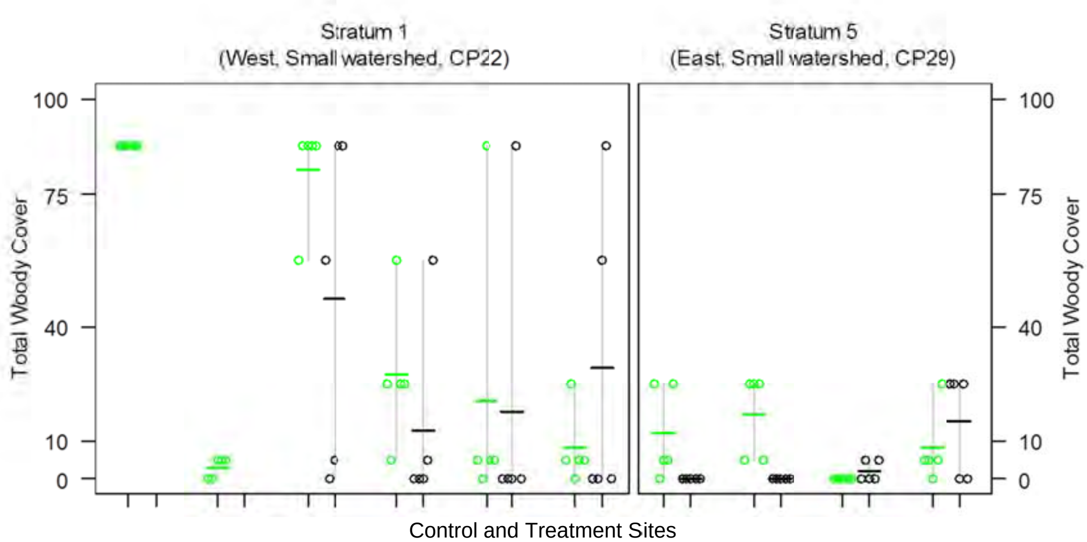

Figure 5. The range of data for Total Woody Cover in Strata 1 and 5 collected during Phase 1. Circles reflect the midpoint of the interval within the five potential categories (0, <10%, 10–40%, 40–75%, >75%). Green circles are colored-coded for treatment sites and black circles for control sites. The small horizontal bars are the mean value with either a treatment or control site for the range of data.

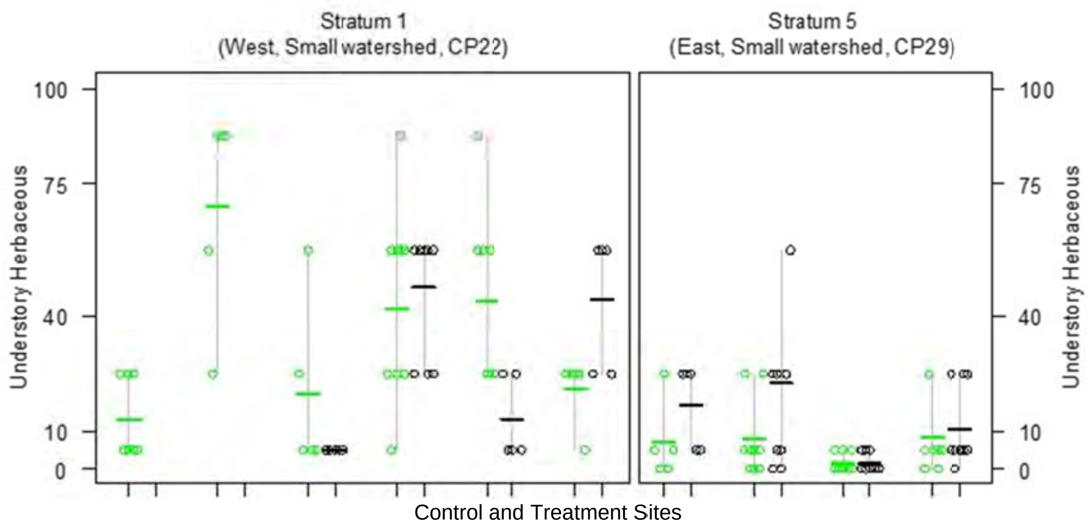

Figure 6. The range of data for Understory Herbaceous Cover in Strata 1 and 5 collected during Phase 1. Circles reflect the midpoint of the interval within the five potential categories (0, <10%, 10–40%, 40–75%, >75%). Green circles are colored coded for treatment sites and black circles for control sites. The small horizontal bars are the mean value with either a treatment or control site for the range of data.

The variability measured in each metric was used to conduct a statistical power analysis and identify the appropriate number of samples needed to detect a difference between treatment and control for each stratum sampled during Phase 1. Although the sample sizes are acknowledged to be low as a practical result of funding constraints, they were sufficiently large to meet the commonly selected statistical targets of 95% confidence, 80% power and delta (effect size) = 20 (for percent data with five categories) and delta = 1 (for index data with a range of 1–5). The results are presented in Tables 9 through 12 below.

Table 9. Power analysis results for Riparian Planting metrics, Phase 1 data only.

Cover percent from category				
Metric (ID No.)	**Stratum**	**Standard deviation**	**Mean**	**Samples needed to detect: *delta = 20***
Total herbaceous cover (15)	1	27.5	54.7	13
	5	13.5	65.4	5
Total woody cover (16)	1	29.7	33.5	15
	5	7.2	6.8	3
Total herbaceous weed cover (17)	1	7.5	6.9	3
	5	2.4	1.9	
Total woody weed cover (18)	1	11.4	8.8	4
	5	0.0	0.0	
Total bare ground (N/A)	1	9.7	6.6	3
	5	13.3	22.4	4

Table 10. Power analysis results for Riparian Structure metrics, Phase 1 data only.

Cover percent from category				
Metric (ID No.)	**Stratum**	**Standard deviation**	**Mean**	**Samples needed to detect: *delta = 20***
Canopy cover total (5)	1	21.2	17.1	8
	5	0.0	0.0	
Understory herbaceous (3a)	1	20.4	31.9	8
	5	7.2	9.5	3
Understory woody plants (3b)	1	27.8	40.7	13
	5	4.3	3.7	2
Ground cover herbaceous (4a)	1	27.1	54.3	13
	5	7.2	65.2	3
Ground cover woody plants (4b)	1	22.2	39.1	9
	5	10.3	12.5	3
Total herbaceous cover (9)	1	25.6	38.4	12
	5	17.0	63.8	6
Total woody cover (6)	1	27.0	38.5	13
	5	9.6	7.8	3
Total herbaceous weed cover (11)	1	4.9	5.0	2
	5	3.3	3.7	2
Total woody weed cover (10)	1	14.2	12.0	5
	5	0.0	0.0	
Total bare ground cover (N/A)	1	2.6	2.4	2
	5	9.1	15.4	3

Table 11. Power analysis results for Canopy Cover metrics, Phase 1 data only.

Canopy density				
Metric (ID No.)	**Stratum**	**Standard deviation**	**Mean**	**Samples needed to detect: *delta* = 20**
Left- and right-bank densiometer readings (5a)	1	3.9	10.5	3
	5	0.0	0.0	
Mean of stream-center densiometer readings (5b)	1	5.4	7.4	4
	5	0.0	0.0	

Table 12. Power analysis results for Erosion metrics, Phase 1 data only.

Category index				
Metric (ID No.)	**Stratum**	**Standard deviation**	**Mean**	**Samples needed to detect: *delta* = 1**
Erosion category (12)	1	0.79	3.23	5
	5	0.95	3.41	7

The estimated sample sizes (samples needed to detect differences) are based on estimated standard deviations, which are random variables. As such, random chance dictates that some estimates will be too large and some too small. Therefore, advice was given to rely on the average sample size for all metrics in Stratum 1 (7.5 sites for either treatment or control and a total of 15 for the stratum) and the average sample size calculated for all metrics in Stratum 5 (3.5 sites for either treatment or control and a total of 7 for the stratum).

Based on the power analysis results and input from the Advisory Group, the following sample sizes were targeted for the three final strata:

- **Stratum 1-2** – 15 sites total with a preferred allocation of 10 treatment and 5 control sites assuming the control sites could be paired with more than one treatment site.
- **Stratum 3-4** – 15 sites total with a preferred allocation of 10 treatment and 5 control sites assuming the control sites could be paired with more than one treatment site. The selected sample size is indirectly informed on Phase 1 analysis.
- **Stratum 5-6** – 10 sites with 5 treatment and 5 control sites. A smaller size is appropriate for this stratum based on the power analysis, but the sample size was increased from 3.5 to 5 to reduce the likelihood of spurious results at such a low sample size.

These plans were fully implemented during Phase 2 and the full set of data from Phase 1 and Phase 2 were combined in order to perform analyses described in the next two sections.

2.5.2 Hypothesis testing

The primary question to be addressed through this monitoring effort can be stated as follows: *Are conditions in treatment (restored) sites significantly improved compared with those at control sites <u>within each stratum</u>?* As described above, the treatment sites were assigned to groups, each containing one control site and one or more matched treatment (i.e., restored) sites. Significant differences between control and treatment sites were identified using ANOVA, in which the effect of each group, or set of sites associated with a single control site, was separated from the effect of the metric (e.g., canopy cover) on differences between control and treatment sites within each stratum. Indicators of success were based on whether or not the metrics reported at treatment sites within each stratum were statistically different (with a p-value equal to or lower than 0.10) from those reported at control sites within that stratum, and if that difference was in the direction that provides greater habitat quality for the treatment sites.

Two metrics for livestock management were reported as simple ‘yes’ versus ‘no’ answers to the questions (1) “Is the fencing intact?”, and (2) “Is there no evidence of livestock presence within the exclusion area?”. The success criteria, per Crawford (2011b), is to have at least 80% of those sites functional for livestock exclusion in the CREP riparian corridor, as indicated by ‘yes’ responses to both questions.

The eighteen field metrics, numbered according to Appendix E of Stillwater Sciences (2016b), were clustered into three groups: (1) channel and channel edge condition, (2) floodplain and terrace vegetation condition, and (3) livestock management. Two metrics originally listed for analysis in Appendix E of Stillwater Sciences (2016b), metric #7 percent cover of conifer and metric #8 percent cover of broad leaf tree species along the channel, showed little to no variation among sites in each stratum. Since there was no variation in values for these two metrics, statistical analyses could not be performed.

A summary of significance tests is provided in Tables 13 and 14. Metrics that indicated significantly different habitat conditions for the treatment vs. the control sites for each of these three groups of metrics is summarized for each stratum below to address the fundamental question: *Are conditions in treatment (restored) sites significantly improved compared with those at control sites <u>within a stratum</u>?*

Table 13. Statistical test results for metrics measured at treatment (restored) and control sites in the three strata. "Treatment effect" indicates if the treatment sites had higher (+) or lower (-) measurements than control sites and "p" values indicate the level of significance of the reported difference, where *** indicates p<0.001, ** indicates p<0.01, and * indicates p<0.05. Higher treatment values (+) for most metrics are ecologically desirable; however higher treatment values for the four metrics on percent weed cover (metric ID numbers 10, 11, 17, and 18) are undesirable.

Target metric	ID No.[1,2]	Field measurement	Statistical tests: Stratum 1-2: West CP 22		Stratum 3-4: East CP 22		Stratum 5-6: East CP 29[3]	
			Treatment effect	"p" value	Treatment effect	"p" value	Treatment effect	"p" value
Vegetation structure along channel bank	1	Presence of >0% cover for all three vegetation layers, including river left and river right plots along 5 transects per site	+	0.18	+	4.E-04***	+	0.32
	2	Percent canopy cover (>5 m)	+	0.64	+	5.E-05***	+	0.32
	3	Percent understory (0.5 m to 5 m)	+	0.17	+	4.E-07***	+	0.037*
	4	Percent ground cover (<0.5 m)	+	0.22	-	0.83	+	0.55
Vegetation overhang over channel	5	4 mid-channel densiometer readings for each of 5 channel transects	-	6.E-04***	+	2.E-08***	+	0.003**
Woody cover and LWD recruitment potential for riparian forest buffers	6	Percent cover for all woody species for river left and river right plots along each channel transect	+	0.23	+	2.E-06***	+	6.E-05***
Herbaceous cover for filtering potential	9	Percent cover of herbaceous species for river left and river right plots along each channel transect	+	0.41	-	7.E-05***	-	0.018*
Control of woody weeds	10	Percent cover of woody weed species for river left and river right plots along each channel transect	-	0.009**	+	0.44	0	NA

Target metric	ID No.[1,2]	Field measurement	Statistical tests					
			Stratum 1-2: West CP 22		Stratum 3-4: East CP 22		Stratum 5-6: East CP 29[3]	
			Treatment effect	"p" value	Treatment effect	"p" value	Treatment effect	"p" value
Control of herbaceous weeds	11	Percent cover of herbaceous weed species for river left and river right plots along each channel transect	+	0.73	-	0.31	+	0.63
Bank stability	12	Reach length **without** actively eroding bank on river right and river left between each set of channel transects	+	9.E-17***	+	0.39	+	9.E-06***
Herbaceous cover for riparian buffers	15	Percent cover of herbaceous species in circular plots	-	0.29	-	0.45	-	0.71
Woody cover for riparian buffers	16	Percent cover of woody species in circular plots	+	0.008**	+	0.045*	NA	NA
Control of herbaceous weeds	17	Percent cover of herbaceous weed species in circular plots	+	0.52	+	0.39	+	0.32
Control of woody weeds	18	Percent cover of woody weed species in circular plots	+	0.58	+	0.014*	-	0.26

1 Metric 7 (percent cover of conifer) and metric 8 (percent cover of broad leaf tree species along the channel) were not analyzed due to a lack of variability

2 Results for metrics 13 and 14 (livestock management metrics) are presented in Table 14 below

3 Since CP 29 does not require woody planting, significant differences between treatment and control sites are not reported for Metric 16 (woody cover for riparian buffers).

Table 14. Number of sites for each binomial response regarding livestock management in the three strata surveyed. Test results are indicated as 'yes' vs. 'no' responses to questions at each CREP site visited.

Livestock management metric	ID No.	Stratum 1-2 West CP 22	Stratum 3-4 East CP 22	Stratum 5-6 East CP 29
No evidence of livestock present (all contracts)	14	8 out of 10	8 out of 10	2 out of 5
Fencing intact (only contracts that include fencing)	13	1 out of 2	5 out of 9	4 out of 4
BOTH fencing intact and no livestock present (only contracts that include fencing)	13, 14	1 out of 2 (50%)	5 out of 9 (56%)	2 out of 4 (50%)

2.5.2.1 Stratum 1-2: West side, Riparian Buffer (CP 22)

Four of the fourteen statistically assessed condition metrics were significantly different between control and treatments sites for the west side riparian buffer sites surveyed in Stratum 1-2, as detailed below and in Table 13. Findings on livestock management indicate a majority (80%) of the sites did not have evidence of livestock present as reported in Table 14 and discussed below.

