OREGON WATERSHED ENHANCEMENT BOARD
OWEB

SALMON RECOVERY FUNDING BOARD

OWEB-SRFB Coordinated Monitoring Program for Livestock Exclusion Projects

2012 Annual Progress Report



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TETRA TECH

OWEB-SRFB Coordinated Monitoring Program for Livestock Exclusion Projects

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Prepared by

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Abstract

Stream restoration activities are being conducted around the world in an effort to restore aquatic habitat function. With approximately a billion dollars being spent nationwide on stream restoration annually (Roni et al. 2010) and a majority of that funding spent in the Pacific Northwest, there is a need to track the effectiveness of restoration projects to assist in optimizing the limited funds available for restoration across the region. Regional coordination across monitoring programs has been sought to increase data compatibility, improve management decisions across jurisdictions, and better utilize monitoring funding and resources. Monitoring data on the effectiveness of projects provide information to project sponsors and watershed councils that can be used to improve communication about restoration approaches and improve future designs.

The Oregon Watershed Enhancement Board invested in the Coordinated Monitoring Program for Livestock Exclusions in partnership with the Washington Salmon Recovery Funding Board in 2006. Under both monitoring programs, the intent of the monitoring efforts was to test whether habitat targeted for restoration had been improved or preserved. This partnership leverages the investment of both states to increase the sample size for monitoring, while at the same time reducing costs for each agency. Data are compiled in a single database and a combined report is produced.

Field sampling indicators and techniques were adapted from the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (Peck et al. 2003). Specific protocols were developed to detect changes in habitat expected to result from project implementation. Livestock Exclusion Projects were evaluated using a Before-After-Control-Impact (BACI) experimental design (Stewart-Oaten et al. 1986). Each project was monitored before and after implementation and is scheduled to be monitored on a rotating schedule in Years 1, 3, 5, and 10. As of 2012, Year 5 data have been collected for 11 of the Livestock Exclusion Projects in the program. Landowner approval for access to the 12th project was denied in 2011, which was Year 5 for that site.

The Coordinated Monitoring Program for Livestock Exclusions is supported by an annual summary report and a web-based reporting tool. A project cost-effectiveness analysis was conducted in 2011, which included an evaluation of the Livestock Exclusion project category. The analysis is discussed in this report along with the results and discussion related to the analysis. A new statistical method, the mean difference method, was also added to the suite of statistical analyses typically performed on the data. This method evaluated the difference between mean pre-implementation and post-implementation values for each indicator in a given category. The trend analysis based on the slopes of trend lines across projects conducted in previous years was continued in 2012, and provides a good indication of how data are changing from year to year. The mean

difference analysis provides a current snapshot of conditions before and after project implementation for a given indicator. The results of the statistical analyses are described in this report.

Data from 5 years of monitoring of Livestock Exclusion Projects were evaluated for overall trends in changes for three variables: bank erosion, canopy density, and vegetation structure. Results from the 2012 analyses indicate that livestock exclusion projects are effectively decreasing bank erosion within the first 5 years after construction. No statistically significant changes were observed with canopy density and riparian vegetation structure; however, average improvements following project implementation were noted. Indications of change and observed trends need to be viewed both within the context of the project and the longer-term perspective that will be developed over the life of the monitoring program as additional monitoring events are completed.

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ACRONYMS AND ABBREVIATIONS

BACI	Before-After-Control-Impact
EMAP	Environmental Monitoring and Assessment Program
OWEB	Oregon Watershed Enhancement Board
SRFB	Washington Salmon Recovery Funding Board
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area

INTRODUCTION

Stream restoration efforts are being conducted throughout the world to enhance or restore function to aquatic systems. In the United States, approximately a billion dollars is spent on stream restoration annually (Roni et al. 2010), with the goal of improving wild Pacific salmon runs, many of which are listed under the Endangered Species Act and serve a vital role in the ecology of the Pacific Northwest. With so much money being spent on restoration, there is a need to track and improve the effectiveness of restoration projects and account for funds being allocated.

Grazing by livestock near salmon streams is considered detrimental to salmonid populations, as shown in studies in the western U.S. documenting reductions of salmonid abundance due to the effects of grazing and reduced riparian conditions (Platts 1991 as cited in Bayley and Li 2008). Rehabilitation of streams affected by livestock access often includes installation of fencing to construct exclosures. Studies have suggested that exclosures that are properly constructed and maintained are effective at protecting banks and riparian vegetation from livestock grazing and other activities; however, most of the previous studies did not include "pre-grazing" information or consider confounding factors (Bayley and Li 2008). Three advantages of increasing riparian vegetation, density, and structure within an exclosure are: 1) improved physical habitat resulting in protection from predatory birds; 2) a decrease in width:depth ratio, which results in favorable conditions for age-0 trout (Moore and Gregory 1988 as cited in Bayley and Li 2008) and is strongly associated with the quality of habitat for salmonids (Brown 1969; Crittenden 1978; and Walling and Webb 1992 as cited in Bayley and Li 2008); and 3) increased feeding opportunities due to invertebrate production (Rhodes and Hubert 1991 as cited in Bayley and Li 2008) and greater terrestrial invertebrate drift (Edwards and Huryn 1996 as cited in Bayley and Li 2008).

Investments in the construction and maintenance of exclosures have been made to improve watershed health within Oregon and across the region. The Oregon Plan strives to "conserve and restore crucial elements of natural systems that support fish, wildlife and people" with an emphasis on restoring salmon and trout throughout the state (Oregon Coastal Salmon Restoration Initiative 1997; Oregon Watershed Enhancement Board 2003). This comprehensive program works to benefit watershed health and wildlife including threatened and endangered salmonids by implementing livestock exclusion projects that improve riparian vegetation and reduce bank erosion. Improved riparian conditions benefit bird species and other wildlife that utilize the riparian corridor, and benefit water quality by reducing the influx of sediment.

The Oregon Watershed Enhancement Board (OWEB) and the Washington Salmon Recovery Funding Board (SRFB) both have the responsibility of funding watershed and salmon

habitat rehabilitation projects in their respective states. Effectiveness monitoring of these projects is critical to evaluate project performance and provide information to better inform future project designs and funding allocations. Most monitoring efforts are developed to meet the specific needs of one program instead of using a coordinated regional approach. However, a coordinated monitoring approach increases the efficiency of monitoring and results in cost savings. Comparable data collected across a region provides better information to aid resource managers in making decisions regarding listed salmon species, many of which range across state lines. With that in mind, OWEB and SRFB developed the Coordinated Monitoring Program for Livestock Exclusion Projects to combine efforts across state jurisdictions and produce coordinated data from a regional perspective in 2006, and the program has continued through 2012.

The Coordinated Monitoring Program for Livestock Exclusions is currently focused on one of the categories, Livestock Exclusion Projects, in both Oregon and Washington. Livestock exclusion projects were selected for the OWEB-SRFB Coordinated Monitoring Program for Livestock Exclusions because: 1) there was a need in Washington to increase the number of livestock exclusion projects monitored so that data analysis could be improved by increasing sample size, 2) there was a need in Oregon to monitor a sub-sample of the large number of livestock exclusion projects implemented, and 3) there has been significant investment by both states in livestock exclusion projects. Livestock exclusion projects are monitored in both Oregon and Washington, and the funding for monitoring and reporting was provided jointly by both states. These data have been combined for analysis in this report, resulting in a regional representation of the effectiveness of this project type. This coordination has resulted in a larger sample size, allowing for more robust data analysis at a reduced cost to both states.

The objectives of livestock exclusion rehabilitation projects are to exclude livestock from riparian areas where the animals can cause significant damage to the stream (e.g., by breaking down streambanks, increasing sedimentation, and damaging shade-producing trees and shrubs), and to allow or enhance recovery where damage has occurred. By excluding livestock, adverse impacts can be avoided and natural recovery of vegetation can take place (Crawford 2011). In some instances, damage recovery can be accelerated by planting riparian vegetation rather than waiting for natural recovery. Determination of the success and cost effectiveness of these projects requires a monitoring program that provides quantitative measures of success. The monitoring goal is to determine whether livestock exclusion projects are effective at excluding livestock, restoring riparian vegetation, and restoring stream bank stability. These parameters are measured over multiple years and compared to change in a control site to determine if project actions are improving conditions at the site (i.e., if the project is effective). Changes are compared to

defined success criteria over a specified time period to determine if the project category is successful.

This report summarizes monitoring and data analysis efforts for the program and includes site-specific summaries for each project monitored. Included is a brief description of data collection methods, data analysis, results, cost-effectiveness analysis, and recommendations for future monitoring and reporting. Initial response trends for some indicators have been detected using up to 5 years of post-project implementation data, but for other indicators it will take longer to detect changes.

METHODS

Field Methods

The OWEB-SRFB Coordinated Monitoring Program for Livestock Exclusion Projects uses field sampling indicators and techniques that were adapted from U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (Lazorchak et al. 1998; Peck et al. 2003) and from Oregon Department of Fish and Wildlife's Methods for Stream Habitat Surveys (Moore et al. 2008) for measuring erosion. Livestock exclusion projects are evaluated using a Before-After-Control-Impact (BACI) experimental design (Stewart-Oaten et al. 1986). Each project is monitored before implementation (Year 0) and after implementation on a rotating schedule (Years 1, 3, 5, and 10). The detailed protocol used to monitor these projects is available in Crawford (2011) and can be found on the Washington Habitat Work Schedule (2012) under Monitoring Protocols 2011. The protocol includes goals and objectives for the monitoring category, success criteria, detailed field data collection descriptions, functional assessment methods, summary statistics, and data analysis procedures.

Projects were selected from those that had been funded by OWEB and SRFB but had not yet been implemented for the given baseline sampling year. Once livestock exclusion projects were identified, suitable control reaches were identified for each site. Grantees and project sponsors provided valuable information and assistance in determining potential control sites for the BACI design. These reaches were often on adjacent properties and permission to access the control site over time was also gained prior to or during this initial contact. Potential control sites were examined and it was determined in the field if they were suitable. Use of a control reach helps manage environmental variation and isolate the effects of the project from variability due to flow differences between sample years. Sites selected for monitoring are shown in Figure 1.

Field data were recorded using Trimble® GeoExplorer Global Positioning System units. Electronic field forms for each monitoring task were built in either Visual CE® or Microsoft Excel® software. Monitoring data collected at each site included a functional assessment of

Figure 1. Livestock Exclusion Project Locations

the exclusion, including noting signs of livestock presence within the exclusion zone, riparian vegetation structure, shading, and bank erosion in both control and impact reaches. Field data were downloaded to field laptops and sent to a permanent centralized database. Summary statistics were then developed for each project site and are included in the project-specific summaries in Appendix A. Livestock Exclusion Projects as a category were also analyzed to determine mean percent change in each indicator over baseline, average changes between pre and post-project conditions, and trends over time.

Data Analysis Methods

The goal of this data analysis was to evaluate the success of each category as a unit. Table 1 lists the projects included in the analysis and the number of years for which post-implementation data have been collected. This report evaluates regional trends through time, including all of the post-implementation data, and the average difference between mean pre-implementation and post-implementation conditions.

Table 1. Livestock Exclusion Projects Included in Data Analysis

Project Number	Project Name	Years of Post-Implementation Data
02-1498	SRFB: Abernathy Creek Riparian Restoration	Years 1, 3, and 5
04-1655	SRFB: Hoy Riparian Restoration	Years 1, 3, and 5
04-1698	SRFB: Vance Creek Riparian Planting and Fencing	Years 1, 3, and 5
05-1447	SRFB: Indian Creek Yates Restoration	Years 1, 3, and 5
05-1547	SRFB: Rauth Coweeman Tributary Restoration	Years 1, 3, and 5
206-095	OWEB: Jordan Creek	Years 1, 3, and 5
206-072	OWEB: Gray Creek	Years 1, 3, and 5
206-283	OWEB: Noble Creek/Maria Gulch	Years 1 and 3*
206-283	OWEB: Johnson Creek	Years 1, 3, and 5
206-357	OWEB: Malheur	Years 1, 3, and 5
205-060	OWEB: Bottle Creek	Years 1, 3, and 5
205-060	OWEB: North Fork Clark	Years 1, 3, and 5

*Access to this site was denied in 2011.

Analyses performed for each monitoring category fall under two methods: those that use decision criteria and those that use statistical tests. Decision criteria were applied to the projects in Table 1 to determine project effectiveness for each monitoring category using several indicators (Table 2).

Table 2. Indicators Monitored for Livestock Exclusion Projects

Monitoring Category	Indicators Monitored
Livestock Exclusion Projects	• Functional assessment of exclusion • Linear proportion of actively eroding banks • Proportion of the reach with three-layer riparian vegetation • Mean canopy density along the banks

The decision criteria were based on the objectives established for the monitoring category and comprised two components: 1) decision criteria that are specific to the monitoring category and the type of project design; and 2) an evaluation of the percent change in the mean difference between impact reaches and control reaches. Decision criteria for each indicator were defined in the protocols used to monitor the projects (Crawford 2011) and are listed in Table 3.

Table 3. Decision Criteria and Summary Statistics for Livestock Exclusion Projects

Monitoring Parameter	Variable	Unit	Test Type	Decision Criteria
Functional Exclusion	The number of livestock exclusions meeting the design criteria for excluding livestock from the stream	#	None. Count of functional exclusions	≥ 80% of exclusions are functional through Year 10. "Functional" means there are no holes in the fencing and no recent signs of livestock inside the exclusion.
Riparian Condition	Actively eroding banks (linear proportion of reach)	%	t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% decrease between Impact and control by Year 10
	Densiometer Reading Mean canopy density at the bank	1-17 score	t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% increase between impact and control by Year 10
	Three-layer riparian vegetation presence (proportion of reach)	%	t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% increase between impact and control by Year 10

Source: Crawford 2011

For each variable with a significant trend, the percent change over baseline was determined for all years monitored. The mean difference between the control and impact reaches in the baseline year (d_0) for all projects was compared to the mean difference between the control and impact reaches in Year 1 (d_1), Year 3 (d_3), and Year 5 (d_5) for all projects. The following equation was used to determine the mean percent difference for each indicator:

$$\left(\frac{\text{Mean Difference Current Year} - \text{Mean Difference Baseline Year}}{\text{Mean Difference Baseline Year}}\right)\times 100$$

The following were the null (H_0) and alternative (H_A) hypotheses being tested for each variable:

For the linear proportion of actively eroding banks:

- H_0: The mean difference between the baseline year (d_0) and the current year (d_1) ≥ 0
- H_A: The mean difference between the baseline year (d_0) and the current year (d_1) < 0

For the mean percent canopy density at the bank and the proportion of the reach with three-layer riparian vegetation present:

- H_0: The mean difference between the baseline year (d_0) and the current year (d_1) ≤ 0
- H_A: The mean difference between the baseline year (d_0) and the current year (d_1) > 0

This analysis is designed to be applied each year through Year 10 to determine if the projects remain effective.

