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Evaluation of Riparian Restoration to Enhance Anadromous Fish Habitat along a Napa County Stream

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Abstract

Understanding the specific conditions that influence successful riparian revegetation can assist projects in meeting their success criteria and ultimately improve habitat for fish and wildlife species. This paper examines a Napa County rangeland stream restoration project designed to enhance habitat for steelhead and other anadromous fish species, and compares the success of revegetation plantings and complementary instream improvements under various installation methods and locations. Though these results are likely site-specific, they provide a reference point to guide future riparian revegetation efforts in the project region.

Factors that appear to result in successful riparian restoration for this project include irrigation installation, placement of plantings in shaded areas or under existing riparian canopy, placement of plantings between the top of bank and toe of channel, exclusion of livestock grazing during establishment of plantings, installation of browse protection, and utilization of plantings of coffeeberry (*Rhamnus californica)*, western spicebush (*Calycanthus occidentalis)* and oaks (*Quercus* sp.) along the top of bank as well as California wild rose (*Rosa californica)*, dogwood (*Cornus* sp.*)*, cottonwood (*Populus* sp.) and Oregon ash (*Fraxinus latifolia)* along the lower portions of the stream banks. Instream activities, such as removal of low flow barriers to fish passage and creation of pools, enhance existing steelhead habitat. However, additional constraints such as altered hydrology resulting from the original instream structures, and wildlife herbivory can decrease effectiveness of riparian revegetation efforts. Without the additional habitat elements provided by riparian vegetation, the value of instream enhancements may be reduced.

Problem Statement

Riparian vegetation is an essential component of healthy, functioning stream ecosystems. The presence of riparian vegetation can increase stream bank stability, decrease erosion, improve water quality, and provide habitat for numerous invertebrates and wildlife species (Napa County RCD 2004). Riparian habitat is particularly important in providing both large woody debris for cover and shade necessary to keep water temperatures cool and oxygen levels adequate for steelhead (*Oncorhynchus mykiss*) and other anadromous fish species (Napa County RCD 2004). California's privately-owned rangelands are working landscapes with a long history of human influence within and adjacent to riparian habitats. In many cases existing vineyards and other development currently occupy the historical floodplain, leaving only a thin band of riparian vegetation along the top of bank (C. Gaber, personal observation). Realignment of streams and installation of culverts, dams, bridges and other instream structures may have altered the hydrologic regime, and may form barriers to fish passage blocking access to upstream spawning habitat. Rangeland streams may or may not be fenced to exclude livestock in adjacent pastures from grazing seasonally or year-round within the stream corridor. In Napa County, non-native plant species such as Himalayan blackberry (*Rubus discolor)* and vinca (*Vinca major)* have established themselves on many stream banks (Napa County RCD 2004).

Stream restoration projects may include re-establishment of native riparian vegetation either as the primary purpose of the project, or as a means to achieve improved channel condition or habitat quality objectives. Because riparian revegetation is such a critical component to successful stream restoration, it is important to identify specific locations in which riparian restoration would be most effective and would provide the most benefit to the stream ecosystem, as well as methods that would ensure the highest survival of the plantings. Historical factors and current land uses may constrain the restoration potential of streams and riparian habitat and should be considered during planning of rangeland stream restoration projects and development of realistic goals and objectives. Restoration of an appropriate flow regime and hydrology also can be crucial to successful establishment of riparian vegetation (Viers et al. 2006).

This paper examines a Napa County rangeland stream restoration and riparian revegetation project constructed under a collaborative agreement between the Landowner, California Department of Fish and Game (CDFG), Napa County Resource Conservation District (RCD), and Natural Resources Conservation Service (NRCS). To protect Landowner privacy, this paper discusses the project location generally and does not include a location map or other specific details. The Fish Barrier Removal and Bank Revegetation Project is located within the Sulphur Creek Watershed in western Napa County near the town of St. Helena. Sulphur Creek and its tributaries drain an area of approximately 18 square miles eastward to the Napa River (Napa County RCD 2004). Habitat within the watershed is largely undeveloped forest, woodland and chaparral. However, in the project region, vineyard, pasture, outbuildings, and barns and other structures associated with cattle operations primarily surround the Project Stream and tributary. Because the Project Stream supports a steelhead population and provides high quality instream and riparian habitat for this species (Napa County RCD 2004; Pearce et al. 2004; Jonathan Koehler, Napa County RCD, personal communication, November, 2007), removal of instream structures and restoration of the stream is a resource agency priority in the watershed (Napa County RCD 2004).

Project construction occurred during October of 2004 and post-project monitoring since implementation has consisted of photopoint monitoring at the four instream structure removal locations as well as monitoring of the shrub and tree revegetation plantings in four areas along the Project Stream and its tributary (Lara Hadhazy, Napa County RCD, personal communication, November, 2007). This paper compares the stream bank location, species selection, and methods of installation for restoration plantings designed to complement instream improvements to anadromous fish habitat in these areas. Though results are likely site-specific, they provide a reference point to guide future riparian revegetation efforts in the project region.