Channel and channel edge condition

Significant differences at or below the $p<0.10$ level were found between control and treatment sites for two of the ten analyzed metrics reported for channel and channel edge condition in the west side CP 22 (Stratum 1–2) (Table 13, ID numbers 1–12). Differences indicated better habitat conditions for the following metrics:

- Cover of woody weeds along channel (Metric ID:10): lower percent cover of woody weed species along the channel
- Bank stability (Metric ID: 12): Percent of sample reach without eroding banks

Only one of the metrics associated with streamside vegetation structure showed significantly better habitat condition between the control and treatment sites: lower percent cover of woody weed species along the channel (Metric ID: 10). Other streamside vegetation metrics trended towards having better conditions than the controls, but showed no statistical difference between control and treatment groups, including percent cover overall, or in the cover of any of the vegetation layers (Metric ID 1, 3, 5, 6, 9, 11). One vegetation structure metric was significantly different between control and treatment sites in the opposite direction from expected: mid-channel densiometer readings were significantly lower in the treatment than in the control sites (Table 13, Metric ID: 4). Despite the general lack of differences observed between control and treatment sites for streamside vegetation, bank erosion was significantly less pervasive in the treatment compared with the control sites (Metric ID: 12).

Floodplain and terrace vegetation condition

The plantings were generally above the channel bank in this stratum and for metrics reported for this area (Metric ID: 15–18 in Table 13), only one metric was significantly different in the expected direction:

- Woody cover for riparian buffers within floodplain and terrace area (Metric ID: 16)

Differences in the other three metrics for the floodplain and terrace area, percent cover of all herbaceous species, herbaceous weeds, and woody weeds, were not significant between the control and the treatment sites (Metric ID: 15, 17, 18).

Livestock management

Eight of the ten CREP contracts that were sampled had no evidence of livestock presence. Only two of the ten CREP contract sites sampled in this stratum included livestock fencing. Livestock exclusion fencing was intact in one of the two sites visited in this stratum, and this same site also had no evidence of livestock occurrences within the exclosure area. Although these numbers indicate that the success criteria of 80% with no livestock evidence was met for this stratum, the number of sites with livestock management as part of the contract is too small to apply to the whole stratum. Detrimental livestock grazing impacts were observed by the field crew in one treatment and one control site in this stratum, so exclosure fencing could be important for success in some areas within this stratum.

2.5.2.2 Stratum 3-4: East side, Riparian Buffer (CP 22)

Eight of the fourteen statistically assessed condition metrics analyzed were significantly different between treatment and control sites for the east side riparian buffer sites surveyed in Stratum 3-4, as detailed below and in Table 13. As reported in Table 14 and discussed briefly below, findings on livestock management indicate a majority (80%) of the sites did not have evidence of livestock presence, with more modest rates of functional exclosures for this stratum.

Channel and channel edge condition

Five out of ten analyzed channel edge and channel condition metrics indicated significantly better condition in treatment than in control sites, specifically:

- Vegetation structure along channel bank
    - Presence of >0% cover for all three vegetation layers along channel (Metric ID: 1)
    - Percent canopy cover (>5 m) (Metric ID: 2)
    - Percent understory (0.5 m to 5 m) vegetation (Metric ID: 3)
- Woody cover along channel (Metric ID: 6)
- Vegetation overhang over channel: mid-channel densiometer readings (Metric ID: 5)

While cover of woody species was higher in the treatment sites (Metric ID: 6), percent cover of herbaceous species along the channel (Metric ID: 9) was significantly lower in the treatment than in the control sites, the opposite from expected. Also, weed cover for both woody and herbaceous species (Metric ID: 10 and 11) showed no significant difference between control and CREP sites along the channel. Within- and among-site variability in bank erosion was particularly high for this stratum in both the control and treatment sites and did not result in a significant difference (Metric ID: 12 and Figure 7).

Floodplain and terrace vegetation condition

In the floodplain and terrace area, which were often the location of the plantings, one out of four measured vegetation metrics was better in the treatment than in the control sites:

- Woody cover for riparian buffers within floodplain and terrace area (Metric ID: 16)

Percent cover of woody weed species (Metric ID: 18) was significantly greater in the treatment than in the control sites. Overall herbaceous and herbaceous weed cover (Metric ID: 15 and 17) were not significantly different in the treatment compared with the control sites.

Livestock management

Nine of the ten CREP sites visited in this stratum included livestock fencing as part of the CREP contract. Fencing was intact in slightly more than half of these CREP sites (5 out of 9), and no evidence of livestock presence was reported for eight out of the ten sites. Again however, there was overlap between these two metrics in less than 80% of the sites: a little over half (56%) of the nine sites had both intact fencing and no evidence of livestock present.

2.5.2.3 Stratum 5-6: East side, Marginal Pastureland Wildlife Buffer (CP 29)

Five of the thirteen statistically assessed condition metrics analyzed were significantly different between treatments and control sites for the east side Marginal Pastureland Wildlife Buffer sites surveyed in Stratum 5-6, as detailed below and in Table 13. Findings on livestock management for Stratum 5-6 indicate that all the fences were intact, but over half of the sites showed evidence of livestock presence, as reported in Table 14 and discussed below.

Channel and channel edge condition

Four out of ten analyzed channel edge and channel condition metrics indicated significantly better condition in treatment than in control sites in these Marginal Pastureland Wildlife Buffers:

- Vegetation structure along channel bank: percent understory (0.5 m to 5 m) vegetation (Metric ID: 3)
- Vegetation overhang over channel: mid-channel densiometer readings (Metric ID: 5)
- Woody cover along channel (Metric ID: 6)
- Bank stability: Percent of sample reach without eroding banks (Metric ID: 12)

Percent cover of herbaceous species along the river banks (Metric ID: 9) was significantly lower in treatments than in control sites, the opposite of what was expected (Table 13).

Floodplain and terrace vegetation condition

No significant differences in vegetation percent cover was reported between treatment (restored) and control sites in this stratum (Metric ID: 15-18).

Livestock management

Livestock exclusion fencing was included in four of the five CREP contracts visited in this stratum. Intact fencing was observed in all four of these sites. However, there was no evidence of livestock presence in only two out of the five sites. Overall, both of these conditions were met in two out of four sites (Table 14); therefore, the success criteria of 80% of the sites reflecting both intact fences and no evidence of livestock within the exclosures was not met for this stratum.

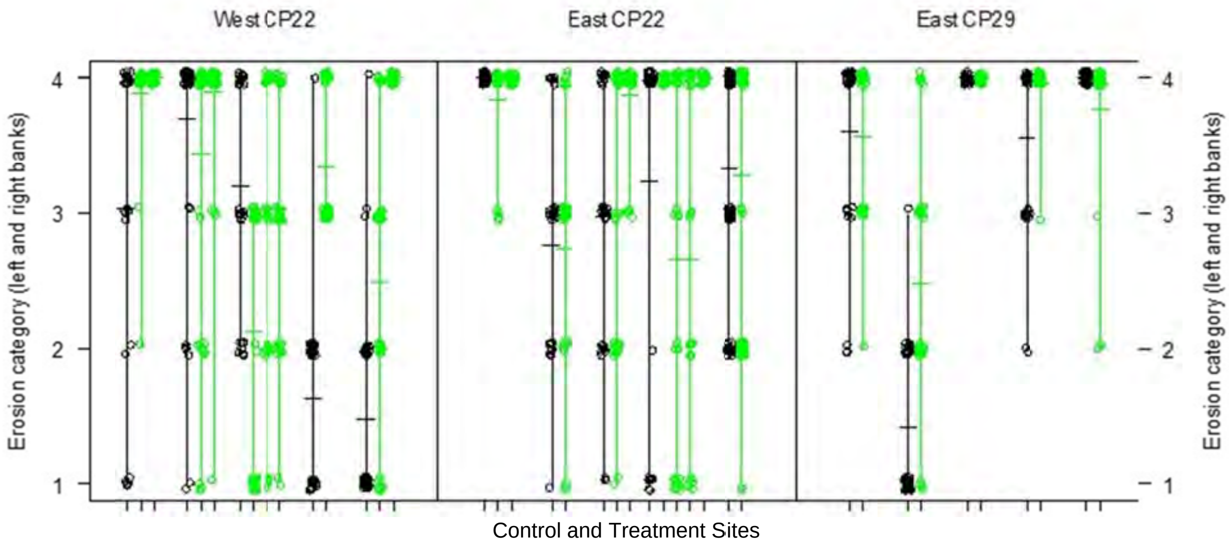

Figure 7. Bank erosion was recorded in categories along a sample reach in each site, where 4 indicates very stable banks and 1 indicates highly eroded and unstable banks. Black lines are control sites and green are CREP sites. Circles represent data points and cross-hatches indicate site means. Controls are clustered with associated treatments in each stratum.

2.5.3 Exploratory analyses

A secondary but important question that was addressed through this monitoring effort can be stated as follows: *Are there any important co-variates influencing the difference between the treatment (restored) and control sites* *within a stratum*?

Potential covariates include field and CREP contract information such as:

- woody planting density
- herbaceous planting density
- year last planted
- site preparation irrigation
- site preparation spraying
- site preparation mowing
- site maintenance irrigation
- site maintenance spraying
- site maintenance mowing

The importance of contributing watershed area was examined as a co-variate in this analysis. ANOVA was applied to address this question, guided by the preferred model fit determined using Akaike's Information Criterion (AIC) (Akaike 1973). Since these are linear models, it was not possible to perform this test with the binary data collected for livestock management. In addition, the statistical models were only effective where there was sufficient variation in the management actions among the treatment sites within a stratum. Where only one site was managed differently, or where all sites were managed the same, there was no means to detect covariate effects on the condition metrics. Therefore, only the covariates for which sufficient variation existed are highlighted in the text and summarized in the tables below. Moreover, it is important to bear in mind that these 'exploratory analyses' were performed for each metric against many potential covariates and with sometimes very small data sets (n= 5 to 10). Thus, there is a high likelihood of spurious positive results and these test results must be thoughtfully interpreted.

2.5.3.1 Stratum 1-2: West side, Riparian Buffer (CP 22)

Table 15 indicates covariates for which there was substantial variation among the ten treatment sites visited in the West Side, CP 22 sites (Stratum 1-2): woody planting density, year last planted, contributing watershed area, and where site maintenance activities include mowing. Table 15 shows the direction of potentially significant relationships between covariates and site condition metrics. Only the condition metrics with a potentially significant correlation to the covariates are shown in Table 15.

Overall, year last planted, which is reported as the calendar year and therefore the greater the year, the shorter the time since the planting occurred, co-varied inversely with channel shade and percent cover of woody species in the planting area (Metric ID: 6 and 16). These results are sensible since the plants would have had less time to grow for those more recently planted sites, but they are not terribly informative for future management plans.

Similarly, percent cover of herbaceous species along the channel banks and in the floodplain and terrace area were greater in sites that were more recently planted (Metric ID: 9 and 15). This likely indicates that the planted woody species had not yet shaded the existing herbaceous species and thereby reduced herbaceous cover.

Contributing watershed area size was inversely correlated to canopy cover (Metric ID: 5), which makes sense given that larger river channels would be expected to have more sunlight exposure than the narrower channels common in higher elevations within the watershed. The inverse correlation between woody planting density and channel shade is unexpected (Metric ID: 5), as was the significant but negative treatment effect compared with controls for canopy cover described under Section 2.5.2 above (Table 13).

Table 15. Summary of exploratory statistical test results for covariates and site condition metrics in Stratum 1–2 (West side CP 22).

ID No.	Metric	Woody	Year last planted	Maintenance mowing	Contributing watershed area
5	4 mid-channel densiometer readings for each of 5 channel transects	-			-
6	Percent cover for all woody species for river left and river right plots along each channel transect		-		
9	Percent cover of herbaceous species for river left and river right plots along each channel transect		+		
15	Percent cover of herbaceous species in circular plots		+		
16	Percent cover of woody species in circular plots		-		

2.5.3.2 Stratum 3-4: East side, Riparian Buffer (CP 22)

Eight of the ten potential covariates had sufficient variation to detect effects on the riparian condition metrics in Stratum 3-4: all but preparatory and maintenance irrigation (Table 16). The direction of any potentially significant relationship between covariates and site condition metrics populate the table, as determined by ANOVA. Ten treatment sites are included in this analysis, although many of the metrics have multiple within-site measurements.

Spraying, either during site preparation or during maintenance, appears to potentially affect site conditions; however, many of the correlations are negative. Thus, spraying is negatively correlated to presence of all three vegetation layers, percent canopy cover and woody species cover along the channel and in the floodplain and terrace (Metric ID: 1, 2, 6 and 16). Spraying is positively correlated to percent cover of overall herbaceous and weed herbaceous cover along the channel and in the floodplain and terrace (Metric ID: 4, 9 and 11). Given the available data, it is not possible to explain the basis for variable correlation resulting from spraying.

Mowing also was positively correlated to site condition metrics, including percent ground cover along the channel and length of non-eroding banks (Metric ID: 4 and 12).

Planting density for woody species was positively correlated to channel shade (Metric ID: 5), but not to other metrics for woody species cover .

As in Stratum 1-2, contributing watershed area is inversely correlated to channel shade (Metric ID: 5). Percent streamside woody canopy cover is also negatively correlated to contributing watershed area (Metric ID: 2).

Table 16. Summary of exploratory statistical test results for covariates and site condition metrics in Stratum 3–4 (East side CP 22).

ID No.	Metric	Woody	Herbs	Year last planted	Prep spraying	Prep mowing	Maint. spraying	Maint. mowing	Contributing watershed area
1	Presence of >0% cover for all three vegetation layers along channel				-		-		
2	Percent canopy cover (>5 m)				-		-		-
4	Percent ground cover (<0.5 m)				+			+	
5	4 mid-channel densiometer readings for each of 5 channel transects	+							-
6	Percent cover for all woody species for river left and river right plots along each channel transect				-				
9	Percent cover of herbaceous species for river left and river right plots along each channel transect				+				
11	Percent cover of herbaceous weed species for river left and river right plots along each channel transect				+				
12	Reach length without actively eroding bank on river right and river left between each set of channel transects					+		+	
16	Percent cover of woody species in circular plots				-				

2.5.3.3 Stratum 5-6: East side, Marginal Pastureland Wildlife Buffer (CP 29)

This stratum includes only five sites and only two of the covariates occurred with sufficient diversity to reveal correlations of metrics to site conditions: herbaceous planting density and year last planted (Table 17). All of the sites were in small contributing watershed areas, so the effects of this co-variate could not be assessed for this stratum. Preparatory and maintenance irrigation, preparatory mowing, and maintenance spraying were all identical across all five sites, making analysis of covariance null. For woody planting density, and preparatory spring and maintenance mowing, only one of the five sites had a different action.

Overall, increased herbaceous planting density was correlated to higher canopy cover in all vegetation layers along the channel (Metric ID: 5) and had variable correlations to plant cover in the planted area (Metric ID: 12 and 17). As in the other strata, year last planted was inversely correlated to channel canopy cover (Metric ID: 5).

Table 17. Summary of exploratory statistical test results for covariates and site condition metrics in Stratum 5–6 (East side CP 29).

ID No.	Metric	Woody planting density	Herbs planting density	Year last planted
5	4 mid-channel densiometer readings for each of 5 channel transects		+	-
12	Reach length without actively eroding bank on river right and river left between each set of channel transects		-	
17	Percent cover of herbaceous weed species in circular plots		+	

2.5.4 Data summary

An illustration of pooled data from all treatment and all control sites within each stratum for percent woody cover in 18-m^2 circular plots and in 100-m^2 streamside plots is presented in Figures 8–10 below. These data cannot be used in statistical tests because of the difference in sampling plot sizes; however, these figures illustrate several points that are visible but harder to decipher when looking at the site-by-site data. These box plots show the distribution of data for percent woody cover in each of the three strata. Each box extends from the first to the third quartile, with a heavy horizontal line at the median; thus each box encapsulates one-half of the data. All other individually shown points outside of the boxes are either below the first or above the third quartiles.

