Site-Specific Riparian Zone Management:

Section V Guidance

Anadromous Salmonid Protection Rule Section V

Technical Advisory Committee (VTAC)

December 2012

Sacramento, California

EXECUTIVE SUMMARY

For several decades in California and other western states, riparian protection standards have been guided by generalized prescriptive rules requiring uniform buffer strips along watercourses. With the passage of the Anadromous Salmonid Protection rules in 2009, the California State Board of Forestry and Fire Protection established a regulatory pathway that provides an alternative approach for riparian protection based on site-specific criteria (14 CCR § 916.9 [936.9, 956.9](v)) [referred to as Section V]. This new pathway seeks to promote more immediate (short-term) responses with active riparian management practices in watersheds with listed anadromous salmonids that might not otherwise occur under the more prescriptive rule protocols. Site-specific management requires consideration of both watershed scale limiting factors (watershed context assessment) and site-based factors, producing a modified riparian management design that provides benefits to the aquatic environment, as well as operational flexibility and benefit to landowners.

Two specific options are included in Section V (see table below). Forest Practice Rule 14 CCR § 916.9(v)(2) [936.9(v)(2), 956.9(v)(2)] specifies that only California Department of Fish and Wildlife (DFW) written concurrence is required prior to plan submittal for alternative measures limited to a specific site in a plan. For larger scale proposals, a full justification is required, as specified in 14 CCR § 916.9(v)(3) [936.9(v)(3), 956.9(v)(3)]. The range of desired objectives for site-specific proposals includes, but is not limited to, increasing large wood loading in watercourse channels, promoting increased biotic diversity, reducing catastrophic wildfire risk, and accelerating conifer tree growth in riparian zones.

Section V Proposal Options	Short Name	Proposal Size/Scale	Brief Summary of Requirements (see rule language for full requirements)
916.9(v)(2)	DFW Concurrence	Specific site in a plan	Obtain written concurrence from DFW.
916.9(v)(3)	Full Justification	Larger scale or more complex proposal	Description of the evaluation area; Description of current condition of riparian zone; Identification of potential beneficial functions potentially affected, and potential effects to the beneficial functions; Description of the site-specific proposal; Schedule for implementation; and a Monitoring Plan.

This document has been developed to guide landowners and Registered Professional Foresters (RPFs) in the use of this new rule section. The document addresses both the V(2) and V(3) options, and provides detailed information on three approaches to complete a full justification

for a V(3) proposal. RPFs are not required to use these approaches and other analytical methods are possible. An optional pre-consultation form is provided in the appendix to allow RPFs to: (1) identify potential issues of concern that may require additional considerations for the site-specific proposal, and (2) determine the potential acceptance of the site-specific proposal by the reviewing agencies. Additionally, summaries of submission requirements for a Section V(3) proposal using one of three suggested pathways, reviewing agencies methods for processing site-specific proposals, and monitoring strategies are provided in this document. The goal is to provide a process to allow landowners to engage in active riparian management, where appropriate, to more rapidly improve watershed conditions for state and federally listed anadromous salmonids.

List of VTAC Participants[1]

Members:

Mike Liquori, Sound Watershed Consulting, Chair
Peter Ribar, Campbell Timberland Management
Dr. Kevin Boston, Oregon State University
Dr. Matt O'Connor, O'Connor Environmental, Inc.
Mark Lancaster, Five Counties Salmonid Conservation Program
Richard Gienger, Restoration Advocate
Dr. Kate Sullivan, Humboldt Redwood Co. (currently US EPA)
Dave Hope, Watershed Science Consultants

Agency Representatives:

Bill Short, California Geological Survey
Bryan McFadin, North Coast Regional Water Quality Control Board
Bill Stevens, National Marine Fisheries Service
Stacy Stanish, Kevin Shaffer, Dr. Stephen Swales, California Department of Fish and Wildlife
Drew Coe, Central Valley Regional Water Quality Control Board
Pete Cafferata, California Department of Forestry and Fire Protection

California Department of Forestry and Fire Protection/State Board of Forestry and Fire Protection Assistance:

Bill Snyder, California Department of Forestry and Fire Protection
Duane Shintaku, California Department of Forestry and Fire Protection
Dennis Hall, California Department of Forestry and Fire Protection
Crawford Tuttle, California Department of Forestry and Fire Protection (through 2011)
George Gentry, State Board of Forestry and Fire Protection

Cover photograph: Riparian area with high densities of small conifers and high fuel loads that would benefit from active management. Photo provided by Kip Van de Water, USFS, Plumas National Forest.

Suggested Citation: VTAC. 2012. Site-specific riparian zone management: Section V guidance. Final report prepared by the Anadromous Salmonid Protection Rule Section V Technical Advisory Committee (VTAC). California Department of Forestry and Fire Protection. Sacramento, CA. 171 p.

---

[1] Dr. Doug Martin, Martin Environmental, provided valuable input for this document.

TABLE OF CONTENTS

EXECUTIVE SUMMARY II

I. INTRODUCTION 1

II. GOALS, INCENTIVES, AND DESIRED OUTCOMES 4

MANAGEMENT OBJECTIVES 4
INCENTIVES FOR LANDOWNERS 5

III. CONCEPTUAL FRAMEWORK: SUMMARY OF RIPARIAN ZONE BENEFICIAL FUNCTIONS 9

ACTIVE RIPARIAN MANAGEMENT AND ANADROMOUS SALMONID HABITAT REQUIREMENTS 9
COHO SALMON—EXAMPLE OF AN ANADROMOUS SALMONID SPECIES REQUIRING ACTIVE RIPARIAN MANAGEMENT 11
BENEFITS OF ACTIVE RIPARIAN MANAGEMENT 12

IV. PRE-CONSULTATION GUIDELINES 15

V. INTRODUCTION TO ANALYTICAL PATHWAYS – RECOMMENDED APPROACHES TO OBTAIN SITE-SPECIFIC PROPOSAL APPROVALS 16
WATERSHED CONTEXT ASSESSMENT 18

VI. SUBMISSION REQUIREMENTS 19

VII. PROPOSAL PROCESSING 20

VIII. MONITORING STRATEGIES 26

IX. REFERENCES 28

X. APPENDICES 42

APPENDIX A--ANALYTICAL PATHWAYS 43

A-1: PATHWAY 1) CLASSIFICATION MATRIX APPROACH 43
STEP 1) EVALUATE EXISTING SITE CONDITIONS 43
STEP 2) IDENTIFY FUNCTIONAL OBJECTIVES 47
STEP 3) SITE PRESCRIPTIONS 52
EXAMPLE 53

A-2: PATHWAY 2) SITUATIONAL SCENARIOS APPROACH 61
STEP 1) EVALUATE EXISTING SITE CONDITIONS 61
STEP 2) ASSESS WATERSHED CONDITIONS (WATERSHED CONTEXT) 61
STEP 3) DETERMINE DESIRED ECOLOGICAL FUNCTIONS 61
STEP 4) IDENTIFY APPLICABLE SITUATIONAL SCENARIO 62
STEP 5) DETERMINE IF ADDITIONAL EXPERTISE IS NEEDED 62

Step 6) Additional Considerations 62
1. Low Current Instream Wood Loading Adjacent to Stands with Low Projections of Riparian Mortality 64
2. Headcutting and/or Incised Channels (relative to the floodplain) 68
3. Riparian Communities with Low Current (or Projected) Wood Recruitment 73
4. Interior Stands with High Catastrophic Wildfire Risk 77
5. Relatively Closed Canopy Riparian Corridors lacking Nitrogen-Fixing Species or with Low Primary Productivity 82
6. Sediment Reduction within Riparian Zones 85
Example 90

A-3: Pathway 3) Analytical Design Process Approach 101
Approach Overview 101
Toolbox for Potential Riparian Assessment Techniques 103
I. Riparian Functional Assessment 109
II. Management Objectives 117
III. Riparian Design 118
Step A) Evaluate Existing Site Conditions 119
Step B) Diagnose Functional Objectives 121
Step C) Develop A Technical Basis For Design 121
IV. Implementation 122
V. Effectiveness Assessment 122

Appendix B -- Pre-Consultation Guidelines 123
Example 136
Appendix C-- Section V Rule Language 152
Appendix D-- Map of the ASP Rule Geographic Scope 157
Appendix E--Watershed Context Information 158
Appendix F--Channel Type Definitions and Diagrams 160
Appendix G-- Glossary 165

I. INTRODUCTION

Historically, the riparian management regulations intended to protect water quality and important ecological resources (e.g., fish and associated biological communities) have typically restricted silvicultural activities within riparian areas by requiring prescriptive uniform buffers (i.e., riparian buffer strips), often based on compromises among environmental, regulatory, and economic concerns. The effectiveness of uniform buffers to address all concerns is questionable given the spatial variability in riparian structure, landform, and ecological processes. In practice, the range of conditions found in forested landscapes can vary significantly, and the effect of one-size-fits-all riparian buffer management strategies may not only limit protection options, but also prohibit resource utilization where environmental risks are low. Recognition of such management limitations is not new and there has been an increasing call by watershed scientists to develop riparian management strategies that are tailored to site-specific conditions (Liquori et al. 2008, Ryan and Calhoun 2010, Benda et al. in press). Furthermore, the ever-increasing availability of analytical tools for resource analysis has facilitated the assessment of resource risks and potential economic benefits for varying riparian management practices.

The recovery trajectory established by the passive riparian buffer strategies defined by standard forest practice rules can extend to a century or more for some functions (e.g., wood supply, floodplain connectivity, others). In addition, riparian buffers often provide continuous corridors of high fuel loading and fire ladders that can increase the severity and spatial extent of fires (Dwire et al., 2010, Van de Water and North 2011). Meanwhile, there exists over a century of silvicultural and ecological science that has generally been ignored by the passive management of riparian areas.

The California State Board of Forestry and Fire Protection (Board) adopted forestry regulations in 2009, known as the Andromous Salmonid Protection (ASP) Rules, that seek to protect, maintain, and improve riparian habitats for state and federally listed anadromous salmonids. The Board adopted an option (14 CCR § 916.9 [936.9, 956.9] Section (v)), referenced here as the Section V Rule, that supports more site-specific decision making in the design of riparian prescriptions that can be applied during the time of adjacent timber harvest.[2] This regulatory pathway offers an alternative to prescriptive uniform buffers and may be more protective of ecological functions (Liquori et al. 2008). The significant decline of salmonid stocks in California in recent years (NMFS 2012, Ambrose 2008) indicates that immediate actions are needed by landowners to rapidly improve aquatic habitat for these fish if their populations are to remain viable. The Section V Rule provides one such avenue for helping listed fish species in California.

[2] The ASP rule Section V rule language is displayed in Appendix C.

The intention of this guidance document is to allow for broad application of the site-specific approach for riparian management. In support of this goal, we've identified several guiding principles that this document is intended to support. This guidance document will:

- Provide approaches that are applicable to ALL landowners regardless of ownership size or permitting requirements.
- Help to facilitate project implementation and habitat restoration.
- Offer broad-based incentives to landowners to encourage use of Section V where appropriate.
- Provide approaches that are environmentally beneficial and operationally feasible.
- Help landowners quickly identify actions that are unlikely to meet regulatory agency requirements, so as to minimize any unnecessary costs.
- Seek to identify opportunities to streamline permitting requirements.
- Promote more immediate (short-term) benefits (where appropriate) with active riparian management practices that would not occur under the more prescriptive standard ASP rule requirements.
- Describe the spatial resolution needed to identify the relative benefit of habitat factors for anadromous salmonid fish species appropriate to the scale of the proposed project.
- Identify how proposed actions relate to process and function at the appropriate scale.
- Identify approaches ranging from site-based to watershed-based for both watershed-scale and local limiting factors for listed anadromous fish species.
- Lead to lessons learned from Section V pilot projects that can be applied to future guidance document revisions (e.g., utilize adaptive management).

Two specific options are included in the Section V rule (Figure 1). Forest Practice Rule 14 CCR § 916.9(v)(2) [936.9(v)(2), 956.9(v)(2)] specifies that only California Department of Fish and Wildlife (DFW) written concurrence is required prior to plan submittal for alternative measures limited to a specific site in a plan. For larger scale or more complex proposals, an assessment is required, as specified in 14 CCR § 916.9(v)(3) [936.9(v)(3), 956.9(v)(3)] (referred to in this document as V(3)). The approaches described in this document (Appendix A) may be used for this assessment.

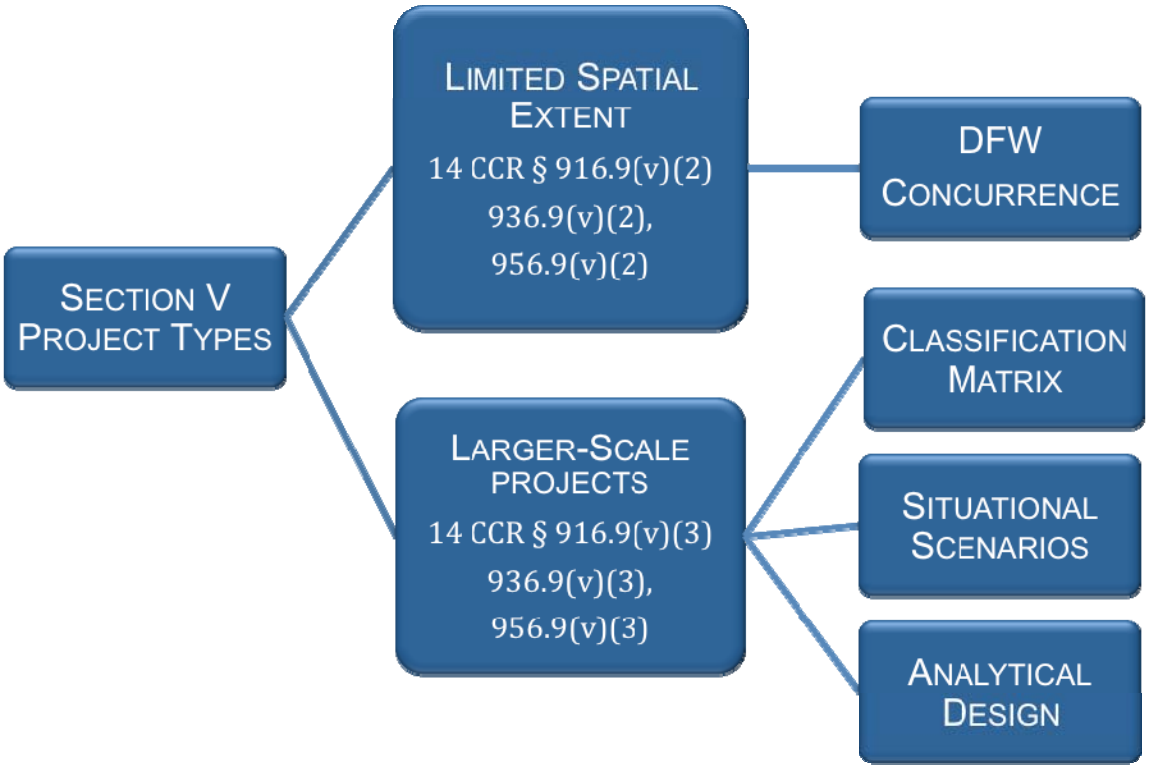


Figure 1. Diagram displaying Section V pathways available to RPFs in California.

The Section V rule allows alternative treatments to the riparian zone with the caveat that the effects of the proposed practices on riparian functions must be at least equal to those expected from the revised prescriptive standards that were adopted. The rule seeks to promote both immediate (short-term) responses to active riparian management practices that might not otherwise occur under the more prescriptive rule protocols, as well as longer-term habitat improvements (Liquori et al. 2008). It was the Board's intent that allowing site-specific plans will create an incentive for landowners to engage in active management and restoration activities in riparian areas. Thus, it may incorporate the use of economic incentives to encourage restoration (Liquori et al. 2012).

Section V requires consideration of both watershed-scale limiting factors (in other words, context assessment) and site-based factors to lead to a modified riparian management design that provides benefits to the aquatic environment. Rapid watershed assessment can help identify watershed-scale limiting factors utilizing existing information sources, so that it can be completed cost effectively and in a reasonable time frame with limited expertise. Resources available for conducting a watershed context assessment are provided in Appendix E.

This document provides a methodology for developing a Section V proposal that defines: (a) what can be modified, (b) where such modifications are appropriate, (c) how to determine appropriate modifications, and (d) what analysis is required to justify site-based plans. This guidance provides the information needed by landowners and Registered Professional Foresters (RPFs) to allow them to better address the risk of proceeding with a Section V proposal and the ability to recoup the costs of a more specific site-based design. It also provides guidance to the regulatory community about how to prevent inappropriate use of these rules.

Proposals submitted under Section V should:

(a) Evaluate existing site conditions,
(b) Diagnose relevant functional ecosystem objectives (e.g., enhancing juvenile salmonid production or reducing the severity of possible fire impacts),
(c) Identify the consequences (and thus feasibility) of riparian management opportunities (e.g., maintenance, enhancement or restoration),
(d) Develop design specifications that restore and/or improve deficient functions, and
(e) Describe the technical basis (rationale) for site design.

II. GOALS, INCENTIVES, AND DESIRED OUTCOMES

MANAGEMENT OBJECTIVES

Riparian management objectives are formulated to achieve ecological and silvicultural goals for the site and watershed. The objectives are important for guiding the design of prescriptions and provide targets for evaluating the effectiveness of the approaches utilized. The objectives are the mechanism for linking site-specific prescriptions to the goals of riparian management.

The goals are the desired outcomes that would result from accomplishing the management objectives and are guided by the California Forest Practice Rules. Riparian management goals in section 14 CCR § 916 [936, 956] of the rules emphasize the protection, maintenance and restoration of beneficial uses of water (e.g., water quality, aquatic habitat, and stream-riparian dependent species). The Board assumed that the ecological goals are met by applying the set of uniform objectives and prescriptions specified in the ASP rules. The Section V process will be guided by the same goals, but differs in that the riparian management objectives are specifically tailored to the riparian functional needs of the site and are formulated to achieve the specific goals appropriate for the site and watershed. The goal is to manage riparian areas for the unique processes a specific riparian area may contribute to the reach and watershed.

