CHAPTER 4: INSTREAM & RIPARIAN HABITAT ENHANCEMENT ACTION PLAN

Context

Intact riparian forest along Salmon Creek.

Stream systems are inherently subject to change. Vegetation distribution and channel form respond dynamically to seasonal, annual, and multi-decadal variations in precipitation and streamflow. They are also shaped by geology, topography, and climatic conditions. Riparian zone and channel processes are inextricably linked. By intercepting and absorbing rainfall and the overland flow of stormwater, vegetation moderates flood flows and filters out nutrients and other pollutants. Varied and extensive root systems hold soil, protecting streambanks from erosion. By slowing down runoff and providing root channels for water absorption, vegetation increases the water absorbed into the land and stored for later release. Reciprocally, the flow regime (magnitude, frequency, duration, timing of stream flows) influences the distribution and regeneration of riparian plants, as do the dynamics of sediment erosion, transport, and deposition within the riparian zone.

The riparian zone provides important habitat and corridors for wildlife. Where intact riparian vegetation stretches along the length of a creek, it becomes a passageway for native wildlife, linking areas of upland and downstream habitat. These passageways are crucial, especially in landscapes where uplands are developed, farmed, and fragmented. The roots and downed wood of large trees provide shelter for salmonids and other aquatic creatures. Trees shade the water and keep it cool. Allowing the riparian corridor enough space to naturally regenerate its complex of trees, shrubs, and groundcover is crucial to wildlife habitat and water quality.

Many native species have evolved to thrive in the dynamic, complex environment of the riparian zone. In many cases, their survival depends on frequent changes in stream flow, channel morphology, and sediment distribution. For example, willow and alder seeds require fresh sands and gravels left by floodwaters to germinate; salmon and steelhead require deep pools, shelter, and gravel riffles created by downed trees and the scour they generate; and amphibians need the seasonal pond features left behind by shifting channels. All riparian species depend on the floodplains formed through the processes of streambank erosion and channel migration.

Dramatic changes in channels and the riparian zone that severely alter the habitability of a stream for a population of native species are typically caused by natural disturbance regimes, such as floods, fire, or disease. Because the frequency of these large events is low and their distribution is often limited to individual reaches or sub-tributaries within a watershed, the impact of these extreme events is minimal. Native aquatic and riparian species have adapted to local disturbance regimes, which made them resilient. However, their resiliency is limited. Chronic and widespread alterations to the environment that are outside of the natural range of variation tax individuals and eventually lead to the waning of populations.

The decline and extirpation of coho salmon in Salmon Creek is a case in point. The arrival of Europeans to the area initiated a long period of dramatic changes to the riparian zone and channel processes that, coupled with fishing pressures and altered water quality and quantity conditions, caused the salmon population to crash. The physical and biological effects of the chronic, cumulative impacts are still occurring.

Historic land-use practices have impaired streams and riparian corridors in the Salmon Creek Watershed. Channel incision, over-widening, simplification, and riparian encroachment make certain conservation and restoration activities imperative for riparian and instream habitat in the watershed:

- Instream habitat complexity in the form of large wood structures, vegetated gravel bars, and inset floodplains needs to be created to provide high-flow refugia, pools, and sediment sorting.
- Riparian forests must be protected and enhanced to provide shade, bank stability, and sources of large wood.
- Grasses and small shrubs in the riparian corridor must be protected, and be of sufficient extent, to provide bank stability and pollutant filtration.
- Delivery of fine sediment from upland sources must be reduced.
- Summer base flows must be maintained and increased to supply instream pools and the estuary with cool, oxygenated water.

Healthy riparian forest and large wood structures (installed by Dragonfly Stream Enhancement) provide complex instream channel.

Instream habitat conditions are commonly assessed in relation to the needs of coho salmon and steelhead. Conditions supportive of salmonids generally support other sensitive aquatic species. Salmonids need deep, shaded, cool pools with lots of shelter and sufficient food for successful rearing. High-quality gravel is critical for successful spawning, as well as to support macroinvertebrate production. In neighboring coastal streams, high-flow refugia is cited as being the primary factor limiting coho and steelhead populations (Stillwater Sciences 2008). Agencies tasked with protecting and recovering salmonid populations and restoring instream habitat conditions have developed habitat indicators and associated values to rank habitat quality; see Table 1.

