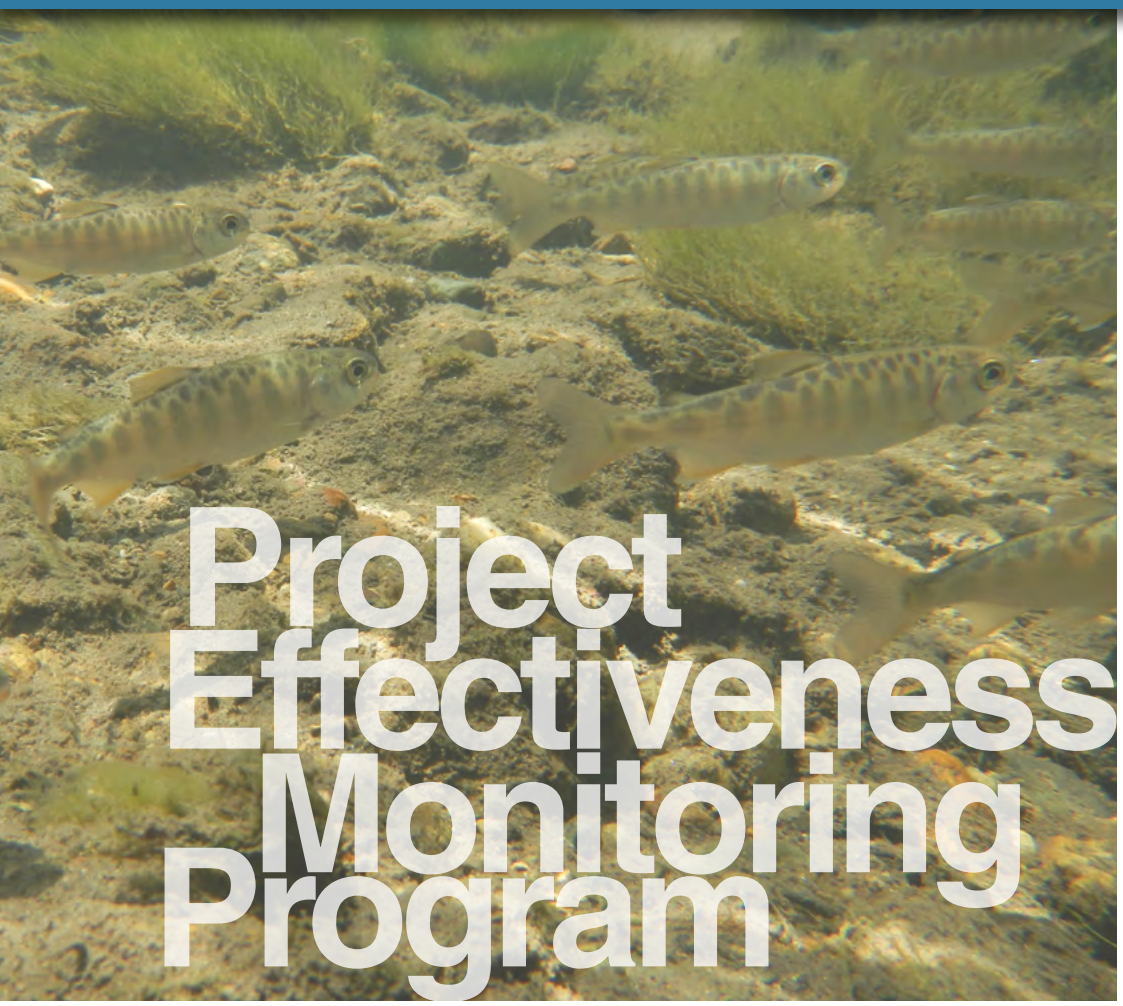
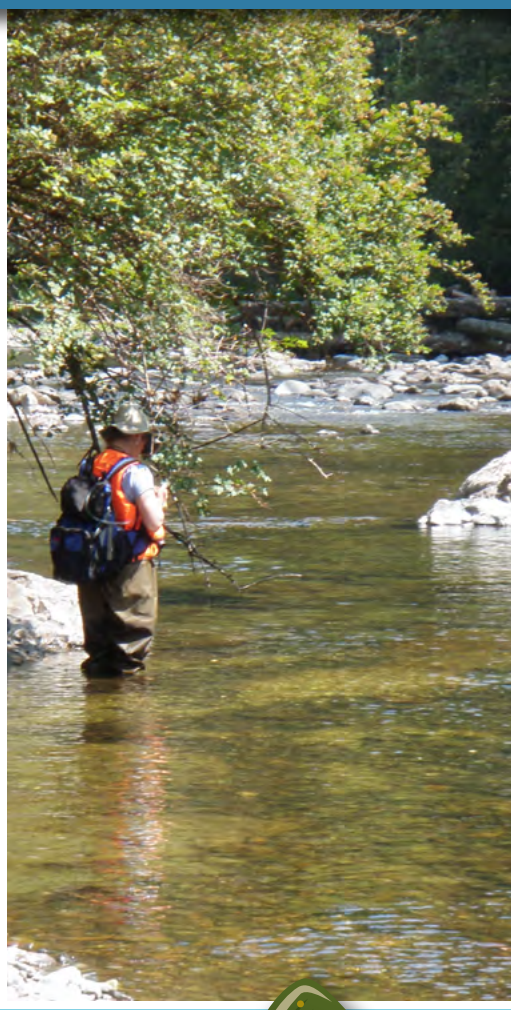
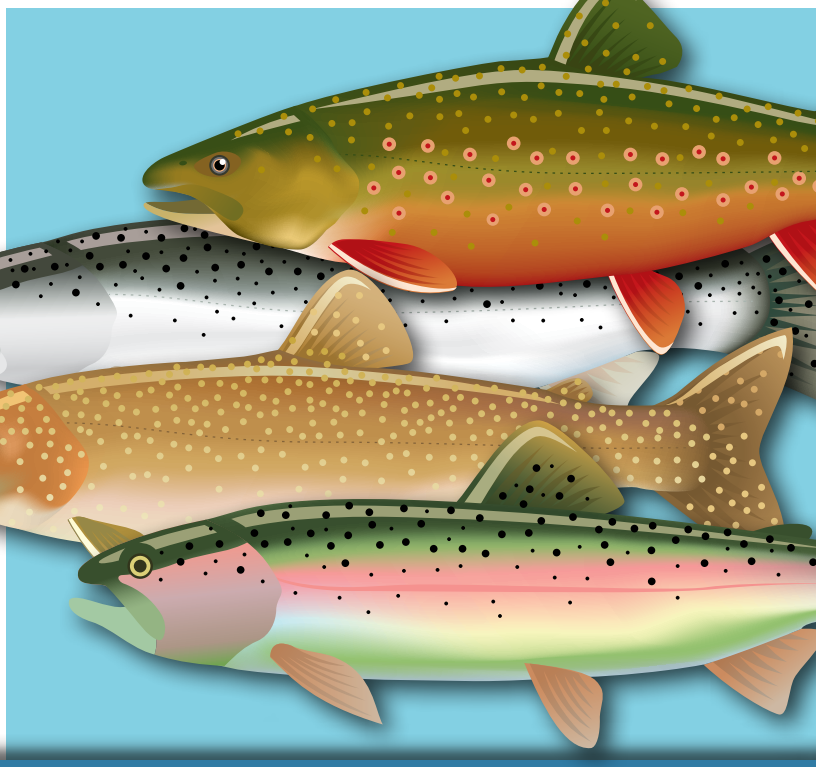
2015 ANNUAL REPORT



Project Effectiveness Monitoring Program

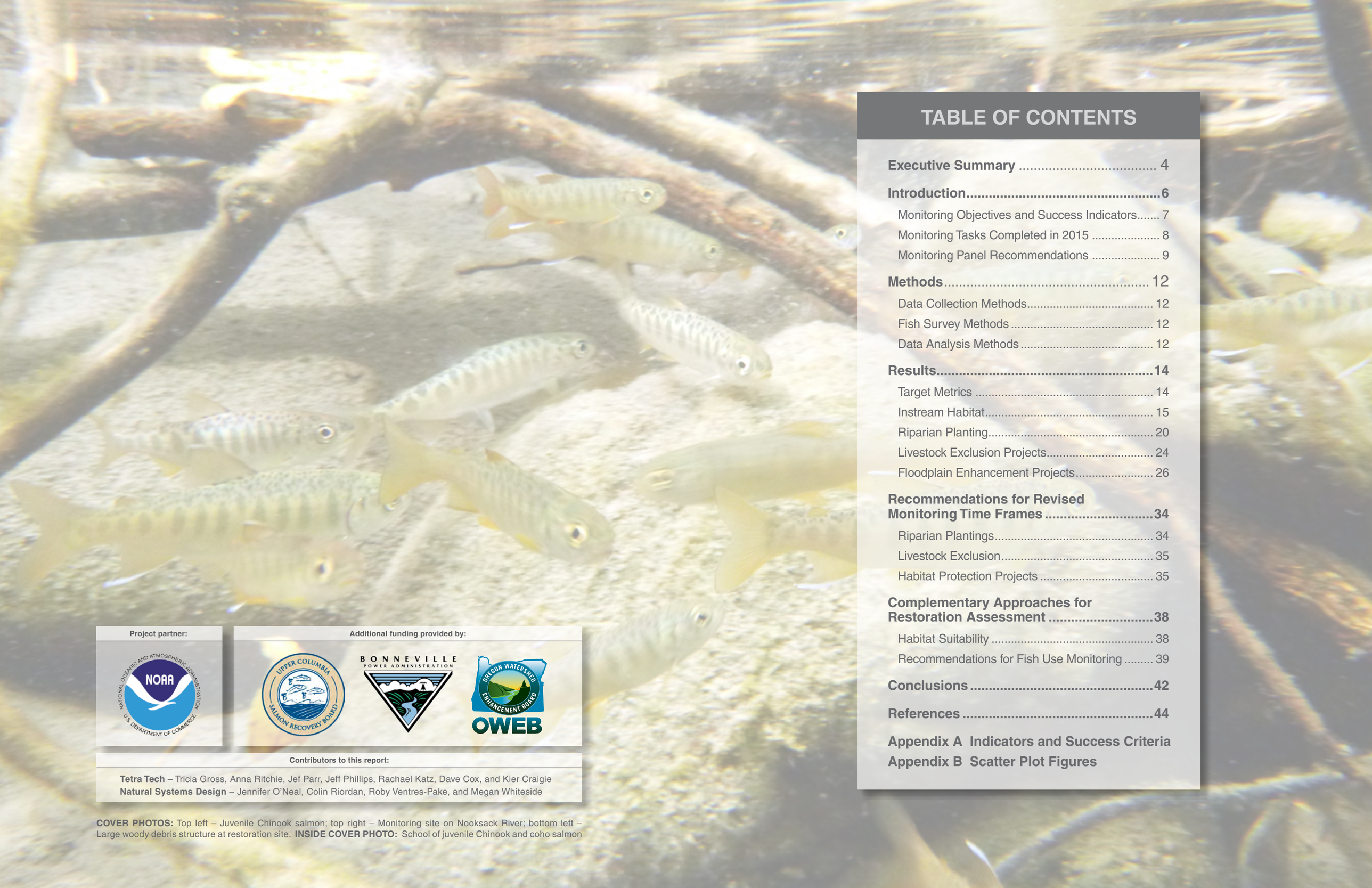




April 2016

WASHINGTON STATE
RECREATION AND CONSERVATION OFFICE
Salmon Recovery
Funding Board

TETRA TECH



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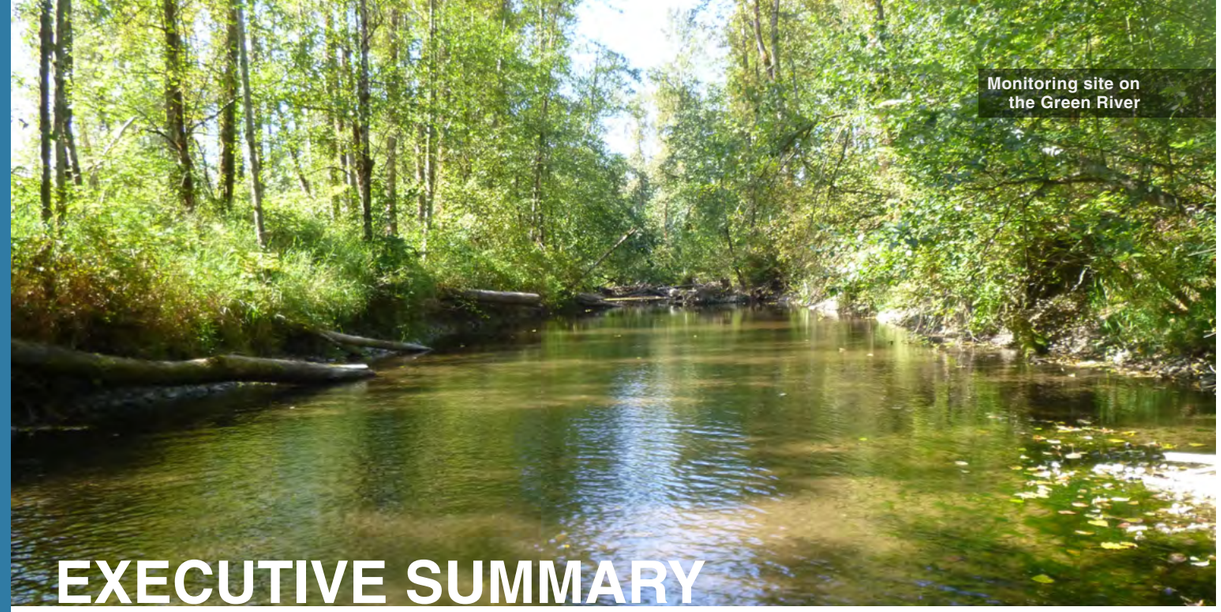
COVER PHOTOS: Top left – Juvenile Chinook salmon; top right – Monitoring site on Nooksack River; bottom left – Large woody debris structure at restoration site. **INSIDE COVER PHOTO:** School of juvenile Chinook and coho salmon


Monitoring site on the Green River

EXECUTIVE SUMMARY

Since 2004, Washington State has conducted a stream habitat restoration effectiveness monitoring program. The Reach-Scale Effectiveness Monitoring Program is funded and supervised by the Salmon Recovery Funding Board (SRFB) and the Governor's Salmon Recovery Office (GSRO). The program is designed to provide feedback on the efficacy of restoration projects at improving stream habitat and local salmonid abundance, with the goal of informing and improving restoration science and implementation. The projects monitored under the program are classified into eight restoration categories, five of which continue to be monitored today: Instream Habitat, Riparian Planting, Livestock Exclusion, Floodplain Enhancement, and Habitat Protection. Because the monitoring is programmatic, it uses standardized protocols to measure and evaluate each project within a given restoration category. The intent of the standardization is to allow for conclusions to be drawn across entire categories of projects and answer questions such as: *Do livestock exclusion projects reduce stream bank erosion?*

Following more than a decade of restoration monitoring under this program, the SRFB Monitoring Panel conducted an extensive review of the Reach-Scale Effectiveness Monitoring Program in 2015. Three recommendations for the program were identified by the panel:

1. Defer sampling of all sites that include a riparian canopy cover as a measure of success and review riparian planting data to determine if waiting additional years to collect data will help detect a response in vegetation from restoration actions.
2. Work with the Panel to identify a revised fish sampling approach to ensure seasonal use of restoration projects by target species is adequately documented.
3. Coordinate with the Panel to develop an improved approach to interpreting and communicating monitoring results in order to provide more meaningful feedback to restoration practitioners, planners, and policy makers.

Tetra Tech and Natural Systems Design have been working with GSRO staff and the Monitoring Panel to address the recommendations that were made. Data review and analysis was completed on the riparian vegetation data discussed in this report. It was determined that delaying the collection of additional riparian data may help improve the likelihood of detecting a significant response in riparian indicators; however, this is not certain. Variability among site conditions at Riparian Planting, Livestock Exclusion, and Habitat Protection projects plays a role in this uncertainty. Efforts are currently underway to identify a revised fish sampling approach in coordination with GSRO staff and the Monitoring Panel. A proposed revised fish sampling approach has been developed and consists of targeted seasonal snorkel surveys to coincide with when target species of fish are expected to be using restoration sites. It also describes the potential integration with existing passive integrated transponder (PIT) tagging systems in some regions of the state, which would allow gathering of additional data at minimal cost. Communications with the SRFB Monitoring Panel are also ongoing, and will include discussions about improved interpretation and communications of monitoring results in 2016.

Analysis of the category-level indicators was performed for the following project categories included data collected in 2015: Instream Habitat, Riparian Planting, Livestock Exclusion, and Floodplain Enhancement. The analyses found that each category of projects was successful in improving some indicators, but not all. Instream habitat projects have successfully improved pool habitat and large woody debris abundance, but as a category, have not increased localized salmonid abundance for any target fish species (Chinook, coho, *Oncorhynchus mykiss* [rainbow trout/steelhead], or bull trout (*Salvelinus confluentus*). Riparian planting projects have been successful in ensuring planting survival, improving woody cover, and improving riparian communities by increasing the proportion of reaches with canopy, understory, and ground cover. However, planting projects have not been as successful at decreasing stream bank erosion or improving stream shading. Livestock exclusion projects have shown decreases in stream bank erosion and improvements in stream shading, but have not successfully increased the proportion of reaches with canopy, understory, and ground cover vegetation to date. As a category, floodplain enhancement projects have successfully improved connectivity of streams to their floodplains and increased localized densities of juvenile Chinook and coho. Several other habitat metrics have not significantly changed after restoration, however, including pool habitat and riparian condition. Densities of juvenile *O. mykiss* have also not shown substantial increases following restoration.

Beyond the category-level analyses, efforts are underway to provide various types of additional feedback on restoration projects across the region. The Upper Columbia Salmon Recovery Board (UCSRFB) and the Bonneville Power Administration (BPA) are using habitat suitability modeling to aid in project planning by modeling and evaluating the potential habitat benefits of restoration actions. Habitat suitability modeling can be applied to numerous projects in the Instream Habitat and Floodplain Enhancement categories where topographic surveys are collected. Video documentation of fish use of restoration projects is also being to be used at certain projects where snorkel surveys are conducted. The collection of underwater video to document fish use can be done with minimal additional effort when snorkel surveys are performed. Such video documentation helps illustrate how fish are (or are not) using features of restoration projects.

INTRODUCTION

Pacific salmon are a cornerstone of culture and economy in the Pacific Northwest. In the twentieth century and early in the twenty-first century, salmon populations declined to the point where Endangered Species Act (ESA) protection was enacted (in the mid-1990s) for several Evolutionarily Significant Units (ESUs). As part of the recovery plans for listed ESUs, stream habitat restoration has been recommended and applied prolifically throughout the region, at a cost of nearly half a billion dollars since 1999 in Washington state alone. In 2004, Washington State established a project-scale effectiveness monitoring program to assess the response of stream habitat and localized salmon populations to the restoration efforts.

The goals of Project Effectiveness Monitoring Program were to address several management questions developed by the Salmon Recovery Funding Board (SRFB) and the Governor's Salmon Recovery Office (GSRO), including:

1. *Are restoration treatments having the intended effects in terms of improvements in localized habitats and use by salmon?*
2. *Are some treatment types more effective than others at achieving specific results?*
3. *Can project monitoring results be used to improve the design of future projects?*

The Project Effectiveness Monitoring Program monitors a subset of the restoration projects funded under the SRFB, in several discrete categories. Eight categories of commonly implemented project types were chosen for monitoring, and can be generally described as:

- MC-1 – Fish Passage (culverts, bridges, dam removal)
- MC-2 – Instream Habitat (placement of rock or wood in the active channel)
- MC-3 – Riparian Planting (planting within the riparian areas to provide shade)
- MC-4 – Livestock Exclusion (install fencing to protect vegetative buffers and reduce erosion)
- MC-5/6 – Floodplain Enhancement (floodplain connectivity, remove levees, reconnect or create off-channel habitat)
- MC-7 – Spawning Gravel (supplement natural gravels in spawning-limited systems)
- MC-8 – Diversion Screening (prevent fish entrainment into water diversion systems)
- MC-10 – Habitat Protection (protect high-quality habitat for its existing function)

Of the original eight categories of monitoring projects, only five are currently active in the program. Fish passage projects are no longer monitored because results indicated that if projects were implemented appropriately and suitable habitat was present, fish would move upstream and utilize newly available habitat. Similarly, diversion screening projects were shown to be successful if maintained adequately over time, so monitoring of that category was discontinued. A sufficient number of spawning gravel projects were not originally included in the sample pool to allow for assessment of this category, so that monitoring has been discontinued.

Monitoring protocols were developed for each project category that describe sampling timing, field data collection methods, analysis methods, and success indicators. In addition to the projects funded through SRFB, the Upper Columbia Salmon Recovery Board (UCSRB) and the Oregon Watershed Enhancement Board (OWEB) provided funding to support sampling of projects administered under their respective organizations, using the same protocols employed for the SRFB program. Projects from the UCSRB and OWEB have been be added to the SRFB sample set for analysis, which provides additional projects for evaluation in the Instream Habitat, Livestock Exclusion, and Floodplain Enhancement categories.

Table 1 lists the project categories and the number of projects monitored under this program in each category, as well as the monitoring schedule, the year that monitoring of the category began, and the anticipated completion year. One year of pre-project data are typically collected, (referred to in Table 1) and in the protocols as Year 0. All other years generally refer to the amount of time after the restoration action has been implemented (e.g., Year 1 = 1 year after restoration, Year 10 = 10 years after restoration). The completion year for an entire monitoring category is 10 years after the last project is added to a category, and therefore is contingent upon the implementation timing of the last project in each category.

Monitoring Objectives and Success Indicators

The same protocol and data analysis procedures are used to evaluate projects within a given monitoring category. Using the same procedures allows the performance of each indicator to be compared across projects in each category. The objective of the Project Effectiveness Monitoring Program is to evaluate the success of projects at the category level, and thus, providing feedback on how the suite of projects in a monitoring category are affecting the desired physical and biological conditions impacting salmonid populations. For example, Livestock Exclusion projects are evaluated to determine if placing fencing around a stream to keep out livestock reduces stream bank erosion.

To account for environmental variability beyond the influence of the restoration actions, a second untreated reach is also monitored each time the treated reach is sampled, which is referred to as a control reach. Control reaches are selected based on certain criteria including proximity and similarity to the impact, or treatment, reach; certainty that no actions will be taken within the chosen control reach over the full monitoring period; and sufficient access to the site. The changes in conditions at the treated reach are compared to changes at the control reach, so any net difference in an indicator used to evaluate a project is relative to the natural variability at the control reach. The collection of one sample before restoration (Year 0) also allows the conditions after the restoration action was implemented to be compared to conditions before restoration was conducted. The combination of the collection of pre-restoration data and the use of a control reach are known as a Before-After Control-Impact (BACI) study design, where success indicators are evaluated relative to pre-treatment levels and environmental variability.

Specific criteria were established for each project indicator, and the combination of indicators that meet those criteria are used to provide feedback on whether the projects as a category are achieving their overarching goals as defined by the monitoring protocols. Appendix A provides a table showing the indicators for each project category, as well as the success criteria for each indicator and the statistical tests used to evaluate them. All the information provided in Appendix A is also available in each of the individual project category monitoring protocols, along with detailed descriptions of the data collection and analyses techniques used to create and evaluate each metric and indicator. Monitoring protocols for all categories can be found at: http://hws.ekosystem.us/monitoring.

While the focus of the Restoration Effectiveness Monitoring Program is to analyze the success of all projects within a

Table 1. Summary of Monitoring Activities under the Active Categories in the SRFB Project Effectiveness Monitoring Program

Monitoring Category	Number of Projects	Monitoring Years	Year Monitoring Was Initiated	Year Monitoring Will Be Completed
MC-2 Instream Habitat	21	0, 1, 3, 5, 10	2004	2026[1/]
MC-3 Riparian Planting	9	0, 1, 3, 5, 10	2004	2018[2/]
MC-4 Livestock Exclusion	5	0, 1, 3, 5, 10	2004	2016[2/]
MC-5/6 Floodplain Enhancement[3/]	22	0, 1, 3, 5, 10	2004	2026[1/]
MC-10 Habitat Acquisition	10	0, 3, 8, 12	2004	2018[2/]

1/ Projects were added in 2012 and 2013 to MC-2 and MC-5/6 categories, which leads to later completion date to collect all 11 years of data.
2/ Initial completion date; Subject to change based upon deferment of monitoring in 2016 to re-evaluate sampling schedule.
3/ MC-5 Constrained Channel and MC-6 Channel Connectivity were combined to a single category in 2010, MC-5/6 Floodplain Enhancement. Original sampling schedule for MC-5 projects was 0, 1, 2, 5, and 10 years, and for MC-6 projects 0, 1, 2, and 5 years.

monitoring category, results from individual projects can help inform why a category may or may not be meeting success criteria. As a result, scatter plots were generated for project metrics for each site in a category and are provided for reference in Appendix B. These plots can be helpful in describing or understanding why a trend is not statistically significant, such as where site response is highly variable across a category.

Use of monitoring data to improve project designs and planning is an ongoing effort that continues to develop as more effective communication strategies between communities of scientists, project designers, and project sponsors are identified. Figure 1 shows the recovery cycle and illustrates how the exchange of information plays a role throughout the process.

Monitoring Tasks Completed in 2015

Project effectiveness monitoring in 2015 under the SRFB program included data collection at 23 project sites across the state of Washington (see Figure 2). Of these sites, eleven (11) were Instream Habitat, five (5) were Riparian Planting, one (1) was Livestock Exclusion, and six (6) were Floodplain Enhancement projects. Additionally, topographic data were processed, data from all of the projects in the SRFB program were analyzed, data sets from other programs were integrated into the analysis, and an annual monitoring report was developed. Monthly progress reports containing information on accomplishments and outreach efforts over the previous reporting periods were also developed and are available through the Project Information System (or PRISM) website at http://www.rco.wa.gov/prism_app/about_prism.shtml.

Collaboration with other monitoring programs and coordination with project sponsors and local monitoring entities (lead entities and regional staff) are also supported as part of this project. Work in 2015 in this arena included a presentation at the 2015 Salmon Recovery Conference and several presentations for both the Snake River Region (Tucannon Coordinating Committee and the Snake River Science Conference) and the Upper Columbia Implementation Team workshops. Coordination of data collection between the SRFB, UCSRB, and Action Effectiveness Monitoring programs has increased the utility of and interest in the data collected as part of the SRFB program. Multi-season snorkel surveys conducted as part of the UCSRB program have also expanded the temporal element of the fish surveys at some of the SRFB sites in the Upper Columbia region. Ongoing collaboration with other monitoring entities across Washington and the Columbia region will continue to provide value to this program.

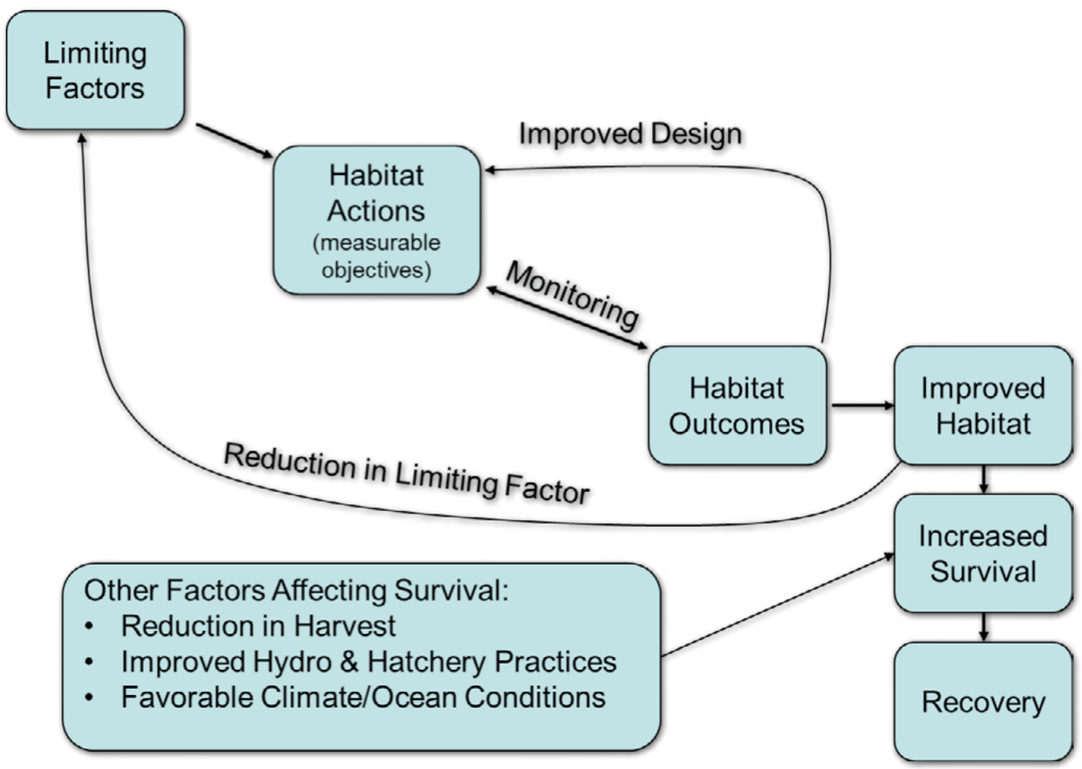


Figure 1. Information Flow through the Salmon Recovery Cycle

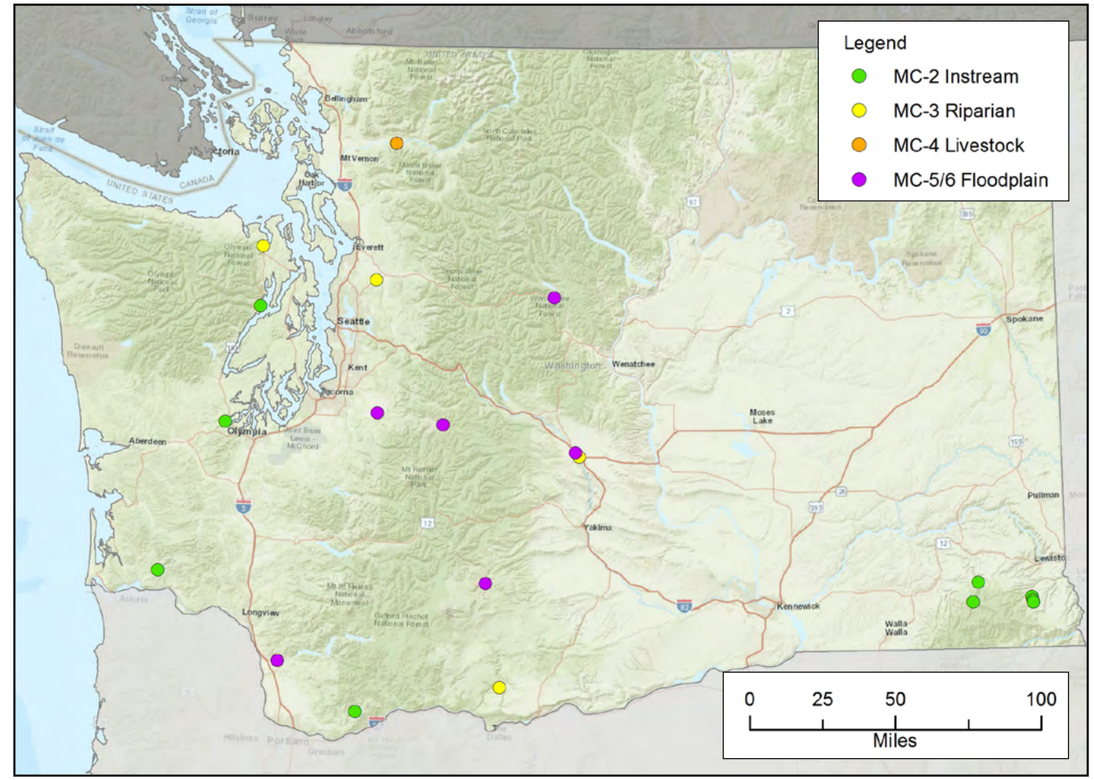


Figure 2. 2015 SRFB Monitoring Locations

Monitoring Panel Recommendations

In 2015, the SRFB Monitoring Panel performed an in-depth evaluation of the Project Effectiveness Monitoring Program. The evaluation resulted in feedback and recommendations from the Panel designed to improve the program and increase the value and utility of monitoring data. Three primary recommendations were issued by the Panel:

1. All monitoring at sites which include a component of riparian canopy cover as a success criteria (riparian restoration, livestock exclusion, and habitat protection) will be deferred and should not be conducted in the 2016 field season. The contractor will provide the Panel with a proposed schedule for these sites with a revised monitoring return interval that will allow sufficient time for these sites to feasibly meet riparian forest canopy success criteria.
2. The contractor will work with the Panel to discuss the merits and feasibility of developing a more robust sampling plan that includes repeated measures throughout the season when target species are known to be present.
3. The contractor will meet with the Monitoring Panel to develop a feasible alternative to interpreting and reporting on the project effectiveness monitoring data in order to strengthen this component of the study.

Riparian Planting, Livestock Exclusion, and Habitat Protection project categories all monitor riparian canopy and include it as a measure of success, and were specifically identified by the Monitoring Panel as those categories that should be deferred until sampling frequency and schedule could be re-evaluated. Results to date for all three categories have shown little to no response in riparian canopy from restoration actions, and additional analysis suggests that this is primarily due to the time required for shrubs and trees to grow to heights that would provide canopy cover over streams. This suggests that the current 10-year time frame for monitoring is not likely sufficient to see a substantial change in canopy cover. For 2016, monitoring in all three categories will be deferred to allow further

investigation into a more appropriate sampling schedule to detect a reliable response in riparian canopy cover. The results of that investigation and recommendations for a revised sampling period are discussed under the *Recommendations for Revised Monitoring Time Frames* section of this report.

Currently, fish sampling is typically conducted using snorkel surveys at the same time as the physical habitat assessment during summer low-flow periods across all the monitoring sites. This approach was employed based on the initial study design and the need to link habitat measurements, which can only be done at lower flows, with fish sampling. However, for some species, such as Chinook salmon, the timing of habitat use by juveniles primarily occurs outside of the low flow season. Previous monitoring reports discussed the limitations of this approach and noted that the original intent of the study design was to try and assess project use by juveniles of multiple species (Chinook, coho, and steelhead), and was limited to a single season by budget limitations. Given that juvenile Chinook use in summer months for some projects may have been low regardless of restoration due to migration timing and life history variation, a need to extend the sampling effort at projects where utilization likely occurs during fall, winter, or spring was identified.

To address the seasonal data gap, a revised fish sampling approach is currently being developed in collaboration with the GSRO and the Monitoring Panel that will ultimately result in a more robust and comprehensive picture of fish use at restoration projects. The details of the approach are still under development, but the proposed methodology includes fish sampling events to be conducted during several seasons throughout the year to better assess the range of life history patterns for juvenile salmonid species present at project sites. Under this approach, sampling would be more frequent to capture seasonal differences in fish use and timing would be determined based on specific target fish species. Additionally, integration with existing fish monitoring infrastructure (e.g., PIT tag arrays, screw traps) could potentially be leveraged where feasible to evaluate longer-term fish responses to restoration efforts.

Interpretation and presentation of monitoring results is an integral part of the Project Effectiveness Monitoring Program. The program is intended to provide feedback on the response of stream ecosystems and salmonids to restoration actions, in order to improve restoration and ensure that the most effective restoration actions to cause the desired improvements in stream habitat and fish response are being implemented. Analysis, interpretation, and communication of the results from monitoring is, therefore, a cornerstone of the program. The comments from the Monitoring Panel included a request for additional details in evaluation of data, specifically in information that could be directly utilized by monitoring practitioners. Discussions with the Monitoring Panel are planned for 2016 to better understand their needs and help shape the approach for that additional analysis in future years of the program.

METHODS

Data Collection Methods

Under the Project Effectiveness Monitoring Program, data collection is standardized and follows the same protocols for each project in a monitoring category. Data is collected for metrics such as changes in stream and floodplain topography (Figure 3), pool characteristics, and sediment and riparian conditions. Protocols are available for viewing online at: http://hws.ekosystem.us/monitoring. A more detailed description of methodology is also discussed in the 2014 Annual Monitoring Report (Tetra Tech 2015). Please refer to those materials for more information on data collection methods, as well as quality assurance and quality control procedures.

Fish Survey Methods

Fish surveys typically take place during the summer low-flow season and include primarily snorkel surveys (see Figure 4). Electrofishing may be used in rare cases if specific site conditions require it (e.g., highly degraded water quality that is unsafe for snorkelers); however, no electrofishing was conducted in 2015. As discussed in the *Monitoring Panel Recommendations* section of this report, the fish sampling methodology is currently under evaluation following recommendations from the SRFB Monitoring Panel. In 2016, work with the GSRO and the Monitoring Panel will continue in an effort to revise the fish sampling methodology to better capture seasonal usage of restoration projects by juvenile salmonids, addressing a key concern of the Monitoring Panel regarding low fish use observations for Chinook salmon documented during the typical summer low-flow survey timeline.

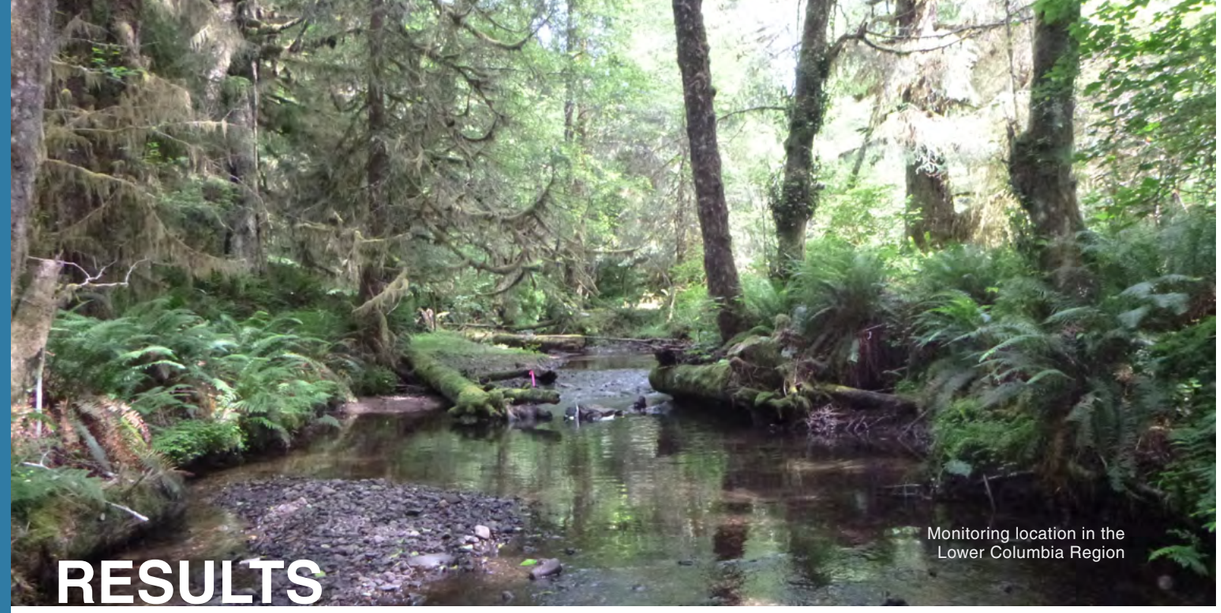
Data Analysis Methods

Under this program, data are analyzed at the category scale by pooling all sites for a given monitoring category together. Linear regression lines are generated to aid in providing an overall trend in each indicator by category. Results for individual sites may be evaluated to better understand the category-level results, but changes at individual sites are not tested for statistical significance.