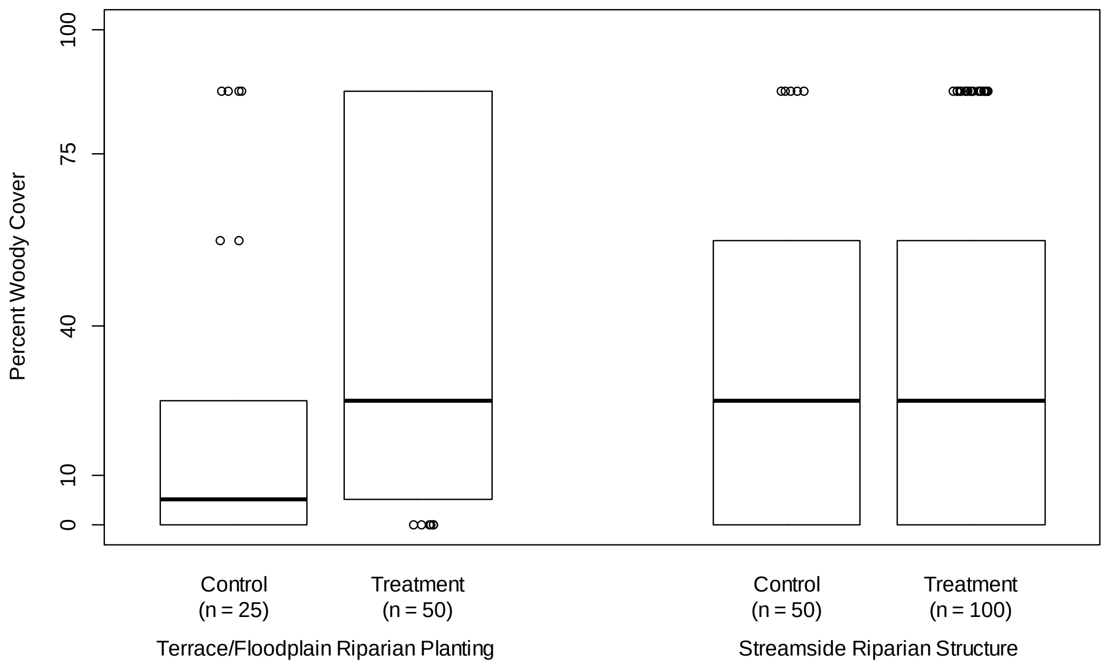

Figure 8. Graphic of pooled woody cover data from the five control and 10 restored (treatment) sites for West CP 22 sites. Each site had five plots, thus the n is 25 for control and 50 for treatment sites for floodplain and terrace riparian area and twice that for streamside riparian structure.

Figure 8 shows combined data for percent woody cover in the floodplain and terrace areas (left) and the channel edge (right) at the West CP 22 treatment and control sites. Data were collected from five plots in the floodplain and terrace area for the five control sites, so the n is 25 (5 x 5) and 50 for the ten treatment sites (5 x 10). Data were collected at ten plots along the channel edge at each site, so the n is 50 for the five control sites (5 x 10) and 100 for the ten treatment sites (10 x 10). Figure 8 clearly shows the lack of difference in woody riparian cover between streamside riparian structure control and treatment (restored) sites and the higher level of woody cover in the floodplain riparian treatment vs. the control sites. This figure also indicates that overall, woody plant cover was similar to slightly higher in the floodplain/terrace areas that were planted than in the streamside plots.

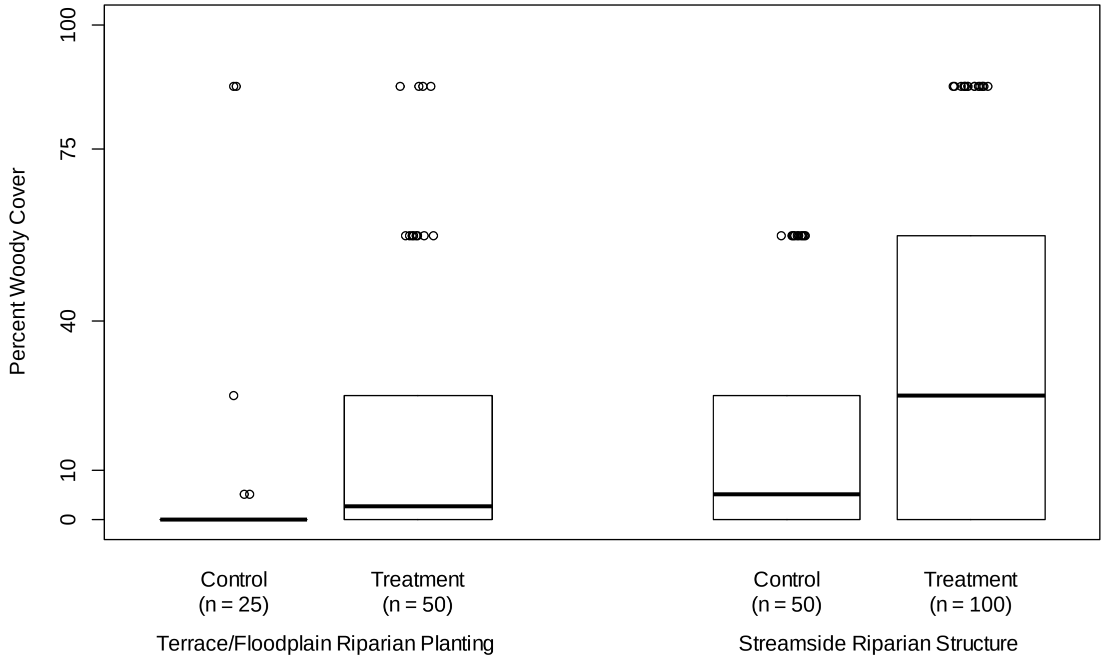

Figure 9. Graphic of pooled woody cover data from the five control and 10 restored (treatment) sites for East CP 22 sites. Each site had five plots, so the n is 25 for control and 50 for treatment sites for riparian floodplain and terrace and twice that for streamside riparian structure.

Figure 9 illustrates the overall higher level of woody vegetation cover in the treatment vs. the control sites in both the streamside riparian structure and the floodplain and terrace riparian plots in the East CP 22 stratum. Also, overall there is greater woody cover in the riparian structure sites.

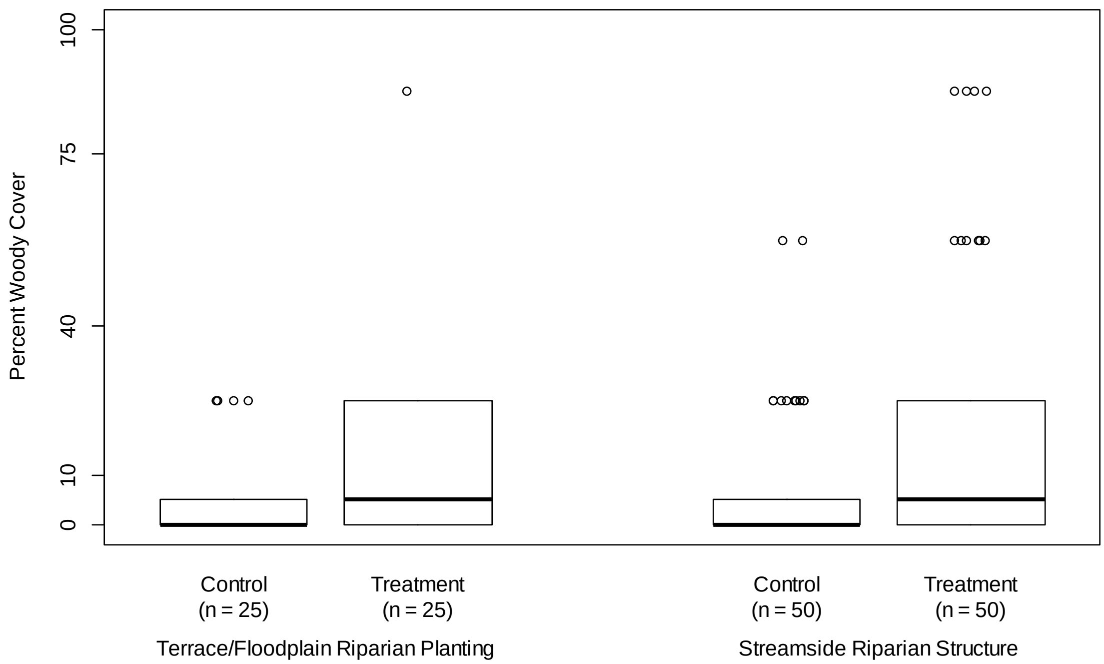

Figure 10. Graphic of pooled woody cover data from the five control and five restored (treatment) sites for East CP 29 sites. For riparian floodplain and terrace plots, each site had five plots, so the n is 25 for control and 25 for treatment sites. For the channel side plots on riparian structure, each site had ten plots, so the n is 50 for control and for treatment sites.

Figure 10 shows data from the treatment and control sites in the East CP 29 stratum. The overall percent cover for woody vegetation in the floodplain and terrace plots and streamside vegetation plots indicates that the treatment (restored) sites have greater overall woody percent cover. Woody species planting is not required for CP 29 and only one of the five treatment sites visited included woody species planting as part of the CREP contract. The small treatment effect shown in Figure 10 could reflect the higher cover at this site combined with effects from other secondary factors, such as reduced herbivory.

3 DISCUSSION (INTERPRETATION OF FINDINGS)

3.1 Overview

Overall effectiveness monitoring results indicate moderate and variable success among the CREP sites. In the following sections, statistical results from the hypothesis testing and exploratory analysis are combined with field observations from each stratum to provide an integrated interpretation of the effectiveness monitoring results.

With the restoration actions focused on developing a vegetated zone populated by native species along the channel, some of the most important indicators of the effectiveness of these treatments in improving the quality of riparian vegetation and stream channel habitat relate to percent vegetation cover both along and adjacent to the channel (e.g., the riparian and the floodplain and terrace area plots), and mid-channel shade (as measured with the densiometer). The two east-side strata (strata 3-4 and 5-6) showed significantly higher percent cover of woody and understory vegetation cover along the channel and as mid-channel shade in treated than in untreated control sites. Moreover, most sites with the Conservation Practice 22 (strata 1-2 and 3-4) had higher woody plant cover in the floodplain and terrace area than their controls, although high mortality rates were observed in Stratum 3-4 (east side). Fencing exclosures were part of 15 out of 25 of the CREP contract sites visited, and were concentrated in the east-side areas. Evidence indicated overall exclosure effectiveness (based on intact fencing and lack of livestock evidence in the exclosures) in eight of these fifteen sites, or a little over half of the sampled sites. Two out of the three strata showed greater bank stability compared with the control sites. Bank stability indicators for Stratum 3-4 (East CP 22) were not significantly different from controls. These findings are discussed more in the following sections.

3.2 Stratum 1-2: West Riparian Buffer (CP 22)

Most of the riparian metrics measured at the ten treatment sites in this stratum covered the same range of variability as observed in the five control sites, except the treatment sites did show lower amounts of bank erosion and greater woody plant cover in the floodplain and terrace area. Thus, while the goals of the CREP program were partially met in these areas, there is also room for improvement. These results potentially indicate that CREP sites are targeting the most impacted areas on the west side and that the control sites represent a slightly less impacted comparison. If this is the case (and we have no way of knowing with the available data), then findings of no significant difference between control and CREP contract sites could indicate net improvement from the original baseline.

3.2.1 Channel and channel edge condition

The lack of significant difference between control and treatment sites in streamside vegetation structure metrics can be at least partially explained by the common field observation that existing natural and mostly native streamside vegetation populated both the treatment and control channel banks and floodplains (Figure 11). The lack of difference in woody riparian cover between streamside control and treatment sites might be due to the fact all streamside landowners in Oregon are subject to the State of Oregon's Agriculture Water Quality Management Area Act, which require that agricultural landowners allow adequate streamside vegetation to thrive in order to provide water quality functions, including shade, filtering, and bank stability. Woody vegetation cover along the streamside was generally lower than in the floodplain and terrace area (Figure 8).

The significantly greater mid-channel densiometer readings in control rather than treatment sites in this Stratum 1-2 (west side, riparian buffer) was unexpected (Table 13), but since the CREP practice is to begin planting at the top of bank (Appendix A), rather than along the banks where opportunities for vegetation to increase channel shade are greater, we expected to find no significant difference between the control and treatments groups. Greater canopy cover in the control than the treatment sites could have occurred due to systematic selection of the most locally degraded sites for the CREP program; however, no information is available to compare pre-treatment conditions for the control and the treatment sites.

Figure 11. In Stratum 1–2 sites, riparian vegetation was composed of pre-existing (non-planted) plants that were mostly native riparian species.

3.2.2 Floodplain and terrace vegetation condition

Increased woody plant cover in the floodplain and terrace area suggests that the CREP program is having a positive effect on the condition of these riparian corridors. However, several observations recorded in field notes and photographs indicate that further improvement may be possible. For example, a common observation was that CREP plantings occurred most often on terraces well above and set back from the existing active channel (Figures 12–14). While the USDA CREP CP-22 and CP-29 practice guide documents (Appendix A) direct planting to begin at the "top of bank", in many cases this relatively remote position of the plantings is likely to minimize their influence on riparian condition closer to the channel. Moreover, some of the plantings observed were planted in plantation style monocultures rather than as a structurally diverse evergreen and deciduous riparian community native to this region (USDA 2005, Franklin and Dyrness 1988).

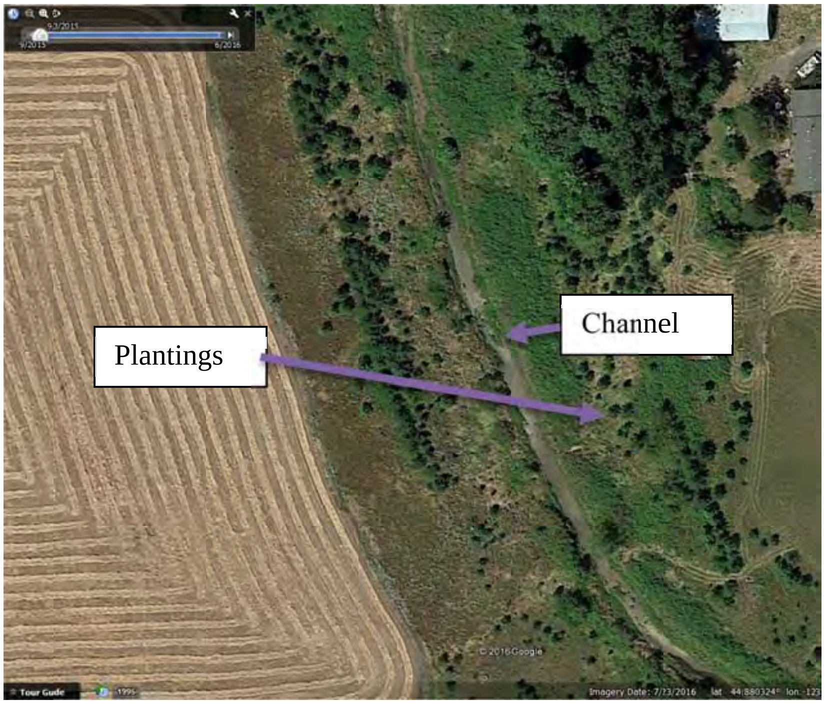

Figure 12. Aerial photo of plantings adjacent to stream channel at a CREP site in Polk County.