Table 1. Selected instream habitat indicators and a value ranking system for coho salmon.

Habitat Attribute	Indicator	Ranking		
		Poor	Fair	Good
Riparian Vegetation	Species composition based on historical condition	<25%	25-50%	>50%
	Avg. Canopy Cover	<75%	75-85%	85-95%
Pool Habitat and Velocity Refuge	Frequency of primary pools*	<30% pools by length	30-40%	40-50%
	Floodplain Connectivity	<50%	50-80%	>80%
	LWD frequency	<4 key pcs/100m	4-6/100m	6-11/100m
	Shelter rating**	Score of <60	60-80	80-100
Gravel Quality and Spawning Substrate	% <0.85 mm % <6.3 mm	>17% >30%	15-17%	12-14% <30%
	% of pool tailouts with ≤50% embeddedness***	<25%	25-50%	>50%

Source: NOAA 2010.

***Primary pools** third and fourth order streams are defined as having a maximum depth of at least 3 feet, occupying at least half of the width of the low flow channel, and being as long as the low flow channel width (CDFG 2004d).

****Pool shelter** includes those elements that provide predator protection, areas of low water velocity that can be used for refuge, and separation of territorial units (CDFG 1988). It is also a useful indicator of pool complexity.

***C**obble embeddedness** depths (the degree to which materials are buried in fine sediment) at pool tailouts are important to successful spawning of salmonids. Embeddedness ratings of 25% or less are considered desirable for spawning salmon. (CDFG 1988)

As our climate changes, functional riparian zones will likely play an even more important role in native species and habitat resiliency (Seavy et al. 2009). A defining feature of many riparian plants is their ability to withstand hydrologic and geomorphic disturbances. Thus, the impacts of increased flooding and drought, which are predicted to accompany climate change in many regions including coastal California, may be tempered by a healthy, complex riparian corridor and instream structure.

Goals

- The riparian corridor is sufficiently wide to provide shade, nutrient filtration, cover, and a sustainable source of large wood.

- The riparian corridor's vegetation density and diversity provide adequate nesting opportunities, food, and shelter and serve as corridors or islands during migration for a variety of terrestrial wildlife species.
- Instream habitat structure complexity supports fish and other aquatic species at all lifestages for robust, self-sustaining populations.
- Water quality and quantity support instream, riparian, and estuarine communities.

Instream & Riparian Recommendation 1: Protect and increase existing riparian corridors.

Scientific Reasoning

Healthy, mature riparian vegetation helps keep water cool and clean, protects streambanks from erosion, moderates flood flows, and provides roots and wood that are vital to creating the diverse habitat that salmonids and many other aquatic creatures need.

Riparian corridor along Salmon Creek in the Freestone Valley, looking southwest.
Photo courtesy of Lauren Hammack.

The benefits that riparian habitat or "buffer" zones along streams provide often depend on the width of the protected area. Recommended buffer widths depend on many variables, including local vegetation types, slope steepness, and stream hydrology. Table 2 below summarizes some key functions of riparian buffers and the widths typically needed to provide those functions.

Considering these functions, many natural resource management agencies advocate a USDA-recommended three-zone system for riparian buffers (Welsch 1991). Zone 1 is the area nearest the creek, and recommendations are typically to maintain undisturbed native forest in an approximately 15-25' wide swath. Moving out from the creek, Zone 2 is considered to be the next 50-100', with forest and understory shrubs providing wildlife habitat and allowing for some human management and thinning. Zone 3 is the outer 20-25' of the buffer and may consist of additional forest, woodland, or grassland. Even if only grasses are present, this outer zone helps slow the velocity of runoff and filter pollutants.

Table 2. Riparian buffer functions and widths.