For category-level analyses, two tests for change are performed. To account for natural variability, change at treated (impact) reaches is assessed relative to change at untreated (control) reaches, by taking each indicator and subtracting the control value from the impact reach value (i.e., relative value = impact reach – control reach). The first test is the difference between the average pre-project condition and the average post-project condition. For post-project conditions, all years of data collected after restoration are combined and averaged to provide an average response of each indicator for all projects in a given category. The second test assesses the change over time by averaging the data for each monitoring year (e.g., all Year 1 data are averaged, all Year 3 data are averaged) and testing to see if the slope of the average change over each monitoring year is significantly different from zero. For both methods, a two-tailed t-test is used to test for significance with an alpha = 0.10. Data are also assessed for normality before performing the t-tests using a Shapiro-Wilks (alpha = 0.05). If the dataset failed the normality test, a two-tailed nonparametric t-test (Wilcoxon test; alpha = 0.10) was used to assess significant trends.

Figure 3. Topographic Survey of Instream Habitat

Figure 4. Snorkel Survey in Salmon Creek



Monitoring location in the Lower Columbia Region

RESULTS

Target metrics were analyzed for the four project categories monitored in 2015 and the results from each of the category-level analyses are presented below. Please refer to the 2014 Annual Monitoring Report (Tetra Tech 2015) for analysis results for other monitoring categories. Additional analysis regarding sampling timing and riparian metric response for Habitat Protection projects is presented in the *Recommendations for Revised Monitoring Time Frames* section of this report.

Target Metrics

Many of target metrics evaluated in this analysis are shared across categories, as shown in Table 2. Descriptions of each of the metrics analyzed are provided below.

Vertical Pool Profile Area

Vertical pool profile area is the area of pool habitat available, relative to residual pool profile depth. Residual pool calculations provide a standardization of pool area, to account for variability in flow. The indicator does not, however, allow for calculations when the channel is dry. If a channel is dry, vertical pool profile area is reported as zero.

Average Residual Pool Depth

The average residual pool depth metric is the average of the residual depths that would be left if surface stream flows were discontinued. This provides a way to standardize depth measurements across different flows, as theoretically, the residual pool depth will only change when there is a change in base topographical conditions, such as scouring or filling in of a pool as a result of flow redirection. As with vertical pool profile area, calculation of residual pool depth is not possible with streams that were dry at the time of survey, so dry channels have a residual depth of zero.

Table 2. Metrics Analyzed for Projects Monitored in 2015

Metrics Analyzed	Project Category			
	MC-2 Instream Habitat	MC-3 Riparian Planting	MC-4 Livestock Exclusion	MC-5/6 Floodplain Enhancement
Vertical Pool Profile Area	■			■
Average Residual Pool Depth	■			■
Large Woody Debris Volume	■			
Juvenile Salmonid Density	■			■
Bank Erosion		■	■	
Canopy Cover		■	■	■
Riparian Vegetation Structure		■	■	■
Riparian Planting Survival		■		
Percent Woody Cover		■		
Average Channel Capacity				■
Floodprone Width				■

Large Woody Debris Volume

Large woody debris (LWD) is of interest in restoration because it functions as a structural driver of stream geomorphology, flow diversity, and as a cover component. LWD is counted throughout the reach and binned into size categories. For reporting, LWD volume is transformed to log base 10 ($\log_{10}$) to normalize the data for analysis.

Juvenile Salmonid Density

Salmonid densities provide an indicator of juvenile fish use. Densities are calculated for the entire reach after snorkel or electrofishing surveys. Additional habitat data is collected during these surveys to inform use of restoration site attributes and/or preferences for different habitat conditions. See the 2014 Annual Report (Tetra Tech 2015) for further discussion on these types of investigations.

Bank Erosion

Bank erosion is measured as the percent linear distance along the banks within the survey reach over which active bank erosion is occurring. Bank erosion is only documented when it is considered active erosion above the bankfull channel. This means, for example, that a stream where a slide occurred 5 years ago, but where vegetation has re-established and sediment is no longer sloughing off, is not considered to be an actively eroding bank.

Canopy Cover (Densiometer Readings)

Canopy cover, or stream shading, is a measure of the stream bank shading provided by riparian vegetation. This metric is the average of left and right bank densiometer readings. The shading estimate includes contributions from immediate bankside vegetation, such as tall grasses, bushes, and overhanging vegetation, as well as from taller trees that are farther away from the bank. Shading estimates are provided as a direct average of the densiometer values. Percentage shading estimates can be calculated by dividing the mean value by 17 (the maximum number possible for this technique) and multiplying the result by 100.

Three-layer Riparian Vegetation Structure

Three-layer riparian vegetation structure is an indicator of the complexity of the riparian vegetation. The indicator requires that all three layers of riparian vegetation (canopy, understory, and groundcover) be present at the point measured. If "none" is entered for vegetation type for any layer, that data point receives a value of zero.

Riparian Planting Survival

Riparian planting survival is only collected at the impact reach, and only during Year 1 and Year 3 monitoring. The success criteria for survival is 80 percent or greater of plantings are alive in Year 3. After Year 3, it is very difficult to accurately detect which plants were from the original plantings and which are a result of volunteer growth; therefore, bank erosion, shading, and three-layer riparian structure are used to evaluate projects following Year 3. Additionally, since riparian planting survival is assessed by counting the living plants in riparian planting plots and individual plantings are not tagged, Year 3 values can be higher than 100 percent if volunteers have started growing in the plots between the monitoring years and are inadvertently counted during the Year 3 survey.

Percent Woody Cover

The percent of woody cover is only collected in the impact reach. This metric evaluates the continued development of riparian plantings beyond the time frame over which it is possible to accurately assess survival. As a result, this metric is not monitored in Year 0. Percent woody cover is an estimated percent of the area within each riparian planting plot that is covered by woody vegetation. This metric helps support the riparian vegetation structure metric described above, as growth of woody vegetation leads to development of understory and canopy layers.

Average Channel Capacity

Average channel capacity is an indicator of the amount of water that can be held within a stream channel. A decrease in channel capacity means less water can be contained in a channel, and more flow would be spilled out onto the floodplain. Therefore, a reduction in channel capacity is the desired change for floodplain enhancement projects, as it indicates a greater connection with the floodplain.

Floodprone Width

Floodprone width is an indicator of the floodplain area around a channel that may be inundated during floods. Floodprone width should decrease in confined systems once the levees or other constraining features are removed or set back, offering more access to the floodplain.

Instream Habitat

There are 24 sites included in the analysis for the MC-2 Instream Habitat project category (Table 3). These include sites monitored as part of the SRFB Project Effectiveness Monitoring Program and sites monitored under the Upper Columbia Salmon Recovery Board (UCSRB) Effectiveness Monitoring Program. These are included as part of the dataset to increase sample size and robustness of the analyses.

Analyses were conducted for three habitat indicator metrics and four fish indicator metrics for this category. Projects in this category vary in age, relative to the time of implementation, and the number of years of post-implementation monitoring. The category metrics were assessed by comparing average change in each metric across the category. In addition to group averages, scatter plots were also generated to provide further explanation of project results (see Appendix B).

Average Difference Pre- vs Post-Implementation

Box plots were generated for all sites with post-implementation data. Pre-project data are an average of the difference between impact and control reaches of all sites for Year 0. Post-project data are an average of the difference across all post-implementation years and therefore represent not a trend analysis but a mean of the data collected during all post-project years.

Habitat Indicators

Three habitat indicators (vertical pool profile area, average residual pool depth, and $\log_{10}$ LWD volume) were assessed for pre- and post-implementation responses for MC-2 Instream Habitat projects. The indicators were tested to see if the pre-project values were significantly different from average post-project values, and the results of the tests are provided in Table 4.

Vertical pool profile area, average residual pool depth, and $\log_{10}$ LWD volume were analyzed for average pre- and post-implementation differences and tested for statistical significance. For project success in the MC-2 category, the three metrics should significantly increase post-implementation compared to pre-implementation. All three indicators were significantly greater post-implementation than pre-implementation, indicating instream habitat projects were successful at improving pool habitat and LWD volume (Table 4 and Figures 5 through 7). Additionally, all three indicators were higher at control reaches pre-project and were higher at impact reaches post-project.

Juvenile Chinook, coho, *O. mykiss*, and bull trout densities were analyzed for average densities and tested for statistical differences before and after restoration (Table 5). For the analyses, any projects without a species present during any year of monitoring were omitted from that species analysis (e.g., all projects without any Chinook observations were omitted the Chinook analysis). MC-2 projects should increase salmonid densities to meet the fish response success criteria established for the category.

Table 3. Projects Included in the MC-2 Instream Habitat Analyses

Project Number	Project Name	Description
02-1444	Little Skookum Creek Phase II	LWD placement and planting on Little Skookum Cr near Shelton, WA
02-1463	Salmon Creek	Channel regrading and LWD placement in Pacific County
02-1515	Upper Trout Creek	LWD placement and planting tributary to Wind River
02-1561	Edgewater Park	Side channel creation and LWD placement on Skagit R in Mt. Vernon, WA
04-1209	Chico Creek	LWD placement project near Shelton, WA
04-1338	Lower Newaukum Creek	ELJ placement on tributary to Green River near Auburn, WA
04-1448	Grays River PUD Bar	Wood and rock veins with planting on Grays River near Roseburg, WA
04-1575	Upper Washougal River	Sediment trapping ELJs on Washougal River
04-1589	Dungeness River Railroad Bridge	ELJ placement on Lower Dungeness River in Sequim, WA
04-1660	Cedar Rapids	LWD and ELJ placement with planting on Cedar River near Renton, WA
05-1533	Doty Edwards	LWD placement and planting on Cedar Creek, tributary to NF Lewis River
07-1803	Skookum Reach	Bank LWD structures on South Fork Nooksack River near Acme, WA
11-1315	Eagle Island	LWD placement, however much of it is outside the study reach
12-1657	George Creek Wildlife Area	LWD placement channel remeander on tributary to Asotin Creek
SF-F3 P2BR	South Fork Asotin Creek Lower 1	Beaver dam analog placement in Asotin Creek IMW
SF-F3 P3BR	South Fork Asotin Creek Lower 2	Beaver dam analog placement in Asotin Creek IMW
SF-F4 P1	South Fork Asotin Creek Upper 1	Beaver dam analog placement in Asotin Creek IMW
SF-F4 P2	South Fork Asotin Creek Upper 2	Beaver dam analog placement in Asotin Creek IMW
PA14	Tucannon Project Area 14	LWD and ELJ placement on middle Tucannon River
PA26	Tucannon Project Area 26	LWD placement and levee removal on middle Tucannon River
PA3	Tucannon Project Area 3	LWD and ELJ placement in upper Tucannon River
UCSRB	Eightmile Ranch	Bank stabilizing LWD structures on Chewuch River
UCSRB	Chewuch Rivermile 10 mainstem	ELJ structures on Chewuch River
UCSRB	Goodfellow	Bank Stabilizing LWD structures on Mainstem Wenatchee River

Table 4. Average Difference between Impact and Control Reaches (impact – control) for Pre- and Post-Implementation Analysis Results for MC-2 Habitat Indicators (alpha = 0.1)

Indicator	Sample Size	Pre-Project Mean	Post-Project Mean	Mean Difference	Test	P-value
Vertical Pool Area (m^2)	24	-5.908	13.390	19.298	Paired Wilcoxon test	< 0.001
Average Residual Pool Depth (cm)	24	-1.045	3.396	4.441	Paired Wilcoxon test	0.004
Log_{10} LWD Volume (m^3)	24	-0.279	0.449	0.728	Paired t-test	< 0.001

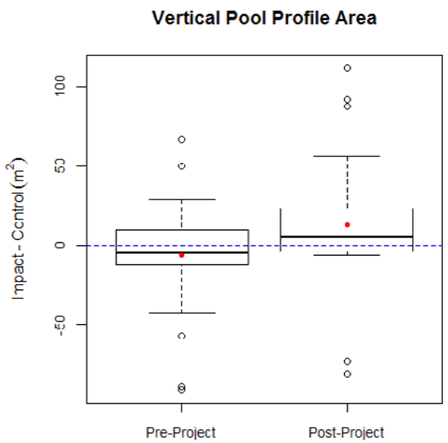


Figure 5. Average Pre- and Post-Project Vertical Pool Profile Area for MC-2 Projects

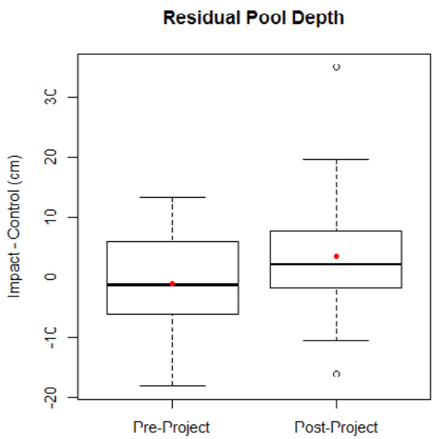


Figure 6. Average Pre- and Post-Project Residual Pool Depth for MC-2 Projects

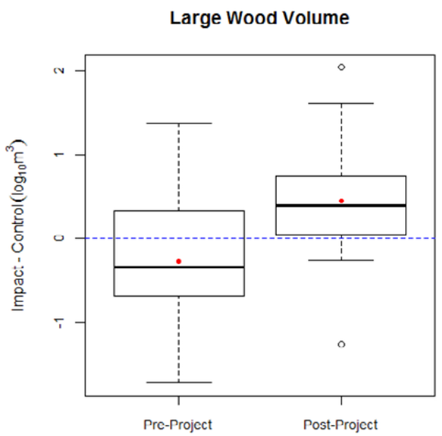


Figure 7. Average Pre- and Post-Project Log_{10} LWD Volume for MC-2 Projects

No statistical difference between pre- and post-restoration conditions was detected for any salmonid species analyzed (Table 5 and Figures 8 through 11). This result indicates that MC-2 projects did not increase salmonid use, and therefore did not meet the success criteria. Project-specific scatter plots (see Appendix B, Figures B-4 through B-7) provide further information on the distribution of salmonids across the projects. Of the 115 sites with Chinook salmon, only 4 projects had an increase in Chinook density post-implementation, and of those, only 2 increased relative to the control reaches. Coho were present at 12 sites and had mixed responses relative to implementation. Six of the sites showed increases, but only 4 increased relative to the control reaches, while 3 of the remaining sites showed less decrease relative to control. Juvenile *O. mykiss* were present at 23 sites, but only 9 of these showed increases in *O. mykiss* density relative to the control reaches. Bull trout were only present (at low densities) at 5 sites and only increased at 1.

Table 5. Average Difference between Impact and Control Reaches (impact – control) for Pre- and Post-Implementation Analysis Results for MC-2 Juvenile Salmonid Indicators (alpha = 0.1)

Indicator	Pre-project	Post-project	Test	P-value
Chinook density (fish/m^2)	0.00319	-0.00786	Paired Wilcoxon	0.421
Coho density (fish/m^2)	0.02603	0.01269	Paired Wilcoxon	0.970
O. mykiss density (fish/m^2)	0.00158	-0.00348	Paired t-test	0.771
Bull trout density (fish/m^2)	0.00012	-2.6x10^{-5}	Paired Wilcoxon	0.8125

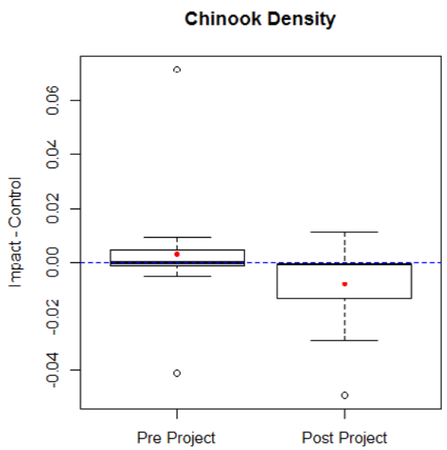


Figure 8. Average Pre- and Post-Project Juvenile Chinook Density for MC-2 Projects

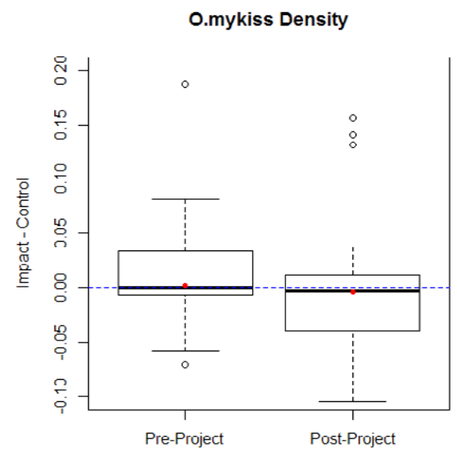


Figure 10. Average Pre- and Post-Project Juvenile *O. mykiss* Density for MC-2 Projects

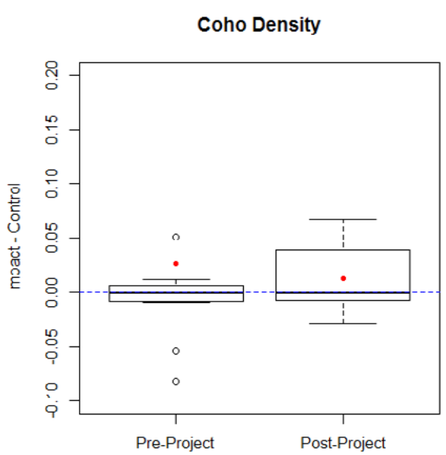


Figure 9. Average Pre- and Post-Project Juvenile Coho Density for MC-2 Projects

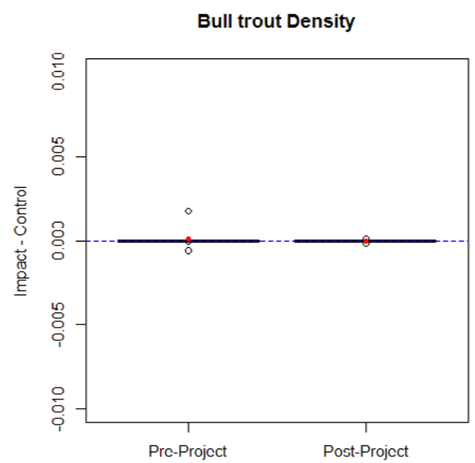


Figure 11. Average Pre and Post-Project Bull Trout Density for MC-2 Projects

Slope Method Analysis

In addition to assessing metrics for the category by mean difference, data were also analyzed by taking the rate of change between impact and control reaches, as measured by a linear slope regression, and assessing change over time to illustrate the direction of change, magnitude, and variability within the category. A positive mean slope showed that an indicator was increasing through time, and a negative slope mean showed that an indicator is decreasing through time. The same metrics were analyzed the for the MC-2 category using the slope method.

Habitat Indicators

Vertical pool profile area, average residual pool depth, and $\log_{10}$ LWD volume were analyzed for the average change per year and to determine if the change was significantly different from zero. Vertical pool profile area, average residual pool depth, and $\log_{10}$ LWD volume all had significantly positive slopes, meaning all three metrics had significantly increased over time (Table 6 and Figure 12). Positive significant slopes for all three indicators suggest that MC-2 projects are meeting success criteria for improving pool habitat and LWD abundance.

Juvenile Salmonid Density

Juvenile Chinook, coho, *O. mykiss*, and bull trout densities were analyzed for average change per year and statistically tested to see if changes were significantly different from zero. To analyze the average change per year in salmonid densities, any projects without a species present during any year of monitoring were omitted from that species' analysis. Results of these analyses indicated that none of the salmonid species evaluated have shown significantly increasing densities over time (Table 7 and Figure 13), suggesting that, on average, MC-2 projects have not been successful at increasing localized fish use at restoration sites. However, it is worth noting that some of the sites included in the analysis only include a single year of post-

Table 6. Slope Method Analysis Results for MC-2 Habitat Indicators (alpha = 0.1)

Indicator	Sample Size	Mean Slope (average change per year)	Direction of Change	Test	P-value
Vertical Pool Area (m^2)	24	5.103	Positive	Wilcoxon test	0.002
Average Residual Pool Depth (cm)	24	1.448	Positive	Wilcoxon test	0.005
Log_{10} LWD Volume (m^3)	24	0.265	Positive	Wilcoxon test	< 0.001

Table 7. Slope Method Analysis Results for MC-2 Juvenile Salmonid Density Metrics (alpha = 0.1)

Indicator	Sample Size	Test Type	Mean Slope (average change per year)	P-value
Juvenile Chinook density (fish/m^2)	16	Wilcoxon	-0.0157	0.301
Juvenile coho density (fish/m^2)	13	Wilcoxon	-0.0043	0.305
Juvenile *O. mykiss* density (fish/m^2)	24	Wilcoxon	-0.0216	0.353
Bull trout density (fish/m^2)	5	Wilcoxon	-6.07x10^{-5}	0.625

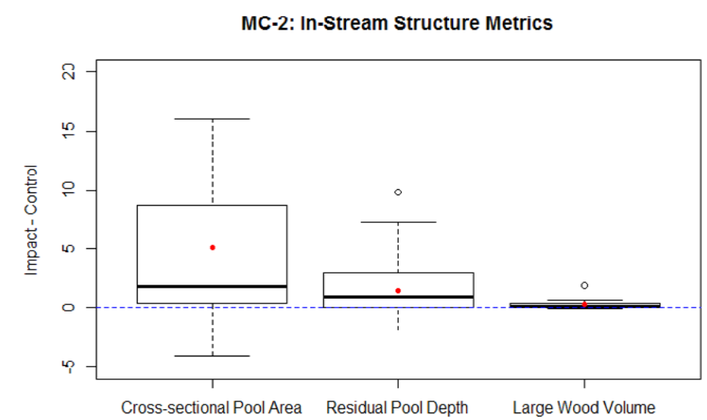


Figure 12. MC-2 Slope Analysis Box Plots for Habitat Indicators

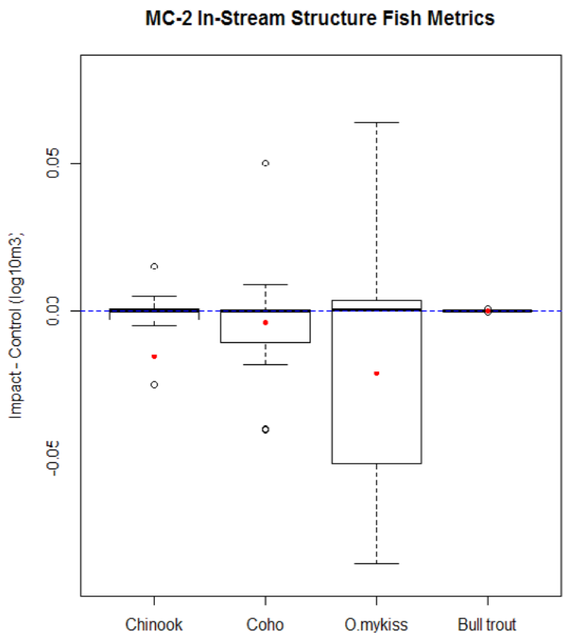


Figure 13. MC-2 Slope Analysis Box Plots for Juvenile Fish Density (some outliers were omitted from the plots to improve readability)

implementation data and that there is a large amount of variation across characteristics.

Riparian Planting

Nine MC-3 Riparian Planting projects were included in data analyses (Table 8). Analyses were conducted for habitat indicator metrics, which included bank erosion, stream shading, and riparian vegetation structure. In addition, planting survival and woody cover were also assessed for the MC-3 category. Projects in this category vary in age, relative to implementation, and years of post-implementation monitoring. Several of the projects reached Year 10 in 2015, and the remainder of the projects in this category are nearing Year 10 (see Appendix B for scatter plots of the metrics showing measures relative to project year). The category metrics for MC-3 are assessed by comparing average change in each metric across the category.

Average Difference Pre- vs Post-Implementation

Box plots were generated for all riparian planting sites with post-implementation data. As described for instream habitat analyses, pre-project data are an average of the difference between impact and control reaches of all sites for Year 0. Post-project data are an average of the difference across all post-implementation years; therefore, the post-project data are not a trend analysis but a mean of the data collected during all post-project years. Three indicators were assessed for pre- and post-implementation responses: bank erosion, stream shading, and riparian vegetation structure. To meet MC-3 category success criteria, bank erosion should significantly decrease and stream shading and three-layer riparian structure should significantly increase. Results of the analyses are shown in Table 9.

Table 8. Projects included in the MC-3 Riparian Planting Analyses

Project Number	Project Name	Description
02-1446	Centralia Riparian	Planting on east bank of mainstem Chehalis River
02-1561R	Edgewater Park	Side channel creation project with planting on lower Skagit River
02-1623	Snohomish River Confluence	Planting on north bank of Snohomish River approximately 1 mile below confluence of the Skykomish and Snoqualmie rivers
04-1649	Salmon Snow Creek	Planting on lower 1 mile reach of small stream (< 7 m wide) near Discovery Bay
04-1655R	Hoy Riparian	Planting and livestock fencing on south bank of Skagit River near Hamilton, WA
04-1660R	Cedar Rapids	Planting, levee removal, and LWD placement on Cedar River East of Renton, WA
04-1676	YTAHP Wilson Creek	Planting on both banks of a small (< 7 meter wide) creek in Ellensburg, WA
04-1698R	Vance Creek	Planting on a small (< 7 meter wide) creek near Elma, WA
04-1711	Lower Klickitat	Planting on mainstem Klickitat River near Klickitat, WA

Table 9. Average Difference between Impact and Control Reaches for Pre- and Post-Implementation (post – pre) Analysis Results for MC-3 Habitat Indicators (alpha = 0.1)

Indicator	Sample Size	Pre-Project Mean	Post-Project Mean	Mean difference	Test	p-value
Bank erosion (%)	9	9.633	8.113	-1.52	Paired t-test	0.82
Stream shading (0-17 score)	9	-2.733	-2.661	0.072	Paired Wilcoxon test	0.91
Three-layer riparian vegetation structure (% of reach)	9	-33.544	-23.143	10.4	Paired Wilcoxon test	0.301

The box plot in Figure 14 displays the difference in bank erosion between control and impact sites pre-project and post-project. Bank erosion decreased slightly after restoration implementation, with an average reduction of 1.52 percent, but did not significantly change (Table 9 and Figure 14). While lack of significant reduction in bank erosion indicates the MC-3 projects were not successful in decreasing bank erosion, it is worth noting the variation in project implementation and setting. Three of the nine sites that had increased bank erosion were at newly constructed channels or had channel avulsion occur after implementation.

The box plot in Figure 15 displays the difference in stream shading between control and impact sites pre-project and post-project. The means were nearly identical with a mean difference of only 0.07, and the result was not statistically significant (p=0.91). While improvements over time appeared to be occurring, as indicated in seven of the nine scatter plots (see Appendix B), they were not significant enough to be detected in the mean post-implementation data. The lack of a significant increase in stream shading after restoration indicates that riparian plantings as a category have not achieved the goal of increasing shading using this analysis method.

The box plot in Figure 16 represents the difference in three-layer riparian structure between control and impact sites pre-project and post-project. The mean values have increased over pre-project conditions, with the mean of the differences equal to 10.4 and a p-value of 0.301. The majority of the projects have shown increases in this metric, relative to control (see Appendix B); however, these increases were not significant enough to be detected in the post-mean analysis. While improvements were noted, the average category post-project conditions were not significantly different than pre-project conditions for this metric, thus indicating that success criteria have not been met.

Post-Implementation-only Monitoring

Two metrics were assessed for post-implementation-only responses: riparian planting survival and percent woody cover. Box plots were generated for all sites with post-implementation data for these metrics.

Riparian Planting Survival

The box plot in Figure 17 represents the mean percent planting survival in Year 1 and Year 3 for impact reaches. This graph demonstrates that, in general, the riparian plantings are surviving until Year 3 and there is very little difference between Year 1 and Year 3. Although the range in data is substantially greater in Year 3, partly due to the results of greater than 100 percent survival in

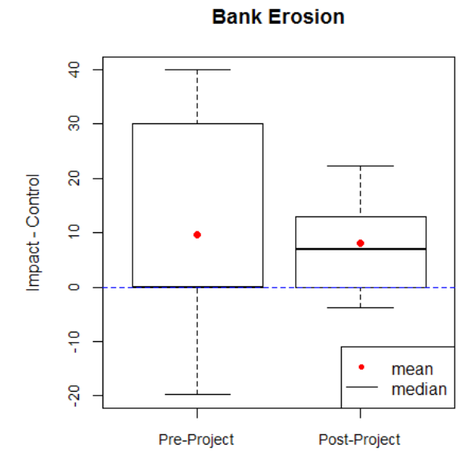


Figure 14. Box Plots Representing Median Bank Erosion, Relative to Control, Pre- and Post-implementation (Post-Project)

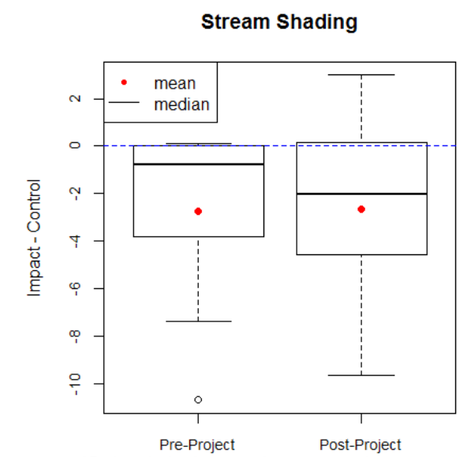


Figure 15. Box Plots Representing Median Bankside Shading, Relative to Control, Pre- and Post-Implementation (Post-Project)

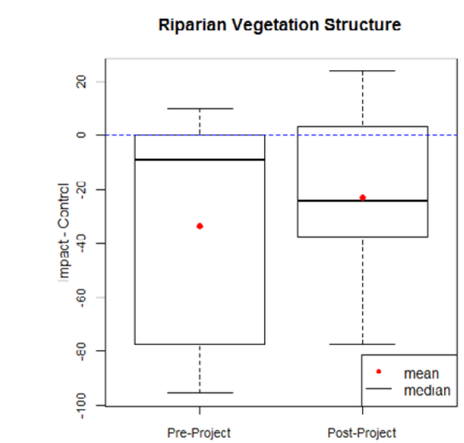


Figure 16. Box Plots Representing Median Vegetation Structure, Relative to Control, Pre- and Post-Implementation (Post-Project)

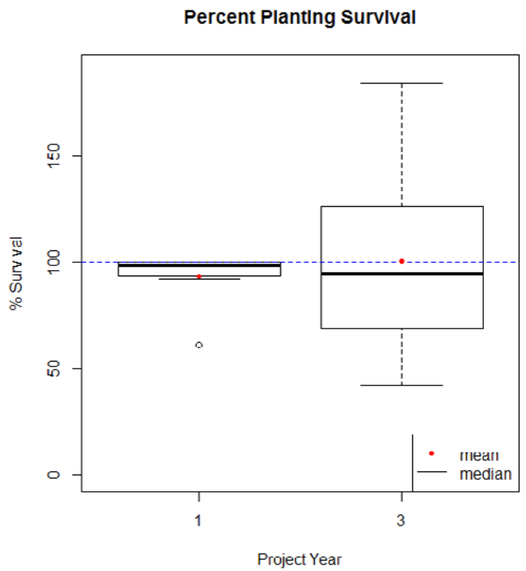


Figure 17. Box Plot Representing the Median Percent Survival of Riparian Plantings in Treatment Reaches in Year 1 and Year 3

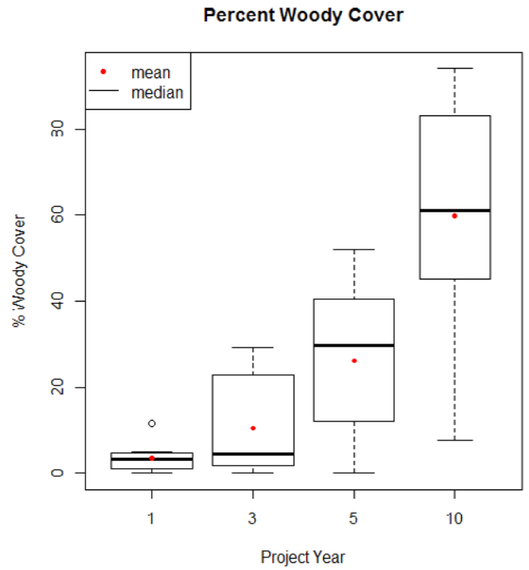


Figure 18. Box Plot Representing the Median Percent Woody Cover for Riparian Planting Projects in Post-Implementation Years (Project Years 1, 3, 5, and 10)

some plots, in general the survival estimates for riparian plantings are not different from Year 1, with a p-value of 0.71. No statistical difference between Year 1 and Year 3 indicates that survival did not decrease from Year 1 to Year 3. Additionally, in both years, survival was near 100 percent, suggesting that plant mortality was not an issue at the projects and current planting practices are effective at ensuring plantings remain alive.

Percent Woody Cover

The box plot in Figure 18 represents the percent woody cover within the riparian planting plots in the impact reaches in Years 1, 3, 5, and 10. Results indicate that percent woody vegetation has substantially increased across the planting sites as a whole, with highly significant differences between the means after Year 3 (Figure 18). Additionally, the mean difference between Year 5 and Year 10 is 33.7, with a p-value of 0.03, indicating there was a statistically significant increase in woody cover.

Slope Method Analysis

In addition to assessing metrics for the category by mean difference, data were also analyzed by taking the rate of change between impact and control reaches, as measured by a linear slope regression, and assessing change over time to illustrate the direction of change, magnitude, and variability within the category. Results of this analysis are summarized in Table 10.

Results of the analyses indicate that the median and mean average change per year is positive for stream shading, vegetation structure, and percent woody cover, and negative for bank erosion. Percent woody cover had the only statistically significant change, while stream shading and riparian vegetation structure were very nearly significant (Table 10 and Figure 19). For project success, as defined by the MC-3 monitoring protocol, installing riparian plantings should increase shading, structure, and woody cover, and decrease bank erosion. Riparian plantings, as a category of projects, appear close to achieving desired results, even though percent woody cover is the only metric with significant change. Both stream shading and vegetation structure are showing close to significant increases (see Table 10). Significant changes for stream shading and riparian vegetation structure may be observed if additional years of monitoring data were to be collected. The average increase in stream shading is 0.45/year, which is approximately 2 percent of the possible metric score, with little variation about the median (as illustrated by the tight box plot in Figure 19). This indicates a small increase in shading each year, which suggests that it may take longer for stream shading to substantially increase to a significant level than the current monitoring schedule permits. Riparian vegetation structure is also increasing at nearly 2 percent per year, which suggests that monitoring these projects for 10 years would only barely allow the monitoring to capture the time frame within which the 20 percent improvement criteria for success could be met. The significant increase in woody cover at MC-3 project sites is a positive sign that riparian plantings are surviving and continuing to grow over time.

Table 10. Slope Method Results for MC-3 Paired t-Test (alpha = 0.10)

Indicator	Sample Size	Mean Slope (Average change/year)	Direction of change	Test	P-value
Bank Erosion (%)	9	-0.610	Decrease	t-test	0.597
Stream Shading (0-17 score)	9	0.450	Increase	t-test	0.102
Riparian Vegetation Structure (% of reach)	9	2.632	Increase	t-test	0.100
Percent Woody Cover (%)	9	5.508	Increase	t-test	0.001[1/]

1/ Indicates a statistically significant change

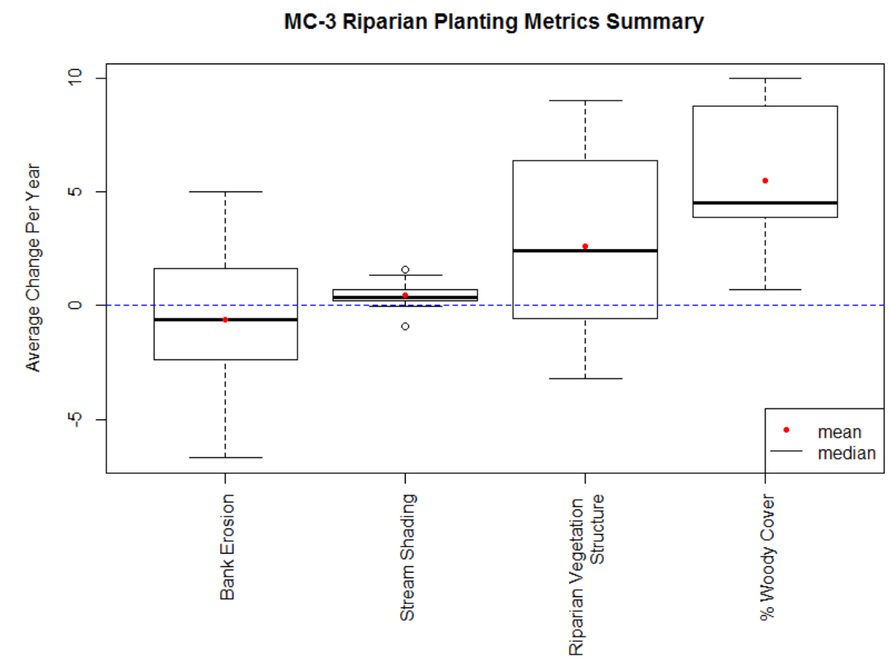
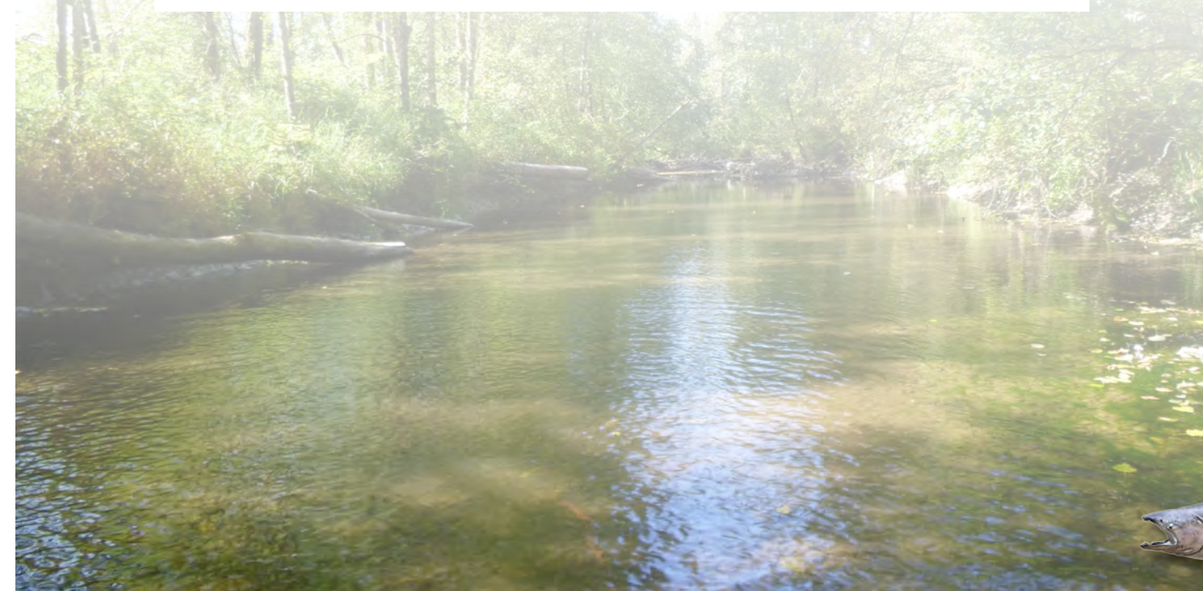


Figure 19. Slope Comparison Method for Determine Direction of Change Relative to Control for MC-3 Projects



Livestock Exclusion Projects

The MC-4 Livestock Exclusion project category includes analysis of stream bank erosion, stream shading, and riparian vegetation structure. Analyses were conducted for 12 projects, including those funded through the SRFB program and others funded through the OWEB. Table 11 provides a list of all the projects included in the MC-4 analyses.