Methods

Prior to visiting the project site I conducted interviews with the project Landowner and Napa County RCD staff who had worked on the Project (Lara Hadhazy, Restoration Project Manager and Jonathan Koehler, Senior Biologist), and reviewed the following documents provided by the Napa County RCD: CDFG Streambed Alteration Agreement (CDFG 2004); NRCS Conservation standards and specifications for project revegetation (NRCS 2002; 2003); revegetation planting data sheets from April 2005 through May 2006, design drawings and maps of project activities, and aerial photos (personal communication, Lara Hadhazy, Napa County RCD); and the March 2006 Project Final Report (Napa County RCD 2006). I conducted these interviews and reviewed these documents to identify the restoration activities that had occurred at the project site, the goals of the project, and the revegetation planting methods that were used.

In addition, I reviewed project information on file with the Napa County RCD on October 30, 2007 and conducted field surveys of the project site and surrounding habitat on November 6 and 11, 2007. The day before my November 11th visit, the project site received 0.7 inches of rain (Landowner, personal communication, November, 2007). I chose to focus my survey efforts on photopoint monitoring and revegetation of four streamside areas (Figure 1, Areas A through D) because post-project monitoring documentation of these areas exists. I relocated the photopoints of the four locations of instream structure removal and took photos to document existing conditions. I resurveyed the four revegetation areas and recorded the species, height and condition for each plant to assess survival of each plant (Harris et al. 2005, Lewis et al. no date). I also recorded features about each revegetation area that could be correlated with survival of the plantings including the position of the area along the stream bank (i.e. top of bank, toe of channel, etc.), the presence of tree canopy cover and species over the area, the presence of fencing to exclude livestock grazing, the degree of browsing evident on plantings, the presence of irrigation, the presence of volunteer non-planted tree seedlings, and the potential impacts of the instream structures and their removal. Lastly, I surveyed the existing riparian corridor along the Project Stream and its tributary and recorded the tree species composition and dominant species within this area for comparison to the revegetation areas.

I used data obtained from the information review and field surveys to evaluate existing conditions in relation to the project goals for streamside revegetation and fish habitat enhancement (Table 1). Though the project revegetation goal includes creating increased shade cover and stream canopy, the project has not existed long enough to assess these habitat elements. Most revegetation plantings have not had sufficient time to grow large enough to form a stream canopy or provide shade cover. In addition, the majority of the tree and shrub plantings were given identification tags with unique numbers making it possible to track individual plants during follow up monitoring. I focused on these tree and shrub plantings for my field survey and data analysis. Untagged willow stakes (*Salix* sp.) were planted along the toe of the channel in Area A as well as Area B (Figures 1 - 5), the two areas with the least existing riparian channel cover. These plantings were not included in the follow up monitoring done by the Napa County RCD and the Landowner indicated that planting of willows has been ongoing at the project site (Landowner, personal communication, November, 2007), making survival and cover in these areas difficult to track. Therefore, I did not take data for these willow plantings or calculate a measure of their survival.

Taking into account the replantings that were still alive, I calculated the overall percent survival of tree and shrub plantings in each of the four revegetation areas (Areas A, B, C and D), the overall percent survival of plantings with a condition of OK or better (based on methods discussed in the field with L. Hadhazy, Napa County RCD), the percent survival of plantings that were alive at the last monitoring date, and the percent survival of plantings that were alive at the last monitoring date and that have a current condition of OK or better. I also calculated the percent survival of each species in each revegetation subarea using all plantings to identify the species with high survival in each area.

Formal revegetation success criteria are not contained in project documentation. However, NRCS specifications suggest an overall 75% survival for revegetation plantings and this success criterion has been followed for the project thus far (Lara Hadhazy, Napa County RCD, personal communication, November, 2007). Restoration projects often use approximately 75% survival as a success criterion (C. Gaber, personal observation). Some projects use a lower 50% survival criterion, but in these cases additional success parameters are often included, such as healthy condition for the surviving plantings (FISRWG 2001) or greater than 80% planted willow canopy cover (TADN 2007). For consistency, I compared the revegetation area survival percentages I calculated to the project 75% survival success criterion. Success criteria for individual species are not often included in restoration plans, so I developed a project-specific species "high survival" criterion, requiring at least 4 plantings of the species in the subarea and 100% survival, or at least 5 plantings of the species in the subarea and at least 80% survival. This standard requires a specific sample size for a determination of success.

Results

The Project Final Report summarizes the riparian restoration efforts that have occurred at the project site since October 2004 (Napa County RCD 2006). First, removal of Himalayan blackberry and vinca occurred along the stream banks of Area A. Next, revegetation plantings were first installed in Areas A, B and C in October of 2004 and in Area D in March of 2006. Revegetation plantings included a variety of native shrubs (coffeeberry, western spicebush, and wild rose) as well as native trees present within the existing Project Stream riparian corridor, such as coast live oak (*Quercus agrifolia)*, California bay laurel (*Umbellularia californica*), big leaf maple (*Acer macrophyllum)*, and valley oak (*Quercus lobata)*. The restoration team planted native grasses and sedges in the channel and along the banks (Table 2) and spread a perennial grass/wildflower seed mix over stream banks and areas with bare soil.

