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2012 Implementation and Effectiveness Monitoring Results for the Washington Conservation Reserve Enhancement Program (CREP): Plant and Buffer Performance

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Washington Conservation Reserve Enhancement Program: Plant and Buffer Performance

Executive Summary

The Conservation Reserve Enhancement Program (CREP) is a voluntary program that offers financial incentives to farmers to restore riparian habitat and preclude agricultural activities in those buffers during the contract duration (10 or 15 years). The primary purpose of CREP is to restore habitat for salmon and steelhead and improve water quality in those streams. It is co-administered by the U.S. Department of Agriculture Farm Service Agency (FSA) and the Washington State Conservation Commission. Federal funding covers about 80% of the costs of CREP.

The program has been in operation for nearly 14 years, and has several important features that contribute to successful habitat restoration:

- By specializing in riparian restoration, staff are highly trained for this function.
- All CREP practices must follow federal standards, which increase the consistency of results.
- Contracts are visited on at least an annual basis in the first 5-6 years. They are sporadically visited thereafter. This assures landowner adherence to the program requirements and allows for measures to be taken to improve plant growth and survival.
- Oversight is provided by two separate agencies, FSA and the Conservation Commission, to help assure standards are met. In addition, the Natural Resources Conservation Service is often involved in site planning.
- Maintenance of the riparian area is funded for a five-year period after planting to control invasive plant species and provide watering during dry periods.
- Contracts are part of an effectiveness monitoring program using random sampling. In addition, all contracts are monitored for implementation performance.

The Washington State Conservation Commission monitors CREP in two ways. Implementation measures are collected for every contract on an annual basis to show the extent of restoration. Randomly selected contracts are monitored for their effectiveness in improving stream and riparian function and structure. This report summarizes the results of both types of monitoring for contracts signed through the end of 2012 and monitored for effectiveness for the calendar years of 2008-2012.

In 2012, we reached a milestone by surpassing 1,000 total contracts. The total number of CREP contracts is now 1,021 after 14 years from the beginning of the program. In 2012, 57 new CRP-1 contracts were signed. Two of these 57

contracts are hedgerow buffers and 12 are wetland enhancement contracts. No CRP-1 contracts were signed for the grass filter strip practice in 2012. The cumulative total number of each of the new practices is: 27 wetland enhancement practices, 13 hedgerow contracts, and no grass filter strip contracts. Compared to the total number of contracts (1,021), the riparian forest buffer practice is by far the most common (96%) with wetland enhancement as the most popular new practice (3% of total). Riparian hedgerows are rare (1%) and no contracts exist for grass filter strips that are not in combination with another riparian planting practice. The 2012 contracts added 28 stream miles, 440 acres of buffer, 175,000 seedlings, and 31,000 feet of fencing.

These buffers are rapidly growing with average rates ranging from 10.6 to 12.7 inches per year in eastern Washington and 14.3 to 29.3 inches per year in western Washington (averaging across plant types). By species, eastern Washington plants that grow the fastest are: blue elderberry, serviceberry, and willow with rates that range from 22-29" per year. In western Washington, the fastest growing CREP plants are: Pacific willow, black cottonwood, red alder, and birch with rates ranging from 31-50" per year. Survival of the CREP plants is 75% in eastern Washington and 90% in western Washington.

More importantly are the results of these actions on the environment. The canopy cover results were remarkable with approximately 72% coverage (shade) in the 5-10 year contracts compared to 9% in the 1-4 year old category. These measurements were conducted only in the small wadeable streams. It is likely that if wide streams were included, the results would be more variable and less significant. However, it shows how quickly and effectively buffers can shade small (25' or less bankfull width) streams enrolled in CREP.

A low level of invasive plant species presence was noted with less than 1% in younger contracts (1-4 years) compared to 3% coverage in mid-year contracts (5-10 years). Bank erosion was low with 8% average in younger contracts and 4% along older CREP sites.

The most common buffer width category is 180' or wider with 39% of all riparian forested buffers developed to 180' or greater in width. Eighty percent of all CREP forested buffers are 100' or greater in width. The average buffer width is 143' while the median is 150'. The buffer composition differs dramatically when comparing eastside to westside. Eastside buffers often have more shrub species (80%). The most common eastside CREP plants are: willow, rose, Ponderosa pine, juniper, black cottonwood, and red-osier dogwood. Trees dominate westside buffers (75%). The most common westside plants are: red alder, western red cedar, Sitka spruce, willow, Douglas fir, black cottonwood, red-osier dogwood, Oregon ash, shorepine, and rose.

These results indicate that CREP is successful in several ways. The sites are preventing the spread of invasive plant species while increasing the coverage by native species that can perform the necessary fish and wildlife functions of a riparian buffer. The CREP plants are surviving and growing quickly, providing important shade to the smaller streams. Previous monitoring has shown that when CREP and other riparian restoration is targeted to significantly span a stream, water temperatures improve for salmonid use (Smith 2012). The implementation of the program has been growing at a steady rate. With federal funding paying for 80% of the total costs, CREP remains an effective and cost-efficient program for riparian restoration on agricultural lands in Washington State.

Introduction

The Conservation Reserve Enhancement Program (CREP) is a voluntary program that offers financial incentives to farmers to restore riparian habitat (streamside trees and shrubs) and to preclude agricultural activities in those buffers during the contract duration (10-15 years). The program began in 1998 with the first signed contracts in 1999. It is cooperatively administered by the U.S.D.A. Farm Service Agency (FSA) and the Washington State Conservation Commission. The federal government pays for approximately 80% of the total costs.

In Washington State, about 37% of salmon streams on private land pass through agricultural land use (USFWS and NMFS 2000). Because much of the agricultural land is located in or near historic floodplain-rich habitat, it is important that efforts continue to develop opportunities to not only improve riparian habitat for healthy watersheds, but also to maintain viable agriculture. Once land is converted to more intensive development (urban and industrial), environmental impacts increase and the prospects to preserve or restore habitat near streams greatly decrease. Between 1982 and 1997, about 20% of the farmland in the Puget Sound region was lost to other uses, especially in King and Snohomish Counties where urban growth has been high (Canty and Wiley 2004).

The primary focus of the Washington CREP is riparian buffer restoration and protection along salmon streams. This includes buffers along streamside wetlands. CREP areas become “no touch” buffers. Fencing and livestock watering facilities are installed on livestock farms to prevent their access to the buffers and stream. The newly planted native trees and shrubs are then actively maintained for five years to increase the likelihood of success. Maintenance primarily includes weed control and watering.

Monitoring is an important component of habitat restoration. Without it, there can be no knowledge of what’s been done, where it has been done, and no measurement of success in the investments and techniques. Implementation monitoring of CREP tracks how much has been done. These measures are: acres treated, stream miles restored, number of contracts, feet of fencing installed, and number of plants planted. The implementation monitoring data is used to show program performance to the Office of Financial Management, the legislature, and the Farm Service Agency. It is also used for management purposes within the Washington Conservation Commission to allocate funds and better manage the program.

It is also important to know how effective CREP is. Our measures of success include plant growth, plant survival, buffer diversity, shade, bank erosion, and non-native plant species control. This year, the results are merged with data collected from past years to show plant growth and buffer composition by species. The species-specific information is of interest to the staff who develop the plans, aiding in future plant selection.

This report describes the methodologies and results for both implementation and effectiveness monitoring assessments in the Washington State CREP from its origins in 1999 through the 2012 calendar year. Together, these measures demonstrate the level of performance for both program growth and environmental benefit.

Methodology

Following Environmental Monitoring and Assessment Program (EMAP) protocols (Peck et al. 2001), 10 sites were randomly selected for field measurements for 2012 and the results were merged with data collected from 2008-2011. Data were also collected in 2006, but those are not yet entered into our data system, making it infeasible to merge those data at this time. Randomization was accomplished using the Research Randomizer (2012). Sites with a pre-existing canopy were either not included, or were measured for other parameters besides canopy cover because pre-established cover would skew the results in a favorable manner. For the analyses, all measurements were grouped according to the number of growing seasons. Projects from the westside or eastside were analyzed separately and/or together.

Effectiveness Monitoring Within the Buffer

Data were collected to answer the following buffer effectiveness monitoring questions by contract site, by growing season, by eastside versus westside, and statewide. Plant type is defined as conifer trees, deciduous trees, or shrubs. This year, results are both grouped by plant type and analyzed by species. Grouping by plant type should reduce some of the plant growth variability. However, it is valuable for technicians to know which plants are the dominant buffer species and which are growing the fastest.

What is the growth rate of plants overall, by type, by species?
What is the percent survival of plants overall?
What is the plant species diversity within buffers?

The field measurements for the buffer effectiveness measures followed the strip-plot design methodology described in Haight (2002). This design is a good choice for assessing a diverse buffer that often has differing conditions near the shoreline versus further upland. Details on setting up the strip-plot are described below. These 20-foot wide strips encompassing the buffer width were assessed for:

- Species of plant
- Plant type (conifer, deciduous, shrub)
- Height of plant (ground to tip of plant) using a laser rangefinder for taller trees
- Live/dead/missing status for each plant (sometimes missing plants are obvious, but other times are not and could be under-recorded)
- The number of plants total, by plant type, and by species per square foot of sampling area were obtained from these data (will likely be converted to per acre later) to calculate buffer density and diversity.
- Presence of non-native invasive plants and extent of coverage (area of plot)
- Notes about the site, such as predation, flooding, fire, and other issues.

The plots were at equally spaced intervals (100’) beginning at a random start near the edge of a project and extending through the project site in areas without significant interplanting. Because some sites have buffer lengths approaching 20,000’, it isn’t feasible to treat large sites as a single site, and for those with distinctly different sections or parcels, one or more parcels would be randomly selected for sampling.

After the interval start point was found, the strip-plot was set up as follows. A tape was run through the buffer width perpendicular to the stream to create the perpendicular tapeline. The buffer width (length of tape) was recorded for later calculations of sample area used in diversity and density estimates (tape length (buffer width) X 20’). All CREP plants within 10-feet of each side of the tapeline were assessed. This has been shown to be a statistically valid yet efficient plot design for riparian buffers of varying ages (Haight 2002). Borderline plants were included if half or more of their trunk radii at diameter breast height (Dbh) (generally 4.5’) is within the 10’ mark.

In addition, data were obtained from the planting records regarding the original height of plants by species and the date of planting to determine the number of growing seasons. Any replanting or thinning data was also recorded.

Data was entered and stored in the Conservation Practice Data System at the Washington Conservation Commission. Data was grouped by plot, project, district, region (eastside/westside), and state to summarize at various levels. Plants were grouped by species and type.

Effectiveness Monitoring in Stream Channel

Stream channel effectiveness monitoring included in-channel measurements of percent canopy cover and condition of bank erosion. These were measured in the stream channel as an extension of the mid-point of the buffer plot described above.

The questions answered include:

- What is the percent canopy cover by site, by region, and by growing season?
- What is the condition of bank erosion by site, by region, and by growing season?
- How does each of these measurements change with age of project (number of growing seasons)?

Percent Shade (canopy cover) Measurements. The percent canopy cover was used to assess shade following EMAP protocols (Peck et al. 2001). At each instream transect, the percent canopy cover was measured using a convex spherical densitometer mid-channel. Four readings were taken at each transect of wadeable streams. They included: upstream, left bank, downstream, right bank. A score of 1-17 was given to each site. The readings were averaged for each transect.

Bank Erosion Measurements. The bank erosion condition was estimated by visually assessing the 20’ length of bank (same side as CREP contract) centered around each in-channel transect (10’ from each direction of transect point). The assessment included noting the percent of bank eroded, the percent of bank lacking vegetation, and the number of slides entering the stream

Data Analysis

Trends over time by growing season were analyzed, as well as differences between groups using ANOVA or Student’s unpaired t-test.

Results

Implementation Monitoring: New Contracts

In 2012, we reached a milestone by surpassing 1,000 total contracts. The total number of CREP contracts is now 1,021 after 14 years from the beginning of the program (Figure 1). In 2012, 57 new CRP-1 contracts were signed (Figure 2). It is likely that the number would be greater if the Farm Bill had not expired on October 1. That prevented new contracts from being signed in the last quarter of the year.

Two-three years ago, new practices were allowed in the Washington CREP in addition to the riparian forest buffer. These included wetland enhancement, riparian hedgerows, and grass filter strips. Of the 57 new contracts this year, two are hedgerow buffers and 12 are wetland enhancement contracts. No CRP-1 contracts were signed for the grass filter strip practice in 2012. The cumulative total number of each of the new practices is: 27 wetland enhancement practices, 13 hedgerow contracts, and no grass filter strip contracts. Compared to the total number of contracts (1,021), the riparian forest buffer practice is by far the most common (96%) with wetland enhancement as the most popular new practice (3% of total). Riparian hedgerows are rare so far (1%) and grass filter strips are non-existent.

The number of signed contracts for 2012 was slightly higher than expected considering that new contracts could not be signed in the last quarter of the year after the Farm Bill expired. The reason for the higher than expected number is likely because the program funding had been restored in the spring of 2012 (Figure 3).