Projects in this category vary in age, relative to implementation and years of post-implementation monitoring; however, similar to the MC-3 Riparian Planting category, many of the MC-4 projects reached Year 10 in 2015, or will shortly (see Appendix B for scatter plots of the metrics showing measures relative to project year). The category metrics are assessed by comparing average change in each metric across the category.

Average Difference Pre- vs Post-Implementation

Box plots were generated for the three category metrics and measure the average condition before and after restoration across monitored livestock exclusion projects. Results of the analyses are summarized in Table 12.

Table 11. Projects included in the MC-4 Livestock Exclusion Analyses

Project Number	Project Name	Description
02-1498	Abernathy Creek	Installation of 5,000 feet of fencing combined with riparian plantings
04-1655LE	Hoy Riparian	Installation of fencing and riparian plantings along 3,218 meters of stream
04-1698LE	Vance Creek	Fencing and riparian planting of 25-foot buffer along 7,644 meters of stream
05-1447	Indian Creek Yates	Fencing, seeding along bank of 965 meters of stream as well as passage improvements
05-1547	Rauth Coweeman	Fencing, instream and passage improvements along 1,207 meters of stream
205-060 (OWEB)	Bottle Creek	Replacement of temporary electric fence with barbed wire "let-down" fence along 2,000 feet of stream
205-060 (OWEB)	NF Clark Creek	Replacement of temporary electric fence with barbed wire "let-down" fence along 2,400 feet of stream
206-072 (OWEB)	Gray Creek	Installation of fencing along both sides of the creek for approximately 1,981 meters
206-095 (OWEB)	Jordan Creek	Installation of fence along creek, establish off-channel watering, removal and control of blackberry, revegetation with native plants
206-283 (OWEB)	Johnson Creek	Installation of fencing along stream bank
206-283 (OWEB)	Noble Creek, Maria Gulch	Fencing and riparian planting along stream
206-357 (OWEB)	MF Malheur	Exclusion fencing along 1 mile of river, instream structures, bank contouring and revegetation

Table 12. Average Difference between Impact and Control Reaches for Pre- and Post-Implementation (post – pre) Analysis Results for MC-4 Habitat Indicators (alpha = 0.1)

Indicator	Sample Size	Pre-Project Mean	Post-Project Mean	Mean of the Difference	Test	P-value
Bank Erosion (%)	12	15.907	-6.619	-22.526	Paired t-test	0.010[1/]
Stream Shading (0-17 score)	12	-2.703	-1.340	1.363	Paired t-test	0.458
Three-layer riparian vegetation structure (% of reach)	12	-20.450	-17.617	2.833	Paired t-test	0.823

1/ Indicates a statistically significant result

As a category, bank erosion significantly decreased over pre-project conditions relative to control for livestock exclusion projects (Figure 20 and Table 12). All impact sites had decreased amounts of bank erosion relative to Year 0 (see scatter plots in Appendix B). This indicates that the project action, excluding livestock from accessing the stream bank, is resulting in the desired effect of reducing bank erosion and thereby improving stream bank conditions and meeting success criteria.

While post-implementation means for riparian metrics (stream shading and riparian vegetation structure) have increased for this category, they do not show significant increases over pre-implementation values (Table 12). In both pre- and post-project years, the mean difference between impact and control is negative, indicating that the control sites, on average, have more shading along the banks than do the impact sites (Figure 21). As this metric combines all post-implementation years, signals may be harder to detect for metrics where results occur near the end of the monitoring period (see discussion of slope analysis below). The three-layer riparian vegetation structure metric only shows a slight, non-significant increase in the post-project mean (Figure 22). Vegetation structure may take many years to regenerate after heavy impact; therefore, like stream shading, evaluation of rate of change may be a more appropriate assessment for the metric in this category.

Slope Method Analysis

In addition to assessing metrics for the category by mean difference, data were also analyzed by using the rate of change to assess change over time. This illustrates the direction of change, magnitude, and provides some indication of variability within the category. Bank

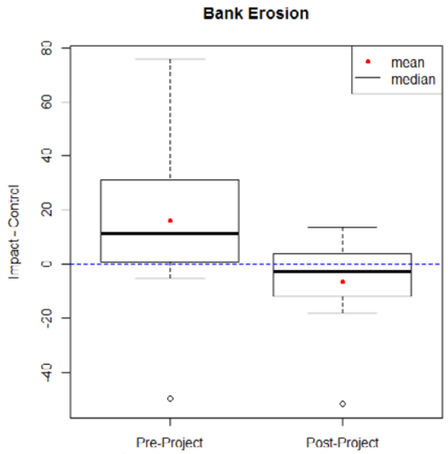


Figure 20. MC-4 Mean Difference Bank Erosion Calculations between Impact and Control Reaches, Pre- and Post-Project

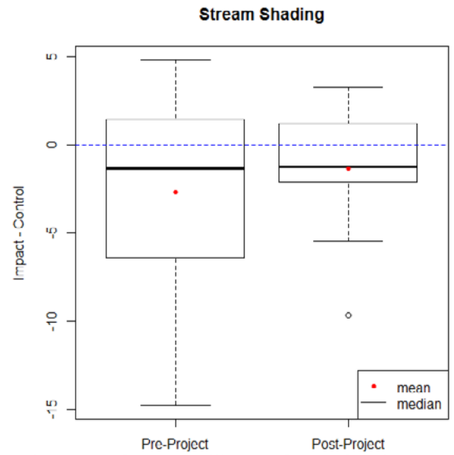


Figure 21. MC-4 Mean Difference Stream Shading Calculations between Impact and Control Reaches, Pre- and Post-Project

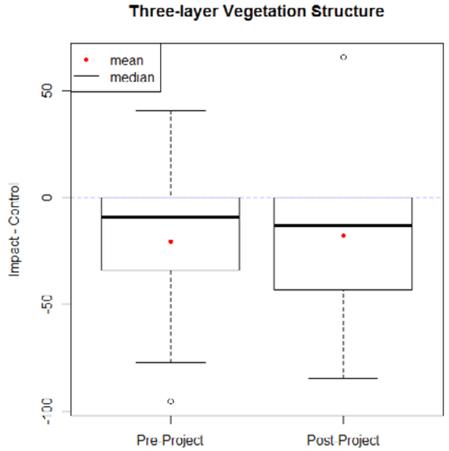


Figure 22. MC-4 Mean Difference Vegetation Structure Calculations between Impact and Control Reaches, Pre- and Post-Project

erosion, stream shading, and three-layer riparian vegetation structure were all analyzed for average change per year. Table 13 and Figure 23 contain the results of the slope (direction of change) analysis for Livestock Exclusion indicators.

Bank erosion has significantly decreased in terms of average change per year, indicating a reduction in erosion over time in impact reaches compared to control reaches. Stream shading has significantly increased after restoration. Although the average change per year is small (Figure 23), it should be noted that the rate of change is out of a total of 17, thus a change of 0.687/year is approximately a 4 percent increase per year in the metric value. For Livestock Exclusion projects, an improvement of this metric over time is expected because it is strongly affected by both woody and herbaceous bank vegetation. Riparian vegetation structure did not have a significant change, although, on average, vegetation structure has increased after restoration (Figure 23) and the p-value is close (0.13) to the alpha level for the test (0.10). As stated earlier, improvement of riparian structure may take longer than the initial monitoring schedule allows to see the significance level required in the monitoring protocol (see *Recommendations for Revised Monitoring Time Frames* section for further discussion).

Floodplain Enhancement Projects

There are 24 sites included in the analysis for the MC-5/6 Floodplain Enhancement category (Table 14). These include sites monitored as part of the SRFB Project Effectiveness Monitoring Program and sites monitored under the Upper Columbia Salmon Recovery Board (UCSRB) Effectiveness Monitoring Program.

The Constrained Channel (MC-5) and Channel Connectivity (MC-6) protocols were combined into a single protocol, MC-5/6 Floodplain Enhancement, in 2010. The Floodplain Enhancement Protocol combines all the measurements from both of the original protocols; however, each original protocol did not have the same suite of measurements. The MC-5 protocol did not collect fish use or riparian data, and the MC-6 protocol did not collect channel constraint measurements (channel capacity and flood-prone width). Because of the initial protocol differences, not all projects contain the full suite of indicators for some or all years of monitoring.

Analyses were conducted for five habitat indicator metrics (vertical pool profile area, average residual pool depth, stream shading, riparian structure, average channel capacity, and floodprone width) and four fish indicator metrics (juvenile Chinook, coho, *O. mykiss*, and bull trout densities). Projects in this category vary in age, relative to implementation and years of post-implementation monitoring. The category metrics are assessed by comparing average change in each metric across the category. In addition to group averages, scatter plots were also generated to provide further explanation of project results (see Appendix B). Due to the merging of protocols in 2010, some older projects, despite being sampled several times, only have 1 or 2 years of data for three-layer riparian vegetation structure, stream shading, average channel capacity, and floodprone width.

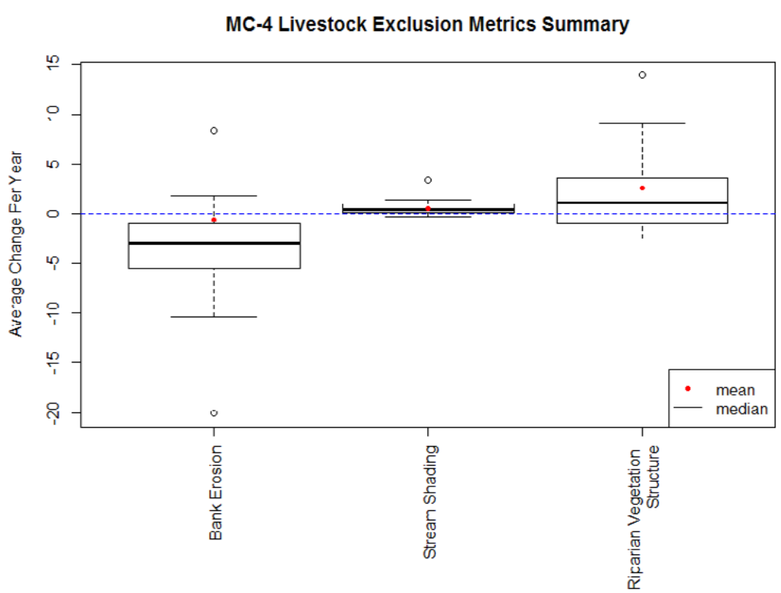


Figure 23. MC-4 Slope-Difference Calculations for Change per year in Livestock Exclusion Metrics

Table 13. MC-4 Slope Method Paired t-Test (alpha = 0.10) Results

Indicator	Sample Size	Mean Slope (average change per year)	Direction of Change	Test	P-value
Bank Erosion (%)	12	-3.78	Negative	T-test	0.08[1/]
Stream Shading (0-17 score)	12	0.687	Positive	Wilcoxon test	0.01[1/]
Three-layer riparian vegetation structure (% of reach)	12	2.395	Positive	Wilcoxon test	0.13

1/ Indicates statistically significant result

Table 14. Projects included in the MC-5/6 Floodplain Enhancement Analysis

Project Number	Project Name	Original Category	Description
02-1561	Edgewater Park	MC-6	Side channel creation and LWD placement on Skagit River in Mt. Vernon, WA
02-1625	South Fork Skagit	MC-5	Levee setback near Conway, WA; tidally influenced
04-1461	Dryden	MC-6	Off-channel ponds at River Mile 15 on the Wenatchee River
04-1563	Germany Creek	MC-6	Off-channel rearing habitat in Lower Columbia
04-1573	Lower Washougal River	MC-6	Convert gravel quarries to off-channel habitat near Camas, WA
04-1596	Lower Tolt River	MC-5	Levee removal near Carnation, WA
05-1398	Fenster Levee Setback	MC-5	Levee setback on Green River in Auburn, WA
05-1446	Lower Boise Creek	MC-5	Relocation of confined channel at confluence with White River
05-1521	Raging River – Preston Reach	MC-5	Levee removal near Preston, WA
05-1546	Gagnon CMZ	MC-6	Creation of off-channel pond on Wenatchee River
06-2190	Riverview Park	MC-6	Side channel creation project on Green River in Kent, WA
06-2223	Greenwater River	MC-5	Levee removal and ELJ placement
06-2239	Fender Mill	MC-6	Dike/road removal and side channel initiation on upper Methow River
06-2250	Chinook Bend	MC-5	Levee removal on Snoqualmie River near Carnation River confluence
06-2277	Upper Klickitat Phase II	MC-6	Side channel reconnection on Klickitat River
07-2020	Reecer Creek	MC-5	Channel remeander and levee setback in Ellensburg, WA
07-1691	Lockwood Cr Phase 3	MC-6	Off-channel creation near La Center, WA
10-1765	Eschbach Park	MC-5/6	Side channel creation on Naches River
12-1307	Billys Pond	MC-5/6	Off-channel pond reconnection on Yakima River in Yakima, WA
12-1657	George Creek Wildlife Area	MC-5/6	Channel remeander and floodplain connection in Asotin County
PA26	Tucannon Project Area 26	MC-5/6	Levee removal and LWD placement on Tucannon River
UCSRB	Boat Launch	MC-5/6	Pond reconnection on Wenatchee River near Leavenworth, WA
UCSRB	Pioneer Side Channel	MC-5/6	Dam removal on side channel of Wenatchee River near Monitor, WA
UCSRB	Chewuch Rivermile 10 Side Channel	MC-5/6	Side channel creation on Chewuch River

Average Difference Pre- vs Post-Implementation

Box plots were generated for all sites with post-implementation data and they represent the difference between control and impact sites pre-project and post-project. Values above zero for vertical pool profile area indicate higher values in the impact reach than in the control reach, while values less than zero indicate greater values in the control reach.

Habitat Indicators

There is a significant difference in vertical pool profile area between pre-project and the average post-project condition. The mean vertical pool profile area increased from -10.58 square meters (m^2) pre-project to 5.3 m^2 post-implementation (Figure 24 and Table 15). This metric increased relative to control for 11 of the 24 impact sites. Increases in this metric indicate creation of deeper pool habitat, which is often desired in restoration sites. This metric value is near the significance threshold, however. Reviewing the site data shows that vertical pool profile area has decreased at 11 of the 24 impact sites (see Appendix B), 9 of which have decreased relative to control. Two of the 11 declining treatments sites had less of a reduction than the control sites, which may indicate restoration sites are mitigating declines in those areas. This variability in results suggests that the significant increase may be driven by large changes in a few sites. Because channel creation projects start, generally, with a field or fairly indistinct channel, depth values are recorded as zero for

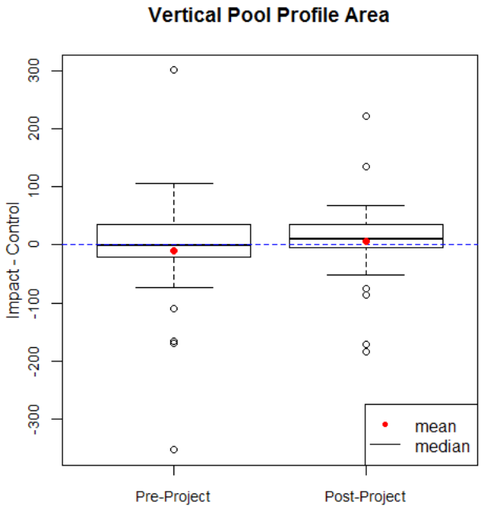


Figure 24. Box Plot of Average Vertical Pool Profile Area Before and After Restoration for Floodplain Enhancement Projects

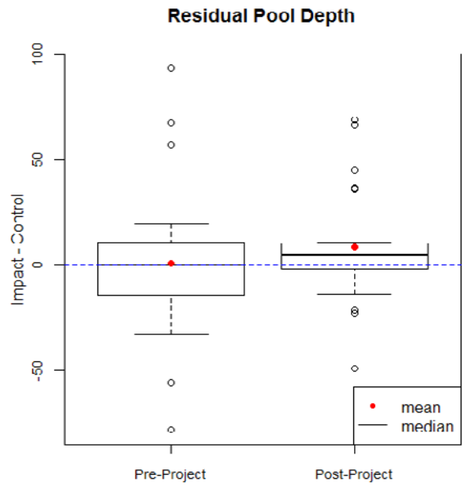


Figure 25. Box Plot of Average Residual Pool Depth Before and After Restoration for Floodplain Enhancement Projects

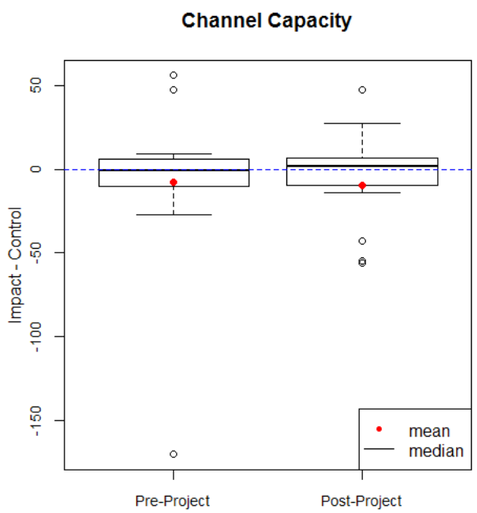


Figure 26. Box Plots for Average Pre- and Post-Project Channel Capacity for MC-5/6 Projects

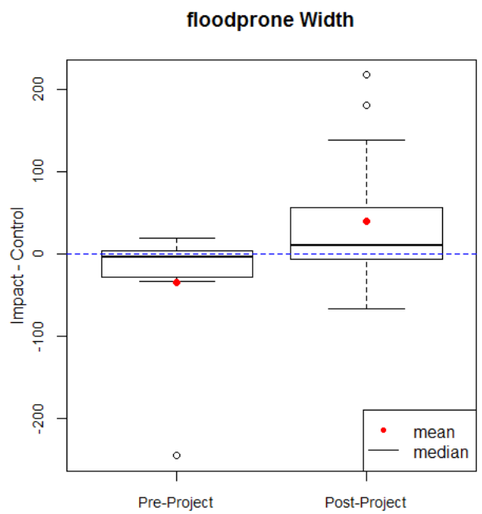


Figure 27. Box Plots for Average Pre- and Post-Project Channel Capacity for MC-5/6 Projects

Table 15. Average Difference between Pre- and Post-Implementation Analysis Results for MC-5/6 Habitat Indicators (alpha = 0.1)

Indicator	Sample Size	Pre-Project	Post-Project	Test	P-value
Vertical Pool Area (m^2)	24	-10.58	5.30	Paired Wilcoxon	0.079[1/]
Average Residual Pool Depth (cm)	24	0.84	8.50	Paired Wilcoxon	0.079[1/]
Average Channel Capacity (m^2)	16	-7.9	-9.8	Paired Wilcoxon	0.376
Floodprone Width (m)	8	-35.2	31.05	Paired Wilcoxon	0.081[1/]
Stream Shading (0-17 score)	19	0.96	-2.6	Paired t-test	0.017[1/]
Riparian Structure (%)	21	-2.796	-11.802	Paired t-test	0.590

1/ Indicates a statistically significant result

Year 0. This allows for a BACI design to be conducted on the data, but may result in skewing the data such that significant increases in pool area for existing channels appear to be increasing, where no significant increase is actually occurring (see Appendix B).

Average residual pool depth has significantly increased from average pre-project condition to average post-project condition for floodplain enhancement projects (Figure 25). The mean of the pre-project differences is 0.84, and the post-project difference is 8.50 (Table 15). Results for average residual pool depth are similar to those for vertical pool profile area (see discussion above and Appendix B).

Average channel capacity has not significantly changed between average pre- and post-project conditions. The pre-project mean was -7.9 m^2, and the post-project mean is - 9.8 m^2 (Table 15 and Figure 26). Channel capacity has decreased at impact reaches of 10 projects. At 7 of the 10 impact reaches with reduced channel capacity, capacity at control reaches has decreased either more or at a similar rate as the impact reaches, meaning reductions in capacity at impact reaches are not any greater than natural trends (see Appendix B). Channel capacity is a measure of the amount of water that can be contained within the stream channel, so a floodplain enhancement project should decrease capacity, allowing a stream to engage its floodplain at a lower flow. While not a significant decrease, the data are trending toward success with a smaller post-project mean than pre-project mean.

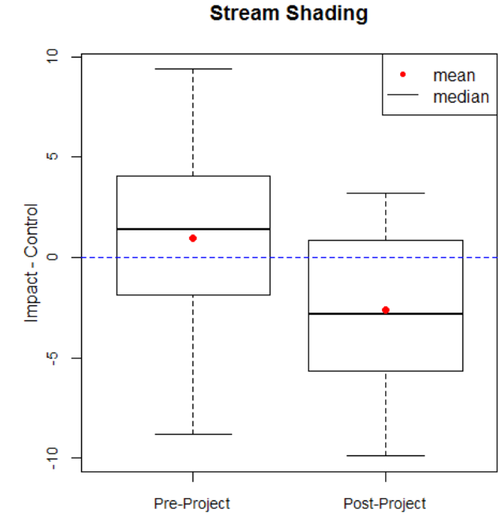


Figure 28. Box Plots for Average Stream Shading Before and After Restoration for Floodplain Enhancement Projects

Floodprone width has significantly increased on average after restoration relative to before restoration, increasing relative to control in six of the eight projects with multiple years of data (Table 15 and Figure 27). A significant increase in floodprone width indicates floodplain enhancement projects are effective at increasing connectivity of streams to the floodplain, resulting in a larger area that will be frequently inundated during high flows.

Average stream shading has significantly decreased after restoration compared to before restoration (Table 15 and Figure 28). The mean of the pre-project differences is 0.96 and the post-project difference is -2.6 (rated on a scale of zero to 17). Stream shading has either decreased or remained nearly unchanged for the majority of projects (13 of 20). Nine projects have decreased stream shading at impact reaches, relative to control (see Appendix B). The success criteria for stream shading is to significantly increase, not decrease, shading, so a significant decrease in stream shading is not a desired outcome. Earth-moving work during implementation of some floodplain enhancement projects can lead to a loss of shade-providing plants initially. For projects that involve channel creation or reconnection, excavators are typically used to dig new channels, and excavated areas are usually cleared of vegetation and replanted after work is completed. The aerial image in Figure 29 illustrates a situation where shading decreased dramatically after restoration, where the old channel was heavily vegetated, but the newly created channel is flowing through a field that was cleared of vegetation for construction. As

Figure 29. Riparian Conditions Along Old Channel and Newly Created Channel at the 07-2020 Reecer Creek Project Following Implementation

vegetation rebounds following implementation, it is expected that stream shading will also increase over time. This is supported by improvements to shading seen over time after restoration following an initial decrease in Year 1, which can be seen in the scatter plots in Figure B-18 (see Appendix B) for sites 02-1561, 04-1461, 05-546, 06-2223, and 07-1519.

Three-layer riparian vegetation has not significantly changed between average pre- and post-restoration conditions (Table 15). Although not significant, vegetation structure has slightly decreased from a pre-project mean of -2.796 (percent of reach) to -11.802 post-project (Figure 30). Similar to initial decreases seen with stream shading, an initial decrease in vegetation structure following restoration construction is not surprising, given the ground disturbances associated with earth work. As riparian vegetation regrows and plantings mature, a rebound in vegetation structure is more likely as more time passes after implementation, as displayed in the scatter plots in Figure B-19 (see Appendix B) for sites 02-1561, 02-1625, 04-1461, 05-1546, and 06-2190.

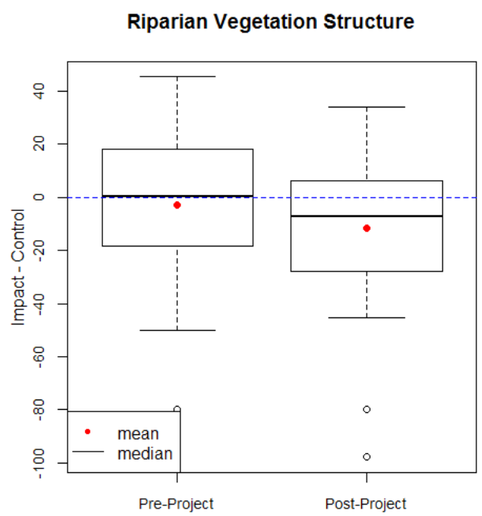


Figure 30. Box Plots of Average Pre- and Post-Restoration Three-Layer Riparian Vegetation Structure for Floodplain Enhancement Projects

Juvenile Salmonid Density

Juvenile Chinook, coho, and *O. mykiss* were analyzed for average densities and tested for statistical differences before and after restoration (Table 16). The number of projects in the MC-5/6 category with juvenile fish density data is smaller than for most other indicators (16 of 24 total MC-5/6 projects). Due to the different protocols initially used for MC-5 and MC-6 projects, MC-5 sites monitored prior to 2010 do not have fish data, with the exception of 05-1466 Lower Boise Creek. Lower Boise fish data have been collected by King County since monitoring began, and are included in the analyses for this report.

Relative juvenile fish density significantly increased for coho and Chinook, and did not significantly change for *O. mykiss* (Table 16 and Figure 31). A significant increase in juvenile abundance means more coho and Chinook have been observed using restoration sites after implementation compared to fish use at control reaches. Juvenile *O. mykiss* relative densities have shown minor (non-significant) increases from before to after the project.

Slope Method Analysis

In addition to assessing metrics for the category by mean difference for MC-5/6 projects, data were also analyzed by taking the rate of change between impact and control reaches, as measured by a linear slope regression, and assessing change over time to illustrate the direction of change, magnitude and variability within the category. A positive mean slope shows that an indicator is increasing through time, and a negative slope shows that an indicator is decreasing through time.

Habitat Indicators

Average change per year was analyzed and tested for a significant difference from zero for vertical pool profile area, average residual pool depth, average channel capacity, floodprone width, stream shading, and riparian structure (Table 17). Floodprone width showed a significantly positive slope (p = 0.016) (Table 17 and Figure 32), indicating a significant increase in floodprone width, which was also detected using the before and after difference test. For floodplain enhancement projects, floodprone width should increase as floodplain connectivity is improved; therefore, results indicate that this category of projects is successful at meeting this criterion. None of the pool and riparian indicators, including average channel

Table 16. Average Difference between Impact and Control (impact – control) Reaches for Juvenile Salmonid Densities Pre- and Post-Restoration, and p-Values (alpha = 0.10) from Statistical Analyses for MC-5/6 Projects

Species	Sample Size	Pre-project Mean	Post-project mean	Test	P-value
Chinook (fish/m^2)	10	-0.032	0.061	Paired Wilcoxon	0.053[1/]
Coho (fish/m^2)	12	-0.050	0.100	Paired Wilcoxon	0.031[1/]
O. mykiss (fish/m^2)	15	-0.010	-6.88 x 10-5	Paired Wilcoxon	0.268

1/ Indicates a statistically significant change

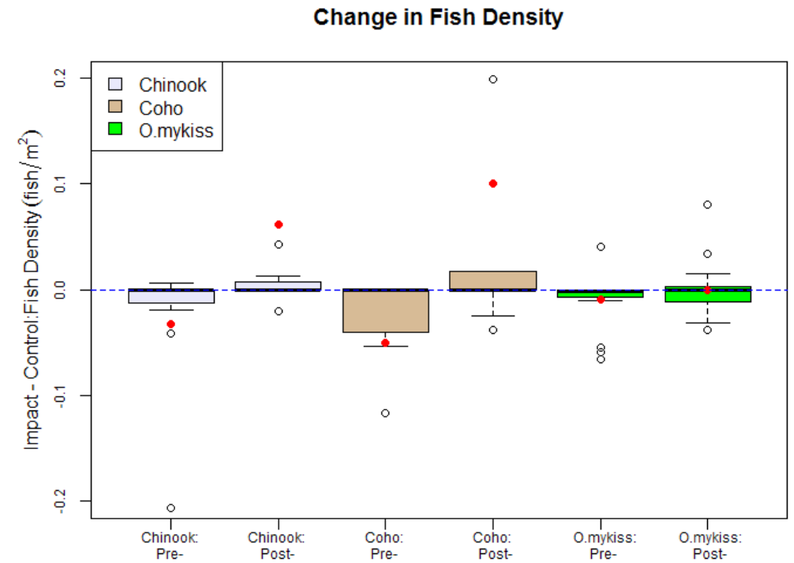


Figure 31. Box Plots for Average Pre- and Post-Restoration Juvenile Salmonid Densities for MC-5/6 Projects

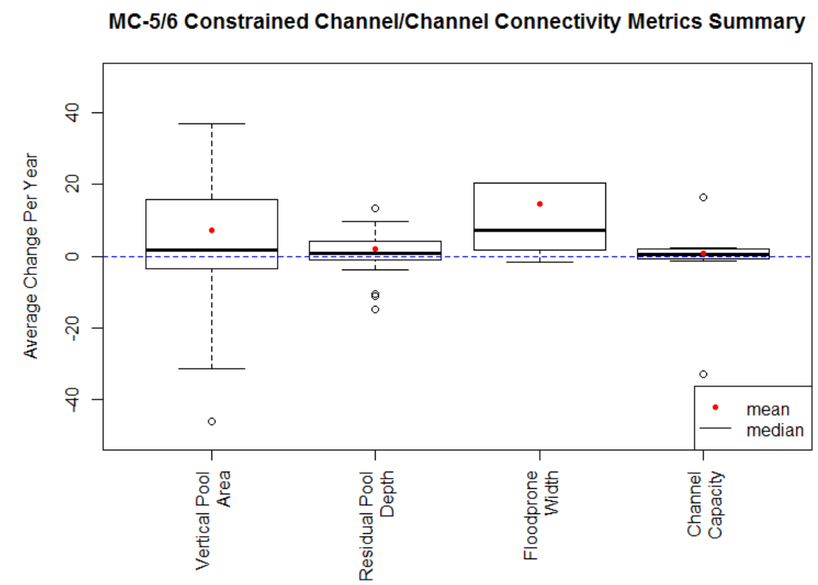


Figure 32. MC-5/6 Slope Analysis Box Plots for Pool and Floodplain Indicators (some outliers were omitted to improve readability)

Table 17. MC-5/6 Slope Method Analysis Results for Channel Morphology and Riparian Indicators (alpha = 0.1)

Indicator	Sample Size	Mean Slope (average change per year)	Direction of Change	Test	P-value
Vertical Pool Area (m^2)	24	7.269	Positive	Wilcoxon test	0.459
Average Residual Pool Depth (cm)	24	1.987	Positive	Wilcoxon test	0.375
Average Channel Capacity (m^2)	16	0.856	Positive	Wilcoxon test	0.384
Floodprone Width (m)	8	14.464	Positive	Wilcoxon test	0.016[1/]
Stream Shading (0-17 score)	19	-0.532	Negative	T-test test	0.184
Riparian Structure (% of reach)	21	-1.705	Negative	Wilcoxon test	0.542

1/ Indicates a statistically significant change

capacity, had slopes significantly different from zero (Table 17 and Figures 32 and 33), indicating no significant change from baseline conditions.

Juvenile Salmonid Density

Juvenile Chinook, coho, and *O. mykiss* densities were analyzed for average change per year and statistically tested to see if changes were significantly different from zero. For these analyses, any projects without a species present during any year of monitoring were omitted from that species' analysis. To meet project success criteria, MC-5/6 projects should significantly increase salmonid densities. Results indicate that juvenile salmonid density changes through time are mixed for floodplain enhancement projects. Juvenile Chinook density has significantly increased through time, while juvenile coho and *O. mykiss* densities have not significantly changed (Table 18 and Figure 34). A significant increase in juvenile Chinook density indicates floodplain enhancement projects are successful in improving Chinook use of restored areas.

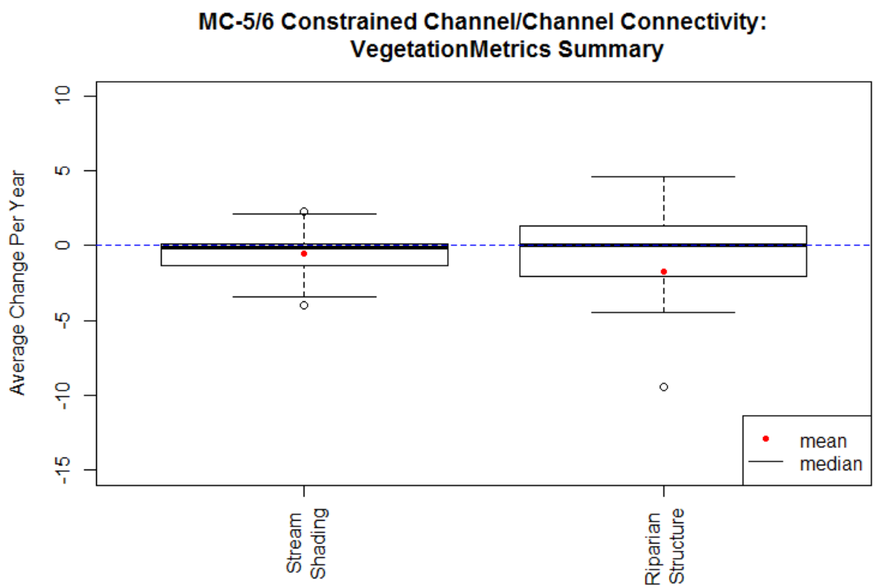


Figure 33. MC-5/6 Slope Analysis Box Plots for Riparian Vegetation Indicators (some outliers were omitted from the plots to improve readability)

Table 18. MC-5/6 slope Method Analysis Results for Juvenile Salmonid Densities (alpha = 0.1)

Indicator	Sample Size	Test	Mean Slope (average change per year)	P-value
Chinook Density (fish/m^2)	10	Wilcoxon	0.165	0.064[1/]
Coho Density (fish/m^2)	12	Wilcoxon	0.061	0.151
O. mykiss Density (fish/m^2)	15	Wilcoxon	-0.001	0.389

1/ Indicates a statistically significant change

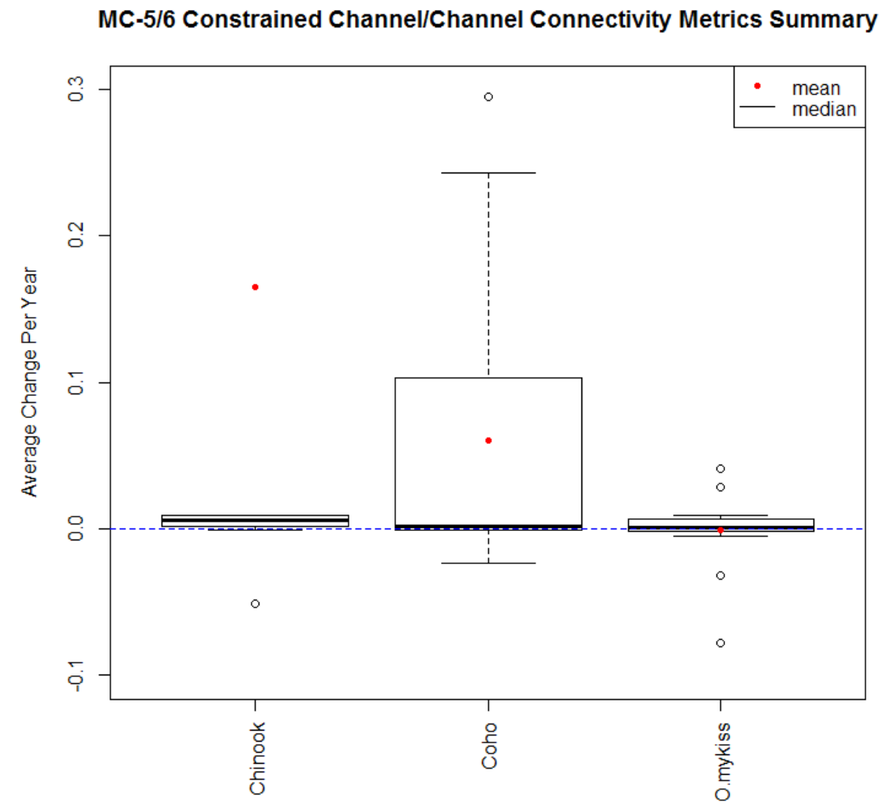


Figure 34. MC-5/6 Slope Analysis Box Plots for Juvenile Fish Density (some outliers were omitted from the plots to improve readability)

Riparian conditions along the Entiat River in Eastern Washington

RECOMMENDATIONS FOR REVISED MONITORING TIME FRAMES

In 2015, the Monitoring Panel conditioned the Project Effectiveness Monitoring Program with the following:

> *All monitoring at sites which include a component of riparian canopy cover as a success criteria (riparian restoration, livestock exclusion, and habitat protection) will be deferred and should not be conducted in the 2016 field season. The contractor will provide the Monitoring Panel with a proposed schedule for these sites with a revised monitoring return interval that will allow sufficient time for these sites to feasibly meet riparian forest canopy success criteria.*

The following subsections provide recommendations for revised monitoring intervals for the three identified monitoring categories based on available literature and data, observations made over the past 10 years of effectiveness monitoring, and feasibility based on cost and other factors.

Riparian Plantings

Most available research recommends 3 to 5 years of time between monitoring events for riparian planting projects. This recommendation was primarily due to lack of project funding for extended studies and because at 3 years, it is typically possible to determine if the plantings are likely to survive. Canopy cover, however, was generally assumed to take longer, up to 10 to 15 years. Roni et al. (2002) estimated it would take 5 to 20 years to detect a response in metrics for riparian planting projects, such as species composition, shading, and vegetation structure. However, the response metric in that study does not coincide with the success criteria established for the SRFB Reach-Scale Effectiveness Monitoring Program of 20 percent improvement in riparian vegetation structure by Year 10. Lewis et al. (2009) state that the monitoring time frame depends on attributes being monitored, including that planting survival can usually be monitored up to Year 3, while significant changes to canopy closure can take 10 years or more to detect.

There are nine project sites monitored in the Riparian Planting category. It is worth noting that the sites with Year 10 data are generally showing substantial improvements in the riparian vegetation structure metric. However, there are a number of challenges associated with site selection and monitoring of differing conditions within this project category. For example, project site 02-1446 shows very little tree growth; however, the plantings were mowed down at this site not long after implementation. The 02-1561 project has 100 percent riparian vegetation structure for Year 1 in the impact reach, which means no improvement in the structure can be detected. Additionally, plantings in the impact reach were installed before construction of a side channel at the same location, thus complicating the assessment of this project as a planting site. Project site 04-1660 lost most of its riparian plots due to stream avulsion, resulting in all samples decreasing in riparian vegetation structure as the stream moved away from the forested area. Plantings at the 04-1676 site are willows and cottonwood, which are generally fast-growing species; however, the plantings are still very short, which could be the result of site-specific soil conditions or other factors unrelated to restoration efforts. Overall, the current monitoring schedule for Riparian Planting projects is likely sufficient to evaluate project success; however, a few more years for the final sample would provide more conclusive results related to project outcome.