Figure 13. Conifers planted in monoculture on high terrace behind existing riparian zone at a CREP site in Yamhill County.

Figure 14. Consistent with CREP practice, plantings begin at the top of bank, which in cases such as this where the channel is heavily incised, reduces the interaction between the planted area and the stream and streamside habitat, thereby limiting potential to benefit channel conditions (same site as shown in previous figure).

3.2.3 Livestock management

Livestock exclosure fencing was part of the contract for only two out of the ten treatment sites visited in this stratum (Table 14). The small sample size and equivalent findings—one of the two had both intact fencing and absence of livestock presence indicators—do not provide sufficient information to draw conclusions on the effectiveness of this aspect of the program in this region. It is important to note that 80% of the CREP contracts did not have evidence of livestock presence. However, observations from at least one of the treatment sites in this stratum indicate that cattle are not always excluded from the CREP buffer and intense grazing can have negative impacts on the habitat.

3.2.4 Covariates and management actions

Himalayan blackberry (*Rubus armeniacus*) and reed canary grass (*Phalaris arundinacea*) were the most commonly observed invasive weed species at these sites, particularly in the floodplain and terrace areas. Plantings were impacted by beaver, and also by cattle in the site where the exclosure was not effective. Since most of the planting and weed management occurred well above the channel banks where the riparian structure plots were established, the positive finding of lower weed species cover along the channel could be a reflection of lower bank erosion or disturbance near the channel in the restored (treatment) vs. the control sites, rather than the result of direct weed management actions.

Much higher woody species cover in the circular plots, as well as observations and site photographs, indicate that planting survival was high at these treatment sites and that associated woody canopy cover was increased in the floodplain and terrace area. Increased planting density logically trended towards higher woody percent cover in the floodplain and terrace area. Recent planting years for these sites range from 2002 to 2011, making the plantings five to 14 years old.

The inverse correlation between 'year planted' and woody cover along the channel edge and mid-channel densiometer readings makes sense, as younger trees and shrubs provide less cover.

3.3 Stratum 3-4: East Riparian Buffer (CP 22)

The sites visited in this stratum were highly variable. Some sites demonstrated good success with the CREP program, with diverse native and healthy plantings along the channel and well maintained and functional exclosure fencing (e.g., Figure 15). Others were not implemented as well, showing very low survival of planted woody species. Most of the sites fell between these two extremes.

Figure 15. Successful Stratum 3–4 CREP site in Gilliam County, with an intact fence and a robust riparian zone.

3.3.1 Channel and channel edge condition

Channel bank vegetation was in better condition in the treatment than the control sites for half of the metrics tested in this stratum, particularly woody vegetation cover and channel shade (Table 13). As stated above, the CREP practice is to begin planting activities at the top of bank rather than along the bank, so this difference could be due to some other variation between the control and the treatment sites. Reviewing notes and photographs from these sites provides some insight into what may have led to this difference. The five control sites were either heavily impacted by cattle grazing or located in very narrow and poorly vegetated riparian corridors. In contrast, most of the treatment sites supported existing and mostly native riparian species along the channel margin that was not planted through the CREP program, but was at least protected from heavy grazing through the exclosure fencing and in at least one case, by the heavy planted vegetation along the adjacent terrace. Existing naturally recruited streamside vegetation was more often reported in sites that had smaller contributing areas than those with larger contributing areas. Channel bank erosion, which ranged widely within most sites, was not significantly better in the treatment than in the control sites (Figure 7). It is not clear why this was the case, although channels in this dry landscape are likely to experience intense flashy flows that can result in punctuated erosion events and require long periods to recover from such erosion. Similarly, water-limited areas such as this region can also require more recovery time from stress, such as caused by intense cattle use and flashy storm events, than channels in the wetter landscape west of the Cascades.

3.3.2 Floodplain and terrace vegetation condition

Woody plant cover was significantly greater in the floodplain and terrace area of the treatment sites than in the control sites, indicating that the CREP program is having a positive effect on riparian corridor habitat. However, woody weeds were also significantly greater in the treatment than the control sites, so that at least some of this increased overall woody vegetation cover is provided by woody weed species rather than by native woody plant species that are more likely to support native fish and wildlife.

As in Stratum 1-2, plantings for many of the CREP sites were set above and back from the existing channel likely based upon interpretation of the 'top of bank' text included in the USDA guidance sheets (Appendix A); this restriction limits the direct positive effects of the plantings on the riparian and aquatic habitat conditions closer to the stream channel edge.

3.3.3 Livestock management

Based on this sampling effort, livestock were present in only one of the nine treatment sites that included livestock exclosure in the CREP contract, and livestock fencing was intact in five of the nine treatment sites with livestock exclosure in the CREP contract (Table 14). Both intact fencing and absence of livestock evidence were observed at just over half of these CREP sites. In one case, livestock from a neighboring landowner were on the CREP site, accessed from the opposite side of the channel and outside of the CREP boundaries, opening the question of responsibility for cattle that are not owned by the CREP landowner. Also, the CREP program acknowledges that isolated events like an occasional animal escaping can occur, and if remedied as quickly as possible, is within program expectations and requirements. It also should be noted that ranchers trailing animals from one site to another can briefly cross a CREP buffer, and that this is allowed within program requirements as well. These types of incidences may account for some of the presence of livestock that was observed when the field crew performed the monitoring.

3.3.4 Covariates and management actions

Russian olive (*Elaeagnus angustifolia*), Kochia (*Kochia scoparia*), Russian thistle (*Salsola tenuifolia*), reed canary grass (*Phalaris arundinacea*), quack grass (*Agropyron repens*) and nightshade (*Solanum* spp.) were common weeds reported both along the channel banks and on the floodplain and terrace area in the CREP sites. Field surveyors observed that some aspects of the implementation practices for planting, maintenance, and weed control in sites in this stratum were not as effective as they could be. For example, there was fairly common use of landscape fabric to control for weeds in the planting sites and few of the plantings were irrigated. As a result, the biodegradable fabric lasted longer on these sites than the plantings (Figure 16a–c). As described in the following section on Adaptive Management, use of landscape fabric has largely been abandoned as a means of weed management. Drip irrigation for the first few growing seasons can greatly increase long-term survival in Mediterranean climates that receive little rainfall during the growing season; however, drip irrigation can also discourage deep root growth that is required for long-term survival after the drip irrigation is removed. Finally, irrigation requires a locally available water source, often not available for these east side CREP sites. Other methods for increasing planting survival in dry climates, besides the very important initial appropriate species selection, might include increased plant size at planting, and planting in deep holes to encourage root access to deeply located groundwater. More information on workable solutions can be found in the Adaptive Management Recommendations (Gilliam County et al. 2017).

Figure 16a-c. Time series from Google Earth imagery of a CREP site in Morrow county where biodegradable fabric was used to suppress weeds but the project resulted in no surviving plants and the fabric did not biodegrade over a 4-year time period.

3.4 Stratum 5-6: East Marginal Pastureland Wildlife Buffer (CP 29)

These sites were located in the drier landscape east of the Cascades and generally along small intermittent or seasonal channels and swales. One of the five CREP sites is an example of a successful project (Figure 17), particularly when compared with the adjacent control site (Figure 18).

Figure 17. An example of a well-managed CREP site in Stratum 5–6, Baker County, which was robustly fenced and had a healthy riparian zone.

Figure 18. This control site stands as a comparison to the CREP site shown in Figure 17. This site is not fenced and the riparian vegetation is virtually non-existent.

In many cases in this stratum, there were few to no visible differences between CREP treatment (Figure 19) and control (Figure 20) sites.

Figure 19. CREP site in Stratum 5–6 in Wasco County.

Figure 20. Control site for the CREP site in the figure above, also in Wasco County.

3.4.1 Channel and channel edge condition

CREP sites had greater percent canopy cover over the channel and understory than control sites. Bank stability was also significantly greater in the treatment than in the control sites. Although positive, the channels in these areas were very indistinct and were dry at the time of the site visits (most in June 2016). Thus, the positive impact that increased channel shade can have on stream habitat is unclear, although bank stability, even for small tributaries in the watershed, can reduce sedimentation downstream during the rainy season. Similarly, even when dry, these riparian corridors can support wildlife species through the increased amount and diversity of associated native vegetation.

3.4.2 Floodplain and terrace vegetation condition

In this stratum, there were no metrics that were significantly better in the treatment vs. the control sites in the floodplain and terrace areas set back from the channel. Since CP-29 does not require woody planting, significant differences between control and treatment sites for woody cover in this area was not assessed.

3.4.3 Livestock management

Intact fencing was observed on all four of the CREP sites contracted to include exclosure fencing in this stratum (Table 14). While fencing was more often present and intact in the CREP sites, there was equivalent evidence of livestock within the CREP exclosures. Some of this evidence included presence of cow patties, some of which, in this dry climate, could be remnant from pre-contract times. Suspension of livestock use with participation in the CREP program within intact exclosures could be part of the reason for the lower degree of bank erosion and greater woody cover reported for these sites compared with the unfenced controls; but this difference in bank erosion needs further exploration.

3.4.4 Covariates and management actions

Management actions implemented in the Stratum 5-6 CREP sites included herbicide spraying during site preparation and maintenance and in one of five cases, maintenance mowing. In spite of these actions, cheat grass (*Bromus tectorum*) was a commonly observed invasive species in these drier east side sites. This species is notoriously difficult to control; however, the common presence and lack of significant difference in weed cover between control and treatments sites suggest a need for additional and/or different weed management actions. Herbaceous vegetation cover was positively correlated to herbaceous planting density, suggesting that increased planting density could result in better site conditions. A field technician noted successful establishment of wild rye (exact species unknown) at one of the CREP sites. Woody species were planted at only one site, so planting density effects on site conditions could not be assessed.

4 ADAPTIVE MANAGEMENT

As noted in Section 1.4, the project age for contracts sampled in this study was at least 7 years and thus reflects projects developed in the early stages of CREP program implementation. It is important to note that CREP technicians have refined practices and employ adaptive management strategies on more recently executed CREP contracts. Examples of such improvements consist of the following:

- refinement of species selection and planting densities based on known site conditions,

- stock selection modifications (i.e. increase planting stock size to improve survival),
- suspend the use of long strips of landscape fabric for weed control,
- increase structural diversity of plantings to improve habitat quality,
- tree and shrub protection to deter browsing mortality,
- enhancement of site preparation and weed management practices,
- inclusion of additional, complimentary management practices outside the CREP project (i.e. bank reshaping and stabilization)

Additional documentation of such efforts are presented in Appendix E of this report. Furthermore, CREP practitioners in Gilliam, Wheeler, and Wasco counties have developed a draft document, *Eastern Oregon Conservation Enhancement Program (CREP) Adaptive Management Guidance* (2017), that provides additional information about the CREP practices and adaptive management techniques being implemented in these counties. The findings of this monitoring study highlight and bolster the importance of the adaptive management practices that are being actively employed at CREP contract sites.

5 CONCLUSIONS AND RECOMMENDATIONS

As stated in the introduction section of this report, the two over-arching questions addressed through this monitoring effort are:

- Is the CREP program positively affecting riparian site conditions as compared with control sites? and
- What are the most important factors affecting successful riparian restoration?

The answer to these questions is “yes with caveats, applicable per stratum”. These answers per stratum are provided below.

West of the Cascades, CP-22 (Stratum 1-2)
Positive CREP action effects on riparian site conditions were small and mixed, with positive effects on woody vegetation cover in the wider riparian corridor on the floodplain and terrace area, but no detected effects on stream-side vegetation or channel shade. No significant (or trending) reduction in weed cover was detected in either the stream-side nor the riparian buffer areas. With very few sites including livestock exclosures and no planting below top of bank, it is unclear what the linkage was between the CREP actions and the lesser extent of eroding banks detected in the CREP treated sites compared with the controls.

The most important factors affecting successful riparian restoration in Stratum 1-2 are uncertain. Because there was so much similarity in how sites were managed, effects of different management actions could not be detected. Nearly all sites applied herbicides and mowed both in preparation for planting and as maintenance, and yet weed cover was equivalent in treatment and control sites. This suggests that these weed management activities should be re-examined, either to change, refine, or increase in frequency, possibly depending on the particular conditions at the site. Also, the lack of detectable increase in riparian vegetation cover and channel shade in these areas is likely linked to the practice of beginning plantings at the ‘top of bank’, leaving the most critical part of the riparian zone where channel shade and sediment and nutrient filtration is most effective, untouched. If permitted within the CREP program, reconsideration of this ‘top of bank’ practice could enable CREP restoration practices to have greater positive effects on channel and riparian condition.

East of the Cascades, CP-22 (Stratum 3-4)
Positive CREP action effects on riparian site conditions in this stratum were detected in several ways, including multiple metrics indicating increased riparian vegetation cover along the channel and in the riparian buffer areas. Indications of increased woody and herbaceous cover, as well as channel canopy cover, were strengthened by the number of metrics that were significantly different in an ecologically positive way in the treatment vs. the control sites in this stratum. Weedy plant cover appears to remain a challenge in these sites as well as those in Stratum 1-2.

The most important factors affecting successful riparian restoration in Stratum 3-4 are similar to those described for Stratum 1-2. Again, although seven out of the ten treatment sites visited applied herbicides and six sites mowed, weed cover was not significantly lower in the treatment compared with the control sites. Therefore, weed management practices employed in these 7+ year-old contracts should be revisited to develop and test alternative weed management actions. Bank stability in these sites was highly variable and not significantly different from the control sites. While planting along eroding banks does not necessarily slow or reverse bank erosion, other actions involving reshaping channel banks could be combined with planting along these reshaped banks. Since such earth-moving activities are outside of the scope of the CREP program, other grant programs could be used to support bank reshaping while the CREP program could support planting along the stabilized banks. By combining these actions and programs, greater improvements to riparian condition could be achieved.

East of the Cascades, CP-29 (Stratum 5-6)
Positive CREP action effects on riparian site conditions in this stratum were nearly as strong as those reported for Stratum 3-4, with positive and significant differences in woody and herbaceous cover adjacent to the (often intermittent) channel, and significantly less length of eroding banks in the CREP treatment sites compared with the controls.

The most important factor affecting successful riparian restoration in Stratum 5-6 appears to be herbaceous seeding density. Again, although all of the treatment sites visited applied herbicides, in many cases both in preparation of planting and as post-planting maintenance, weed cover was not significantly lower in the treatment compared with the control sites. The positive correlation between seeding density and herbaceous cover suggests that increased seeding density benefits riparian conditions, but more explicit testing of this should be performed, in ways adapted to specific-site conditions.

Recommendations
Although a number of the CREP sites surveyed were well-designed, implemented, and managed, several recommendations are made based on the monitoring data and field observations summarized above:

- Revisit the rationale behind the current practices that allow actions only starting at the top of bank. The inability to address conditions between the top of bank and the channel limits the overall effectiveness that the program can have on improving conditions of the streamside environment. Specifically, we recommend that planting areas be located within moderate to frequently flooded floodplain and/or along the channel banks. Done correctly, this could improve bank stability and positively affect channel shading and riparian vegetation structural and species diversity.
- Explore locally feasible options for increasing survival rates for first two to three growing seasons, particularly east of the Cascades.