There are five general management objectives and five management options that may be structured to form a riparian management strategy (Table 1). The objectives (e.g., to maintain or restore riparian functions) facilitate both passive and active management approaches that

may incorporate options ranging from protection (passive no-touch) to active manipulation of stand structure and include timber harvest. The selection of objectives and options are guided by management goals and by site suitability criteria which are based on stream reach and riparian zone characteristics. The suitability criteria in Table 1 are generic and are intended as an initial guide for developing a management strategy. However, more explicit suitability criteria could be formulated to define function specific management objectives (e.g., restore large wood recruitment or restore fire-tolerant stand conditions) that are common for a given region and forest type.

Table 1. Description of riparian management objectives and site suitability criteria.

Management	Objective	Suitability Criteria
Protect	Minimize disturbance to allow natural recovery of key ecosystem service functions and processes.	Sites currently on the trajectory toward recovery, and unlikely to respond well to additional treatments.
Maintain	Maintain riparian-dependent exchange functions at levels necessary to sustain aquatic ecological services.	Sites with moderate to high dependence on riparian functions and where function status is rated good.
Improve	Improve performance or response timing for one or more key riparian-dependent functions. A temporary alteration of the trajectory for one function may be offset by enhancement of another function.	Sites with moderate to high dependence and where there is potential to promote/enhance aquatic ecological services as a result of altering one or more key riparian-dependent functions.
Restore	Restore riparian-dependent functions to levels necessary for sustaining aquatic ecological services.	Sites with moderate to high dependence on riparian functions, where function status is rated fair to poor, and where delivery potential is rated medium to high.
Generally Available	Provide flexibility in addressing other higher-priority issues; the constraints on this variable can be generally reduced.	Existing conditions and trends that indicate low sensitivity to a particular variable.

This table can be applied to each of the primary riparian exchange function variables (e.g., wood, sediment, temperature, nutrients) to determine the relative level of importance that each variable may have toward improving overall site conditions. For example, a stream with abundant shade and low temperatures, low wood loading, and excess sediment accumulations in a mixed conifer/hardwood WLPZ might be rated to “improve” wood loading, reduce sediment sources, maintain nutrients, and “generally available” with regard to temperature. More detail as to how to use this table is described in Appendix A-1, Classification Matrix Approach.

INCENTIVES FOR LANDOWNERS

Landowners might opt to engage in a Section V project to:

- Harvest some trees to offset costs of proactive improvements
- Provide an alternative permitting pathway in collaboration with third parties (e.g., off-site mitigation)
- Provide a pathway supporting off-site mitigation opportunities (typically in collaboration with other landowners or organizations)
- Improve overall site stewardship
- Balance multiple objectives in ways that are ecologically beneficial (e.g., fire risk reduction and habitat improvements)
- Provide access to known problem areas through riparian zones
- Replace merchantable trees with lower value trees (e.g., substitution of retaining slightly smaller pine trees in exchange for removal of Douglas-fir)
- Facilitate more active management that supports long-term financial gains (e.g., reduced fire risk, larger trees at rotation age, etc.), site improvements, and/or stewardship, for example:

    - Thinning
    - Access
    - Acceleration of large tree development
    - Uneven-aged management
    - Gap conversion to conifer or hardwood

Passive recovery of riparian areas may contribute to recover sensitive species (e.g., salmonids and others). Due to the typically slow speed of passive recovery, however, additional active measures are merited to expedite riparian recovery, and rewarding landowners willing to take the additional risk of managing in sensitive areas is an important component of Section V. While the current financial incentives are limited, Section V is intended to provide landowners greater flexibility that might provide other incentives. Riparian tree values alone are generally too low to offset all costs associated with planning, permitting, and implementing a Section V site-specific proposal. Additional future incentives are being developed that may include:

- Tax incentives
- Ecosystem service markets
- Mitigation banking
- An exemption process (so that restoration/enhancements do not have to go through the normal Timber Harvesting Plan (THP) process) – similar to CEQA Categorical Exemptions (CatEx) or Mitigated Negative Declarations (Neg Dec). This process might include an initial study for permitting relief (regulatory relief)
- Restoration Modified THP (covers all agencies)
- Enrollment in Programmatic Habitat Conservation Plans (HCPs) for “Restoration Forestry”

These approaches will require additional investigation in coming years.

Lack of financial incentives and regulatory hurdles appear to be significant reasons why private landowners have not implemented significant numbers of anadromous salmonid habitat restoration projects in connection with their commercial timber harvesting ventures in California to date. In recent times, organizations such as the California Forestry Association (CFA) have reported to the Board that there has been an exponential increase in costs associated with preparation of THPs and fees associated with commercial logging operations (Thompson and Dicus 2005). At present, the state and national economic conditions are depressed and many timberland owners are not interested in harvesting their timber, since log prices are low and the cost and difficulty of obtaining all the necessary permits is high. Therefore, financial incentives and simplified permitting are both likely to be necessary if salmonid restoration projects are to be implemented soon on private timberland, particularly for small nonindustrial landowners.

The Anadromous Salmonid Protection Rules of 2009 (ASP rules) are designed to protect and enhance salmon habitat in connection with commercial timber operations. Nevertheless many people feel that the ASP rules create a disincentive for salmon habitat restoration work because near-stream timber operations generally requires considerable expense in terms of planning and permitting; this sentiment was expressed in a recent 2011 on-line survey conducted by the VTAC (Liquori et al. 2012). The general impression is that it is easier and less costly to prepare a THP when riparian areas are left untreated. Aside from grant program work, such as work conducted under the Department of Fish and Wildlife's (DFW) Fisheries Restoration Grant Program (FRGP), non-subsidized private habitat restoration work is very limited unless conducted by volunteer organizations. Thus, most public and private groups who focus on recovery of listed salmon species agree that too little work is being done in the short term, and listed coho salmon are in jeopardy of extinction in many parts of its range in California.

As reported in the DFG (2004) *Recovery Strategy for California Coho Salmon*: "Private lands comprise approximately 63% of the total land within the range of coho salmon. Approximately 36% of all lands in coho salmon range are private agricultural and forested lands." This represents a huge land base where meaningful restoration activities could occur if private landowners were motivated and interested in submitting plans that included a fisheries restoration aspect.

Offsite mitigation can provide a mechanism for improving incentives for landowners to undertake site-specific proposals in WLPZs to enhance habitat for listed salmonids. While it is not commonly used in THPs, it is not unusual when it comes to other CEQA or NEPA projects. Recently the CEQA Guidelines were revised under Section 15126.4(c), where subsection (3) includes a provision for consideration of offsite mitigation to address greenhouse gas emissions. Both CEQA and NEPA projects dealing with wetland conversions have been associated with offsite mitigation where wetlands are developed or improved offsite to mitigate the loss of wetlands associated with the project. Offsite mitigation (or measures) is mentioned in three locations in the California Forest Practice Rules [14 CCR §§ 913.1(a)(2)(E), 916.4(a)(1), and 916.8(c)(5)], but they do not pertain to mitigation associated with the Board's ASP rules or Section V proposals. It may be that this avenue has gone unrecognized by most

landowners, or the use of offsite mitigation is still viewed as too expensive. The VTAC believes, however, that this is a viable option of improving incentives for landowners.

Potential funding sources to assist landowners with site-specific proposals are numerous. These include, but are not limited to, those shown in Table 2. For a more comprehensive list, see the following website provided by the Sierra Nevada Conservancy: http://www.sierranevada.ca.gov/other-assistance/funding-sources.

Table 2. List of selected funding sources for riparian improvement proposals.

Agency	Program Name
SWRCB	319(h), other grants
CAL FIRE	California Forest Improvement Program (CFIP)
	Forest Legacy Program (FLP)
	California Forest Stewardship Program
Calif. State Parks	Habitat Conservation Fund grants
	Land and Water Conservation Fund grants
USDA	Conservation Reserve Program
NRCS	Environmental Quality Incentives Program (EQIP)
	Wildlife Habitat Incentive Program (WHIP)
	Conservation Technical Assistance (CTA)
	Wetlands Reserve Program (WRP)
US EPA	Region 9 grants and funding
Wildlife Conservation Board	Grants

III. Conceptual Framework: Summary of Riparian Zone Beneficial Functions

Active Riparian Management and Anadromous Salmonid Habitat Requirements

Private timberlands in California support a variety of state and federally listed species. A large percentage of remaining salmon and steelhead spawning, rearing, migrating and feeding habitats occur on non-federal forestlands. For instance, approximately 85-90 percent of the last remaining populations of federally endangered Central California Coast coho salmon exist on private forestlands (Figure 2), while approximately 77 percent of federally threatened Northern California steelhead habitat and approximately 80-88 percent of federally threatened California Coastal Chinook salmon habitat occurs on private lands.

Coho salmon, Chinook salmon, and steelhead are anadromous fish, spending some time in both fresh- and saltwater. These salmonids spend much of their lifecycle in the ocean but are hatched, reared, and return to spawn in freshwater. The older juvenile and adult life stages occur in the ocean, until the adults ascend freshwater to spawn. Eggs (laid in gravel nests called redds), alevins (gravel dwelling hatchlings), fry (juveniles newly emerged from stream gravels), and young juveniles all rear in freshwater until they become large enough to migrate to the ocean to finish rearing and maturing to adults. Cool, clear water, adequate instream cover, clean spawning gravels, and properly functioning riparian stands are essential features of salmonid habitat.

Forestry practices interact with watershed and riparian processes and can positively or negatively affect upstream and downstream freshwater habitat for salmonids. The impacts of historical logging operations on salmonids and their habitat were undoubtedly severe. Legacy impacts continue to affect salmonid habitat. Sound forestry practices, particularly in riparian zones, can help maintain and restore the riparian functions that are linked to salmonid habitats. The retention and active management of riparian areas in a manner compatible with the freshwater life histories of salmonids is vital to maintaining salmonid habitat that is in good condition and to restoring degraded habitat.[3] The non-federal forestlands of California play a critical role for ensuring freshwater survival and the likelihood of long term recovery of salmonids. Retention of viable, working forest landscapes, including riparian zones, is therefore essential to salmonids.

[3] For example, Spence et al. (1996) state that for second-growth forests, limited harvest, thinning, planting, or other manipulations in riparian zones may be appropriate in order to facilitate recovery and protection of key functions, particularly in coastal forests. They report that these activities should only be allowed when they can be performed without adversely impacting other riparian functions or values.

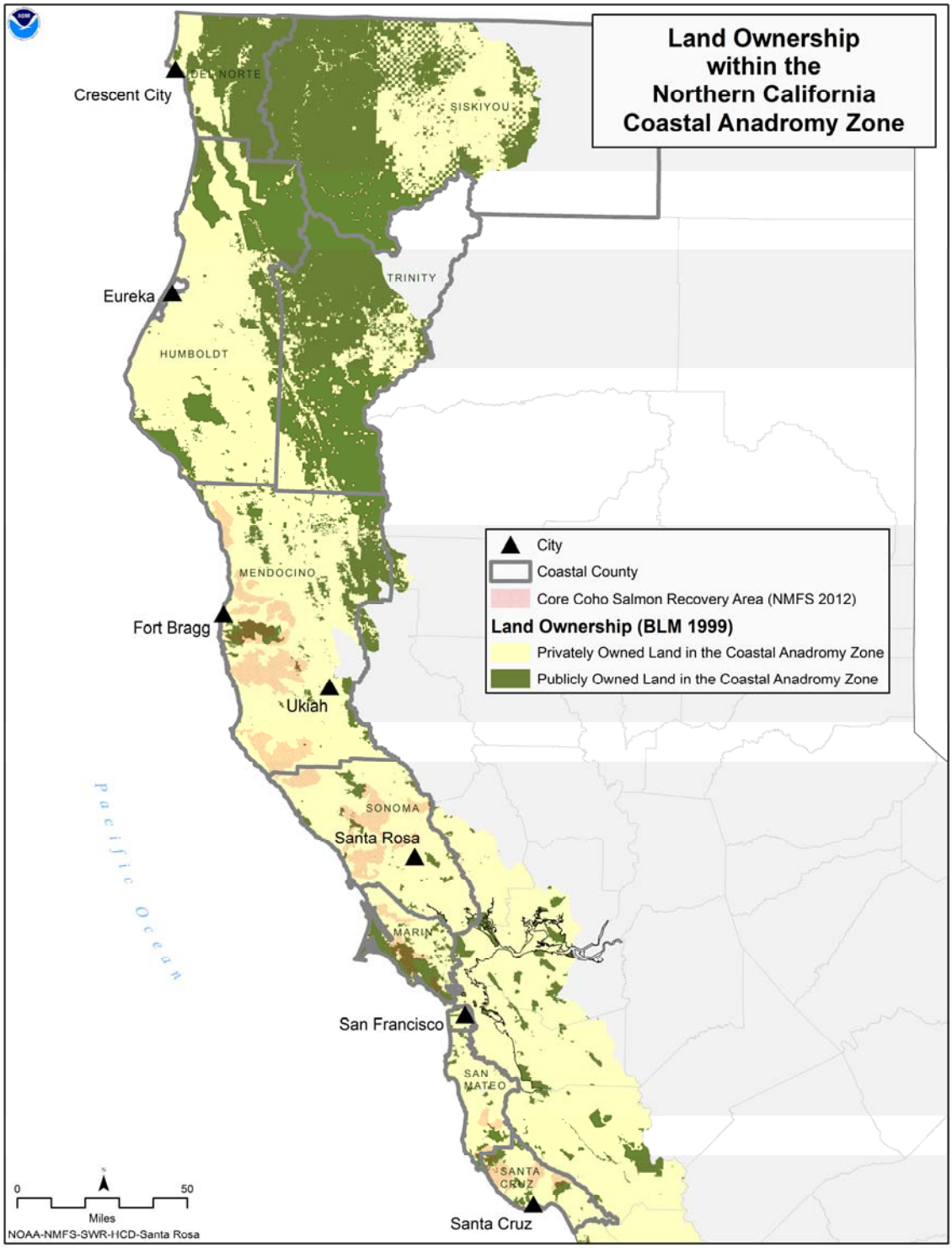


Figure 2. Map of private and public land ownership within the Coastal Anadromy Zone from Del Norte County to Santa Cruz County, including core coho salmon recovery areas (image produced by NMFS).

Coho Salmon—Example of an Anadromous Salmonid Species Requiring Active Riparian Management

Central California Coast (CCC) coho salmon are in an 'extinction vortex' (NMFS 2012). That is, their low population cannot overcome ongoing declines, their genetic diversity is compromised, their habitat is degraded and fragmented, and spawners are at such low numbers they cannot find one another to reproduce. Their dire status is a call for immediate action to prevent their extinction by, among other things, restoring habitat conditions and watershed processes across their historical range. A priority action includes installing large wood structures in coho salmon habitat. Large woody debris originating from riparian trees is a form of cover in many streams and its importance is widely recognized (Bisson et al. 1987, Holtby 1988).

When riparian trees fall into watercourses, they create conditions which scour the gravel bottoms of streambeds and create deep pools. These pools are the preferred habitat of coho salmon. Coho salmon prefer the slower moving areas of a stream provided by pools as feeding habitat and cover from predators. Pools also provide an increase in the volume of rearing habitat which allows a greater density of juveniles than an equivalent length of stream without pool habitats.

Moyle et al. (2008) include the following paragraph describing the problems associated with the removal of large wood in stream channels: "It is hard to overestimate the importance of loss of large woody debris as the result of historical logging practices. The streams in the Santa Cruz Mountains and Mendocino Coast contain little of the low-gradient, wide-valley streams that tend to be the most productive habitat for coho salmon. Thus the role of large wood in these steeper streams was, in all likelihood, absolutely essential for providing refuge during high flow events in winter, because there were fewer opportunities for off-channel habitat refuges. Lack of habitat structure is clearly a major problem facing CCC coho, especially in the winter months when refuges from high flows are needed (e.g., Stillwater Sciences 2008). Even in state parks in the region, which often have 100-year old riparian forests, large in-channel wood remains extremely scarce and is largely present as the result of enhancement projects (e.g., Ferguson 2005)."

A current paradigm within forest management is that replenishment of large wood in stream channels depends upon recruitment from riparian areas. For example, under the existing California Forest Practice Rules, the primary objective of the core zone is streamside bank protection to promote bank stability, wood recruitment by bank erosion, and canopy retention. The primary objective for the inner zone is to develop a large number of trees for large wood recruitment. Even the outer zone has additional wood recruitment as an objective. Retaining large trees that are most conducive to recruitment is a priority in Class I watercourses with confined channels in the coastal anadromy zone. One weakness of this paradigm is that coho salmon cannot wait for banks to erode, nor wait for large trees to develop, nor rely on chance that a tree conducive to falling into the stream will actually fall into the stream. Coho salmon need large wood in streams now if we are to recover the population.

Benefits of Active Riparian Management

The scientific basis for most regulatory buffer widths is often described in terms of source-distance relationships that relate width to the cumulative inputs (or limits) for various riparian functions. The effective width for various functions has been defined by a series of generalized relationships originally described in FEMAT (1993), and explored by many others (e.g., Castelle and Johnson 2000; Young 2001; Benda et al. 2002; Benda et al. 2003). "Source distance" curves seek to relate the cumulative effectiveness of each exchange function in terms of the distance from the stream bank. However, there is little empirical information, and large degrees of variation in existing data about the biological effectiveness associated with specific riparian buffer widths (Young 2001, Gregory et al. 1991). Recent studies also indicate that the shape of source-distance curves are strongly influenced by the dominant mechanisms or riparian characteristics for contributing (or preventing) the key input associated with each exchange function in that setting (Martin and Grotefendt 2007, Liquori 2006, Benda et al. 2005, Benda and Bigelow in review). Liquori et al. (2008) identify other key issues associated with using source distance curves, and recommend moving toward a more spatially-explicit approach for riparian management.

The basic structure of riparian regulatory prescriptions in California's Forest Practice Rules are similar to that found in most western states (Everest and Reeves 2007, Young 2000, Richardson et al. 2012). Longitudinally continuous buffers are required on all fish-bearing streams, and the lower reaches of non-fish streams, largely based on source-distance relationships for key riparian functions. Buffer requirements are based on a combination of variables: beneficial uses, including fish presence/domestic water source, watercourse size/flow regime, and geographic region. Differences in these factors drive buffer width requirements.