The planting methods for most of the tree and shrub plantings included installation of weed mats, fertilizer, mycorrhizae packets, bamboo stakes, penny nails or metal anchors, mesh browse protection, Driwater® gel packs providing time release irrigation, identification tags and three-foot painted metal poles to aid in relocating individual plants (Napa County RCD 2006). The Landowner watered the plantings for the first two years by hand and installed timed drip irrigation in April 2006. Weeding and maintenance of the plantings occurred two to three times per year between October 2004 and May 2005.

During this time, the Napa County RCD staff and volunteers monitored the plantings. During each visit the surveyors consistently recorded whether the plant was present, dead or gone, or not able to be located. Additional information provided for some monitoring surveys included height of the plant, condition (i.e. healthy, OK, or not OK), and evidence of browsing. In March 2006 the surveyors replaced dead plantings that had been washed out or covered with sediment during the January 2006 rains with new plantings. The Napa County RCD last monitored revegetation plantings in Area A on July 12, 2005 and in the other three areas on May 16, 2006.

The planting methods for the four revegetation areas were similar in terms of initial set up, maintenance and irrigation. However, current and pre-project site conditions differ among these areas (Table 3), potentially impacting the percent survival of plantings in each area (Table 4) and of each species (Table 5).

Area A

Area A consists of three subareas along the Project Stream: Near Shed, Downstream of Dam, and Opposite Bank (Figures 1 - 3). Both the Near Shed and Opposite Bank subareas are located under existing riparian canopy just upstream of the wingwalls and sill that remains from the old check dam removed as part of the project. A dirt road runs adjacent to the eastern side of the Project Stream and the Near Shed subarea. This side of the Project Stream lacks cattle exclusion fencing at this location but it does not appear that livestock have access to this area. The Opposite Bank subarea is located along the top of bank and along a lower terrace of the western bank. The western side of the Project Stream is fenced to exclude cattle in the adjacent pasture from entering the stream.

The Downstream of Dam subarea forms the largest portion of Area A. Plantings occur from the top of the bank down to the toe of the channel under the existing willow canopy. The older California wild rose, cottonwood, dogwood and Oregon ash plantings located low on the banks of the Downstream of Dam subarea were mostly in healthy condition, indicating good placement of these plantings along the stream bank. Fencing excludes cattle from this area but some browse protectors are missing and evidence of wildlife browsing exists. Vegetation differences above and below the dam are consistent with other studies that report higher canopy cover and vegetation height upstream of check dams (Bombino et al. 2006). The Downstream of Dam subarea is a much more open reach that lacks the high canopy cover and stream shade of the dense tall oaks and other woody species present upstream. The willows along the lower banks do not extend all the way over the channel or across the floodplain (Figure 2). This reach is also wider than upstream, partly due to bank scour that occurred after the January 2006 flood (Napa County RCD 2006).

The lack of shading for maintaining cool temperatures reduces the value of pools just downstream of the dam as steelhead refugia during dry months. Though the central part of the dam was removed and some sediment was observed moving downstream after this flood (Napa County RCD 2006), the remaining wingwalls may be partially restricting flow and sediment transport through this location and influencing downstream hydrology. Riparian revegetation occurred within this subarea to increase channel canopy cover and shade, restore connectivity of the large tree species present within other reaches of the Project Stream, reduce erosion, and improve instream habitat for steelhead. No steelhead were observed in these pools during the November survey, though a lower pool contained steelhead in August of 2005 (Jonathan Koehler, Napa County RCD, personal communication, November, 2007) and the concrete apron no longer obstructs fish passage.

Area B

The two subareas of Area B (Terrace Area and Opposite Bank) are located along an unnamed seasonal tributary to the Project Stream. Similar to the Downstream of the Dam subarea of Area A, this reach represents a break in stream canopy cover dominated by large trees. Upstream and downstream of this reach the tributary supports a shady riparian corridor of coast live oak, valley oak and California bay laurel. However, vegetation along this reach consists primarily of some in-channel willows (Figures 4 and 5). The vegetation difference in this reach could be the result of its location downstream of a former barrier to flow (earthen fill with a corrugated metal pipe culvert) removed in 2004. This reach lacks pools and canopy cover for steelhead, but project removal of the instream structure opened up the tributary to spawning steelhead. Debris that has washed up against a fence across the tributary at the location of the former culvert should be cleared to ensure passage.

Revegetation occurred along this reach of the tributary to enhance habitat by providing canopy cover, shade and connectivity of large woody riparian species. Area B is excluded from livestock grazing and surrounded by valley oak and California bay laurel woodland. These trees overhang portions of the Opposite Bank while the Terrace Area is primarily adjacent to this habitat. Area B met the revegetation success criteria with a survival of 75%. However, survival of plantings was much higher in the Terrace Area than in the Opposite Bank (86% versus 48%). This difference could be due to the hotter and drier conditions along the Opposite Bank compared to the Terrace Area, but it is also possible that the drip irrigation system is not functioning properly in the western portion of this subarea.