Figure 1. The total number of signed CREP contracts by year in Washington State.

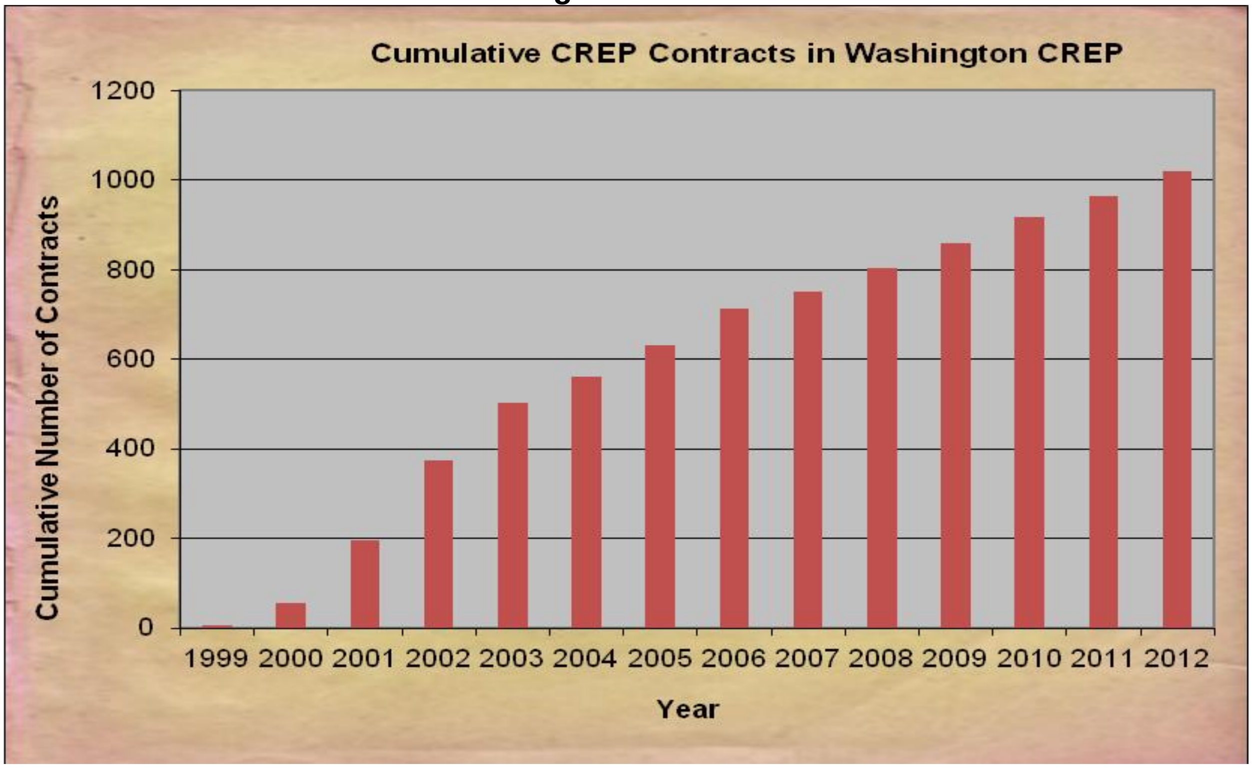


Figure 2. The number of contracts in the Washington CREP by year.

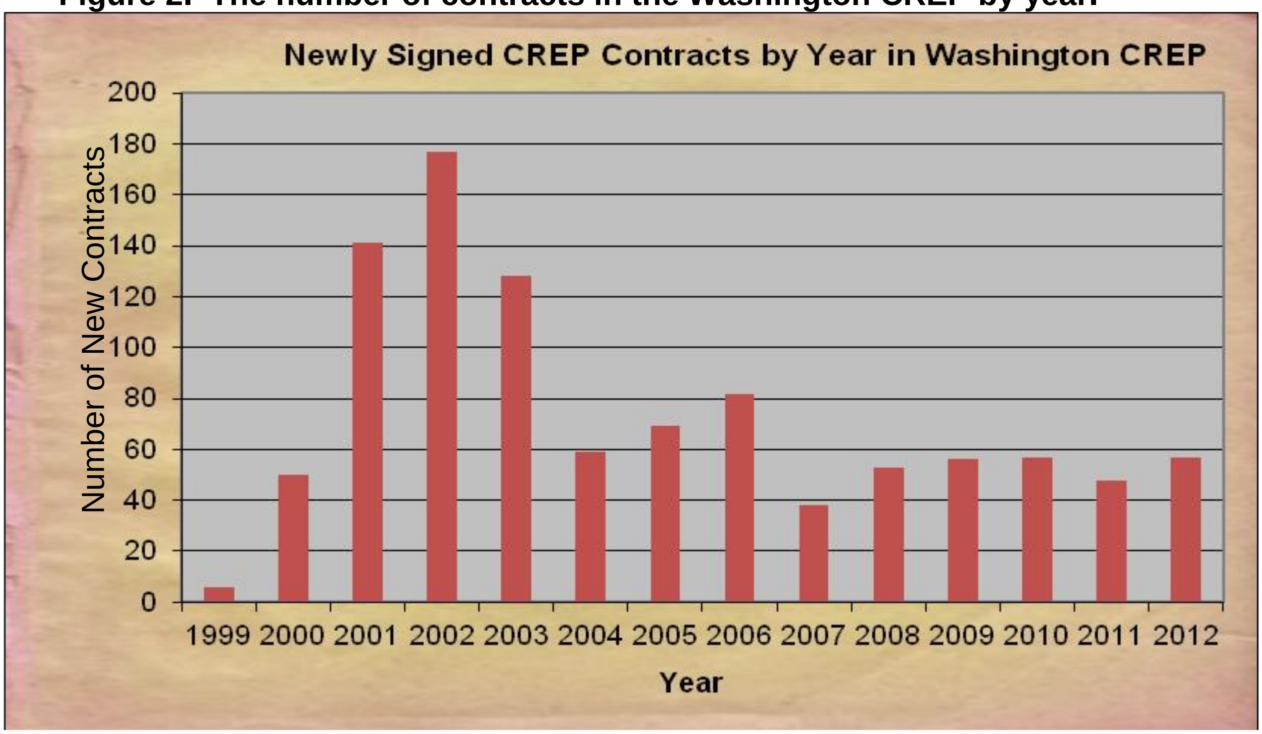
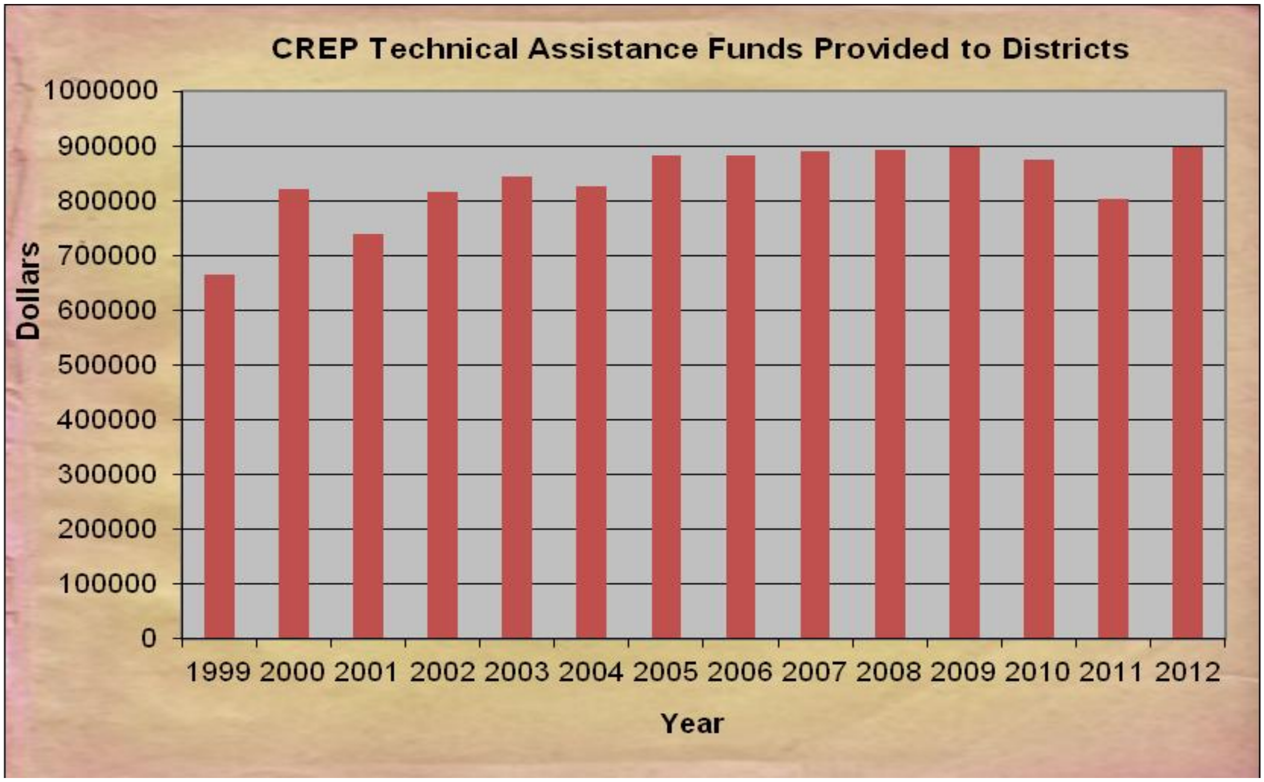


Figure 3. CREP technical assistance funds provided to Washington State Conservation Districts.



The CREP contracts are scattered throughout western Washington and congregated in southeast Washington. Very few are in central Washington (Figure 4). The districts with the greatest number of contracts overall are: Whatcom, Walla Walla County, Columbia, Skagit, and Pomeroy Conservation Districts. However, the most active ones in 2012 were: Whatcom, Lewis County, Clallam, Snohomish and King Conservation Districts (Figure 5).

Figure 4. Location of CREP Sites in Washington State.