As described in the 2014 Annual Report (Tetra Tech 2015), the slow average growth rates of species commonly used in planting projects may make it difficult to detect significant changes in canopy density and riparian vegetation structure within 10 years of monitoring. While literature varies in reporting growth rates, and differences between western Washington and eastern Washington growth conditions were apparent (Tetra Tech 2015), research suggests that extending the sampling time frame for this category may allow better detection of changes in riparian canopy. Sampling of projects in this category is currently being conducted in Years 0 (baseline), 1, 3, 5, and 10. Because canopy closure generally does not occur for 10 to 15 years, it is recommended that the sampling events be extended out to Years 0, 1, 3, 8, and Year 15 to improve the likelihood of detecting results for canopy cover and riparian vegetation structure. While factors such as animal browsing, invasive species, and mowing may affect success at some sites, monitoring on this expanded timeline will increase the ability to measure success of riparian planting projects in general.

Livestock Exclusion

Available literature suggests that most monitoring entities observed an improvement in plant community development within 3 years following implementation of Livestock Exclusion projects (Ranganath et al. 2009; Hosten and Whitridge 2007). Vegetation structure, such as a three-layer riparian development, was rarely evaluated as a success criterion for these projects; however, studies often found an increase in groundcover vegetation in areas that excluded grazing (Ranganath et al. 2009). A study by Hosten and Whitridge (2007) showed an increase in vegetative cover and woody vegetation more than 10 years after exclosure placement, but noticed slower recovery at some sites, likely due to soil compaction. Results indicated relatively static recovery in slower growing plants such as conifers (Hosten and Whitridge 2007). Research has shown recovery of many riparian vegetation functions, such as canopy density or shade, sediment storage, hydrologic improvement, bank stabilization, and other channel characteristics where incision is not severe within 5 to 10 years (Roni et al .2002). Roni et al. (2002) estimated a time frame of 5 to 20 years to detect a response in vegetation characteristics for fencing projects.

Livestock exclusion sites have shown improvement within the first few years in the metrics for bank erosion and stream shading. Riparian vegetation structure has shown a lack of response within the time monitored and it is suspected this is due to the time it takes for the riparian canopy to develop. A review of the sites included in MC-4 monitoring category indicates that a significant category signal for this metric may not be detectible. Four of the study sites were already forested at implementation; therefore, additional canopy development would not be detectable. The eastern Oregon site (Malheur River) will likely not grow anything taller than a shrub, no matter how many years it is monitored, due to the nature of native vegetation and growing conditions in that geographic area. Conditions are arid, the stream is down-cut which leaves the banks relatively high (lowering the water table), and surrounding vegetation includes grasses and a few willows. Therefore, the opportunity for colonization by canopy providing vegetation is greatly reduced. Pasture sites are mostly occupied with grasses, and trees are unlikely to establish in those areas. Only the Livestock Exclusion sites paired with riparian plantings (sites 04-1655 and 04-1698) are likely to give a true signal at the 10- or 15-year mark.

Livestock Exclusion projects monitored as part of this program are currently sampled in Years 0 (baseline), 1, 3, 5, and 10. Shifting the sampling schedule to Years 1, 3, 8, and 12 would provide more time for trees to grow; however, the other factors described above for projects in this sample pool may mean that a category response to vegetation metrics is not likely to be detected.

Habitat Protection Projects

The frequency and duration at which monitoring activities are conducted depend on the temporal detail needed for a given project category or metric. The current monitoring schedule for MC-10 Habitat Protection projects is every 3 to 5 years, from time of purchase, resulting in monitoring events in Years 0 (baseline), 3, 8, and 12. Monitoring of Habitat Protection projects is essentially status and trend monitoring, because it involves tracking the conditions at a given site over time without a restoration action being implemented. Therefore, unlike projects that involve active restoration, rapid change following an action or project is not expected. Literature suggests that agencies and organizations routinely monitor habitat conditions for a variety of reasons (e.g., recovery from impacts, general status and trends, comparison to non-protected sites, confirmation of habitat quality, etc.) which may require different monitoring intervals and status and trends monitoring sampling designs vary. For example, in the Columbia Habitat Monitoring Program (CHaMP), intensively monitored watersheds may be sampled

multiple times per year, with some metrics collected annually and others less frequently. The sampling design for CHaMP includes annual sites as well as sites on rotating schedules that are sampled every 3 years (Larsen et al. 2011). Washington State's Watershed Health Monitoring Program employs a rotating panel design with sites in certain regions being sampled every 4 years (Washington State Department of Ecology 2015). In general, it appears that many programs use a 3- to 5-year spacing for basin trend monitoring, while site-specific monitoring, such as IMWs, may be more frequent. The existing monitoring schedule for projects in the MC-10 category is between 3 and 5 years, which fits within the timelines of other projects in the region. Delaying the final year of monitoring another year or two would likely not improve the response for vegetation metrics, but neither would it negatively affect the analysis, unless project sponsors are interested in potential changes at a smaller temporal scale.

The decision criteria for success at habitat protection projects assume the reason for selecting the sites was to improve or maintain the habitat and biological community within the protected area. The success criteria differ from those of the other categories where riparian metrics are used to evaluate project performance, such as Livestock Exclusion and Riparian Planting, in that the lack of a change in the metrics is considered successful for habitat protection while significant improvement is needed at livestock and riparian projects for success.

Habitat Protection projects are monitored for a wide range of metrics, canopy density being only one of them. Adding more time between sampling events for the majority of the acquisition sites is unlikely to make a difference in canopy cover regeneration because many of the project parcels are already forested and have riparian metric scores near the maximum possible (Table 19). It is also worth noting that 3 of the 10 Habitat Protection projects monitored under this program are estuarine projects, so canopy density is not monitored, making the sample size for this particular metric smaller and the ability to note changes at the category scale more difficult.

Overall, it may be dubious to expect a significant increase in riparian vegetation indicators from habitat protection projects, but it is still worthwhile to monitor them to ensure no significant degradation is occurring.

Table 19. Canopy Structure and Shading Metric Results and Potential for Acquisition Sites

Project Number	Project Name	Waterbody	Region	Riparian Vegetation Structure	Possible to Meet 20% Improvement Criterion?	Shading	Possible to Meet 20% Improvement Criterion?
00-1669	Chelan Douglas Land Trust	Entiat River	Rural, eastern Washington	Year 0 = 59.1% Year 8 = 100%	Yes	Year 0 = 9.4 Year 8 = 8.6	Yes
00-1788	King County	Rock Creek	Urban, western Washington	Year 0 =95.5% Year 8 = 95.5%	No	Year 0 =16.9 Year 8 = 17	No
00-1841	Metzler Park, King County	Green River	Urban, western Washington	Year 0 = 100% Year 8 = 95.5%	No	Year 0 =17 Year 8 = 16.5	No
01-1353	Logging Camp Creek	Logging Camp Creek	Rural, eastern Washington	Year 0 = 95.5% Year 8 =86.4%	No	Year 0 =16.3 Year 8 = 17	No
02-1485	Chimacum Creek	Chimacum Creek – Estuary	Rural, western Washington	Estuary	N/A	Estuary	N/A
02-1535	WeyCo Mashel	Mashel River	Rural, western Washington	Year 0 = 81.8% Year 8 = 54.5%	Yes	Year 0 = 13 Year 8 = 10	Yes
02-1592	Curley Creek	Curley Creek – Estuary	Rural, western Washington	Estuary	N/A	Estuary	N/A
02-1622	Issaquah Creek	Issaquah Creek	Rural, western Washington	Year 0 = 86.4% Year 8 = 95.5%	No	Year 0 =15.1 Year 8 = 15.5	No
02-1650	Methow Critical	Methow River	Rural, eastern Washington	Year 0 = 100% Year 8 = 100%	No	Year 0 = 10.3 Year 8 = 10.5	Yes
04-1335	Piner Point Estuary	Puget Sound – Estuary	Rural, western Washington	Estuary	N/A	Estuary	N/A

N/A = Metric not measured at the site

Data collection at monitoring site

COMPLEMENTARY APPROACHES FOR RESTORATION ASSESSMENT

Habitat Suitability

Habitat suitability index (HSI) modeling is used by a wide array of natural resource management practitioners to assess the availability of habitat for species of interest or concern. The process of HSI modeling involves assessing the abundance and quality of defined components of habitat for an organism. For freshwater salmonid habitat, the components are typically water depth and velocity in a stream, and sometimes substrate size and fish cover. More information on the process for HSI modeling using data collected under the Reach-Scale Effectiveness Monitoring Program can be found in the 2014 Annual Report (Tetra Tech 2015).

HSI modeling is beginning to be used by restoration planners and practitioners to assess the potential benefits of a restoration project. The UCSRB and Bonneville Power Administration are both encouraging project sponsors to perform suitability modeling as a standard practice in the restoration design process. Utilizing HSI modeling to evaluate the benefits of planned restoration can help assess if the project will achieve the intended improvements in habitat that it is designed to achieve. If the project is not modeled to achieve the intended improvements to habitat, the design can be changed before implementation. Altering the design before implementation could save money by identifying modifications before construction, rather than seeking additional funds to alter a project after restoration occurs. On the Merced River in California, suitability modeling performed after restoration implementation found a project did not achieve the intended improvements to juvenile salmon rearing habitat it was intended to (Gard 2006). Additionally, the investigator noted that the suitability assessment could have been performed before the restoration was completed, thus detecting the lack of improvement in habitat beforehand, and allowing for adaptive management and changes to the restoration design (Gard 2006). Gard (2006) also noted the importance of considering stream flow when performing modeling. Suitability modeling should be performed at flows when life stages are intended to be in the river and utilizing the project. For example, modeling for spawning benefits should be conducted at discharges when spawning typically occurs in a given stream, or juvenile habitat should be modeled at high-flow discharges if the project is intended to improve high-flow refugia. Utilizing pre-project and post-project topographic data collected by the SRFB Project Effectiveness Monitoring Program, HSI values before and after restoration could be compared to see if the project realized the intended benefits as constructed, rather than just as designed, and can be tracked over time to see if the habitat is maintained.

Video Assessment of Fish Use and Behavior

While video documentation is not conducted for quantitative analysis, review of the footage provides some indications of fish utilization of different structure types and placements. Information on fish behavior at specific project sites can be useful in describing fish utilization of restoration projects in general, as well as for illustrating key fish habitat features for consideration in project design.

At some sites, it was clear that fish were using logs for cover even when it appeared the wood was not affecting water velocity. Fish were recorded using overhead wood cover in Project Area (PA) 3 of the Tucannon River. At this site, juvenile salmonids were observed aligning themselves under logs, within riffle habitat conditions, where they were hidden from above. This additional cover may provide improved forage conditions, expanding the area where fish can forage while still being under, or near, overhead cover. If water velocities were too high, however, the cover benefit of wood did not appear to matter. For example, at restoration sites in both PA 3 and PA 14 in the Tucannon River, very little fish use of placed wood was observed when it was located in high-velocity areas and very little flow reduction occurred. Video footage shows areas of cover but no fish present, and turbulence is visible in the sands and gravels being pushed about. It may be that velocity in these areas exceeded what was intended for restoration purposes. This type of wood placement should be evaluated for fish benefits. It should be noted, however, that at the time of the video monitoring, these sites had not yet undergone high-flow events (flows were lower than normal for the Tucannon River in 2015) and some placements were designed to let the river flow help define how the structures fully engage with the channel.

Monitoring of placed wood structures over time may help to determine whether such they provide direct functional use for fish and how that use changes over time. Viewing the underwater flows as well as fish use around these structures can help assess whether design intent is being met. For example, if the structure becomes more engaged with the streambed, it may begin to change physical habitat conditions, such as creating scour pools or back-eddies that can provide flow-refugia and cover near higher velocity areas that can provide good foraging habitat.

Salmonids were often observed congregating around root wads and structures that created flow breaks in fast sections of river, but fewer salmonids were noted as using cover elements where high velocities remained unattenuated. Structures placed along banks were found to be highly utilized by juvenile salmonids in some cases. For example, at the Skookum Reach site, hundreds of juvenile coho were found using very small areas at the bank structures that were engaged with the river during the survey in 2014. These juveniles were observed in high-density swimming near the structure and overhanging logs and utilizing the cover when disturbed.

While LWD enhancement generally focuses on placement of large structures, fish use was not always associated with the size of wood. At numerous sites, fish were observed utilizing small woody debris along streambanks and in backwaters, as well as congregating in and around smaller branches caught in larger placed structures. Video footage from multiple years of surveys at the lower Dosewallips River site showed juvenile fish utilizing smaller branches in backwatered areas along the bank as well as larger fish using deeper scour pools around bank structures such as rootwads or large boulders. In some cases, relatively large numbers of fish were found using comparatively small areas of habitat. At PA 24 in the Tucannon River, 15 juvenile salmonids (Chinook and steelhead parr) were observed mid-riffle, all associated with a 9-millimeter-diameter beaver-chewed branch that was snagged on a large cobble. Video footage allowed us to review the recorded account and behavior relative to the minimal structure present. While the affected area was less than half of a square meter and likely temporary in nature, it was highly utilized by the juvenile salmonids at the time. This type of habitat association is often not recorded in standard surveys but can provide useful insight about fish behavior and habitat utilization.

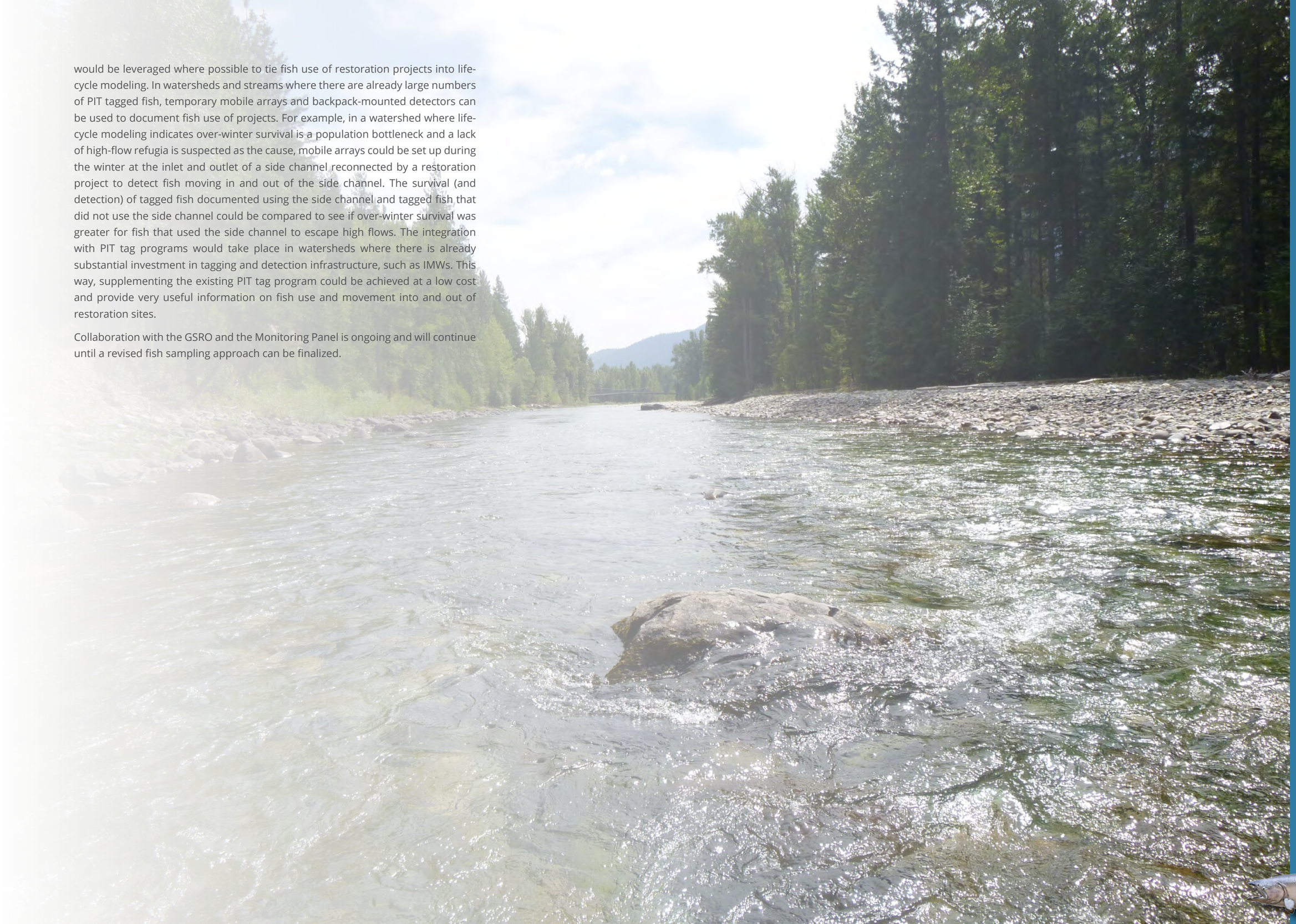
Recommendations for Fish Use Monitoring

The fish sampling approach is currently under review and may be revised as a result of recommendations from the SRFB Monitoring Panel in 2015. The goal of revising the fish sampling methodology is to better capture and characterize fish use of restoration projects. Currently, fish sampling only occurs during the low-flow season, from late spring to early fall. However, in some watersheds, juvenile salmon populations, particularly Chinook, outmigrate before the low-flow season, so the subsequent fish use surveys during low-flow season may miss the majority of juveniles who have already migrated out of the system. The current proposal for a revised fish sampling approach seeks to address the data gap of fish use of restoration projects outside of the low-flow season.

The revised fish sampling proposal consists of two major components—multi-season snorkel surveys and integration of PIT tag programs and infrastructure. The multi-season snorkel surveys include sampling restoration projects during the times of year that juvenile fish use by the target species is expected to occur, and also provide seasonal fish use information for a subset of projects where multiple snorkel surveys per year are conducted. These snorkel surveys are the primary component of the proposal, and it is anticipated that, at a minimum, the surveys will be implemented. Under the second component of the proposal, existing PIT tag programs and infrastructure (i.e., permanent PIT tag arrays placed in streams/rivers)

would be leveraged where possible to tie fish use of restoration projects into life-cycle modeling. In watersheds and streams where there are already large numbers of PIT tagged fish, temporary mobile arrays and backpack-mounted detectors can be used to document fish use of projects. For example, in a watershed where life-cycle modeling indicates over-winter survival is a population bottleneck and a lack of high-flow refugia is suspected as the cause, mobile arrays could be set up during the winter at the inlet and outlet of a side channel reconnected by a restoration project to detect fish moving in and out of the side channel. The survival (and detection) of tagged fish documented using the side channel and tagged fish that did not use the side channel could be compared to see if over-winter survival was greater for fish that used the side channel to escape high flows. The integration with PIT tag programs would take place in watersheds where there is already substantial investment in tagging and detection infrastructure, such as IMWs. This way, supplementing the existing PIT tag program could be achieved at a low cost and provide very useful information on fish use and movement into and out of restoration sites.

Collaboration with the GSRO and the Monitoring Panel is ongoing and will continue until a revised fish sampling approach can be finalized.



Fish and wildlife interaction at monitoring location in the Wenatchee River

CONCLUSIONS

The SRFB Reach-Scale Effectiveness Monitoring Program has been monitoring stream restoration projects for over a decade. While the program has provided valuable feedback on the efficacy of restoration projects, there continue to be opportunities to improve the program by building upon lessons learned over the last 10 years.

In 2015, the SRFB Monitoring Panel completed a comprehensive review of the Project Effectiveness Monitoring Program and identified key areas for improvement. The panel had three primary recommendations for the program that have been discussed in this report. They recommended deferring riparian vegetation monitoring for at least 2016, so that a review of riparian data and literature could be conducted to determine if postponing the final years of monitoring for vegetation projects would help improve the likelihood of detecting a significant improvement in riparian metrics. Review of the existing riparian data collected under the SRFB program and other studies has suggested that delaying riparian planting monitoring could be marginally beneficial in helping to detect significant responses for indicators where there has been a lack of change to date. The Monitoring Panel also recommended revising the fish sampling approach to better capture seasonal fish use of restoration projects outside of the low-flow season. Efforts are underway to collaborate with Panel members and the GSRO to finalize the revised methodology.

The third recommendation was to improve the interpretation and communication of monitoring results for future years of reporting. This topic is under discussion with the GSRO and the Monitoring Panel and, while some of their concerns were addressed in this report, the details of others are still being developed.

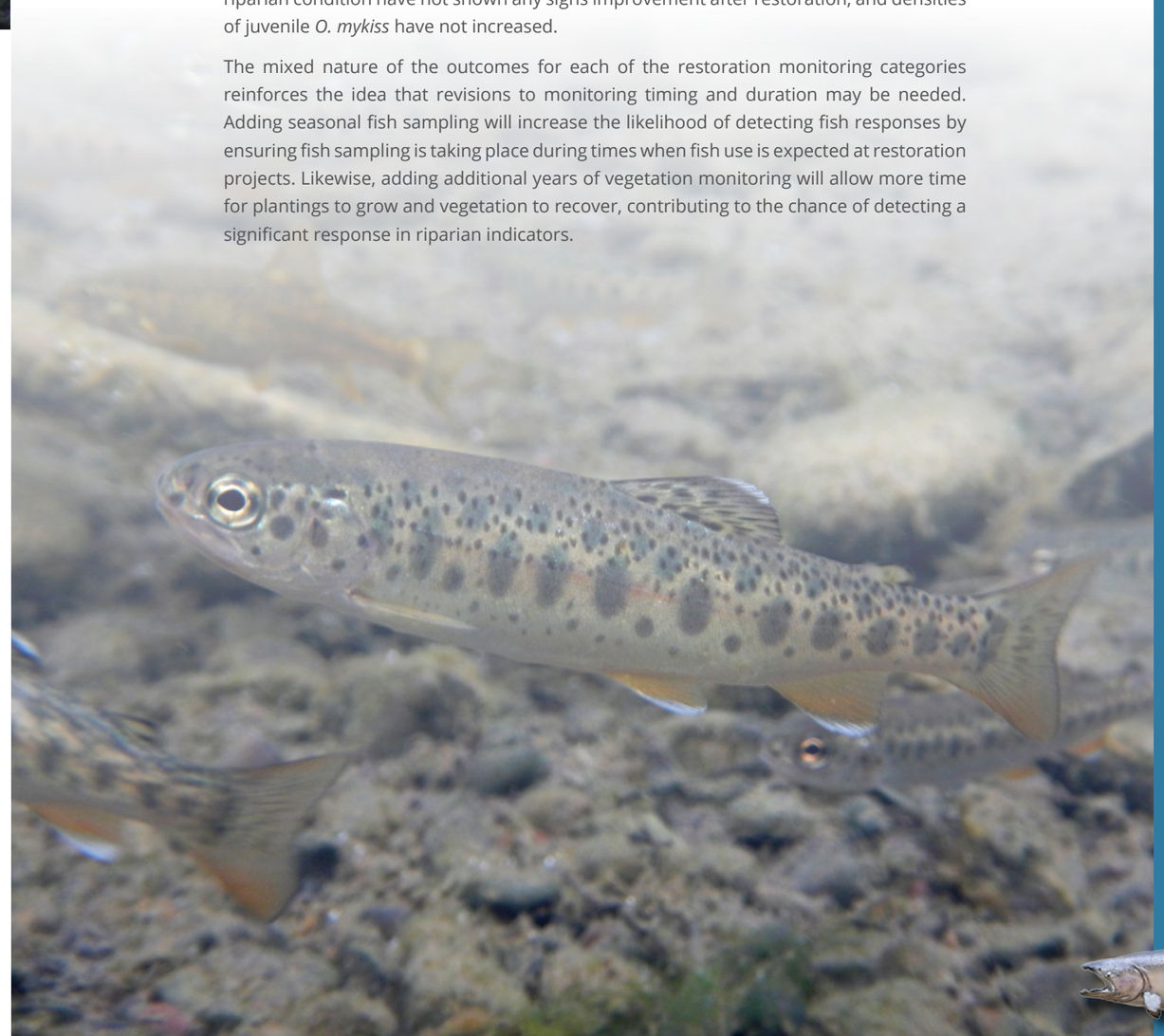
The traditional monitoring category-level analyses were performed in 2015 for all monitoring categories with new data collected in 2015. This included projects in the MC-2 Instream Habitat, MC-3 Riparian Planting, MC-4 Livestock Exclusion, and MC-5/6 Floodplain Enhancement categories. By analyzing the indicators for each category, several significant results were found that provide insight into which categories are meeting success criteria and which are not. Instream Habitat projects have been successful in improving all habitat indicators monitored, which includes pool habitat and LWD abundance. However, Instream Habitat projects have been less successful in affecting salmonid use, with no significant changes in juvenile Chinook, juvenile coho, juvenile *O. mykiss*, or bull trout densities following implementation.

Riparian Planting (MC-3) projects were successful at ensuring planting survival, improving woody cover, and improving riparian communities by increasing the proportion of reaches with canopy, understory, and ground cover. These results show that Riparian Planting projects are successful in improving the quality and quantity of riparian vegetation along streams. Planting projects did not, however, improve streambank erosion or stream shading. Improving both bank erosion and shading depends on having mature vegetation that can provide deep roots to secure stream banks and be tall enough to provide shade; therefore, waiting for projects to become more mature may help yield more significant results.

Livestock Exclusion projects (MC-4) were successful at reducing stream bank erosion, and appear to also be on track to improve stream shading. Stream shading only had significant results via the average change over time analysis indicating that shade-providing plants are increasing as projects keep livestock out of streams. This metric was not found to be significantly greater when analyzed by comparing the average post-implementation condition to the pre-project condition. Livestock projects have not successfully helped to increase the area where canopy, understory, and groundcover vegetation are present, but it may take more time for vegetation to recover to contribute to the canopy layer.

Floodplain Enhancement projects (MC-5/6) have successfully improved connectivity of streams to their floodplains, as measured by an increase in floodprone width after restoration. Salmonid use of restored areas shows some signs of improvement as well, with significant increases in densities of juvenile Chinook and coho. Chinook show a strong response, significant in both analyses, while the coho response is mixed. However, several other habitat metrics have not significantly changed after restoration. Pool habitat and riparian condition have not shown any signs improvement after restoration, and densities of juvenile *O. mykiss* have not increased.

The mixed nature of the outcomes for each of the restoration monitoring categories reinforces the idea that revisions to monitoring timing and duration may be needed. Adding seasonal fish sampling will increase the likelihood of detecting fish responses by ensuring fish sampling is taking place during times when fish use is expected at restoration projects. Likewise, adding additional years of vegetation monitoring will allow more time for plantings to grow and vegetation to recover, contributing to the chance of detecting a significant response in riparian indicators.



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APPENDIX A
Indicators and Success Criteria

Table A-1. Indicators and Success Criteria for Active Project Categories

Monitoring Level	Indicators	Metric	Test Type	Success Criteria
MC-2 Instream Habitat				
Structure	Number of instream structures within the study reach	#	None. Threshold	≥ 80% of structures are intact by Year 10. Intact means that 50% of material of each structure is in place within the impact reach.
Stream Morphology	Mean residual pool vertical profile area	m^2	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
	Mean residual depth	cm	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
	Large wood ($\log_{10}$ LWD volume)	m^3	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
Juvenile Fish Abundance	Juvenile salmonid abundance by species	fish/m^2	Paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
MC-3 Riparian Planting				
Plantings	Number of plantings remaining alive in planting area	#	None. Threshold	≥ 50% of plantings are living by Year 3.
	Mean percent cover of woody species in riparian planting area	%	None. Threshold	≥ 80% cover of woody riparian species by Year 10.
Riparian Condition	Mean percent canopy density at bank densiometer reading	1 – 17 score	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
	3-layer riparian vegetation presence	% (of reach)	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
	Actively eroding banks	% (of reach)	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
MC-4 Livestock Exclusion				
Livestock Exclusion Fencing	Number of functional livestock exclusions	#	None. Threshold	≥ 80% of exclusions are functional by Year 10. “Functional” means there are no holes in fencing and no recent signs of livestock.

Monitoring Level	Indicators	Metric	Test Type	Success Criteria
Riparian Condition	Mean percent canopy density at bank densiometer reading	1 – 17 score	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
	3-layer riparian vegetation presence	% (of reach)	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
	Actively eroding banks	% (of reach)	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
	Percentage of pool tail fines	%	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
MC-5/6 Floodplain Enhancement				
Stream Morphology	Average Channel Capacity	Avg. m^2	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
	Mean residual pool vertical profile area	m^2	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
	Mean residual depth	cm	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
	Floodprone width	Avg. m	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
Riparian Condition	Mean percent canopy density at bank densiometer reading	1 – 17 score	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
	3-layer riparian vegetation presence	% (of reach)	Linear Regression or paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
Juvenile Fish Abundance	Juvenile salmonid abundance by species	fish/m^2	Paired t-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10.
MC-10 Habitat Protection				
Riparian Condition	Mean percent canopy density at bank densiometer reading	1 – 17 score	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	3-layer riparian vegetation presence	% (of reach)	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Actively eroding banks	% (of reach)	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.

Monitoring Level	Indicators	Metric	Test Type	Success Criteria
Stream Morphology	Mean residual pool vertical profile area	m^2	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Mean residual depth	cm	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Large wood (log_{10} LWD volume)	m^3	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Percent substrate embedded	%	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Percent substrate as fines	%	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
Stream Animal Assemblages	Macroinvertebrate multimetric index (MMI)	MMI score	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Fish species assemblages	FI score	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
Upland Habitat	Absolute percent cover of non-native herbaceous vascular plant spp	%	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Relative percent cover of non-native herbaceous vascular plant spp	%	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Absolute percent of non-native shrub spp	%	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Relative percent cover of non-native shrub spp	%	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Basal area of conifers per acre	ft^2/acre	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Stem count of conifers per acre	#/acre	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Basal area of deciduous trees per acre	ft^2/acre	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Stem count of deciduous trees per acre	#/acre	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.

Monitoring Level	Indicators	Metric	Test Type	Success Criteria
Intertidal Habitat	Percent cover of algae per transect	%	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Linear extent of algae along the intertidal transect	#	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Percent cover of vascular plants	%	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Linear extent of vascular plants along the intertidal transect	#	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Percent slope from mean high tide to mean low tide	%	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Mean percent of the substrate transect in fines	%	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.
	Linear extent of fine sediment along the intertidal transect	#	Linear Regression or non-parametric test	Alpha = 0.10. Detect a minimum 20% change between Base Year 0 and Year 3, 8, or 12.

APPENDIX B
Scatter Plot Figures

MC-2 SCATTER PLOTS

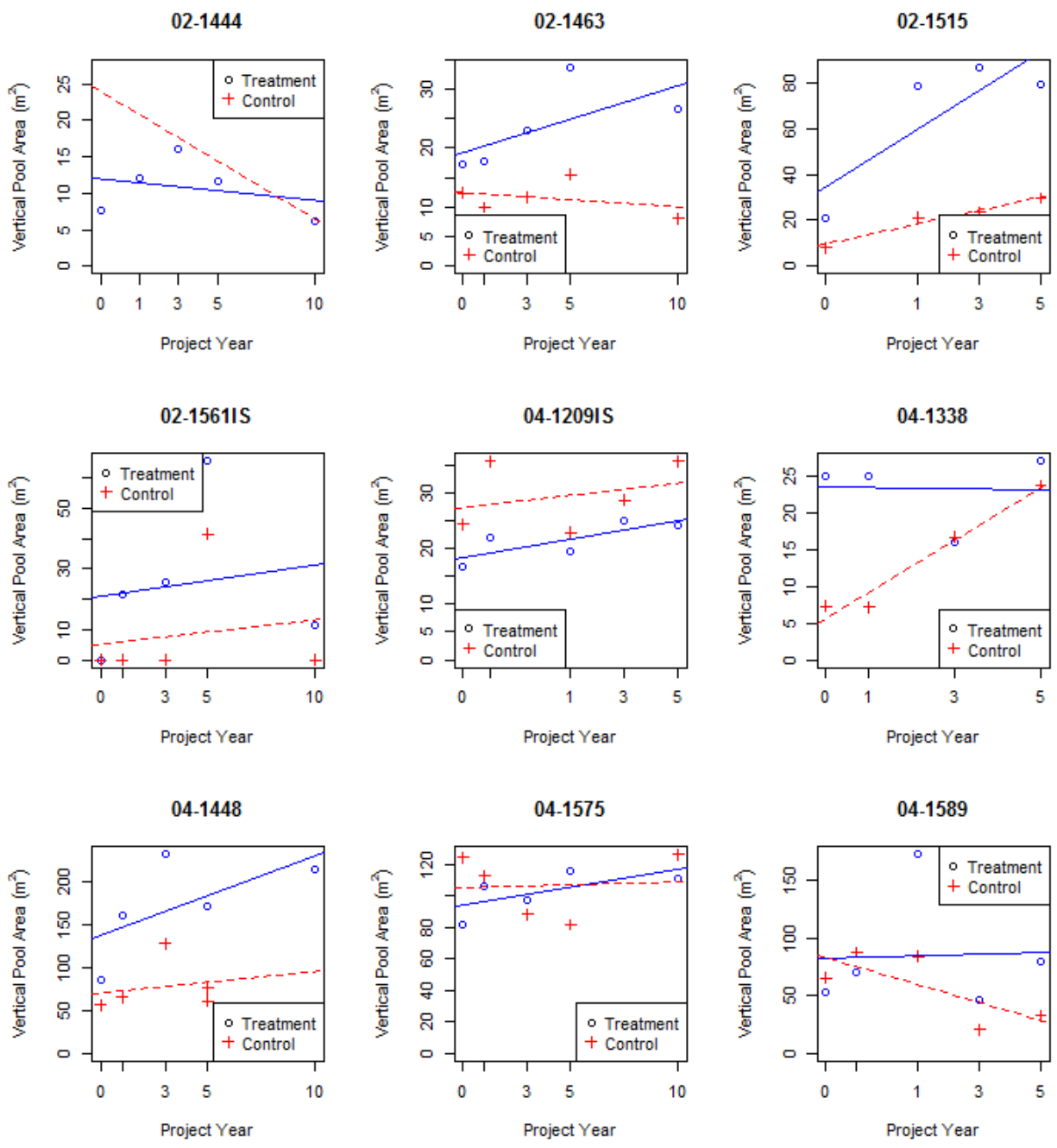


Figure B-1. Scatter Plots of Vertical Pool Profile Area for MC-2 Projects

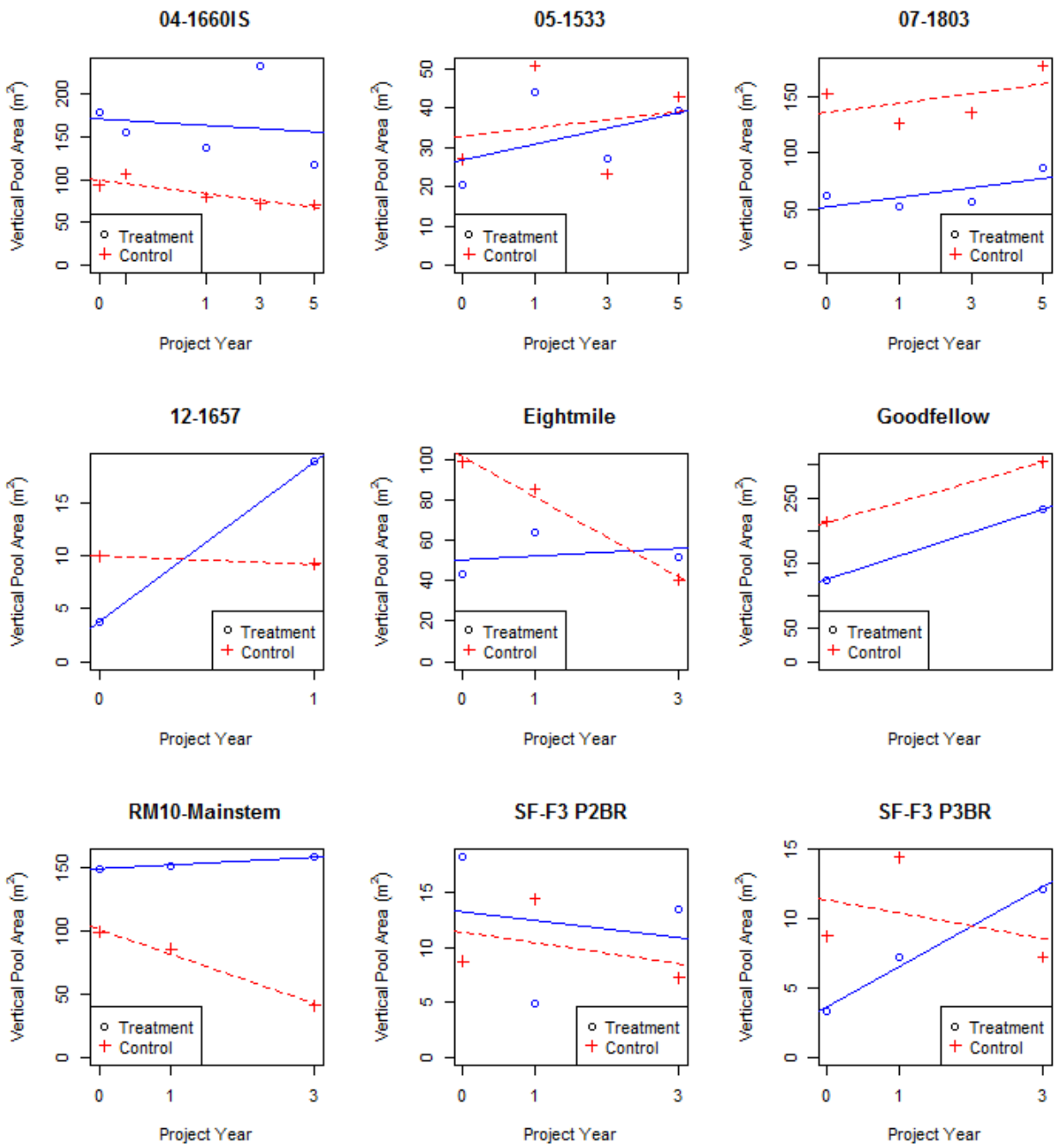


Figure B-1 *continued*. Scatter Plots of Vertical Pool Profile Area for MC-2 Projects