Area C

Both the Bee Area and Corral Area subareas of Area C are located above the top of bank under existing riparian canopy (Figure 6). The Bee Area runs along the unnamed tributary and Project Stream near their confluence just downstream of the newly installed railcar bridges. The Corral Area is located between the Project Stream and a livestock corral. These areas are fenced to exclude livestock and show little evidence of browsing or volunteer tree seedling presence. Overall survival of revegetation plantings since the first installation in Area C was 78%, meeting the project success criteria, and likely driven by the highly successful western spicebush and new and replanted species. All plantings that survived had a condition of OK or better. Planting survival was higher in the Bee Area compared to the Corral Area (90% versus 72%).

The southern bank of the tributary in the Bee Area is highly eroded potentially due to restriction of flow from the smaller pipe culvert that was located in this area prior to its replacement with the bridge (Figure 7). Additional erosion occurred during the January 2006 floods (Napa County RCD 2006). Riparian revegetation occurred within this area to stabilize the eroding stream banks and provide additional shade for pools within the Project Stream. Removal of the double culvert and asphalt just upstream of these pools and the addition of boulders enhanced the pool habitat and passage for steelhead.

Steelhead were observed in the largest of these pools in August of 2005 (Jonathan Koehler, Napa County RCD, personal communication, November, 2007) and during the November 2007 field survey (C. Gaber, personal observation). The January 2006 flood deposited approximately four feet of sediment along the west bank of the Project Stream just downstream of the double culvert removal site (Napa County RCD 2006) (Figure 8). However, much of this sediment had washed downstream by November 2007 (C. Gaber, personal observation). Similar to Area A, this area experienced erosion and sedimentation during the flood and the Landowner restabilized the banks with boulders. Sedimentation in Area C was much more severe than in Area A, potentially because the remaining wingwalls of the former dam in Area A were holding back some sediment.

Area D

Revegetation activities within Area D began in the spring of 2006. This area is located above the top of bank at the Project Stream and tributary confluence, under the riparian canopy, and next to a dirt road similar in setting to the Near Shed subarea of Area A (Figure 9). Coast live oak, alder (*Alnus* sp.) and willow overhang this area. Cattle occasionally have access to this unfenced area. Evidence of large herbivore browsing was present but the majority of the herbivore damage to big leaf maple, western spicebush and snowberry (*Symphoricarpos albus* var. *laevigatus)* plantings appeared to be due to insects, resulting in low survival (33%) of healthy plantings (condition of OK or better).

Discussion

The Fish Barrier Removal and Bank Revegetation Project utilized a combination of instream structure removal and riparian revegetation to enhance steelhead habitat. Prior to implementation of the project, the Project Stream supported spawning gravels and pools suitable for steelhead refugia during dry months, but instream structures formed potential low flow barriers to steelhead. Replacement of dams, culverts and other fill materials with bridges and navigable boulders restored steelhead passage to the Project Stream and tributary. Installation of additional instream boulders enhanced the existing pools just downstream of pre-project structures in Areas A and C. In addition to instream habitat elements, Area C provides pools with the riparian cover, stream shade and likely lower temperatures necessary for supporting steelhead.

The oaks and other riparian species in Area C also may be responsible for the revegetation success within this area. Oak woodland canopy creates a cooler, moister microclimate that protects seedlings from desiccation and extreme temperatures (Parker and Muller 1982, Maranon and Bartolome 1993). Locating revegetation plantings under existing riparian canopy likely increases success of plantings. This microclimate could be especially important during a dry year of lower than average rainfall such as 2007. Riparian canopy could also explain the high survival (86%) in the Terrace Area of Area B in contrast to the low percent survival (46%) of plantings along the Opposite Bank just across the tributary. The Terrace Area is likely a more suitable restoration site and place for oak regeneration due to its more shady and moist conditions, the location of the plantings from the top of the bank down to the toe of the channel instead of just above the top of bank, and potentially a better functioning irrigation system.

In addition to its lower riparian cover, plantings in Area A experienced a greater degree of herbivory than those in Areas B and C. Some researchers suggest that the presence wildlife herbivory is a significant difficulty for restoration of degraded riparian corridors (Opperman and Merenlender 2000) and that removal of herbivory using exclosures can increase channel complexity, riparian vegetation and steelhead habitat, in a more cost-effective way than creating or altering instream structures (Opperman and Merenlender 2004). Though Area A supported high survival of many species such as coffeeberry, California wild rose, snowberry and Oregon ash, especially from the top of bank down to the toe of the channel, California buckeye (*Aesculus californica*) and toyon (*Heteromeles arbutifolia*) plantings were highly affected by browsing, decreasing overall success. Deer are likely the primary large herbivores in Area A, as cattle are excluded from this area. Area D was the only area not excluded from livestock grazing. Cattle do not have access to this area often and grazing of these plants by cattle is likely only occasional. In this area herbivory by insects appears to be the main factor limiting successful revegetation.