- Ensure that CREP landowners include some structural and species diversity in the planting mix; similarly ensure that landowners use recommended plant species that are appropriate for the region and for different micro-topographies (floodplain, channel banks, upper terrace, etc.) and that planting occurs in appropriate seasons.
- Ensure that planting densities are appropriate for the sites for all vegetation layers to allow for within-site structural variation, with some areas dominated by shrubs and others by trees, and yet others by native forbs and grasses and grass-like species.
- Plant trees and shrubs to allow for canopy gaps to support understory and ground cover vegetation.
- Monitor for and treat invasive plants throughout the life of the CREP contract.
- Consider additional methods to encourage CREP landowners to install and maintain effective exclosure fencing.
- Develop a formal mentoring program so that experienced CREP technicians can share lessons learned with new technicians.
- Discuss findings of this study in existing interagency forums such as the CORE Partnership.
- Consider monitoring newly implemented sites in 10–15 years or implement Tier 3, a Before-After-Control-Impact (BACI) study, to track newly implemented CREP projects for 10–15 years.

6 ACKNOWLEDGEMENTS

We are grateful for the thoughtful guidance provided by the OWEB project manager and other personnel, as well as the time and insights given by other members of the Advisory Group in developing and implementing these protocols for this project. Many dedicated CREP technicians and FSA and NRCS representatives from around the state contributed useful information from the CREP contracts and critical advice in locating appropriate treatment and control sites. We wish to thank the many technicians and landowners that took the time to meet us in the field and guide us to the CREP sites. Finally, we acknowledge Sitka Technology Group and Cascade Environmental Group, who were instrumental in successfully implementing this project.

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Appendices

Appendix A

Conservation Reserve Program: Conservation Practices

FACT SHEET

UNITED STATES DEPARTMENT OF AGRICULTURE
FARM SERVICE AGENCY

Revised December 2013

Conservation Reserve Enhancement Program - Oregon State

Overview

USDA's Farm Service Agency (FSA), Commodity Credit Corporation (CCC) and the state of Oregon are jointly implementing a voluntary Conservation Reserve Enhancement Program (CREP) to protect environmentally sensitive land along streams and other water bodies. The original agreement was signed in 1998 and is viewed as a community-based, results oriented effort based on local participation and a unique partnership between agricultural land owners, the state and federal government and, in some cases, municipalities.

Oregon's CREP addresses high-priority conservation issues of both local and national significance, such as impacts to water quality, loss of critical habitat for threatened and endangered wildlife species, soil erosion and reduced habitat for fish populations such as the nine salmon and two trout species listed under the Federal Endangered Species Act.

Program Goals

Goals of the Oregon CREP are:

- Reducing water temperature to natural levels;
- Reducing the sediment and nutrient pollution from agricultural land adjacent to streams;
- Restoring stream bank vegetation to a properly functioning condition and;
- Stabilizing stream banks to normal non-flood conditions.

Program Authorizations

The Oregon CREP is authorized to enroll up to 100,000 acres including forested riparian buffers, filter strips, restored wetlands and herbaceous wildlife buffers.

Program Responsibilities

Under this agreement CCC provides a signing incentive payment equaling 50 percent of the cost of establishing conservation practices plus a practice incentive payment, an annual rental rate, an annual maintenance payment when applicable under national policy and a portion of the technical assistance cost.

The state of Oregon will pay 25 percent of the cost of establishing conservation practices, all the costs of monitoring requirements and a portion of the technical assistance costs.

Payments and Incentives

Annual rental payments will be based on the soil rental rate for cropland acres and a county-based rental rate for marginal pastureland. Rates for irrigated land may be paid on the condition that the participant also signs an agreement with the state to lease irrigation rights on the contract acreage under an in-stream use for the length of the contract.

In addition to annual rental rates and, under certain practices, maintenance payments, CCC will make annual incentive payments at the following rates:

- For filter strips, 25 percent of the normal rental rate;
- For riparian buffers and wetland restoration, 50 percent of the normal rental rate.

In any case in which more than 50 percent of the land along a five-mile stream segment is enrolled, producers will receive a one-time cumulative impact incentive payment of four times the basic annual rental rate.

Eligible Practices

For Oregon's CREP eligible practices are:

- CP21 (Filter Strip);
- CP22 (Forested Riparian Buffer);
- CP23 (Wetland Restoration);
- CP29 (Marginal Pastureland Wildlife Habitat Buffer) and;
- CP30 (Marginal Pastureland Wetland Buffer).

Eligibility

Eligible land includes those acres along a stream (or wetland) with a historic presence of a salmonid species or in areas covered by Oregon's Water Quality Management Plans. In addition to offering eligible acreage along seasonal or perennial streams or hydrologically connected wetlands the applicant must satisfy the basic eligibility requirement for the Conservation Reserve Program (CRP).

Land must be cropland that has been planted or considered planted four of the six crop years 2002 through 2007 and must be physically and legally capable of being cropped. Marginal pastureland also is eligible to be enrolled as long as it is suitable for the selected practice.

Producers are eligible if the land has been owned or operated by the applicant for at least one year prior to enrollment. Land with an existing CRP contract or an approved offer with a contract pending are not eligible for CREP until that contract expires.

Oregon CREP enrollment is on a continuous basis and interested applicants can sign up at the local USDA Service Center.

More Information

Additional information about CREP is available at the Oregon State FSA Office and on the FSA website at www.fsa.usda.gov/.

Conservation Reserve Program

CP-22

RIPARIAN BUFFER

Water Quality Enhancement | Wildlife Habitat Enhancement | Carbon Sequestration

Why Choose CRP? You Benefit. Land, Water and Wildlife Benefit.

Riparian tree buffers improve water quality and provide vital habitat for wildlife. The Conservation Reserve Program (CRP) provides farmers and landowners with practices like this to achieve many farming and conservation goals. Whatever the conservation challenge - soil conservation, water quality protection, or wildlife habitat enhancement - CRP is a proven land performance and management solution.

Why Riparian Buffers?

For farmers and landowners interested in improving water quality and creating habitat for fish and wildlife, a riparian buffer - a strip of trees bordering perennial or seasonal streams, waterbodies and wetlands areas - is a beneficial solution. Offered in **continuous sign-up**, CP-22:

- Filters nutrients from runoff
- Traps sediment
- Cools water temperatures
- Stabilizes stream banks
- Sequesters Carbon

Financial Benefits

CP-22 participants are guaranteed:

- 10-15 years of annual rental payments with an additional 20% Rental Rate Incentive
- Payments covering up to 90% of the eligible costs of establishing the practice
  - 50% from a Cost-Share Payment and
  - 40% from a Practice Incentive Payment (PIP)
- Sign-up Incentive Payment (SIP) up to $100/acre
- Maintenance Rate Incentive
- Mid-Contract Management Cost Share
- Additional incentives may be available in your state under the Conservation Reserve Enhancement Program (CREP)

Photo courtesy of Benjamin Longstaff, Integration and Applications Network, UMCES

CP-22

Eligible Land

- Suitable for planting trees
- Compliant with USDA's highly erodible land and wetland provisions
- Planted or considered planted 4 out of 6 years between 2008 and 2013 or meets marginal pastureland eligibility requirements
- Located immediately adjacent to and parallel to one of the following:
  - Permanent water body
  - Perennial or seasonal stream
  - Sinkhole or karst area
  - Semi-permanent or seasonally flooded area
  - Wetlands

Practice Requirements

- Not be less than 35' and not more 100' (or 30% of the floodplain unless under certain circumstances)
- Begin at the top of the stream bank
- Consist of naturally regenerated seeded or planted trees and shrubs suitable for the site

For More Information:
Contact your local USDA, Farm Service Agency:
http://offices.usda.gov

Owner/Operator Eligibility

Participants must:

- Have owned or operated the land for more than 12 months prior to program sign-up
- Be in control of the land for the length of the contract
- Meet USDA payment eligibility provisions

Obligations

Participants will:

- Not harvest or graze the practice area
- Work with USDA-approved conservationist to develop a conservation plan
- Perform periodic management activities according to the conservation plan
- Complete seeding/planting of the practice within 12 months of the effective date of the contract

Proven Conservation Benefits

- An acre of buffer adjacent to cropland holds back 2.5 tons of soil, 6.4 pounds of nitrogen, and 1.1 pounds of phosphorus in runoff
- In 2014, CRP lowered greenhouse gas emissions by the equivalent of 43 million metric tons of CO_2 - the same benefits as taking nearly 8 million cars off the road for a year

FSA will ultimately determine participant and land eligibility.

Photo courtesy of VA, FSA and PA, FSA respectively

Conservation Reserve Program

CP-29

MARGINAL PASTURELAND WILDLIFE BUFFERS

Wildlife Habitat | Soil and Water Quality | Flood Control

Why Choose CRP? You Benefit. Land, Water and Wildlife Benefit.

Grass buffers bordering waterbodies play a critical role in enhancing water quality and restoring wildlife habitat. The Conservation Reserve Program (CRP) provides farmers and landowners with practices like this to achieve many farming and conservation goals. Whatever the conservation challenge – soil conservation, water quality protection, or wildlife habitat enhancement – CRP is a proven land performance and management solution.

Why Wildlife Buffers?

For landowners and farmers with marginal pastureland adjacent to streams, wetlands, and other water body types, creating Wildlife Habitat Buffers reduces sediment, nutrient, and pesticide runoff. They also restore native plant communities that stabilize stream banks and reduce erosion. Made up of native grasses, wildflowers or shrubs, Wildlife Habitat Buffers provide shelter and food for wildlife, as well as vital nutrition for pollinators and other beneficial insects. Offered in **continuous sign-up**, CP-29:

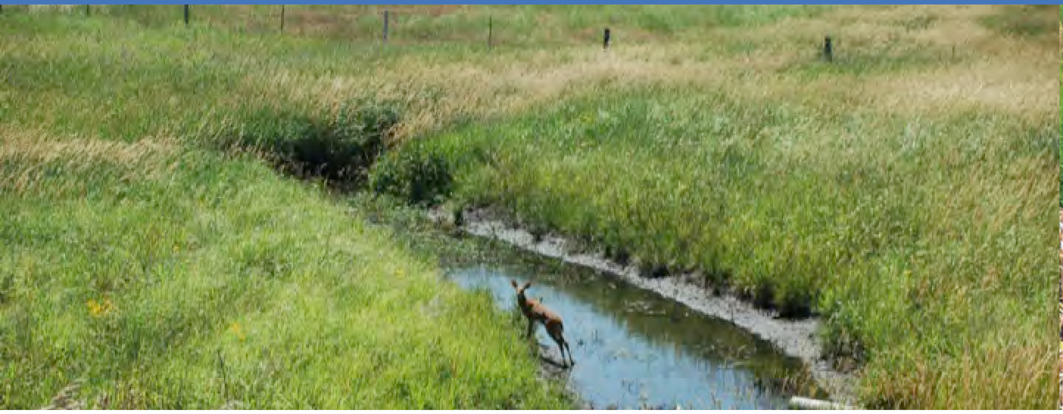
- Improves water quality by intercepting and filtering sediment and nutrient runoff
- Provides vital habitat for wildfowl, grassland birds, pollinators and other wetland species
- Protects soil

Financial Benefits

CP-29 participants are guaranteed:

- 10-15 years of annual rental payments with an additional 20% Rental Rate Incentive
- Payments covering up to 90% of the eligible costs of establishing the buffer practice
  - 50% from a Cost-Share Payment and
  - 40% from a Practice Incentive Payment (PIP)
- Sign-up Incentive Payment (SIP) up to $100/acre
- Maintenance Rate Incentive
- Mid-Contract Management Cost Share
- Additional incentives may be available in your state under the Conservation Reserve Enhancement Program (CREP)

CP-29



Eligible Land

- Meets marginal pastureland eligibility requirements and is immediately adjacent to and parallel to one of the following:
  - Permanent waterbody
  - Perennial or seasonal stream
  - Sinkhole or karst area
  - Semi-permanent or seasonally flooded area
  - Wetlands
- Suitable to be devoted to a wildlife habitat buffer
- Compliant with USDA's highly erodible land and wetland provisions

Practice Requirements

- Buffer will not be less than 20' and not more 120' in width
- Buffer will begin at the top of the stream bank
- Shall consist of naturally regenerated or seeded, planted trees, and shrubs suitable for the site
- Noxious weeds and other undesirable plants, insects, and pests shall be controlled

Owner/Operator Eligibility

Participants must:

- Have owned or operated the land for more than 12 months prior to program sign-up
- Be in control of the land for the length of the contract
- Meet USDA payment eligibility provisions

Obligations

Participants will:

- Not harvest or graze the practice area
- Work with USDA-approved conservationist to develop a conservation plan
- Perform periodic management activities on the wetland and buffer according to the provided conservation plan
- Complete seeding of the practice within 12 months of the effective date of the contract

Proven Conservation Benefits

- An acre of buffer adjacent to cropland holds back 2.5 tons of soil, 6.4 pounds of nitrogen, and 1.1 pounds of phosphorus in runoff
- In 2014, CRP lowered greenhouse gas emissions by the equivalent of 43 million metric tons of CO_2 - the same benefits as taking nearly 8 million cars off the road for a year
- In prime habitat, a 4% increase in CRP vegetation is associated with a 22% increase in pheasant counts

FSA will ultimately determine participant and land eligibility.

For More Information:
Contact your local USDA, Farm Service Agency:
http://offices.usda.gov

Photos provided by Iowa Dep.t of Agriculture-Div of Soil Conservation, NRCS Bob Nichols and Pheasants Forever Peter Berthelsen respectively

Appendix B

Statistical Results by Site

Table B-1. West CP 22.

Test	Site		Mean value of metric				
	treatment	control	treatment	control	t-statistic	p-value[1]	significance
1	T1	C1	0.20	0.10	0.60	0.28	
	T2	C1	0.00	0.10	-1.00	0.83	
	T3	C2	1.00	NA	NA	NA	
	T4	C2	0.80	1.00	-1.00	0.81	
	T5	C3	0.20	0.80	-2.12	0.97	
	T6	C3	0.80	0.80	0.00	0.50	
	T7	C3	1.00	0.80	1.00	0.19	
	T8	C4	0.40	0.20	0.77	0.23	
	T9	C5	0.40	0.00	1.63	0.089	.
	T10	C5	NA	NA	NA	NA	
2	T1	C1	3.0	5.8	-0.44	0.67	
	T2	C1	0.0	5.8	-1.00	0.83	
	T3	C2	45.3	30.0	1.03	0.17	
	T4	C2	41.5	30.0	0.56	0.30	
	T5	C3	1.0	24.5	-1.44	0.89	
	T6	C3	12.0	24.5	-0.73	0.75	
	T7	C3	38.0	24.5	0.74	0.24	
	T8	C4	2.0	1.0	0.77	0.23	
	T9	C5	2.0	1.0	0.63	0.27	
	T10	C5	21.0	1.0	4.85	0.084	.
3	T1	C1	96.0	85.5	1.25	0.11	
	T2	C1	81.0	85.5	-0.46	0.67	
	T3	C2	92.5	86.5	0.92	0.20	
	T4	C2	82.5	86.5	-0.31	0.61	
	T5	C3	21.0	74.0	-3.61	0.99	
	T6	C3	58.5	74.0	-0.84	0.79	
	T7	C3	67.0	74.0	-0.34	0.63	
	T8	C4	69.3	28.0	4.11	9.E-04	***
	T9	C5	18.5	26.5	-0.57	0.71	
	T10	C5	78.5	26.5	4.61	0.084	.