Function	Width	Rationale & References
Nutrient reduction	10-100+ feet	Vegetated, and especially forested, riparian areas can reduce nutrient input to waterways. Plants take up nutrients and trap nutrient-rich sediments. Vegetation also supports denitrifying bacterial activity in the soil. (WDFW 1997, Martin et al. 1999) Nutrient removal efficiency of riparian buffers varies with many factors, including the types of soil, nutrients, input pathways, and vegetation involved. A USEPA review estimates that, in general, 50% nitrogen removal efficiency is achieved with a 10' buffer, 75% efficiency with a 92' buffer, and 90% removal with a 367' buffer. (USEPA 2005)
Large woody debris recruitment	100-150 feet	To supply the LWD beneficial to salmonids, buffers must be sufficiently wide to support the growth and recruitment of mature large trees including redwood, Douglas-fir, and bay (WDFW 1997). A 100' buffer typically allows for three to five mature tree widths; redwood crowns average 25-35' wide, Douglas-fir averages 15–25', alder averages 30-40', and bay canopies are typically 25' or wider (Gilman & Watson 1994).
Bank stability and reduction of fine sediment delivery	35+ feet	Roots of riparian vegetation, including rhizomatous sedges and rushes as well as woody species, can hold soil in place and reduce erosion immediately beside the creek (Rashin et al. 2006). Other research indicates additional benefits at widths of 100+ feet (WDFW 1997).
Water temperature reduction	100 feet	Increased shade from riparian trees reduces water temperature, benefiting aquatic species. 100' buffer typically needed to provide 50-100% shading of stream (WDFW 1997).
Regeneration of diverse native riparian vegetation	150+ feet	Riparian vegetation typically contributes to a cooler, moister microclimate that supports its own regeneration. Narrow or denuded riparian areas may become hotter, drier, and less likely to support germination and growth of riparian species (Brosofske et al. 1997). Wide riparian buffers allow space for a diversity of age classes in the woody vegetation. This diversity supports the stand's ability to regenerate naturally and persist in the long term. Limited age structure complexity often indicates that riparian trees are not naturally regenerating or are not reaching maturity. Wider buffers also correlate to lower invasive species cover, leaving more opportunities for native species to regenerate. (Russell 2004)

Function	Width	Rationale & References
Wildlife habitat and corridor protection	100-2,000 feet	Mammals – In a Sonoma County study, activity level of native mammalian predators was highest in riparian areas with wide (2,200’) buffers. In narrow (65’) buffers, activity was half as great; in denuded areas, it was one-quarter as great (Hilty & Merenlender 2004). Birds – 200- 650’ (WDFW 1997). Reptiles and amphibians - 100-312’ (WDFW 1997). Invertebrates – 100’ (WDFW 1997, Warner & Hendrix 1984).

The riparian zone functions described above are impaired in the Salmon Creek Watershed. Although many reaches are shaded by vegetation, the riparian corridors are often narrow and lacking in complexity or large trees (KRIS 1994). Early logging and clearing for agricultural fields removed mature riparian trees, narrowed the riparian corridor, and simplified the channel. Residential development, livestock grazing, vineyard development, and some bank stabilization measures continue to confine the riparian corridor to an unstable width. In many stream reaches, there is only a single row of mature riparian trees at the top of bank. If streambank retreat—which is natural and desirable in incised systems such as Salmon Creek—removes the single riparian tree, the bank becomes vulnerable to rapid and unchecked erosion. In addition to destabilizing effects on the streambank, a thin canopy affects water temperature and inhibits tree re-establishment. Geomorphic assessments of Salmon Creek and its tributaries indicate that severe bank erosion occurs primarily where riparian forest is limited or absent (PCI, unpublished data).

CDFG habitat assessments rate canopy cover in the watershed as fair (averaging 65%). Canopy cover of 80% or more is considered desirable. This rating is a measure of shading of the streambed, not an indicator of corridor width, continuity, or functionality. Below-average canopy cover was noted on the mainstem and Coleman Valley, Finley, Nolan, and Thurston Creeks. With the measures described below, valuable riparian habitat can be protected and enhanced in the watershed.

Action 1a: Increase and protect riparian corridor widths to improve function and habitat quality.

Implementation Measures

- Educate landowners and residents about the benefits of riparian corridors and functional widths.
  - Develop fact sheets for distribution.
  - Develop workshops that include site visits to demonstration sites with a range of riparian conditions and land-use situations.
- Install riparian fencing along stream reaches accessed by livestock.
  - Set fences back from top of bank a minimum of two tree canopy widths, more where possible to maximize riparian functions.
  - Provide off-channel water sources.
  - Develop riparian pasture management and grazing plans.
- Develop a program to assist rural residential landowners in managing their land for wider riparian corridors.