Conclusions

Understanding the site specific conditions that lead to successful riparian revegetation of particular plant species can assist in meeting the project success criteria and enhancing fish and wildlife habitat. The factors that appear to result in successful riparian restoration for this project include irrigation installation, placement of plantings in shaded areas or under existing riparian canopy, placement of plantings between the top of bank and toe of channel, exclusion of livestock grazing during establishment of plantings, installation of wildlife browse protection, and utilization of plantings of native coffeeberry, western spicebush and oaks along the top of bank as well as California wild rose, dogwood, cottonwood and Oregon ash along the lower portions of the stream banks. Siting revegetation plantings in areas that contain suitable instream substrate but currently lack riparian cover may provide the greatest fish habitat benefit. In the project area, Areas A and B would benefit the most from increased canopy cover and shade, and reduced erosion and sedimentation. In addition to successful revegetation plantings evaluated in this report, planted willow stakes in these areas are beginning to add to the value of this habitat with shade and cover. However, enhancement of fish habitat in Area A may be somewhat limited by the potential hydrologic influence of the wingwalls of the old dam and the presence of herbivory. The utilization of plantings of coffeeberry and other species that show little evidence of wildlife browse as well as regular maintenance of browse protection around plantings could help reduce the effect of herbivory in this area.

At this stage of the riparian restoration, using monitoring and success criteria based on percent survival of individual plantings is still feasible and useful. However, as adaptive management of planting locations and species continues and plantings become established, monitoring methods should shift to evaluating the habitat function of the revegetation plantings. In the future it may be more appropriate to conduct transect surveys to determine percent cover of riparian habitat or to use a densiometer to assess shade and canopy cover (Harris et al. 2005, Lewis et al. no date, UCCE 2007). These methods would align revegetation success criteria with the larger fish habitat enhancement goals of the project.

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Table 1: Project Goals and Corresponding Project Activities

Project Goals	***Project Activities***
Removal of four barriers to fish passage	• Project Stream: (1) removal of summer check dam concrete apron and (2) replacement of instream culverts and asphalt at road crossing with railway flatcar bridge • Tributary: (1) removal of instream culvert / earthern crossing and (2) replacement of additional instream culvert at road crossing with railway flatcar bridge
Restoration of natural channel flow conditions to aid steelhead passage Stabilization of eroding stream banks	• Installation of rock vortex weir structures within the Project Stream and its tributary • Removal of non-native Himalayan blackberry and vinca (Area A) • Revegetation of four streamside areas (Areas A-D) with native riparian species
Increased shade cover and improved stream canopy	• Revegetation of four streamside areas (Areas A-D) with native riparian species

Data Source: CDFG 2004.

Table 2. Species Planted in Each Revegetation Area

Trees	***A***	***B***	***C***	***D***	***Planting location***
Alder		X			Low bank/toe of channel
Big leaf maple	X	X	X	X	Mid-top of bank
Blue oak	X		X		Top of bank
Box elder	X	X			Low – mid bank
California bay laurel		X	X	X	Mid - top of bank
California buckeye	X	X			Mid - top of bank
Coast live oak	X	X	X	X	Top of bank
Cottonwood	X	X			Low bank/toe of channel
Dogwood	X	X			Low –mid bank
Oregon ash	X	X			Low – mid bank
Pacific madrone		X			Top of bank
Valley oak	X	X	X		Top of bank
Walnut	X	X			Top of bank

Shrubs	***A***	***B***	***C***	***D***	***Planting location***
California wild rose	X	X			Mid-top of bank
Ceanothus	X		X		Top of bank
Coffeeberry	X	X			Top of bank
Currant	X		X		Mid-top of bank
Scrub oak	X				Mid-top of bank
Snowberry	X	X	X	X	Mid-top of bank
Toyon	X	X	X		Top of bank
Western spicebush			X	X	Mid-top of bank

Grasses, sedges	***A***	***B***	***C***	***D***	***Planting location***
Carex barbarae	X	X	X		Mid – top of bank
Elymus glaucus	X	X			Mid bank
Festuca californica		X			Top of bank
Juncus patens	X	X	X		Low bank
Juncus balticus	X	X	X		Low bank
Leymus triticoides	X				Mid – top of bank
Nassella pulchra	X	X	X		Top of bank

Data Source: Napa County RCD 2006; personal communication, Lara Hadhazy, Napa County RCD).

Table 3. Revegetation Area Site Conditions

	Area A			Area B		Area C		Area D
	Near Shed	Downstream of Dam	Opposite Bank	Terrace Area	Opposite Bank	Bee Area	Corral Area	
Position along stream bank	Top of bank	Top of bank down to channel	Top of bank / mid-bank	Top of bank down to channel	Top of bank	Top of bank	Top of bank	Top of bank
Position in relation to pre-project instream structure	Upstream	Downstream	Upstream	Downstream	Downstream	Downstream	Upstream	Downstream
Tree canopy cover	CLO / VO[1]	WIL along edge	CLO/BAY	BAY/VO adjacent	BAY/VO	BAY/VO	MAP/WIL	CLO/WIL/ ALD
Livestock fencing	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Irrigation	Yes	Yes	Yes	Yes	Yes? [2]	Yes	Yes	Yes
Browsing/Herbivory present	Minimal	Some	Minimal	Minimal	Minimal	Minimal	Minimal	Lots
Volunteer tree seedlings present	Yes – VO	Yes - VO	Yes - CLO	Yes - CLO	No	Minimal	Minimal	Yes – CLO
Species with high survival[3]	COF/SNO	ASH/COF/ ROS/SNO	ASH	ASH/CLO/ MAP/ROS/VO	VO	CLO/SNO/ SPI	SPI	MAP