Test	Site		Mean value of metric				
	treatment	control	treatment	control	t-statistic	p-value[1]	significance
4	T1	C1	101.3	94.8	0.76	0.23	
	T2	C1	99.5	94.8	0.65	0.27	
	T3	C2	102.0	72.0	2.35	0.031	*
	T4	C2	76.0	72.0	0.27	0.40	
	T5	C3	88.0	95.0	-0.58	0.71	
	T6	C3	78.0	95.0	-1.15	0.86	
	T7	C3	81.5	95.0	-0.85	0.79	
	T8	C4	100.3	98.5	0.20	0.42	
	T9	C5	94.0	78.0	1.16	0.15	
	T10	C5	85.5	78.0	0.59	0.29	
5	T1	C1	1.10	1.15	-0.07	0.53	
	T2	C1	9.65	1.15	6.60	2.E-07	***
	T3	C2	7.75	3.75	2.21	0.017	*
	T4	C2	5.55	3.75	1.30	0.10	
	T5	C3	3.90	15.00	-9.53	1.00	
	T6	C3	1.15	15.00	-21.18	1.00	
	T7	C3	6.75	15.00	-5.86	1.00	
	T8	C4	9.15	16.75	-5.03	1.00	
	T9	C5	0.00	0.00	NA	NA	
	T10	C5	0.35	0.00	1.32	0.10	
6	T1	C1	53.8	37.8	1.58	0.066	.
	T2	C1	6.0	37.8	-4.12	1.00	
	T3	C2	87.5	40.8	3.37	0.004	**
	T4	C2	26.3	40.8	-0.80	0.78	
	T5	C3	20.0	25.5	-0.42	0.66	
	T6	C3	22.3	25.5	-0.26	0.60	
	T7	C3	28.3	25.5	0.19	0.43	
	T8	C4	26.3	5.0	4.08	4.E-04	***
	T9	C5	9.3	13.8	-0.53	0.70	
	T10	C5	37.8	13.8	1.67	0.060	.

Test	Site		Mean value of metric				
	treatment	control	treatment	control	t-statistic	p-value[1]	significance
9	T1	C1	44.3	57.0	-1.32	0.90	
	T2	C1	40.8	57.0	-1.06	0.85	
	T3	C2	15.0	2.5	3.64	0.002	**
	T4	C2	21.0	2.5	1.63	0.069	•
	T5	C3	29.5	22.0	0.49	0.32	
	T6	C3	10.5	22.0	-1.12	0.86	
	T7	C3	15.8	22.0	-0.56	0.71	
	T8	C4	75.5	40.8	2.36	0.019	*
	T9	C5	37.8	25.3	0.76	0.23	
	T10	C5	8.0	25.3	-1.60	0.93	
10	T1	C1	27.5	34.8	-0.97	0.83	
	T2	C1	0.0	34.8	-7.00	1.00	
	T3	C2	0.0	14.0	-1.83	0.95	
	T4	C2	6.0	14.0	-0.96	0.82	
	T5	C3	1.0	11.8	-1.78	0.95	
	T6	C3	2.0	11.8	-1.61	0.93	
	T7	C3	6.5	11.8	-0.78	0.77	
	T8	C4	6.0	0.0	2.71	0.012	*
	T9	C5	11.3	13.3	-0.23	0.59	
	T10	C5	19.0	13.3	0.60	0.28	
11	T1	C1	2.5	2.0	0.43	0.34	
	T2	C1	4.5	2.0	0.98	0.17	
	T3	C2	15.0	3.0	2.88	0.005	**
	T4	C2	1.5	3.0	-0.57	0.71	
	T5	C3	2.5	14.8	-1.40	0.90	
	T6	C3	4.5	14.8	-1.14	0.86	
	T7	C3	9.8	14.8	-0.48	0.68	
	T8	C4	4.5	1.0	4.20	3.E-04	***
	T9	C5	9.8	1.0	1.01	0.17	
	T10	C5	1.5	1.0	0.49	0.31	

Test	Site		Mean value of metric				
	treatment	control	treatment	control	t-statistic	p-value[1]	significance
12	T1	C1	3.88	3.04	3.43	9.E-04	***
	T2	C1	4.00	3.04	4.15	2.E-04	***
	T3	C2	3.44	3.70	-1.49	0.93	
	T4	C2	3.90	3.70	1.61	0.056	•
	T5	C3	2.13	3.20	-4.63	1.00	
	T6	C3	2.95	3.20	-1.11	0.86	
	T7	C3	2.93	3.20	-1.35	0.91	
	T8	C4	3.35	1.63	12.37	8.E-18	***
	T9	C5	2.50	1.48	5.32	6.E-07	***
	T10	C5	4.00	1.48	22.31	4.E-24	***
15	T1	C1	69.5	64.0	0.30	0.39	
	T2	C1	81.5	64.0	0.97	0.19	
	T3	C2	2.0	48.5	-2.50	0.97	
	T4	C2	12.5	48.5	-1.66	0.93	
	T5	C3	81.5	50.5	2.35	0.029	*
	T6	C3	31.0	50.5	-0.92	0.81	
	T7	C3	45.5	50.5	-0.26	0.60	
	T8	C4	71.0	70.0	0.04	0.48	
	T9	C5	30.0	38.0	-0.56	0.70	
	T10	C5	22.5	38.0	-1.20	0.87	
16	T1	C1	27.5	12.5	1.06	0.16	
	T2	C1	3.0	12.5	-0.84	0.78	
	T3	C2	87.5	41.0	2.39	0.037	*
	T4	C2	81.5	41.0	1.99	0.053	•
	T5	C3	8.0	29.0	-1.11	0.84	
	T6	C3	62.5	29.0	1.40	0.10	
	T7	C3	27.5	29.0	-0.06	0.52	
	T8	C4	20.5	17.5	0.12	0.45	
	T9	C5	69.0	21.0	3.67	0.008	**
	T10	C5	69.0	21.0	3.67	0.008	**

Test	Site		Mean value of metric				
	treatment	control	treatment	control	t-statistic	p-value[1]	significance
17	T1	C1	20.0	0.0	4.00	0.008	**
	T2	C1	9.0	0.0	2.25	0.044	*
	T3	C2	1.0	1.0	0.00	0.50	
	T4	C2	17.5	1.0	0.94	0.20	
	T5	C3	3.0	18.5	-0.89	0.79	
	T6	C3	3.0	18.5	-0.89	0.79	
	T7	C3	22.5	18.5	0.17	0.44	
	T8	C4	3.0	1.0	1.26	0.12	
	T9	C5	0.0	3.0	-2.45	0.96	
	T10	C5	2.0	3.0	-0.58	0.71	
18	T1	C1	10.0	12.5	-0.19	0.57	
	T2	C1	0.0	12.5	-1.11	0.83	
	T3	C2	0.0	7.0	-1.51	0.90	
	T4	C2	36.0	7.0	1.74	0.074	•
	T5	C3	3.0	18.5	-0.89	0.79	
	T6	C3	2.0	18.5	-0.95	0.80	
	T7	C3	23.5	18.5	0.21	0.42	
	T8	C4	1.0	0.0	1.00	0.19	
	T9	C5	63.0	16.0	3.65	0.006	**
	T10	C5	17.0	16.0	0.13	0.45	

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; • $p < 0.10$

[1] Significant results highlighted in gray.

Table B-2. East CP 22.

Test	Site		Mean value of metric				
	treatment	control	treatment	control	t-statistic	p-value[1]	significance
1	T11	C6	0.20	0.00	1.50	0.084	•
	T12	C6	0.30	0.00	1.96	0.041	*
	T13	C7	0.80	0.10	4.20	3.E-04	***
	T14	C8	0.70	0.80	-0.49	0.69	
	T15	C8	0.90	0.80	0.60	0.28	
	T16	C9	0.20	0.00	1.50	0.084	•
	T17	C9	0.20	0.00	1.50	0.084	•
	T18	C9	0.00	0.00	NA	NA	
	T19	C9	0.20	0.00	1.00	0.19	
	T20	C10	0.40	0.00	1.63	0.089	•

Test	Site		Mean value of metric				
	treatment	control	treatment	control	t-statistic	p-value[1]	significance
2	T11	C6	1.0	0.0	1.50	0.084	.
	T12	C6	1.5	0.0	1.96	0.041	*
	T13	C7	25.8	2.5	2.90	0.084	.
	T14	C8	23.3	8.0	1.78	0.051	.
	T15	C8	27.0	8.0	2.90	0.084	.
	T16	C9	3.0	0.0	1.20	0.13	
	T17	C9	8.3	0.0	1.37	0.10	
	T18	C9	0.0	0.0	NA	NA	
	T19	C9	5.0	0.0	1.00	0.19	
	T20	C10	16.5	0.0	1.46	0.11	
3	T11	C6	63.8	41.8	2.17	0.022	*
	T12	C6	67.5	41.8	2.27	0.018	*
	T13	C7	80.8	21.5	5.54	2.E-05	***
	T14	C8	62.3	51.0	0.95	0.18	
	T15	C8	67.8	51.0	2.42	0.013	*
	T16	C9	93.5	36.5	5.81	9.E-06	***
	T17	C9	24.3	36.5	-1.40	0.91	
	T18	C9	60.3	36.5	2.81	0.006	**
	T19	C9	73.0	36.5	2.68	0.017	*
	T20	C10	66.5	38.5	1.10	0.15	
4	T11	C6	100.3	92.5	1.15	0.13	
	T12	C6	80.0	92.5	-1.20	0.88	
	T13	C7	77.5	77.3	0.03	0.49	
	T14	C8	68.5	83.8	-1.96	0.97	
	T15	C8	88.5	83.8	0.84	0.21	
	T16	C9	102.8	85.0	3.36	0.002	**
	T17	C9	80.3	85.0	-0.48	0.68	
	T18	C9	87.5	85.0	0.81	0.22	
	T19	C9	91.5	85.0	1.05	0.16	
	T20	C10	103.0	108.5	-0.35	0.63	

Test	Site		Mean value of metric				
	treatment	**control**	**treatment**	**control**	**t-statistic**	**p-value[1]**	**significance**
5	T11	C6	14.05	2.60	6.99	2.E-08	***
	T12	C6	8.10	2.60	2.80	0.004	**
	T13	C7	16.00	8.40	4.51	1.E-04	***
	T14	C8	8.60	11.60	-1.80	0.96	
	T15	C8	12.60	11.60	0.64	0.26	
	T16	C9	12.05	2.00	5.86	8.E-07	***
	T17	C9	3.65	2.00	1.14	0.13	
	T18	C9	5.80	2.00	2.13	0.021	*
	T19	C9	10.00	2.00	4.96	1.E-05	***
	T20	C10	0.00	0.00	NA	NA	
6	T11	C6	59.0	38.8	1.68	0.057	•
	T12	C6	64.0	38.8	2.20	0.021	*
	T13	C7	57.0	4.0	7.54	5.E-06	***
	T14	C8	52.5	44.5	0.75	0.23	
	T15	C8	47.5	44.5	0.35	0.37	
	T16	C9	33.8	0.0	4.12	0.001	**
	T17	C9	15.5	0.0	3.97	0.002	**
	T18	C9	0.0	0.0	NA	NA	
	T19	C9	5.0	0.0	1.50	0.084	•
	T20	C10	22.8	10.5	1.10	0.15	
9	T11	C6	46.5	57.3	-1.01	0.83	
	T12	C6	27.5	57.3	-4.07	1.00	
	T13	C7	37.3	78.5	-4.86	1.00	
	T14	C8	37.8	54.0	-1.81	0.96	
	T15	C8	50.8	54.0	-0.38	0.65	
	T16	C9	69.0	84.5	-1.76	0.95	
	T17	C9	69.8	84.5	-1.56	0.93	
	T18	C9	87.5	84.5	1.00	0.17	
	T19	C9	40.8	84.5	-3.08	0.99	
	T20	C10	28.8	43.8	-0.86	0.80	

Test	Site		Mean value of metric				
	treatment	control	treatment	control	t-statistic	p-value[1]	significance
10	T11	C6	0.0	0.0	NA	NA	
	T12	C6	0.0	0.0	NA	NA	
	T13	C7	0.0	0.0	NA	NA	
	T14	C8	0.5	0.0	1.00	0.17	
	T15	C8	0.0	0.0	NA	NA	
	T16	C9	0.0	0.0	NA	NA	
	T17	C9	2.5	0.0	1.00	0.17	
	T18	C9	0.0	0.0	NA	NA	
	T19	C9	0.0	0.0	NA	NA	
	T20	C10	0.5	0.0	1.00	0.17	
11	T11	C6	4.0	7.0	-1.42	0.91	
	T12	C6	2.0	7.0	-2.31	0.98	
	T13	C7	14.0	16.3	-0.34	0.63	
	T14	C8	2.5	18.3	-2.90	0.99	
	T15	C8	17.8	18.3	-0.06	0.53	
	T16	C9	50.3	28.3	1.91	0.037	*
	T17	C9	19.8	28.3	-0.96	0.82	
	T18	C9	27.5	28.3	-0.08	0.53	
	T19	C9	25.0	28.3	-0.25	0.60	
	T20	C10	2.5	8.5	-1.60	0.93	
12	T11	C6	3.85	4.00	-2.13	0.98	
	T12	C6	4.00	4.00	NA	NA	
	T13	C7	2.74	2.77	-0.15	0.56	
	T14	C8	3.00	2.97	0.13	0.45	
	T15	C8	3.88	2.97	5.72	5.E-07	***
	T16	C9	4.00	3.23	3.22	0.002	**
	T17	C9	2.67	3.23	-1.65	0.95	
	T18	C9	2.67	3.23	-1.71	0.95	
	T19	C9	4.00	3.23	3.22	0.002	**
	T20	C10	3.29	3.33	-0.29	0.61	

Test	Site		Mean value of metric				
	treatment	**control**	**treatment**	**control**	**t-statistic**	**p-value[1]**	**significance**
15	T11	C6	27.5	36.5	-0.59	0.71	
	T12	C6	57.5	36.5	1.63	0.089	•
	T13	C7	75.0	75.0	0.00	0.50	
	T14	C8	44.0	87.5	-3.46	0.99	
	T15	C8	50.5	87.5	-3.15	0.98	
	T16	C9	81.5	58.5	1.21	0.14	
	T17	C9	63.0	58.5	0.21	0.42	
	T18	C9	81.5	58.5	1.21	0.14	
	T19	C9	87.5	58.5	1.61	0.092	.
	T20	C10	71.0	87.5	-1.00	0.81	
16	T11	C6	42.5	42.0	0.02	0.49	
	T12	C6	11.0	42.0	-1.57	0.91	
	T13	C7	12.5	0.0	1.11	0.17	
	T14	C8	47.0	0.0	4.48	0.006	**
	T15	C8	48.5	0.0	2.61	0.030	*
	T16	C9	0.0	0.0	NA	NA	
	T17	C9	10.0	0.0	1.63	0.089	•
	T18	C9	0.0	0.0	NA	NA	
	T19	C9	0.0	0.0	NA	NA	
	T20	C10	19.5	0.0	1.14	0.16	
17	T11	C6	2.0	1.0	0.63	0.27	
	T12	C6	1.0	1.0	0.00	0.50	
	T13	C7	27.5	1.0	3.12	0.017	*
	T14	C8	4.0	16.0	-2.12	0.95	
	T15	C8	21.5	16.0	0.46	0.33	
	T16	C9	56.5	0.0	4.04	0.008	**
	T17	C9	56.5	0.0	4.04	0.008	**
	T18	C9	46.5	0.0	3.24	0.016	*
	T19	C9	16.0	0.0	2.87	0.023	*
	T20	C10	2.0	11.0	-1.52	0.90	

Test	Site		Mean value of metric				
	treatment	control	treatment	control	t-statistic	p-value[1]	significance
18	T11	C6	0.0	0.0	NA	NA	
	T12	C6	1.0	0.0	1.00	0.19	
	T13	C7	0.0	0.0	NA	NA	
	T14	C8	5.0	0.0	1.00	0.19	
	T15	C8	0.0	0.0	NA	NA	
	T16	C9	0.0	0.0	NA	NA	
	T17	C9	0.0	0.0	NA	NA	
	T18	C9	0.0	0.0	NA	NA	
	T19	C9	0.0	0.0	NA	NA	
	T20	C10	0.0	0.0	NA	NA	

*** p < 0.001; ** p < 0.01; * p < 0.05; • p < 0.10
[1] Significant results highlighted in gray.

Table B-3. East CP 29.