- Develop guidance on minimizing land-use activities within the biotic resource zones.

Action 1b: Enhance riparian corridor structure complexity and species richness.

Implementation Measures

- Educate landowners along riparian corridors on the components of a healthy riparian corridor.
  - Host workshops on native species planting and invasive removal and control.
  - Produce handouts guiding landowners on riparian plant composition and landscaping for diversity.
- Plant riparian trees and herbaceous shrubs in riparian areas with insufficient density and complexity.
  - Maintain plantings until well established.

Instream & Riparian Recommendation 2: Increase instream channel complexity.

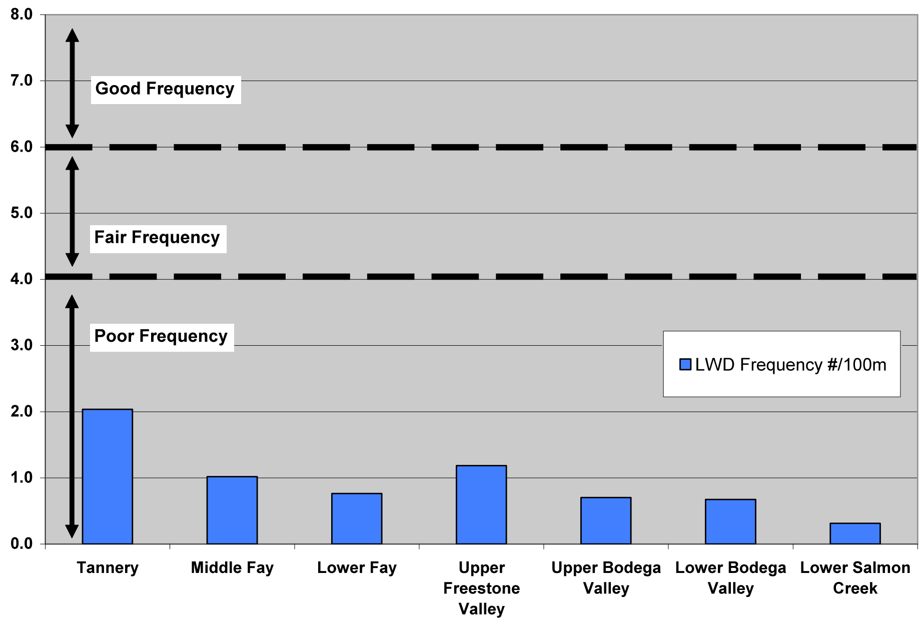
Scientific Reasoning

Large wood accumulations, mature trees along the active channel, and gently sloping vegetated streambanks are all needed to create and maintain instream channel complexity for high-quality aquatic habitat. Large woody debris (LWD) is an important driver for both geomorphic process (channel form as well as sediment sorting and deposition) and ecologic conditions (habitat elements, cover, and organic material input) (Opperman 2005, citing Beechie and Sibley 1997; Bisson et al. 1987; National Research Council 1996). It has been documented that coho salmon juvenile abundance is positively correlated to the presence of large wood within a stream reach (Bryant and Woodsmith 2009). In Mediterranean climate systems, such as Salmon Creek, with their low summer streamflows, the successful rearing of juvenile salmonids is likely particularly linked to the habitat value of pools associated with woody debris structure (Opperman 2005).

Naturally recruited (upper photo) and installed (lower photo) large wood structures.

Several measures of large wood frequency and its relation to instream habitat quality have been developed and used in assessing northern California stream conditions (NCRWQCB 2006a; NMFS 1996). NOAA's NMFS (2010) has set ratings for LWD frequency for streams with bankfull widths less than 10 m. Salmon Creek and its tributaries fall under the "Poor" rating with LWD frequencies ranging from 0.3 to 2.0 pieces per 100 m (Figure 4). Frequency of key large wood pieces is used as a metric of habitat quality for coho salmon and steelhead. Note that the frequency in all reaches of Salmon Creek and its tributaries is rated as poor according to NMFS indicator targets (NOAA 2010).