For the trend analysis based on slope, regional trends through time for livestock exclusion projects were evaluated in this report. This type of analysis, a longitudinal analysis, is intended to create a profile summary, summarizing the trend across all sites with a single number. In this case, the regression slope of the data points for a given indicator is used as the trend summary. Regional differences from zero for the regression slopes can then be assessed using a t-test or nonparametric equivalent test. This can be viewed as an extension of the paired t-test, using the slope rather than the absolute difference between two years. Because the linear regression slope is being used, this test is most sensitive to a linear increase occurring across the sampled years.

An estimate was made of the least-squares regression slope of the response (impact minus control for each sampled variable) regressed against time, where time is measured relative to project implementation. Because the projects were not all implemented in the same year, the years were standardized to the project implementation timeframe (e.g., Year 0, Year 1). The first year after project implementation is always labeled Year 1, and the year immediately prior to implementation is Year 0.

For each variable, or indicator, linear slopes were estimated and the slopes were evaluated for approximate normality. If the slopes differed significantly from a normal distribution (Shapiro-Wilks p-value < 0.05), a one-tailed nonparametric t-test (Wilcoxon test; alpha = 0.10) was used to assess significant trends. Otherwise, a one-tailed t-test was used. The assumptions for the t-test are the following:

- Sites represent an independent random sample from all possible sites.
- Slope estimates are approximately normally distributed.

Trends were not evaluated for variables with data from fewer than three sites. Also, if the average slope was negative (or positive for bank erosion), we know there cannot be a significant improvement regardless of the statistical test used, so there was no test for variables showing negative slopes. A slope box plot graph was developed showing the average of the trendline slopes for the net difference between the impact and control reaches for each indicator across all projects. For each variable, the change estimated by linear trend as a percent of the baseline (impact – control) mean at Year 1, 3, and 5 was determined. This provides an absolute measure to compare to the benchmark of 20 percent change through time. The percent change over baseline was determined for each indicator showing a significant change in Year 5 and those results are included below. Note that these estimates are based on the assumption of linear increase or decrease through time.

For each indicator tested in 2012, the average difference method was applied to evaluate average changes in conditions before and after project implementation. The mean for each indicator across all sites was determined for all pre-project years (baseline data) combined and for all post-implementation years combined. The mean pre-project value was then plotted versus the mean post-project value. This type of analysis allowed easily identifiable comparisons between the pre- and post-project conditions indicating the level of change caused by the project. The average difference method is best at detecting larger, more dramatic changes in overall conditions, while the slope method is better at detecting small incremental changes through time.

RESULTS SUMMARY AND DISCUSSION

Livestock exclusion projects were evaluated as a category to assess trends in indicator response from year to year and the average change between pre-project and post-project conditions. A functional assessment was also performed for projects in this category. Decision criteria for livestock exclusion projects were discussed in the previous section of this report and are shown in Table 3. Statistical analysis is not conducted on individual projects; however, data for each project is provided in the site-specific report pages in Appendix A.

A significant reduction in bank erosion was detected using both the slope method and the average difference method (Table 4). The other two variables (canopy density and riparian vegetation structure) did not show significant trends when assessed on a regional scale. Additional monitoring events are needed to detect trends for these variables, as the time required for changes in vegetation is extensive. The results of the trend evaluation for the Livestock Exclusion Projects category are included in Table 4.

Table 4. Summary of Results for Livestock Exclusion Projects

Slope Method				
Indicator	**Test**	**Mean Slope**	**Standard Error of the Mean Slope**	**p-value**
Linear Proportion of Actively Eroding Banks (%)	one-tailed t-test (negative slope)	-4.0	2.0	0.034
Mean Canopy Density (1-17)	one-tailed Wilcoxon test (positive slope)	0.68	0.46	0.13
Riparian Vegetation Structure (%)	one-tailed t-test (positive slope)	1.9	1.9	0.16
Average Difference Method				
Indicator	**Test**	**Mean Difference**	**Standard Error of the Mean Difference**	**p-value**
Linear Proportion of Actively Eroding Banks (%)	one-tailed t-test (negative step change)	-22	8.4	0.011
Mean Canopy Density (1-17)	one-tailed t-test (positive step change)	0.77	1.0	0.24
Riparian Vegetation Structure (%)	one-tailed t-test (positive step change)	1.3	3.5	0.37

Note: Blue highlight indicates statistically significant results.

For the Livestock Exclusion category, significant results were detected for bank erosion in Year 5 (Table 4). The percent change over baseline was calculated to determine if a change of 20 percent or more occurred. In each year monitored, livestock exclusion projects as a category exceeded a 20 percent change over baseline (Table 5), meeting the decision criteria described in Table 3. For each monitoring year, livestock exclusions, as a category, exceeded 20 percent change over baseline.

Table 5. Percent Change Over Baseline for Livestock Exclusion Indicators with Statistically Significant Results

	Percent Change Over Baseline		
Indicator	**Year 1**	**Year 3**	**Year 5**
OWEB and SRFB projects			
Linear Proportion of Actively Eroding Banks (%)	**-158**	**-114**	**-143**
OWEB projects only			
Linear Proportion of Actively Eroding Banks (%)	**-264**	**-149**	**-206**

All but one project monitored showed reduced bank erosion by at least 20 percent in Year 5 (Figure 2). In Years 1 and 3, several projects had a percent difference of 100

because there was no difference between the impact and control reach in Year 0, Year 1, or Year 3, and 100 percent is used as the default value.

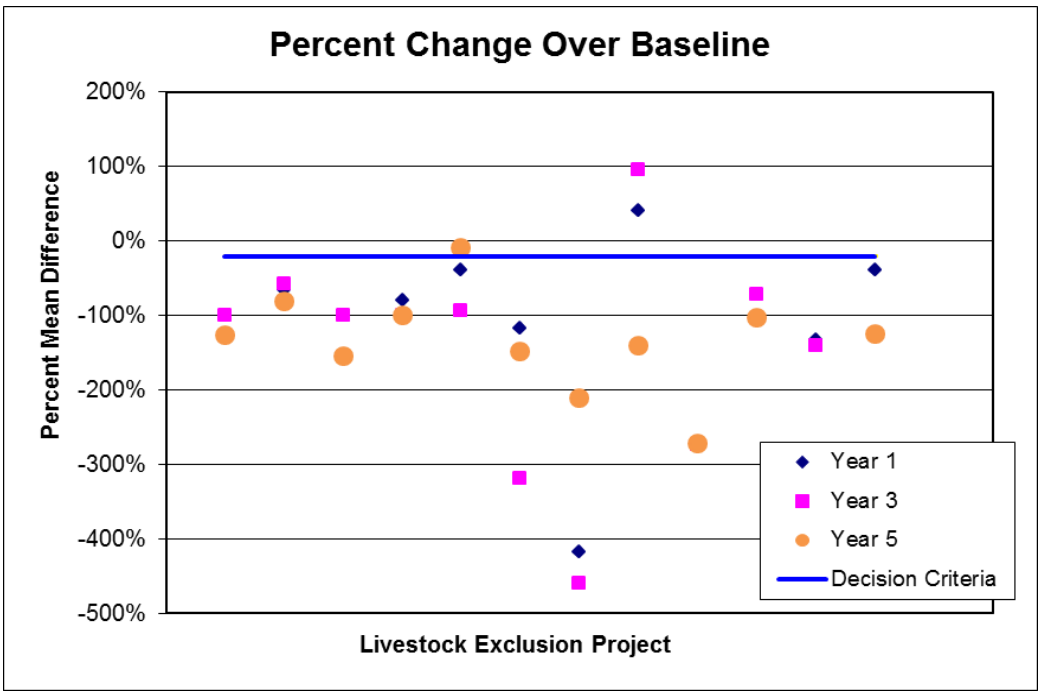

Figure 2. Percent Change Over Baseline

The slope box plot graph for livestock exclusion indicators (Figure 2) shows the average of the trend line slopes for the difference in each indicator between the impact and the control across all projects. Bank erosion and riparian vegetation structure are all showing improving trends toward change, with some variability. For bank erosion, improvement is shown as a decreasing trend through time (negative slope), while for canopy density and riparian vegetation structure improvement is shown as an increasing trend (positive slope). Mean canopy density, however, has shown little indication of change and much lower variability (Figure 3).

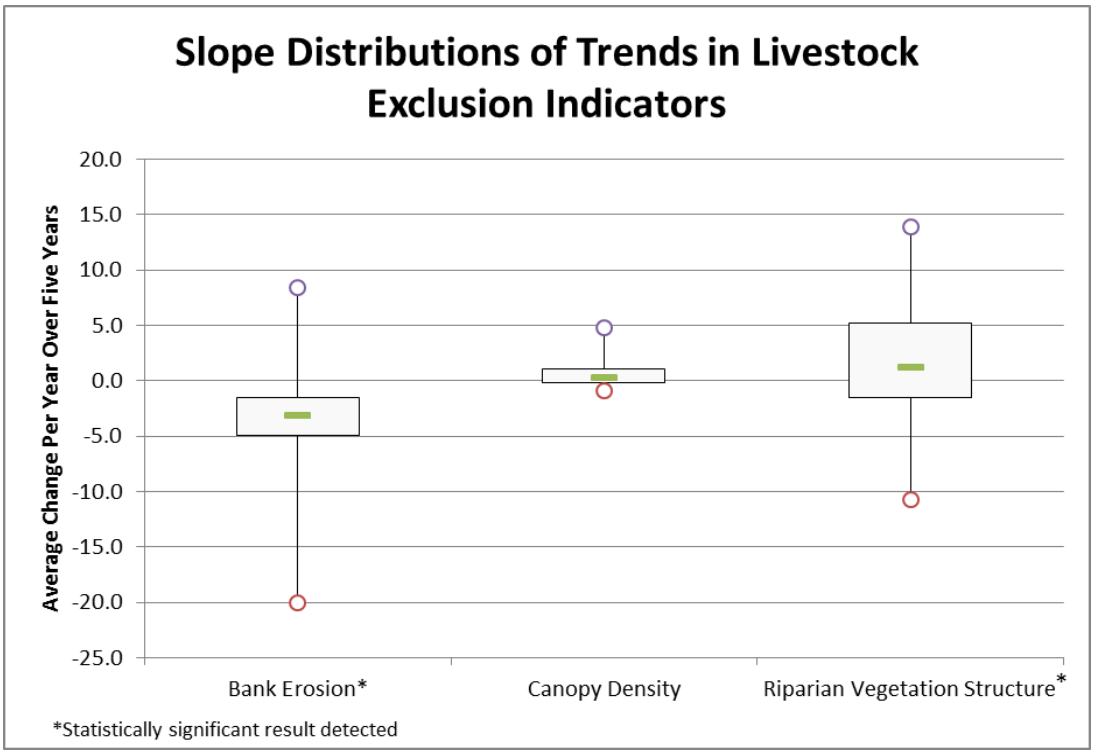

Figure 3. Slope Box Plot Showing Trends for Each Indicator Tested

When comparing average pre-project and post-project conditions across all Livestock Exclusion sites, a significant decrease in bank erosion was seen following project implementation (Figure 4). This is an improvement in habitat condition, as the goal for this project category is to decrease the linear proportion of actively eroding banks over time.

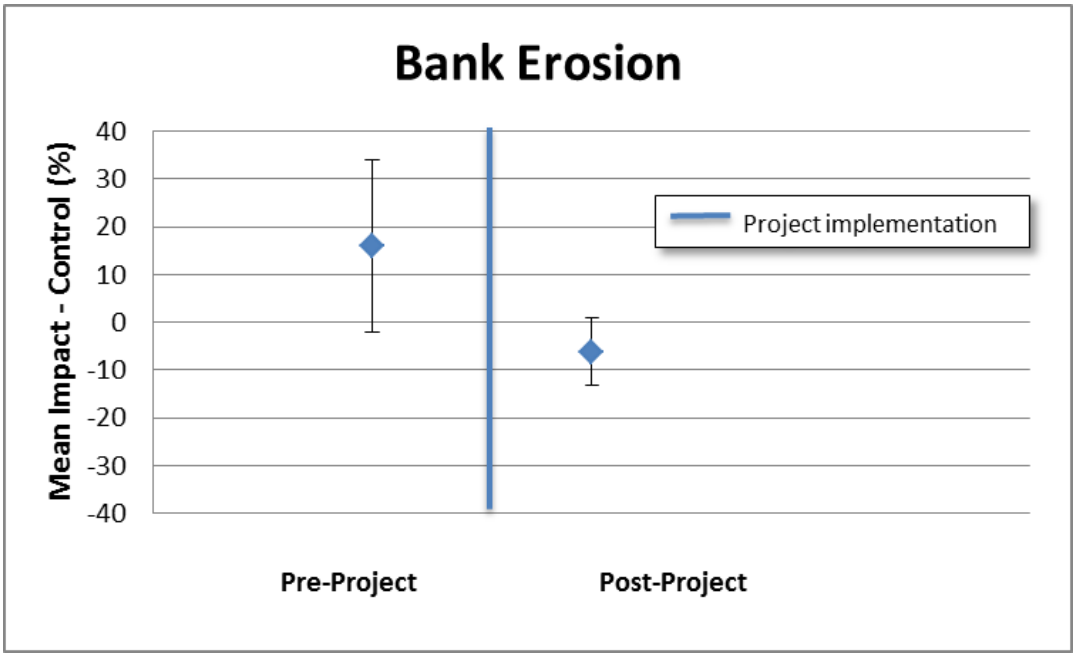

Figure 4. Mean Plot of Pre-Project versus Post-Project Conditions for Bank Erosion

There has been little variability in the response of canopy density structure through time and statistically significant results were not found for this indicator in Year 5 (Table 4 and Figure 3). However, a slight average increase in canopy density following project implementation was apparent when comparing average pre-project and post-project conditions (Figure 5).