Test	Site		Mean value of metric				
	treatment	control	treatment	control	t-statistic	p-value[1]	significance
1	T21	C11	0.10	0.00	1.00	0.17	
	T22	C12	0.00	0.00	NA	NA	
	T23	C13	0.00	0.00	NA	NA	
	T24	C14	0.00	0.00	NA	NA	
	T25	C15	0.00	0.00	NA	NA	
2	T21	C11	0.5	0.0	1.00	0.17	
	T22	C12	0.0	0.0	NA	NA	
	T23	C13	0.0	0.0	NA	NA	
	T24	C14	0.0	0.0	NA	NA	
	T25	C15	0.0	0.0	NA	NA	
3	T21	C11	68.0	28.8	3.55	0.001	**
	T22	C12	15.0	17.0	-0.25	0.60	
	T23	C13	18.0	14.0	0.70	0.25	
	T24	C14	2.5	1.5	0.88	0.19	
	T25	C15	15.6	23.0	-0.95	0.82	
4	T21	C11	89.5	86.3	0.52	0.31	
	T22	C12	83.8	75.5	0.61	0.28	
	T23	C13	73.5	86.0	-2.29	0.98	
	T24	C14	73.5	60.3	1.11	0.14	
	T25	C15	89.7	87.5	0.51	0.31	

Test	Site		Mean value of metric				
	treatment	control	treatment	control	t-statistic	p-value[1]	significance
5	T21	C11	14.60	7.85	3.28	0.001	**
	T22	C12	0.00	0.00	NA	NA	
	T23	C13	0.00	0.00	NA	NA	
	T24	C14	0.00	0.00	NA	NA	
	T25	C15	0.00	0.00	NA	NA	
6	T21	C11	63.0	20.5	4.08	4.E-04	***
	T22	C12	5.5	0.0	1.67	0.064	•
	T23	C13	11.0	16.5	-1.18	0.87	
	T24	C14	1.5	3.0	-1.34	0.90	
	T25	C15	26.5	0.0	4.35	9.E-04	***
9	T21	C11	41.3	69.3	-3.22	1.00	
	T22	C12	31.5	37.8	-0.35	0.64	
	T23	C13	54.0	69.5	-2.07	0.97	
	T24	C14	72.0	56.8	1.31	0.10	
	T25	C15	54.3	84.5	-3.06	0.99	
10	T21	C11	0.0	0.0	NA	NA	
	T22	C12	0.0	0.0	NA	NA	
	T23	C13	0.0	0.0	NA	NA	
	T24	C14	0.0	0.0	NA	NA	
	T25	C15	0.0	0.0	NA	NA	
11	T21	C11	3.5	6.0	-1.07	0.85	
	T22	C12	7.3	4.0	0.53	0.30	
	T23	C13	0.0	1.0	-1.50	0.92	
	T24	C14	5.0	0.0	2.12	0.031	*
	T25	C15	5.0	6.0	-0.31	0.62	
12	T21	C11	3.57	3.60	-0.21	0.58	
	T22	C12	2.48	1.43	6.42	9.E-09	***
	T23	C13	4.00	4.00	NA	NA	
	T24	C14	3.97	3.56	3.86	2.E-04	***
	T25	C15	3.77	4.00	-2.04	0.97	
15	T21	C11	75.0	75.0	0.00	0.50	
	T22	C12	50.5	69.5	-1.37	0.89	
	T23	C13	57.5	63.0	-0.47	0.67	
	T24	C14	81.5	44.5	3.71	0.003	**
	T25	C15	63.0	87.5	-2.11	0.95	

Test	Site		Mean value of metric				
	treatment	control	treatment	control	t-statistic	p-value[1]	significance
16	T21	C11	18.5	7.0	0.64	0.28	
	T22	C12	12.0	0.0	2.23	0.045	*
	T23	C13	8.0	15.0	-0.93	0.81	
	T24	C14	0.0	2.0	-1.63	0.91	
	T25	C15	17.0	0.0	3.47	0.013	*
17	T21	C11	1.0	2.0	-0.63	0.73	
	T22	C12	4.0	5.0	-1.00	0.81	
	T23	C13	0.0	0.0	NA	NA	
	T24	C14	0.0	0.0	NA	NA	
	T25	C15	1.0	5.0	-0.78	0.76	
18	T21	C11	0.0	0.0	NA	NA	
	T22	C12	0.0	0.0	NA	NA	
	T23	C13	0.0	0.0	NA	NA	
	T24	C14	1.0	0.0	1.00	0.19	
	T25	C15	0.0	0.0	NA	NA	

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; • $p < 0.10$
[1] Significant results highlighted in gray.

Appendix C

Statistical Results by Strata

Table C-1. West CB 22.

Data set	Metric	Test	Model fit		Treatment effect				
			r-squared	p	estimate	std. err.	t statistic	p-value	significance
Riparian structure	All layers present	1	0.39	2.E-08	0.12	0.09	1.35	0.18	
Riparian structure	Percent canopy	2	0.38	3.E-08	1.99	4.28	0.47	0.64	
Riparian structure	Percent understory	3	0.39	2.E-08	7.91	5.71	1.38	0.17	
Riparian structure	Percent groundcover	4	0.10	0.084	5.63	4.55	1.24	0.22	
Canopy cover	Overhead cover (densiometer)	5	0.36	5.E-27	-2.23	0.65	-3.45	6.E-04	***
Riparian structure	Percent woody	6	0.15	3.E-04	6.5	5.39	1.21	0.23	
Riparian structure	Percent herbaceous	9	0.24	1.E-07	4.28	5.16	0.83	0.41	
Riparian structure	Percent woody weed	10	0.19	1.E-05	-7.24	2.73	-2.65	0.009	**
Riparian structure	Percent herbaceous weed	11	0.03	0.51	0.76	2.18	0.35	0.73	
Bank erosion	Bank erosion	12	0.26	1.E-36	0.73	0.08	8.57	9.E-17	***
Riparian planting	Percent herbaceous	15	0.33	3.E-05	-7.86	7.44	-1.06	0.29	
Riparian planting	Percent woody	16	0.38	3.E-06	20.64	7.55	2.73	0.008	**
Riparian planting	Percent herbaceous weed	17	0.17	0.022	3.72	5.75	0.65	0.52	
Riparian planting	Percent woody weed	18	0.06	0.53	2.49	4.46	0.56	0.58	
Riparian structure	Percent bare earth[1]		0.01	3.E-01	0.75	0.76	0.98	0.33	

*** p < 0.001; ** p < 0.01; * p < 0.05; • p < 0.10
[1] Additional metric calculated to aid data interpretation.

Table C-2. East CB 22.

Data set	Metric	Test	Model fit		Treatment effect				
			r-squared	p	estimate	std. err.	t statistic	p-value	significance
Riparian structure	All layers present	1	0.40	8.E-13	0.25	0.07	3.63	4.E-04	***
Riparian structure	Percent canopy	2	0.30	7.E-09	10.85	2.6	4.18	5.E-05	***
Riparian structure	Percent understory	3	0.19	5.E-05	28.36	5.3	5.35	4.E-07	***
Riparian structure	Percent groundcover	4	0.14	0.002	-0.76	3.55	-0.21	0.83	
Canopy cover	Overhead cover (densiometer)	5	0.33	7.E-24	4.3	0.75	5.75	2.E-08	***
Riparian structure	Percent woody	6	0.45	2.E-17	19.89	4.04	4.92	2.E-06	***
Riparian structure	Percent herbaceous	9	0.26	3.E-08	-19.89	4.85	-4.10	7.E-05	***
Riparian structure	Percent woody weed	10	0.01	0.85	0.29	0.38	0.77	0.44	
Riparian structure	Percent herbaceous weed	11	0.27	1.E-08	-3.29	3.21	-1.02	0.31	
Bank erosion	Bank erosion	12	0.10	2.E-11	0.07	0.08	0.86	0.39	
Riparian planting	Percent herbaceous	15	0.25	0.001	-4.85	6.41	-0.76	0.45	
Riparian planting	Percent woody	16	0.28	3.E-04	12.66	6.19	2.04	0.045	*
Riparian planting	Percent herbaceous weed	17	0.06	0.51	0.64	0.75	0.86	0.39	
Riparian planting	Percent woody weed	18	0.34	2.E-05	13.41	5.34	2.51	0.014	*
Riparian structure	Percent bare earth[1]		0.05	4.E-03	-2.01	0.69	-2.89	0.004	**

*** p < 0.001; ** p < 0.01; * p < 0.05; • p < 0.10

[1] Additional metric calculated to aid data interpretation.

Table C-3. East CB 29.

Data set	Metric	Model fit		Treatment effect				
		r-squared	p	estimate	std. err.	t statistic	p-value	significance
Riparian structure	All layers present	0.05	0.5	0.02	0.02	1.00	0.32	
Riparian structure	Percent canopy	0.05	0.5	0.11	0.11	1.00	0.32	
Riparian structure	Percent understory	0.47	2.E-10	8.14	3.83	2.12	0.037	*
Riparian structure	Percent groundcover	0.20	0.002	2.23	3.71	0.60	0.55	
Canopy cover	Overhead cover (densiometer)	0.68	1.E-45	1.35	0.45	2.99	0.003	**
Riparian structure	Percent woody	0.51	3.E-13	13.5	3.22	4.19	6.E-05	***
Riparian structure	Percent herbaceous	0.22	3.E-04	-12.9500	5.3700	-2.41	0.018	*
Riparian structure	Percent woody weed	NA	NA	0	0	NA	NA	
Riparian structure	Percent herbaceous weed	0.07	0.24	0.75	1.54	0.49	0.63	
Bank erosion	Bank erosion	0.67	9.E-75	0.29	0.06	4.52	9.E-06	***
Riparian planting	Percent herbaceous	0.10	0.46	-2.4	6.51	-0.37	0.71	
Riparian planting	Percent woody	0.12	0.3	6.3	4.19	1.50	0.14	
Riparian planting	Percent herbaceous weed	0.10	0.43	0.2	0.2	1.00	0.32	
Riparian planting	Percent woody weed	0.22	0.049	-1.2	1.06	-1.13	0.26	
Riparian structure	Percent bare earth[1]	0.00	6.E-01	0.60	1.22	0.49	0.62	

*** p < 0.001; ** p < 0.01; * p < 0.05; • p < 0.10

[1] Additional metric calculated to aid data interpretation.

Appendix D

Statistical Results for Covariates

Table D-1. West CP 22 ANOVA.

Test	ANOVA				p-value				r-squared			
	drainclassT*	plantDensWood	plantYear2	maintMow	drainclassT	plantDensWood	plantYear2	maintMow	drainclassT*	plantDensWood	plantYear2	maintMow
1	+	-	-	-	0.012	0.33	0.06	0.79	0.10	0.01	0.06	0.00
2	+	-	-	+	0.72	0.050	0.015	0.13	0.00	0.06	0.09	0.04
3	-	-	-	-	0.008	0.021	0.045	0.85	0.11	0.08	0.06	0.00
4	-	-	-	-	0.032	0.49	0.77	0.63	0.07	0.01	0.00	0.00
5	-	-	+	-	2.E-07	9.E-08	0.000	0.79	0.13	0.13	0.13	0.00
6	-	-	-	-	0.08	0.78	0.001	0.97	0.03	0.00	0.11	0.00
9	-	+	+	-	0.003	0.65	0.001	0.07	0.08	0.00	0.10	0.03
10	+	+	-	-	0.32	0.36	0.006	0.11	0.01	0.01	0.08	0.03
11	+	-	-	+	0.60	0.30	0.47	0.27	0.00	0.01	0.01	0.01
12	-	-	-	-	0.001	2.E-06	0.000	3.E-06	0.02	0.05	0.04	0.05
15	-	-	+	-	0.047	0.52	0.000	0.84	0.08	0.01	0.24	0.00
16	+	+	-	+	0.08	0.11	0.000	0.94	0.06	0.05	0.31	0.00
17	+	+	-	+	0.016	0.30	0.08	0.38	0.12	0.02	0.06	0.02
18	-	-	+	+	0.70	0.40	0.73	0.28	0.00	0.01	0.00	0.02

* drainclassT = contributing watershed area

Table D-2. West CP 22 AIC.

Test	drainclassT*	plantDensWood	prepMow	maintMow	Covariates	AICc	Covariates	AICc	Covariates	AICc
1	1.0	6.6	3.3	7.5	prepSpray	92	plantDensWood+prepSpray	79	drainclassT+plantDensWood+prepSpray	78
2	6.0	2.2	1.7	3.8	plantYear2	597	plantDensWood+prepSpray	586	plantDensWood+prepSpray+maintMow	580
3	10.1	11.9	17.3	17.4	prepIrrigate	620	plantYear2+prepIrrigate	610	plantDensWood+plantYear2+prepIrrigate	609
4	0	1.5	0.3	1.8	drainclassT	580	drainclassT+prepIrrigate	580	drainclassT+plantDensWood+prepIrrigate	581
5	1.2	0	25.5	28.9	plantDensWood	1234	drainclassT+plantDensWood	1204	drainclassT+plantDensWood+plantYear2	1186
6	8.5	11.6	11.6	11.7	plantYear2	983	plantYear2+prepIrrigate	972	plantYear2+prepIrrigate+prepSpray	968
9	1.5	10.2	8.4	7.1	plantYear2	979	plantYear2+prepMow	974	drainclassT+plantYear2+prepIrrigate	967
10	6.8	7.0	7.7	5.3	plantYear2	816	plantYear2+maintMow	813	plantYear2+prepMow+maintMow	814
11	1.7	0.9	0.6	0.8	prepIrrigate	782	plantDensWood+prepIrrigate	782	plantDensWood+prepIrrigate+prepSpray	782
12	28.6	15.9	29.2	17.1	prepIrrigate	1093	plantYear2+prepIrrigate	1056	plantYear2+prepIrrigate+prepSpray	1035
15	9.4	13.1	13.6	13.5	plantYear2	493	plantYear2+prepSpray	490	plantDensWood+plantYear2+prepSpray	491
16	15.2	15.8	17.1	18.5	plantYear2	491	plantYear2+prepSpray	486	drainclassT+plantYear2+prepSpray	488
17	17.0	22.1	22.6	22.4	prepIrrigate	450	prepIrrigate+prepMow	450	plantYear2+prepIrrigate+prepMow	451
18	3.5	2.9	0	2.5	prepMow	433	drainclassT+prepMow	433	drainclassT+plantYear2+prepMow	435

* drainclassT = contributing watershed area

Table D-3. East CP 22 ANOVA.