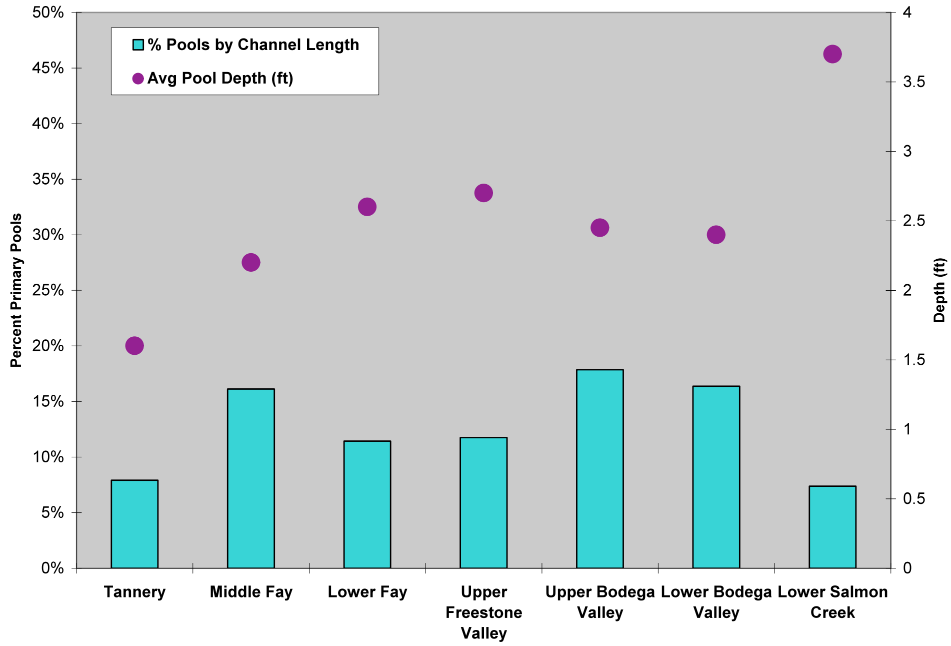
Figure 4. Frequency of key large wood pieces per 100 m.



Source: PCI 2010.

A related metric—the percent of primary pools by length—also rates "Poor." Good habitat requires 40-50% of the channel length to be pools, and, in the Salmon Creek Watershed, primary pools only account for 7-18% of the channel length (Figure 5) (PCI 2010, Appendix A).

Figure 5. Pool frequencies and depths in reaches of Salmon Creek and tributaries.



Source: PCI 2010.

In coastal, hardwood-dominated watersheds, such as Salmon Creek, live trees adjacent to the channel are key elements in the formation of pools and instream structure that support salmonids and other aquatic species (Opperman and Merelander 2007; Opperman 2005). Live mature trees, when they are located immediately adjacent to the channel, provide shade over the creek, insects and leaves to feed fish and aquatic invertebrates, and material for large wood accumulations. The complex root masses provide bank stability and, when undercut, premium habitat for salmonids and the endangered freshwater shrimp.

Riparian corridor along Fay Creek with good riparian benches but poor instream complexity for fish habitat, July 2008

Many reaches of Salmon Creek and its major tributaries are incised, disconnected from their historic floodplains, and have few inset flood benches (PCI 2010, Appendix A). Vertical, unvegetated banks maintain high velocities and are prone to erosion and bank retreat. Over time, incised channels will typically widen and establish inset floodplains, going through a series of forms commonly referred to as channel evolution (FISRWG 1998; Schumm et al. 1984; Simon 1989). This could take decades or centuries, and channel management practices such as bank stabilization attempt to arrest this process. Bank retreat in incised channels allows vertical banks to become gently sloping and inset benches to develop where riparian vegetation can establish. Vegetated slopes and inset benches stabilize banks, reduce the impacts of flood flows, and provide critical high-flow velocity refugia for salmonids.

Action 2a: Increase wood in stream channels.