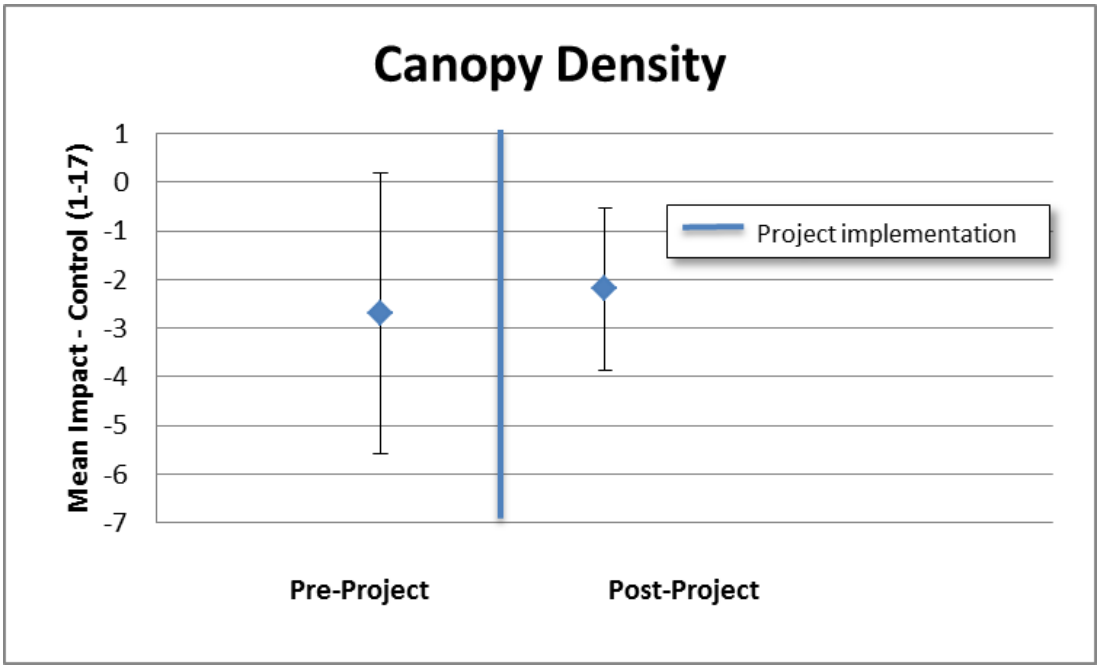

Figure 5. Mean Plot of Pre-Project versus Post-Project Conditions for Canopy Density

Although statistically significant results were not found for riparian vegetation structure, it has shown an improving trend toward change, as shown in the slope box plot (Figure 3). However, very little difference between pre- and post-project means has been found for this indicator (Figure 6).

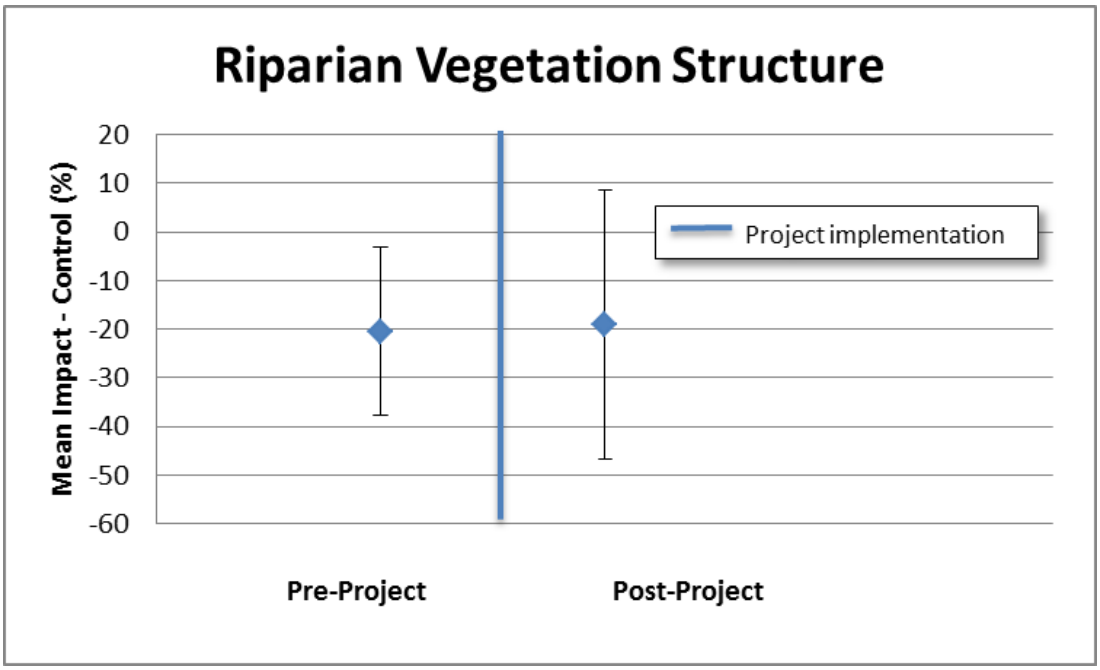

Figure 6. Mean Plot of Pre-Project versus Post-Project Conditions for Riparian Vegetation Structure

Evaluation of livestock projects includes an assessment of exclusion function. This assessment evaluates whether the fencing structure is fully intact and is successfully excluding livestock from the fenced area. Observations of animal droppings, wildlife grazing or browsing, and other indicators are documented as well. Of the projects included in the analysis for Year 1, 83.3 percent of them were evaluated as functional. For Year 3, 75 percent of the projects included in the analysis were considered functioning. In Year 5, eleven livestock exclusion projects were monitored and seven of them, or approximately 64 percent, were found to be functional (Figure 7). Therefore, in Year 3 and Year 5, the livestock exclusion projects, as a category, did not meet the success criteria of 80 percent of projects in the category being intact by Year 10.

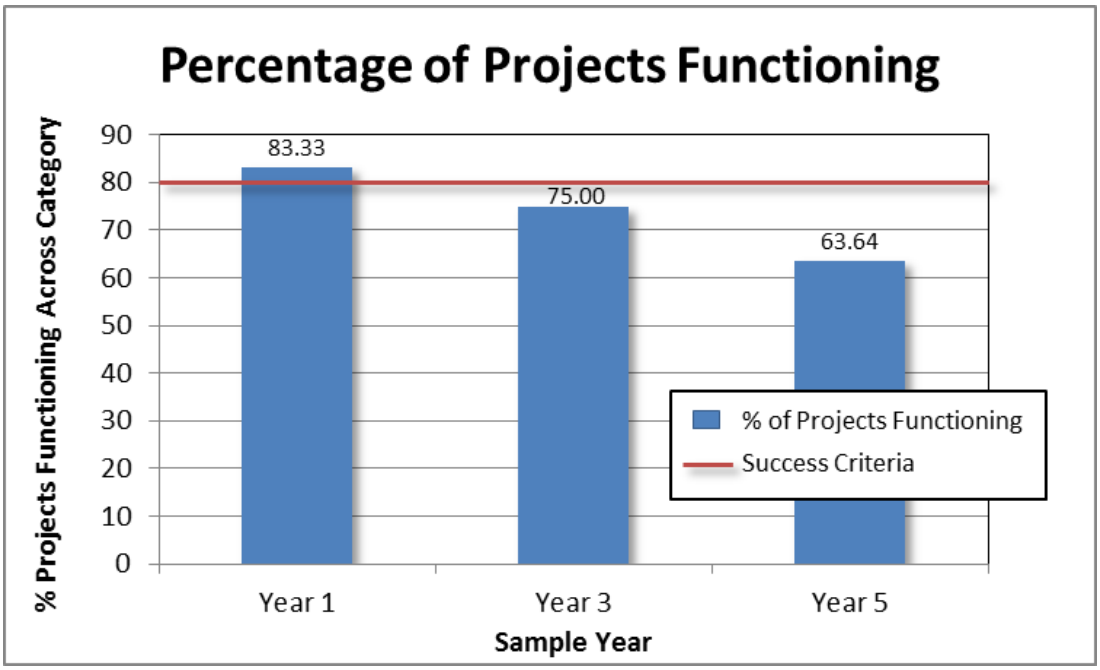

Figure 7. Percentage of Projects Monitored that Meet Success Criteria for Livestock Exclusion Category

At least one project was deemed non-functional in every year of monitoring. In one case, funding for fencing was obtained and the fencing was partially installed, but never completed because the landowner decided not to graze cattle on the land. As a result, this project has been non-functional during each monitoring event. Another project was deemed not functional was due to a large tree falling across the exclusion fencing and subsequently allowing livestock to access the stream. This project has consistently met the success criteria in the past and is expected to meet them again once the fence is repaired. In other cases, gates installed in the fencing structure or poorly maintained fences allowed livestock access and resulted in a non-functional determination. Improvements in the implementation and maintenance of projects are needed to improve the success of the restoration project category as a whole.

PROJECT COST-EFFECTIVENESS ANALYSIS

Project cost-effectiveness analysis was conducted in 2011, which included the evaluation of livestock exclusion projects (Tetra Tech 2011). To determine which categories of projects are the most cost-effective, the change in each indicator was compared to the functional period cost, or the cost of a project divided by the expected functional period for that type of a project. The expected functional period is defined as the amount of time a project should continue to work as intended. For livestock exclusion projects, an average value of

25 years was used in the analysis and annual functional period costs used in the analysis ranged from $188 to $14,823.

Results of the analysis indicated that livestock exclusion projects were the most cost-effective at improving riparian vegetation structure, mean canopy density, and decreasing bank erosion (Figure 8), as compared to other project types tested. This may suggest that in areas where livestock graze along streams, there is more severe damage than in areas where livestock are not present. The removal of livestock via fencing may have more dramatic effects on increasing vegetation metrics in the short-term, such that the relative increase for these projects is much more notable as compared to a control reach. In contrast, areas where riparian planting projects are installed may already have vegetation, but the goal may be to improve the quality of that vegetation. Hence, the differences seen in canopy density, riparian vegetation structure, and bank erosion may be less noticeable.

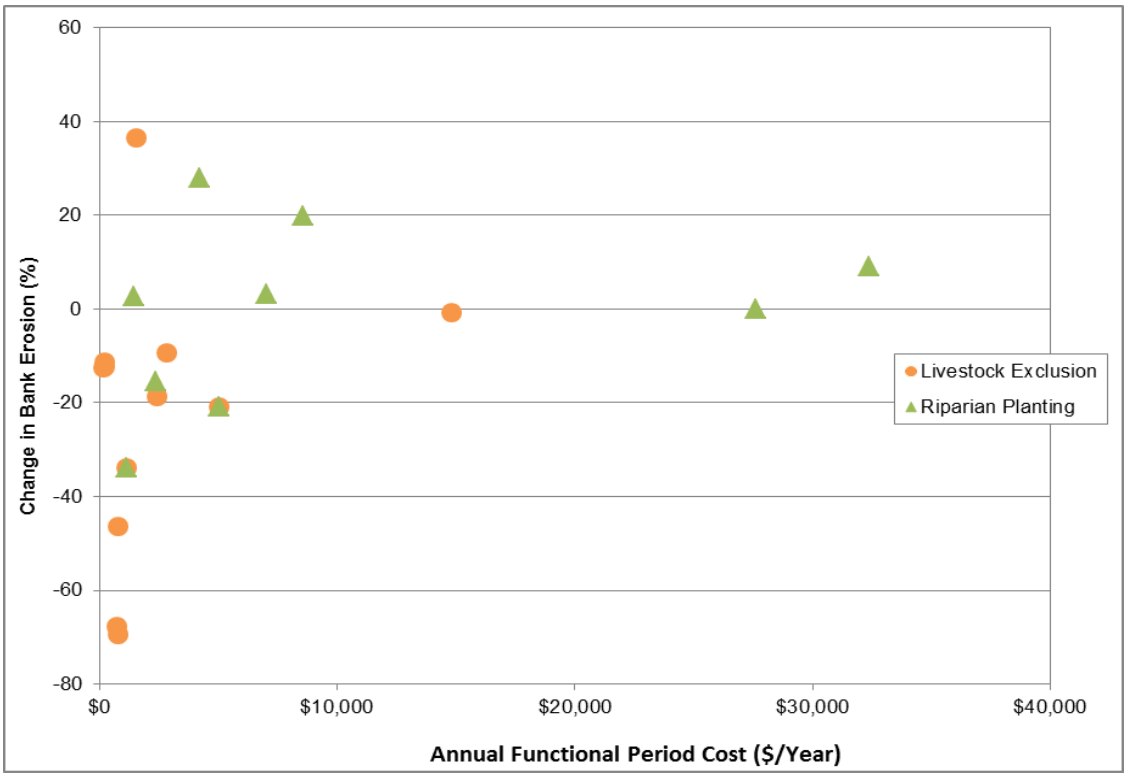

Figure 8. Change in Bank Erosion versus Annual Functional Period Cost

The economic analysis utilized projects with varying numbers of years of data. These data were included to increase the number of data points used for the analyses. Because projects vary in their response time after implementation, using projects with different numbers of years of data may introduce increased variance in the results. Once projects have been evaluated for the full 10-year monitoring cycle, the economic analysis will be much stronger and more reliable. Additionally, the cost effectiveness observations in this report are merely observations of the data, and statistical analyses have not been

performed on any of these data to date. Statistical analysis may be performed in the future to assess the quantitative differences in cost effectiveness between project types.

CONCLUSIONS AND RECOMMENDATIONS

Livestock exclusion projects are showing a significant decreasing trend in bank erosion using the slope method, which indicates a positive result for this indicator. A significant result for mean bank erosion was also reflected in the average difference method comparing post-project to pre-project conditions. Statistically significant results were not found for any of the other indicators tested in Year 5. Little change is being seen for canopy density within this category; however, a slight average improvement was noted post-project implementation. Riparian vegetation structure also shows little change, but trend analysis indicates a positive trend toward improvement with some variability. Additional time is required to detect significant change in vegetation indicators. This coordinated monitoring program is scheduled to continue to monitor each livestock exclusion project for 10 years and will determine overall effectiveness at that time.

The livestock exclusion projects showed significant reductions in bank erosion due to the installation of fencing along streams in areas grazed by livestock. Results were stronger in areas that were planted, in addition to having fencing installed. It is recommended that the measurement of canopy density and vegetation structure be delayed until vegetation has had a chance to establish. If plantings are not included as part of the project, the response of the canopy density and vegetation structure indicators is likely to take more time. Additionally, invasive plant species such as reed canarygrass (*Phalaris arundinacea)* can successfully compete with native plants and rapidly take over an area, preventing native species from thriving and reducing the riparian structure. Controlling invasive species as a part of livestock exclusion projects may be a key element in maintaining adequate canopy density and riparian structure to ensure project success.