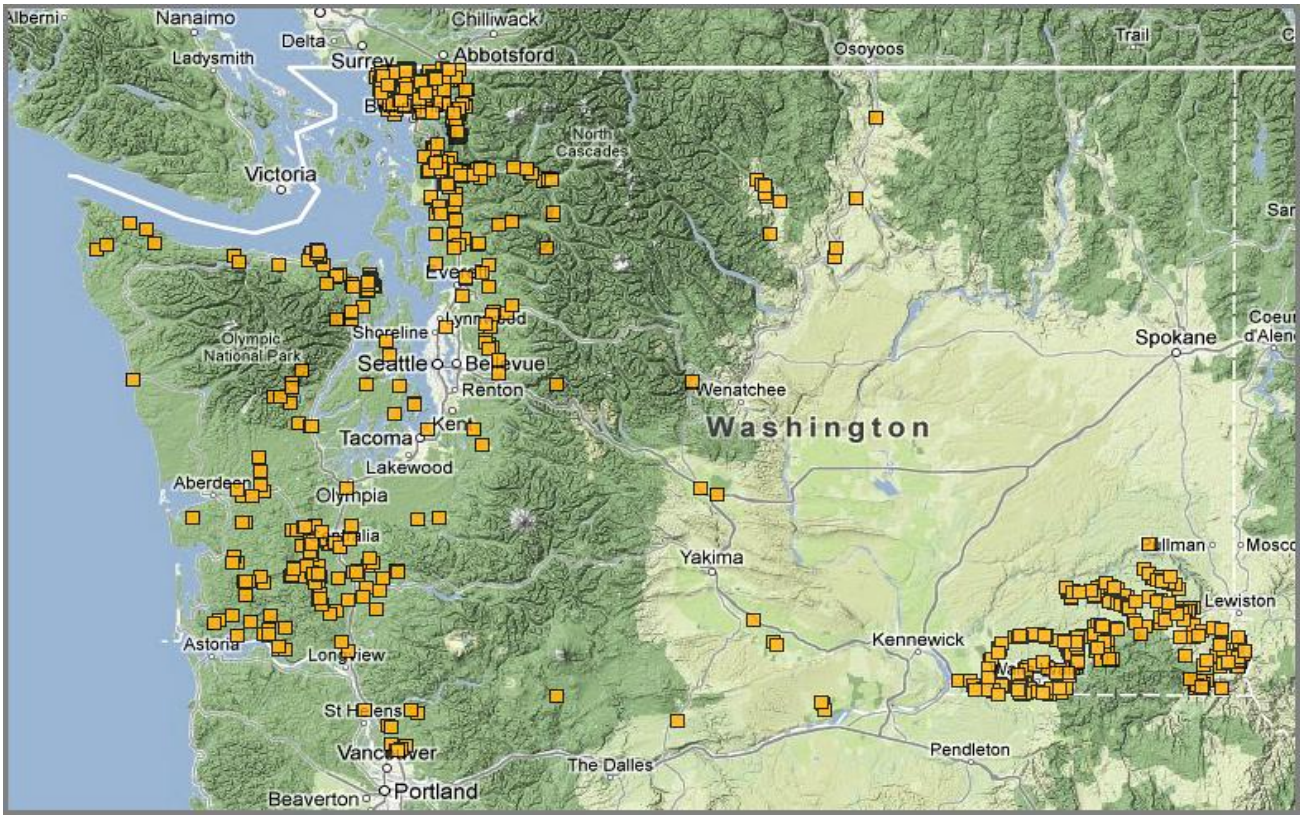
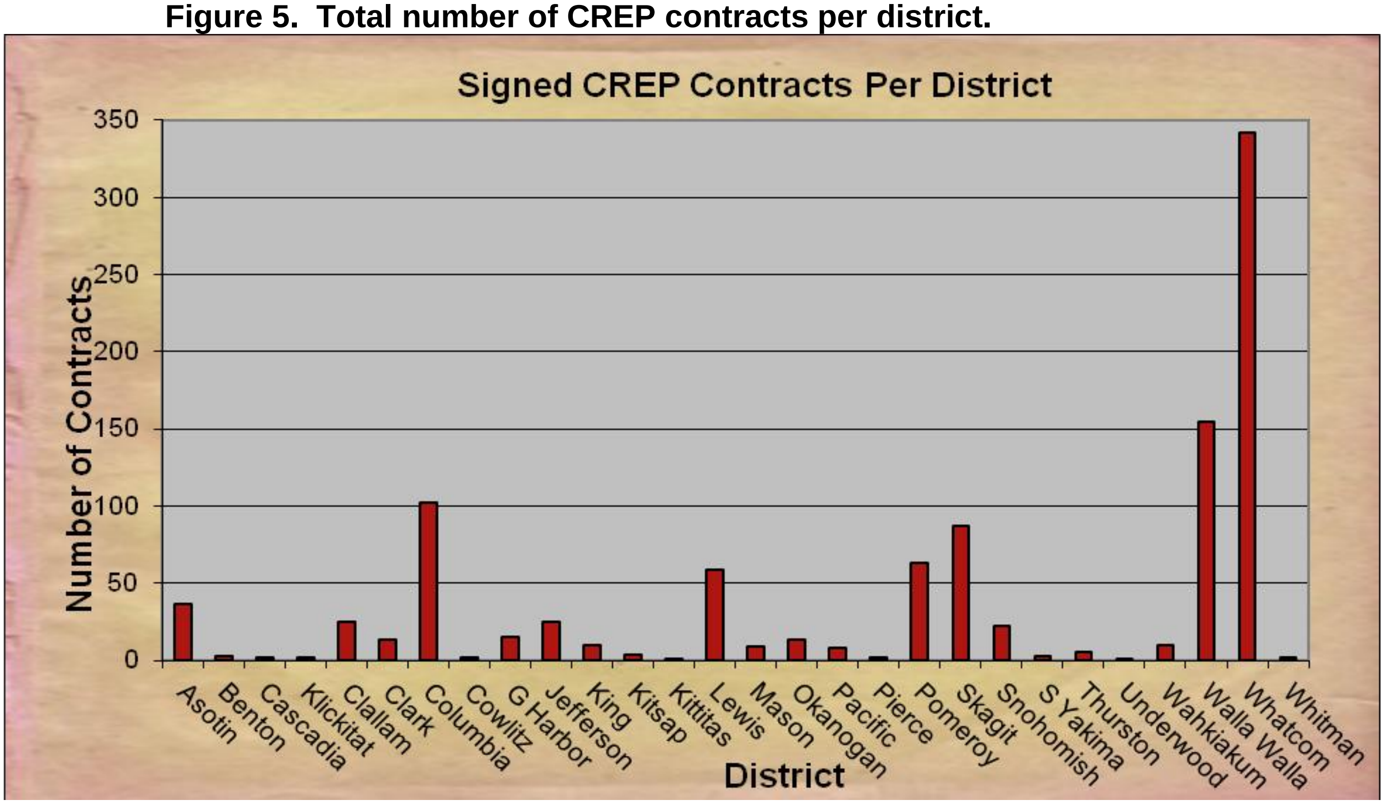


Figure 5. Total number of CREP contracts per district.



Implementation Monitoring: Riparian Benefits

In 2012, 28 additional stream miles were restored and protected in the Washington CREP, bringing the total number of stream miles under contract to 735 (Figure 6). CREP buffer acres increased by 440 with a new total of 13,662 acres of riparian buffer restored and protected with CREP contracts (Figure 7).

Figure 6. Stream miles protected by CREP buffers.

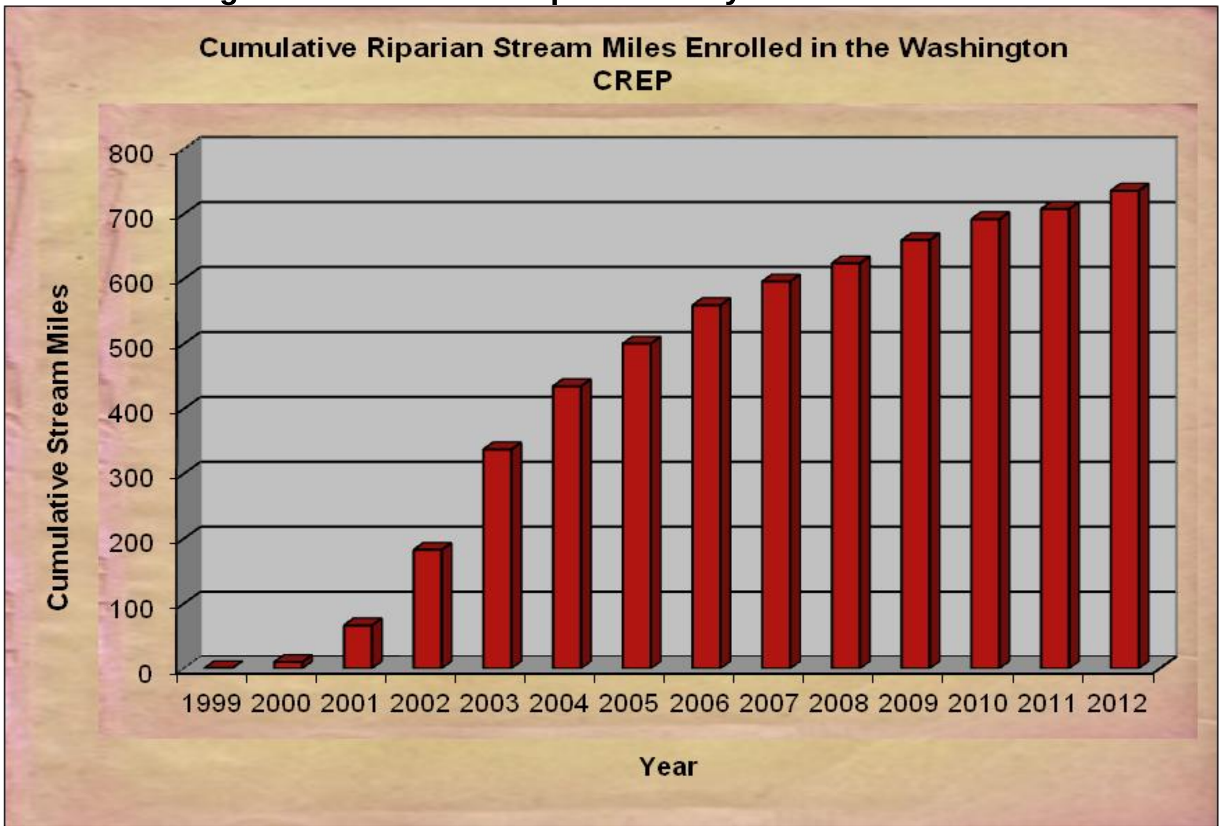
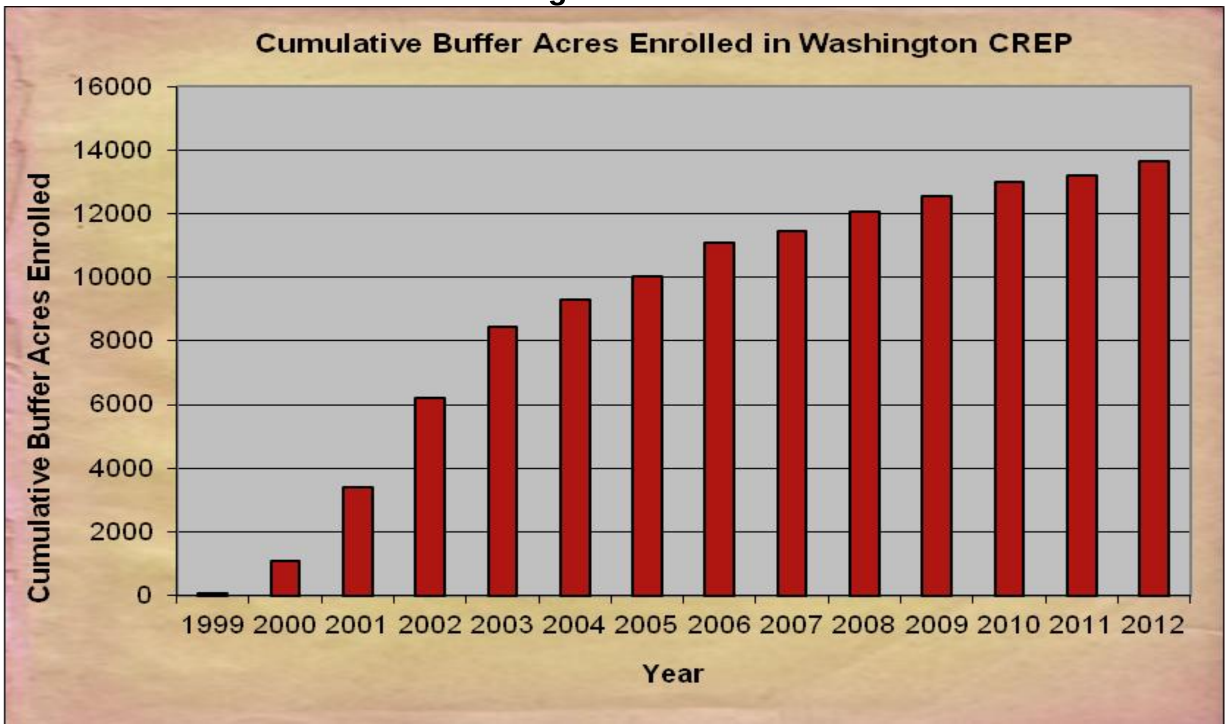
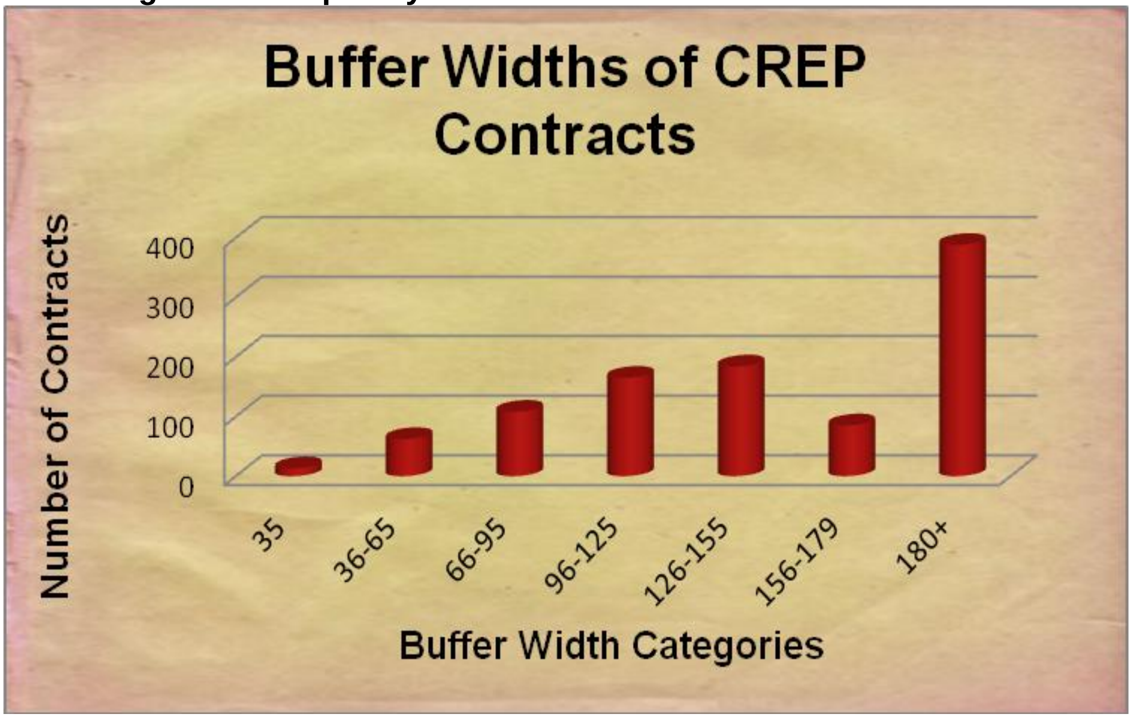


Figure 7. Total cumulative acres of riparian buffer enrolled in the Washington CREP.