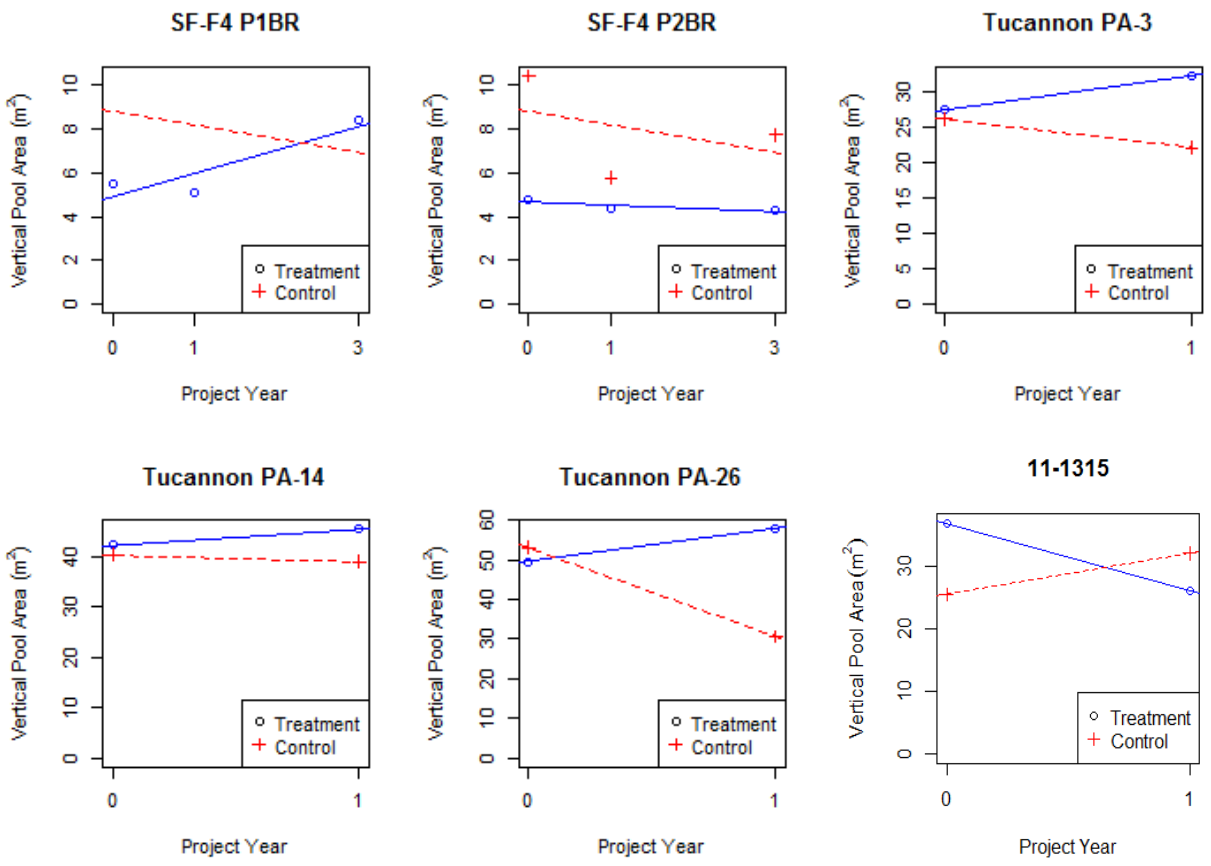


Figure B-1 *continued*. Scatter Plots of Vertical Pool Profile Area for MC-2 Projects

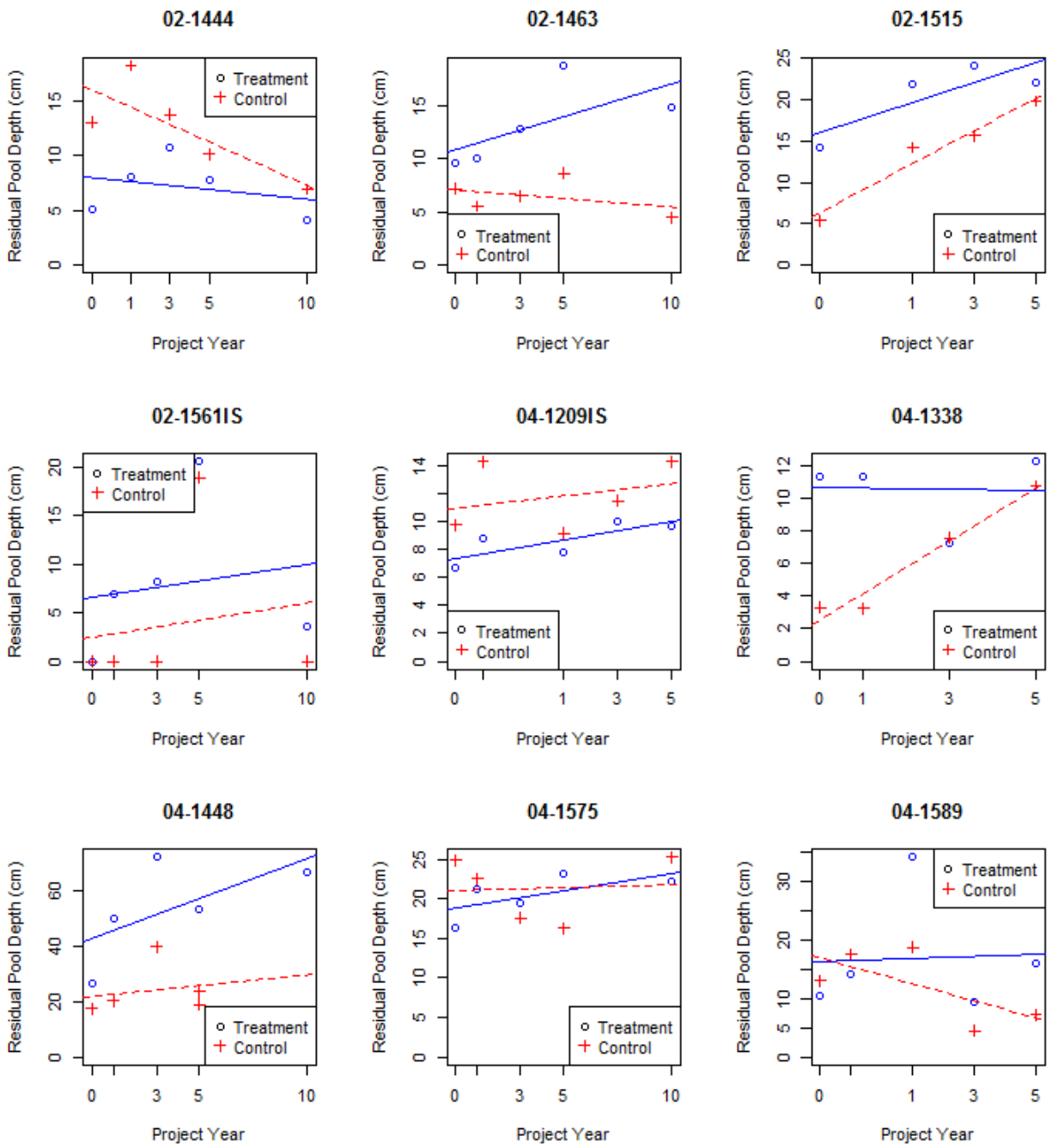


Figure B-2. Scatter Plots of Average Residual Pool Depth for MC-2 Projects

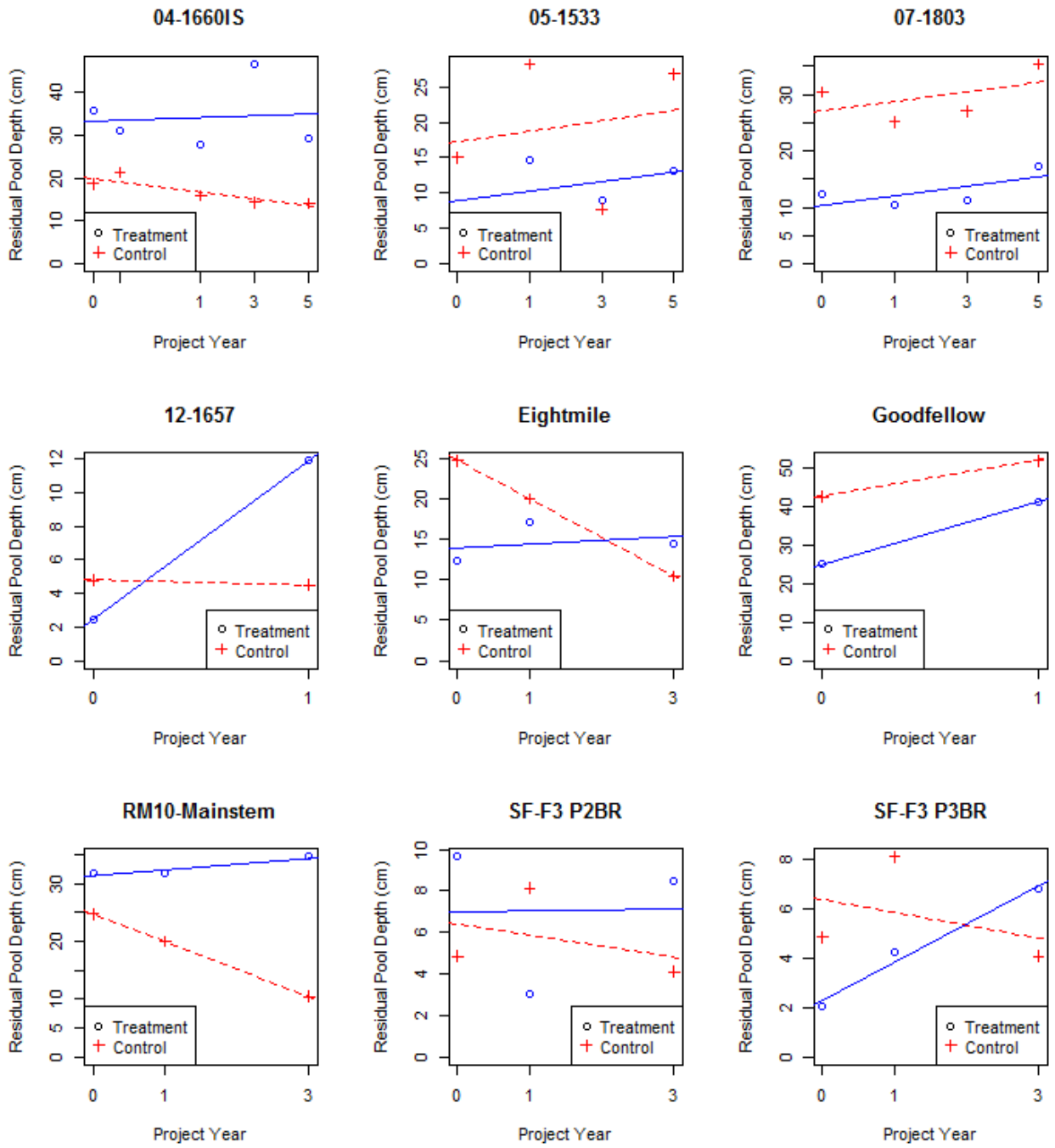


Figure B-2 *continued*. Scatter Plots of Average Residual Pool Depth for MC-2 Projects

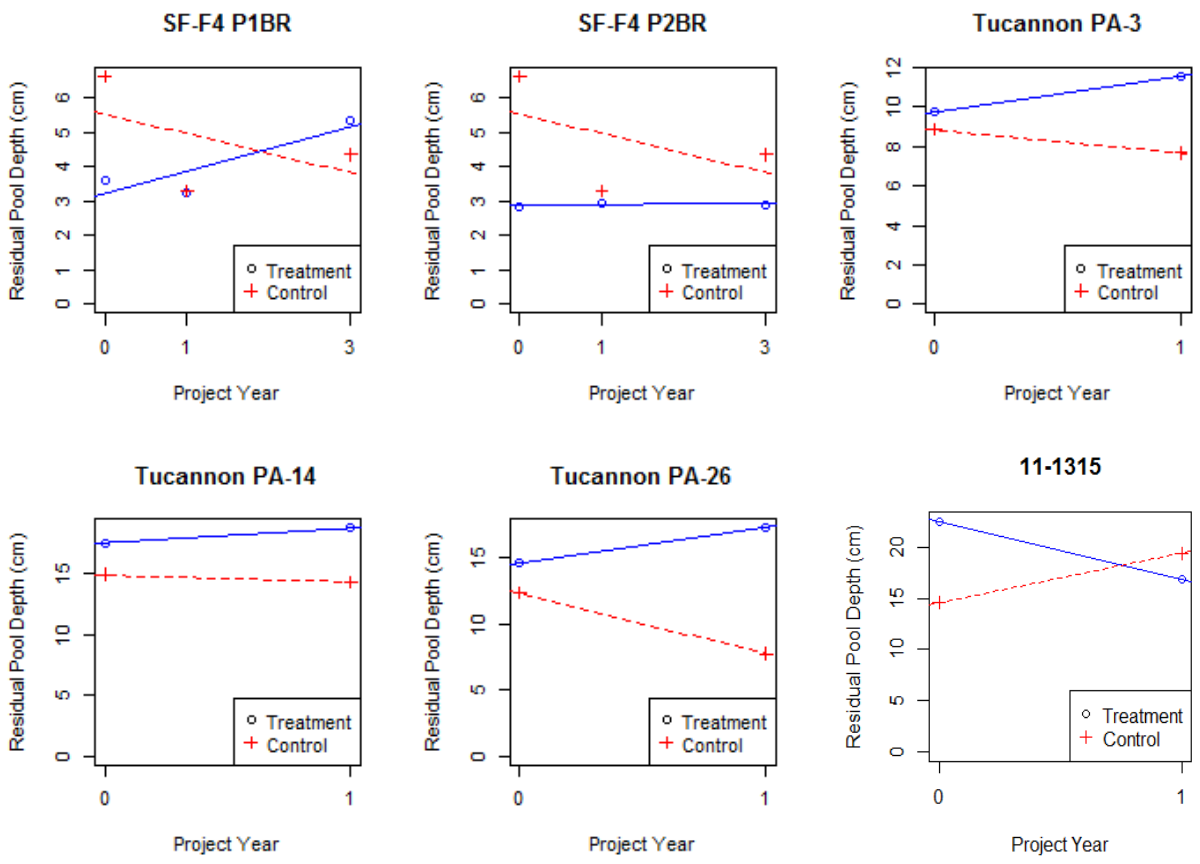


Figure B-2 *continued*. Scatter Plots of Average Residual Pool Depth for MC-2 Projects

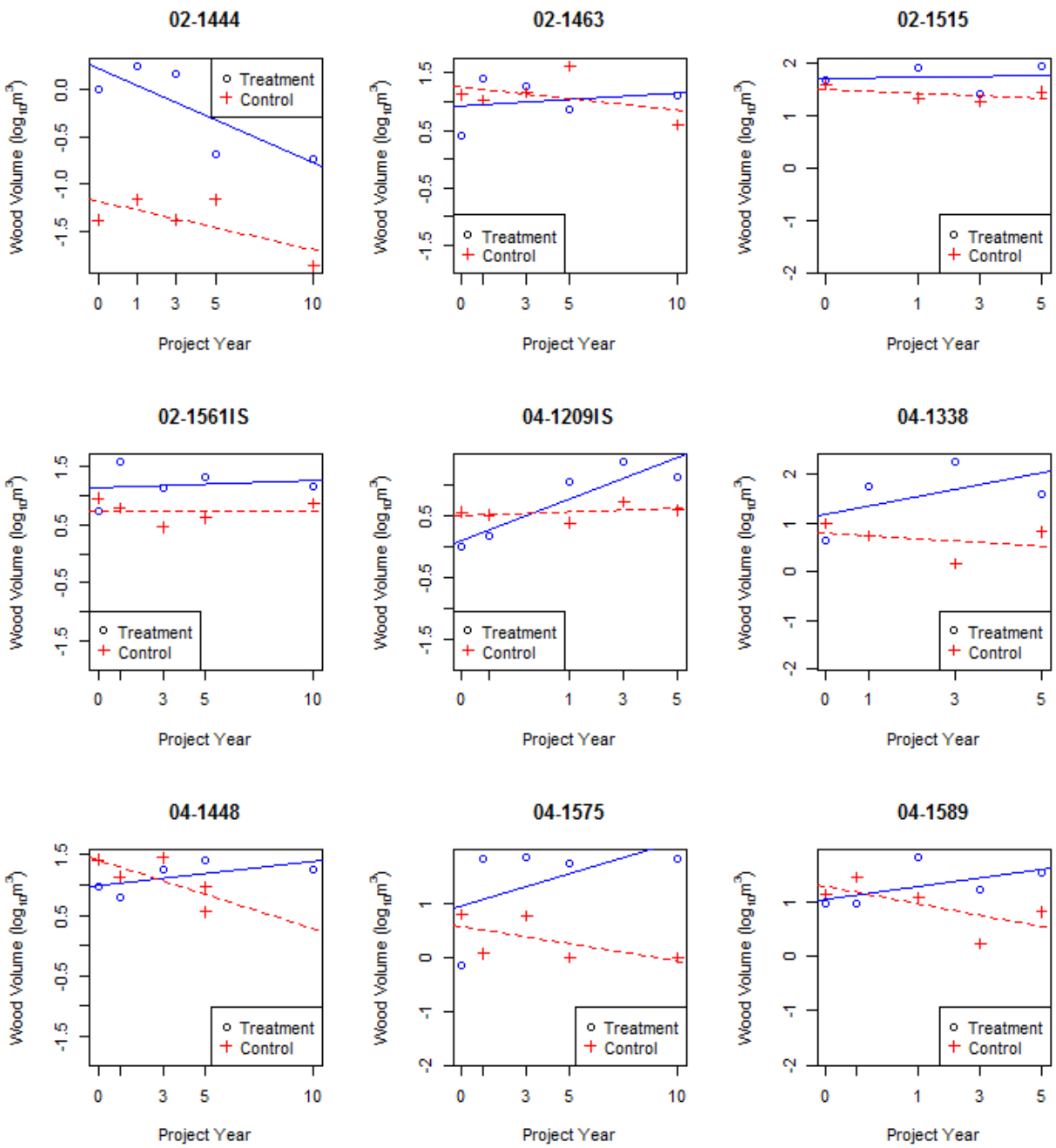


Figure B-3. Scatter Plots of $\log_{10}$ LWD Volume for MC-2 Projects

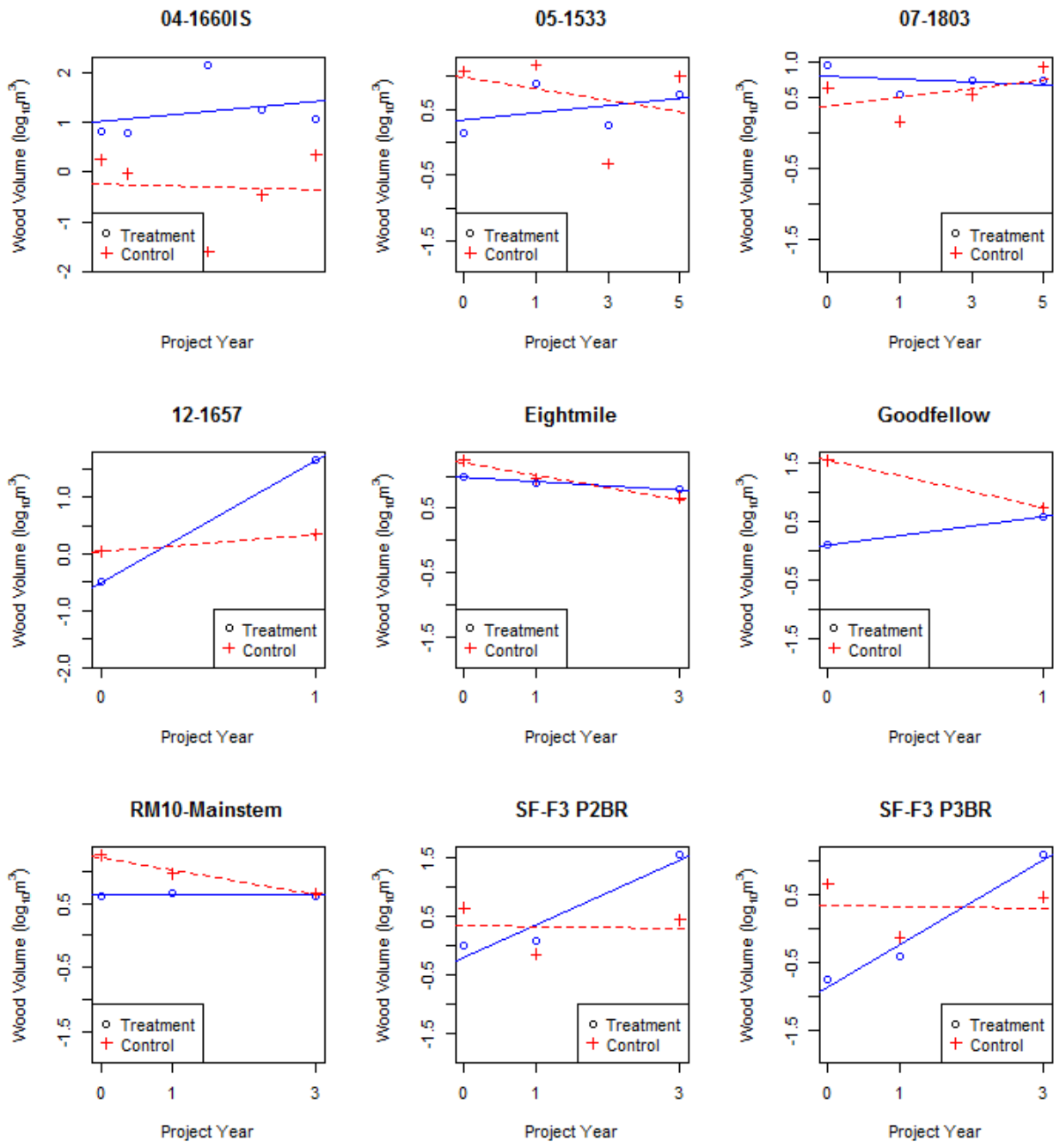


Figure B-3 *continued*. Scatter Plots of $\log_{10}$ LWD Volume for MC-2 Projects

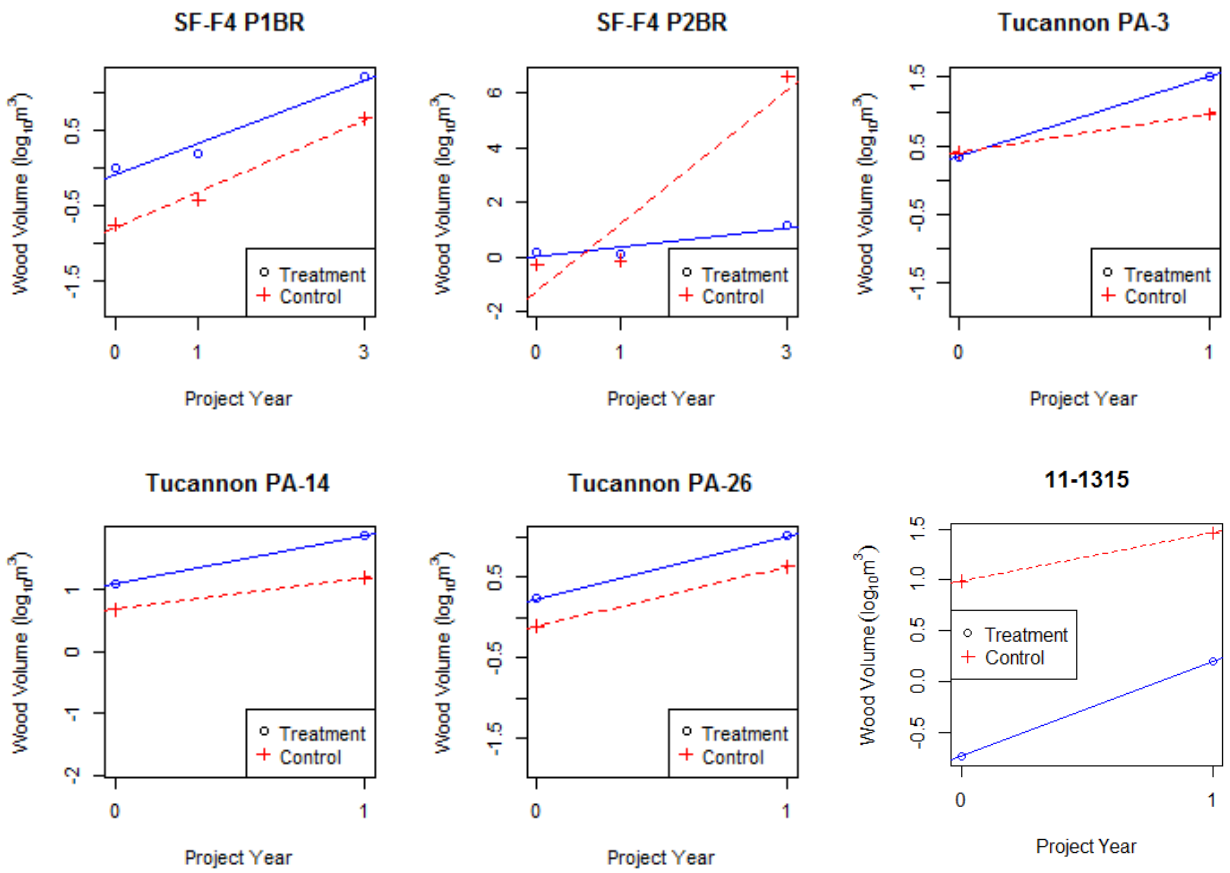


Figure B-3 *continued*. Scatter Plots of log_{10} LWD Volume for MC-2 Projects

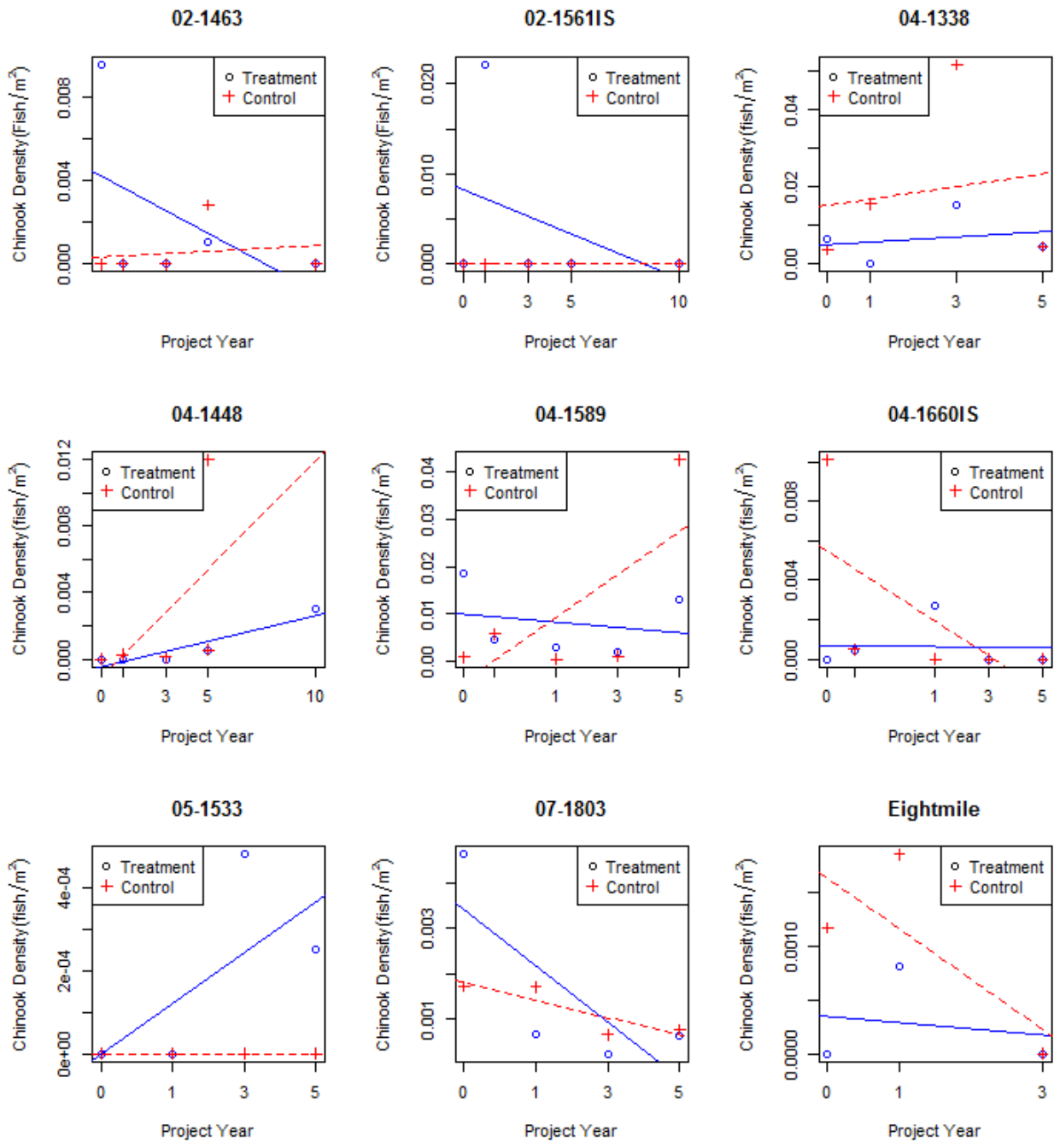


Figure B-4. Scatter Plots of Juvenile Chinook Density for MC-2 Projects

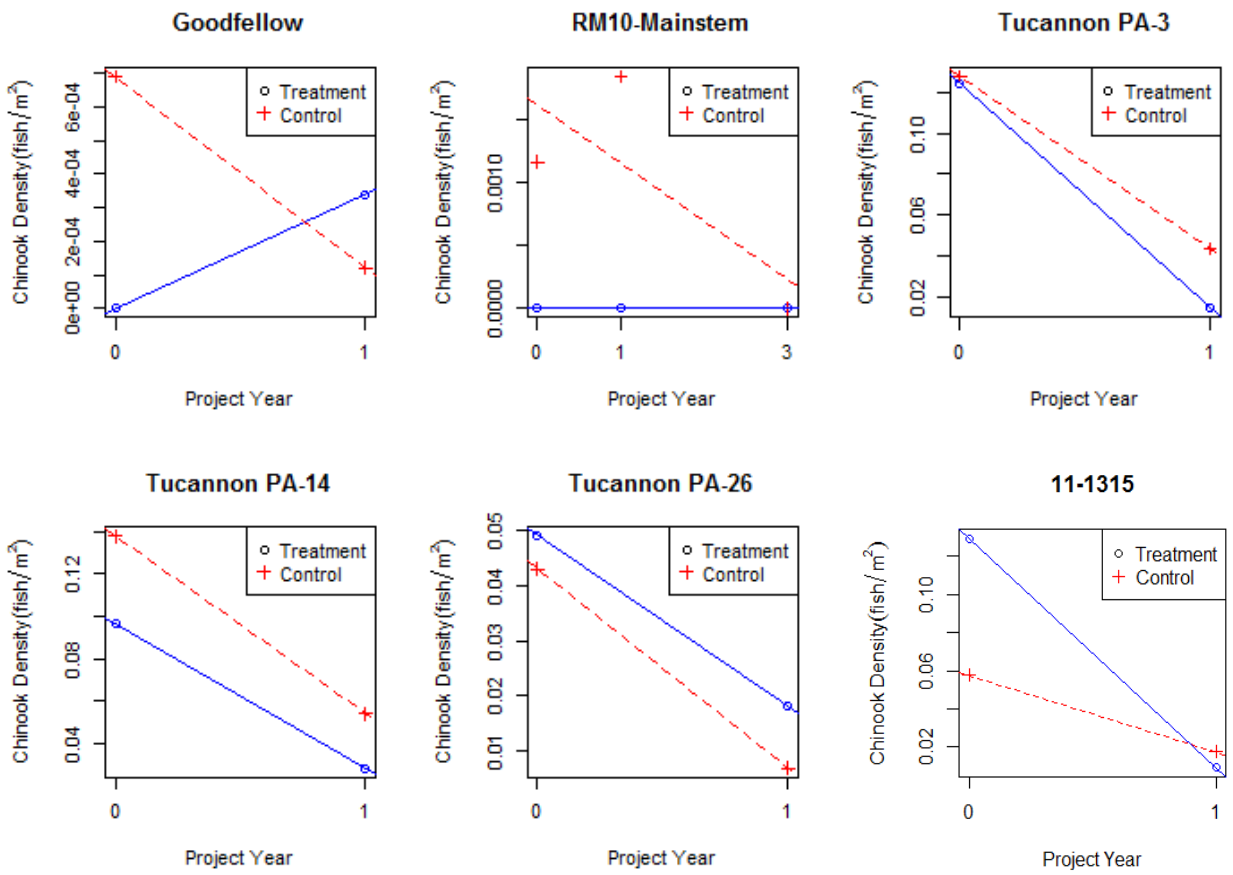


Figure B-4 *continued*. Scatter Plots of Juvenile Chinook Density for MC-2 Projects