By Year 3, 75 percent of projects were found to be functional, and by Year 5, that number dropped to only 64 percent. In some cases, uncontrollable natural events, such as trees falling across the fence structure, resulted in a project being non-functional. However, in other cases, clear evidence of livestock access to the stream due to improperly installed or maintained structures was found. Five years of monitoring suggests that over time, maintenance of the fence and of the project as a livestock exclusion structures declines. It is imperative that fences are installed with the intent to exclude livestock from the stream for the life of the project or longer and that they are maintained in properly working condition. The landowner's buy-in to the project objective is therefore a key element in maintaining the effectiveness of the fencing itself and lack of commitment could be a detriment to the success of an individual project. Fence structures should be also inspected

regularly to ensure that natural events, such as trees falling, are not left undetected, which could result in livestock access to the stream.

Effect on Biota

Rehabilitation techniques in general as reviewed by Roni et al. (2008) show encouraging results for improving habitat and local fish abundance. However, little or no long-term monitoring of these techniques has been conducted on livestock exclusion projects and additional time may be needed before a change in fish or other biota is detectable for this project type. Most exclusion projects that have been monitored were not selected as part of a long-term experimental design with a control that could be tested efficiently. Also, cumulative effects of multiple or longer exclusions have not been investigated. Overgrazing of many areas designated for restoration is predominant, and larger areas of exclusions are necessary to evaluate water quality and habitat changes in stream reaches. There is a need for assessment of watershed processes and factors limiting biotic production, consideration of upstream or watershed-scale factors that influence the outcome of reach-scale or localized rehabilitation projects, and monitoring and evaluation at adequate temporal and spatial scales.

There are unanswered questions about the effects of exclusions on adult populations of fish, and there is a need for large-scale monitoring and evaluation on a basin-scale (Bayley and Li 2008). Few studies have examined effects of individual or multiple projects on a sufficiently broad scale such as an entire watershed or fish population (Roni et al. 2008). Although the livestock exclusion project may positively affect local fish abundance, this coordinated monitoring program unfortunately does not currently include the funds to monitor fish and other biota presence. It is recommended that future monitoring of livestock exclusion projects include fish abundance to evaluate improvements due to the projects.

Other benefits to protecting riparian vegetation include reduced influx of sediment, nutrients, and pesticides (Roni et al. 2008). These indicators (sediment, nutrient, and pesticide levels) are related to water quality, which can affect fish directly or indirectly by affecting food resources. Although they are not currently monitored as part of this program, they could be included in future monitoring of livestock exclusion projects to expand the assessment of project success and potential effects on biota.

Bias Reduction

The Coordinated Monitoring Program for Livestock Exclusions has implemented regional protocols to monitor the effectiveness of livestock exclusion projects. These results will help to provide accountability for rehabilitation investments and promote information sharing across jurisdictions to improve design and implementation of livestock exclusion projects. These data can be used to track the success of projects through time and can be

used to determine whether project objectives are being met. Within the first 5 years after implementation, significant reductions in bank erosion have been documented for this project category, providing evidence that project objectives are being met.

Roni et al. (2008) evaluated livestock exclusion rehabilitation techniques on a world-wide scale, and found that it is difficult to distinguish between failure of a particular technique and failure to consider broader processes during project implementation. Project monitoring did not consider geology, channel type, climate, exotic species, site preparation, native ungulates, effective control of grazing intensity and duration, size of the exclusion or buffer zone, and upstream processes or impacts (Roni et al. 2008). This program utilizes the BACI design. As part of the sample design, a control reach is monitored for each project in this category. Use of a control reach allows any environmental or watershed-scale changes, such as natural variability in habitat conditions, flows, and even fish returns, to be accounted for and not attributed directly to the project. Although it is not imperative that conditions within an impact and control reach are exactly the same, it is important that conditions within control reaches are stable so that the natural range of environmental variation can be accounted for by the control. This allows any additional change in the impact reach beyond that which is naturally occurring to be attributed to the project. The same method is used to establish the reach length and transect locations for the control and impact as well as for all projects in the monitoring program. Therefore, this monitoring program takes into consideration most of the variables listed in Roni et al. (2008) that most livestock exclusion projects did not consider.

Using the same methods to evaluate control and impact reaches on many projects throughout two states is a positive step toward reducing bias in evaluating each indicator for two reasons: 1) comparing an impact to a control reach attempts to eliminate normal environmental changes over time, and 2) using consistent methods on many projects in a region instead comparing data from projects that use slightly different methods allows data to be compared across the region more accurately. However, biases can still exist when monitoring is done by different individuals, even with training, when best professional judgment is required. For example, evaluating the percent of active erosion can be a biased judgment call, as the methods do not use a precise measuring tool to evaluate active erosion between transects. The evaluation of baseline conditions can significantly affect calculations for percent difference for every monitoring year thereafter on a single project basis. For example, if there was no difference in bank erosion between the impact reach and control reach for a project, the percent difference cannot be calculated for that individual project. Each subsequent monitoring year would have no calculation for that project if there was no difference in Year 0. This effect is eliminated when projects are evaluated on a regional level and the bank erosion results are averaged prior to calculating the percent difference.

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Appendix A
PROJECT-SPECIFIC SUMMARIES

205-060 Bottle Creek Livestock Exclusion Project – OWEB

The Bottle Creek project site was associated with past timber harvest and land management practices that allowed easy access to the stream by cattle for approximately 80 years. The Bottle Creek Project was sponsored by the Union Soil and Water Conservation District in response to the need for improvements in riparian condition along the banks of the creek.

This project was intended to benefit steelhead and resident redband rainbow trout (and potentially bull trout and spring Chinook) by replacing an existing, temporary electric fence with a permanent, four-strand, barbed wire "let down" fence to exclude livestock from approximately 2,000 feet of Bottle Creek. The "let down" fence is laid down in the winter to prevent significant damage to the fence from snow. The objective of this project was to exclude cows from the riparian area so that deciduous riparian vegetation could be protected and enhanced, providing additional shading to the stream. In addition, this project was designed to improve streambank stability, resulting in decreased sedimentation into the stream.

METHODS

The Bottle Creek Livestock Exclusion Project is monitored according to the Salmon Recovery Funding Board Protocol for Monitoring the Effectiveness of Livestock Exclusion Projects (Crawford 2011). At both the control and impact reaches, riparian conditions are assessed for vegetation structure and canopy density, and percent of actively eroding banks is estimated. Pool tail fines are assessed for the first 10 pools encountered in the channel. The fencing in the impact reach is evaluated to determine if it is intact and functioning to exclude livestock from the stream. Baseline monitoring of livestock exclusion projects is conducted in Year 0, prior to implementation of the project, to capture pre-existing conditions at both the control and impact reaches. Following implementation, the same sites are surveyed in Years 1, 3, 5, and 10 to assess changes that result from the project. Use of a control reach allows environmental or watershed-scale changes to be accounted for and helps to isolate the effects of the project. With each monitoring event, summary statistics are developed from the data that are collected and trends in site variables are tracked through time.

The Bottle Creek Livestock Exclusion Project is located on Bottle Creek, within the Upper Grande Ronde Watershed, in Union County, Oregon. The impact and control reaches are located on U.S. Forest Service land, near the town of Union, in Township 5S, Range 42E, Section 31. Aric Johnson is the contact person for the Bottle Creek project.

RESULTS

Data collected at the Bottle Creek project site in 2011 showed very little change in canopy density or riparian vegetation structure in both the impact and control reaches between Year 0 and Year 5 (Table 1). When comparing the two reaches, an increasing trend continues in canopy density, while vegetation structure showed an increase over pre-project condition, and then a flattened trend from Years 3 to 5. Bank erosion increased slightly in both the control and impact reaches in Year 5; however, when comparing the two reaches, the decreasing trend in bank erosion due to the project appears to have leveled off in Year 5 (Table 1). Over time, as vegetation growth increases, improvements are expected in canopy density and vegetation structure. Table 1 summarizes the data collected during pre- and post-implementation monitoring of the Bottle Creek Livestock Exclusion Project.

Table 1. Summary Statistics for Pre- and Post-Implementation Monitoring

	Year 0 (6/19-6/20/06)		Year 1 (6/14/07)		Year 3 (6/9/09)		Year 5 (9/14-9/15/11)	
Variable	**Control**	**Impact**	**Control**	**Impact**	**Control**	**Impact**	**Control**	**Impact**
Riparian Characteristics								
Canopy Density (1-17)	14.68	11.23	15.09	10.86	15.50	14.55	15.00	14.32
Riparian Vegetation Structure (%)	100	77.30	100	77.30	95.5	86.4	100	86.4
Bank Erosion (%)	6.5	11.0	2.0	1.3	12.4	2.5	14.9	5.1
Riparian Livestock Exclusions								
Exclusion Design (y/n)	N/A	N/A	N/A	Yes	N/A	Yes	N/A	No
Area of Exclusion (acres)	N/A	N/A	N/A	12.5	N/A	12.5	N/A	12.5

SUMMARY

Five years of monitoring at this site has revealed fairly stable conditions in canopy density and riparian vegetation structure. While bank erosion has shown a slight increase in the control reach over 5 years, a decrease has been seen in the impact reach, indicating a positive result to date. Exclusion fencing at this site has been found in tact during all years of monitoring, except Year 5. Observations leading to this finding are described in detail below.

In 2011, field personnel observed a large tree that recently had fallen across the exclusion fencing at Bottle Creek. This tree caused the fence to fail and, as a result, cattle were observed grazing inside the exclusion area. Photos below show the tree lying across the fence, cattle within the impact reach, an eroded area of streambank where cattle had been accessing the stream, and cattle droppings near the stream. It did not appear as though the fallen tree had been down very long, as it still had green branches and leaves; however,

livestock were accessing the exclusion area as a result of the damage. Livestock were observed grazing near the stream in the impact reach and evidence of livestock accessing the stream itself was also documented. Other than the area affected by the fallen tree, the fencing appeared to be intact. Survey personnel notified the project sponsor of the observed damage to the fence.

The Bottle Creek Livestock Exclusion Project will be resurveyed in 2016, and a comparison will be made with statistics collected in previous years to determine the effectiveness of the project.

Tree lying across exclusion fencing in 2011

Livestock within fenced area in 2011

Trail being used by cattle to access creek in 2011

Cattle droppings inside exclusion area in close proximity to stream in 2011

205-060 North Fork Clark Creek Tributary Exclusion Project – OWEB

The North Fork Clark Creek Tributary project site is in an area that has been used for timber harvest in the past. Additionally, land-use management has allowed livestock access to the stream for 25 to 30 years, resulting in deteriorated conditions along the riparian corridor. The Union Soil and Water Conservation District sponsored this project to address the need for improvements in riparian condition along the banks of the creek.

This project was intended to benefit steelhead and resident redband rainbow trout (and potentially bull trout and spring Chinook) by replacing the previously existing, temporary electric fence with a permanent, four-strand, barbed wire "let down" fence to exclude livestock from approximately 2,400 feet of North Fork Clark Creek. The objective of the North Fork Clark Creek project was to exclude livestock from the riparian area so that deciduous riparian vegetation could be protected and enhanced, providing additional shading to the stream. In addition, this project was designed to improve streambank stability, resulting in decreased sedimentation into the creek.

METHODS

The North Fork Clark Creek Tributary Livestock Exclusion project is monitored according to the Salmon Recovery Funding Board Protocol for Monitoring the Effectiveness of Livestock Exclusion Projects (Crawford 2011). At both the control and impact reaches, riparian conditions are assessed for vegetation structure and canopy density, and percent of actively eroding banks is estimated. Pool tail fines are assessed for the first 10 pools encountered in the channel. The fencing in the impact reach is evaluated to determine if it is intact and functioning to exclude livestock from the stream. Baseline monitoring of livestock exclusion projects is conducted in Year 0, prior to implementation of the project, to capture pre-existing conditions at both the control and impact reaches. Following implementation, the same sites are surveyed in Years 1, 3, 5, and 10 to assess changes that result from the project. Use of a control reach allows environmental or watershed-scale changes to be accounted for and helps to isolate the effects of the project. With each monitoring event, summary statistics are developed from the data that are collected and trends in site variables are tracked through time.

The project area is located on North Fork Clark Creek, within the Upper Grande Ronde Watershed, in Union County, Oregon. The impact and control reaches are located on U.S. Forest Service land near the town of Elgin, in Township 1S, Range 41E, Section 18. Aric Johnson is the contact person for the North Fork Clark Creek Tributary project.

RESULTS

Data collected at the North Fork Clark Creek Project in 2011 indicate positive changes in two of the parameters measured. Canopy density has remained largely unchanged at this site over the last 5 years (Table 1). A slight decrease was noted in the control reach, while

the impact reach remained more stable in Year 5. Although bank erosion increased in Year 5 in both the control and impact reaches, it continues to be significantly lower in the impact reach than in Year 0 (Table 1). Both the impact reach and the control reach have been at the maximum level for vegetation structure since monitoring began in 2006 and this was maintained through 2011. In 2009, the fencing in the impact reach was in the "let-down" position at the time of the survey. As a result, it was not functioning as an exclusionary fence at the time of the survey. Although this created the potential for livestock to access the stream, no evidence of livestock presence was observed. Table 1 summarizes the data collected during pre- and post-implementation monitoring of the North Fork Clark Creek Livestock Exclusion Project.

Table 1. Summary Statistics for Pre- and Post-Implementation Monitoring

Variable	Year 0 (6/20/06)		Year 1 (6/15/07)		Year 3 (6/10/09)		Year 5 (9/13-9/14/11)	
	Control	Impact	Control	Impact	Control	Impact	Control	Impact
Riparian Characteristics								
Canopy Density (1-17)	14.14	14.82	13.14	15.41	14.32	14.82	11.59	14.05
Riparian Vegetation Structure (%)	100	100	100	100	100	100	100	100
Bank Erosion (%)	37.0	38.5	4.8	0	7.7	2.3	31.5	8.95
Riparian Livestock Exclusions								
Exclusion Design (y/n)	N/A	N/A	N/A	Yes	N/A	No[1/]	N/A	Yes
Area of Exclusion (acres)	N/A	N/A	N/A	6.5	N/A	6.5	N/A	6.5

[1/] Fencing was in the "let-down" position at the time of monitoring.

In addition to collecting data, photographs are taken at the site during each monitoring event to document changes in the condition of the stream and exclusion area over time. The following photos were taken at North Fork Clark Creek Tributary during Year 5, showing fencing intact along the impact reach and substantial vegetation growing along the banks of the creek.