The vast majority (96%) of CREP contracts use the riparian forest buffer practice. In this practice, buffer widths can range from a minimum of 35’ to 180’ from the stream edge. Buffers can and do extend wider than 180’, but rental payments do not pay for buffers greater than 180’. Figure 8 shows the frequency of various buffer widths found in CREP. The most common buffer width category is 180’ or wider with 39% of all riparian forested buffers developed to 180’ or greater in width. Eighty percent of all CREP forested buffers are 100’ or greater in width. The average buffer width is 143’ while the median is 150’.

Figure 8. Frequency of various buffer widths at CREP sites.



Implementation Monitoring: Seedlings, Troughs, and Fencing

About 175,000 native tree and shrubs were planted in 2012 for a total, cumulative 5.2 million seedlings planted throughout the last 14 years of CREP (Figure 9). In addition, a total of over 1.5 million feet of fencing has been installed along CREP riparian buffers to exclude livestock from these sensitive areas with about 31,000 feet installed in 2012 (Figure 10). Lastly, a total of 211 watering facilities have been installed in CREP over the last 14 years to facilitate livestock exclusion from salmon streams (Figure 11).

Figure 9. Total, cumulative seedlings planted in the Washington CREP.

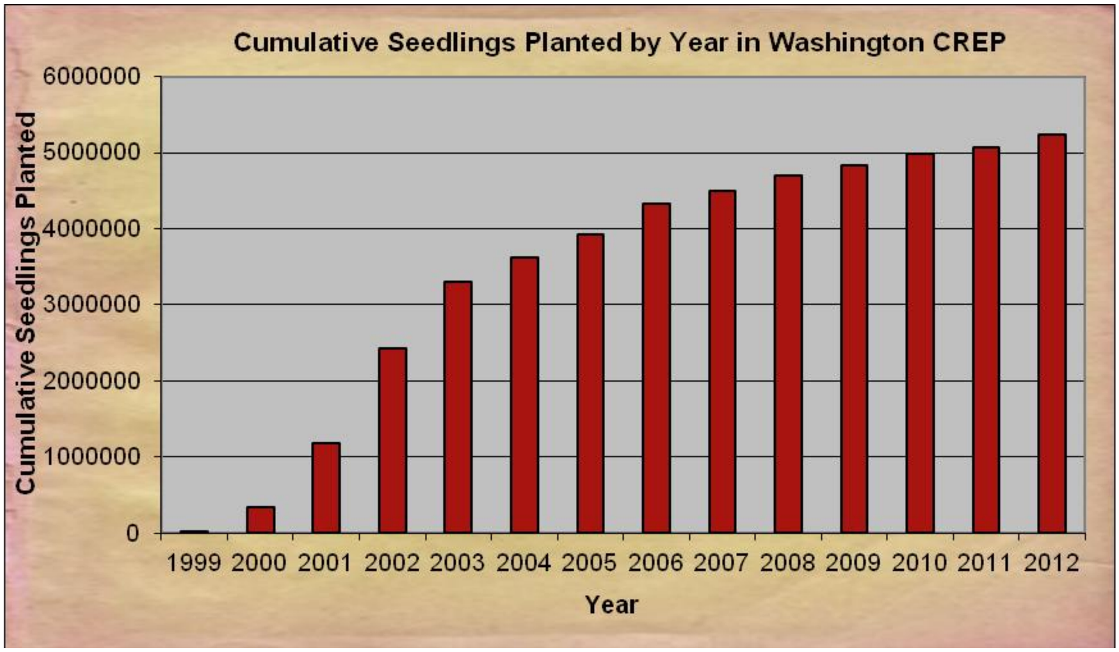


Figure 10. Total, cumulative feet of fence installed in the Washington CREP.

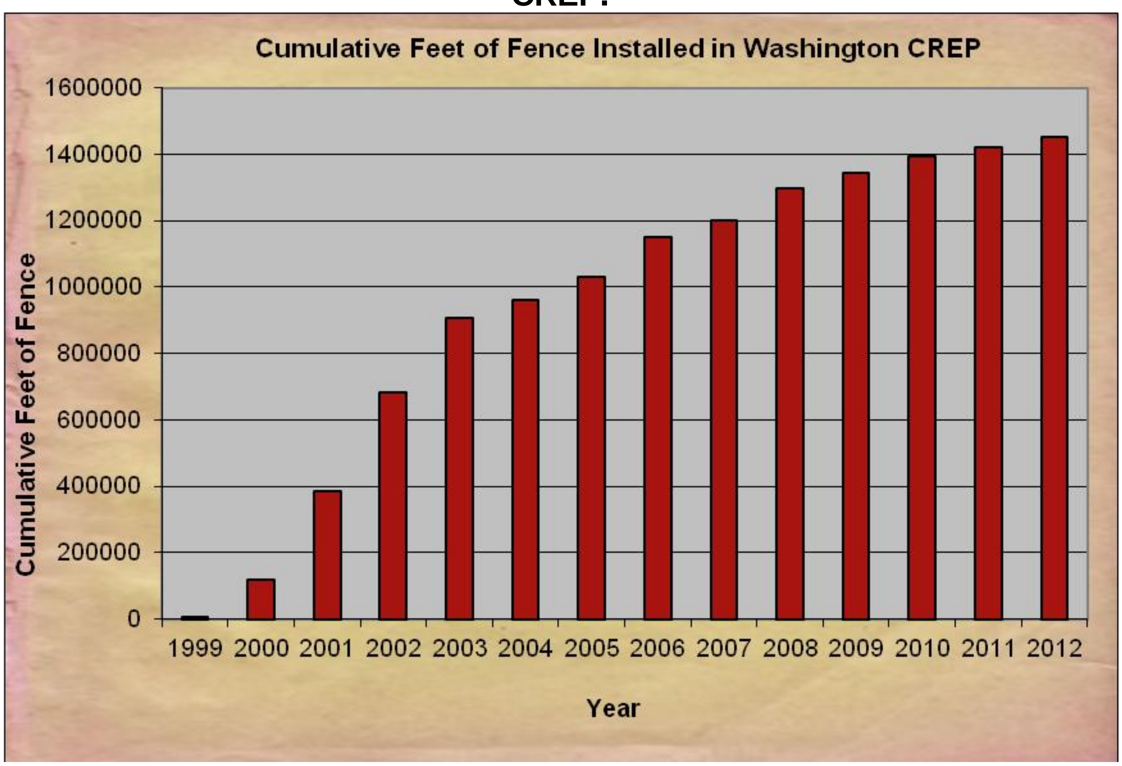
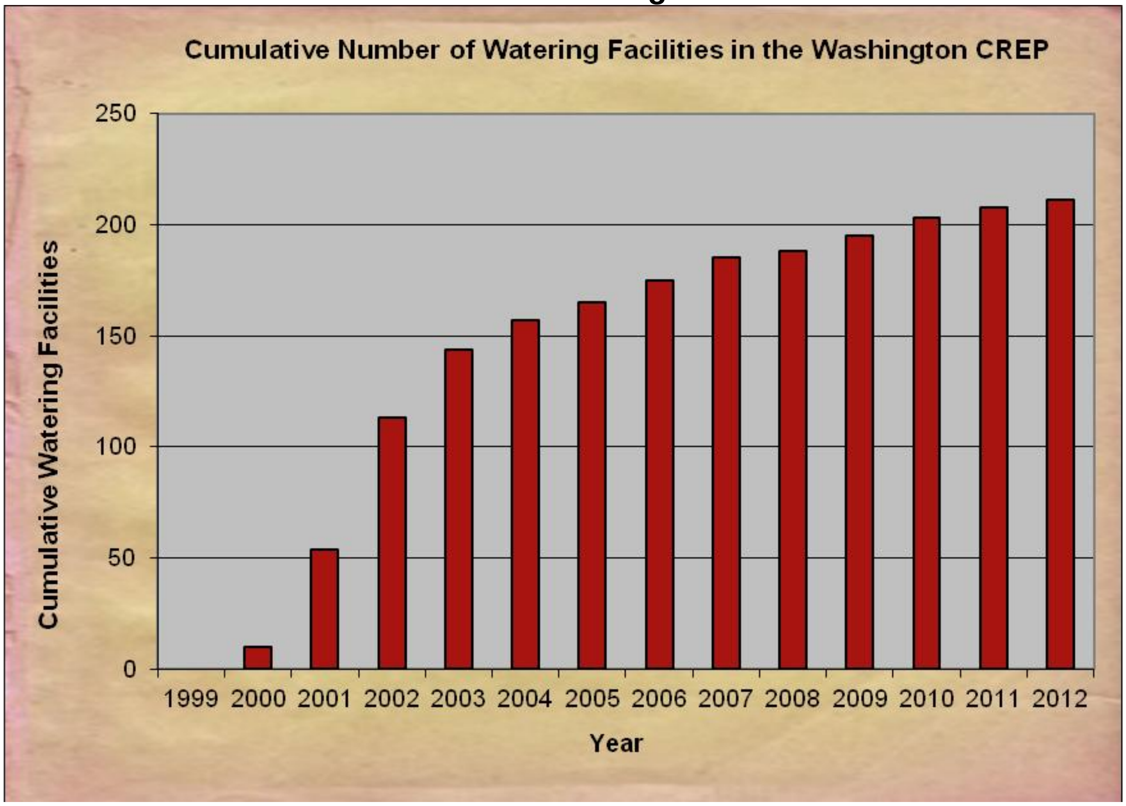


Figure 11. Total number of watering facilities such as troughs and wells, installed in the Washington CREP.



Effectiveness Monitoring: Buffer Composition

Results from 2008-2012 were merged to analyze the plant composition of CREP riparian buffers by plant type and by plant species. By plant type number, shrubs dominated many of the CREP buffers on the eastside, comprising 80% of eastside CREP buffers (Figure 12). Trees encompassed 20% of the riparian with 13% conifer and 7% deciduous tree species. By species, the most commonly used on the eastside were: willow species, rose, ponderosa pine, juniper, black cottonwood, and red-osier dogwood (Figure 13). A total of 21 different species were used in the sampled eastside CREP sites with all but the above listed species in low frequency.

Figure 12. CREP buffer plant composition by type in eastern Washington.

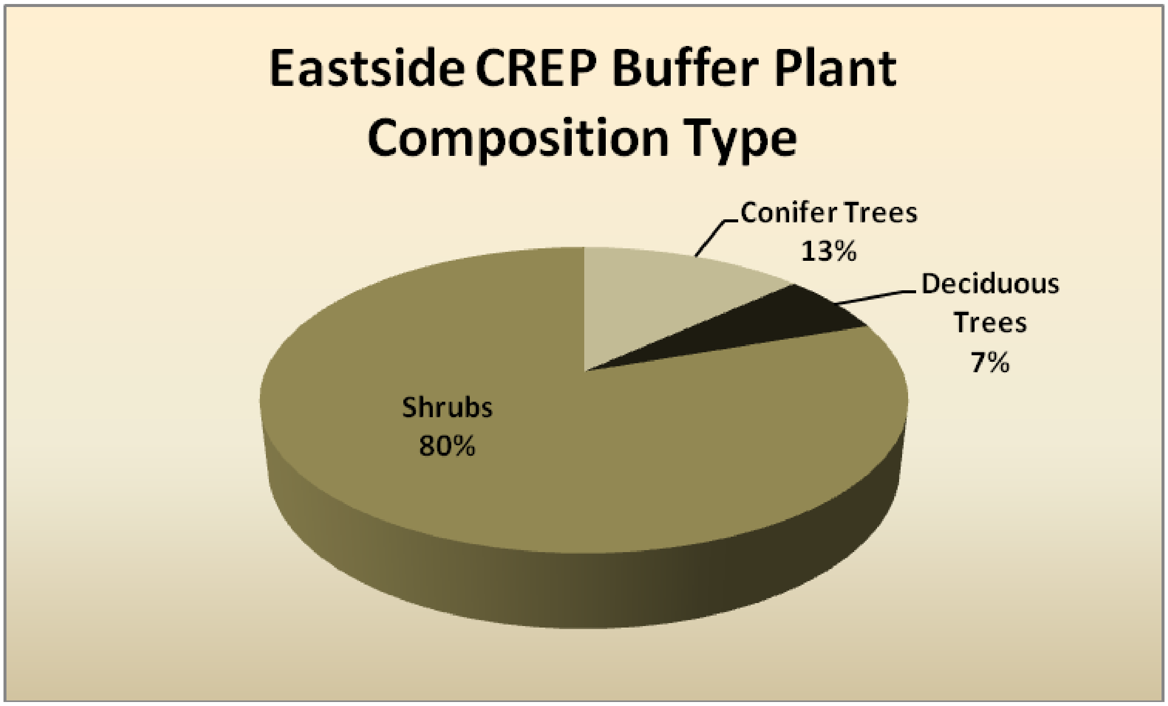
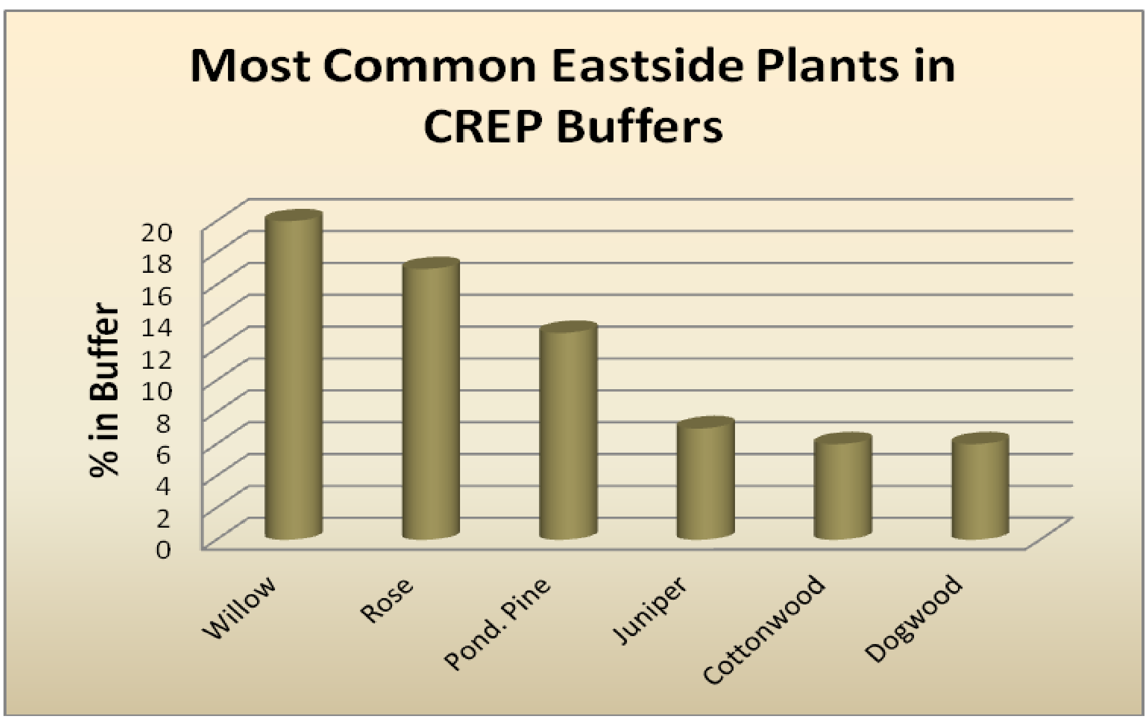