[1] ALD = alder, ASH = Oregon ash, BAY = California bay laurel, CLO = coast live oak, COF = coffeeberry, MAP = big leaf maple, ROS = California wild rose, SNO = snowberry, SPI = western spicebush, VO = valley oak, WIL = willow.
[2] Drip irrigation tubing is present at all revegetation areas though it appears that this subarea may not be receiving water.
[3] High survival = At least 4 plantings of species in subarea and species survival 100%, or at least 5 plantings of species in subarea and species survival at least 80%.

Data Source: C. Gaber, Field Survey, 2007.

Table 4. Percent Survival of Plantings in Each Revegetation Area

	Area A	Area B	Area C	Area D
Total Percent Survival Since First Installation	Overall: 72% Near Shed: 83% Downstream of Dam: 72% Opposite Bank: 56%	Overall: 75% Terrace Area: 86% Opposite Bank Area: 48%	Overall: 78% Bee Area: 90% Corral Area: 72%	Overall: 63%
Percent Survival with Condition of OK or Better	68%	68%	78%	30%
Total Percent Survival Since Last Monitoring Date	76%	77%	82%	71%
Percent Survival with Condition of OK or Better Since Last Monitoring Date	72%	70%	82%	33%

Data Source: C. Gaber, Field Survey, 2007; personal communication, Lara Hadhazy, Napa County RCD.

Table 5. Survival of Restoration Plantings by Species

AREA A	Total # planted	# alive 11/07	Percent survival
Near Shed			
ASH	3	2	67
BUC	2	2	100
CLO	2	2	100
COF	5	4	**80**
COT	1	1	100
CUR	1	1	100
MAP	1	0	0
SNO	6	5	**83**
TOY	3	3	100
Downstream of Dam			
ASH	5	5	**100**
BLU	2	1	50
BOX	1	0	0
BUC	4	1	25
CEA	1	1	100
CLO	2	2	100
COF	14	12	**86**
COT	4	3	75
DOG	3	3	100
MAP	5	2	40
ROS	17	15	**88**
SCO	2	1	50
SNO	10	8	**80**
TOY	11	1	9
VO	5	3	60
WAL	1	1	100
Opposite Bank			
ASH	10	8	**80**
BUC	1	0	0
COT	4	0	0
CUR	1	1	100
VO	1	0	0
WAL	1	0	0

AREA B	Total # planted	# alive 11/07	Percent survival
Terrace Area			
ALD	1	0	0
ASH	5	4	**80**
BAY	1	1	100
BUC	1	1	100
CLO	5	5	**100**
COF	10	6	60
COT	4	1	25
MAD	1	0	0
MAP	5	4	**80**
ROS	16	15	**94**
SNO	4	3	75
TOY	6	3	50
VO	4	4	**100**
WAL	1	1	100
Opposite Bank Area			
ASH	2	0	0
BAY	1	0	0
BOX	1	0	0
CLO	6	4	67
COT	2	0	0
DOG	2	1	50
MAD	1	1	100
MAP	7	3	43
ROS	3	1	33
VO	3	3	**100**

AREA C	Total # planted	# alive 11/07	Percent survival
Corral Area			
BAY	1	1	100
CLO	9	4	44
MAP	2	2	100
SPI	5	5	**100**
VO	1	1	100
Bee Area			
BAY	1	1	100
BLU	2	0	0
CLO	4	4	**100**
CUR	2	0	0
MAP	1	1	100
SNO	5	4	**80**
SPI	5	5	**100**
TOY	3	3	100
VO	2	1	50

AREA D	Total # planted	# alive 11/07	Percent survival
BAY	1	1	100
CLO	4	1	25
MAP	5	4	**80**
SNO	7	4	57
SPI	10	7	70

Species Codes

ALD	**Alder**
ASH	**Oregon ash**
BAY	**California bay laurel**
BLU	**Blue oak**
BOX	**Box elder**
BUC	**California buckeye**
CEA	**Ceanothus**
CLO	**Coast live oak**
COF	**Coffeeberry**
COT	**Cottonwood**
CUR	**Currant**
DOG	**Dogwood**
MAD	**Madrone**
MAP	**Big leaf maple**
ROS	**California wild rose**
SCO	**Scrub oak**
SNO	**Snowberry**
SPI	**Spicebush**
TOY	**Coast live oak**
VO	**Coffeeberry**
WAL	**Walnut**