Intact fencing along impact reach in 2011 (Year 5)

Impact reach at Transect K facing downstream in 2011 (Year 5)

SUMMARY

Riparian conditions at this site have remained stable over the last 5 years. Riparian vegetation structure has remained at 100 percent in both reaches each year. After remaining fairly consistent in Years 0, 1, and 3, a slight decrease in canopy density was noted in the control reach in Year 5, while the impact reach remained stable. Since project implementation, bank erosion in the impact reach has declined and has remained substantially lower than was documented prior to the project in Year 0.

This project includes a "let down" fence that is laid down in the winter to prevent significant damage to the fence from snow. The "let down" practice does not appear to be negatively affecting the exclusion performance at this site, as no evidence of livestock use was documented within either reach. At the time of the survey in 2011 (Year 5), the fencing was functioning and was not in its "let down" condition. Year 10 monitoring of this site is scheduled for 2016, which will complete the monitoring cycle for this project.

206-283 Noble Creek/Maria Gulch Livestock Exclusion Project – OWEB

The Noble Creek/Maria Gulch Project is sponsored by the Tenmile Lakes Basin Partnership in response to depleted riparian zone functions along the creek, as well as reduced bank stability and shading. These habitat elements have been impacted by agricultural land use practices employed since the late 1920s. This project provided fencing and riparian planting to reduce the input of sediment from bank erosion in Maria Gulch, a tributary to Noble Creek.

This project provided fencing and riparian planting to reduce the input of sediment from bank erosion in Maria Gulch, a tributary to Noble Creek. The fencing and planting project were intended to prevent livestock access to the stream, reduce sediment input and non-point source runoff, and to improve riparian vegetation quality and shading. Fencing was installed on both the control reach (Noble Creek) and on the impact reach (Maria Gulch). Planting on Maria Gulch was located approximately 100 yards upstream of the impact reach. Native seedlings were planted on Noble Creek within the control reach. The land owners within the project area are Joe and Maria Goularte, private landowners; and Mike Mader serves as the contact person for this project.

Maria Gulch Impact Transect A in 2006 (Year 0)

Maria Gulch Impact Transect A in 2009 (Year 3)

METHODS

The Noble Creek/Maria Gulch Livestock Exclusion Project is monitored according to the Salmon Recovery Funding Board Protocol for Monitoring the Effectiveness of Livestock Exclusion Projects (Crawford 2011). At both the control and impact reaches, riparian conditions are assessed for vegetation structure and canopy density, and percent of actively eroding banks is estimated. Pool tail fines are assessed for the first 10 pools encountered in the channel. The fencing in the impact reach is evaluated to determine if it is intact and functioning to exclude livestock from the stream. Baseline monitoring of livestock exclusion projects is conducted in Year 0, prior to implementation of the project, to capture pre-existing conditions at both the control and impact reaches. Following implementation, the same sites are surveyed in Years 1, 3, 5, and 10 to assess changes that

result from the project. Use of a control reach allows environmental or watershed-scale changes to be accounted for and helps to isolate the effects of the project. With each monitoring event, summary statistics are developed from the data that are collected and trends in site variables are tracked through time.

The project area is located in the Tenmile Lakes Watershed east of Lakeside, Oregon, off of Noble Creek Road. The control reach is a currently fenced site on Noble Creek that will remain fenced over the period of monitoring. The impact site is Maria Gulch, a tributary to Noble Creek.

RESULTS

In Year 3, canopy density remained largely unchanged in both the control and impact reaches (Table 1). Riparian vegetation structure increased in both reaches between Years 1 and 3 (Table 1). A decrease in bank erosion was noted in both reaches in Year 3, with more substantial reduction in the impact reach (Table 1). Table 1 summarizes the data collected during monitoring of the Noble Creek/Maria Gulch Livestock Exclusion Project in Years 0, 1, and 3.

Table 1. Summary Statistics for Pre- and Post-Implementation Monitoring

Variable	Year 0 (6/6/06)		Year 1 (6/27/07)		Year 3 (6/17/09)	
	Control	Impact	Control	Impact	Control	Impact
Riparian Characteristics						
Canopy Density (1-17)	11.86	10.36	14.50	15.50	14.96	15.27
Riparian Vegetation Structure (%)	4.5	45.5	0	50.0	9.1	90.9
Bank Erosion (%)	0	49.6	27.8	11.3	21.0	1.3
Riparian Livestock Exclusions						
Exclusion Design (y/n)	N/A	N/A	N/A	Yes	N/A	Yes[1/]
Area of Exclusion (acres)	N/A	N/A	N/A	3.5	N/A	3.5

[1/] The fence on the impact reach was intact but there were game trails leading to the creek. The fence on control reach was not intact and there was evidence of livestock in stream.

In addition to collecting data, photographs are taken at the site during each monitoring event to document changes in the condition of the stream or river over time. The 2009 photo from Year 3 shows the fence in place and increased vegetation growth as compared to 2006 (Year 0). Wildlife has access to the impact reach from the hillside on the left bank. Notice the game trail adjacent to the fence in the 2009 photo.

Impact Transect F facing downstream in 2006 (Year 0)

Impact Transect F facing downstream in 2009 (Year 3)

SUMMARY

The Noble Creek/Maria Gulch site includes a small stream meandering through a combination of agricultural lands and forested areas. This project has demonstrated improvement in all three measured variables by Year 3. Following project implementation, increases have been noted for canopy density and vegetation structure. A substantial decrease in bank erosion has been seen in the impact reach, indicating a positive result for this indicator as well

In 2009 (Year 3), the fencing was inspected along the impact reach and found to be fully intact along the right bank as shown in the photo above. There is no fence along the left bank of the impact reach which is adjacent to a forested hillside. The forest is inhabited by elk and other wildlife, which potentially can impact the stream habitat at the project site. There was evidence of game trails to the stream from the hillside as well as along the fence line as shown in the 2009 photo above.

The fence along the control reach on Noble Creek was not intact in the vicinity of Transect F (see photo below), and the gate was left open for livestock to pass through. Evidence of livestock access to Noble Creek is shown in the photo below.

Impaired fence on control reach (Noble Creek 2009)

Evidence of livestock in control reach (2009)

206-072 Gray Creek Livestock Exclusion Project – OWEB

The Gray Creek project is located on active dairy land that has been used for agricultural purposes for at least the past 25 years. Approximately 120 cattle have used the land adjacent to the creek for grazing and had access to the creek, which has resulted in degradation of the aquatic habitat. The Coquille Watershed Association sponsored this project with the intention of improving riparian and stream conditions along Gray Creek through livestock exclusion practices, by fencing along both sides of the creek.

The objective of the project was to install livestock exclusion fencing to prevent livestock access to the creek, thereby allowing riparian vegetation cover and bank stability to increase along Gray Creek. The project involved fencing along both sides of the creek for approximately 1.23 miles, excluding a total area of approximately 2.8 acres. The fence was designed with two setbacks, one at 5 feet and one at 12 feet, to allow for maintenance of the waterway. Maintenance of the waterway includes trenching (dredging) the stream of the vegetation and sediment approximately every 7 years to allow the adjacent fields to adequately drain.

METHODS

The Gray Creek Livestock Exclusion project is monitored according to the Washington Salmon Recovery Funding Board Protocol for Monitoring the Effectiveness of Livestock Exclusion Projects (Crawford 2011). At both the control and impact reaches, riparian conditions are assessed for vegetation structure and canopy density, and percent of actively eroding banks is estimated. Pool tail fines are assessed for the first 10 pools encountered in the channel. The fencing in the impact reach is evaluated to determine if it is intact and functioning to exclude livestock from the stream. Baseline monitoring of livestock exclusion projects is conducted in Year 0, prior to implementation of the project, to capture pre-existing conditions at both the control and impact reaches. Following implementation, the same sites are surveyed in Years 1, 3, 5, and 10 to assess changes that result from the project. Use of a control reach allows environmental or watershed-scale changes to be accounted for and helps to isolate the effects of the project. With each monitoring event, summary statistics are developed from the data that are collected and trends in site variables are tracked through time.

The Gray Creek project area is located in the Coquille Watershed, southwest of Coquille, Oregon, approximately 0.5 mile from the Watershed Council Office along State Highway 42. The habitat within the proposed project area is a low-gradient meandering stream that runs through a dairy at the site. The control reach is located at the Coquille Valley Elks Golf Course, upstream along Gray Creek, across Highway 42. The Coquille Watershed Association sponsored this project and the land owners within the project area include the Coquille Valley Elks Golf Course along the control reach, and Mike and Lisa Miranda,

private landowners, along the impact reach. Dennis Wise, Director of the Coquille Watershed Association, is the contact for this project.

RESULTS

In Year 5, several variables showed positive trends when comparing the control and impact reaches at Gray Creek. Both canopy density and riparian vegetation structure showed improvement after steadily, but slowly declining since Year 0. Overall, canopy density is greater than prior to project implementation and, although riparian vegetation structure is slightly lower, the current trend appears positive. Bank erosion showed a slight decrease in Year 5, indicating a positive trend as well. Bank erosion is higher than measured in Year 0; however, much of the erosion at this site may be attributed to maintenance activities, rather than lack of project effectiveness. During the Year 5 survey, fencing was assessed and all posts and lines were observed to be intact in the impact reach, effectively excluding livestock from Gray Creek. Table 1 summarizes the data collected during pre- and post-implementation monitoring of the Gray Creek Livestock Exclusion Project.

Table 1. Summary Statistics for Pre- and Post-Implementation Monitoring

Variable	Year 0 (6/8/06)		Year 1 (6/26/07)		Year 3 (6/15/09)		Year 5 (7/12/11)	
	Control	Impact	Control	Impact	Control	Impact	Control	Impact
Riparian Characteristics								
Canopy Density (1-17)	11.64	16.36	13.46	15.77	14.82	17.0	11.72	17.0
Riparian Vegetation Structure (%)	27.3	0	36.4	0	59.1	0	36.4	0
Bank Erosion (%)	63.2	13.4	64.0	34.8	7.3	5.0 [1/]	8.25	0
Riparian Livestock Exclusions								
Exclusion Design (y/n)	N/A	N/A	N/A	Yes	N/A	Yes	N/A	Yes
Area of Exclusion (acres)	N/A	N/A	N/A	2.8	N/A	2.8	N/A	2.8

[1/] Erosion is estimated for Year 3 due to vegetation cover and lack of visibility of bank.

In addition to collecting data, photographs are taken at the site during each monitoring event to document changes in the condition of the stream or river over time. The following photos were taken at Gray Creek during Year 0 and Year 5. Fence installation and dense vegetation growth in the stream are apparent in the Year 5 photo.

Impact reach at Transect A in 2006 (Year 0)

Impact reach at Transect A in 2011 (Year 5)

SUMMARY

Gray Creek is primarily an agricultural drainage with heavy vegetation, which provides drainage for the adjacent fields. Maintenance on the drainage ditch is performed approximately every 7 years to remove excessive vegetation and sediment deposits to allow the creek to drain the fields. At the time of the survey in 2011, the banks were steeply cut and the creek bed was deep as a result of maintenance activities. Direct access to the creek not feasible; therefore, the creek was assessed from the banks. Dense growth of reed canarygrass in the riparian zone and skunk cabbage in the creek made it necessary to estimate erosion from the banks.

The primary reason for excluding livestock from a waterway is to promote riparian vegetation growth and prevention of excessive erosion. However, maintenance of the creek strips the banks, exposing unconsolidated material that is prone to erosion, which is carried into the waterway, raising the streambed elevation, and thus promoting the need for further maintenance. The creek primarily functions as a drain for the adjacent farms and the activities required to maintain that function negate the potential benefits of the fencing installation.

206-095 Jordan Creek Livestock Exclusion Project – OWEB

The Jordan Creek Project is located in an area that has been used in agricultural production for approximately the past 50 years, resulting in impacted habitat conditions within the creek and adjacent riparian areas. This project was sponsored by the Long Tom Watershed Council with the intent to primarily benefit cutthroat trout and other cold water species (i.e., state-listed western brook lamprey) which may also be present in Jordan Creek and the Coyote Creek sub-watershed. The project included the installation of woven wire fencing to exclude use of the creek by livestock, the establishment of off-channel watering facilities for livestock use, sloping of the bank in areas where it was too steep for planting, and planting of trees and shrubs in areas adjacent to the creek. Riparian zone restoration included the removal and long-term control of blackberry, followed by re-vegetation with native trees.

The objectives of the Jordan Creek Project included a reduction in bank erosion, the eradication and control of blackberry and other invasive and non-native vegetation, and an increase in native tree and shrub cover to 80 percent within the riparian area. By providing shade to over 80 percent of the channel, a reduction in summer stream temperatures in Jordan Creek by an average of 2°C was anticipated. Additional goals of the project included increasing large wood, pool frequency, and channel sinuosity within the creek.

METHODS

The Jordan Creek Livestock Exclusion project is monitored according to the Washington Salmon Recovery Funding Board Protocol for Monitoring the Effectiveness of Livestock Exclusion Projects (Crawford 2011). At both the control and impact reaches, riparian conditions are assessed for vegetation structure and canopy density, and percent of actively eroding banks is estimated. Pool tail fines are assessed for the first 10 pools encountered in the channel. The fencing in the impact reach is evaluated to determine if it is intact and functioning to exclude livestock from the stream. Baseline monitoring of livestock exclusion projects is conducted in Year 0, prior to implementation of the project, to capture pre-existing conditions at both the control and impact reaches. Following implementation, the same sites are surveyed in Years 1, 3, 5, and 10 to assess changes that result from the project. Use of a control reach allows environmental or watershed-scale changes to be accounted for and helps to isolate the effects of the project. With each monitoring event, summary statistics are developed from the data that are collected and trends in site variables are tracked through time.

Jordan Creek is in the southwest region of the Long Tom Watershed in the Upper Willamette River Basin. The site is in Lane County, within the Long Tom Watershed and Coyote Creek sub-watershed. Historically, neither the control nor the impact reach were

fenced and both were actively used by horses. The land owner within the project area is Deborah Mattson, and Cindy Thieman serves as the contact person for this project.

RESULTS

Data from the Jordan Creek Livestock Exclusion project indicate an overall increase in canopy density and riparian vegetation structure in the impact reach as compared to the control reach. Canopy density in the impact reach increased substantially between Year 1 and Year 3, and continued to increase in Year 5, showing an overall positive trend since project implementation. Despite a slight decrease in Year 5, the trend for riparian vegetation structure appears positive as well, with an overall increase since Year 0. Active bank erosion has decreased substantially in the impact reach from Year 0 and remains low in Year 5 (Table 1). When comparing impact and control reaches, bank erosion has decreased overall since project implementation. Table 1 summarizes the data collected during pre- and post-implementation monitoring of the Jordan Creek Livestock Exclusion Project.