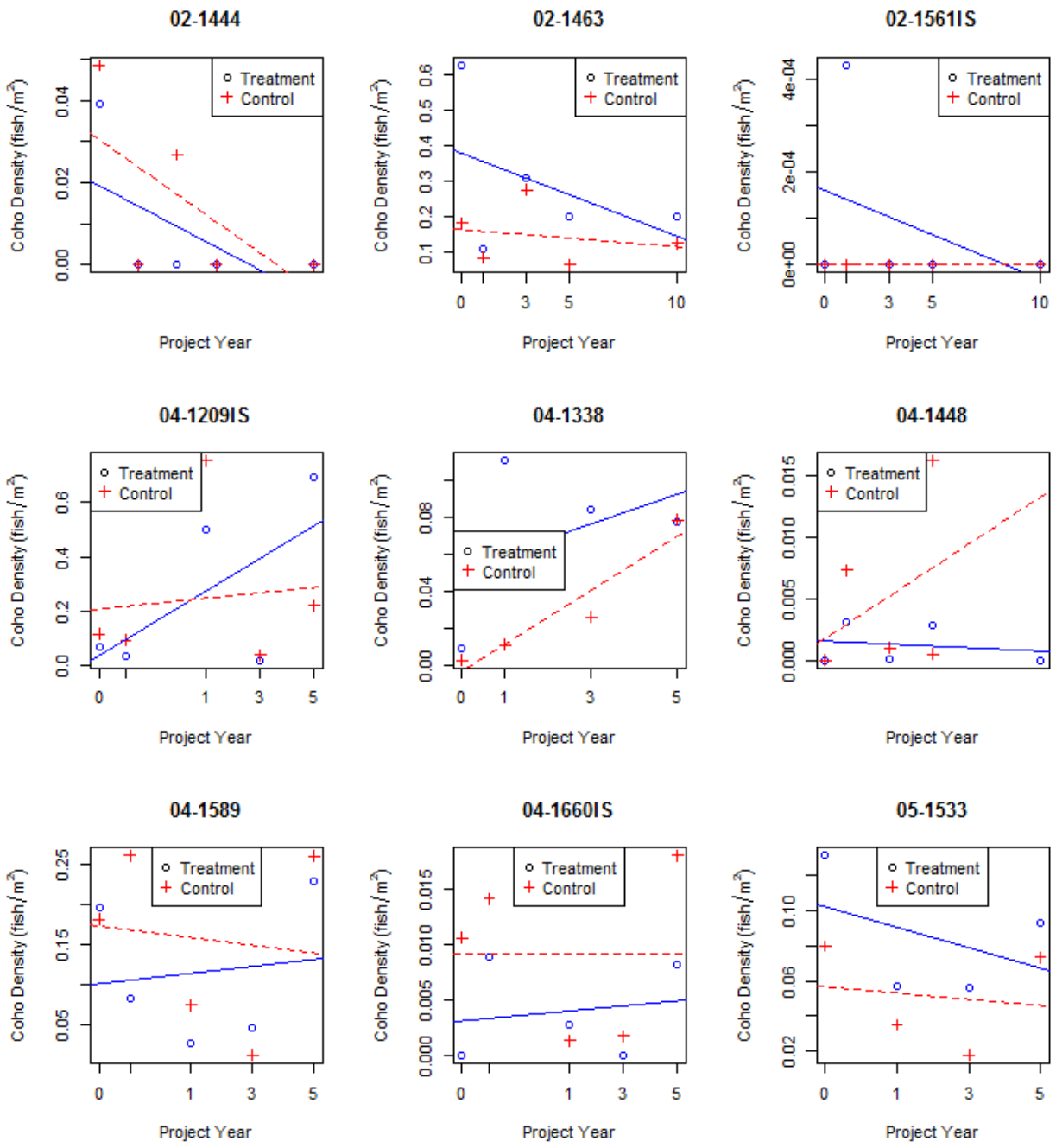


Figure B-5. Scatter Plots of Juvenile Coho Density for MC-2 Projects

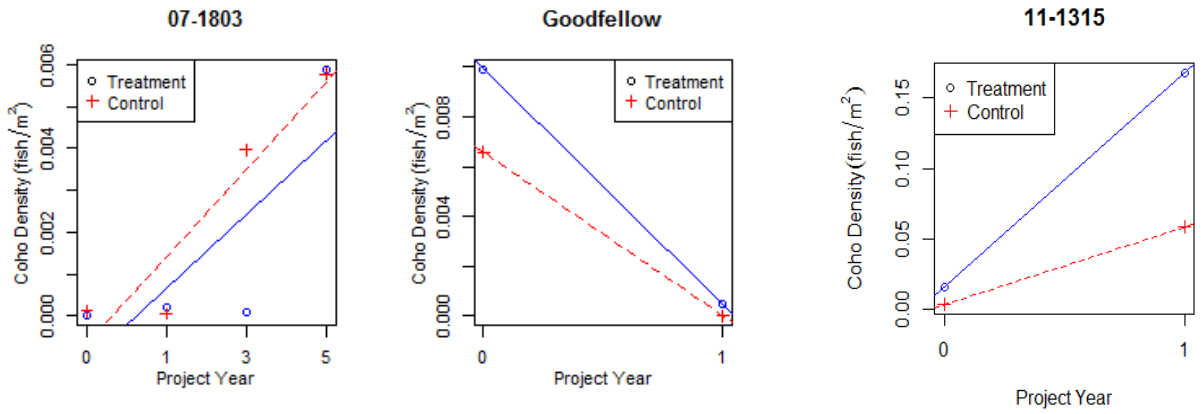


Figure B-5 *continued*. Scatter Plots of Juvenile Coho Density for MC-2 Projects

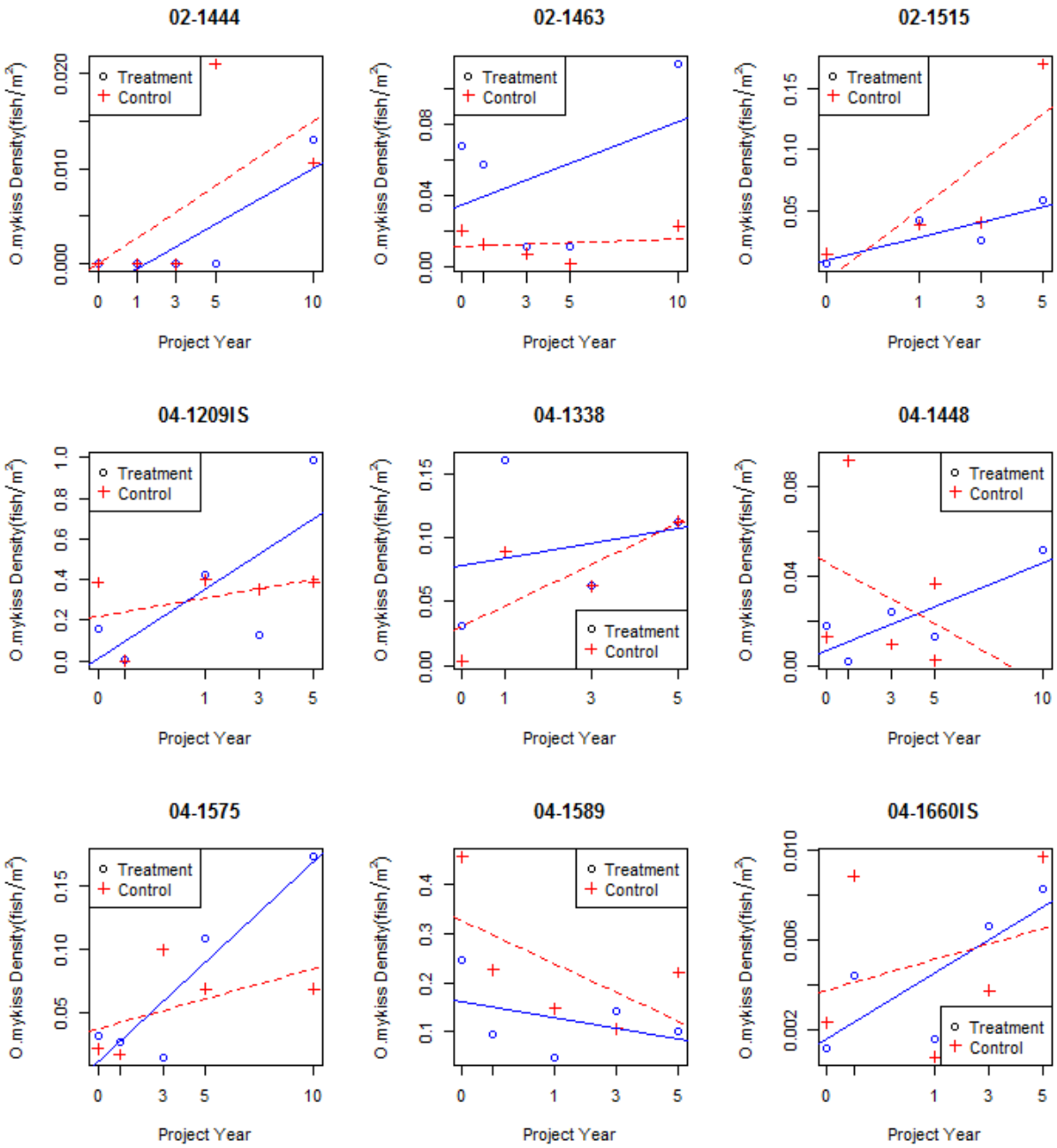


Figure B-6. Scatter Plots of Juvenile *O. mykiss* Density for MC-2 Projects

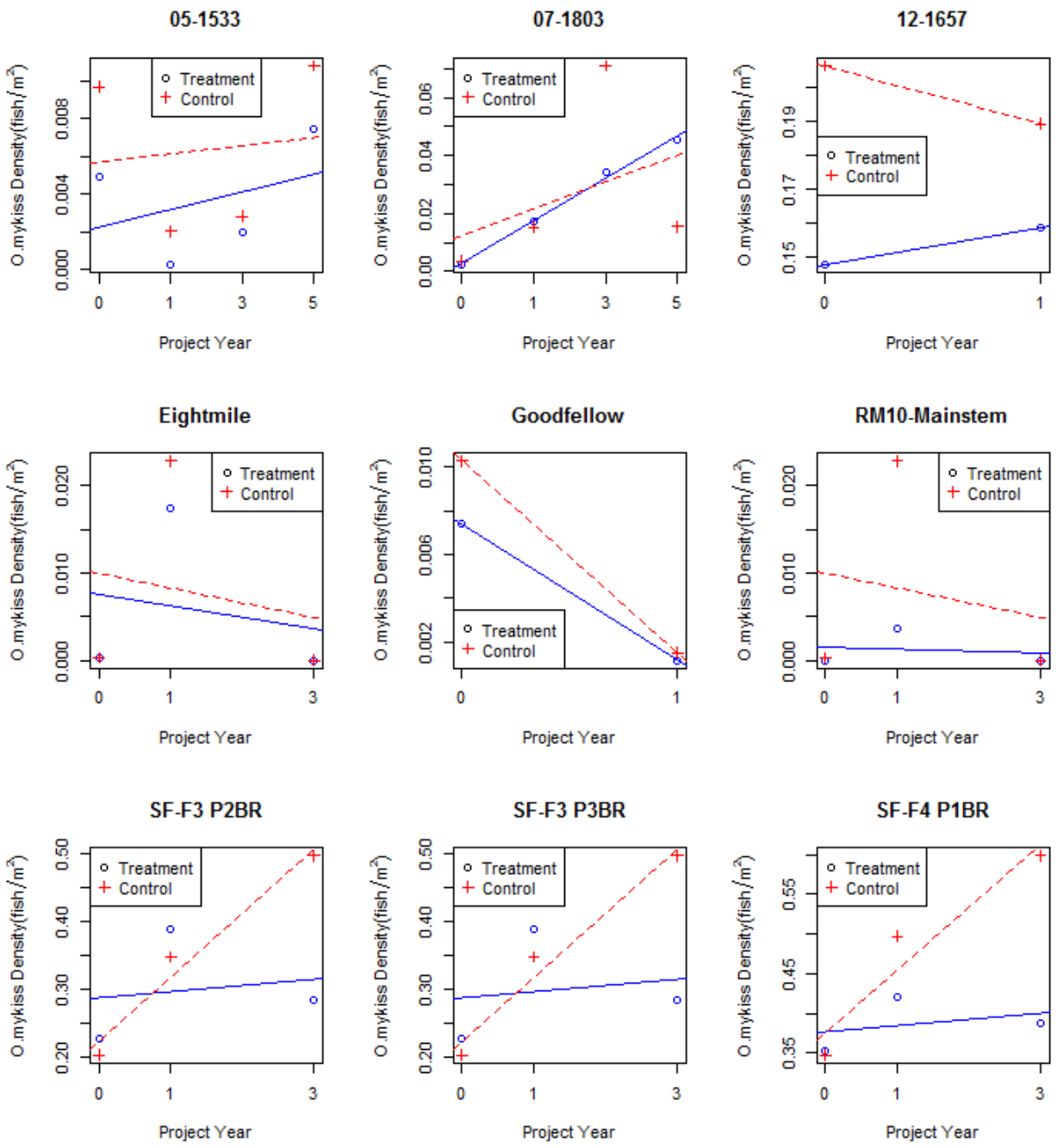


Figure B-6 *continued*. Scatter Plots of Juvenile *O. mykiss* Density for MC-2 Projects

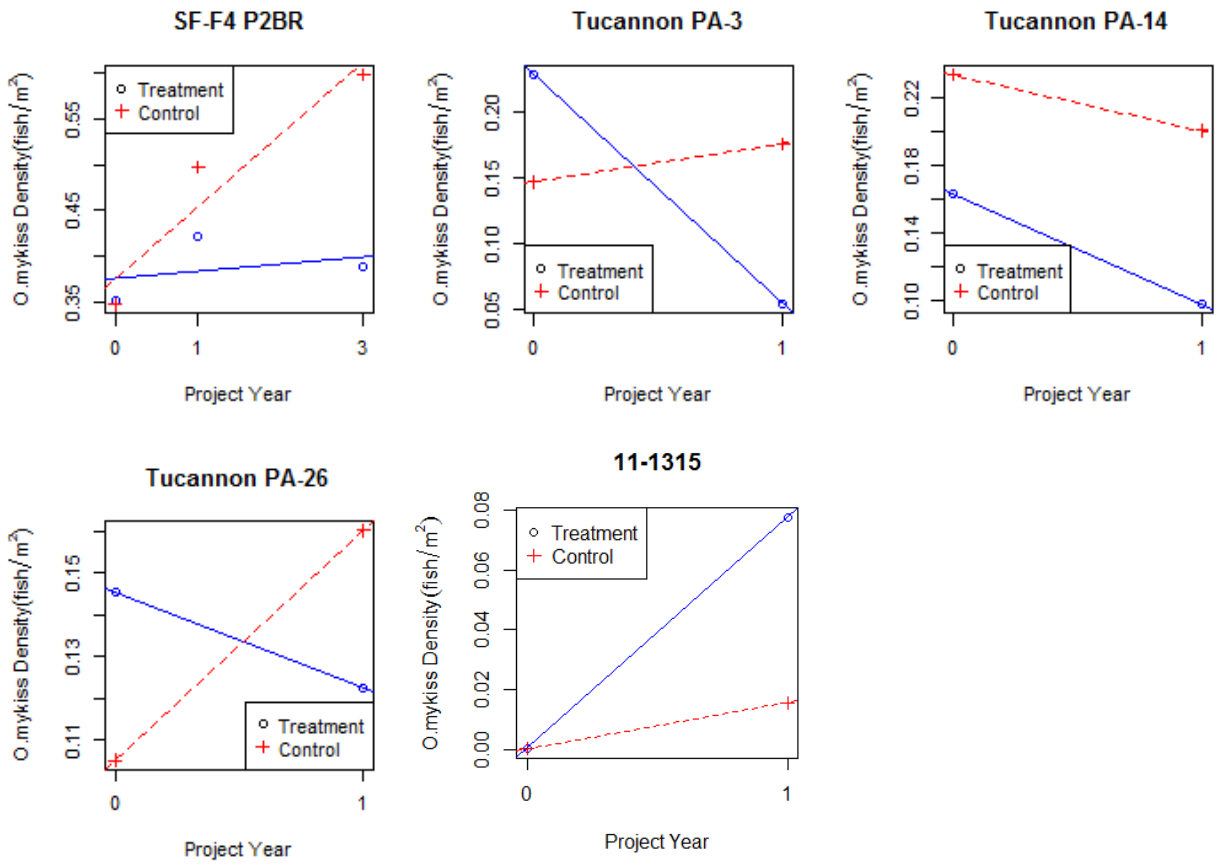


Figure B-6 *continued*. Scatter Plots of Juvenile *O. mykiss* Density for MC-2 Projects

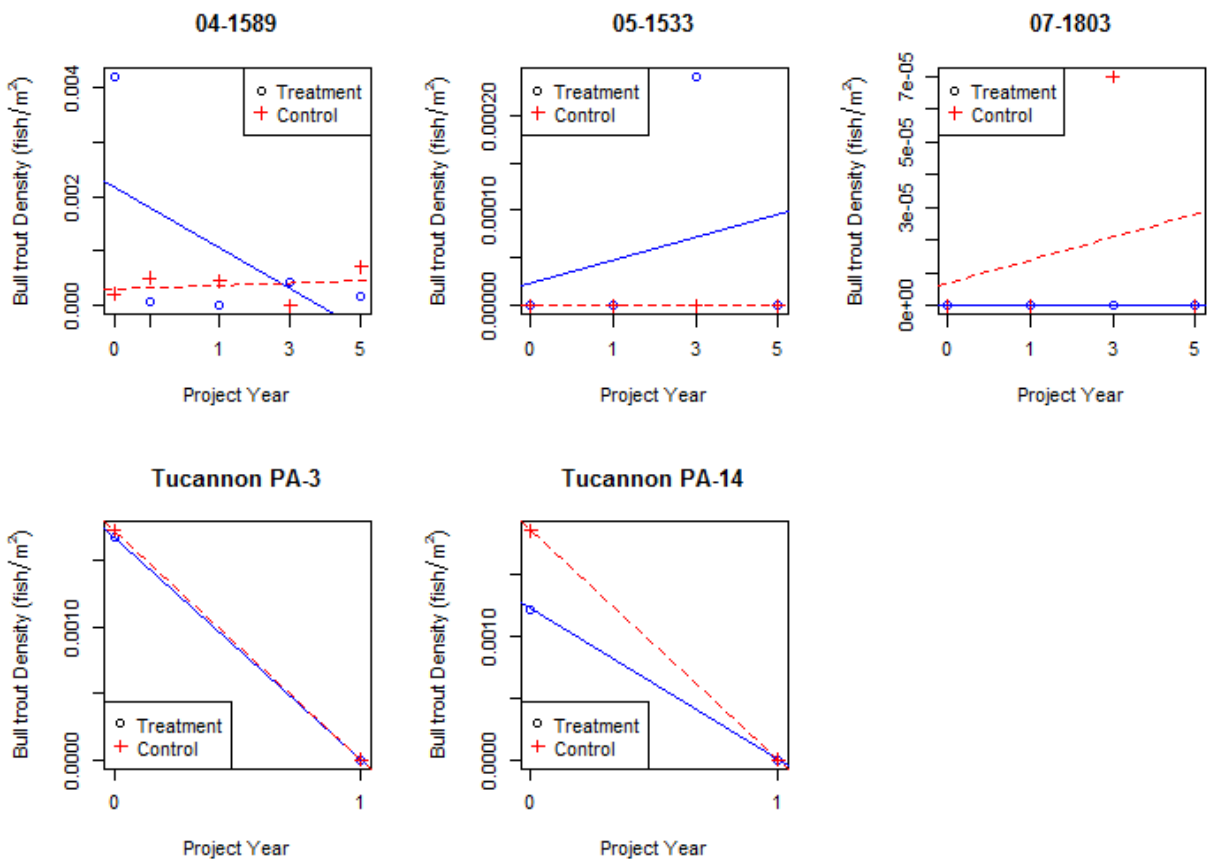


Figure B-7. Scatter Plots of Bull Trout Density for MC-2 Projects

MC-3 SCATTER PLOTS

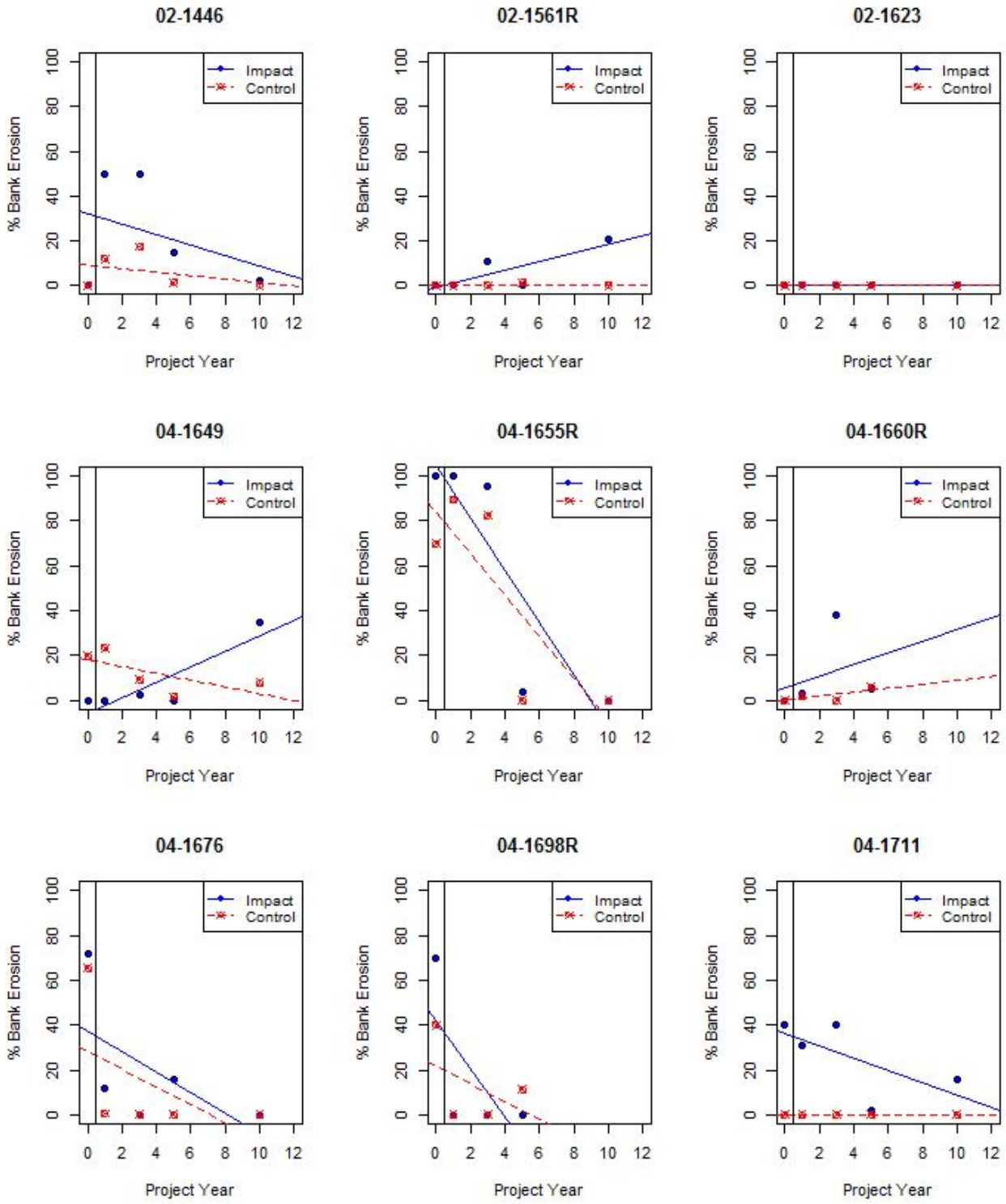


Figure B-8 MC-3 Percent Bank Erosion by Impact year for Each Impact-Control Site Pair

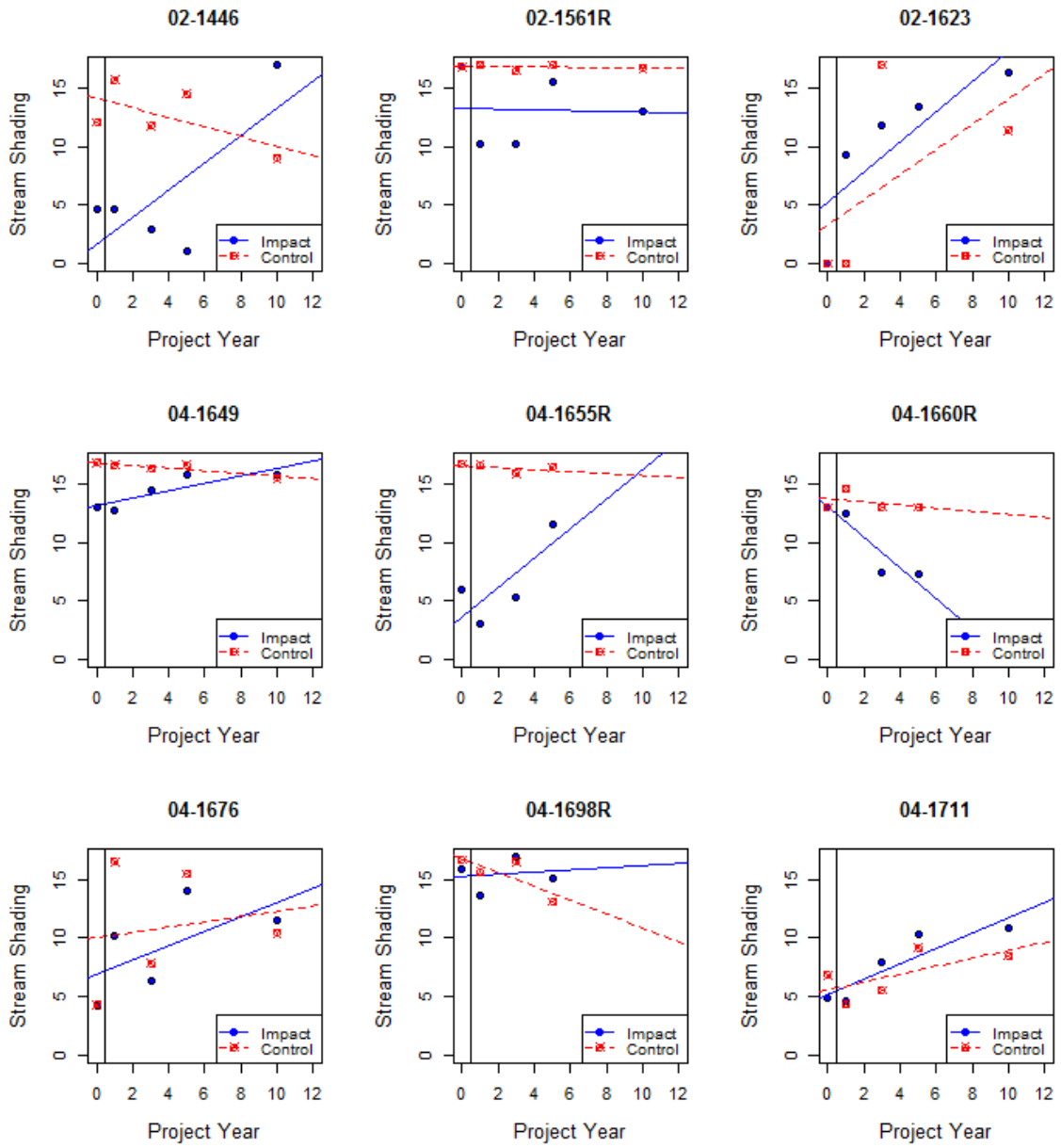


Figure B-9. Mean Riparian Shading Values for MC-3 Projects; All Project Years

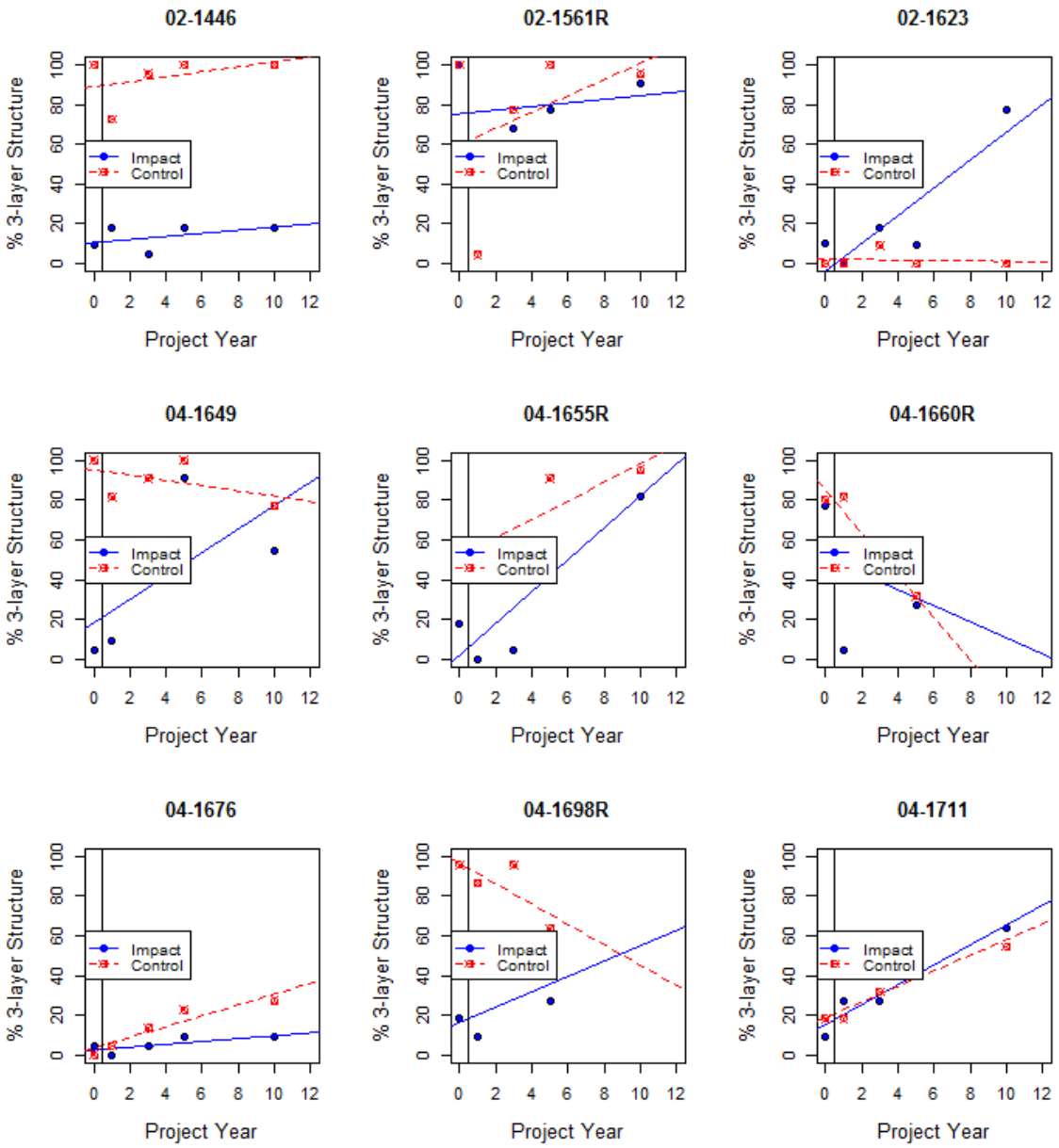


Figure B-10. Mean Vegetation Structure Values for MC-3 Projects; All Project Years

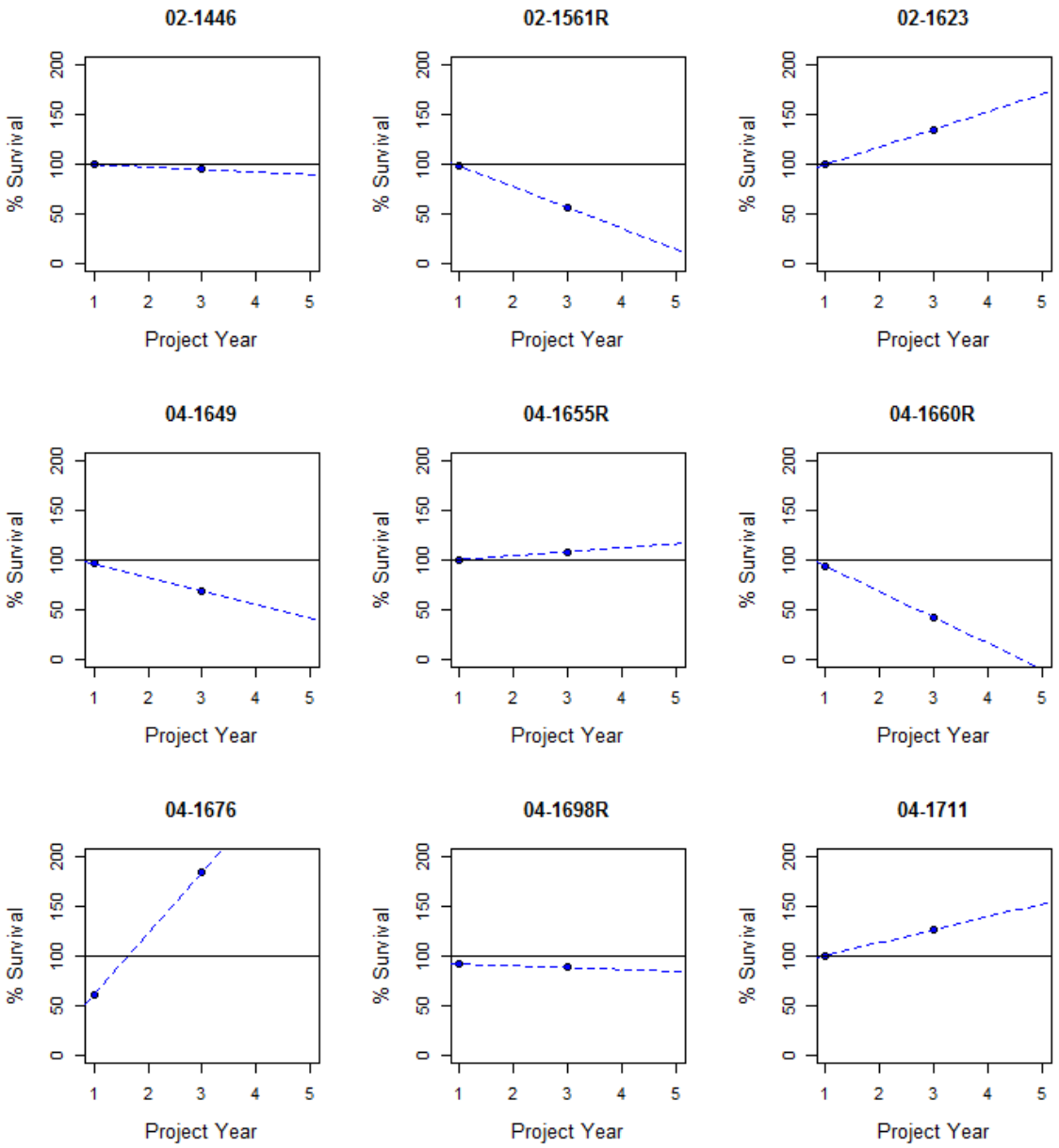


Figure B-11. Percent Survival for Plantings in Impact Reach during Year 1 and Year 3, Post-Implementation Monitoring

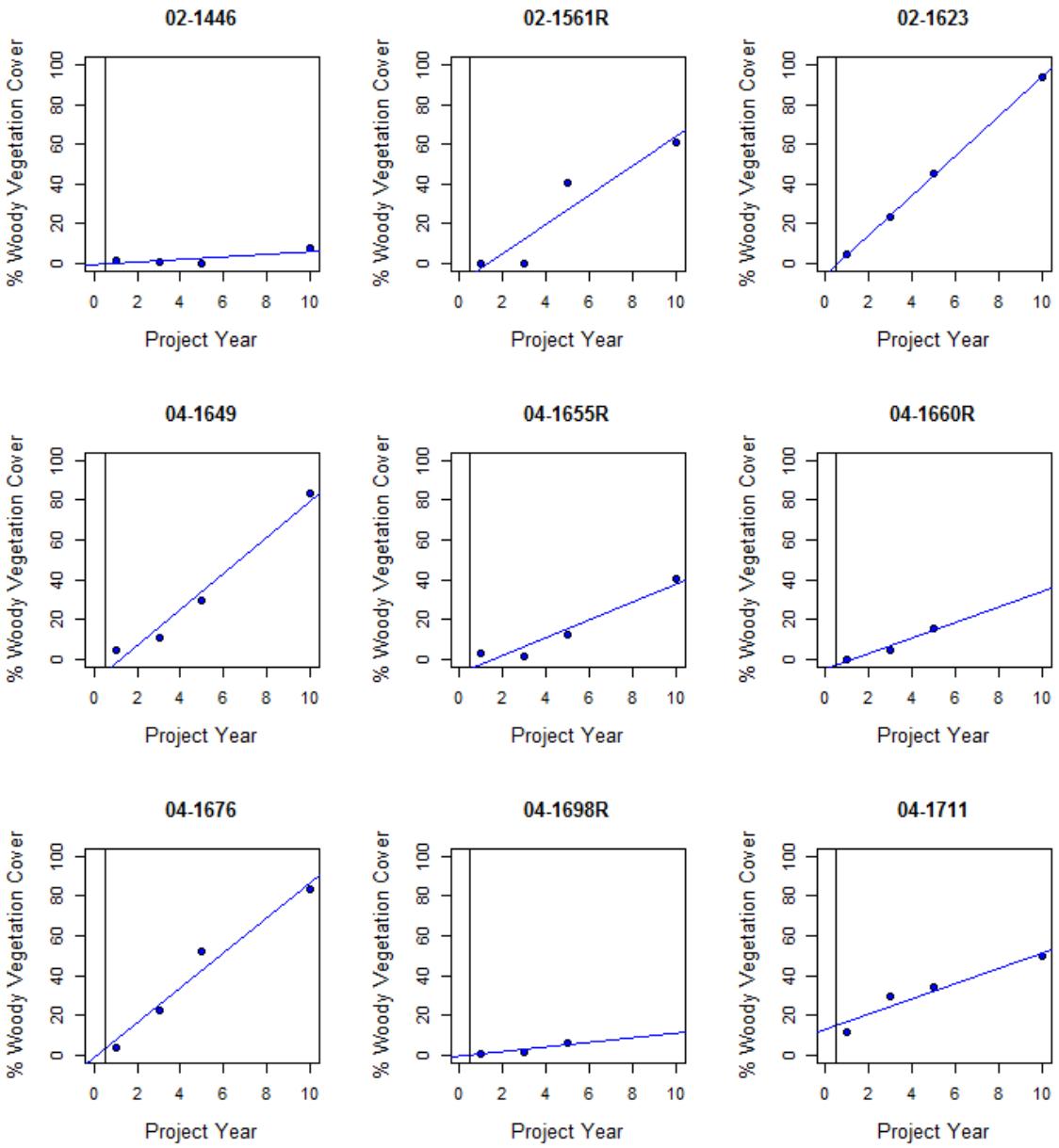


Figure B-12. Percent Woody Cover Over Time for All Post-Implementation Years

MC-4 SCATTER PLOTS

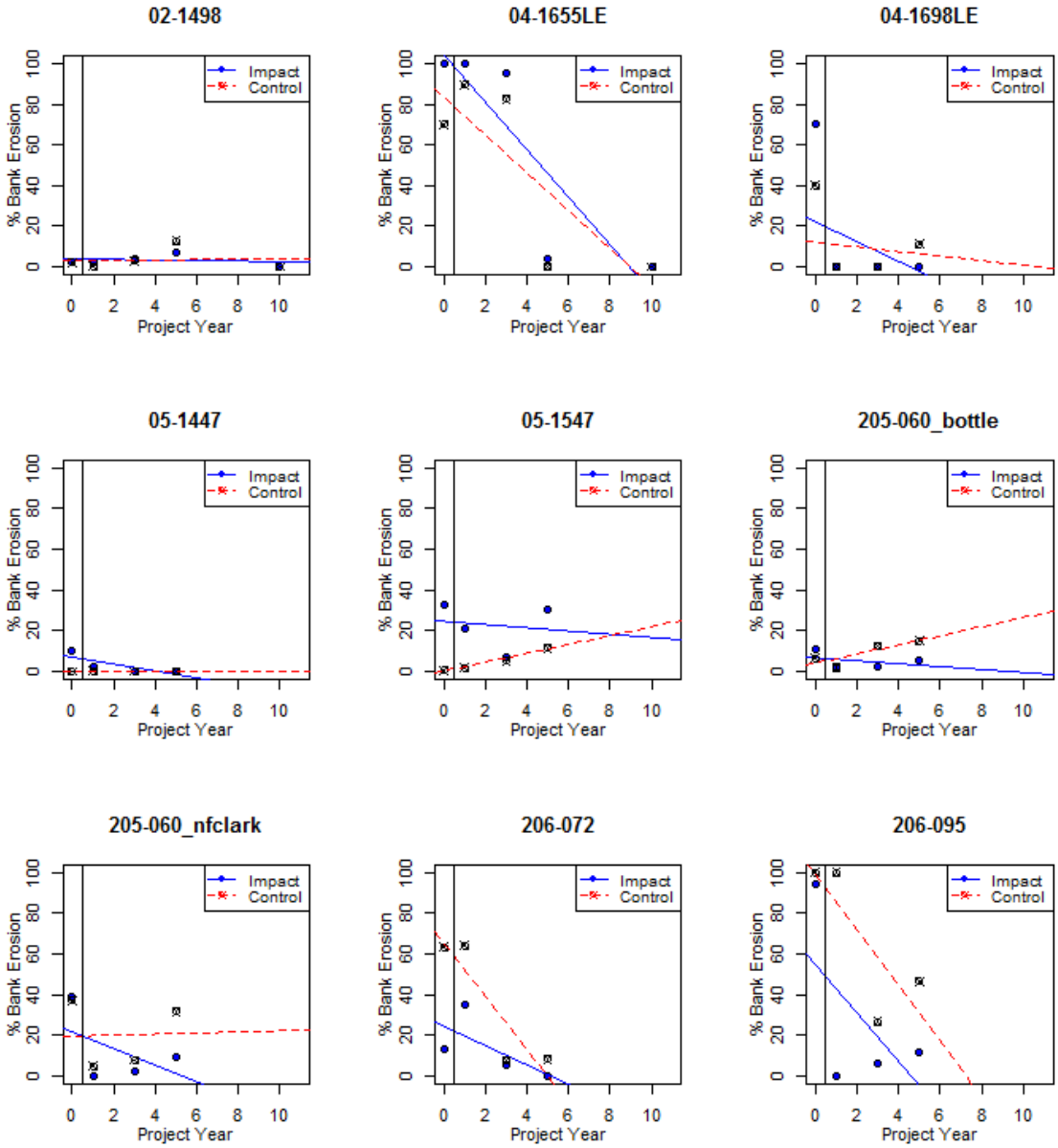


Figure B-13. MC-4 Percent Bank Erosion by Impact Year for Each Impact-Control Site Pair

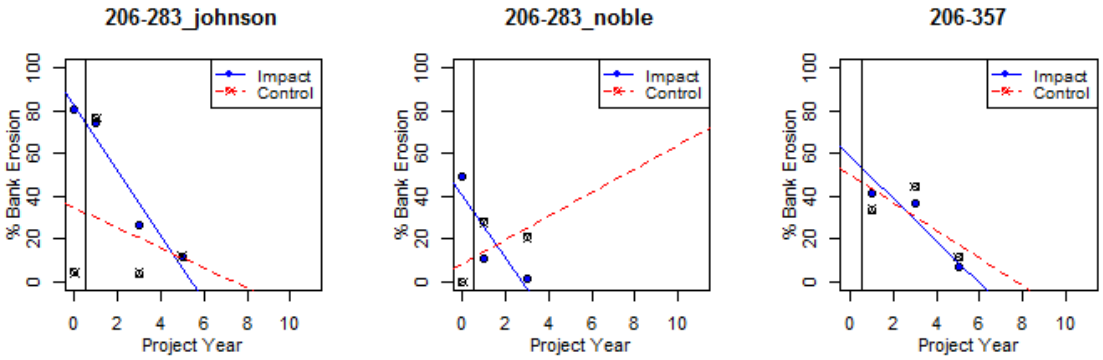


Figure B-13 *continued*. MC-4 Percent Bank Erosion by Impact Year for Each Impact-Control Site Pair