While these uniform buffer prescriptions are required to "protect" aquatic resources, there is growing concern that protection strategies can undermine or alter important ecosystem function processes that are responsible for creating and maintaining resource functions (Liquori et al. 2008). These types of passive strategies provide limited opportunities for ecosystem-based management strategies that could lead to improved ecosystem function, while also providing for resource utilization (e.g., limited timber harvest). Active management could therefore yield greater economic value while also providing greater ecological values. Although some harvest is allowed in the outer portions of buffers with the standard rules, the effectiveness to influence buffer functions and timber potential are limited by distance (i.e., source functions diminish with distance) and the small area available for treatment. The Board recognized that opportunities are limited by only allowing passive management (i.e., no touch) in riparian zones when they included Section V in the ASP rules, allowing for site-specific riparian proposals to be developed.

A functionally uniform and continuous riparian management approach is over simplified when compared with the extensive science and body of knowledge about riparian functions, disturbance, silviculture, and associated ecological response. In appropriate situations, more actively managed riparian areas can be designed to protect, maintain, restore, or enhance

riparian functions. By contrast, passive practices may offer only limited protection capacity and slow recovery trajectories. Other limitations of passive management include:

- **Fixed buffer width approaches do not incorporate watershed and landscape scale variability**. For example, the physical benefits of in-stream wood is more important in the central and northern parts of the California Coast Ranges than the Sierra Nevada (Berg et al. 1998, Benda and Bigelow in review), and is more important in mid-order channels than in headwater channels (Nakamura and Swanson 2003). Benda and Bigelow (in review) found wood loading variability at the watershed scale was significantly greater than variability at the landscape scale. Similarly, more shade for temperature sensitivity is needed for some streams but not for others (Allen 2008). Lewis et al. (2000), for example, show that stream temperatures within a "zone of coastal influence" in California are significantly lower than those measured farther inland. The theme of spatial and geographical variability extends across most of the key issues with each riparian exchange function (Liquori et al. 2008).

- **Fixed buffer width approaches may not adequately address key site-specific factors that drive riparian functions** (e.g., wood recruitment processes, channel sensitivity to wood and temperature, intrinsic heat loading potential, etc). Instead, standard rules apply broad assumptions or gross averaging methods to vast geographical areas, assuming the most 'conservative' (i.e., wider) buffer sufficiently protects all riparian functions. However, interactions among and between riparian exchange functions influence both the short-term and long-term suitability of habitat for salmonids and other species. For example, canopy openings affect heat exchange (Allen 2008, Gomi et al. 2006, Sullivan et al. 2000), nutrient cycling (Cummins 2002), macroinvertebrate production (Bottorff and Knight 1996, Danehy et al. 2007, Hoover et al. 2007, Moldenke and VerLinden 2007, Wipfli and Musselwhite 2004), soil moisture (Tabacchi et al. 2000), vegetative species colonization patterns (Oliver and Larsen 1990), and riparian stand growth (Franklin et al. 2002, Oliver and Larsen 1990). Thus, fixed buffer width approaches tend to both support some functions and potentially harm other functions that are beneficial for these species (Ice 2010). Managing for only one function (e.g., temperature or large wood) may put other key functions (e.g., primary productivity and food production) at risk (Kiffney and Roni 2007, Wilzbach et al. 2005, MacCracken et al. in press). In some watersheds, deciduous litter inputs may be the limiting biological factor and managing to maximize wood source distance may reduce the development of deciduous understory and associated exchange functions (Wipfli and Musselwhite 2004, Romero et al. 2005).

- **Fixed buffer width approaches do not address timber growth potential or stand dynamic conditions that are driven by landform, soil moisture, and existing stand structure** (Naiman et al. 1998, Rot 2000, Villarian et al. 2009). Riparian stand characteristics respond differently to passive management in different settings. Some areas may become overgrown and fire-prone. Others may support rapid growth potential. Site-specific management approaches can identify the appropriate prescription based on the site's unique ability to achieve various ecological functions

(e.g., Bisson et al. 2003, Nakamura and Swanson 2003). For example, for watersheds with coast redwood stands, Thornburgh et al. (2000) reported that very high tree densities can preclude the development of large trees for decades. Thinning has been found to be an effective means of enhancing old forest development in coast redwood forests by accelerating tree growth, modifying species composition, and increasing stand-level variability (O'Hara et al. 2010).

- **Fixed buffer width approaches do not sufficiently address the altered disturbance potential for windthrow or fire**. Management actions within or near riparian areas are just one of many forms of disturbance that affect the evolution of the riparian stand. As management increases risks for some ecosystem processes, it also reduces risks in others, and it is the sum of effects that controls the outcome for ecosystems (Everett et al. 2003, Nakamura and Swanson 2003). There is a growing recognition that a riparian zone does not "buffer" (e.g., protect) the stream from disturbances, but in fact alters the disturbance regimes in ways that both benefit and harm habitat conditions (Kreutzweiser et al. 2012). Riparian management can affect riparian disturbance regimes by affecting the types of disturbance, the magnitude of disturbances, and the frequency of disturbances (Dwire and Kauffman 2003, Beschta et al. 2000, Swanson et al. 1998, Van de Water and North 2011). Since disturbance regimes are one of the driving factors that influence riparian stand dynamics and succession (Oliver and Larsen 1990; Naiman et al. 1998, Franklin et al. 2002), the long-term trajectory of riparian stands can be substantially influenced not only by the direct manipulation from forest management, but by the indirect effects of forest management on natural processes (Dwire et al. 2010, Rieman et al. 2003, Roby and Azuma 1995). For example, recently observed fire behaviors in riparian zones (e.g., Angora Fire, Murphy et al. 2007), where low intensity ground fires become damaging crown fires upon entering riparian zones, demonstrates how some riparian buffers can harm salmonids and other aquatic species by exposing the stream to risks it may not have experienced otherwise. Van de Water and North (2011) have recently reported that Sierra Nevada riparian forests are significantly more fire prone under current management regimes with excluded harvest that allow for a build-up of fuels when compared to riparian areas that have been exposed to an active-fire regime. Additionally, under current conditions, riparian forests were found to be significantly more fire prone than upland forests. Similarly, increased tree windthrow in exposed buffers can result in excessive wood loading that can have short-term (e.g., channel burial) and long-term consequences (e.g., reduced future supply) (Lisle and Napolitano 1998, Liquori 2006, Martin and Grotefendt 2007).

- **Fixed buffer width approaches do not consider all relevant dimensions** (lateral, longitudinal, spatial, and temporal). Riparian management by width alone ignores multidimensional factors as reported in the literature (Liquori et al. 2008). Fixed buffer width approaches are typically one-dimensional, and do not consider time (future condition), buffer length, or composition (species, age, density). Most regulatory systems only consider width functions, yet spatial variability and dynamic processes dictate that riparian functions are not only influenced by width but by the influence of landforms and processes that change longitudinally along the channel network

(Nakamura and Swanson 2003, Benda and Bigelow in review). The effective width for functions depends on process and structure, both of which vary by location.

For each of these deficiencies with a fixed buffer width approach, the site-specific method can provide more explicit solutions by using existing scientific tools, models, classifications, and mapping technologies. For example, wood supply and temperature modeling can be integrated with growth and yield models to identify (and set harvest prescriptions for) riparian areas where restoration or enhancement strategies can be applied (e.g., Welty et al. 2002, Beechie et al. 2000). Similarly, areas prone to thermal sensitivity have been identified for California watersheds by Allen (2008).

The methods described in this document will help promote a shift in thinking from a "protection" mindset (e.g., buffering the stream) to an "ecosystem processes" mindset that is consistent with several general themes in the literature in recent years (Nakamura and Swanson 2003, Rieman et al. 2003, Young 2001). These papers suggest that a more appropriate management objective is to ensure that critical ecosystem processes and functions are maintained to provide desired riparian (and instream) conditions in managed settings. To provide such functions, a site-based management approach is required.

IV. PRE-CONSULTATION GUIDELINES

The pre-consultation guidelines developed by the VTAC are included as Appendix B in this document, along with an example of how to use the guidelines. This is an optional form for RPFs to: (1) identify potential issues of concern that may require additional considerations for the site-specific proposal, and (2) give the landowner and/or RPF the ability to determine the potential acceptance of the site-specific proposal.

As stated in the introduction, for alternative measures limited to a specific site in a plan, all that is needed is for the RPF to pre-consult with DFW and obtain written concurrence (based upon substantial evidence) prior to plan submittal. No further documentation is required, as is specified in 14 CCR § 916.9(v)(2) [936.9(v)(2), 956.9(v)(2)]. For larger scale or more complex site-specific proposals, the more comprehensive assessment described in chapters V through VIII and Appendix A of this document are intended to be utilized as appropriate, following the requirements included in 14 CCR § 916.9(v)(3) [936.9(v)(3), 956.9(v)(3)].

If desired, both the site-specific proposals using the DFW Concurrence (14 CCR 916.9(v)(2)) or the Full Justification (14 CCR 916.9(v)(3)) pathways may use the pre-consultation guidance form provided in Appendix B.

V. Introduction to Analytical Pathways – Recommended Approaches to Obtain Site-Specific Proposal Approvals

This chapter outlines guidelines for developing technically justified assessments for site-specific proposals under Section V of the ASP rules [14 CCR § 916.9 [936.9, 956.9] Section (v)(3)]. The design process outlined here provides an opportunity to develop riparian projects that more closely provide locally relevant riparian exchange functions in a manner that each site can support. The key elements that have been considered include:

- The spatial and temporal distribution of "functional process" zones.
- The timing and characteristics of input delivery.
- The processes responsible for recruitment based on geomorphic and riparian criteria.

The guidelines described in this document support three pathways (provided in Appendix A-1, A-2, and A-3), any one or more of which can be utilized for a detailed Section V(3) assessment (Table 3).

Table 3. Approaches for a Section V site-specific proposal (see Appendix A-1, A-2, and A-3).

Proposal Options	Short Name	Proposal Size/Scale	Advantages	Disadvantages
916.9(v)(2)	DFW Concurrence	Specific site in a plan	Only requires written concurrence from DFW	Only applies to limited site-specific location in a THP
916.9(v)(3) Pathway 1)	Classification Matrix	Larger scale or more complex proposal	Simple; limited training and expertise needed; identifies specific priorities for riparian site improvements	Limited guidance provided on specific management actions to apply; generalized ratings that may not apply in all situations
916.9(v)(3) Pathway 2)	Situational Scenarios	Larger scale or more complex proposal	Simple; limited training and expertise needed; identifies the most common conditions requiring active management.	May over-generalize conditions appropriate for active management; may miss some appropriate conditions meriting active management
916.9(v)(3) Pathway 3)	Analytical Design Process	Large project or complex situation; watershed scale proposal	Very flexible approach with large-scale applicability	Requires considerable data and expertise by applied scientists with experience in riparian ecology and other disciplines

Brief descriptions of these three pathways follow, along with typical applications.

Pathway 1) **The Classification Matrix Approach** is based on simple classifications that can be applied by any RPF with only limited expertise in riparian ecology. It helps to identify specific priorities for riparian site improvements using a risk-based rule matrix. However, this pathway offers only limited guidance about which management actions might be undertaken to make such improvements. Typical application of Pathway 1 include:

- Where an RPF wishes to apply a relatively simple assessment procedure that outlines generally applicable goals and processes that are appropriate to most forested landscapes in California
- The project scale is relatively small, and more technical expertise is not cost-effective

Pathway 2) **Generalized Situational Scenarios** identify common conditions found within California riparian areas within the scope of the ASP rules, and provide suggested approaches to the RPF regarding riparian condition improvements. Typical application of Pathway 2 include:

- The site is consistent with the generally similar situations outlined in this section
- The RPF is using 3rd-party recovery documents (e.g., NMFS 2012) to provide the context and project goals

Pathway 3) **The Analytical Design Process** is a more flexible approach that requires additional data and expertise by riparian experts. This approach relies on the expertise of the proposing organization(s) to justify their proposal. Typical application of Pathway 3 include:

- Areas where recovery documents indicate conflicting goals and the landowner is willing to develop supporting evidence that leads to a different technical conclusion
- Lands with an existing HCP or other larger-scale planning reports where the landowner is seeking to be transparent about (i.e., document) adaptive management (note that a Section V proposal is not required with an HCP)
- Landowners adjacent to (or within) relevant planning areas associated with other planning documents (e.g., use of 3rd-party technical reports that may be relevant to the landowner), where the technical analysis (but not necessarily the prescriptions) will be applied
- Organizations with sufficient technical expertise and/or unusually robust datasets relevant to the project
- Small landowners who are technical experts (or are working with 3rd parties providing technical expertise)
- Those interested in larger-scale analysis (e.g., watershed assessments, multiple adjacent planning units, etc.)

- Unusually complex situations (issues that require additional technical expertise)
- Situations where technical experts identify that Pathways I or II are not appropriate for the existing site conditions

Each of these pathways requires an analysis of both potential individual and cumulative impacts (positive and negative) of the site-specific proposal in terms of impacts on anadromous salmonid distribution and abundance in the watershed. The measures proposed must avoid or mitigate significant adverse impacts [see 14 CCR § 916.9 [936.9, 956.9] Section (v)(3)(A)(4) in Appendix C].

Watershed Context Assessment

All pathways for 14 CCR § 916.9(v) [936.9(v), 956.9(v)] require a significant watershed assessment, which is more commonly and formally referred to as consideration of cumulative watershed effects.

The riparian design associated with the 14 CCR § 916.9(v) [936.9(v), 956.9(v)] rules can be influenced by an understanding of opportunities and constraints that might arise from the cumulative impacts assessment, a requirement of all THPs. It is also recommended as part of the Pre-Consultation guidance to acknowledge any known cumulative effects issues. The Anadromous Protection Salmonid rules require that all THPs where the ASP rules apply must consider "pre-plan adverse cumulative watershed effects on the populations and habitat of anadromous salmonids" (14 CCR § 916.9(b)). Such information may guide the RPF toward riparian opportunities that might help to mitigate for cumulative (or legacy) effects. For example, knowledge of preferred spawning and rearing habitat areas might identify opportunities for large wood placement.

The RPF should make sure the requirements of 14 CCR § 916.4(a) and (b)(a-g) are met in the THP and it is recommended that these be considered on a Planning Watershed scale, along with Technical Rule Addendum #2 and its Appendix, especially as pertains to Watershed and Biological Resources. Clarity and utility of the presentation of the information is key for both good site or reach-specific recovery projects, as well as recovery on a Planning Watershed scale. It should be noted that the Timberland Recommendations of the California Coho Recovery Strategy approved in 2004 call for recovery plans on a Planning Watershed scale, determination of limiting factors on a Planning Watershed scale, and organization of information on a Planning Watershed basis (DFG 2004). Pathway 3 has been specifically developed for those interested in developing watershed-scale (or landscape-scale) approaches using Section V and much of the analysis developed for this pathway will also support cumulative effects analysis.

Several types of information sources are available for obtaining background watershed condition data and it is strongly suggested that RPFs utilize existing sources when undertaking a rapid watershed assessment. Rapid watershed assessment to determine watershed-scale limiting factors is to utilize existing information sources so that it can be completed cost effectively and in a reasonable time frame with limited expertise. A list of potentially useful sources of existing information for watershed context assessment is provided in Appendix E.

VI. SUBMISSION REQUIREMENTS

Section V(3) [full justification] site-specific proposal submissions require the following items. The complete requirements are provided in Appendix C.

- Rationale for the site-specific proposal.
    - Map(s).
    - Photos.
    - Site description.
        - Channel zone area.
        - Core Zone.
        - Inner Zone.
        - Outer Zone.
  - Identification of the standard prescription that would be replaced by the project proposed.
  - Detailed description of the site-specific measure(s) or nonstandard operational provision(s) proposed—based upon the best available science.
  - Identification of the beneficial functions that may be affected by the proposal.
  - Identification of the potential effects to beneficial functions, both positive and negative. RPF may use a reasoned analysis to describe the effects and may assign ratings of high, moderate and low to those effects that may individually or cumulatively limit anadromous salmonid distribution and abundance.
  - Site-specific proposal metrics/standards.
    - Relates to enforceability.
  - Narrative of proposed implementation.
    - Equipment/personnel to be used.
    - Cost effectiveness.
  - Schedule for implementation.
  - A monitoring plan (see Section XI).
- Site/Watershed Project Description
  - Description of the evaluation area (include location, waterbody, USGS quadrangle, CAL WATER planning watershed number, etc.).
  - Description of the current condition of the riparian zone within the evaluation area related to the beneficial functions.
    - Existing vegetation, timber stand characteristics (e.g., WLPZ overstory canopy, basal area, etc.).
    - Condition of existing roads, skid trails, landings, and watercourse crossings.
    - Channel types, unstable areas, flood prone areas, and overflow channels.
- List of other agency requirements
  - Permits
  - Summary of additional information required
    - Coordinate with agency staff

VII. PROPOSAL PROCESSING

This chapter describes how the four Review Team agencies will evaluate Section V(3) [full justification] site-specific proposals. Note that there are differences between the agencies in terms of how they plan to review full justification proposals, based on their individual expertise. Individual names at the various agencies are not provided since personnel changes are frequent and the document would quickly become out of date. Under the California Environmental Quality Act (CEQA), CAL FIRE is the lead agency for proposal review.

California Department of Forestry and Fire Protection (CAL FIRE):

CAL FIRE Forest Practice Inspectors and Watershed Protection Program staff or available Biological staff in Sacramento will participate in pre-consultation for Section V site-specific proposals when they are requested by the RPF preparing a plan. This may include a field evaluation, if requested. CAL FIRE staff will participate in pre-consultations promptly, but within the timeframes dictated by their other work assignments.[4] When a THP is submitted to CAL FIRE for filing acceptance with a Section V site-specific proposal, CAL FIRE staff will review the proposal to determine if it contains the information specified in 14 CCR § 916.9 [936.9, 956.9] (v)(3). Office reviews of Section V proposals will be conducted by CAL FIRE's THP Review Team staff located in Santa Rosa, Redding, and Fresno. Staff in these locations may request assistance in review from CAL FIRE's Watershed Protection Program staff or available Biological staff in Sacramento. If additional information is required, the plan will be returned to the RPF, similar to what is done for other types of required information. Additional information may be requested to clarify the proposal without necessitating return of a plan.