Table 1. Summary Statistics for Pre- and Post-Implementation Monitoring

Variable	Year 0 (8/14/06)		Year 1 (9/13/07)		Year 3 (6/18/09)		Year 5 (7/14/11)	
	Control	Impact	Control	Impact	Control	Impact	Control	Impact
Riparian Characteristics								
Canopy Density (1-17)	16.82	2.05	16.64	1.77	16.96	15.59	16.96	16.8
Riparian Vegetation Structure (%)	100	4.5	100	9.1	100	22.7	100	13.6
Bank Erosion (%)	100	94.5	100	0	26.5	6	46.5	11.5
Riparian Livestock Exclusions								
Exclusion Design (y/n)	N/A	N/A	N/A	Yes	N/A	Yes	N/A	Yes
Area of Exclusion (acres)	N/A	N/A	N/A	7.8	N/A	7.8	N/A	7.8

In addition to collecting data, photographs are taken at the site during each monitoring event to document changes in the condition of the stream over time. The following photos from Jordan Creek show new growth of vegetation along the stream in the photo from 2011.

Impact reach at Transect F facing upstream in 2006 (Year 0)

Impact reach at Transect F facing upstream in 2011 (Year 5)

SUMMARY

Since project implementation, riparian indicators have all shown improvement over data collected prior to project implementation in Year 0, indicating a trend toward success for this project. Canopy density and riparian vegetation structure have both increased in the impact reach over the last 5 years, while conditions in the control reach have remained fairly stable. Bank erosion has decreased in both reaches, with more substantial changes noted in the impact reach by Year 5. This project has remained functional during all years of monitoring. Year 10 monitoring of the Jordan Creek site is scheduled for 2016, which will complete the monitoring cycle for this project.

206-283 Johnson Creek Livestock Exclusion Project – OWEB

The Johnson Creek Project is located on private land that has been managed for agriculture since the late 1920s. The land around the creek was one of the first areas developed for farming in the region. Actively eroding banks along Johnson Creek, and other creeks, have contributed to a 10-fold increase in the amount of sediment delivered to Tenmile Lakes. This increase in sedimentation has led to effects on salmon habitat and water quality. The Tenmile Lakes Basin Partnership sponsored the Johnson Creek Project in an effort to address this issue and improve conditions within Johnson Creek and, ultimately, within Tenmile Lakes.

The riparian zone functions and bank stability in Johnson Creek have been reduced due to past land use practices in the area. The objective of this project was to improve the riparian condition and reduce sediment input by installing fencing along the creek and excluding livestock from using the area. This effort is expected to result in benefits to the watershed over the long term through increases in ground water storage, stream complexity and shading of the channel, and a reduction in non-point source run-off.

METHODS

The Johnson Creek Livestock Exclusion project is monitored according to the Washington Salmon Recovery Funding Board Protocol for Monitoring the Effectiveness of Livestock Exclusion Projects (Crawford 2011). At both the control and impact reaches, riparian conditions are assessed for vegetation structure and canopy density, and percent of actively eroding banks is estimated. Pool tail fines are assessed for the first 10 pools encountered in the channel. The fencing in the impact reach is evaluated to determine if it is intact and functioning to exclude livestock from the stream. Baseline monitoring of livestock exclusion projects is conducted in Year 0, prior to implementation of the project, to capture pre-existing conditions at both the control and impact reaches. Following implementation, the same sites are surveyed in Years 1, 3, 5, and 10 to assess changes that result from the project. Use of a control reach allows environmental or watershed-scale changes to be accounted for and helps to isolate the effects of the project. With each monitoring event, summary statistics are developed from the data that are collected and trends in site variables are tracked through time.

The project area is located along Johnson Creek, in the Tenmile Lakes Watershed, in Section 36 of Township 23S and Range 12W. The project site is south of the town of Lakeside, Oregon, and east of Highway 101. Bob and Fontella Hankins are private landowners within the project area and Mike Mader serves as the primary contact for this project.

RESULTS

Data collected at the Johnson Creek site in Year 5 indicate a continued positive trend in all three indicators monitored (Table 1). Canopy density has increased in the impact reach

since project implementation, while conditions in the control reach have remained stable. Riparian vegetation structure has increased in both the control and impact reaches since Year 0, but conditions in the impact reach have remained stable between Year 1 and Year 5. Bank erosion increased in the control reach in Year 5, but decreased in the impact reach (Table 1). Overall, bank erosion in the impact reach as compared to the control reach is substantially lower than prior to project implementation. As vegetation matures through time, further improvement in measured parameters is expected. Table 1 summarizes the data collected during pre- and post-implementation monitoring of the Johnson Creek Livestock Exclusion Project.

Table 1. Summary Statistics for Pre- and Post-Implementation Monitoring

Variable	Year 0 (6/7/06)		Year 1 (6/28/07)		Year 3 (6/16/09)		Year 5 (7/13/11)	
	Control	**Impact**	**Control**	**Impact**	**Control**	**Impact**	**Control**	**Impact**
Riparian Characteristics								
Canopy Density (1-17)	16.05	6.77	15.32	13.96	16.77	15.52	16.41	16.1
Riparian Vegetation Structure (%)	0	0	4.5	4.5	13.6	4.5	4.5	4.5
Bank Erosion (%)	4.3	80.2	76.5	74.5	4.3	26.3	12	11.5
Riparian Livestock Exclusions								
Exclusion Design (y/n)	N/A	N/A	N/A	No	N/A	No	N/A	No
Area of Exclusion (acres)	N/A	N/A	N/A	4	N/A	4	N/A	4

In addition to collecting data, photographs are taken at the site during each monitoring event to document changes in the condition of the stream or river over time. The following photos were taken at Johnson Creek during Year 0 and Year 5. Fence installation and dense vegetation growth along the stream are apparent in the Year 5 photo.

Impact reach at Transect A in 2006 (Year 0)

Impact reach at Transect A in 2011 (Year 5)

The livestock fencing appeared intact at the time of the survey in 2011; however, there were gates in the fencing, which were open and would have allowed livestock to access the creek. Evidence of livestock near the gate at Transect G was documented in the photos shown below.

Gate located in fencing at Transect G of the impact impact reach (Year 5)

Livestock tracks observed near Transect G of the reach (Year 5)

SUMMARY

At the project site, Johnson Creek travels through agricultural lands and consists of deep pools, steep banks, and fine sediment. Measured parameters at Johnson Creek continue to show overall positive trends for the site by Year 5. The series of photos below show an exposed right bank at Transect A in the impact reach during Year 1 and the sloughing that occurred before the Year 3 monitoring in the same area where the rebar was placed in Year 1. In Year 5, erosion was observed in the same area in Transect A.

Impact reach at Transect A in 2007 (Year 1)

Impact reach at Transect A in 2009 (Year 3)

Impact reach at Transect A in 2011 (Year 5)

This erosion was not caused by livestock, but was likely due to high water flows, and is expected continue occurring with high flow events in the future. Year 10 monitoring of the Johnson Creek project is scheduled for 2016, which will complete the monitoring cycle for this site.

The observation of open gates in the fencing in Year 5 illustrates that the exclosure is not functional and that livestock could have access to or through the riparian area at some point in time. Although no livestock have been observed within the exclusion during any monitoring event, indications of livestock use or access, such as trampled or grazed vegetation, gates incorporated into the fencing, and impaired wires in the fencing, have resulted in the structure being found as non-functional during every survey year (Table 1). However, the riparian vegetation conditions and levels of bank erosion are continuing to improve along the fenced reach.

206-357 Middle Fork Malheur River Bank Stabilization Project – OWEB

The Middle Fork Malheur River project area has been in agricultural production since at least the early 1900s. Downcutting and erosion along the river are the result of livestock in the area accessing the creek as a water source. As part of this project, Rosgen J-hook vane structures, bank sloping and re-vegetation, and buffer fencing were used to re-direct streamflows away from the eroding bank, create pool habitat, and re-establish riparian vegetation. Approximately 100 head of cattle were excluded from over 1 mile of the Middle Fork Malheur River when the project was completed. This project was expected to benefit approximately 1 mile of stream habitat. The objectives of this project were to improve fish habitat, including habitat for bull trout listed on the Endangered Species List, and reduce excessive bank erosion on the Middle Fork of the Malheur River in the Drewsey Valley by rehabilitating several badly downcut and eroding sections of streambank. Harney Soil Water Conservation District sponsored this project and Marty Suter serves as the primary contact.

Impact reach prior to livestock fencing in Year 0 (2006)

Impact reach at Transect A in Year 5 (2012)

METHODS

The Middle Fork Malheur River Bank Stabilization Project is monitored according to the Salmon Recovery Funding Board Protocol for Monitoring the Effectiveness of Livestock Exclusion Projects(Crawford 2011). At both the control and impact reaches, riparian conditions are assessed for vegetation structure and canopy density, and percent of actively eroding banks is estimated. Pool tail fines are assessed for the first 10 pools encountered in the channel. The fencing in the impact reach is evaluated to determine if it is intact and functioning to exclude livestock from the stream. Baseline monitoring of livestock exclusion projects is conducted in Year 0, prior to implementation of the project, to capture pre-existing conditions at both the control and impact reaches. Following implementation, the same sites are surveyed in Years 1, 3, 5, and 10 to assess changes that result from the project. Use of a control reach allows environmental or watershed-scale changes to be accounted for and helps to isolate the effects of the project. With each

monitoring event, summary statistics are developed from the data that are collected and trends in site variables are tracked through time.

The project area is located in Harney County within the Middle Fork Malheur River subbasin. The impact reach is approximately 0.23 mile in length and is located on the Marshall property at the overlook to the Malheur River. The control site is also 0.23 mile long and is approximately 0.4 mile upstream. The project is located on private lands owned by Gary Marshall and Marc O'Toole.

RESULTS

Vegetation indicators at this site have remained largely unchanged between Year 1 and Year 5. Slight increases in canopy density have been noted in both the impact and control reaches following project implementation. Riparian vegetation structure increased slightly in both reaches in Year 3, but decreased in Year 5 back to percentages similar to what was found in Year 0, prior to the project. Alternatively, bank erosion has decreased substantially in both reaches since project implementation. In the impact reach, bank erosion had continually decreased from year to year. Table 1 summarizes the data collected during Year 0, Year 1, Year 3, and Year 5 monitoring of the Middle Fork Malheur River Livestock Exclusion Project.

Table 1. Summary Statistics for Pre- and Post-Implementation Monitoring

	Year 0 (8/16/06)		Year 1 (8/21/08)		Year 3 (8/11/10)		Year 5 (9/11-9/12/12)	
Variable	**Control**	**Impact**	**Control**	**Impact**	**Control**	**Impact**	**Control**	**Impact**
Riparian Characteristics								
Canopy Density (1-17)	1.59	3.73	7.14	3.09	6.09	5.27	6.46	5.23
Riparian Vegetation Structure (%)	4.5	0	4.5	0	31.8	13.6	9.1	0
Bank Erosion (%)	58.5	71.3	33.8	41.5	44.5	37.0	11.75	6.75
Riparian Livestock Exclusions								
Exclusion Design (y/n)	N/A	N/A	N/A	Yes	N/A	Yes	N/A	No
Area of Exclusion (acres)	N/A	N/A	N/A	62	N/A	62	N/A	62

SUMMARY

In 2012, Year 5 monitoring was conducted at the Malheur site. The site consists of a wide, flat stream traveling through agricultural lands, with large quantities of algae and fine substrate. Overall, riparian conditions remain fairly stable at this site after 5 years of monitoring. While slight increases have been noted in canopy density, riparian vegetation structure in the impact reach is the same as what was documented in Year 0, prior to the project. Bank erosion has decreased substantially in both the impact and control reaches over the last 5 years. In the impact reach in Year 5, bank erosion was determined to be

almost 89 percent lower than what was found in Year 0, indicating a positive trend at this site.

Evidence of recent livestock access to the impact reach was documented during the survey (see photos below). Although evidence of recent access was observed, no cattle were observed in or near the stream within the impact reach at the time of the survey. Since observations made during field surveys only reflect conditions at that time, it was not possible to determine the extent to which cattle were allowed access to the stream, or for what period of time. Despite apparent access by livestock, bank erosion numbers decreased in both the control and impact reaches in Year 5 (Table 1).

Cow feces and tracks near river in impact reach.

Cattle print along left bank at Transect B in impact reach.

02-1498 Abernathy Creek Riparian Restoration – SRFB

The Abernathy Creek Riparian Restoration Project aimed to restore 84 acres of riparian area along Abernathy Creek, a tributary to the Columbia River, which provides critical spawning and rearing habitat for Endangered Species Act–listed Chinook, chum, and steelhead, as well as for coho and sea-run cutthroat trout. The project involved the removal of weedy plant species, the exclusion of livestock through the installation of approximately 5,000 feet of fencing, and planting of native trees and shrubs, including conifers, within the riparian area. As a whole, the project included 35 acres of riparian area treated for plant removal/control. The project is expected to benefit approximately 2.5 miles of stream habitat.

As part of this project, conservation easements were purchased from private landowners who agreed to leave the riparian areas undisturbed in perpetuity. The cooperative efforts of those landowners allowed sensitive areas to remain intact, while maintaining use of the areas for recreational activities, such as hiking and fishing. These easements encompassed approximately 44 acres of land and 11,000 linear feet of Abernathy Creek shoreline. The remaining 40 acres of land within the project area is Washington Department of Fish and Wildlife (WDFW) property located at the mouth of Abernathy Creek.

Cowlitz County sponsored the Abernathy Creek Project, which was designed to restore approximately 84 acres of riparian habitat along Abernathy Creek, including 2.5 miles of shoreline. Prior to the project, the creek had excessive sediments, lacked large woody debris, and had water temperatures that exceeded state standards. This project was designed to mitigate these conditions by restoring riparian vegetation, fencing out livestock, and restricting vehicle access at the mouth of the creek.

Project partners include Cowlitz County, Cowlitz Conservation District, Academy Surveying, WDFW, Cowlitz Indian Tribe, the U.S. Fish and Wildlife Service (USFWS), and the Washington Jail Industries Board. The contact person for this project is Darin Houpt.