Figure 13. The most common CREP plants in eastern Washington sites. Full plant names can be found in Appendix 1 and were shortened here for better graphic readability.



In contrast, the westside CREP buffers were comprised predominately of trees with 41% deciduous and 34% conifer (Figure 14). Shrubs encompassed 25% of the buffer plant composition. Of 34 different species recorded in the westside CREP samples, the most common, in order from high to lower frequency, were red alder, western red cedar, Sitka spruce, willow shrub species, Douglas fir, black cottonwood, red-osier dogwood, Oregon ash, shore pine, and rose (Figure 15).

Figure 14. The composition of CREP buffers by plant type on the westside.

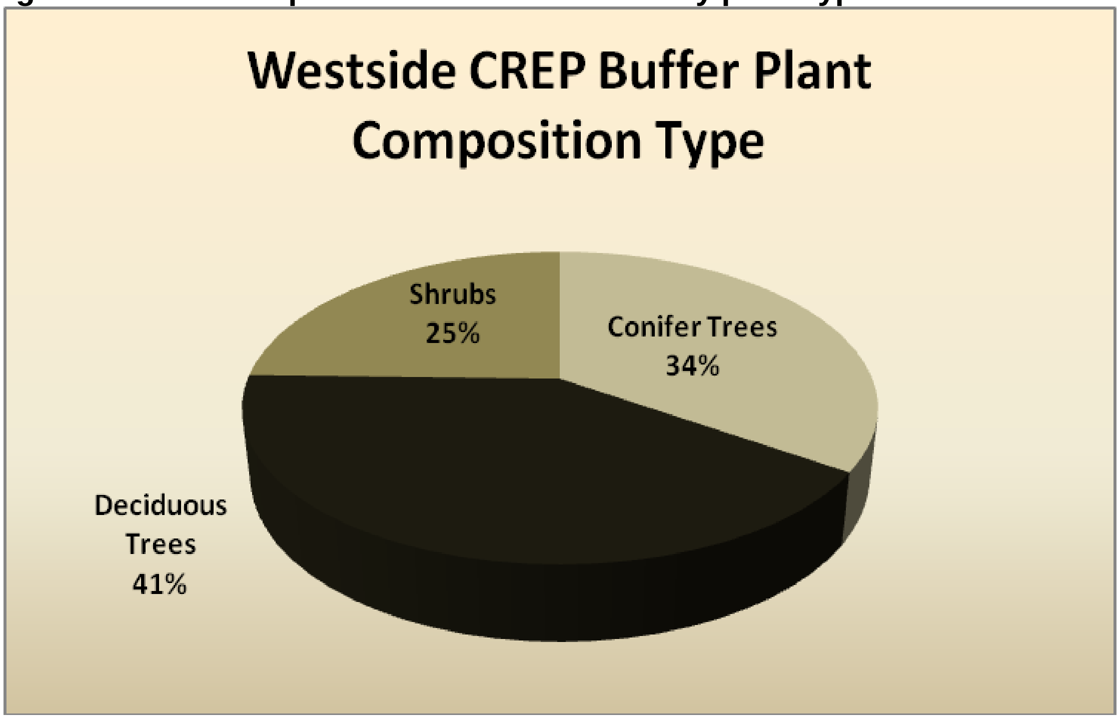
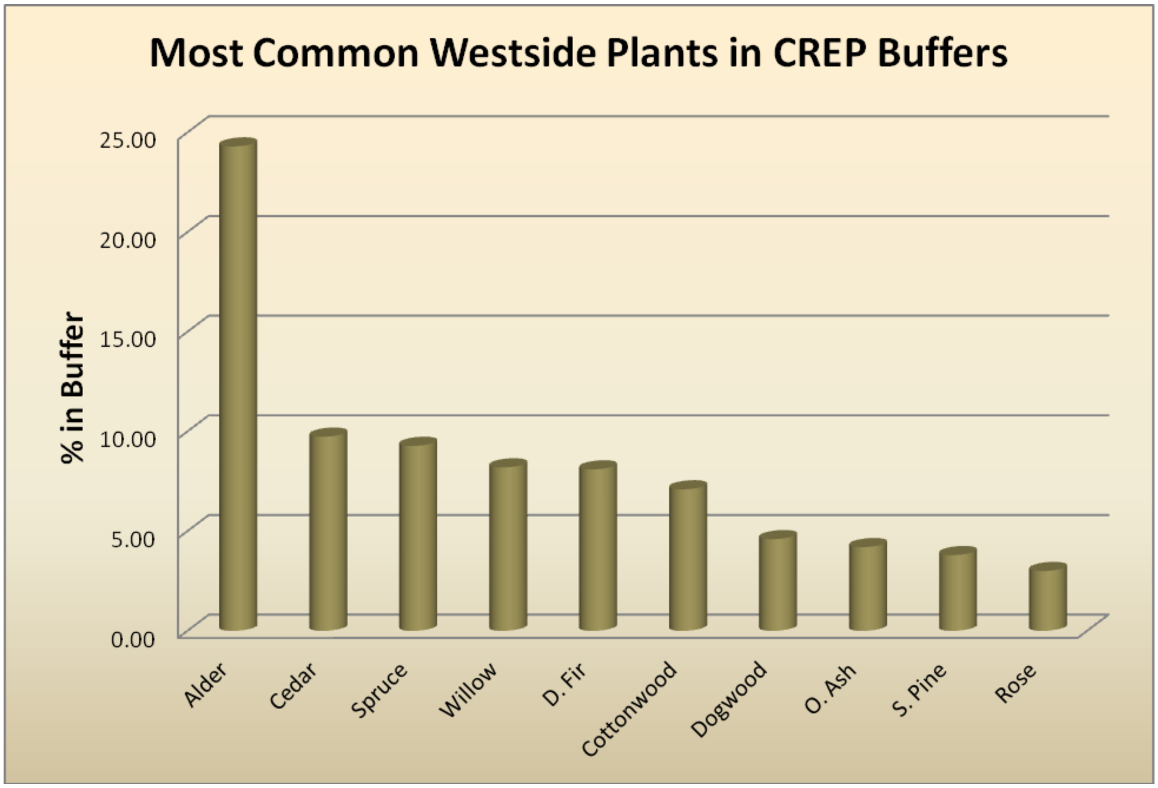


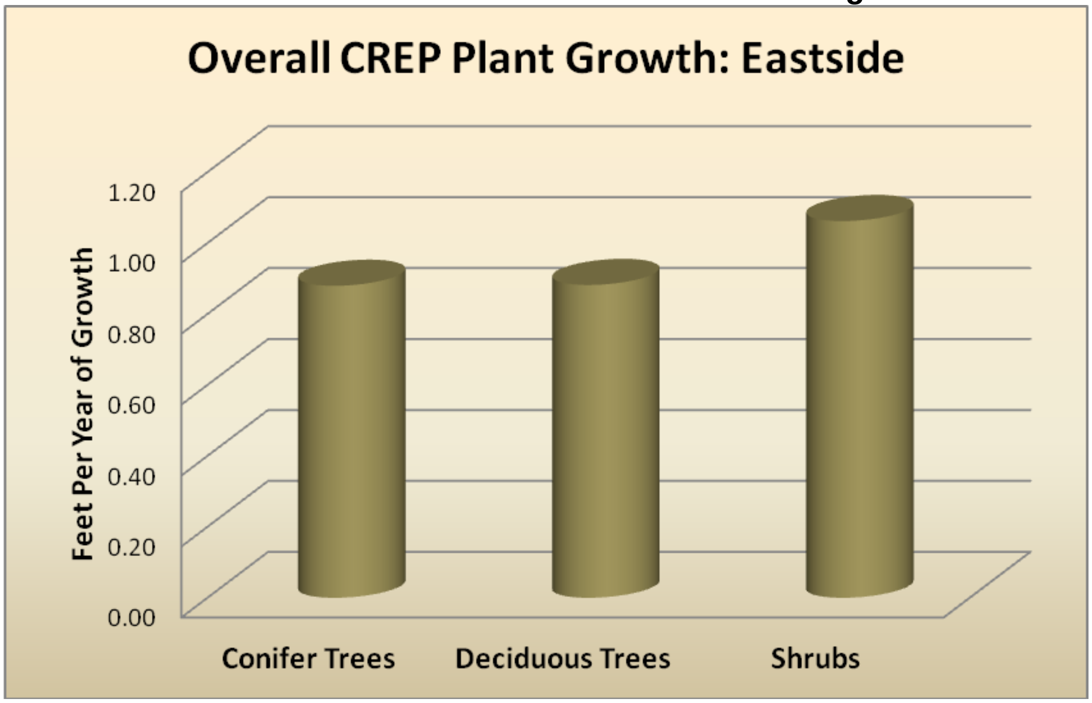
Figure 15. The most common CREP plants in western Washington sites. Full plant names can be found in Appendix 1 and were shortened here for better graphic readability.