If there has been no pre-consultation with CAL FIRE Unit staff, each Section V proposal will be evaluated in the field by the CAL FIRE Forest Practice Inspector as part of the pre-harvest inspection (PHI) for the plan. CAL FIRE will solicit input on all Section V proposals from the other Review Team agencies as part of the normal plan review process and may request information provided by the agencies through the pre-consultation process. CAL FIRE will evaluate each Section V proposal for potential impacts to resources, both individual impacts and cumulative impacts, as well as ensuring the proposal meets the goals of 14 CCR § 916.9 [936.9, 956.9] to protect, maintain and contribute to the restoration of properly functioning salmonid habitat and listed salmonid species.

Department contacts for Section V review include:

[4] Note that pre-consultation with any of the Review Team agencies (CAL FIRE, DFW, CGS, RWQCBs) will not produce formal agency approval, but this information is intended to provide feedback to the RPF during the planning process. CAL FIRE will confirm forest practice rule (FPR) conformance through evaluation of documentation included in the THP and through the Review Team process.

Forester III, Cascade, Sierra, and Southern Regions
Forest Practice Manager
CAL FIRE Northern Region Operations Headquarters
6105 Airport Road
Redding, CA 96002

Forester III, Coast Region
Forest Practice Manager
CAL FIRE Northern Administration Office
135 Ridgway Avenue
Santa Rosa, CA 95401

Forester II, Review Team Chairperson
CAL FIRE Southern Administrative Office
1234 East Shaw Avenue
Fresno, CA 93710

Staff Chief, Forest Practice Regulation
CAL FIRE Sacramento Headquarters
PO Box 944246
Sacramento, CA 94244

California Geological Survey (CGS):

Upon receipt of a Section V proposal, CGS will review the contents to assess whether CGS input appears warranted. CGS will typically evaluate the proposal with regard to its potential effects on slope stability; erosion; and fluvial geomorphic processes, including potential effects on bank and channel stability; as well as for potential effects on public safety. Based on this evaluation CGS may: (1) inform the RPF that CGS would like to participate in the field pre-consultation; and/or (2) inform the RPF of concerns and/or additional considerations that should be addressed as part of the Section V proposal process, or (3) inform the RPF that CGS's input does not appear necessary as part of the pre-consultation evaluation of the proposed project. Reviews of Section V proposals will be conducted by CGS's THP Review Team staff within their typical geographic regions; additional CGS staff may be called upon if specific expertise is deemed warranted.

Section V proposals can be sent to CGS THP Review Team staff at the addresses below.

CAL FIRE Northern District:

CGS THP Staff
c/o CAL FIRE
6105 Airport Road
Redding, CA 96002

CAL FIRE Coastal District:

Humboldt and Del Norte Counties:
CGS THP Staff
2120 Campton Rd., Suite E
Eureka, CA 95503

Mendocino County:
CGS THP Staff c/o CAL FIRE
17501 North Highway 101
Willits, CA 95490

Sonoma and Southern Coastal Counties:
CGS THP Staff c/o CAL FIRE
135 Ridgway Avenue
Santa Rosa, CA 95401

CAL FIRE Southern District:

CGS THP Staff
801 K Street, MS 13-40
Sacramento, CA 95814

California Department of Fish and Wildlife (DFW):

Upon receipt of a Section V proposal, DFW will review the contents to assess the proposed activity. DFW will typically evaluate the proposal with regard to its potential direct and indirect effects on listed, anadromous salmonids. Based on this evaluation DFW: (1) will inform the RPF that DFW would like to participate in the field pre-consultation; and (2) inform the RPF of concerns and/or additional considerations that should be addressed as part of the Section V proposal process. Reviews of Section V proposals will be conducted by DFW's THP Review Team staff within their typical geographic regions; additional DFW staff may be called upon if specific expertise is deemed warranted.

Section V proposals can be sent to DFW THP Review Team staff at the addresses below.

DFW Redding Office
601 Locust Street
Redding, CA 96001
(530) 225-2090

DFW Eureka Office
619 Second Street
Eureka, CA 95501
(707) 445-6493

DFW Fort Bragg Office
32330 North Harbor Drive
Fort Bragg, CA 95437
(707) 964-1691

DFW Yreka Office
1625 South Main Street
Yreka, CA 96097
(530) 842-0882

Central Valley Regional Water Quality Control Board (Central Valley Water Board):

Central Valley Water Board staff encourages project proponents to discuss preliminary Section V site-specific proposals and to submit a description of the proposed project using the pre-consultation guidance document. Consultation prior to formal submission of the THP will allow for resolution of issues that may preclude the issuance of a Waiver or, if applicable, Waste Discharge Requirements.

Upon receipt of a Section V proposal, Central Valley Water Board staff will evaluate the proposal in the context of the requirements of the Water Quality Control Plan for the Sacramento and San Joaquin River Basins (Basin Plan), including the likely impacts of the proposal relative to the following:

- Water quality objectives related to sediment (e.g., settleable solids, suspended sediment, and turbidity)
- Water quality objectives for temperature
- Eligibility for enrollment in either the timber waiver or, if applicable, waste discharge requirements
- If applicable, TMDL load allocations and implementation plans
- All applicable prohibitions

Based on this evaluation, Central Valley Water Board staff will inform the project proponent of issues that would need to be explored and possibly addressed prior to issuance of a Waiver or, if applicable, Waste Discharge Requirements.

Water quality requirements related to timber harvest activities in the Central Valley Region can be found in the following documents:

- Conditional Waiver of Waste Discharge Requirements for Discharges Related to Timber Harvest Activities (R5-2010-0022) - http://www.swrcb.ca.gov/centralvalley/board_decisions/adopted_orders/waivers/r5-2010-0022.pdf

- Central Valley Water Board's Basin Plans - http://www.swrcb.ca.gov/centralvalley/water_issues/basin_plans/index.shtml

A current list of impaired waterbodies can be found at the following link:

- http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/impaired_waters_list/index.shtml

Section V proposals can be sent to CVRWQCB THP Review Team staff at the address below:

Central Valley Regional Water Quality Control Board
Redding Office (5r)
364 Knollcrest Drive, Ste 205
Redding, CA 96002
(530) 224-4845

North Coast Regional Water Quality Control Board (North Coast Water Board):

North Coast Water Board staff encourages project proponents to request consultation on Section V proposals prior to submission, and to submit a description of the proposed project using the pre-consultation guidance document. Consultation prior to formal submission of the THP will allow for resolution of issues that may preclude the issuance of Waste Discharge Requirements or a Waiver.

Upon receipt of a Section V proposal, North Coast Water Board staff will evaluate the proposal in the context of the requirements of the *Water Quality Control Plan for the North Coast Region*, including the likely impacts of the proposal relative to the following:

- All applicable prohibitions
- Water quality objectives related to sediment
- The water quality objective for temperature
- TMDL load allocations and implementation plans
- Eligibility for enrollment in either the timber Waiver or General Waste Discharge Requirements for timber

Based on this evaluation, North Coast Water Board staff will inform the project proponent of issues that would need to be explored and possibly addressed prior to issuance of Waste Discharge Requirements or a Waiver.

Water quality requirements related to timber harvest activities in the North Coast Region can be found in the following documents:

North Coast Timber Regulatory Program:

http://www.waterboards.ca.gov/northcoast/water_issues/programs/timber_operations

North Coast Water Quality Control Plan (Basin Plan):

http://www.waterboards.ca.gov/northcoast/water_issues/programs/basin_plan/

Consultation regarding Section V proposals should be directed towards the Timber Program staff at the following location:

North Coast Regional Water Quality Control Board
5550 Skylane Blvd., Suite 1400
Santa Rosa, CA 95403
(707) 576-2220

VIII. MONITORING STRATEGIES

For a Section V(3) full justification site-specific proposal, a monitoring plan, consistent with 14 CCR § 916.11 [936.11, 956.11], is required [see 14 CCR § 916.9 [936.9, 956.9](v)(3)(A)(7)].

As specified in CCR § 916.11 [936.11, 956.11], evaluation procedures may include, but are not limited to: (1) procedures for effectiveness and implementation monitoring, (2) existing landowner monitoring programs, or (3) photographic monitoring. CAL FIRE will enforce monitoring requirements included as part of a THP (note that the life of a THP is now five years, with a possible extension of two additional years, plus a three year erosion control maintenance period in the area covered by the ASP rules).

A Section V(3) proposal monitoring plan will be expected to focus on evaluating the implementation success and short-term effectiveness of the prescribed practices. The scale and detail of the submitted monitoring plan is to be commensurate with the scope of the site-specific proposal.

Clearly, some parameters are easier to monitor than others. For example, changes in large wood loading rates from actively managed buffer strips and associated changes in instream habitat parameters take many years to several decades to monitor (Martin and Shelly 2006) and are beyond the scope of the monitoring requirements specified in for Section V(3) proposals. Success in reducing the risk of catastrophic wildfire in actively managed riparian zones also may not be known for decades. Similarly, changes in primary productivity and corresponding anadromous fish response with active riparian management producing added light and nutrients (e.g., Wilzbach et al. 2005) is beyond the scope of the Section V(3) monitoring requirements. In contrast, changes in instream pool volumes and depths associated with large wood enhancement projects can be monitored following several large winter storm events (Figure10). The monitoring plans submitted with Section V(3) proposals are to be based on reasonableness and practicality.

At a minimum at the project-scale, monitoring plans should include:

- Digital photographs documenting pre-project, post-project implementation, and post-project conditions following one or more winters from defined, repeatable photo-points (stations). Photo point monitoring protocols are provided in: Hall 2002, CCRWQCB 2005, and Longstreth et al. 2008.

For larger-scale proposals:

- Short-term (rapid-response) effectiveness monitoring (at least one year/over-wintering period) should be addressed and include:
    a) Photo point monitoring (as described above).
    b) Use of specific monitoring protocols suited to site-specific measures implemented on the ground (e.g., Level II DFW habitat typing, re-evaluation of pre-project aquatic habitat parameters (e.g., pool depth), movement of tagged

trees placed in the channel, etc.) [monitoring is to be coordinated and integrated with monitoring activities being conducted by other state and federal agencies to the extent possible].

- Possible longer-term effectiveness monitoring.

Lessons learned from monitoring site-specific proposals will lead to more effective riparian management over time. There is the potential for unintended consequences as site-specific proposals for active riparian management are implemented, and monitoring can provide early feedback for refined practices.

Longer-term effectiveness monitoring studies will generally be beyond the capacity of any single project proponent. This type of monitoring will likely need to be developed under the umbrella of existing monitoring programs (particularly for larger companies), cooperative instream monitoring programs with multiple entities, or with a cooperative, multi-agency state sponsored monitoring program.[5] Such an approach is currently under development by the State Board of Forestry and Fire Protection's Monitoring Study Group (MSG) and Research and Science Committee (RSC). It is anticipated that the Board will form the Effectiveness Monitoring Committee (EMC) in the early part of 2013, following the completion of the VTAC's work. The EMC will advise the Board on how to build a monitoring program that can provide an active feedback loop to policy makers for adaptive management, particularly related to the effectiveness of Forest Practice Rules mandated for protection and recovery of listed anadromous salmonid species. Section V site-specific proposals for rapid improvement of aquatic habitats will likely be a component of this new monitoring program.

[5] Current Board/CAL FIRE cooperative instream monitoring projects include: Caspar Creek watershed study (USFS PSW and CAL FIRE), Judd Creek watershed study (SPI and CAL FIRE), South Fork Wages Creek watershed study (CTM and CAL FIRE), and the Little Creek watershed study (Cal Poly SLO/Swanton Pacific Ranch, CAL FIRE, and others).

IX. REFERENCES

Adams, T. N. and K. Sullivan. 1989. The physics of forest stream heating: a simple model. TFW-WQ3-90-007, Wasthington Department of Natural Resources, Olympia, WA. 30 p.

Allen, D.M. 2008. Development and application of a process-based, basin-scale stream temperature model. Doctoral Dissertation. University of California, Berkeley. 168 p.

Allen, D., W. Dietrich, P. Baker, F. Ligon, and B. Orr. 2007. Development of a mechanistically based, basin-scale stream temperature model: applications to cumulative effects modeling. Pp. 11-24 in: R. B. Standiford, G. A. Fiusti, Y. Valachovic, W. J. Zielinski and M. J. Furniss, eds. Proceedings of the Redwood Region Forest Science Symposium: What Does the Future Hold? USDA Forest Service, Albany, CA. USDA Forest Service, Gen. Tech. Rep. PSW-GTR-194.

Amaranthus, M.P. 1984. Stream temperatures in the Pacific Northwest: critical factors and prediction method. Unpublished Final Report. USDA Forest Service. Region 6. Siskiyou National Forest. Grants Pass, OR. 25 p.

Ambrose, C. 2008.. Passenger pigeons, dodo birds…condors and coho? Salmonid Restoration Federation. Winter 2008/2009 Newsletter. Pg 3.

Arkle, R.S. and D.S. Pilliod. 2010. Prescribed fires as ecological surrogates for wildfires: A stream and riparian perspective. Forest Ecology and Management 259: 893–903.

Beche, L.A., S.L. Stephens, and V.H. Resh. 2005. Effects of prescribed fire on a Sierra Nevada (California, USA) stream and its riparian zone. Forest Ecology and Management 218: 37–59.

Beechie, T.J., G. Pess, P. Kennard, R.E. Bilby, and S. Bolton. 2000. Modeling recovery rates and pathways for woody debris recruitment in northwestern Washington streams. North American Journal of Fisheries Management 20: 436-452.

Beechie, T. J. and T. H. Sibley. 1997. Relationships between channel characteristics, woody debris, and fish habitat in northwestern Washington streams. Transactions of the American Fisheries Society 126: 217-229.

Benda, L. 2005. Geomorphology of steepland headwaters: the transition From hillslopes to channels. Journal of the American Water Resources Association 41: 835-851.

Benda, L. and P. Bigelow. In review. Recruitment, storage, transport and function of wood in northern California streams. Journal of Forest Ecology and Management.

Benda, L. E., P. Bigelow, and T.M. Worsley. 2002. Recruitment of wood to streams in old-growth and second-growth redwood forests, Northern California, U.S.A. Canadian Journal of Forest Research 32: 1460-1477.

Benda, L. and T. Cundy. 1990. Predicting deposition of debris flows in mountain channels. Canadian Geotechnical Journal 27(4): 409-417.

Benda, L., M.H. Hassan, M. Church, and C.L. May. 2005. Geomorphology of steepland headwaters: The transition from hillslopes to channels. J. Amer. Water Resources Assoc. 41(4): 835-851.

Benda, L., D. Martin, K. Cummins, J. Bailey, and C. James. (accepted). Toward spatially explicit riparian management. Forest Science.

Benda, L., D. Miller, K. Andras, P. Bigelow, G. Reeves, and D. Michael. 2007. NetMap: A new tool in support of watershed science and resource management. Forest Science 53: 206-219.

Benda, L., D. Milller, J. Sias, D. Martin, R. Bilby, C. Veldhuisen, and T. Dunne. 2003. Wood recruitment processes and wood budgeting. Pp. 49-73 in: S. V. Gregory, K. Boyer, and A. M. Gurnell, eds. The Ecology and Management of Wood in World Rivers. American Fisheries Society, Bethesda, MD.

Benda, L. and J. Sias. 2003. A quantitative framework for evaluating the wood budget. Journal of Forest Ecology and Management 172 (1): 1-16.

Beneger, J.R. 2011. Evaluation of constructed wood jams in a forest, graveled stream. Master of Science Thesis. Humboldt State University, Arcata, CA. 108 p.

Berg, N., A. Carlson, and D. Azuma. 1998. Function and dynamics of woody debris in stream reaches in the central Sierra Nevada, California. Canadian Journal of Forest Research 55: 1807-1820.

Beschta, R.L., M.R. Pyles, A.E. Skaugset, and C.G. Surfleet. 2000. Peakflow response to forest practices in the western Cascades of Oregon, USA. Journal of Hydrology 233: 102-120.

Bilby, R. E., J. T. Heffner, B. R. Fransen, J. W. Ward, and P. A. Bisson. 1999. Effects of immersion in water on deterioration of wood from five species of trees used for habitat enhancement projects. North American Journal of Fisheries Management 19: 687-695.

Bilby, R. E. and J. W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. Transactions of the American Fisheries Society 118: 368-378.

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dolloff, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski, and J.R. Sedell. 1987. Pp. 143-190 in: Salo, E.O. and T.W. Cundy, eds. Large woody debris in forested streams in the Pacific Northwest: past, present and future. Streamside Management: Forestry and Fishery Interactions. Institute of Forest Resources Contribution Number 57. Seattle, WA: University of Washington.

Bisson, P.A., B.E. Rieman, C. Luce, P.F. Hessburg, D.C. Lee, J.L. Kershner, G.H. Reeves, and R.E. Gresswell. 2003. Fire and aquatic ecosystems of the western USA: Current knowledge and key questions. Forest Ecology and Management 178 (1-2): 213-229.

Bottorff, R.L. and A.W. Knight. 1996. The effects of clearcut logging on stream biology of the North Fork of Caspar Creek, Jackson Demonstration State Forest, Fort Bragg, CA -- 1986 to 1994. Final Report prepared for the California Department of Forestry and Fire Protection, Contract No. 8CA63802. Sacramento, CA. 177 p.

Boyd, M. and B. Kasper. 2003. Analytical methods for dynamic open channel heat and mass transfer: Methodology for heat source model Version 7.0. Oregon Department of Environmental Quality, Salem, OR.

Bragg, D. C., L. Kershner, and D. W. Roberts. 2000. Modeling large woody debris recruitment for small streams of the central Rocky Mountains. U. S. Department of Agriculture, Rocky Mountain Research Station, Fort Collins, CO. General Technical Report RMRS-GTR-55. 36 p.

Brake, D., M. Molnau, and J.G. King. 1997. Sediment transport distances and culvert spacings on logging roads within the Orgeon Coast Mountain Range. Presented at the 1997 American Society of Agricultural Engineers (ASAE) Annual International Meeting. Paper 975018. St. Joseph, MI. 12 p.