Impact reach Transect K in 2004 (Year 0)

Impact reach Transect K in 2009 (Year 5)

METHODS

This program includes the monitoring of projects using a BACI sample design. An impact reach is selected within the project area where change is expected to result from the project. A control reach is typically selected upstream of the impact reach, and in close proximity, whenever possible. Once the control and impact reaches are established, each reach is monitored for one year before implementation to collect baseline, or Year 0, data that reflect pre-existing conditions. Following project implementation, those same reaches are surveyed on a rotating schedule, depending on project type, to assess changes that result from the project. This program is designed to obtain information at the category level; therefore, project-level statistical analyses are not conducted. Statistics are developed across each monitoring category on an annual basis and are reported in annual progress reports.[1]

As part of the sample design, a control reach is monitored for each project in this category. Use of a control reach allows any environmental or watershed-scale changes, such as natural variability in habitat conditions, flows, and even fish returns, to be accounted for and not attributed directly to the project. Although it is not imperative that conditions within an impact and control reach are exactly the same, it is important that conditions within control reaches are stable so that the natural range of environmental variation can be accounted for by the control. This allows any additional change in the impact reach beyond that which is naturally occurring to be attributed to the project.

The Abernathy Creek Livestock Exclusion Project is monitored according to the Washington Salmon Recovery Funding Board Protocol for Monitoring the Effectiveness of Livestock Exclusion Projects (Crawford 2011). Baseline monitoring of livestock exclusion projects is conducted in Year 0, prior to implementation of the project, and again in Years 1, 3, 5, and 10 to assess changes that result from the project. At both the control and impact reaches, riparian conditions are assessed for vegetation structure and canopy density, and percent of actively eroding banks is estimated. The riparian characteristics surveyed at this site evaluate the percentage of three-layer vegetation (i.e., groundcover, understory, and canopy) in the riparian area and the amount of shade that is being provided to the stream by the riparian vegetation. These metrics are intended to track the health and stability of the riparian corridor along the project area and both are expected to increase through time. By monitoring the linear extent of actively eroding banks, the amount of erosion, or relative sediment input to the stream, occurring in areas where livestock are excluded can be tracked to determine if there is a decrease through time as would be expected. Pool tail fines are also assessed for the first 10 pools encountered in the channel

[1] Additional information regarding sample design and statistical analyses can be obtained from the annual progress reports located on Habitat Work Schedule at http://www.rco.wa.gov/doc_pages/other_pubs.shtml#effectiveness.

and the fencing in the impact reach is evaluated to determine if it meets the exclusion design, or whether it remains intact and functioning to exclude livestock from the stream. In addition to collecting data, photographs are taken at the site during each monitoring event to document changes in the condition of the site over time.

As part of the restoration of this site, the project involved removal of weedy plant species and planting of native trees and shrubs in the impact reach. It is not uncommon that several restoration actions may be implemented at a single project site, but not all project components are monitored at every site through this program. For the Abernathy Creek project, the livestock exclusion component is the focus of the monitoring effort, rather than the riparian planting component.

The project area is located along Abernathy Creek (Water Resource Inventory Area [WRIA] 25), a tributary to the Columbia River, in Cowlitz County, Washington. The project area begins at the highly disturbed mouth of the creek (on WDFW property) and continues through conservation easements purchased by Cowlitz County, situated below the USFWS Abernathy Technical Center. The impact reach is 787 feet in length and is located within one of the conservation easement areas on private property. The control reach is also 787 feet long and is located 1.3 miles upstream from the impact reach on USFWS property, adjacent to the Abernathy Fish Technology Center.

RESULTS

The portions of the Abernathy Creek project monitored through this program were completed in 2005, prior to Year 1 monitoring. Baseline, or Year 0, monitoring was completed in 2004, and post-project monitoring was conducted in Years 1, 3, and 5. Invasive plant removal and riparian planting were two components of this project that were implemented, but were not monitored as part of this program. Monitoring of this site focused on the livestock exclusion portion of the project and the indicators measured for projects in that monitoring category.

Riparian characteristics are monitored at the Abernathy Creek site to assess riparian vegetation structure and canopy density through time. During every visit to this site, the riparian vegetation structure has been 100 at both the control and impact reaches, indicating that 100 percent of the reaches monitored contained all three layers of riparian vegetation (canopy cover, understory, and ground cover) (Table 1). Canopy cover has also remained consistently high at this site. In the control reach, values have ranged from approximately 16.5 to 16.7, which is very near the maximum value of 17. In the impact reach, canopy cover has also been high at this site, despite a slight dip seen in the impact reach in Year 3. In Year 5, canopy density increased again and reached levels that exceeded those measured prior to project implementation.

Bank erosion is measured at the Abernathy Creek site during each monitoring event. In general, the percentage of bank erosion has been relatively low at both the control and impact reaches, with values ranging from 0.25 percent to 12.8 percent (Table 1). After a slight decrease in Year 1, bank erosion in the control reach increased in Year 3 and Year 5. In the impact reach, slight increases in bank erosion have been documented during each year of monitoring.

Table 1. Summary Statistics for Pre- and Post-Implementation Monitoring

Variable	Year 0 (6/11-6/12/04)		Year 1 (6/7-6/8/05)		Year 3 (6/4-6/5/07)		Year 5 (6/5/09)	
	Control	Impact	Control	Impact	Control	Impact	Control	Impact
Riparian Characteristics								
Canopy Density (1-17)	16.68	15.55	16.55	15.41	16.46	14.18	16.50	15.86
Riparian Vegetation Structure (%)	100	100	100	100	100	100	100	100
Bank Erosion (%)	2	2	0.25	2.5	2.8	3.8	12.8	7.3
Riparian Livestock Exclusions								
Exclusion Design (y/n)	N/A	N/A	N/A	No[1/]	N/A	No[1/]	N/A	No[1/]
Area of Exclusion (acres)	N/A	N/A	N/A	84	N/A	84	N/A	84

[1/] Fencing was never completed because landowner never grazed cattle on the portion of the land within the project

In addition to riparian characteristics and bank erosion, the effectiveness of the livestock exclusion itself is monitored at this site. The fencing is inspected to determine if it is fully intact and functioning to prevent livestock from accessing the 84-acre exclusion area. Although funding was obtained for fencing at this site, the exclusion structure was never finished because the landowner did not obtain cattle to graze on the portion of land within the project. As a result of the incomplete status of the fence, this project has failed to meet the exclusion design criteria in all years of monitoring.

SUMMARY

Data collected at the Abernathy project site indicate that the high quality riparian habitat present at the site is being maintained. Riparian vegetation structure has remained at 100 percent for all years of monitoring. Canopy density remains high at this site and changes observed are within the range of natural variability at this site. Bank erosion continues to increase slightly; however, the erosion observed in 2009 was likely a result of high stream flow due to storm events. Erosion observed in the impact and control reaches is not likely due to any livestock activity as the property owner does not own livestock at this time, and there was no evidence of livestock access to the stream banks. The exclusion fencing is not complete, and would not exclude livestock if present. Absence of livestock induced erosion along the stream banks should allow the riparian plantings to mature and increase canopy density and diversity. We recommend that project sponsors should verify the long-term use of the project area before investing in additional fencing to complete the exclosure.

04-1655 Hoy Riparian Restoration (Livestock Exclusion) – SRFB

The Hoy Riparian Restoration project is located within a 2-mile section of the middle Skagit River east of the town of Hamilton, Washington. This section of river is one of the most important spawning areas for Chinook salmon, chum salmon, pink salmon, and steelhead in the lower and middle Skagit River. Spawning surveys conducted in recent years indicated that this section of the river possesses the highest concentration of fall Chinook salmon spawners in the middle Skagit River. Fall Chinook salmon are one of six distinct populations of Chinook in the Skagit watershed, and this population is undergoing the greatest decline. The riparian vegetation corridor along many areas of the project site has been substantially impacted by cattle grazing and land clearing for farming. The poor riparian conditions resulting from these activities have led to erosion along the river bank. In 2005, a livestock exclusion fence was installed at the edge of the plantings to exclude cattle that graze in the adjoining hay field. This project was designed to restore the riparian area along this property and protect the river banks, sustaining the morphology of the river channel over approximately 2 miles.

The objective of the project was to restore and protect natural streamside vegetation, improve stream temperature, reduce erosion, improve filtration, and recruit large woody debris. Restoration of riparian vegetation is intended to result in protection of the river bank along the Hoy property, which is intended to ultimately sustain the river channel morphology in this area of the middle Skagit. This project is co-sponsored by Seattle City Light and the Skagit Land Trust.

Impact reach before livestock exclusion fencing in 2005 (Year 0). Fence shown here was original fencing and was removed by bank erosion between 2005 and 2006.

Impact reach after fencing in 2010 (Year 5)

METHODS

The Hoy Riparian Restoration (Livestock Exclusion) Project is monitored according to the Salmon Recovery Funding Board Protocol for Monitoring the Effectiveness of Livestock

Exclusion Projects (Crawford 2011). At both the control and impact reaches, riparian conditions are assessed for vegetation structure and canopy density, and percent of actively eroding banks is estimated. Pool tail fines are assessed for the first 10 pools encountered in the channel. The fencing in the impact reach is evaluated to determine if it is intact and functioning to exclude livestock from the stream. Baseline monitoring of livestock exclusion projects is conducted in Year 0, prior to implementation of the project, to capture pre-existing conditions at both the control and impact reaches. Following implementation, the same sites are surveyed in Years 1, 3, 5, and 10 to assess changes that result from the project. Use of a control reach allows environmental or watershed-scale changes to be accounted for and helps to isolate the effects of the project. With each monitoring event, summary statistics are developed from the data that are collected and trends in site variables are tracked through time.

This project was located on Seattle City Light property along the Skagit River in Skagit County. The project area is a 2-mile section of the middle Skagit River east of the town of Hamilton. The 240-acre property is located on the south side of the Skagit River. Both the control and impact reaches measure 689 feet in length.

RESULTS

All three measured indicators have shown improvement over the last 5 years of monitoring at this site. Canopy cover has increased in the impact reach while remaining stable in the control reach (Table 1). Improvements have been seen in both the control and impact reaches for riparian vegetation structure by Year 5. Bank erosion has decreased substantially at this site in both the control and impact reaches between Year 0 and Year 5. Table 1 summarizes the data collected during Year 0, Year 1, Year 3, and Year 5 monitoring of the Hoy Riparian Restoration Project.

Table 1. Summary Statistics for Pre- and Post-Implementation Monitoring

Variable	Year 0 (5/6/05)		Year 1 (7/19/06)		Year 3 (5/5/08)		Year 5 (6/15/10)	
	Control	Impact	Control	Impact	Control	Impact	Control	Impact
Riparian Characteristics								
Canopy Cover (1-17)	16.7	6.0	16.6	3.1	15.9	5.3	16.4	11.6
Riparian Vegetation Structure (%)	59.1	18.2	50.0	0	50.0	4.5	90.9	59.1
Bank Erosion (%)	37.5	54.0	55.3	50.0	82.5	95.5	0	4.0
Riparian Livestock Exclusions								
Exclusion Design (y/n)	N/A	N/A	N/A	Yes	N/A	Yes	N/A	Yes
Area of Exclusion (acres)	N/A	N/A	N/A	38.0	N/A	38.0	N/A	38.0

Gate within exclusion fence.

Exclusion fence in 2010 (Year 5).

SUMMARY

In 2010, the exclusion fence was intact and there was no sign of cattle within the exclusion, suggesting that the fence is functioning properly. Vegetation data collected in Year 5 (2010) indicate that there has been an increase in riparian vegetation structure and canopy cover within the enclosed area since Year 0 (2005) due to the survival of plantings and the establishment of volunteer willow (Table 1). Bank erosion has also decreased within the enclosed area since Year 0 (2005). Overall, these results indicate that the project is functioning effectively and is achieving the project goals of protecting streamside vegetation and reducing erosion. Year 10 monitoring for this project is scheduled to occur in 2016.

04-1698 Vance Creek Livestock Exclusion – SRFB

Vance Creek supports cutthroat trout, coho salmon, and possibly chum salmon, as well as lamprey, sculpin, mud minnows, and other aquatic life. The creek has been historically manipulated to accommodate agriculture, mining, and residential development. Despite these actions, coho salmon and cutthroat trout continue to use the stream in limited numbers. Two primary limiting factors affecting the habitat are high sediment input and lack of riparian cover. In an effort to help restore the function of the creek and riparian zones, local landowners agreed to allow fencing and riparian planting along a 25-foot buffer on both sides of the stream. With the help of volunteer and student labor from the local school district, and support of the Chehalis Basin Education Consortium, the lower portion of the stream was replanted and fences were installed to exclude livestock. The Vance Creek Project is expected to benefit approximately 4.75 miles of stream habitat.

The objectives of the project were to protect and restore natural streamside vegetation, improve stream temperature, reduce erosion, improve filtration, and recruit large woody debris. This project provided 2.35 miles of fencing and 0.36 acre of riparian planting to improve fish habitat in Vance Creek, a tributary to the Chehalis River. The creek is 8.9 miles long with 6.2 miles of documented salmonid spawning and rearing habitat. The target species for this project was coho salmon. The Chehalis Basin Fisheries Task Force sponsored this project and Lonnie Crumley is the contact person. Livestock exclusion fencing was installed in 2007, north of the creek, where horses are pastured.

Impact reach – overgrown with reed canary grass (2009).

Impact reach with livestock fencing and riparian planting area Year 3 (2009).

Impact reach – Transect A looking upstream (2011)

Impact reach with livestock fence and riparian planting area Year 5 (2011)

METHODS

The Vance Creek Livestock Exclusion Project is monitored according to the Salmon Recovery Funding Board Protocol for Monitoring the Effectiveness of Livestock Exclusion Projects (Crawford 2011). At both the control and impact reaches, riparian conditions are assessed for vegetation structure and canopy density, and percent of actively eroding banks is estimated. Pool tail fines are assessed for the first 10 pools encountered in the channel. The fencing in the impact reach is evaluated to determine if it is intact and functioning to exclude livestock from the stream. Baseline monitoring of livestock exclusion projects is conducted in Year 0, prior to implementation of the project, to capture pre-existing conditions at both the control and impact reaches. Following implementation, the same sites are surveyed in Years 1, 3, 5, and 10 to assess changes that result from the project. Use of a control reach allows environmental or watershed-scale changes to be accounted for and helps to isolate the effects of the project. With each monitoring event, summary statistics are developed from the data that are collected and trends in site variables are tracked through time.