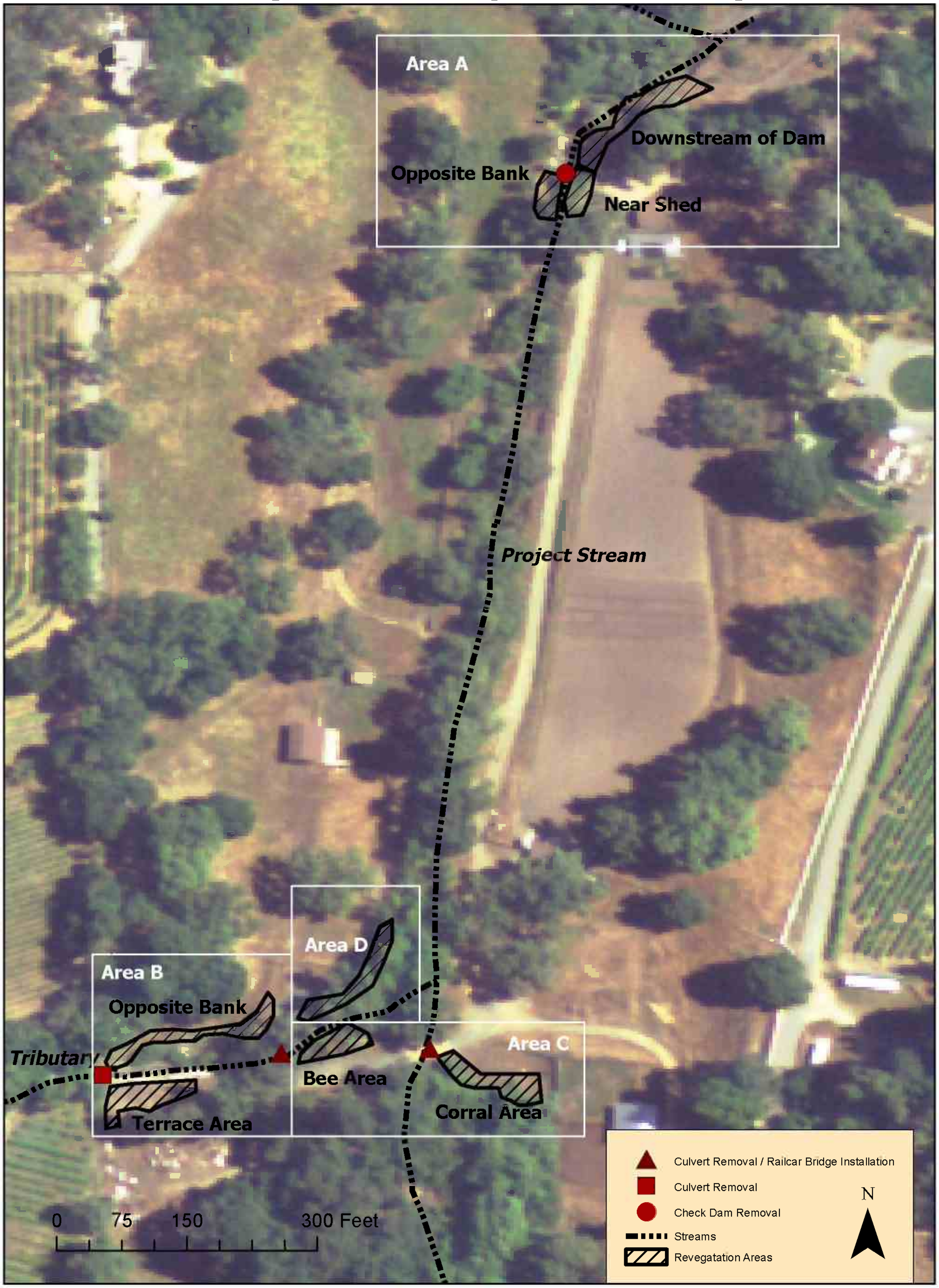
NOTE: Species with high survival are in bold.

Data Source: C. Gaber, Field Survey, 2007; personal communication, Lara Hadhazy, Napa County RCD.

Table 6. Scientific Names of Tree and Shrub Species

Trees	
Big leaf maple	*Acer macrophyllum*
Box elder	*Acer negundo* var. *californicum*
California buckeye	*Aesculus californica*
Alder	*Alnus* sp.
Pacific madrone	*Arbutus menziesii*
Dogwood	*Cornus* sp.
Oregon ash	*Fraxinus latifolia*
Walnut	*Juglans* sp.
Cottonwood	*Populus* sp.
Coast live oak	*Quercus agrifolia*
Blue oak	*Quercus douglasii*
Valley oak	*Quercus lobata*
Willow	*Salix* sp.
California bay laurel	*Umbellularia californica*
Shrubs	
Western spicebush	*Calycanthus occidentalis*
Ceanothus	*Ceanothus* sp.
Toyon	*Heteromeles arbutifolia*
Scrub oak	*Quercus dumosa*
Coffeeberry	*Rhamnus californica*
Currant	*Ribes* sp.
California wild rose	*Rosa californica*
Snowberry	*Symphoricarpos albus*

Figure 1. Project Site Map



Data Source: Napa County RCD 2006.