Brown, G.W. 1980. Forestry and water quality. Oregon State University Book Stores, Inc. School of Forestry. Oregon State University, Corvallis, OR. 124 p.

Burnett, K. M. and D. J. Miller. 2007. Streamside policies for headwater channels: an example considering debris flows in the Oregon coastal province. Forest Science 53: 239-253.

Burnett, K.M., G.H. Reeves, D.J. Miller, S. Clarke, K. Vance-Borland, and K. Christiansen. 2007. Distribution of salmon-habitat potential relative to landscape characteristics and implications for conservation. Ecological Applications 17(1): 66-80.

Cafferata, P.H. 1990. Watercourse temperature evaluation guide. Unpublished report prepared for the California Department of Forestry. Sacramento, CA. 13 p.

Cafferata, P., M. Berbach, J. Burke, J. Hendrix, R. Klamt, R. Macedo, T. Spittler, K. Vyverberg, and C. Wright-Shacklett. 2005. Flood prone area considerations in the coast redwood zone. Final Report of the Riparian Protection Committee. California Department of Forestry and Fire Protection. Sacramento, CA. 67 p.

Caldwell, J. E., K. Doughty, and K. Sullivan. 1991. Evaluation of downstream temperature effects of type 4/5 waters. Washington Department of Natural Resources, Olympia, WA. 71 p. plus appendices.

California Department of Fish and Game (DFG). 2004. Recovery strategy for California coho salmon. Report to the California Fish and Game Commission. 594 p.

California Department of Fish and Game (DFG). 2010. California salmonid stream habitat restoration manual, 4th Edition. Sacramento, CA.

California Department of Forestry and Fire Protection and California Department of Fish and Game (CAL FIRE and DFG). 2010. Anadromous salmonid protection rules: interpretive questions and answers for RPFs and landowners. Sacramento, CA. 63 p.

Campbell, R., J. Dieu, D. Glass, B. Gustavson, J. Thompson, J. Light, M. Liquori, K. Sullivan and B. Rowe. 1997. Habitat status of streams on state and private lands in the state of Washington, Washington Forest Protection Association. Olympia, WA. 77 p.

Castelle, A.J. and A.W. Johnson 2000. Riparian vegetation effectiveness. NCASI Technical Bulletin No. 799. 26 p.

Cederholm, C. J., R. E. Bilby, P. A. Bisson, T. W. Bumstead, B. R. Fransen, W. J. Scarlett, and J. W. Ward. 1997. Response of juvenile coho salmon and steelhead to placement of large woody debris in a coastal Washington stream. North American Journal of Fisheries Management 17: 947 - 963.

Central Coast Regional Water Quality Control Board (CCRWQCB). 2005. Standard operating procedure 5.2.3. Photo documentation procedure. San Luis Opisbo, CA. 10 p. Available online at: http://www.waterboards.ca.gov/centralcoast/board_info/agendas/2005/feb/item4/item4_attach2b.pdf

Chan, S., P. Anderson, J. Cissel, L. Larsen, and C. Thompson. 2004. Variable density management in riparian reserves: lessons learned from an operational study in managed forests of western Oregon, USA. For. Snow Landsc. Res. 78(1/2): 151–172.

Charron, I. and E. A. Johnson. 2006. The importance of fires and floods on tree ages along mountainous gravel-bed streams. Ecological Applications 16: 1757-1770.

Clary, W. P., and B. F. Webster. 1989. Managing grazing of riparian areas in the Intermountain Region. General Technical Report INT-263. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT. 11 p.

Cummins, K. W. 2002. Riparian-stream linkage paradigm. Verh. Internat. Verein. Limnol. 28: 49-58.

Cummins, K. W., M. A. Wilzbach, D. M. Gates, J. B. Perry, and W. B. Talliaferro. 1989. Shredders and riparian vegetation. BioScience 39: 24-30.

Danehy, R.J., S.S. Chan, G.T. Lester, R.B. Langshaw, and T.R. Turner. 2007. Periphyton and macroinvertebrate assemblage structure in headwaters bordered by mature, thinned, and clearcut Douglas-fir stands. Forest Science 53(2): 294-307.

Dent, L., D. Vick, K. Abraham, S. Schoenholtz, and S. Johnson. 2008. Summer temperature patterns in headwater streams of the Oregon Coast Range. Journal of the American Water Resources Association 44: 803-813.

DeWalle, D. R. 2010. Modeling stream shade: riparian buffer height and density as important as buffer width. Journal of the American Water Resources Association 46: 323-333.

Dietrich, W.E., D. Bellugi, and R. Real de Asua. 2001. Validation of the shallow landslide model SHALSTAB for forest management. In M.S. Wigmosta and S.J. Burges (eds.), Land Use and Watersheds: Human influence on hydrology and geomorphology in urban and forest areas. American Geophysical Union Water Science and Application 2: 195-227.

Dietrich, W. E.; J. McKean, D. Bellugi, and T. Perron. 2007. The prediction of shallow landslide location and size using a multidimensional landslide analysis in a digital terrain model. In: C.L. Chen and J.J. Major, eds. Proceedings of the Fourth International Conference on Debris-Flow Hazards Mitigation: Mechanics, Prediction, and Assessment (DFHM-4); Chengdu, China, September 10-13, 2007. The Netherlands, Amsterdam: IOS Press. 12 p.

Dwire, K.A., and J.B. Kauffman. 2003. Fire and riparian ecosystems in landscapes of the western USA. Forest Ecology and Management 178: 61-74.

Dwire, K.A., C.C. Rhoades, and M.K. Young. 2010. Potential effects of fuel management activities on riparian areas. In: Elliot, W.J.; Miller, I.S.; Audin, L., eds. Cumulative watershed effects of fuel management in the

western United States. Gen. Tech. Rep. RMRS-GTR-231. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 175-205.

Everest, F.H. and G.H. Reeves. 2007. Riparian and aquatic habitats of the Pacific Northwest and southeast Alaska: ecology, management history, and potential management strategies.. Gen. Tech. Rep. PNW-GTR-692. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 130 p.

Everett, R., R. Schellhaas, P. Ohlson, D. Spurbeck, and D. Keenum. 2003. Continuity in fire disturbance between riparian and adjacent sideslope Douglas-fir forests. Forest Ecology and Management 175: 31-47.

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic, and social assessment. Report of the Forest Ecosystem Management Assessment Team. U.S. Government Printing Office 1993-793-071.

Ferguson, L. 2005. Quantification of the role of large woody debris for coho habitat restoration. M.S. thesis, University of California, Davis. 60 p.

FishNet 4C. 2004. County road maintenance guidelines for protecting aquatic habitat and salmon fisheries. Fisheries network of the central California coastal counties. Petaluma, CA. Available online at: http://www.fishnet4c.org/projects_roads_manual.html

FISRWG (Federal Interagency Stream Restoration Working Group). 1998. Stream corridor restoration: principles, processes, and practices. FISRWG--15 Federal agencies of the US government. GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN 3/PT.653. ISBN-0-934213-59-3.

Franklin, J. F., T. A. Spies, R. Van Pelt, A.B. Carey, D.A. Thornburgh, D.R. Berg, D.B. Lindenmayer, M.E. Harmon, W.S. Keeton, D.C. Shaw, K. Bible, and J. Chen. 2002. Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. Forest Ecology and Management 155: 399-423.

Gary, D.H. and R.B. Sotir. 1996. Biotechnical and soil bioengineering slope stabilization: a practical guide for erosion control. New York: John Wiley and Sons, Inc. 400 p.

Gomi, T., R.D. Moore, and A.S. Dhakal. 2006. Headwater stream temperature response to clear-cut harvesting with different riparian treatments, coastal British Columbia. Wat. Resour. Res. 42: W08437.

Gomi, T., R. D. Moore, and M. A. Hassan. 2005. Suspended sediment dynamics in small forest streams of the Pacific Northwest. Journal of the American Water Resources Association 41: 877-898.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones. BioScience 41: 540-551.

Hall, F.C. 2001. Photo point monitoring handbook: part A—field procedures. Gen. Tech. Rep. PNW-GTR-526. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 48 p.

Holtby, L.B. 1988. Effects of logging on stream temperatures in Carnation Creek, British Columbia, and associated impacts on the coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 45: 502-515.

Hoover, S., L. Shannon, and J. Ackerman. 2007. The effect of riparian condition on invertebrate drift in mountain streams. Aquat. Sci. 69: 544-553.

Ice, G.G. 2000. The use of active watershed management to achieve or accelerate the accomplishment of watershed goals. In: Proceedings of Watershed Management and Operations Management. American Society of Civil Engineers (ASCE). June 20-24, 2000. Fort Collins, CO. 12 p.

Ice, G.G. 2010. New ideas for riparian and stream management: an evolving science. Unpublished paper presented to the Oregon Society of American Foresters 2010 Annual Meeting and Conference. Forestry from the Ground Up. Albany, OR: April 9-11, 2010. 12 p.

Isaak, D. J. and R. F. Thurow. 2006. Network-scale spatial and temporal variation in Chinook salmon (*Oncorhynchus tshawytscha*) redd distributions: patterns inferred from spatially continuous replicate surveys. Canadian Journal of Fisheries and Aquatic Sciences 63: 285-296.

James, C.E. 2003. Southern exposure research project: a study evaluating the effectiveness of riparian buffers in minimizing impacts of clearcut timber harvest operations on shade-producing canopy cover, microclimate, and water temperature along a headwater stream in northern California. Ph.D. dissertation. University of California, Berkeley. 382 p.

Johnson, S. L. 2004. Factors influencing stream temperatures in small streams: substrate effects and a shading experiment. Canadian Journal of Fisheries and Aquatic Sciences 61: 913-923.

Keller, G. and J. Sherar. (2003. Low volume roads engineering: best management practices field guide. USDS Forest Service/USAID. Available online at: http://ntl.bts.gov/lib/24000/24600/24650/Index_BMP_Field_Guide.htm

Keppeler, E.T., P.H. Cafferata, and W.T. Baxter. 2007. State Forest Road 600: a riparian road decommissioning case study in Jackson Demonstration State Forest. California Forestry Note No. 120. California Department of Forestry and Fire Protection. Sacramento, California. 22 p.

Kiffney, P, and P. Roni. 2007. Relationships between productivity, physical habitat, and aquatic invertebrate and vertebrate populations of forest streams: an information-theoretic approach. Transactions of the American Fisheries Society 136: 1088–1103.

Kobziar, L.N. and J.R. McBride. 2006. Wildfire burn patterns and riparian vegetation response along two northern Sierra Nevada streams. Forest Ecology and Management 222: 254–265.

Kramer, M., A. , M. T. Hansen, and E. Kissinger. 2001. Abiotic controls on long-term windthrow disturbance and temperate rain forest dynamics in Southeast Alaska. Ecology 82: 2749-2768.

Kreutzweiser, D.P., P.K. Sibley, J.S. Richardson, and A.M. Gordon. 2012. Introduction and a theoretical basis for using disturbance by forest management activities to sustain aquatic ecosystems. Freshwater Science 31(1): 224-231.

Ledwith, T.S. 1996. The effects of buffer strip width on air temperature and relative humidity in a stream riparian zone. M.S. thesis. Humboldt State University. Arcata, CA. 88 p.

Lewis, L. 2000. Soil bioengineering: an alternative to roadside management. Tech. Rept. 0077 1801--SDTDC. San Dimas, CA: U.S. Department of Agriculture, Forest Service, Technology and Development Program. 47 p. Available online at: http://www.wsdot.wa.gov/publications/fulltext/Roadside/SoilBioEng.pdf

Lewis, T., D. Lamphear, D. McCanne, A. Webb, J. Krieter, and W. Conroy. 2000. Regional assessment of stream temperatures across northern California and their relationship to various landscape-level and site-specific attributes. Forest Science Project, Humboldt State University Foundation, Arcata, CA. 230 p.

Ligon, F., A. Rich, G. Rynearson, D. Thornburgh, and W. Trush. 1999. Report of the Scientific Review Panel on California forest practice rules and salmonid habitat. Final Report prepared for the California Resources Agency and the National Marine Fisheries Service. Sacramento, CA. 181 p.

Lindquist, J.L. 2004. Precommercial stocking control of coast redwood: a seventeen-year status report (1981-1998). California Forestry Report No. 2. California Department of Forestry and Fire Protection. Sacramento, CA. 24 p.

Liquori, M. K. 2006. Post-harvest riparian buffer response: implications for wood recruitment and buffer design. Journal of American Water Resources Association 42(1): 177-189.

Liquori, M., P. Cafferata, K. Boston, R. Gienger, and D. Hope. 2012. The VTAC committee: developing guidance for an alterative regulatory pathway to the Anadromous Salmonid Protection rules. Pp. 79-89 in: Standiford, R.B., Weller, T.J., Piirto, D.D.; Stuart, J.D, (Technical Coordinators) Proceedings of Coast Redwood Forests in a Changing California: A Symposium for Scientists and Managers. Gen. Tech. Rep. PSW-GTR-238. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

Liquori, M. and C.R. Jackson. 2001. Channel response from shrub dominated riparian communities in eastern Cascade forests and associated effects on salmonid habitat. Journal of the American Water Resources Association 37(6): 1639-1652.

Liquori, M.K., D. Martin, L. Benda, R. Coats, and D. Ganz. 2008. Scientific literature review of forest management effects on riparian functions for anadromous salmonids. Final Report prepared for the California State Board of Forestry and Fire Protection. Sacramento, CA. 328 p.

Lisle, T.E. and M. Napolitano. 1998. Effects of recent logging on the main channel of North Fork Caspar Creek. Pp. 81-85 in: Ziemer, R.R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. General Tech. Rep. PSW GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

Longstreth, D., A. Lukacic, J. Croteau, A. Wilson, D. Hall, P. Cafferata, and S. Cunningham. 2008. Interagency Mitigation Monitoring Program pilot project final report. California Resources Agency, California Environmental Protection Agency, Central Valley Regional Water Quality Control Board, North Coast

Regional Water Quality Control Board, California Department of Fish and Game, California Department of Forestry and Fire Protection, California Geological Survey. Sacramento, CA. 38 p. plus Appendices. Available online at: http://www.fire.ca.gov/CDFBOFDB/PDFS/IMMP_PilotProjectRpt_FinalVer.pdf

MacCraken, J.G., M.P. Hayes, and J.A. Tyson. in review. Stream-associated amphibian response to manipulation of forest canopy shading. PowerPoint presentation of the paper is available online at: http://www.ruraltech.org/video/2012/cmer/04_MacCracken/index.html

MacDonald, L.H. and D.B.R. Coe. 2007. Influence of headwater streams on downstream reaches in forested areas. Forest Science 53(2): 148-168.

MacDonald, L., A. Smart and R. C. Wissmar. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. EPA/910/9-91-001. U.S. Environmental Protection Agency, Region 10. Seattle, WA. 166 p.

Madej, M.A. 2001. Erosion and sediment delivery following removal of forest roads. Earth Surface Processes and Landforms 26: 175-190.

Marquardt, T., T. Hailemariam, and P. Anderson. 2010. Accuracy and suitability of selected sampling methods within conifer dominated riparian zones. Forest Ecology and Management 260: 313–320.

Martin, D. J. 2001. The influence of geomorphic factors and geographic region on large woody debris loading and fish habitat in Alaska coastal streams. North American Journal of Fisheries Management 21: 429-440.

Martin, D. J. and L. E. Benda. 2001. Patterns of instream wood recruitment and transport at the watershed scale. Transactions of the American Fisheries Society 130: 940-958.

Martin, D. J. and R. A. Grotefendt. 2007. Stand mortality in buffer strips and the supply of woody debris to streams in Southeast Alaska. Canadian Journal of Forest Research 37: 36-49.

Martin, D.J. and A. Shelly. 2006. Status and trends of fish habitat condition on private timberlands in southeast Alaska: 2005 summary. Final Report prepared for Sealaska Corporation and the Alaska Department of Natural Resources. Juneau, Alaska. 83 p.

May, C.L. 2002. Debris flows through different forest age classes in the central Oregon Coast Range. J. Am. Water Resour. Assoc. 38(4): 1097–1113.

May, C. L. and R. E. Gresswell. 2003. Large wood recruitment and redistribution in headwater streams in the southern Oregon Coast Range, U.S.A. Canadian Journal of Forest Research 33: 1352-1362.

Mazza, R. 2009. Density management and riparian buffer study in Western Oregon: Phase 1 results, launch of phase 2 [brochure]. Available online at: http://www.fs.fed.us/pnw/pubs/density-management-brochure.pdf

McDade, M.H., F.J. Swanson, W.A. McKee, J.F. Franklin, and J. Van Sickle. 1990. Source distance for coarse woody debris entering small streams in western Oregon and Washington. Canadian Journal of Forest Research 20: 326-330.

McGurk, B.J. 1989. Predicting stream temperature after riparian vegetation removal. Pp. 157-164 in: Abell, D.L., Technical Coordinator. Proceedings of the California Riparian Systems Conference: protection, management, and restoration for the 1990s; 1988 September 22-24; Davis, CA. Gen. Tech. Rep. PSW-GTR-110. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture.

Meleason, M.A., S.V. Gregory, and J.P. Bolte. 2003. Implications of riparian management strategies on wood in streams of the Pacific Northwest. Ecol. Appl. 13: 1212–1221.

Micheli, E.R. and J.W. Kirchner. 2002. Effects of wet meadow riparian vegetation on streambank erosion. 2. Measurements of vegetated bank strength and consequences for failure mechanics. Earth Surface Processes and Landforms 27: 687-697.

Mitchell, S., T. Hailemariam, and Y. Kulis. 2001. Empirical modeling of cutblock edge windthrow risk on Vancouver Island, Canada, using stand level information. Forest Ecology and Management 154: 117-130.

Moldenke, A. and C. Ver Linden. 2007. Effects of clearcutting and riparian buffers on the yield of adult aquatic macroinvertebrates from headwater streams. Forest Science 53(2): 308-319.

Montgomery, D. R., E. M. Beamer, G. R. Pess, and T. P. Quinn. 1999. Channel type and salmonid spawning distribution and abundance. Can. J. Fish. Aquat. Sci. 56: 377-387.