Effectiveness Monitoring: Plant Growth

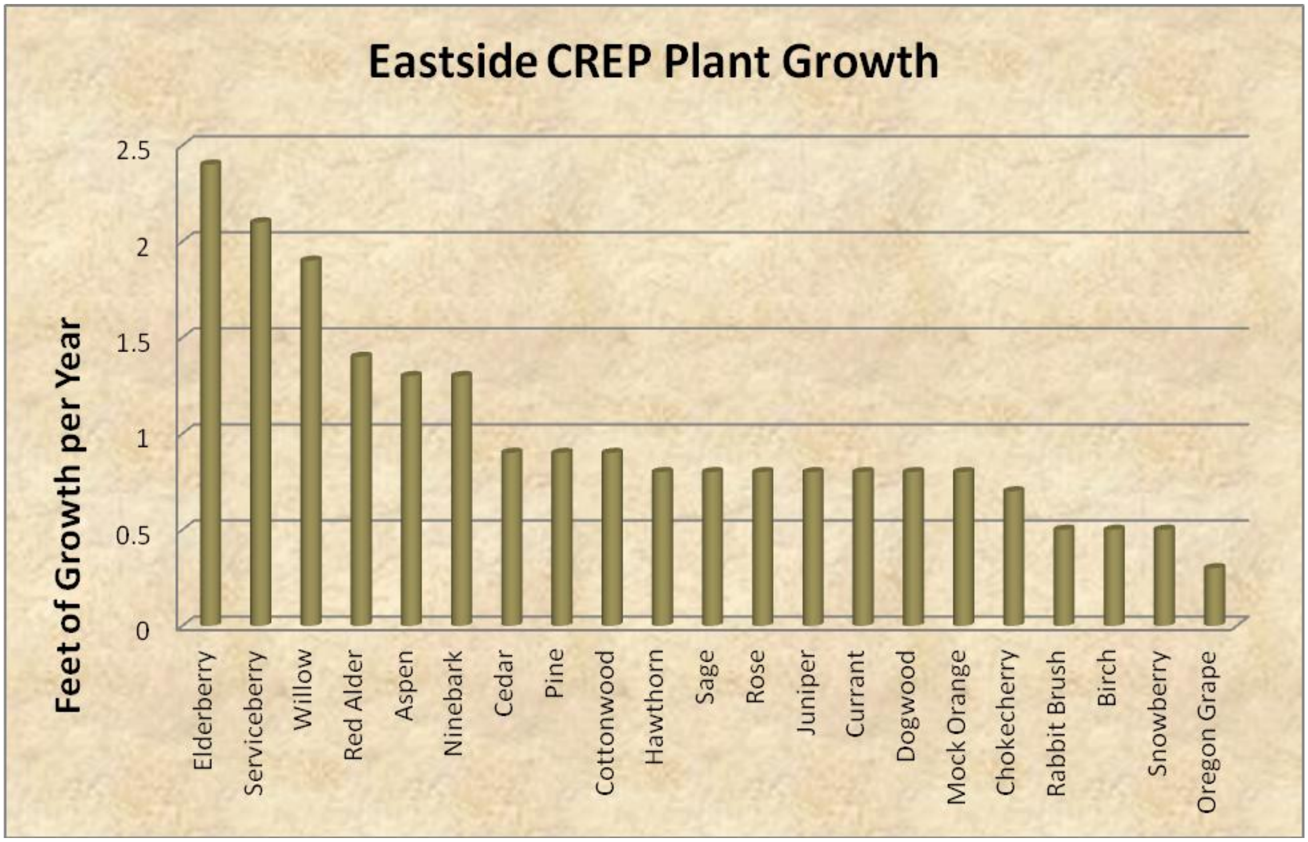
The year 2012 marked our sixth year of effectiveness monitoring sampling of Washington CREP sites. Data for five of those years has been inputted into the Conservation Practice Data System enabling us to combine results across those years, stratified into two groups: western and eastern Washington. At the eastern Washington CREP sites, conifer (ponderosa pine) and deciduous trees grew at an average of 10.6 inches per year, while shrubs (mostly willow) grew an average of 12.7 inches per growing season (Figure 16).

Figure 16. Plant growth per year of installed plants in the Washington CREP on the east side of the Cascade Range.



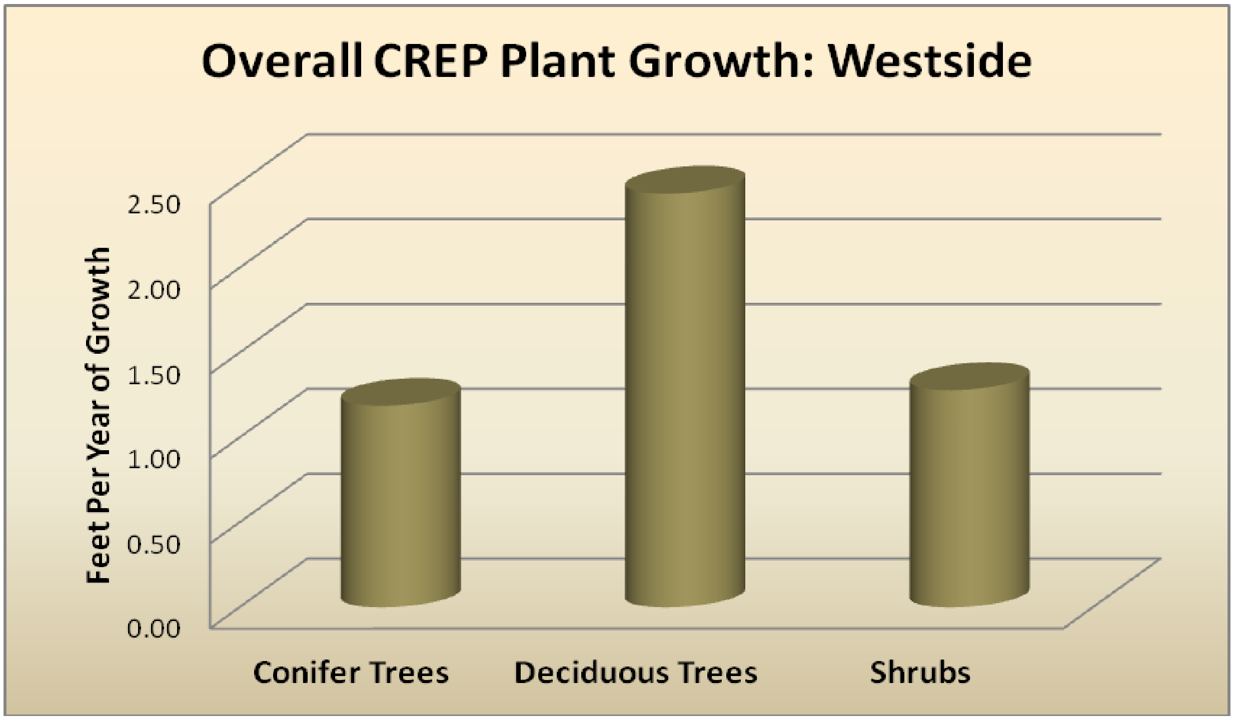
Data were also analyzed by plant species (willow shrub species were merged) for both the east and west sides. Species plant growth was greatest in blue elderberry (28.7” per year), serviceberry (25.3” per year), and willow shrubs (22.3” per year). Growth rates for other species are shown in Figure 17.

Figure 17. Plant growth per year by species in eastern Washington CREP sites. Plant names are shortened for graph readability and are listed in full in Appendix 1.



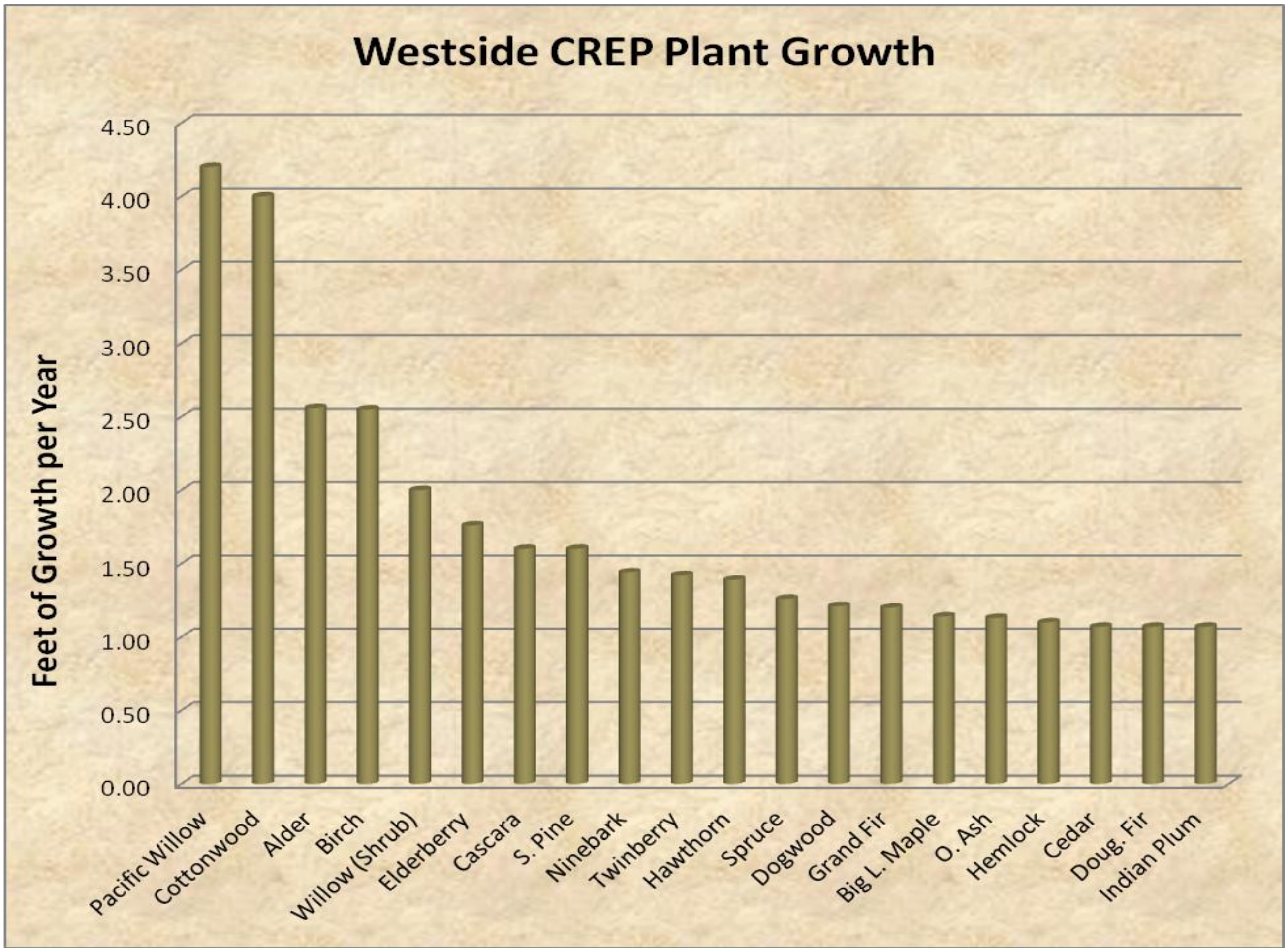
In western Washington, conifers and shrubs grew at an average of 14.3 and 15.4 inches per year respectively, and deciduous trees grew at a mean of 29.3 inches per growing season (Figure 18).

Figure 18. Plant growth by plant type in western Washington CREP sites.



The fastest growing CREP plants in western Washington sites were: Pacific willow (49.8" per year), black cottonwood (48.4" per year), red alder (30.7" per year), and birch (30.6" per year). Shore pine was the fastest growing conifer at 19" per year. A more complete list of growth rates can be found in Figure 19.

Figure 19. Plant growth per year by species in eastern Washington CREP sites. Plant names are shortened for graph readability and are listed in full in Appendix 1.



Effectiveness Monitoring: Plant Survival

Survival of CREP plants at eastern Washington sites is shown in Figure 20 with a mean survival across sites of 75 percent. Western Washington CREP plant survival has a mean of 90% (Figure 21). Our plant survival goal is 85%.

Figure 20. CREP plant survival (mean of 2008-2012 results).

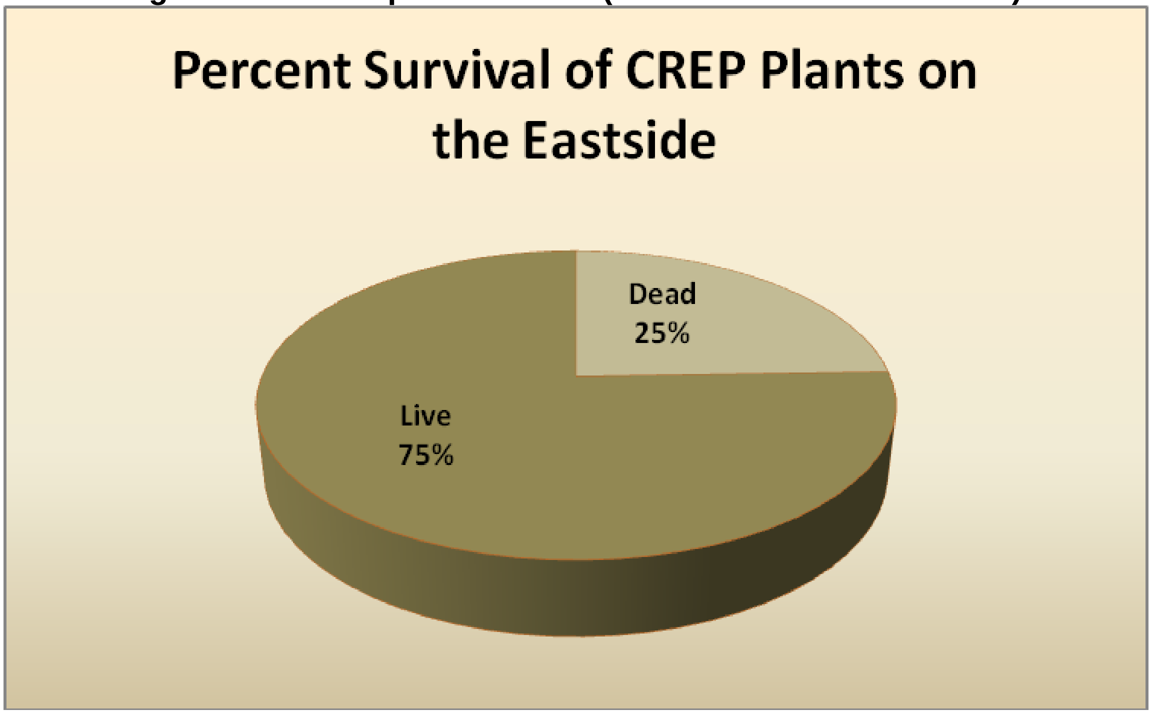
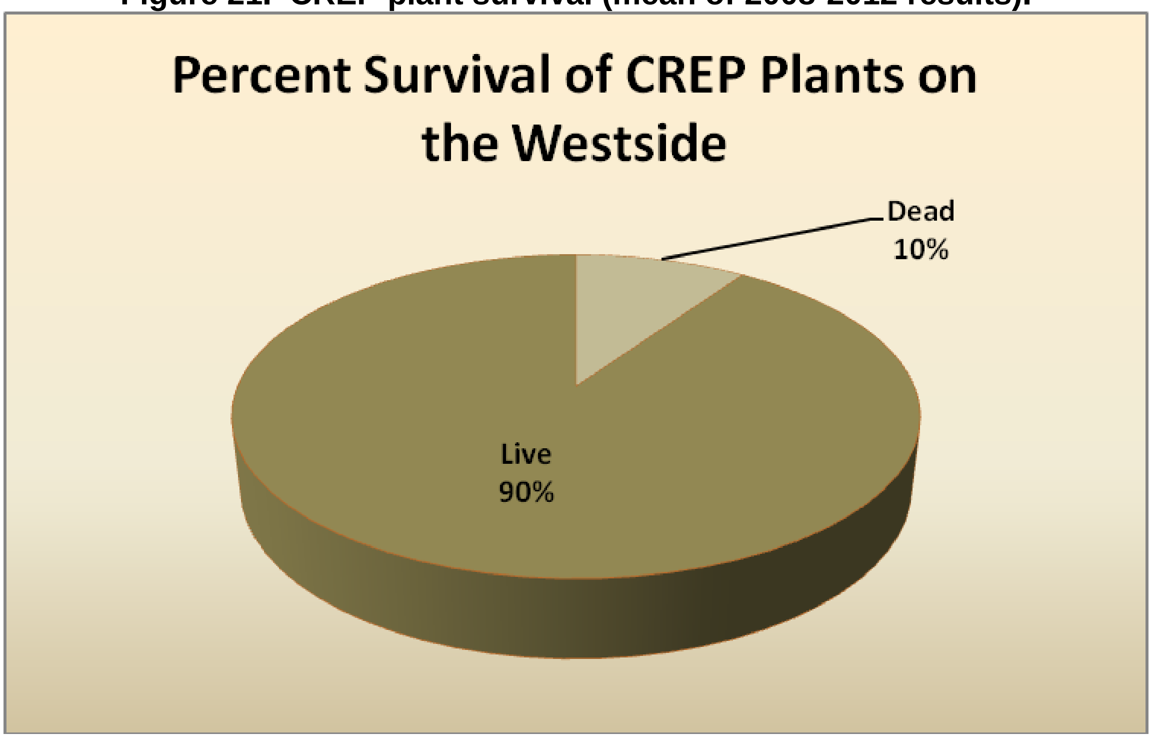