Implementation Measures

- Educate landowners and residents on the importance of large wood in stream channels and the legal constraints on its unauthorized removal.
    - Develop and distribute fact sheets that address concerns of bank erosion and flooding.
    - Host workshops.
- Leave naturally downed large wood in channel unless it is threatening infrastructure.
- Install large wood structures.
- See Recommendation 1 for actions to increase available wood and promote natural recruitment through riparian corridor enhancement.

Action 2b: Allow bank widening and inset flood bench development in reaches not constrained by buildings or infrastructure.

Implementation Measures

- Use non-rock, biotechnical engineering practices to stabilize banks.
    - Slope banks back at a minimum of 2:1 slope; 3:1 or 4:1 is optimal for riparian habitat and bank stability.
    - Install floodplain benches at elevations that will be inundated at typical annual high flows.
- Allow natural bank retreat and slumping.
    - Plant slumped areas to stabilize.

Action 2c: Promote tree establishment along the active channel and on streambanks for bank stabilization, live wood complexity, and undercut bank development.

Implementation Measures

- Remove chronic disturbances, such as grazing; see Instream & Riparian Recommendation 1.
- Stabilize and slope eroding banks with bioengineering approaches and plant early successional riparian species such as willow along with hardwood and conifer species.
- Leave or install large wood on active channel margins and banks to slow flood velocities, deposit fine sediment, and protect seedlings.
- Allow undercut banks to develop.

Instream & Riparian Recommendation 3: Reduce fine sediment delivery and maintain gravel quality.

Scientific Reasoning

The presence of excessive fine sediment can degrade instream habitat and cause aquatic species population declines by inhibiting successful reproduction. For salmonids and other fish, excessive sediment can interfere with successful reproduction due to fine materials suffocating and covering eggs and larvae. Insufficient gravels can limit spawning habitat quantity and quality. High sediment loads can fill pools and lead to widespread channel aggradation.

Turbidity levels—a measure of suspended fine sediment—are chronically high during and after winter storm events in Salmon Creek and its tributaries; see Chapter 5 for details. However, assessments of streambed composition and gravel quality indicate that there is not excessive fine sediment deposition. Gravel embeddedness (CDFG 2004; GRRCD and PCI 2007) and percent of sediment less than 0.85 and/or 6.3 mm (PCI 2010, Appendix A) rate as "Good" for coho salmon habitat in Fay Creek and other tributaries, according to NMFS indicator targets (NOAA 2010). Reaches along mainstem Salmon Creek in Freestone and Bodega Valleys do not meet the sediment composition criteria for good spawning and incubation habitat; however, these reaches are geomorphically predisposed to fine sediment deposition and are not out of equilibrium (PCI 2010, Appendix A).

Historic land-use practices, such as clear-cut logging, crop production, and high-density livestock operations, led to accelerated erosion (PCI 2006; GRRCD and PCI 2007). While these intensive land use practices have largely ceased, the impacts of the increased sediment loads are still seen in the stream system with low pool depths and accelerated aggradation in lower Salmon Creek and the estuary (PCI 2006). Currently, upland gullies, landslides, residential development, and roads are the main sources of fine sediment in the watershed (GRRCD and PCI 2007; PWA 2006). Compacted road surfaces produce fine sediment. Old ranch and logging roads often have failing ditches and culverts that cause wash outs and gullies. Road ditches concentrate runoff and transport sediment directly to streams. Properly designed and maintained roads can significantly reduce sediment delivery to streams (Weaver and Hagans 1994).

Action 3a: Reduce fine sediment delivery from upland gully erosion, residential development, livestock operations, vineyards, and roads.

Implementation Measures

- Educate landowners, construction operators, and public works departments on BMPs for reducing erosion and managing sediment delivery to streams.
  - Hold public workshops on stormwater management and road maintenance practices.
  - See Chapter 3 for additional suggestions.
- Improve grasslands and cross-fence pastures to reduce sheet and rill erosion on livestock ranches and dairies.
- Install riparian fencing to reduce streambank erosion.
- Decommission non- or under-used roads.
- Upgrade poorly designed roads.
- Document and repair upland gullies delivering sediment directly to the stream system.

Action 3b: Improve in-channel complexity for the capture and sorting of suitable spawning gravels.

See Instream & Riparian Recommendation 2.