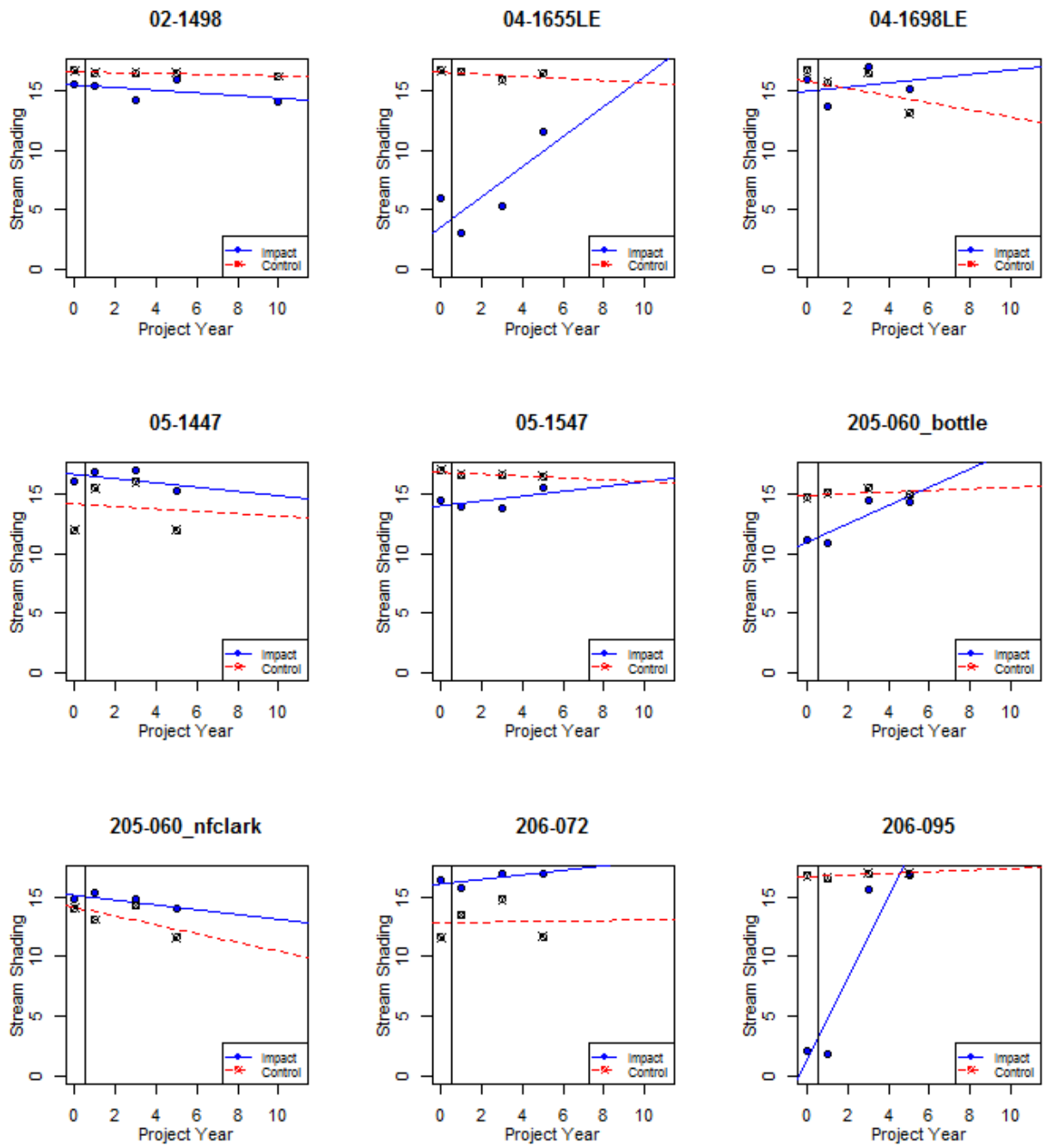


Figure B-14. Stream Shading Measures for MC-4 Sites

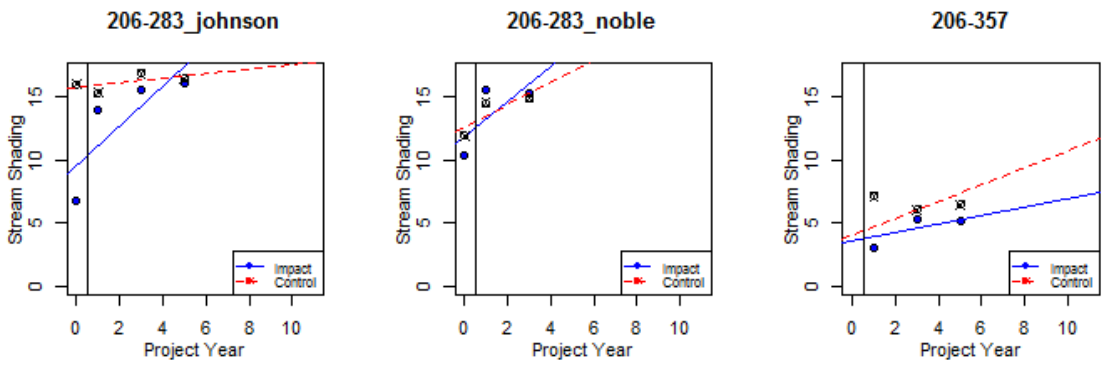


Figure B-14 *continued*. Stream Shading Measures for MC-4 Sites

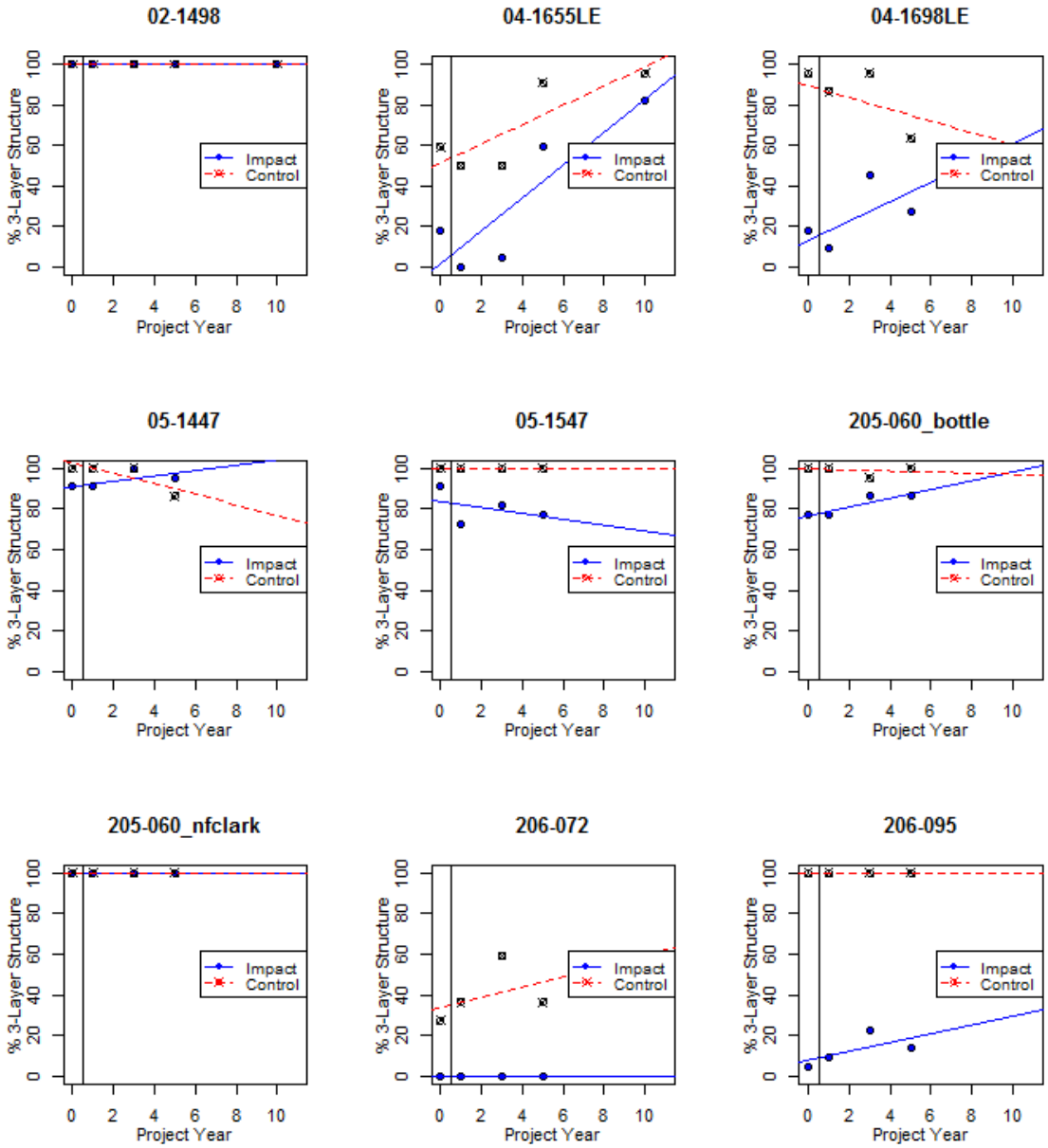


Figure B-15. Vegetation Structure (as Percent of Reach with 3-Layer Vegetation Structure) for MC-4

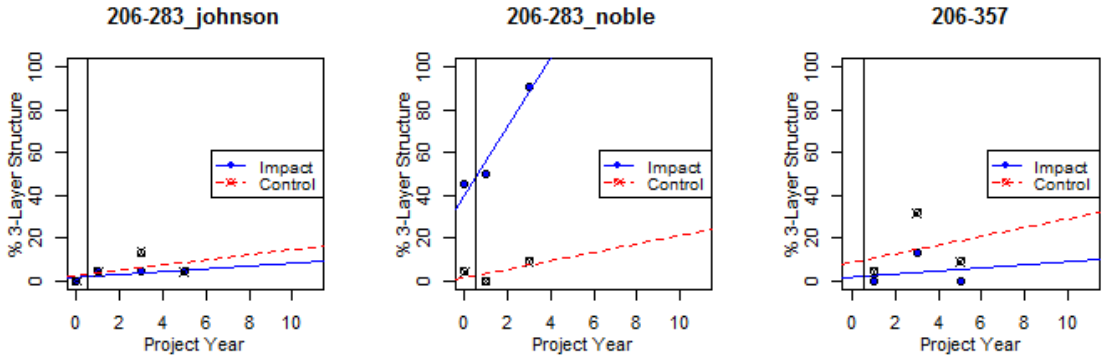


Figure B-15 continued. Vegetation Structure (as Percent of Reach with 3-Layer Vegetation Structure) for MC-4

MC-5/6 SCATTER PLOTS

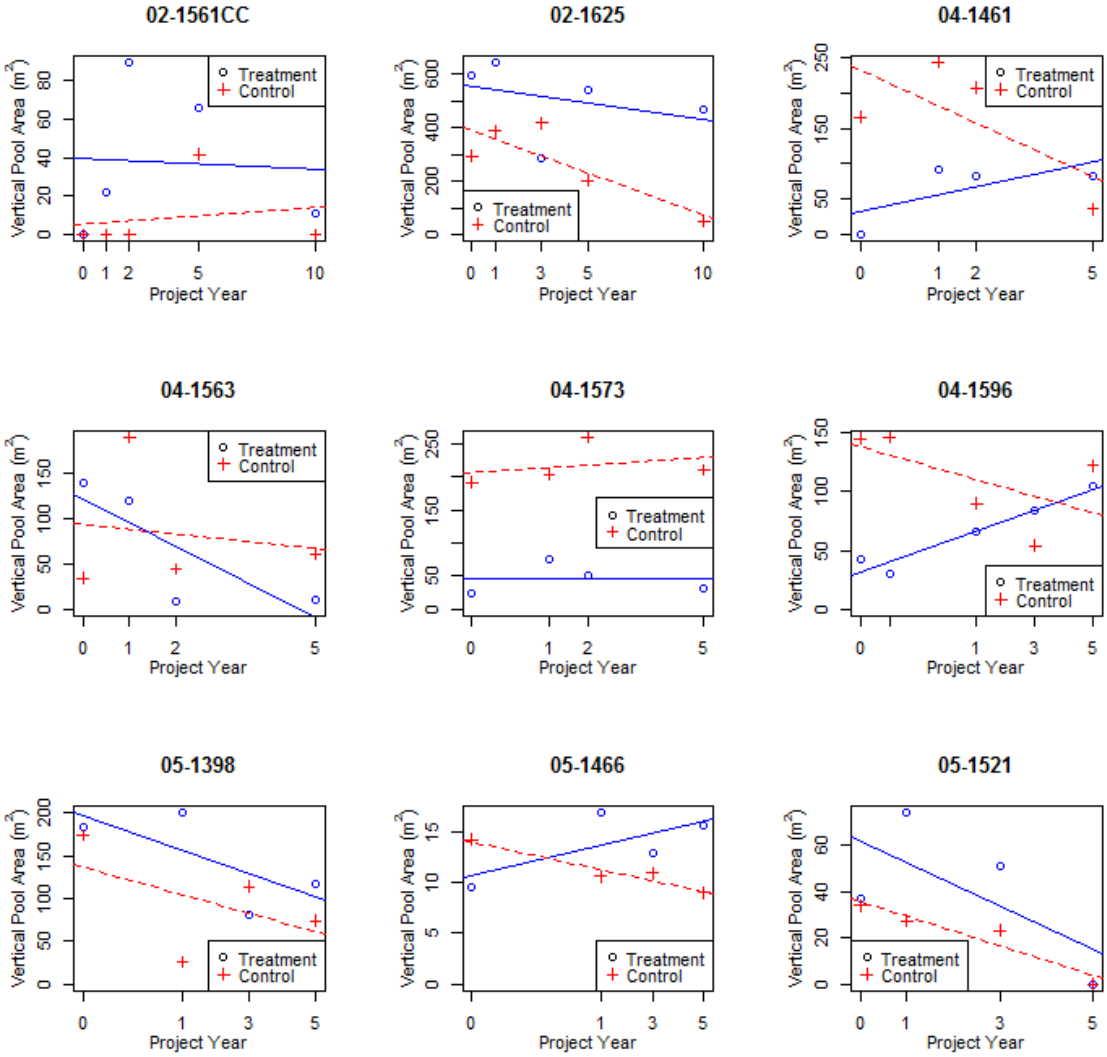


Figure B-16. Vertical Pool Profile Area Scatter Plots and Linear Regressions for MC-5/6 Projects

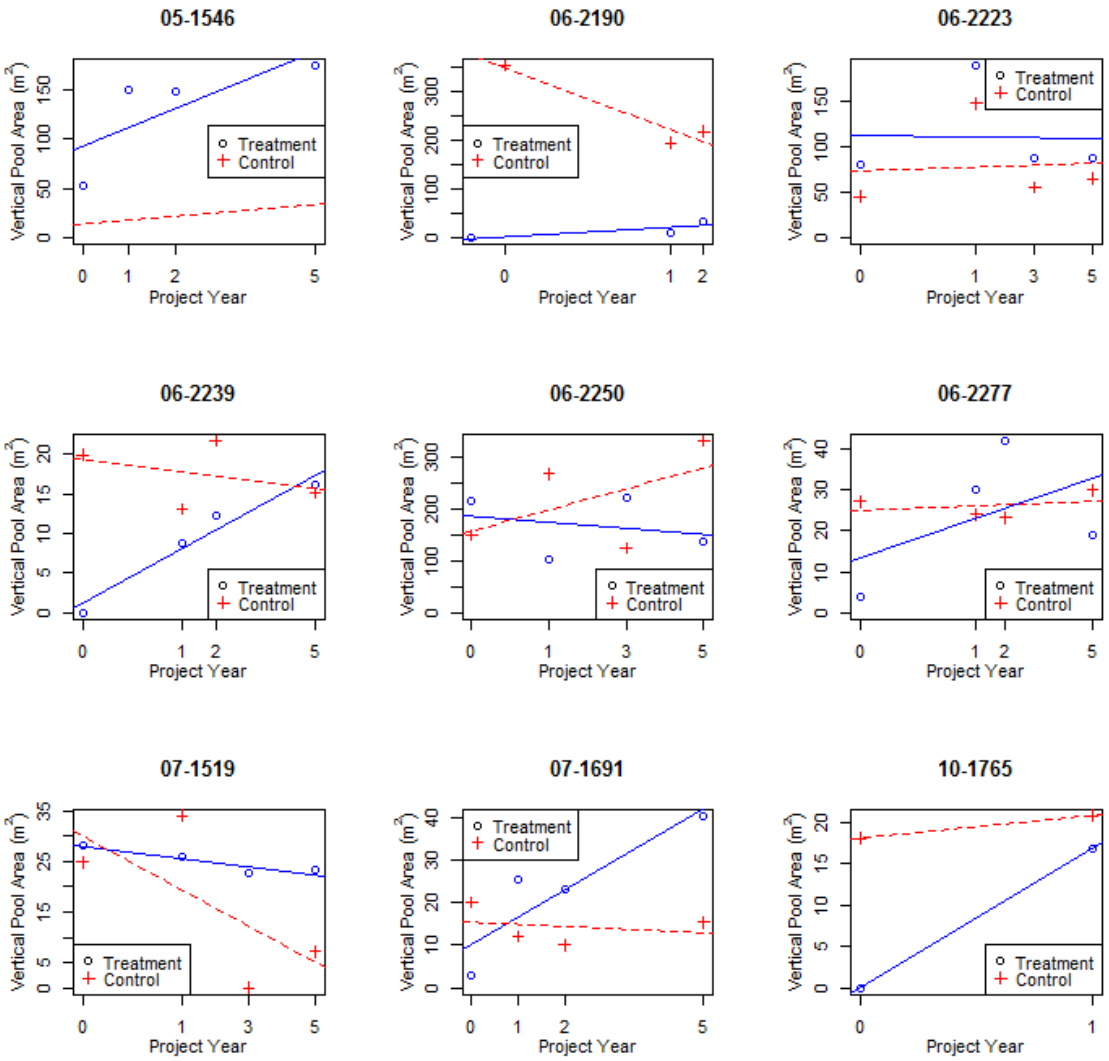


Figure B-16 *continued*. Vertical Pool Profile Area Scatter Plots and Linear Regressions for MC-5/6 Projects

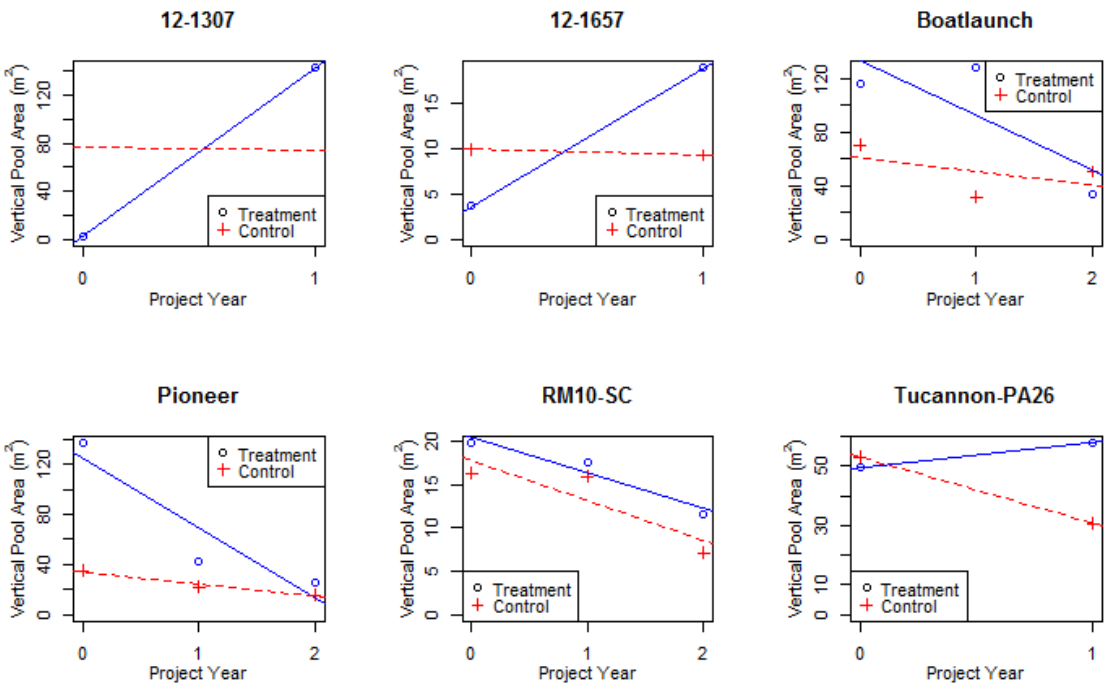


Figure B-16 *continued*. Vertical Pool Profile Area Scatter Plots and Linear Regressions for MC-5/6 Projects

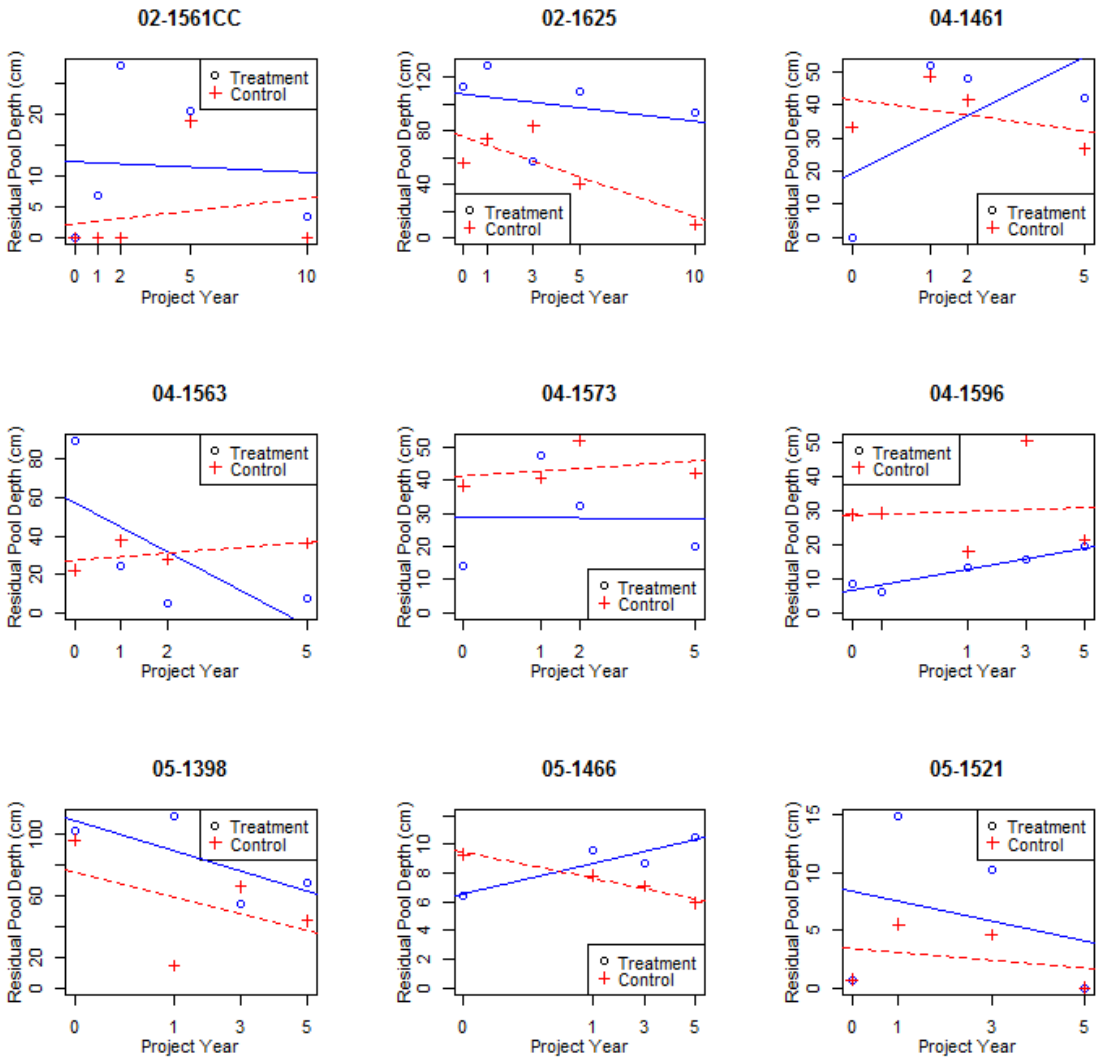


Figure B-17. Residual Pool Depth Scatter Plots and Linear Regressions for MC-5/6 Projects

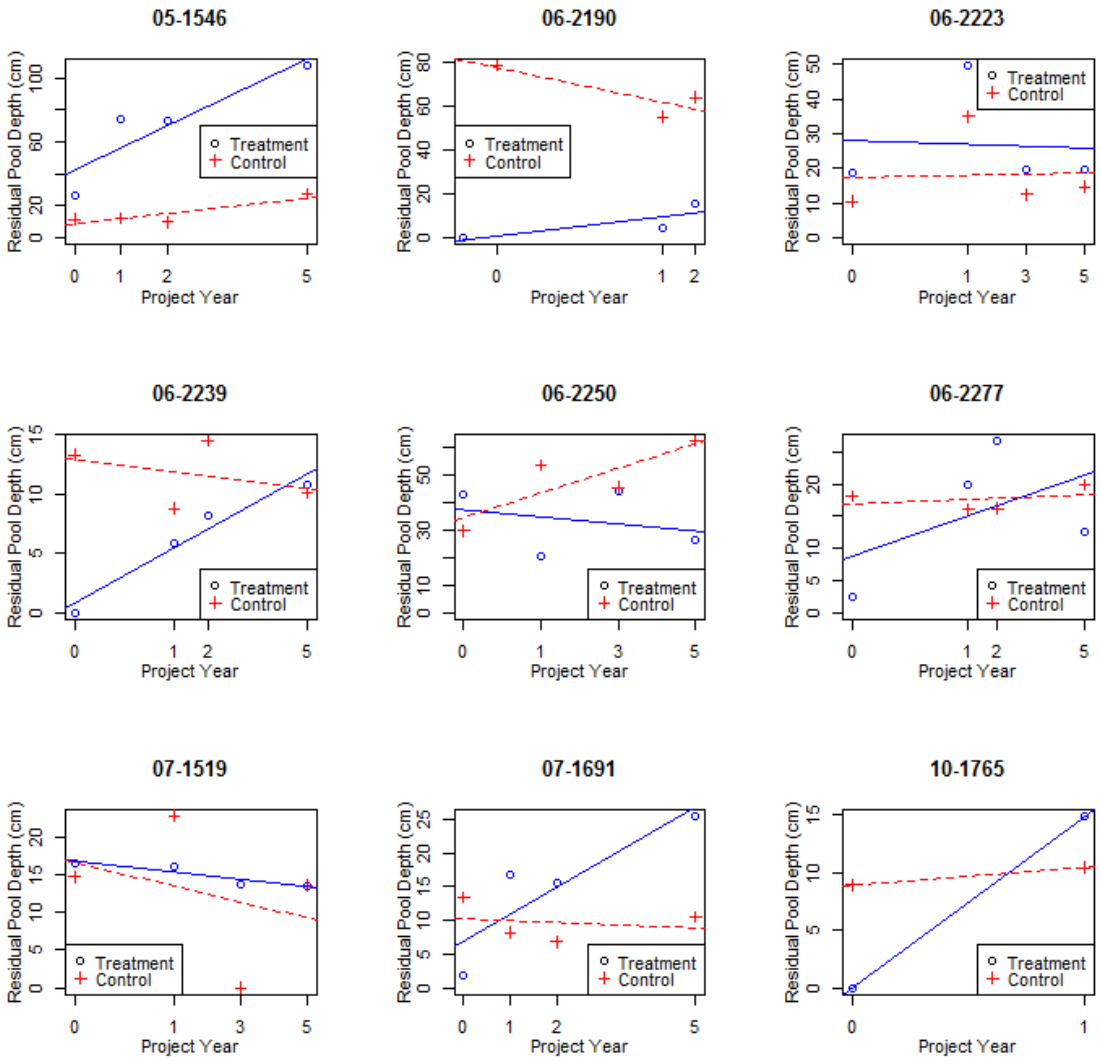


Figure B-17 *continued*. Residual Pool Depth Scatter Plots and Linear Regressions for MC-5/6 Projects

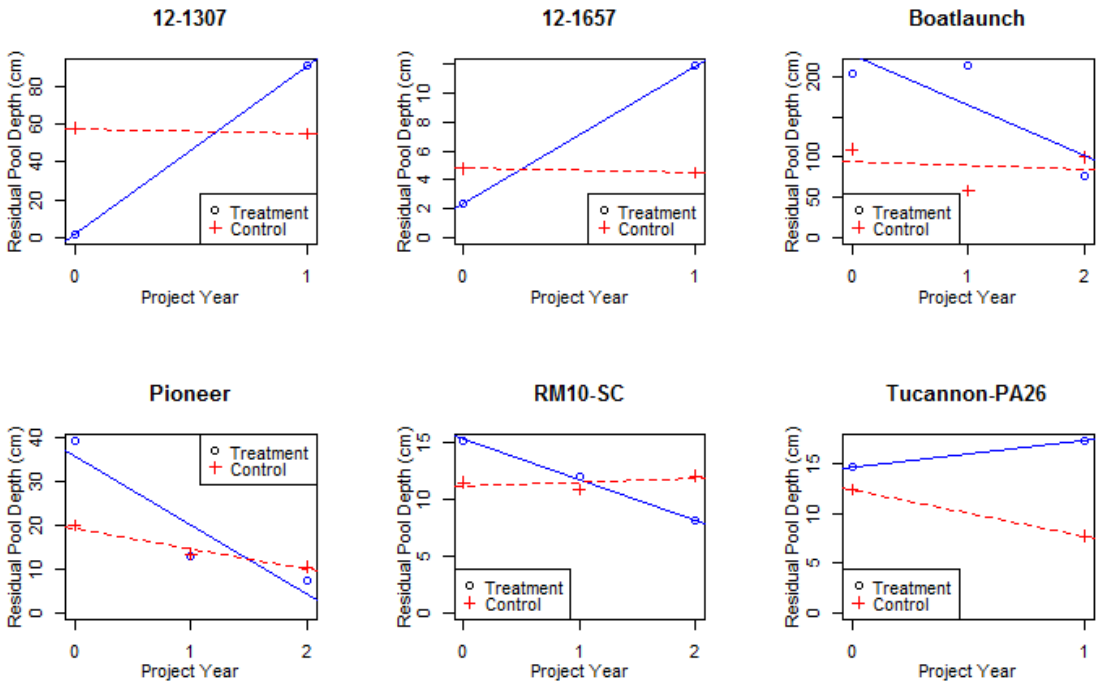


Figure B-17 *continued*. Residual Pool Depth Scatter Plots and Linear Regressions for MC-5/6 Projects

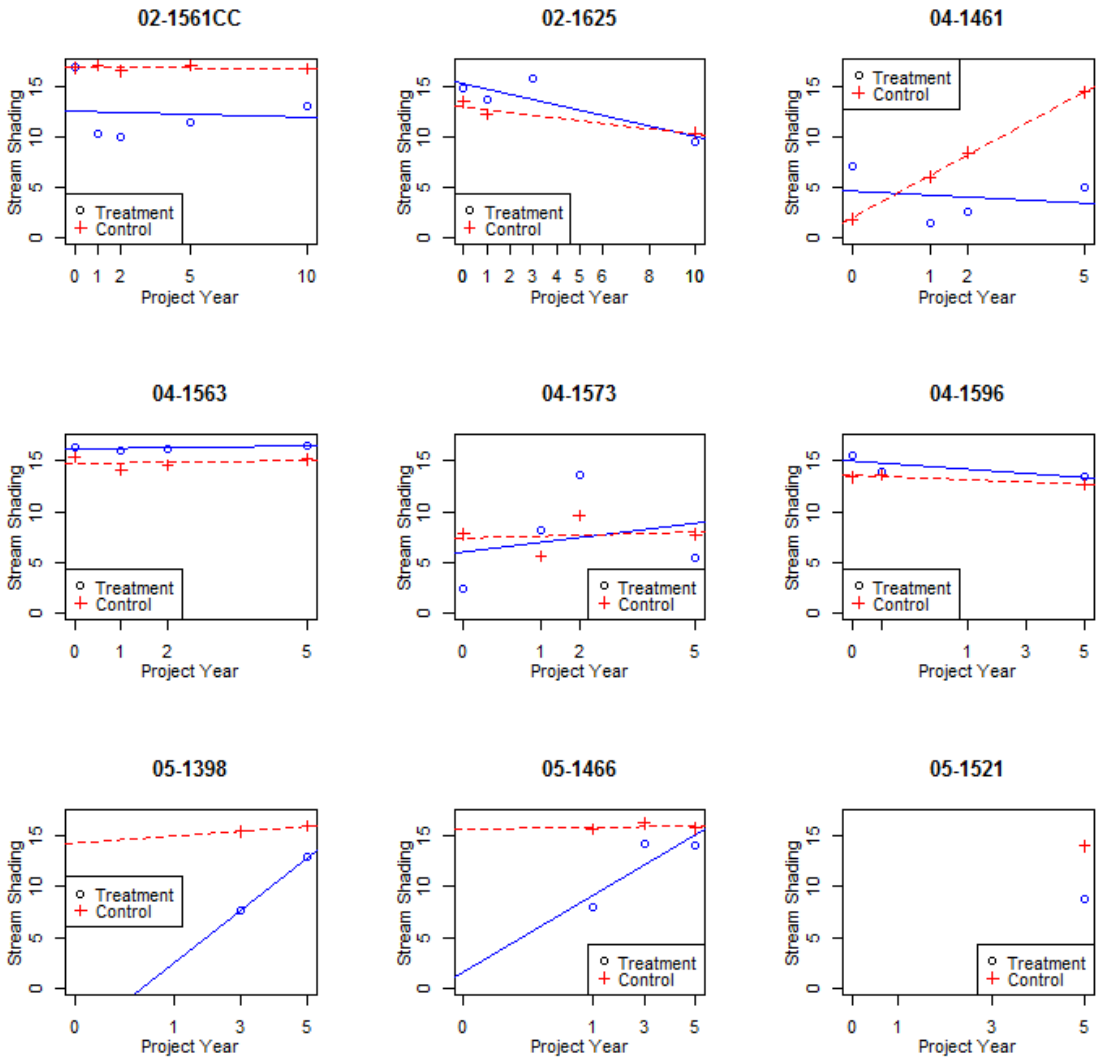


Figure B-18. Stream Shading Scatter Plots and Linear Regressions for MC-5/6 Projects

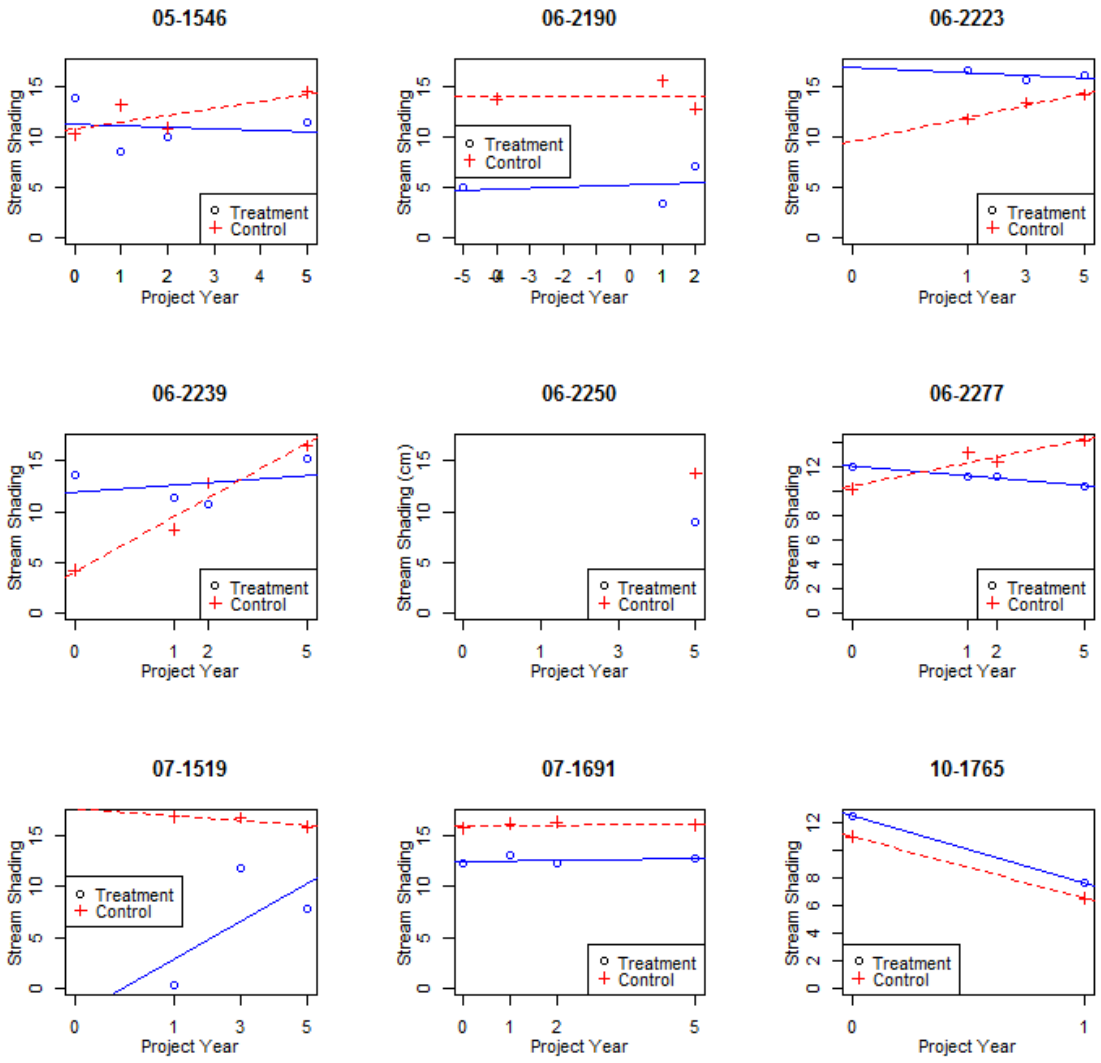


Figure B-18 *continued*. Stream Shading Scatter Plots and Linear Regressions for MC-5/6 Projects

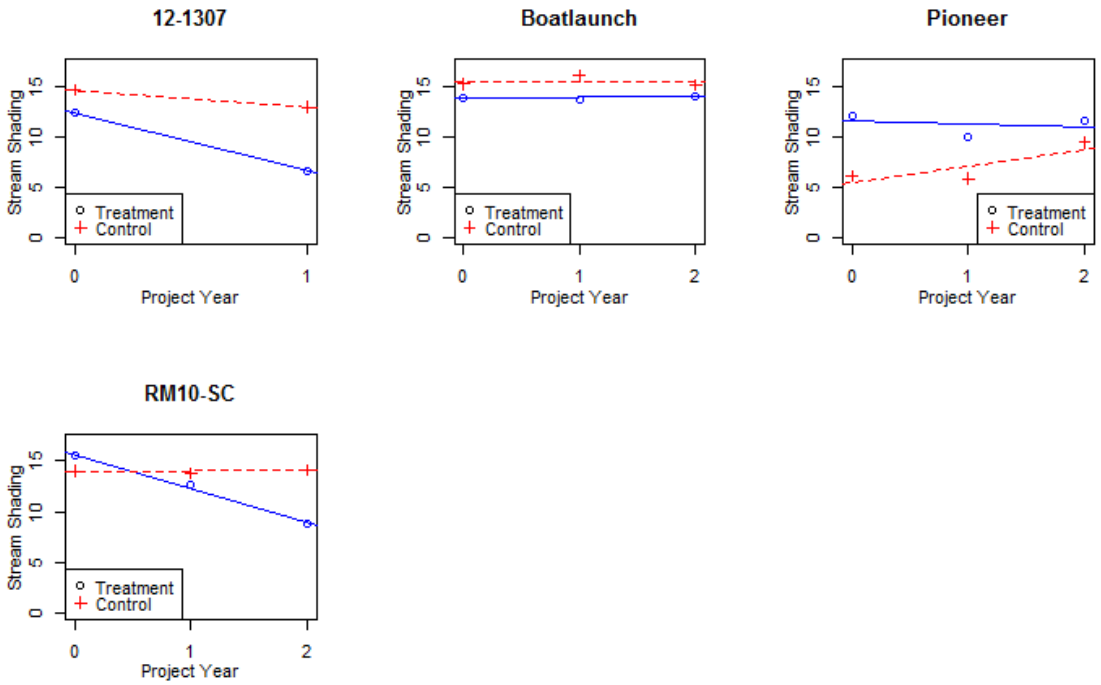


Figure B-18 *continued*. Stream Shading Scatter Plots and Linear Regressions for MC-5/6 Projects