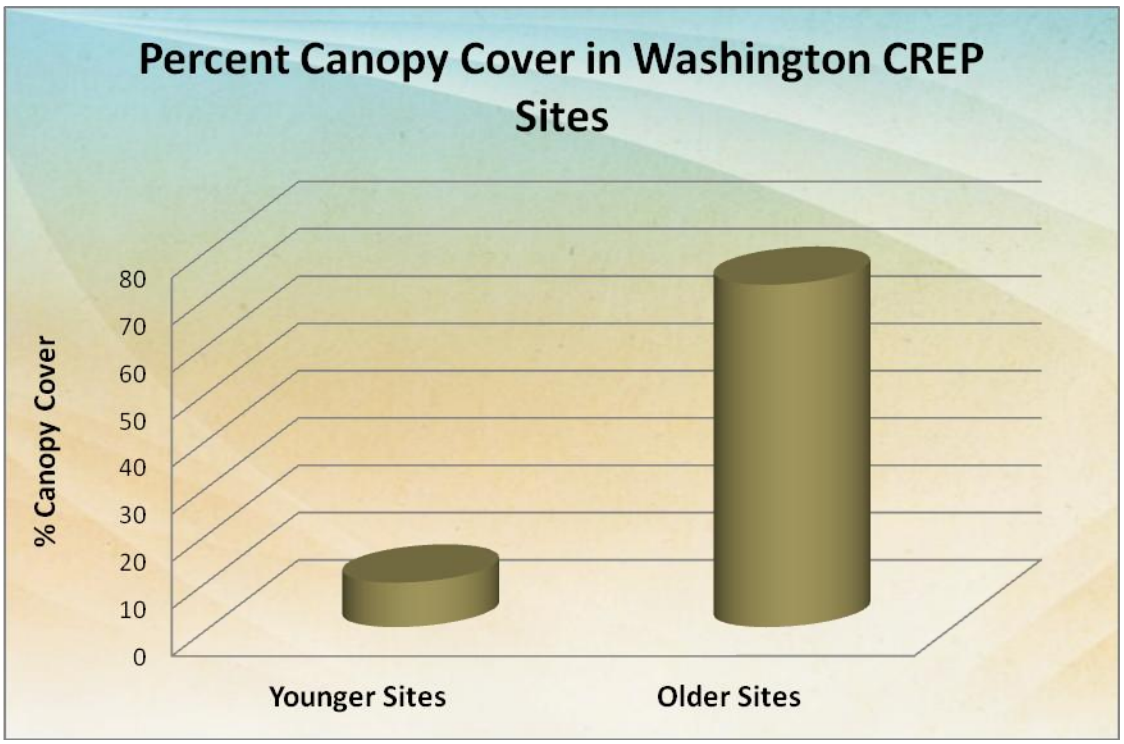
Figure 21. CREP plant survival (mean of 2008-2012 results).



Effectiveness Monitoring: Canopy Cover

The amount of shade over the CREP-planted stream reaches was estimated as percent canopy cover measured mid-channel. This was measured only in wadeable CREP stream reaches because the larger mainstem reaches were not able to be sampled mid-channel. For the sampled streams, shade significantly increased ($P<0.0001$) over the CREP reaches that were planted at least 4 years prior as compared to younger CREP sites (Figure 22). The mean percent canopy cover for young sites (0-4 years old) was 9, while older sites had a mean of about 72 percent. These results are not applicable to wider streams as those are more difficult to shade and require a combination of wide buffers and taller (more mature) trees. If canopy cover were measured for the wider streams, the results would likely be much more variable and less significant between the two age groups.

Figure 22. Percent canopy cover over small (wadeable) CREP enrolled-stream reaches.



Effectiveness Monitoring: Bank Erosion and Extent of Invasive Species

The percentage of eroding banks was low throughout most Washington CREP sites with an average of 8 percent along younger (less than 5 years) sites and 4 percent along older sites (Figure 23). These two groups are not significantly different from each other ($p=0.4608$). Bank erosion is expected to be low within CREP projects because sites with significant levels of erosion are not eligible for

CREP.   However, we monitor to make sure that our actions are not contributing to increased bank erosion over time.

The percent of land coverage by invasive plant species averaged less than one percent for younger (0-4 growing seasons) and 3 percent for older (5-10 years) contracts (Figure 24). There were no significant differences between these two groups (p=3988).

Figure 23. Percent bank erosion along CREP reaches in eastern Washington.

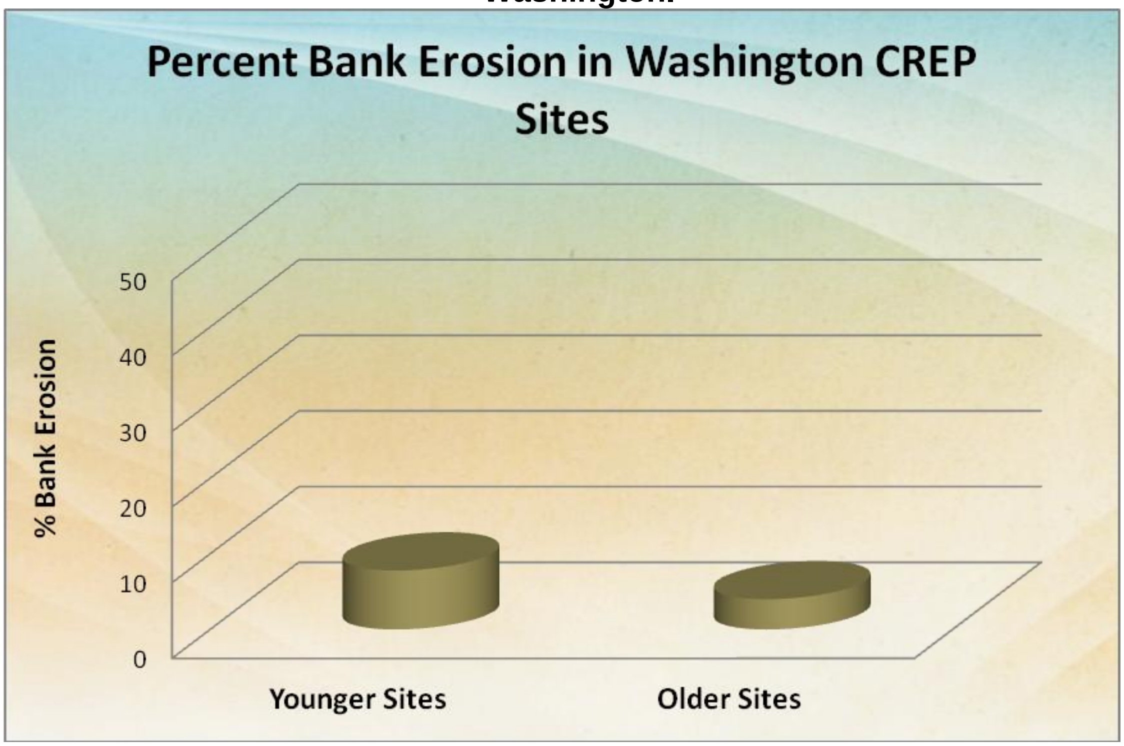
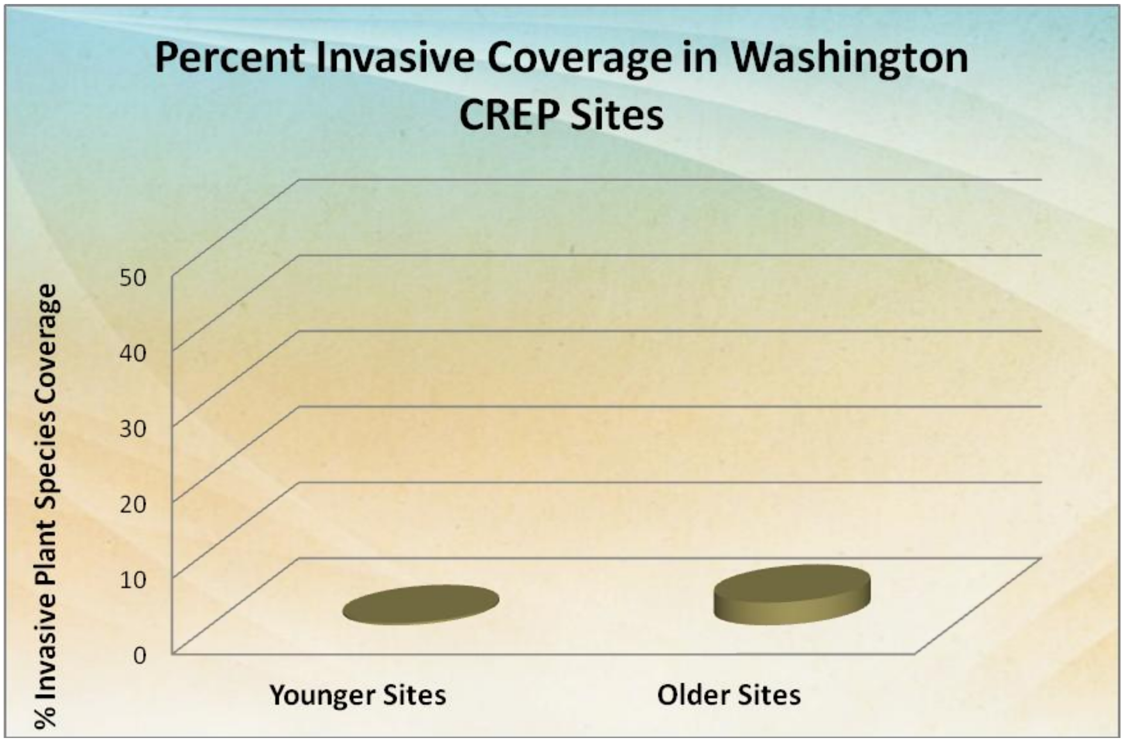


Figure 24. Percent of invasive plant species coverage within CREP buffers.



Discussion

Program Progress

The number of CREP contracts enrolled in 2012 was greater than expected. The expiration of the Farm Bill cut-off three months of possible enrollment, yet this was a relatively high year in contract numbers compared to the last six years of the program. The main reason for the increase in contracts is that the state level funding was fully restored this year.

Another interesting change is the shift in location of project activity in the state. In the past, southeast Washington and north Puget Sound have been our most active areas in CREP. That appears to be changing. While north Puget Sound remains very active, there is much less activity in southeast Washington and more activity in other western areas such as Lewis and Clallam Counties.