Montgomery, D.R. and J.M. Buffington. 1993. Channel classification, prediction of channel response, and assessment of channel condition. Report TFW-SH10-93-002 prepared for the SHAMW Committee of the Washington State Timber/Fish/Wildlife Agreement. 84 p.

Montgomery, D. R. and J. M. Buffington. 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin 109: 596-611.

Montgomery, D. R., J. M. Buffington, R. D. Smith, K. M. Schmidt, and G. Pess. 1995. Pool spacing in forest channels. Water Resour. Res. 31: 1097-1105.

Moore, D. R., D. L. Spittlehouse, and A. Story. 2005. Riparian microclimate and stream temperature response to forest harvesting: a review. Journal of the American Water Resources Association 41: 813-834.

Moyle, P.B., J.A. Israel, and S.E. Purdy. 2008. Salmon, steelhead and trout in Californa: status of an emblematic fauna. A report commissioned by California Trout. Center for Watershed Sciences, University of California, Davis. 316 p.

Murphy, M.L., and K.V. Koski. 1989. Input and deletion of coarse woody debris in Alaska streams. N. Am. J. Fish. Manag. 9: 427–436.

Murphy, K., T. Rich, and T. Sexton. 2007. An assessment of fuel treatment effects on fire behavior, suppression effectiveness, and structure ignition on the Angora Fire. USDA Forest Service R5-TP-025. Vallejo, CA. 32 p.

Naiman, R.J., P.A. Bisson, R. G. Lee, and M. G. Turner. 1998. Watershed management. Pp. 642-661 in: R.J. Naiman and R.E. Bilby, eds. River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. Springer, New York, NY.

Nakamura, F. and F. J. Swanson. 2003. Dynamics of wood in rivers in the context of ecological disturbance. Pp. 279-298 in: S. V. Gregory, K. L. Boyer, and A. M. Gurnell, eds. The Ecology and Management of Wood in World Rivers. American Fisheries Society, Bethesda, MD.

NMFS (National Marine Fisheries Service). 2012. Recovery plan for central California coast coho Salmon (*Oncorhynchus kisutch*) Evolutionarily Significant Unit. National Marine Fisheries Service, Southwest Region, Santa Rosa, California. Available at: http://swr.nmfs.noaa.gov/recovery/index.htm

North, M., P. Stine, K. O'Hara, W. Zielinski, and S. Stephens. 2009. An ecosystem management strategy for Sierran mixed-conifer forests. Gen. Tech. Rep. PSW-GTR-220. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 49 p.

O'Connor Environmental. 2000. Garcia River large woody debris instream monitoring. Final Report prepared for the Mendocino County Resource Conservation District, Ukiah, CA. 18 p.

O'Connor, M.D. and R.R. Ziemer. 1989. Coarse woody debris ecology in a second-growth Sequoia sempervirens forest stream. Pgs 165-171 in: Abell, D.L., technical coordinator. Proceedings of the California Riparian Systems Conference: protection, management, and restoration for the 1990s; 1988 September 22-24; Davis, CA. General Tech. Rep. PSW-110. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture.

O'Hara, K.L., J.C.B. Nesmith, L. Leonard, and D.J. Porter. 2010. Restoration of old forest features in coast redwood forests using early-stage variable-density thinning. Restoration Ecology 18: 125–135.

Oliver, C. D. and T. M. Hinckley. 1987. Species, stand structure, and silvicultural manipulation patterns for the streamside zone. Pp. 257-276 in: Streamside Management: Forestry and Fishery Interactions. University of Washington, Institute of Forest Resources, Seattle, WA.

Oliver, C.D. and B.C. Larson. 1990. Forest stand dynamics. McGraw-Hill, New York. 467 p.

Oliver, C.D. and B.C. Larson. 1996. Forest stand dynamics, updated edition. New York: John Wiley. 520 p.

Pacific Watershed Associates (PWA). 2005. Evaluation of road decommissioning, CDFG Fisheries Restoration Grant Program, 1998 to 2003. Final Report prepared for the Califonria Department of Fish and Game. Arcata, CA. 81 p.

Paustian, S. J., A. Anderson, D. Blanchet, S. Brady, M. Cropley, J. Edgington, J. Frysell, G. Johnejack, D. Kelliher, M. Kuehn, S. Maki, R. Olsen, J. Seesz, and M. Wolanek. 1992. A channel type users guide for the Tongass National Forest, Southeast Alaska. USDA Forest Service, Alaska Region.

Poor, C.J. and J.J. McDonnell. 2007. The effects land use a stream nitrates. Journal of Hydrology 322: 54-68.

Richardson, J.S., T. M. Hoover, and A. Lecerf. 2009. Coarse particulate organic matter dynamics in small streams: towards linking function to physical structure. Freshwater Biology 54: 2116-2126.

Richardson, J.S., R.J. Naiman, and P.A. Bisson. 2012. How did fixed-width buffers become standard practice for protecting freshwaters and their riparian areas from forest harvest practices? Freshwater Science 31(1): 232-238.

Richardson, J. S., R. J. Naiman, F. J. Swanson, and D. E. Hibbs. 2005. Riparian communities associated with Pacific Northwest headwater streams: assemblages, processes, and uniqueness. Journal of the American Water Resources Association 41: 935-947.

Rieman, B., D. Lee, D. Burns, R. Gresswell, M. Young, S. Stowell, J. Rinne, and P. Howell. 2003. Status of native fishes in the western United States and issues for fire and fuels management. Forest Ecology and Management 178: 197-211.

Roads Riparian Team. 2005. Riparian Restoration: Roads Field Guide. 0577 1801P. San Dimas, CA: U.S. Department of Agriculture, Forest Service, San Dimas Technology and Development Center. 128 p.

Roby, K.B., and D.L. Azuma. 1995. Changes in a reach of a northern California stream following wildfire. Environmental Management 19: 591-600.

Rollerson, T. P., C. M. Peters, and W. J. Beese. 2009. Variable retention windthrow monitoring project: 2001-2010. Final Report, Campbell River, B.C.

Romero, N., R. Gresswell, and J. Li. 2005. Changing patterns in coastal cutthroat trout (*Oncorhynchus clarki clarki*) diet and prey in a gradient of deciduous canopies. Can. J. Fish. Aquat. Sci. 62: 1797–1807.

Roni, P. and T.P. Quinn. 2001. Density and size of juvenile salmonids in response to placement of large woody debris in western Oregon and Washington streams. Can. J. Fish. Aquat. Sci. 58: 282–292.

Rosgen, D. L., 1994. A classification of natural rivers. Catena 22: 169-199.

Rot, B.W., R.J. Naiman, and R.E. Bilby. 2000. Stream channel configuration, landform, and riparian forest structure in the Cascade Mountains, Washington Can. J. Fish. Aquat. Sci. 57: 699-707.

Ryan, D.F. and J.M. Calhoun, tech. eds. 2010. Riparian adaptive management symposium: a conversation between scientists and management. Gen. Tech. Rep. PNW-GTR-830. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 135 p.

Safford, H.D., J.T. Stevens, K. Merriam, M.D. Meyer, and A.M. Latimer. 2012. Fuel treatment effectiveness in California yellow pine and mixed conifer forests. Forest Ecology and Management 274: 17-28.

Sobota, D. J. 2003. Fall direction and breakage of riparian trees along streams in the Pacific Northwest. M.S. thesis. Oregon State University, Corvallis, OR. 126 p.

Spence, B.C., G.A. Lomnicky, R.M. Hughes and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. Funded jointly by the U.S. EPA, U.S. Fish and Wildlife Service and National Marine Fisheries Service. TR-4501-96-6057. Man Tech Environmental Research Services Corp., Corvallis, OR.http://www.nwr.noaa.gov/1habcon/habweb/ManTech/front.htm - TOC 356 p.

Sridhar, V., A. L. Sansone, J. LaMarche, T. Dubin, and D. P. Lettenmaier. 2004. Prediction of stream temperature in forested watersheds. Journal of the American Water Resources Association 40: 197-213.

Steel, E. A., B. E. Feist, D. W. Jensen, G. R. Pess, M. B. Sheer, J. B. Brauner, and R. E. Bilby. 2004. Landscape models to understand steelhead (*Oncorhynchus mykiss*) distribution and help prioritize barrier removals in the Willamette basin, Oregon, USA. Canadian Journal of Fisheries and Aquatic Sciences 61: 999-1011.

Steinblums, I.J., H.A. Froehlich, and J.K. Lyons. 1984. Designing stable buffer strips for stream protection. J. For. 82: 49-52.

Stillwater Sciences. 2008. Lagunitas limiting factors analysis: limiting factors for coho salmon and steelhead. Report prepared for the Marin County Resource Conservation District, Pt. Reyes Station, California. 72 p.

Stone, K.R., D.S. Pilliod, K.A. Dwire, C.C. Rhoades, S.P. Wollarb, and M.K. Young. 2010. Fuel reduction management practices in riparian areas of the western USA. Environmental Management 46: 91–100.

Story, A., R. D. Moore, and J. S. Macdonald. 2003. Stream temperatures in two shaded reaches below cutblocks and logging roads: downstream cooling linked to subsurface hydrology. Canadian Journal of Forest Research 33: 1383-1396.

Sullivan, K., D.J. Martin, R.D. Cardwell, J. E, Toll, and S. Duke. 2000. An analysis of the effects of temperature on salmonids of the Pacific Northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute, Portland, Oregon. 192 p.

Sullivan, K.J., K. Tooley, J.E. Doughty, J.E. Caldwell, and P. Kenudsen. 1990. Evaluation of prediction models and characterization of stream temperature regimes in Washington. Washington State Department of Natural Resources, Timber/Fish/Wildlife Report TWF-WQ3-90-006.

Swales, S. 2010. California forest management practices and the conservation of anadromous salmonids. California Department of Fish and Game. Fisheries Branch Administrative Report 2010-03. Fisheries Branch. Sacramento, CA. 55 p.

Swanson, F. J. 2003. Wood in rivers: a landscape perspective. Pp. 299-314 in: S. V. Gregory, K. L. Boyer, and A. M. Gurnell, eds. The Ecology and Management of Wood in World Rivers. American Fisheries Society, Bethesda, MD.

Swanson, F.J., S.L. Johnson, S.V. Gregory, and S.A. Acker. 1998. Flood disturbance in a forested mountain landscape. Bioscience 48(9): 681-689.

Tabacchi, E., L. Lambs, H. Guilloy, A.M. Planty-Tabacchi, E. Muller, and H. Decamps. 2000. Impacts of riparian vegetation on hydrological processes. Hydrological Processes 14: 2959-2976.

Tague, C., S. Valentine, and M. Kotchen. 2008. Effect of geomorphic channel restoration on streamflow and groundwater in a snowmelt-dominated watershed: Water Resources Research 44, W10415. 10 p.

Teraoka, J.R. and C.R. Keyes. 2011. Low thinning as a forest restoration tool at Redwood National Park. Western Journal of Applied Forestry 26(2): 91-93.

Teti, P.A. and R.G. Pike. 2005. Selecting and testing an instrument for surveying stream shade. BC Journal of Ecosystems and Management 6(2): 1–16.

Thompson, R.P. and C.A. Dicus. 2005. The impact of California's changing environmental regulations on timber harvest planning costs. Final Report prepared for the California Institute for the Study of Specialty Crops and the Forest Foundation. Cal Poly, San Luis Obispo. 40 p.

Thornburgh, D.A., R.F. Noss, D.P. Angelides, C.M. Olson, F. Euphrat, and H.H. Welsh Jr. 2000. Managing redwoods. Pp. 229-261 in: R.F. Noss, ed. The Redwood Forest: History, Ecology and Conservation of the Coast Redwoods. Island Press, Washington D.C.

USFS (U.S. Forest Service). 1995. Ecosystem analysis at the watershed scale, Version 2.2. Portland, OR, USDA.

Van de Water, K. and M. North. 2010. Fire history of coniferous riparian forests in the Sierra Nevada. Forest Ecology and Management 260: 384-395.

Van de Water, K. and M. North. 2011. Stand structure, fuel loads, and fire behavior in riparian and upland forests, Sierra Nevada Mountains, USA; a comparison of current and reconstructed conditions. Forest Ecology and Management 262: 215-228.

Van Sickle, J. and S.V. Gregory. 1990. Modeling inputs of large woody debris to streams from falling trees. Can. J. For. Res. 20: 1593-1601.

Villarian, L., D. Chapin, and J. Jones. 2009. Riparian forest structure and succession in second-growth stands of the central Cascade Mountains, Washington, USA. Forest Ecology and Management 257: 1375–1385.

Waananen, A.O. and J.R. Crippen. 1977. Magnitude and frequency of floods in California. U.S. Geological Survey. Water Resources Investigation 77-21. Menlo Park, CA. 96 p.

Weaver, W. E. and D. K. Hagans. 1994. Handbook for forest and ranch roads: A guide for planning, designing, constructing, reconstructing, maintaining and closing wildland roads. Pacific Watersheds Associates for Mendocino County Resource Conservation District. Ukiah, California. 161 p. Available online at: http://www.krisweb.com/biblio/gen_mcrcd_weaveretal_1994_handbook.pdf

Welty, J.J., T. Beechie, K. Sullivan, D.M. Hyink, R.E. Bilby, C. Andrus, and G. Pess. 2002. Riparian aquatic interaction simulator (RAIS): A model of riparian forest dynamics for the generation of large woody debris and shade. Forest Ecology and Management 162(2-3): 299-318.

WFPB (Washington Forest Practice Board). 1997. Standard methodology for conducting watershed Analysis, Module B-surface erosion; and roads module. Version 4.0. Forest Practice Board. Washington State Department of Natural Resources, Olympia, WA.

WFPB (Washington Forest Practice Board). 2001. Guidelines for large woody debris placement strategies. Board Manual—Section 26. Olympia, WA. 11 p.

WFPB (Washington Forest Practices Board). 2008. Guidelines for alternate plans, Section 21, Board Manual. Olympia, WA. Available online at: http://www.dnr.wa.gov/BusinessPermits/Topics/ForestPracticesRules/Pages/fp_board_manual.aspx

Whiteway, S.L., P.M. Biron, A. Simmermann, O. Venter, and J.W.A. Grant. 2010. Do in-stream restoration structures enhance salmonid abundance? A meta-analysis. Can. J. Fish. Aquat. Sci. 67: 831–841.

Wilzbach, M.A., B.C. Harvey, J.L. White, and R.J. Nakamoto. 2005. Effects of riparian canopy opening and salmon carcass addition on the abundance and growth of resident salmonids. Can. J. Fish. Aquat. Sci. 62: 58-67.

Wipfli, M.S. and J. Musselwhite. 2004. Density of red alder (*Alnus rubra*) in headwaters influences invertebrate and detritus subsidies to downstream fish habitats in Alaska. Hydrobiologia 520: 153-163.

Wooster, J. and S. Hilton. 2004. Large woody debris volumes and accumulation rates in cleaned streams in redwood forest in southern Humboldt County, California. Res. Note PSW-RN-426. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. 16 p.

Young, K.A. 2000. Riparian zone management in the Pacific Northwest: Who's cutting what? Environ. Manage. 26(2): 131–144.

Young, K.A. 2001. A review and meta-analysis of the effects of riparian zone logging on stream ecosystems in the Pacific Northwest. Centre for Applied Conservation Research, Forest Sciences Department, University of British Columbia. 33 p.

Zwieniecki, M.A. and M. Newton. 1999. Influence of streamside cover and stream features on temperature trends in forested streams of western Oregon. Western Journal of Applied Forestry 14(2): 106-113.

X. APPENDICES

APPENDIX A— ANALYTICAL PATHWAYS

A-1. PATHWAY 1) CLASSIFICATION MATRIX APPROACH

A-2. PATHWAY 2) SITUATIONAL SCENARIOS APPROACH

A-3. PATHWAY 3) ANALYTICAL DESIGN PROCESS APPROACH

APPENDIX B—PRE-CONSULTATION GUIDELINES

Appendix C—Section V RULE LANGUAGE

APPENDIX D— MAP of the ASP Rule Geographic Scope

APPENDIX E—WATERSHED CONTEXT INFORMATION

APPENDIX F—CHANNEL TYPE DEFINITIONS AND DIAGRAMS

APPENDIX G—GLOSSARY

APPENDIX A-1. PATHWAY 1) CLASSIFICATION MATRIX APPROACH

The Classification Matrix Approach involves a three-step process that evaluates existing site conditions, identifies functional objectives, and develops site prescriptions based on those objectives. This approach is generally more appropriate at the stream reach scale (e.g., 1,000 feet), and not for large watershed assessments (e.g., 20 square miles). Pathway 3) is more applicable for riparian designs prescribed across wide spatial scales.

STEP 1) EVALUATE EXISTING SITE CONDITIONS

This step requires an assessment of existing site conditions from available field surveys, maps, aerial photos, GIS layers, and other data sources. Each stream segment where site-specific management is proposed within the THP area should be classified according to the specific criteria described below.

Riparian Vegetation Classification

The purpose of riparian classification is to identify the likely conditions that will supply wood, heat, and nutrients to the site. The following riparian classification is modified from WFPB (1997), and includes the following elements:

Composition of Vegetation (based on stem count)

- Conifer (C) [≥70% coniferous species], or
- Hardwood (H) [≥ 70% hardwood species], or
- Mixed (M) [all other cases].

Relative Tree Size

The tree size reflects the relative tree diameter necessary to function in a given geomorphic channel class (or stream size with a given bankfull channel width). Specific diameter classes can be established using Figure 3 (from Bilby and Ward 1989) to identify the size of dominant (or intermediate/suppressed) trees.[6] The sub-classes are defined as follows:

- Smaller than functional (S), or
- Larger than functional (L), or
- Mixed (M).

For example, for a watercourse channel with a bankfull channel width of 50 feet, the relative tree diameter necessary to function as large wood would need to be approximately 24 inches, based on the relationships displayed in Figure 3 (see red arrows). If the dominant conifer tree diameter in the stand is greater than 24 inches, the relative tree size is called "larger than

[6] Mortality-driven wood supply often comes from below, and thus size classifications to intermediate and/or suppressed trees may also be considered.

functional." If the dominant conifer tree size is less than 24 inches, it is called "smaller than functional."