The project is located on Vance Creek, south of the town of Elma, in Chehalis County. Vance Creek originates in forest lands northwest of Elma, flows through residential lands, an abandoned gravel mine (now a County park), then through farmlands, entering the Chehalis River at river mile 20. Approximately one-quarter of the riparian area restored was county-owned and the remainder was privately owned. The control reach is located in Vance Creek County Park. Both the impact and control reaches measure 492 feet in length.

RESULTS

At the time of the surveys, the fencing at the site was found to be intact and was rated as functional for the site. The fencing is electric, and prevents livestock from accessing the creek. From Year 1 through Year 5, there was no evidence of livestock in the riparian area. Canopy density at the site remains high and is comparable with the control reach. Riparian

vegetation structure increased at the project site from Year 1 (9.1 percent) to Year 3 (45.5 percent). In Year 5, decreases in riparian structure were noted in both the impact and the control reaches. Bank erosion has been reduced substantially as a result of the project from a level of 70 percent in the impact reach prior to the project to zero along the impact reach after project implementation. Table 1 summarizes the data collected during pre- and post-implementation monitoring of the Vance Creek Project.

Table 1. Summary Statistics for Pre- and Post-Implementation Monitoring

Variable	Year 0* (10/4/06)		Year 1 (9/11/07)		Year 3 (6/15/09)		Year 5 (6/6/11)	
	Control	Impact	Control	Impact	Control	Impact	Control	Impact
Riparian Characteristics								
Canopy Density (1-17)	16.65	15.91	15.68	13.68	16.5	17	13.1	15.1
Riparian Vegetation Structure (%)	95.5	18.2	86.4	9.1	95.5	45.5	63.6	27.3
Bank Erosion (%)	40	70	0	0	0	0	11.3	0
Riparian Livestock Exclusions								
Exclusion Design (y/n)	N/A	N/A	N/A	Yes	N/A	Yes	N/A	Yes
Area of Exclusion (acres)	N/A	N/A	N/A	5.0	N/A	5.0	N/A	5.0

SUMMARY

In Year 5, water was very high during the sampling period, making the stream unwadeable. From approximately transect A to transect E surveyors were able to access the stream channel to collect data. Upstream of Transect F, thick vegetation including spirea (*Spiraea* spp.), blackberry (*rubus armeniacus*), and reed canarygrass(*Phalaris arundinacea*), in combination with high water, created marshy conditions that made it impossible to locate or access a defined stream channel in the project area. For this portion of the reach, no densiometer readings were collected; however, vegetation structure was assessed from a distance. Data collected at the site indicate no change in bank erosion (none present at the site) in the impact reach and a small increase (11.3 percent) in the control reach. Canopy density measured in Year 5 remained comparable to levels measured in Year 3, much of which is due to thick reed canarygrass and spirea. Vegetation structure decreased between Year 3 and Year 5 in both the control reach and impact reaches. Generally, the level of function at this site has been measured as high, and the livestock exclusion has proven to be effective at protecting vegetation from grazing; however, the increase in invasive species such as reed canarygrass and blackberry is affecting the overall success of the project. As the riparian plantings mature at this site, a further increase in riparian vegetation structure is expected. Additional monitoring at this site is planned to occur in 2016.

05-1447 Indian Creek Yates Restoration Project – SRFB

The Indian Creek Yates Restoration Project addresses protection of high priority habitats in WRIA 62. It is one of the few streams in WRIA 62 where bull trout observations have occurred in recent years. The project implements the first priority action in the eighth ranked high priority subbasin in the Pend Oreille Lead Entity area. In 1995, a fish habitat survey indicated that, of the 2.36 miles of Indian Creek assessed, 28 percent of the spawning habitat in the surveyed area was found within the project area.

Fish habitat in the project reach has been impacted by an impassable culvert and livestock grazing. Historically, at the upstream end of the barrier, splash boards were placed to create a small pond. Silt deposited in the pond and filled the channel for approximately 197 feet upstream of the culvert. The riparian area was used for grazing three horses. The horses trampled the stream banks and riparian area, limiting the recruitment of riparian shrubs. The Indian Creek Yates Restoration Project was designed to address these issues and improve fish habitat and connectivity within approximately 0.6 mile of the creek.

This project was intended to benefit bull trout. The objectives of the project were to replace the undersized culvert with a small bridge; dredge the upstream channel section and stabilize the silt deposits by seeding; and construct a riparian fence to promote bank stabilization and re-vegetation. Implementation of this project was intended to restore connectivity throughout Indian Creek, as no other barriers are known to exist. This project was sponsored by the Kalispel Indian Tribe and Todd Anderson is the primary contact person.

Exclusion fencing in Year 5 (2011)

Impact reach in Year 5 (2011)

METHODS

The Indian Creek Yates Restoration Project is monitored according to the Salmon Recovery Funding Board Protocol for Monitoring the Effectiveness of Livestock Exclusion Projects (Crawford 2011). At both the control and impact reaches, riparian conditions are assessed

for vegetation structure and canopy density, and percent of actively eroding banks is estimated. Pool tail fines are assessed for the first 10 pools encountered in the channel. The fencing in the impact reach is evaluated to determine if it is intact and functioning to exclude livestock from the stream. Baseline monitoring of livestock exclusion projects is conducted in Year 0, prior to implementation of the project, to capture pre-existing conditions at both the control and impact reaches. Following implementation, the same sites are surveyed in Years 1, 3, 5, and 10 to assess changes that result from the project. Use of a control reach allows environmental or watershed-scale changes to be accounted for and helps to isolate the effects of the project. With each monitoring event, summary statistics are developed from the data that are collected and trends in site variables are tracked through time.

The project area is located on Indian Creek, a tributary to the Pend Oreille River, in Pend Oreille County, within the Pend Oreille River subbasin (WRIA 62). The impact reach is 160 meters in length and is located on the Walker property within Township 32N, Range 45E, and Section 20. The control reach also measures 160 meters in length.

RESULTS

Data collected at the Indian Creek Yates Restoration site indicate improvement or maintenance in all three measured variables. Baseline data at the project site revealed high levels of canopy density and riparian vegetation structure, and low levels (10 percent) of bank erosion. Since project implementation, these levels have been maintained or improved in the impact reach, as compared to the control reach. Table 1 summarizes the data collected during Year 0, Year 1, Year 3, and Year 5 monitoring at Indian Creek Yates Restoration Project.

Table 1. Summary Statistics for Pre- and Post-Implementation Monitoring

	Year 0 (5/30-5/31/06)		Year 1 (8/20-8/21/07)		Year 3 (5/28-5/29/09)		Year 5 (6/1-6/2/11)	
Variable	**Control**	**Impact**	**Control**	**Impact**	**Control**	**Impact**	**Control**	**Impact**
Riparian Characteristics								
Canopy Density (1-17)	12.0	16.1	15.5	16.8	16.1	17.0	12.0	15.2
Riparian Vegetation Structure (%)	100	90.9	100	90.9	100	100	86.4	95.5
Bank Erosion (%)	0	10.0	0.3	2.3	0	0	0	0
Riparian Livestock Exclusions								
Exclusion Design (y/n)	N/A	N/A	N/A	Yes	N/A	Yes	N/A	Yes
Area of Exclusion (acres)	N/A	N/A	N/A	4.5	N/A	4.5	N/A	4.5

Summary

Bank erosion remained at zero between Year 3 and Year 5, after the initial decrease between Year 0 and Year 3 in the impact reach. Canopy density and vegetation structure remain high (above 85 percent) in the control and impact reaches, both showing a small decrease between Year 3 and Year 5 indicating this trend is not project related. Areas along the bank where livestock formerly accessed the creek continue to fill in with vegetation and appear to be recovering. Additionally, recent riparian plantings along a portion of the impact reach will likely further improve canopy density and riparian conditions in the future.

05-1547 Rauth Coweeman Tributary Restoration – SRFB

The Coweeman subbasin was identified as one of the most significant areas for salmon recovery among the Washington Cascade strata subbasins, based on fish population significance and realistic prospects for restoration. The Rauth Coweeman Tributary Restoration Project was intended to provide short-term and long-term benefits to all life stages of Chinook salmon, coho salmon, steelhead, chum salmon, and sea-run cutthroat. As stated in the Coweeman Subbasin Plan, all Coweeman River salmon and steelhead populations need to be restored to a high level of viability to meet regional recovery objectives. This project encompassed the lower 2,000 feet of an unnamed tributary to the Coweeman River. This was a multi-faceted project that included tasks to: provide fish passage by replacing a known barrier, provide access to 2.5 miles of habitat; restore the appropriate cross section to lower 400 feet of channel; install woody debris to restore pool habitat; establish and improve woody vegetation in 2.25 acres of riparian area; and construct a livestock exclusion fence to protect riparian plantings, benefitting approximately 1,207 meters of stream habitat. The project was complemented by a Family Forest Fish Passage Program-funded culvert replacement conducted in 2004.

The landowner and Toutle High School students provided the labor to remove the existing fence, conduct site preparation activities necessary to establish woody riparian vegetation, and plant the riparian vegetation. They were willing to help to maintain the riparian plantings for the first 2 years and reconstruct the livestock exclusion fence as needed. The Cowlitz Conservation District provided plants and fencing materials.

The goal of the project was to restore native riparian vegetation along a salmon-bearing stream. The objectives of the project were to restore natural streamside vegetation, improve stream temperature, reduce erosion, increase natural filtration, and recruit large woody debris. Approximately 450 feet of stream bank was fenced on the Rauth property to protect riparian plantings from livestock. In addition to the livestock fencing, this project was designed to improve fish passage through barrier removal, restore channel cross-section, improve pool and riffle habitat through installation of large woody debris, and restore 2.25 acres of riparian habitat.

Livestock being excluded by fence in 2011 (Year 5)

Impact reach at Transect A facing upstream (Year 5)

This project addressed the needs identified in the Lower Columbia Salmon Recovery Plan. The Cowlitz Wahkiakum Conservation District sponsored this project and Darin Houpt is the contact person.

METHODS

The Rauth Coweeman Livestock Exclusion Project is monitored according to the Washington Salmon Recovery Funding Board Protocol for Monitoring the Effectiveness of Livestock Exclusion Projects (Crawford 2011). Baseline monitoring of livestock exclusion projects is conducted in Year 0, prior to implementation of the project, and again in Years 1, 3, 5, and 10 to assess changes that result from the project. At both the control and impact reaches, riparian conditions are assessed for vegetation structure and canopy density, and percent of actively eroding banks is estimated. Pool tail fines are assessed for the first 10 pools encountered in the channel. The fencing in the impact reach is evaluated to determine if it is intact and functioning to exclude livestock from the stream. The riparian characteristics surveyed at this site are intended to track the health and stability of the riparian corridor along the project area. After implementation, mean canopy density and riparian vegetation structure were expected to increase. Length of actively eroding banks was expected to decrease, and the exclusion was expected to remain functional. In addition to collecting data, photographs are taken at the site during each monitoring event to document changes in the condition of the site over time.

As part of the site preparation for this project, invasive species were removed from within the impact reach, but not in the control reach. Although the monitoring of this site was not focused on invasive species control or riparian planting, those activities conducted within the impact reach could affect post-implementation results. It is not uncommon that several restoration actions may be implemented at a single project site, but not all are monitored

through this program. For this site, the livestock exclusion component is the focus of the monitoring effort, rather than the riparian planting component.

The Rauth Coweeman project is located in Cowlitz County within the Cowlitz River subbasin (WRIA 26). The impact reach is 492 feet in length and is located on the Rauth property within Township 8N, Range 1W, and Section 26. The control reach is also 492 feet in length and is located 100 yards upstream from the impact reach on the Rauth/Nesbit property. The project site is on an unnamed tributary to the Coweeman River at river mile 13.3. The Coweeman River is a tributary to the Cowlitz River at about river mile 0.5.

RESULTS

Data collected at the Rauth Coweeman project site indicate short-term improvements in some measured parameters. The linear extent of actively eroding banks decreased in the impact reach between Year 0 and Year 1, while slightly increasing in the control reach. Between Year 1 and Year 3, a slight increase in the control reach was noted again, while a decrease in erosion was documented in the impact reach. Flooding that occurred in the creek after the monitoring in Year 3 caused some limited bank erosion that was not tied to livestock use or captured during Year 3 monitoring. Flood-related erosion was evident in Year 5, however, with increases in bank erosion in both the control and impact reaches. No evidence of livestock use or access to the creek was noted in Year 5, suggesting that the erosion documented was solely a result of naturally occurring conditions at the site. Table 1 summarizes the data collected during monitoring of the Rauth Coweeman Project.

Table 1. Summary Statistics for Pre- and Post-Implementation Monitoring

	Year 0 (5/19/06)		Year 1 (10/12/07)		Year 3 (5/5/09)		Year 5 (5/3/11)	
Variable	**Control**	**Impact**	**Control**	**Impact**	**Control**	**Impact**	**Control**	**Impact**
Riparian Characteristics								
Canopy Density (1-17)	16.96	14.55	16.64	13.86	16.64	13.82	16.5	15.5
Riparian Vegetation Structure (%)	100	90.9	100	72.7	100	81.8	100	77.3
Bank Erosion (%)	0.5	32.5	1.8	21.3	5.1	7.2	11.5	30
Riparian Livestock Exclusions								
Exclusion Design (y/n)	N/A	N/A	N/A	Yes	N/A	Yes	N/A	Yes
Area of Exclusion (acres)	N/A	N/A	N/A	2.3	N/A	2.3	N/A	2.3

SUMMARY

There is good vegetative cover along both banks in the impact reach and, other than flooding effects, the banks are stable. Small decreases were noted in canopy density for both the control and impact reaches in Year 1, but these levels remained very stable from Year 1 to Year 5, with a notable increase in the impact reach in Year 5. Riparian vegetation structure was maintained in the control reach, but decreased in the impact reach in Year 1.

This was due to removal of invasive vegetation within the impact reach to allow native species to establish and grow. From Year 1 to Year 5, the riparian vegetation structure has varied slightly with increases between Years 1 and 3 and a slight decrease in Year 5.

Additionally, in Year 5, pool tail fines were measured in both the impact and control reaches, with a greater percentage seen in the impact reach for fines less than 2 millimeters (mm) and fines less than 6 mm. This metric was added to the livestock exclusion monitoring protocol in 2010 when the protocols were updated and revised to integrate with other regional monitoring programs. Project-level trends in this indicator will be tracked through time moving forward. The fence was found to still be in place and functional. Future monitoring of this site is scheduled for Year 10, which will be in 2016. No additional monitoring is currently planned for this site until then.



TETRA TECH