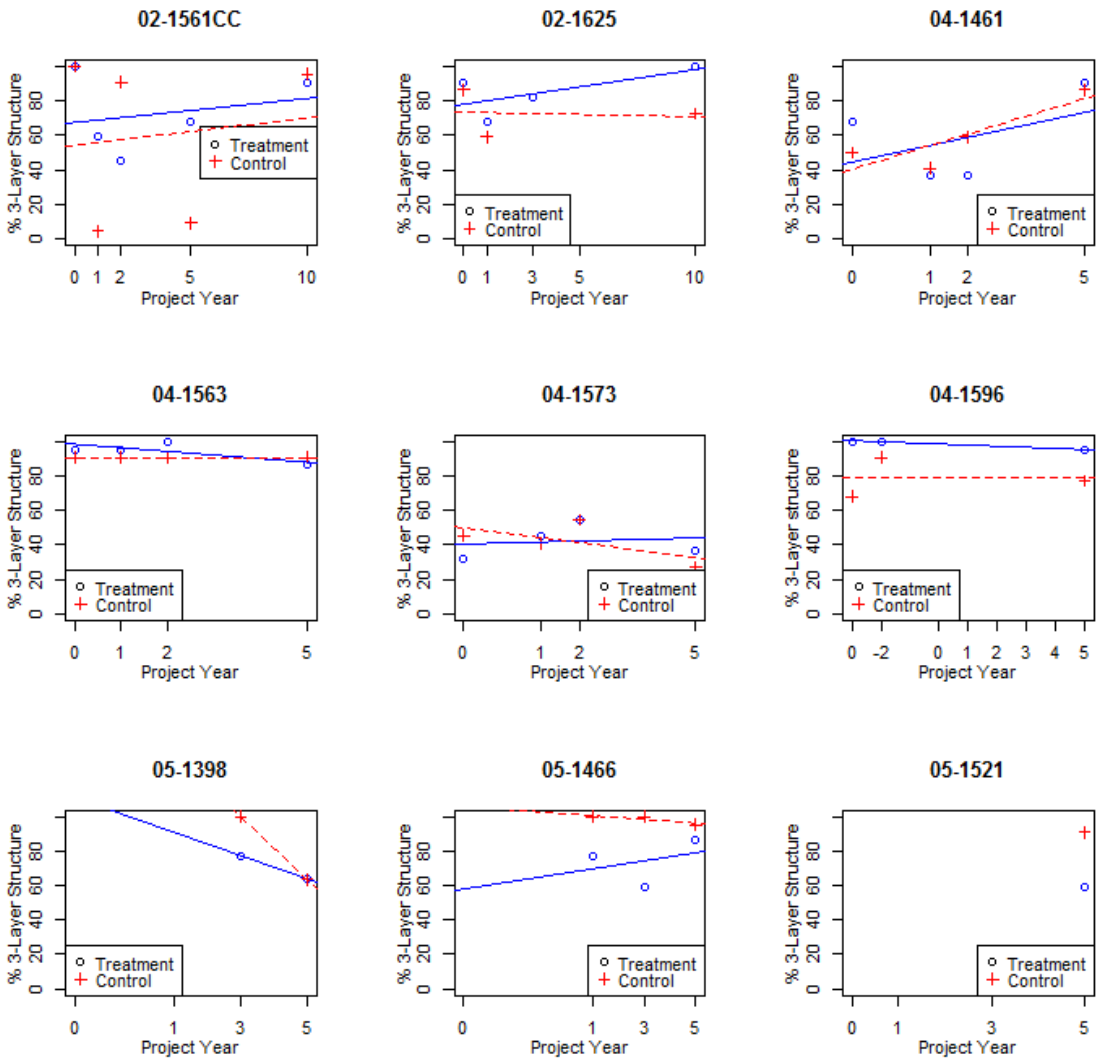


Figure B-19. Three-Layer Riparian Vegetation Structure Scatter Plots and Linear Regressions for MC-5/6 Projects

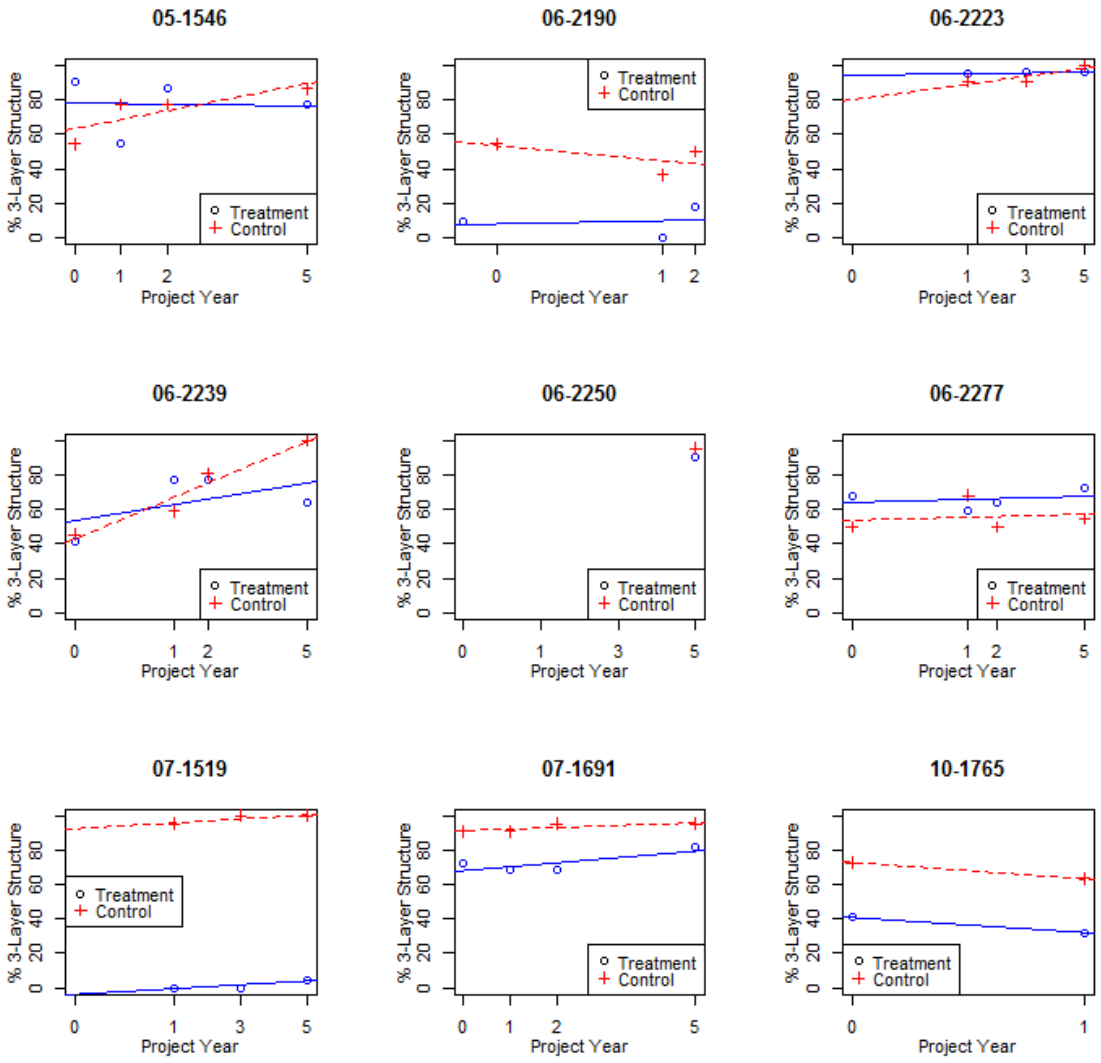


Figure B-19 *continued*. Three-Layer Riparian Vegetation Structure Scatter Plots and Linear Regressions for MC-5/6 Projects

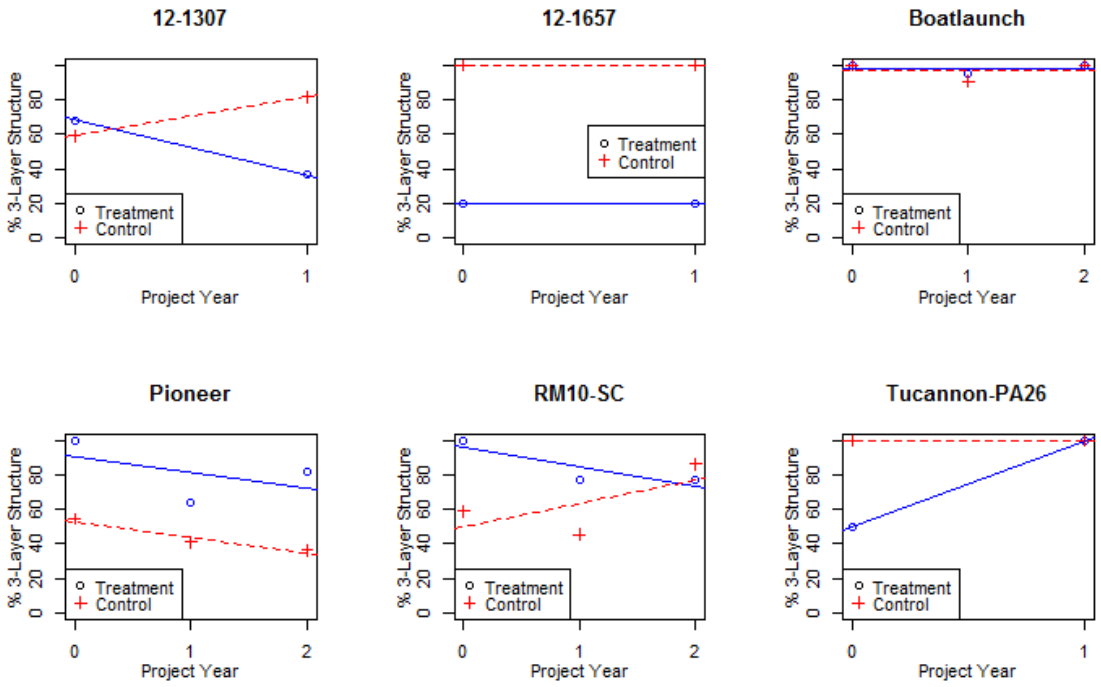


Figure B-19 *continued*. Three-Layer Riparian Vegetation Structure Scatter Plots and Linear Regressions for MC-5/6 Projects

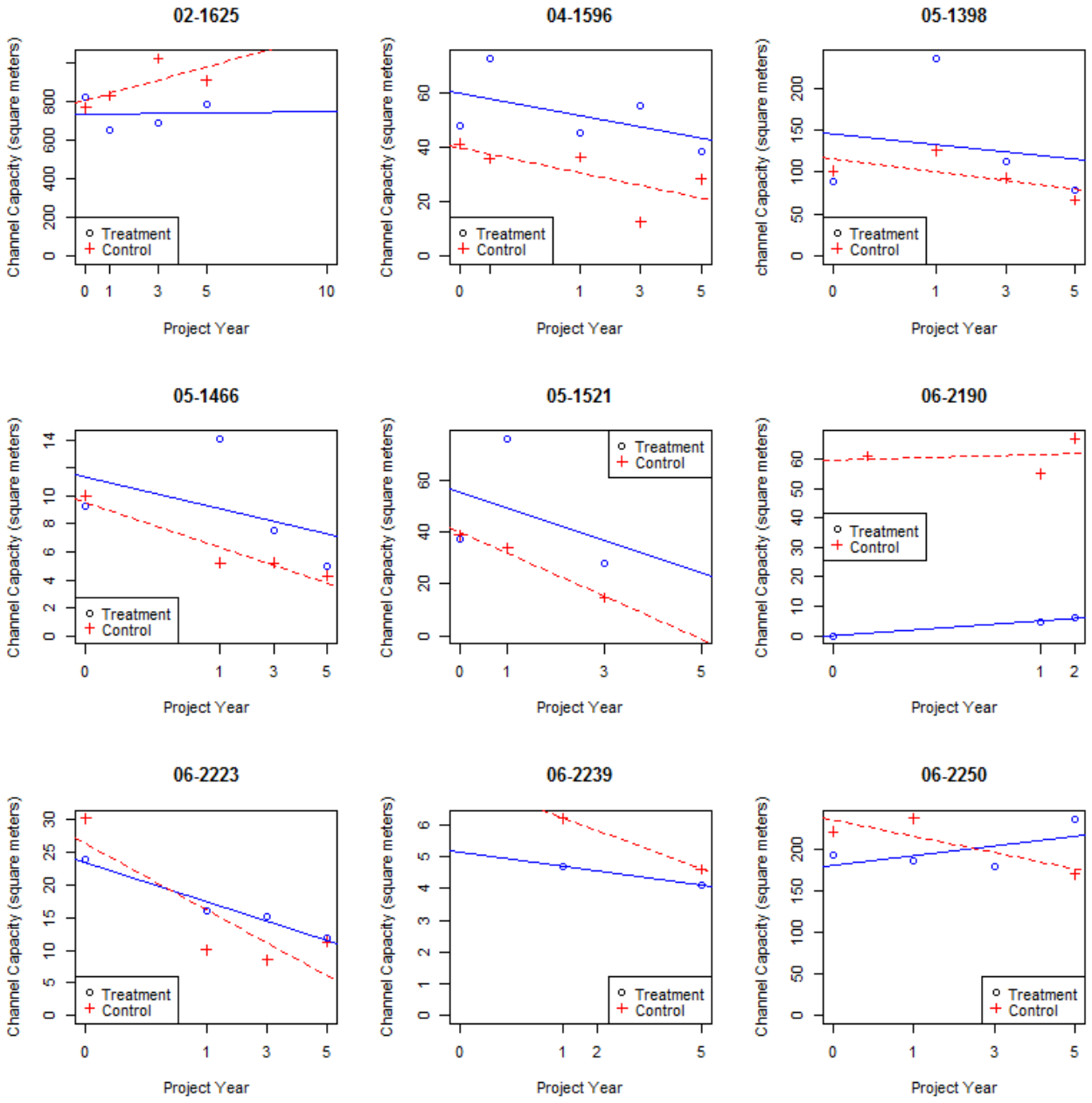


Figure B-20. Average Channel Capacity Scatter Plots and Linear Regressions for MC-5/6 Projects

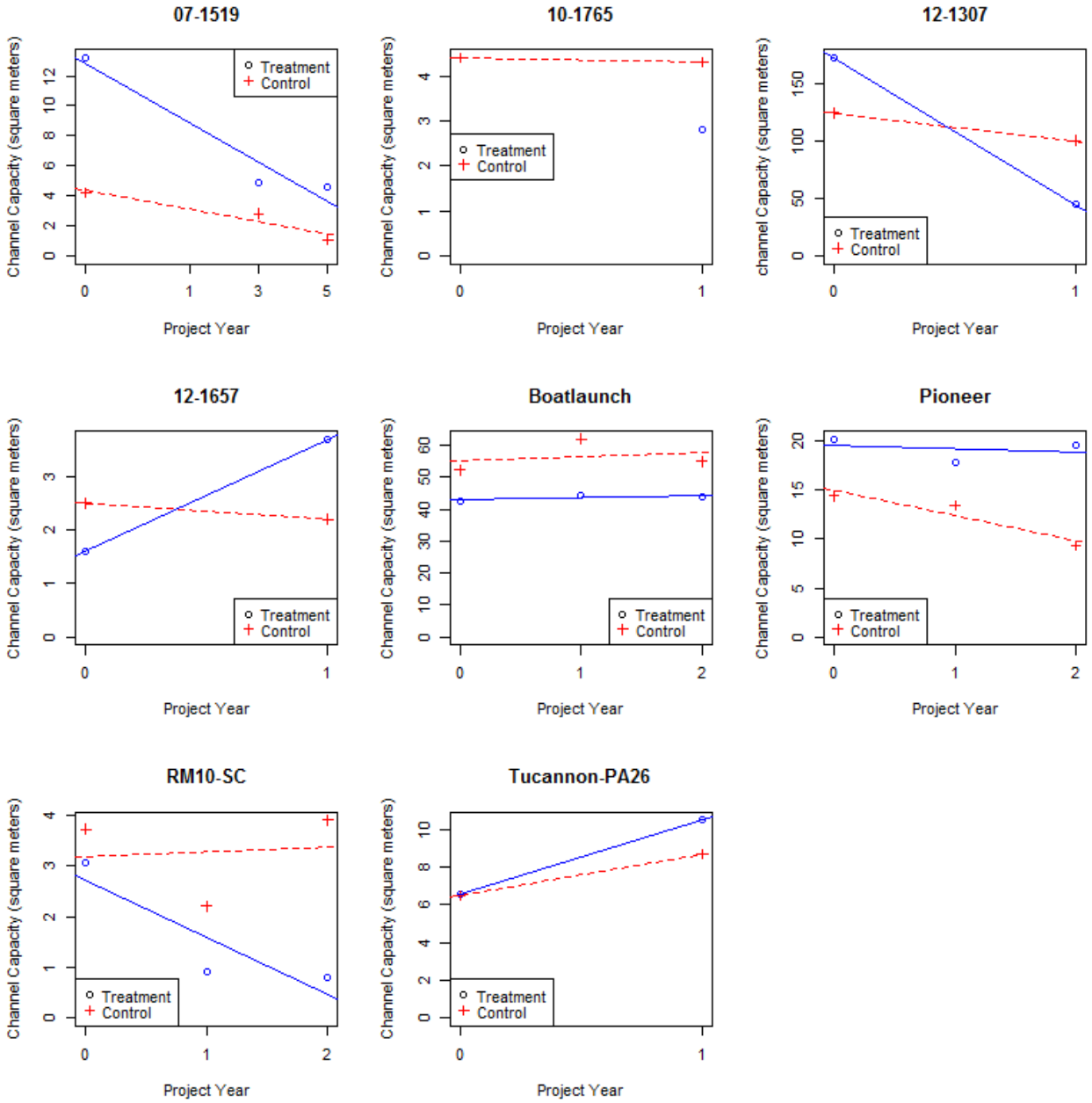


Figure B-20 *continued*. Average Channel Capacity Scatter Plots and Linear Regressions for MC-5/6 Projects

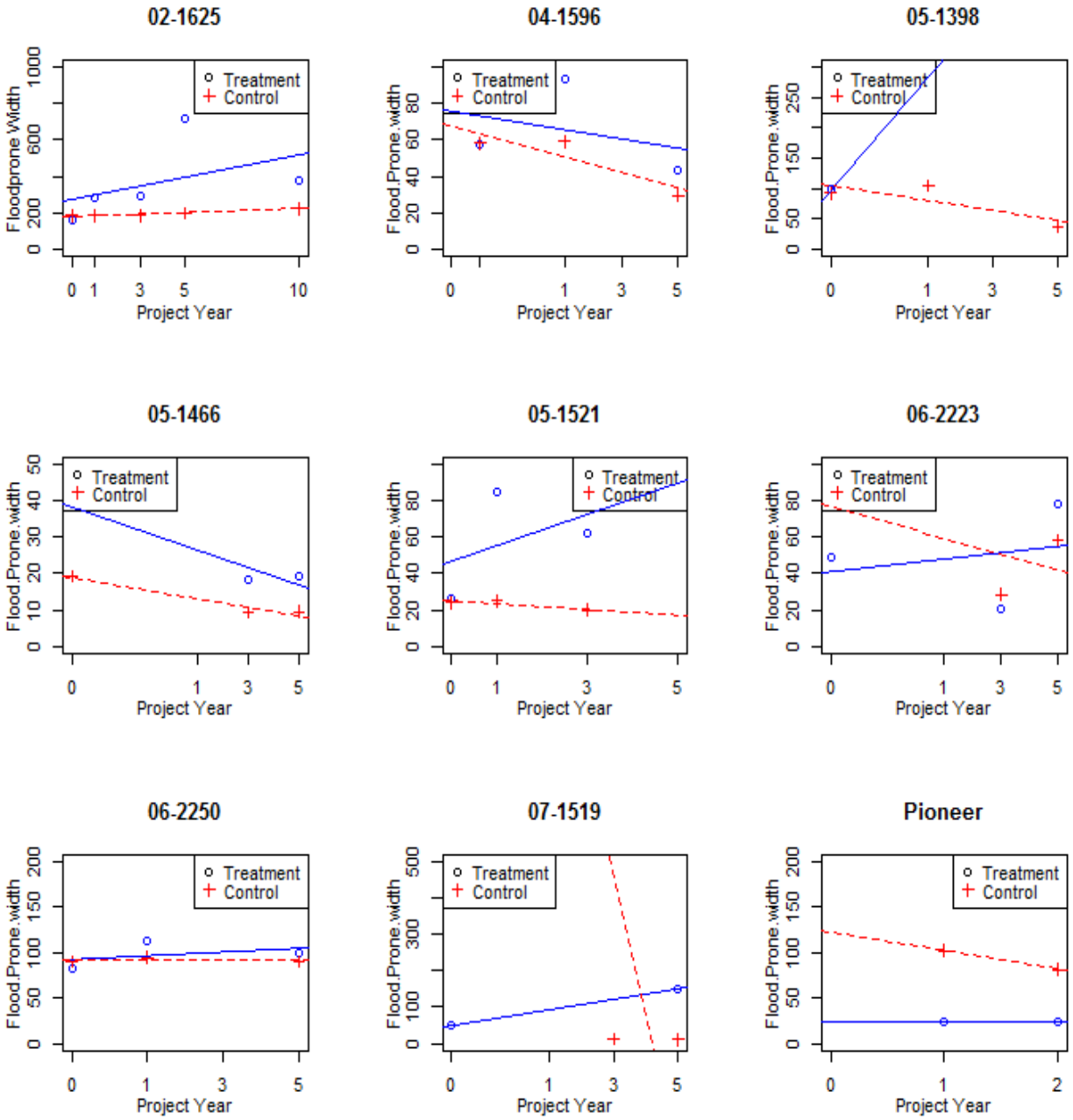


Figure B-21. Floodprone Width Scatter Plots and Linear Regressions for MC-5/6 Projects

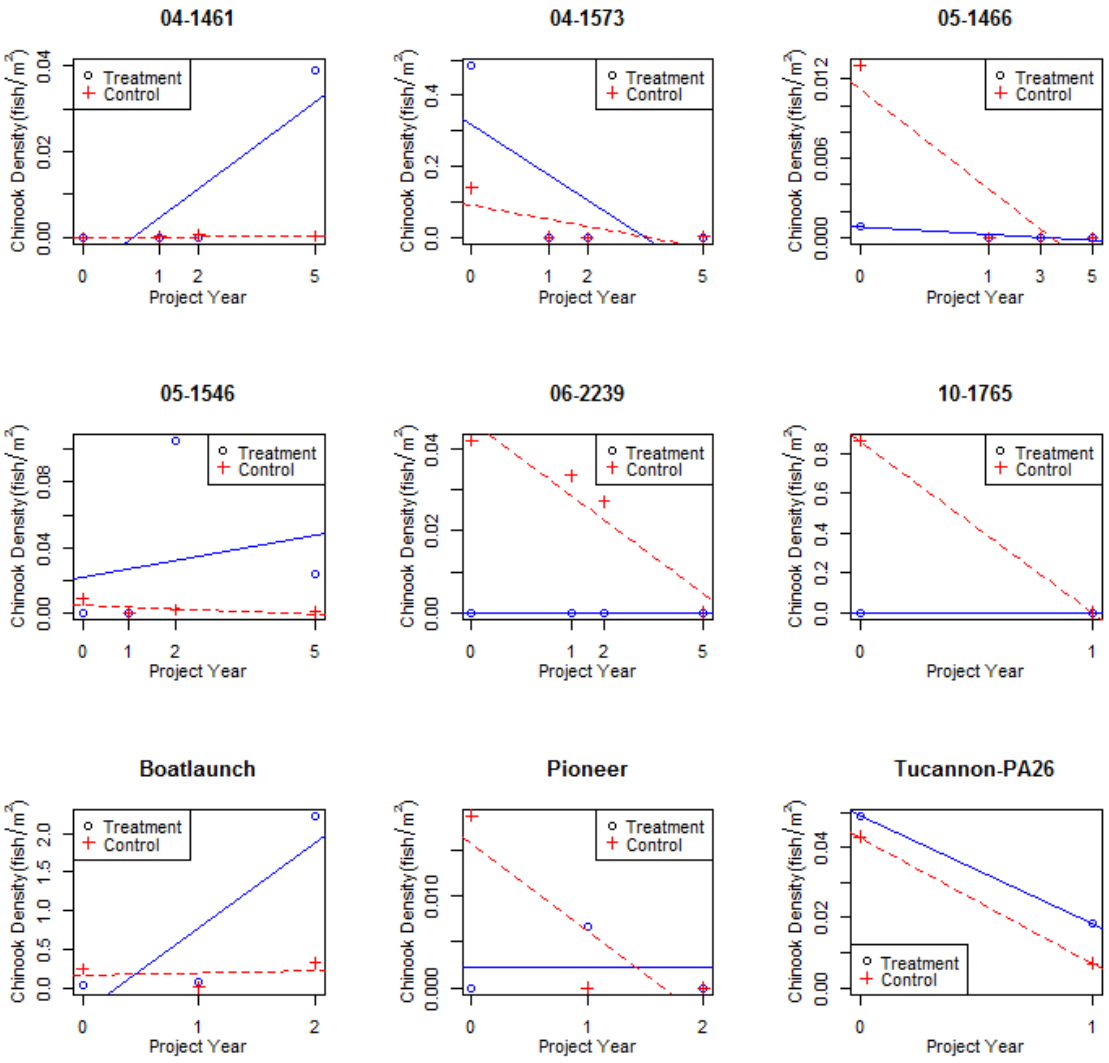


Figure B-22. Juvenile Chinook Scatter Plots and Linear Regressions for MC-5/6 Projects

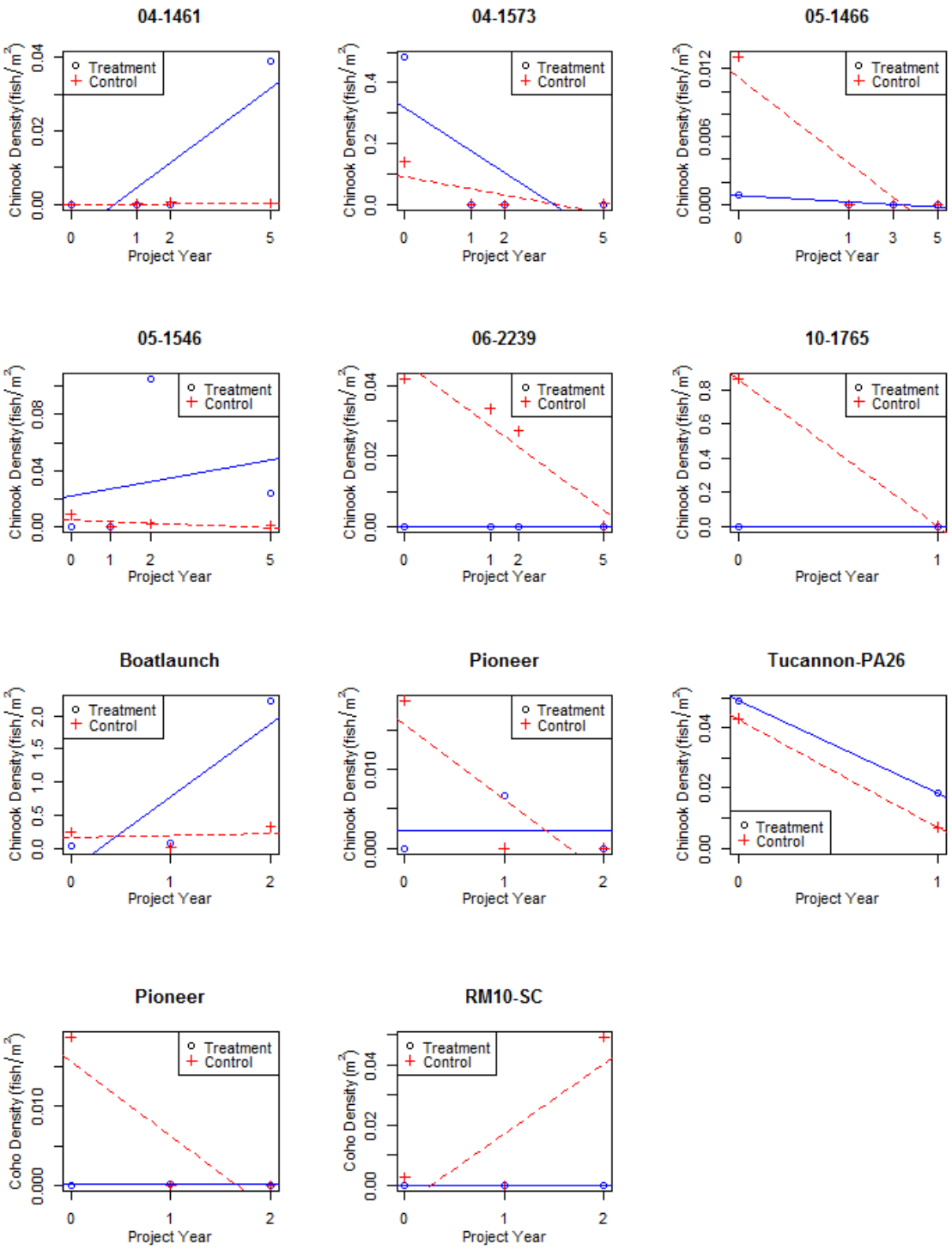


Figure B-23. Juvenile Coho Density Scatter Plots and Linear Regressions for MC-5/6 Projects

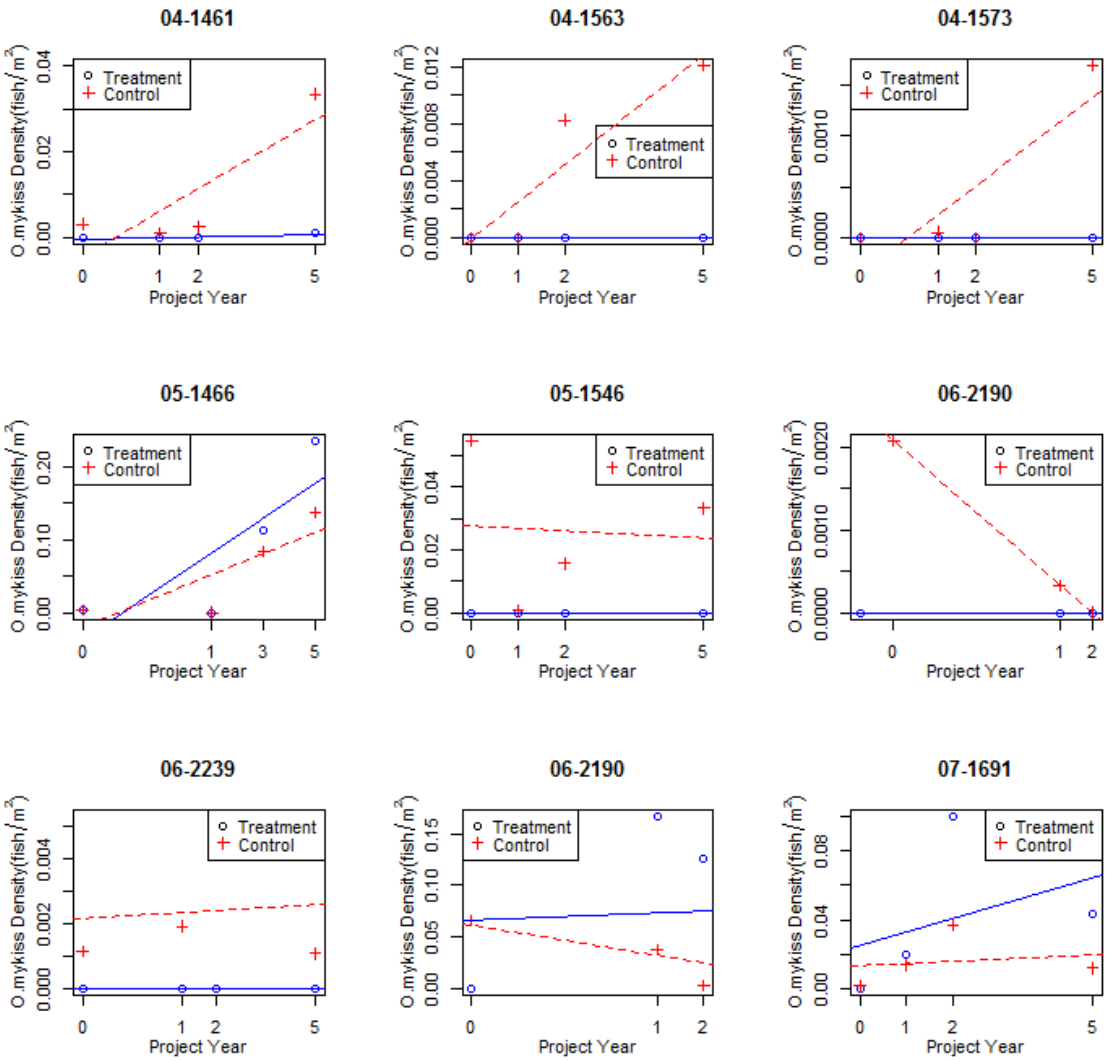


Figure B-24. Juvenile *O. mykiss* Density Scatter Plots and Linear Regressions for MC-5/6 Projects

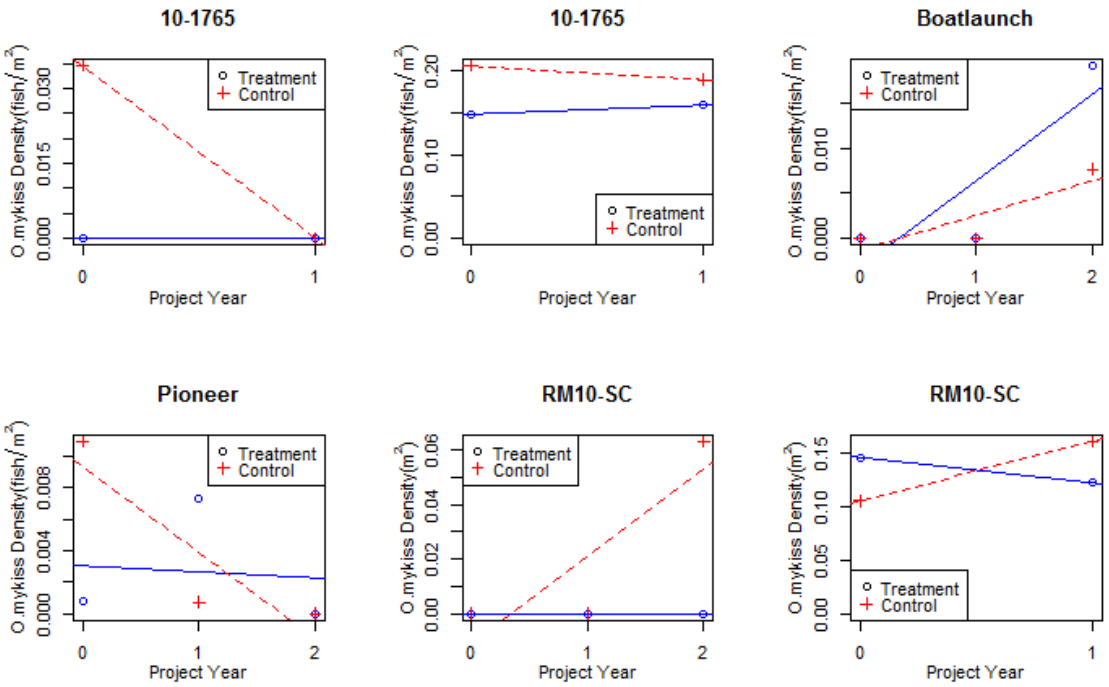
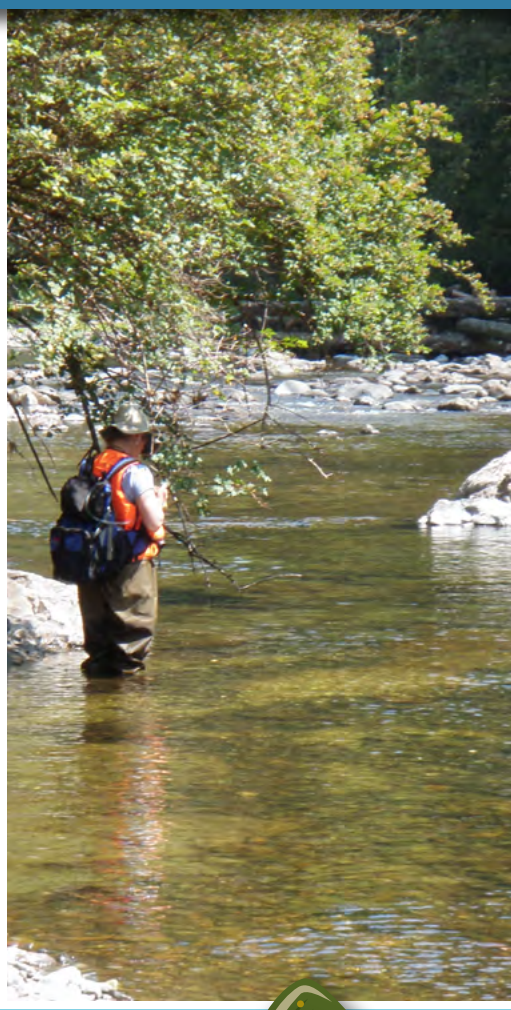
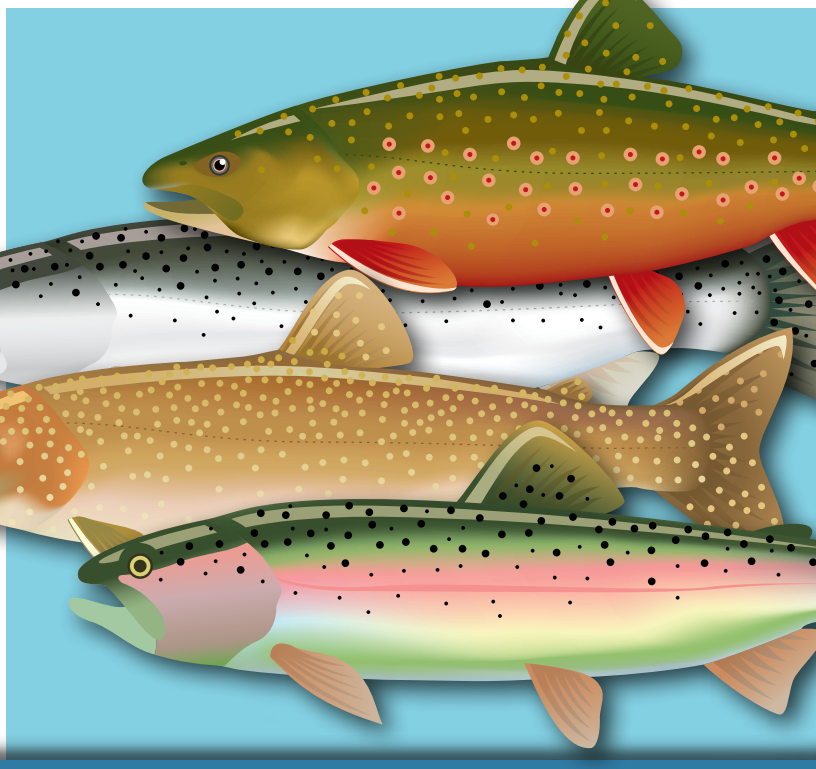


Figure B-24 *continued*. Juvenile *O. mykiss* Density Scatter Plots and Linear Regressions for MC-5/6 Projects





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