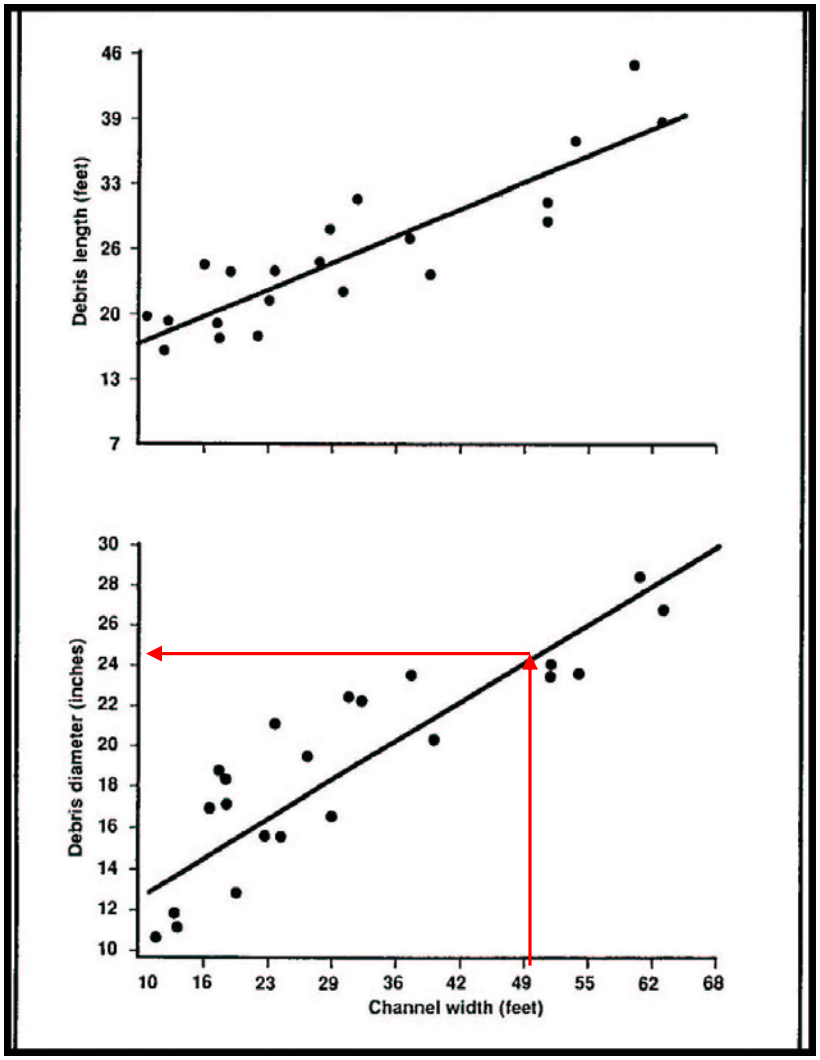


Figure 3. Plots of large wood length (top) and diameter (bottom) vs channel width (from Bilby and Ward 1989).

Relative Stand Density

The stocking level sub-classification describes a generalized condition of stand growth and mortality dynamics. The classes include:

- Differentiating (dense, active mortality) – (D), or
- Fully stocked (moderate, mortality eminent) – (F), or
- Under stocked (open, active growth) – (U).

The classifications described above require a basic understanding of silviculture and natural stand dynamics (see Oliver and Larsen 1996). Relative Stand Density conditions vary by species and stand age assemblages.

Differentiating (dense) stands are those that are generally experiencing sufficient competition-induced mortality as to provide the potential for natural wood recruitment as trees die or become weakened (and thus prone to toppling). In such cases, the mortality class comes primarily from sub-dominant trees if they are to provide sufficient quality as large woody debris. Small intermediate and suppressed trees generally provide poor quality woody debris.

Fully Stocked (moderate) stands are those that may not be experiencing active competition-induced mortality, but that are experiencing a sufficient reduction in growing space as to expect mortality to begin before the next anticipated harvest cycle. In such cases, the tree sizes that are expected to occur at or near the time of mortality should be of sufficient size to function as high-quality woody debris.

Under Stocked (open) stands are those that have an excess of available growing space such that trees are unlikely to experience much mortality for some period of time (generally exceeding that of the next anticipated harvest cycle).

Inherent in this classification is a general condition that describes the site's existing condition/trajectory and ability to influence riparian functions (e.g., wood supply, nutrient supply, and thermal loading) and disturbance risks (e.g., fire, wind, flood, etc.).

Geomorphic Classification

The geomorphic classification encompasses several factors into a simple analytical tool that can be utilized in the field, using aerial photographs, and/or using GIS tools. Geomorphic classification will be attributed to channel segments with consistent geomorphic conditions. The metrics used will inherently describe relative channel sensitivity, habitat types, transport potential for sediment and wood, habitat effects, etc. The classification should include both stream geomorphic criteria and specific biological hotspot criteria. Geomorphic classification may require evaluation of contributing upslope areas as well as downstream delivery of functional outputs (i.e., wood, water, sediment, nutrients, and heat).

There are several types of geomorphic stream classification that can be considered or adopted. Simple classes can be developed that roughly describe conditions using factors like slope, channel confinement, and channel width (WFPB 1997). Others may be adopted (e.g., Montgomery and Buffington 1997, Rosgen 1994), but require additional technical training to correctly identify in the field.[7] Numerous GIS applications that provide channel classification

[7] Montgomery and Buffington (1997) includes photographs and detailed descriptions of the different channel types (see Appendix E). This paper is available online at: http://www.fs.fed.us/rm/boise/publications/watershed/rmrs_1997_montomeryr001.pdf

tools may also be developed or adopted if a standardized approach is desired. In the example used herein, we apply a typing system that combines stream size (based on channel width or regionally calibrated basin areas) with the Montgomery-Buffington classification (Appendix F).

In general, confinement can be defined as:

Confined: [Valley Floor Width (VW) < 2 Bankfull Channel Widths (CW)]
Moderately Confined: [2 Bankfull Channel Widths (CW) < Valley Floor Width (VW) < 4 Bankfull Channel Widths (CW)]
Unconfined: [Valley Floor Width (VW) > 4 Bankfull Channel Widths (CW)]

Channel gradient and typical channel bed morphology can generally be defined as:
<1% (pool riffle),
1-2% (pool riffle, plane bed),
2-4% (plane bed, forced pool riffle),
4-8% (step pool),
8-20% (cascade), and
>20% (colluvial).

Biological-Geomorphic Hotspots

Biological-geomorphic hotspots are landscape features that typically represent areas with enhanced ecological or geomorphic function (Liquori et al. 2008). Analysis of contributing upslope areas may be required to properly identify these features. Such features include debris flow source areas, floodplains, confluence zones, alluvial fans, side channels, and off-channel habitats. The locations, distribution, and size of these features are generally predictable, as they are a result of interactions among landforms and geomorphic processes.

- **Debris flow source areas** – channels that link steep, unstable hillslopes prone to generating debris flows (defined by a Certified Engineering Geologist (CEG) or Professional Geologist (PG)) to downstream fish-bearing channels. The channel links must connect at confluence angles <70% to be part of the source area.[8] In these areas, sufficient sources of riparian wood can be important to downstream wood recruitment.

- **Debris and alluvial fans** – low gradient (<6%) tributary junctions with confluence angles >70%.[9]

---

[8] May (2002) identified a correlation between the volume of sediment generation and the run-out length of debris-flows, which is a function of the stream channel gradient and tributary junction angles (Benda and Cundy 1990).

[9] Confluence angles are defined as the angle formed by the junction of two streams. High confluence angles (typically exceeding about 70%) are generally prone to deposition at or near the confluence. Lower confluence angles typically carry debris into downstream reaches (see Figure 4).

- **Tributary junctions** – Class II watercourses at the confluence of one (or more) Class I watercourses.

- **Class II transitions** – Larger Class II watercourses functionally connected to or extending upstream from the end of Class I watercourses.

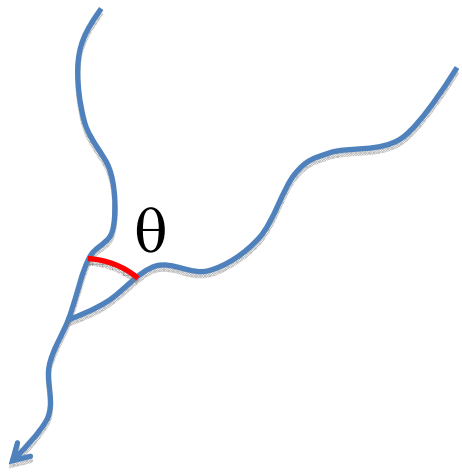
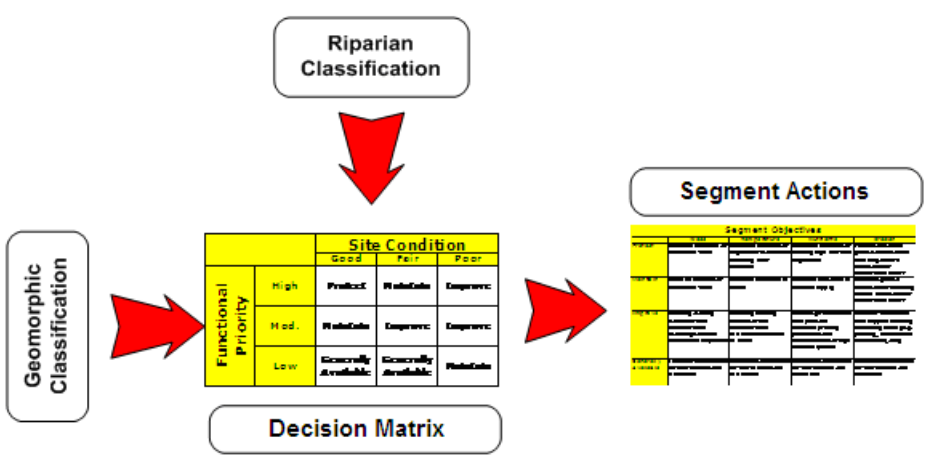


Figure 4. Confluence angle is defined as the angle at which two watercourses intersect. Typically confluence angles above 70 degrees are more depositional than those below 70 degrees (Benda and Cundy 1990).

STEP 2) IDENTIFY FUNCTIONAL OBJECTIVES

The Classification Matrix procedure applies a series of ratings derived from the classifications made during step 1 to identify functional objectives for the riparian design. There are four matrix (tables) that are used to determine stream segment actions. In order, these are: (A) geomorphic (channel classification) function priority matrix, (B) riparian site condition classification matrix, (C) segment decision matrix, and (D) segment actions matrix. This approach is diagramed below and is explained in the sections that follow.



2A. Geomorphic (Channel Classification) Functional Priority Rating Matrix

The Geomorphic (Channel Classification) Functional Priority Rating Matrix [10] uses the geomorphic typing determined in step 1 to identify appropriate functional response priorities for wood supply, thermal loading, nutrient supply, and erosion risk (Table 4). Functional priority ratings estimate the probable riparian function dependence on any given exchange function *for a given stream type*. These ratings are derived from generalized relationships between geomorphic functions and processes, and their relationship to aquatic habitat responses. The purpose of Table 4 is to provide RPFs with a tool for estimating the likely dependence in the absence of more specific evidence or limited expertise in riparian/stream ecology. The ratings provided in Table 4 are generalized and may not apply in all situations (and thus should be validated by a subject expert where possible).

For example, if the channel geomorphic classification was determined to be forced pool riffle and plane bed (using the Montgomery and Buffington (1997) classification system) for a medium sized [11] Class I fish-bearing watercourse, the functional priority ratings for wood, temperature, nutrients, and erosion are either high or moderate (see the red arrows and box in Table 4).

---

[10] The tables presented here represent a preliminary draft, subject to additional refinement by cross-referencing against existing literature (including Liquori et al. 2008).

[11] Class I channel size is determined by drainage area, bankfull channel width, channel confinement, and stream order. In general, low order streams are small Class I watercourses (typically 250 to 2,500 acres drainage area, confined or moderate confinement, 10-20 ft bankfull channel width, and second or third order). Large Class I watercourses would be expected to be significant rivers (typically > 25,000 acres drainage area, unconfined, > 50 feet bankfull channel width, and fourth or fifth order). Medium Class I watercourses have intermediate characteristics (typically 2,500 to 25,000 acres drainage area, moderate confinement or unconfined, 20-50 feet bankfull channel width, third to fourth order).

Table 4. Geomorphic (channel classification) functional priority rating matrix (see Appendix F).

			Functional Priority Rating			
Class	**Size**	**Type***	**Wood**	**Temperature**	**Nutrients**	**Erosion**
I	Large	Regime	Moderate	Low	Low	High
		Braided	Moderate	Low	Low	High
		Pool Riffle	High	Low	Low	High
	Medium	Regime	Moderate	Moderate	High	High
		Braided	Moderate	Moderate	High	High
		Pool Riffle	Moderate	Moderate	High	High
		Forced Pool Riffle	High	Moderate	High	High
		Plane Bed	High	High	High	Moderate
		Step-Pool	Moderate	High	Moderate	Low
		Cascade	Low	High	Moderate	Low
	Small	Pool Riffle	High	High	High	High
		Forced Pool Riffle	High	High	High	High
		Plane Bed	High	High	High	Moderate
		Step-Pool	Moderate	High	Moderate	Low
		Cascade	Low	High	Moderate	Low
II	All	Pool Riffle	Moderate	Moderate	Moderate	High
		Forced Pool Riffle	High	Moderate	Moderate	High
		Plane Bed	Low	Moderate	Low	Moderate
		Step-Pool	Low	Moderate	Low	Low
		Cascade	Low	Moderate	Low	Low
III	All	Colluvial	Varied	Moderate	Low	Varied
Hotspots	All	Debris Flow Sources	High	Moderate	Low	High
		Debris/alluvial Fans	High	Moderate	Low	High
		Tributary Junctions	Moderate	Moderate	High	Moderate
		Class II Transition	Low	High	High	Moderate
		Sensitivity Zone	**75% SPTH**	**33 feet**	**66 feet**	**Variable** *(min 33 feet)*

2B. Riparian Site Conditions Classification Matrix

The Riparian Site Conditions Classification Matrix (Table 5) is used to identify existing functional response potential for wood supply, thermal loading, and nutrient supply. Inherent Functional Levels estimate the probable riparian function dependence on any given exchange function *for a given riparian condition*. For example, an understocked (U) hardwood stand (H) dominated by small trees (S) relative to the stream size (see Figure 3) would have an existing condition that is poor relative to potential wood recruitment, good with respect to nutrient dynamics, and moderate with respect to thermal loading (temperature dependence on riparian canopy) (see the red arrow and box in Table 5). In this case, Table 5 informs us that improving wood supply is very important, nutrient supply is currently adequate, and shading to regulate thermal loading is marginally acceptable.

These ratings are derived from generalized relationships between known riparian functions and processes, as well as their relationship to aquatic habitat responses, and therefore should be considered preliminary until empirically validated. Table 5 provides a rapid assessment tool for the RPF to assign Inherent Functional Levels for each riparian reach associated with a given project.

The site condition for erosion is independent of the riparian classification. Instead, the erosion site condition classification can be drawn from geomorphic criteria. Potential criteria may

include the degree of channel incision, channel stability indices, gravel embeddedness, pool filling, sediment supply, or other factors to be developed.

Riparian Class			Inherent Functional Levels		
			Wood Supply	Nutrient Supply	Thermal Loading
C	S	D	Moderate	Poor	Good
C	S	F	Poor	Poor	Good
C	S	U	Poor	Moderate	Moderate
C	L	D	Good	Moderate	Good
C	L	F	Good	Moderate	Good
C	L	U	Moderate	Moderate	Moderate
C	M	D	Good	Moderate	Good
C	M	F	Good	Moderate	Good
C	M	U	Moderate	Moderate	Moderate
H	S	D	Moderate	Good	Good
H	S	F	Poor	Good	Good
H	S	U	Poor	Good	Moderate
H	L	D	Moderate	Good	Good
H	L	F	Poor	Good	Good
H	L	U	Poor	Good	Moderate
H	M	D	Moderate	Good	Good
H	M	F	Poor	Good	Good
H	M	U	Poor	Good	Moderate
M	S	D	Moderate	Moderate	Good
M	S	F	Moderate	Moderate	Good
M	S	U	Poor	Good	Moderate
M	L	D	Good	Moderate	Good
M	L	F	Good	Good	Good
M	L	U	Moderate	Good	Moderate
M	M	D	Good	Good	Good
M	M	F	Good	Good	Good
M	M	U	Moderate	Good	Moderate

Table 5. Riparian site conditions classification matrix.

RIPARIAN CLASS KEY:

Composition of Vegetation (left column)

C = Conifer [≥70% conifer]

H = Hardwood [≥ 70% hardwood]

M = Mixed [all other cases]

Relative Tree Size (middle column)

S = Smaller than functional

L = Larger than functional

M = Mixed

Relative Stand Density (right column)

D = Differentiating (dense, active mortality)

F = Fully Stocked (moderate, mortality eminent)

U = Under stocked (open, active growth)

2C. Segment Decision Matrix

The results from the Riparian Site Conditions Classification Matrix and from the Geomorphic (Channel Classification) Functional Priority Matrix are then combined to identify specific functional objectives for each riparian exchange function (wood supply, nutrient supply, thermal loading, and erosion) in each watercourse segment of the THP being considered for a site-specific proposal utilizing the Section V(3) full justification pathway. Using the Segment Decision Matrix (Table 6), the site design identifies the level of protection or enhancement required for each function.

Using the results of the examples provided in sections 2A and 2B above, with a rating of poor for wood supply from the Riparian Site Conditions Classification Matrix and a rating of high for wood for functional priority from the Geomorphic (Channel Classification) Functional Priority

Matrix, the result is “improve for large wood loading” (see the red arrow and box in Table 6). This type of analysis provides reasonable justification for an RPF to propose a site-specific proposal to improve wood loading for this location.

Table 6. Segment decision matrix.