CREP Buffer Widths and Function

The vast majority (96%) of CREP projects use the riparian forest buffer practice. This has a minimum width of 35’ and the program provides funding for up to 180’ in buffer width. Some buffers extend past 180’ using exclusion fencing and upland watering facilities to direct livestock away from steep areas. The most common buffer width used in the Washington CREP is 180’ and 80% of existing

CREP contracts have riparian buffer widths of 100’ or greater. The average width is 143’.

Riparian buffers that are 100’ or wider are able to provide a wide-array of functions. Literature values indicate that high levels of shade (50-100%) are achieved with these widths (see review by Knutson and Naef 1997, Spence et al. 1996). Riparian buffers at these widths are fully functional for filtering nutrients, controlling bank erosion, supplying leaf litter and organic material, and retaining soil moisture (Spence et al. 1996, Knutson and Naef 1997, Fischer and Fishenich 2000). The provision of large woody debris requires buffer widths of approximately 100-180’ (Cederholm 1994, Knutson and Naef 1997). Many of the CREP buffers are adequate for this function. However, for wide streams with narrower buffers (35-100’), it is likely that those sites will not be fully functional in large woody debris recruitment. These are low in number in the Washington CREP.

The removal of other pollutants, such as pesticides and fecal coliform, often requires additional practices in addition to a CREP buffer. Also, filtering is generally more effective using grass filter strips and grass/shrub buffers rather than forested buffers (Fisher and Fischenich 2000, Mankin et al. 2007). Grass/shrub buffers have been demonstrated to be effective at removing nitrogen, phosphorus, and total suspended solids using widths of 8m (26’).

In concert with the literature results, our monitoring of the Washington CREP shows that shade (canopy cover) is greatly improved in as little as five years. Projects under five-years old were compared against those that were five-years or older and the older contracts averaged 72% canopy cover compared to 9% in younger contracts. This compares to a review of riparian restoration studies in the Pacific Northwest Inland, which showed shade improvements from 3% at baseline to 31% by year four (Wall 2011). Oregon projects increased to supply 46% shade by years 10-14 after planting (Demeter Design 2010). Riparian restoration projects funded by the Salmon Recovery Funding Board did not show in increase in canopy cover at year 5, the oldest year in their study (Tetratech 2010).

Increasing shade is an effective way to decrease water temperatures and improve conditions for salmon and steelhead that rely on cool water temperatures. Opperman and Merenlender (2004) have shown that restored riparian areas led to acceptable water temperatures for steelhead as compared to controls. Similarly, in areas targeted for large-scale riparian restoration using Washington CREP and other programs, water temperatures have cooled (Smith 2012). In addition, salmon began using 20 miles of habitat in the Tucannon River in Washington State that prior to riparian restoration was too warm for salmonids (Gallinat and Ross 2011).

CREP Buffer Composition and Plant Growth

CREP riparian buffers are designed to primarily benefit salmon and steelhead. Desirable characteristics of such buffers include:

- Native plants to support a native ecosystem.
- A significant conifer component in areas that historically supported conifers to provide longer-lasting large woody debris to streams.
- A diversity of tree and shrub species to support an array of functions and food web components.
- A component of fast-growing native plants to aid in controlling invasive plant species and more quickly provide shade to cool water temperatures.
- The inclusion of other farm practices, where needed, to reduce land management impacts. These typically include fencing and upland water facilities to exclude livestock from riparian areas. It could also include the use of a grass filter strip between cropland and streams to reduce pollutants.

Two of these characteristics are required: the use of native plants (with rare exception) and inclusion of other farm practices where needed. All CREP buffers are "no touch". Contracts are signed with landowners to require the ecological functionality of the buffers and no management (agriculture) is allowed within them. Part of this includes the requirement for fencing to be installed where livestock are present to preclude them from riparian and stream areas. In addition, native plants are used as much as possible. Funding reimburses plant costs, but will only do so when acceptable plants are used for a given region. These programmatic requirements are in place to assure that CREP buffer objectives are met.

The remaining characteristics are desired, and our monitoring shows how close we are to achieving those objectives and points out where improvements could be made. Buffer plant diversity is one of those characteristics. The most effective riparian buffers will ultimately have a mix of plant types as they mature, and diversity is a characteristic that develops over time in natural forests. Old growth forests are much more heterogeneous than young forests (Franklin et al. 1981). Past monitoring has shown that CREP buffers are very diverse in western Washington with a median of 11 plant species per sampled area and less diverse, but still adequate in eastern Washington with 5 plant species per sampled area (Smith 2011).

Yet another desired characteristic is the presence of conifer trees. These are important to contribute large wood to the stream. As trees mature and fall into the stream, they help shape streambed and channel morphology to the benefit of native fish species (Bisson et al. 1987; Cederholm et al. 1997). Western Washington CREP sites had a large conifer component (34%) in their buffers. Eastern Washington sites, much less (13%). However, some riparian areas historically did not support conifers. For example, the low to mid-reaches of the Snake River tributary systems were historically dominated by cottonwood (Kuttel

2002). This is the area where much of the eastern Washington CREP sites are located and current levels of conifer are low. Because this area did not historically support much conifer, the lower levels are justified.

The most commonly found plants in Washington CREP sites are: willow, black cottonwood, rose, red-osier dogwood, Ponderosa pine (eastern sites), juniper (eastern sites), red alder (western sites), western red cedar (western sites), Sitka spruce (western sites), and Douglas fir (western sites). Many of these are adapted to wet conditions, such as willow, cottonwood, dogwood, red alder, western red cedar, Sitka spruce, while Ponderosa pine is well-suited for drought-prone sites (Crawford 2003, Bennett and Ahrens 2007, Coos Watershed Association 2012).

Another desirable component is to have at least some fast-growing native plants. This can provide shade and cooler water temperatures sooner, and can aid in the control of invasive plant species. Invasive plant species are a major problem. Changes in dominant riparian plants result in changes in riparian function (Richardson et al. 2007), and invasive plants generally have reduced riparian function. Maintenance of newly restored riparian buffers is vital to the control of invasive species and for improved growth and survival of the native tree and shrub species (Roni et al. 2002, Oregon Watershed Enhancement Board 2010, Cramer 2012). Many authors recommend several years of maintenance, with one recommending up to ten years to control invasive species (Lennox et al. 2011). We fund active maintenance of the buffers for up to five years after planting, primarily to assure control of invasive plant species. Invasive plant species coverage is low in CREP sites (3% or less average). This compares to riparian restoration sites in Oregon had invasive plant species coverage ranging from 1-49% depending on the region (Demeter Design 2011).

It is useful though to know which native tree and shrub species are high growth performers so that they can be used in problematic sites if appropriate for those sites (selected plants must still meet the local conditions such as flood/drought tolerance, etc.). The plants with the greatest growth in eastern Washington restoration sites are: blue elderberry, serviceberry, and willow. Of these, willow species are the only one of these plants that is commonly planted in this region. Districts may want to consider greater use of elderberry and serviceberry where faster buffer growth is needed. In addition, elderberry can grow to be tall enough to supply considerable shade along smaller streams.

Western Washington CREP plants with high growth rates are: Pacific willow, black cottonwood, red alder, and birch. Shore pine was the westside's fastest growing conifer, but Sitka spruce, western hemlock, Douglas fir, and western red cedar all grew well too. The western Washington top growing plants were also among those most commonly planted at CREP sites.

Overall, the CREP plants in Washington State are growing at rates that are generally equivalent or greater than those documented elsewhere. Growth rates for most of the sampled contracts are high for both the arid regions in the east and the wet areas of the west. When comparing to the available information, the CREP sites are meeting or exceeding expectations.

In these other studies, conifer growth of 1+0 Douglas fir plugs and 2+0 bareroot was 4.2 inches and 4.3 inches per year after two years respectively, in western Oregon (Helgerson 1985). Ponderosa pine grew 4.1 and 4.7 inches per year for plugs and bareroot. In another study, mixed age conifers grew an average of 1.9 inches per year for Douglas fir and 2.6 inches per year for western hemlock along the Pacific coast (Hann et al. 2003). British Columbia reported riparian conifer growth rates of 6.1 to 17.6 inches per year (Poulin and Warttig 2005). Most of these growth rates are lower than our conifer rates of 10.6 inches per year in eastern Washington and 14.3 inches per year in western Washington.

Results for deciduous tree growth are highly variable. Washington CREP deciduous trees averaged 29.3 inches per year in western Washington and 10.6 inches in eastern Washington, while shrubs grew an average of 15.4 inches per growing season in western Washington and 12.7 inches per year in eastern Washington. In a similar restoration project in western Oregon, red alder grew an average of 39.4 inches per year (Bishaw 2002), compared to 30.7 for the same species in the Washington CREP. In another study in British Columbia, black cottonwoods grew an average of 66 inches per year over a ten-year period (Burns and Honkala 1990), whereas the same species in western Washington CREP sites grew 48.4" per year. Along the Sacramento River, cottonwoods and willows planted in restoration sites were the most successful species in terms of growth, at 28" per year (Alpert et al. 1999). Pacific willow, a commonly used small tree in CREP projects, averaged 13.2-36" per year in Corvallis, Oregon (USDA Soil Conservation Service and Oregon State University Agriculture Experiment Station 1988). Pacific willow in the Washington CREP was our fastest growing plant at 49.8" per year.

While there are no set standards for plant growth in CREP, we consider sites successful if the growth/year of CREP plants plus the original height are showing a 20% increase compared to the original height. All of the sampled CREP plant types (conifer, deciduous, and shrub) in both regions greatly exceeded this measure of success.

Plant Survival

Plant survival is another measure of riparian buffer success. It is more difficult to measure, especially as the buffers age, because missing plants become more difficult to notice. Average percent survival of sites across eastern Washington was under the goal of 85%. It averaged 75%. Two sites had very high mortalities. The western Washington sites performed very well with 90% average survival.

Survival results differ greatly in the literature, and depend heavily on weather patterns and environmental conditions, which can vary locally. In an Oregon study, survival of conifers averaged 98% for bareroot stock and 89% for plugs after two growing seasons (Helgerson 1985). However, in a recent restoration project along Beaver Creek in Oregon, survival was about 50% during the first year (due to beaver damage), but after providing better protection, increased to a range of 67-75% after three years (Bishaw et al. 2002). A riparian project in the Oregon high desert reported early survival results of 70-80% for a mix of ponderosa pine, deciduous trees, and shrubs (Fox Creek Farm 2006). The Oregon Watershed Enhancement Board (Anderson and Graziano 2002) monitored many riparian restoration sites and found that slightly less than half of these projects had tree survival rates of 75% or greater. Riparian restoration projects in Vermont had better survival of around 72% at year three after planting (Szafranski 2012). These comparisons are similar to our results in eastern Washington and lower than our western Washington average.

The Salmon Recovery Funding Board (SRFB) in Washington State defines plant survival as successful when survival is 50% or greater at year 10 (Crawford 2004).   In year 3, 89% of their riparian projects met this criterium (Tetra Tech 2011). Several of our sampled CREP contracts are 8-9 years old with survival of 80-100%. The NRCS plant stocking specifications assume a15-20% mortality within the first few years, which is why we chose a goal of 85% survival. The majority of Washington CREP sites are generally performing better than these assumptions.

These results demonstrate that the Washington State CREP buffers are successfully growing and surviving with generally rich plant species diversity. The small streams are quickly shaded, and the five-year maintenance program appears to be successful in controlling invasive plant species at least through the 10 years of sampled contracts.

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Appendix 1. List of Plant Species Monitored in Washington CREP Sites.

Common Name	Species Name
Aspen (Quaking)	*Populus tremuloides*
Bigleaf Maple	*Acer macrophyllum*
Birch (Water Birch)	*Betula occidentalis*
Black Cottonwood	*Populus balsamifera*
Blue Elderberry	*Sambucus nigra ssp.*
Cascara	*Rhamnus purshiana*
Chokecherry	*Prunus virginiana*
Current (Golden)	*Ribes aureum*
Douglas Fir	*Psuedotsuga menziesii*
Douglas Hawthorn	*Crataegus douglasii*
Grand Fir	*Abies grandis*
Hemlock (Western)	*Tsuga heterophylla*
Indian Plum	*Oemleria cerasiformis*
Juniper (Western)	*Juniperus occidentalis*
Mock Orange	*Philadelphus lewisii*
Oregon Ash	*Fraxinus latifolia*
Oregon Grape	*Mahonia aquifolium*
Pacific Ninebark	*Physocarpus capitatus*
Pacific Willow	*Salix lucida*
Ponderosa Pine	*Pinus ponderosa*
Rabbit Brush	*Ericameria nauseosa*
Red Alder	*Alnus rubra*
Red-Osier Dogwood	*Cornus Stolonifera*
Rose	*Rosa spp.*
Sagebrush	*Artemisia tridentate*
Serviceberry	*Amelanchier alnifolia*
Shore Pine	*Pinus contorta*
Sitka Spruce	*Picea sitchensis*
Snowberry	*Symphoricarpus albus*
Twinberry (Black)	*Lonicera involucrate*
Western Red Cedar	*Thuja plicata*
Willows	*Salix spp.*