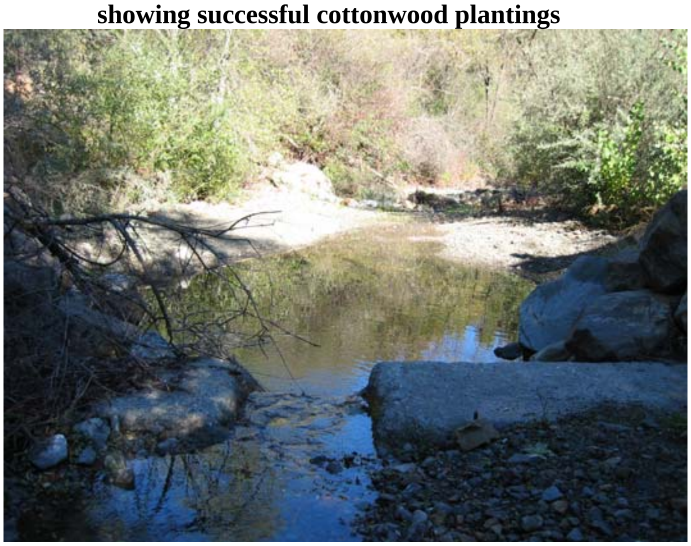
Figure 2. Revegetation Area A

Near Shed Area – facing downstream

Opposite Bank – facing downstream

Downstream of Dam Area – facing stream, showing successful cottonwood plantings

Downstream of Dam Area – facing downstream



Downstream of Dam Area – at old dam

Downstream of Dam Area – facing revegetation area

Figure 3. Area A Check Dam Site 2004 -2007

October 2004 During Demolition, Photo by Lara Hadhazy, Napa County RCD

January 2005, Photo by Lara Hadhazy, Napa County RCD

January 2006
After Flood

Photo by Lara Hadhazy,
Napa County RCD

November 2007

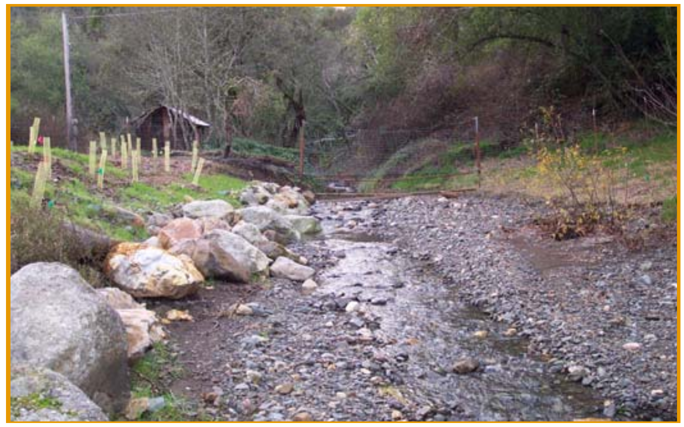
Figure 4. Revegetation Area B

Opposite Bank – facing upstream along tributary

Terrace Area – facing upstream along tributary

Figure 5. Area B Culvert Removal Site 2002 -2007

2002, Photo by Lara Hadhazy, Napa County RCD



January 2005, Photo by Lara Hadhazy, Napa County RCD

November 2007

Figure 6. Revegetation Area C

Bee Area – facing downstream along tributary

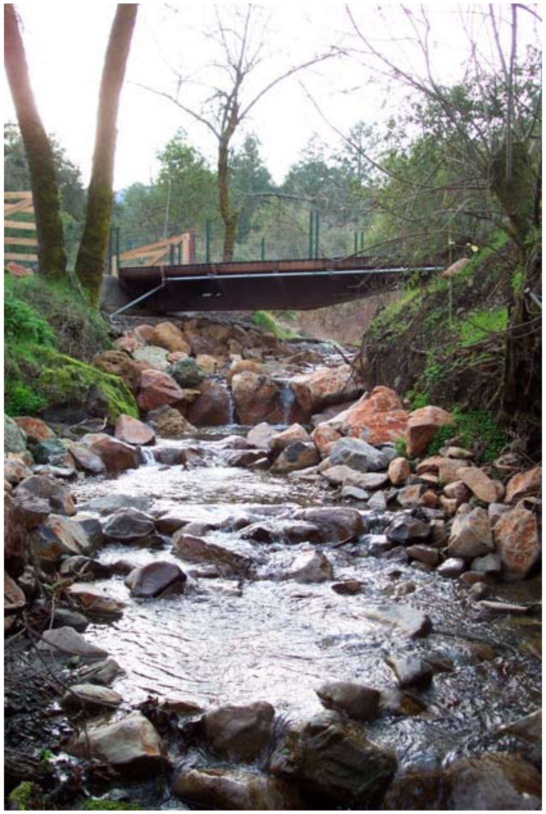
Corral Area – facing upstream along Project Stream,
Showing successful spicebush plantings

Figure 7. Area C Tributary Bridge Installation Site 2002 -2007

April 2002,
Photo by Lara Hadhazy, Napa County RCD

Photos by Lara Hadhazy, Napa County RCD

January 2005



January 2006

November 2007

Figure 8. Area C Project Stream Bridge Installation Site 2002 -2007

April 2002

January 2005

January 2006 – showing sediment deposition and rock repair on bank

Photos by Lara Hadhazy, Napa County RCD

November 2007- pools below bridge

November 2007

Figure 9. Revegetation Area D

Area D - facing upstream near tributary / Project Stream confluence