	ANOVA							p-value							r-squared						
Test	**drainclassT***	**plantDensWood**	**plantYear2**	**prepSpray**	**prepMow**	**maintSpray**	**maintMow**	**drainclassT**	**plantDensWood**	**plantYear2**	**prepSpray**	**prepMow**	**maintSpray**	**maintMow**	**drainclassT**	**plantDensWood**	**plantYear2**	**prepSpray**	**prepMow**	**maintSpray**	**maintMow**
1	+	+	-	-	-	-	-	0.67	0.002	0.000	5.E-07	0.027	4.E-04	0.016	0.00	0.10	0.13	0.25	0.05	0.13	0.06
2	+	+	-	-	-	-	-	0.13	0.003	0.001	1.E-04	0.002	8.E-05	0.007	0.03	0.10	0.11	0.15	0.10	0.16	0.08
3	-	+	-	-	+	-	+	0.001	0.09	0.29	0.24	0.032	0.50	0.015	0.11	0.03	0.01	0.02	0.05	0.01	0.07
4	-	-	+	+	+	+	+	0.21	0.07	0.005	0.001	0.006	0.08	4.E-04	0.02	0.04	0.09	0.12	0.08	0.03	0.13
5	-	+	-	-	+	+	+	7.E-09	2.E-06	0.048	3.E-04	0.001	0.34	1.E-04	0.16	0.11	0.02	0.07	0.05	0.00	0.07
6	-	+	-	-	-	-	-	2.E-06	0.015	0.48	1.E-07	0.75	0.94	0.53	0.21	0.06	0.01	0.25	0.00	0.00	0.00
9	+	-	-	+	+	+	+	0.25	0.38	0.84	0.003	0.11	0.72	0.60	0.01	0.01	0.00	0.09	0.03	0.00	0.00
10	+	-	+	+	-	+	-	0.27	0.77	0.64	0.48	0.10	0.56	0.38	0.01	0.00	0.00	0.01	0.03	0.00	0.01
11	-	-	-	+	+	+	+	0.71	0.94	0.26	0.006	0.012	0.10	0.003	0.00	0.00	0.01	0.08	0.06	0.03	0.09
12	-	-	-	+	+	+	+	0.002	7.E-06	0.98	0.79	4.E-12	4.E-07	9.E-11	0.02	0.05	0.00	0.00	0.12	0.07	0.11
15	+	+	-	+	+	-	+	0.46	0.46	0.61	0.13	0.89	0.90	0.79	0.01	0.01	0.01	0.05	0.00	0.00	0.00
16	+	-	-	-	-	-	-	0.61	0.79	0.39	0.033	0.54	0.12	0.44	0.01	0.00	0.02	0.09	0.01	0.05	0.01
17	+	-	-	-	-	-	-	0.58	0.98	0.13	0.15	0.30	0.44	0.44	0.01	0.00	0.05	0.04	0.02	0.01	0.01
18	+	+	-	+	+	+	+	0.75	0.47	0.60	0.043	0.86	0.45	0.81	0.00	0.01	0.01	0.08	0.00	0.01	0.00

* drainclassT = contributing watershed area

Table D-4. East CP 22 AIC.

Test	drainclassT*	plantDensWood	plantYear2	prepSpray	prepMow	maintSpray	maintMow	Covariates	AICc	Covariates	AICc	Covariates	AICc
1	26.0	16.7	13.2	0	21.1	13.4	20.2	prepSpray	107	prepSpray+maintSpray	106	prepSpray+maintSpray+maintMow	106
2	13.7	7.0	5.3	1.0	6.2	0	8.5	maintSpray	773	prepSpray+maintSpray	768	drainclassT+plantDensWood+prepSpray	766
3	15.5	23.3	25.0	24.8	21.4	25.7	20.1	maintIrrigate	842	plantDensHerb+maintIrrigate	839	plantDensHerb+maintIrrigate+maintMow	836
4	11.4	9.6	5.0	1.2	5.4	9.9	0	maintMow	798	prepSpray+maintIrrigate	796	plantDensHerb+prepSpray+maintIrrigate	791
5	0	0	19.4	10.0	12.5	22.5	8.4	drainclassT	1328	plantDensWood+prepMow	1292	plantDensWood+prepSpray+maintMow	1277
6	5.8	23.1	28.6	0	29.0	29.1	28.7	prepSpray	952	drainclassT+prepSpray	933	plantYear2+prepSpray+maintMow	928
9	7.6	8.2	9.0	0	6.4	8.9	8.7	prepSpray	969	plantYear2+prepSpray	962	plantDensHerb+plantYear2+prepSpray	960
10	6.8	8.0	7.8	7.6	5.3	7.7	7.3	maintIrrigate	471	prepMow+maintIrrigate	472	plantDensWood+prepMow+maintIrrigate	474
11	8.8	8.9	7.6	1.1	2.4	6.1	0	maintMow	901	plantYear2+prepSpray	885	drainclassT+plantYear2+prepSpray	866
12	39.0	28.1	48.3	48.3	0	22.3	5.9	prepMow	1007	maintIrrigate+maintSpray	985	plantDensWood+maintIrrigate+maintSpray	976
15	1.8	1.8	2.1	0	2.4	2.4	2.3	prepSpray	475	plantYear2+prepSpray	473	plantDensWood+plantYear2+prepSpray	469
16	4.5	4.7	4.0	0	4.4	2.2	4.1	prepSpray	479	plantDensWood+prepSpray	479	plantDensWood+prepSpray+maintSpray	480
17	2.0	2.4	0	0.2	1.2	1.7	1.7	plantYear2	272	plantDensHerb+prepSpray	272	plantDensHerb+prepSpray+prepMow	273
18	8.3	7.9	8.2	4.1	8.4	7.8	8.4	maintIrrigate	473	plantDensHerb+prepSpray	471	plantDensHerb+plantYear2+prepSpray	458

* drainclassT = contributing watershed area

Table D-5. East CP 29 ANOVA.

Test	ANOVA		p-value		r-squared	
	plantDensHerb	plantYear2	plantDensHerb	plantYear2	plantDensHerb	plantYear2
1	+	-	0.32	0.39	0.02	0.02
2	+	-	0.32	0.39	0.02	0.02
3	+	-	4.E-05	0.09	0.33	0.07
4	+	-	0.07	0.90	0.08	0.00
5	+	-	8.E-05	6.E-05	0.15	0.15
6	+	-	0.023	0.56	0.10	0.01
9	-	+	0.001	0.49	0.22	0.01
10*						
11	+	-	0.59	0.31	0.01	0.02
12	-	+	6.E-18	1.E-06	0.38	0.14
15	-	-	0.15	0.36	0.09	0.04
16	+	+	0.23	0.77	0.06	0.00
17	-	-	0.14	0.43	0.09	0.03
18	+	-	0.004	0.20	0.31	0.07

* No woody weeds present in East CP29.

Table D-6. East CP 29 AIC.

Test	plantDensHerb	plantYear2	Covariates	AIC	Covariates	AIC	Covariates	AIC
1	2.6	2.8	plantDensWood	-40	plantDensWood+plantDensHerb	-38	plantDensWood+plantDensHerb+plantYear2	-36
2	2.6	2.8	plantDensWood	101	plantDensWood+plantDensHerb	103	plantDensWood+plantDensHerb+plantYear2	105
3	36.1	50.9	plantDensWood	369	plantDensWood+plantYear2	367	plantDensWood+plantYear2+maintMow	367
4	0	3.4	plantDensHerb	373	plantDensHerb+prepSpray	373	plantDensHerb+plantYear2+prepSpray	373
5	225.1	224.5	plantDensWood	411	plantDensWood+plantDensHerb	413	plantDensWood+plantDensHerb+plantYear2	415
6	40.6	45.7	plantDensWood	430	plantDensWood+plantYear2	423	plantDensWood+plantYear2+prepSpray	420
9	0	12.1	plantDensHerb	472	plantDensHerb+plantYear2	474	plantDensWood+plantDensHerb+maintMow	476
10*	-	-	-	-	-	-	-	-
11	2.3	1.5	prepSpray	367	prepSpray+maintMow	368	plantDensWood+prepSpray+maintMow	370
12	34.2	86.5	maintMow	290	plantDensWood+maintMow	284	plantDensHerb+prepSpray+maintMow	283
15	0.7	2.0	maintMow	229	plantYear2+maintMow	227	plantDensWood+plantYear2+maintMow	229
16	0.4	1.9	plantDensHerb	221	plantDensHerb+maintMow	222	plantDensHerb+prepSpray+maintMow	224
17	0	1.7	plantDensHerb	73	plantDensHerb+plantYear2	74	plantDensWood+plantDensHerb+plantYear2	75
18	4.7	12.2	maintMow	101	plantDensHerb+maintMow	102	plantDensHerb+prepSpray+maintMow	103

* No woody weeds present in East CP29.

Appendix E

OWEB Summary of CREP Adaptive Management

ADAPTIVE MANAGEMENT OF THE OREGON CREP PROGRAM
Oregon Watershed Enhancement Board, February 2017

Oregon and the FSA signed an agreement to create the CREP Program in Oregon in 1998. CREP practitioners have been adapting their strategies for implementing the program based on lessons learned during implementation since the inception of the program. Seasoned CREP practitioners who have experienced the evolution of the program have unique insights into what makes the overall program and individual projects successful in their areas (Gilliam, Wheeler and Wasco CREP Programs, 2016). For example, changes in tree protection materials and planting stock size have resulted in higher planting survival rates in some areas of the state.

The findings of Stillwater 2017 CREP analysis reinforce the importance of such adaptive management strategies in implementing a successful CREP Program across Oregon. Many of the recommendations that are made in the Stillwater 2017 CREP analysis have already been incorporated by the CREP technicians to improve the success and effectiveness of riparian buffers. It is important to note that this study monitored CREP projects that were implemented over seven years ago, so has not captured some of the effects of the adaptive measures that have been applied in recent years.

The CREP programs in Gilliam, Wheeler, and Wasco counties have recently drafted a document titled Eastern Oregon Conservation Reserve Enhancement Program (CREP) Adaptive Management Guidance. This document begins to share the lessons learned through their combined years of experience, and provides thoughtful guidance and suggestions to new technicians enrolling landowners in the CREP program. The document is expected to be released in the Summer or Fall of 2017 and updated annually. For more information, please contact the CREP technicians at the Gilliam, Wheeler, and Wasco SWCDs.

ADAPTIVE MANAGEMENT THEMES
Several adaptive management themes have emerged from this document and conversations with CREP technicians on the west side of the Cascades. These themes include, but are not limited to:

- species selection
- planting densities
- planting stock size
- planting location
- tree and shrub protection
- mulching
- site preparation
- livestock exclusion

A major component of implementing a successful adaptive management approach requires having experience and being familiar with the geographic, ecological and social conditions of the area. In addition, communicating with other CREP technicians in neighboring counties can help new CREP technicians learn which implementation techniques are most suitable for a particular project site. No one knows the technical and administrative side of the CREP program like long-term CREP technicians (Gilliam, Wheeler and Wasco CREP Programs, 2016). Several technical details, described below, which are derived from this document, are important to consider when working with a landowner to implement a CREP project and are related to the conclusions and recommendations listed in the following section.

Species selection

Early CREP project planting plans included prescriptions for several different species that were known to grow in Eastern Oregon. These plans included as many as 15-20 different species for one project. In these scenarios some species were suitable for the site, but many were not and consequently did not survive. This approach to developing planting plans was not successful. As adaptive management, technicians began to better understand and assess species site requirements, soils information, and representative vegetation known to occur in the system upstream or downstream. Taking this information into consideration, CREP technicians reduced the number of species in each planting plan, and plant survival greatly increased.

This approach can also be applied in western Oregon, for example, Willamette Valley (WV) ponderosa pine, cedar, and grand fir are appropriate riparian species for the west side of the Cascades if they are planted in the right areas (e.g., higher elevation locations, outer buffer edges, dry areas, etc.). WV ponderosa are very successful on west side projects due to their ability to handle wet conditions and dry conditions better than any other native conifer.

Planting Densities

Early NRCS guidance for planting densities in Eastern Oregon required 35 plants per 100 stream feet for each side of the stream to be planted. These numbers were used regardless of existing vegetation, accounting for natural regeneration or planting suitability. This resulted in overly dense projects that simply failed due to limited available resources. Technicians have learned to examine each project site carefully to understand current vegetative presence, potential natural revegetation, and area suitable to riparian plantings. This has generally reduced planting numbers by 50% for most projects. This has greatly improved plant survival and saved a significant amount of time and money.

Plant stock

Early CREP planting plans used planting stock from nurseries that were 1 year-old and in 10 cubic-inch containers. These plants were less expensive and seemed to make sense with higher densities mentioned above in the beginning of the program. Unfortunately, the smaller stock was less capable of withstanding drought conditions once planted, which resulted in lower survival rates. Technicians began requiring larger, 2-3 year-old stock, in 1 gallon containers. These larger trees required new planting methods, such as soil augers or stingers being used to ensure the plant is installed appropriately. The larger, older trees proved to be much more resilient in drought conditions and survival rates increased.

Tree and shrub protection

Through adaptive management, technicians now install woven wire cages that are 1.5 feet in diameter and 5-6 feet tall. They are anchored with two steel posts or three 3/8 inch rebar. This type of protection prevents wildlife browsing during plant establishment and allows a sufficient amount of room for the plant to expand. The mesh wire pattern allows for air flow during the hotter summer months. The steel posts/rebar used to support this type of protection offers adequate support to prevent wildlife from trampling. This method has had the greatest impact on plant survival. Knowing the area and wildlife patterns is key. In some areas of Wasco County where deer and elk predation upon trees and shrubs is low, simple mesh seedling protection tubes still do the trick. Part of the importance of installing plant protection is also removing it to allow a plant to grow freely after it has been established and is no longer at risk of impacts from wildlife broswing.

Mulching

In older CREP plantings one common method of mulching used was with long continuous woven fiber mulch mats. This method did provide an adequate reduction in competition; however, the lineal installation often forced planting farther away from the stream and into unsuitable sites. This method of mulching also resulted in plantation type plantings. Although said to be photodegradable these mats often didn't degrade rapidly enough, resulting in girdling of the installed plants. Removal of this type of mulching is also extremely labor intensive. Another method of mulch used in older CREP plantings was 1 ft. by 1 ft. individual woven mats. This mulching method reduced plant girdling and was much easier to remove; however, it did not provide a sufficient reduction in competition and resulted in fewer plants surviving. Practices have adapted to use 3 feet by 4 feet or 4 feet by 4 feet individual woven fiber mulch mats. This type of mulching provides an adequate reduction in competition and moisture retention. Plant girdling is not as common with this method and removal is much easier than with the longer continuous type. New planting methods within zone as mentioned above have eliminated the need for mulch in some situations.

Site preparation

It is now common to use intensive site preparation prior to the installation of any plants. Controlling non-desirable vegetation for a full year (or even two) prior to planting is not out of the ordinary. Where feasible, tillage and fallow are used to control weeds and annual grasses, and increase soil moisture prior to herbaceous seeding. These methods have resulted in successful herbaceous plantings, which have greatly reduced encroaching weeds and limited the amount of ongoing maintenance needed.

Livestock use exclusion

It is now a common practice to take livestock movement into consideration when planning a CREP buffer. Designing a fence so that livestock can move freely outside of these fences reduces the level of maintenance to the CREP landowner contractor and ensures proper access control. Sufficient livestock water sources are also provided when planning these types of projects, again to reduce the level of livestock pressure. If needed, other funding options are considered to better manage livestock adjacent to these projects, including increased upland water sources, cross fencing, range seeding, weed management, and technical assistance.