Channel Classification	Functional Priority	Riparian Classification: Site Condition – Good	Fair	Poor
	High	Protect	Maintain	Improve
	Mod.	Maintain	Improve	Improve
	Low	Generally Available	Generally Available	Maintain

Wood	Temperature	Nutrients	Erosion

The levels of protection or enhancement are described as follows:

- **Generally Available** – These sites offer the greatest opportunity for management activities with the least risk to functional impacts. Such sites could provide opportunities to balance the spatial distribution of various treatments across an entire treatment area.

- **Protect** – These sites reflect areas that are highly functional within sensitive areas. Harvest strategies should be targeted that protect these sites with minimal treatment.

- **Maintain** – These sites offer opportunities to maintain existing functions with minor (modest) treatments directed to promote future “good” conditions.

- **Improve** – These sites offer the best opportunities to improve site conditions with limited risk of impacts. Such locations may benefit by aggressive treatments with appropriate analytical support required.

2D. Segment Action Matrix

The Segment Decision Matrix then defines generalized site objectives for each riparian exchange function, as illustrated in Table 7.

Table 7. Segment action matrix.

Typical Segment Actions				
	Wood	**Temperature**	**Nutrients**	**Erosion**
Protect	Maximize retention of recruitable wood	Maximize retention of vegetation that blocks incoming solar radiation	Maximize retention of existing high nutrient vegetation	Prevent and avoid ground disturbances that may disturb banks and/or concentrate runoff
Maintain	Limit removal of recruitable wood	Limit reduction in shade	Limit reduction in nutrient supply	Limit ground disturbances that may disturb banks and/or concentrate runoff
Improve	Use Silvicultural treatments (e.g., thinning, underplanting, etc) to achieve desired improvements (e.g. increase growth, affect mortality trends, etc)	Carefully identify individual tree selection that encourages growth of shade-producing vegetation	Encourage treatments that promote balanced primary production and establishment of high-nutrient species	Consider treatments that support recovery of eroding lands (e.g. planting, biotechnical stabilization, etc)
Generally Available	Treatment constraints for this function are minimized	Treatment constraints for this function are minimized	Treatment constraints for this function are minimized	Treatment constraints for this function are minimized

Carrying forward the results of the example discussed in sections 2A, 2B, and 2C above, the segment objectives for improving large wood loading includes using silvicultural treatments to achieve desired enhancements in riparian stand conditions (this might include a low thinning, for example) (see the red box in Table 7).

Note that in many cases, there may be conflicts between and among functional priorities. For example, a segment may require a "Protect" action for Wood and an "Improve" strategy for Nutrient Supply, which can result in opposing prescriptions. To accommodate such conflicts, the relative priorities among riparian exchange functions (e.g., wood, thermal regulation, nutrients, and temperature) can be distributed spatially across the site in a manner that takes advantage of the unique site characteristics.

STEP 3) SITE PRESCRIPTIONS

Given the objectives described above, the RPF can apply their professional judgment to establish the appropriate level of protections to each segment. If desired, additional guidance can be provided by technical specialists. Other resources appropriate for developing prescriptions can be found under Pathways 2 and 3 in the following appendices. The potential for misapplication with this pathway is minimized by the need to provide multiple levels of protection at a site, as well as with the THP Review Team approval process. In some locations, riparian buffers may be wider or narrower than the standard California Forest Practice Rule requirements, dependent upon the necessary functions required of the site being evaluated.

EXAMPLE OF PATHWAY 1) CLASSIFICATION MATRIX APPROACH

East Branch of Soquel Creek, Santa Cruz County

Brief Watershed Context Assessment

The Soquel Creek watershed is located in the Santa Cruz Mountains, near the city of Santa Cruz (Figure 5). The watershed covers approximately 27,000 acres (42.2 square miles), and empties into Monterey Bay in the town of Capitola. Prior to using the Classification Matrix Approach to determine appropriate management actions to enhance habitat for listed salmonids in Soquel Creek, a rapid watershed context assessment was conducted.

Existing watershed assessments and studies reviewed included the NMFS Central California Coast (CCC) coho salmon recovery plan (NMFS 2012), the Soquel Creek Watershed Assessment and Enhancement Plan (RCDSCC 2003), and Lassettre and Kondolf's (2003) report titled *Process Based Management of Large Woody Debris at the Basin Scale*. The NMFS (2012) coho recovery plan shows that the East Branch of Soquel Creek is the least developed portion of the basin and a priority area for coho protection and restoration (Figure 5).

The RCDSCC (2003) watershed assessment and enhancement plan reported that the highest densities of young-of-the-year steelhead, also federally listed, occur on the Soquel Demonstration State Forest (SDSF) portion of the East Branch of Soquel Creek. This part of the East Branch was stated as being the primary spawning grounds for steelhead in the Soquel Creek watershed. Low summer baseflow has been found to reduce juvenile steelhead growth rates, with conservation and preservation of baseflow one of the assessment recommendations.

Several watershed assessments have reported that the Soquel Creek basin has a long history of wood removal work, since past large flood events have produced wood jams at downstream culverts and bridges. Multiple studies and assessments have shown that large wood loading is very low in the basin (e.g., Lassettre and Kondolf 2003). The NMFS (2012) coho recovery plan lists large wood loading and off-channel/floodplain quality as poor. Three of the highest priority actions for restoration to prevent coho extinction in the Soquel Creek watershed include: (1) increasing the quantity of off-channel habitat, (2) increasing the amount of large wood in the channel, and (3) improving floodplain connectivity to provide rearing habitat (NMFS 2012). A PowerPoint presentation with photographs, figures, and diagrams for this example is available at:
http://www.bof.fire.ca.gov/board_committees/vtac/vtac_powerpoints/vtac_powerpoints/pilotprojectprotocolebsoquelexample-final.pdf.

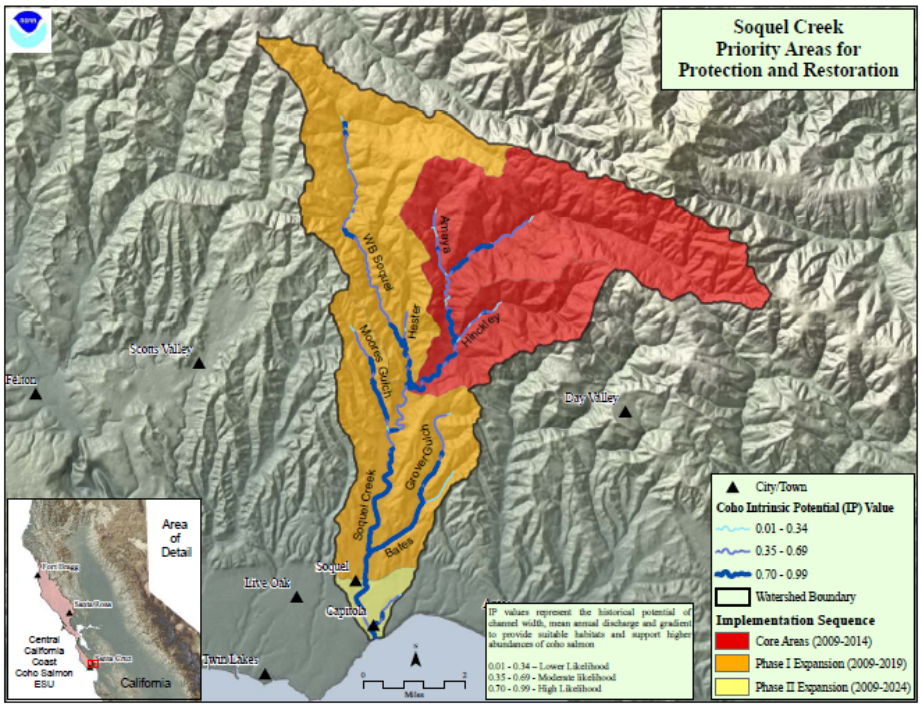


Figure 5. Priority areas for coho salmon protection and restoration for the Soquel Creek watershed (East Branch shown as a core area in red) (from NMFS 2012).

STEP 1) EVALUATE EXISTING SITE CONDITIONS

Existing site conditions along a 0.7 mile reach of the East Branch of Soquel Creek within SDSF were evaluated with field surveys, maps, and aerial photographs.

Relative Vegetation Classification

- Composition of Vegetation—The riparian vegetation is primarily conifer along the East Branch, with a large deciduous component below the Fern Gulch confluence. Conifer trees make up <70% of the tree stems in the riparian zone, as do hardwood stems; hence the vegetation is classified as "mixed."

- Relative Tree Size—The dominant WHR class in the 300 ft wide late succession management area along the East Branch of Soquel Creek is 4D (11-24 in QMD and canopy cover >60%). The mean bankfull channel width is approximately 50 feet, requiring a large wood diameter of approximately 26 inches using Figure 3 in the

Pathway 1 description (assumed to be applicable to the central part of the California Coast Ranges). Therefore, the conifers were classified as smaller than functional.[12]

- Relative Stand Density—Due to the relatively open spacing of the coast redwood and infrequent Douglas-fir trees present in the flood prone area along the East Branch of Soquel Creek, the relative stand density was classified as "under stocked" (open, active growth). Competition-induced mortality of the conifers is unlikely.

Geomorphic Classification

- Confinement—Based on field inspection and map measurements, the channel is unconfined (valley floor width = ~ 500 ft; bankfull channel width = 50 ft; valley floor width is greater than 4 bankfull channel widths).

- Channel gradient—Channel gradient averages 2-3%.

- Channel classification—Using the Montgomery and Buffington (1997) classification scheme, the channel reach morphology is either plane bed or forced pool riffle.

Biological-Geomorphic Hotspots

- Several mapped debris flow source areas along small headwater channels in this portion of the East Branch of Soquel Creek watershed exist in steep inner gorge areas along the channel.

STEP 2) IDENTIFY FUNCTIONAL OBJECTIVES

The next part of the Classification Matrix pathway directs the user to identify functional objectives for the riparian design, using the site condition classifications made in Step 1, with the four matrix tables.

- Geomorphic (Channel Classification) Functional Priority Rating Matrix—Using the channel geomorphic classification calls of plane bed and forced pool riffle for a medium sized Class I watercourse, the functional priority ratings for wood, temperature, nutrients, and erosion are either high or moderate (Table 8). High is used in all cases. For example, the proper function of a forced pool riffle channel is highly dependent on large wood.

[12] The watershed area is approximately 6,700 acres (10.5 square miles), generating high stream power with the capacity to move large wood with inadequate diameter and length with relative ease.

- Riparian Site Conditions Classification Matrix—Using the riparian site condition classification information obtained in step 1, it is possible to fill out this matrix identifying existing functional response potential (Table 9). Using M for mixed species vegetation, S for smaller than functional diameter conifers, and U for under-stocked conditions for conifers, poor is circled for inherent wood supply, good for inherent nutrient supply, and moderate for inherent shading affecting thermal loading.

- Segment Decision Matrix—Combining the ratings from the previous two matrices with the "segment decision matrix", improve is selected for wood and erosion, maintain for temperature, and protect for nutrients (Table 10).

Table 8. Geomorphic (channel) classification functional priority rating matrix for the East Branch of Soquel Creek watershed.

			Functional Priority Rating			
Class	**Size**	**Type***	**Wood**	**Temperature**	**Nutrients**	**Erosion**
I	Large	Regime	Moderate	Low	Low	High
		Braided	Moderate	Low	Low	High
		Pool Riffle	High	Low	Low	High
	Medium	Regime	Moderate	Moderate	High	High
		Braided	Moderate	Moderate	High	High
		Pool Riffle	Moderate	Moderate	High	High
		Forced Pool Riffle	High	Moderate	High	High
		Plane Bed	High	High	High	Moderate
		Step-Pool	Moderate	High	Moderate	Low
		Cascade	Low	High	Moderate	Low
	Small	Pool Riffle	High	High	High	High
		Forced Pool Riffle	High	High	High	High
		Plane Bed	High	High	High	Moderate
		Step-Pool	Moderate	High	Moderate	Low
		Cascade	Low	High	Moderate	Low
II	All	Pool Riffle	Moderate	Moderate	Moderate	High
		Forced Pool Riffle	High	Moderate	Moderate	High
		Plane Bed	Low	Moderate	Low	Moderate
		Step-Pool	Low	Moderate	Low	Low
		Cascade	Low	Moderate	Low	Low
III	All	Colluvial	Varied	Moderate	Low	Varied
Hotspots	All	Debris Flow Sources	High	Moderate	Low	High
		Debris/alluvial Fans	High	Moderate	Low	High
		Tributary Junctions	Moderate	Moderate	High	Moderate
		Class II Transition	Low	High	High	Moderate
		Sensitivity Zone	**75% SPTH**	**33 feet**	**66 feet**	**Variable** *(min 33 feet)*

Table 9. Riparian site conditions classification matrix for the East Branch of Soquel Creek.

Riparian Class	Inherent Functional Levels		
	Wood Supply	Nutrient Supply	Thermal Loading
C S D	Moderate	Poor	Good
C S F	Poor	Poor	Good
C S U	Poor	Moderate	Moderate
C L D	Good	Moderate	Good
C L F	Good	Moderate	Good
C L U	Moderate	Moderate	Moderate
C M D	Good	Moderate	Good
C M F	Good	Moderate	Good
C M U	Moderate	Moderate	Moderate
H S D	Moderate	Good	Good
H S F	Poor	Good	Good
H S U	Poor	Good	Moderate
H L D	Moderate	Good	Good
H L F	Poor	Good	Good
H L U	Poor	Good	Moderate
H M D	Moderate	Good	Good
H M F	Poor	Good	Good
H M U	Poor	Good	Moderate
M S D	Moderate	Moderate	Good
M S F	Moderate	Moderate	Good
M S U	Poor	Good	Moderate
M L D	Good	Moderate	Good
M L F	Good	Good	Good
M L U	Moderate	Good	Moderate
M M D	Good	Good	Good
M M F	Good	Good	Good
M M U	Moderate	Good	Moderate

RIPARIAN CLASS KEY:

Composition of Vegetation (left column)

C = Conifer [≥70% conifer]

H = Hardwood [≥ 70% hardwood]

M = Mixed [all other cases]

Relative Tree Size (middle column)

S = Smaller than functional

L = Larger than functional

M = Mixed

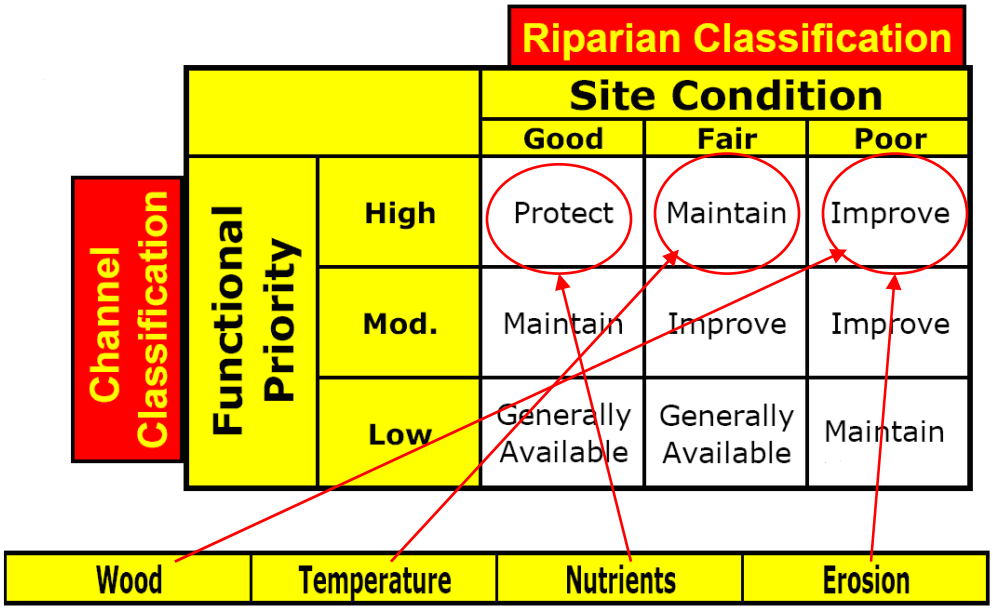
Relative Stand Density (right column)

D = Differentiating (dense, active mortality)

F = Fully Stocked (moderate, mortality eminent)

U = Under stocked (open, active growth)

Table 10. Segment decision matrix for the East Branch of Soquel Creek.



- Segment Action Matrix—The last matrix defines generalized site actions for each riparian exchange function, using the results of the previous matrices. The segment actions include improving wood loading by carefully identifying individual trees in the riparian zone for thinning, excavation for direct entry, etc.; maintaining temperature by limiting reduction in shade; protecting nutrient input by maximizing retention of existing hardwood vegetation; and improving erosion by considering treatments that support recovery of erosion sites (Table 11).

Table 11. Segment action matrix for the East Branch of Soquel Creek.

Typical Segment Actions				
	Wood	**Temperature**	**Nutrients**	**Erosion**
Protect	Maximize retention of recruitable wood	Maximize retention of vegetation that blocks incoming solar radiation	Maximize retention of existing high nutrient vegetation	Prevent and avoid ground disturbances that may disturb banks and/or concentrate runoff
Maintain	Limit removal of recruitable wood	Limit reduction in shade	Limit reduction in nutrient supply	Limit ground disturbances that may disturb banks and/or concentrate runoff
Improve	Use Silvicultural treatments (e.g., thinning, underplanting, etc) to achieve desired improvements (e.g. increase growth, affect mortality trends, etc)	Carefully identify individual tree selection that encourages growth of shade-producing vegetation	Encourage treatments that promote balanced primary production and establishment of high-nutrient species	Consider treatments that support recovery of eroding lands (e.g. planting, biotechnical stabilization, etc)
Generally Available	Treatment constraints for this function are minimized	Treatment constraints for this function are minimized	Treatment constraints for this function are minimized	Treatment constraints for this function are minimized

STEP 3) SITE PRESCRIPTIONS

Given these segment objectives, it is appropriate to establish prescriptions for this segment of the East Branch of Soquel Creek. Along the Fern Gulch Timber Sale, which borders this part of the East Branch, three prescriptions can be developed:

- A large wood placement project.
- Late succession management area use.
- Hihn's Mill Road improvements to reduce sediment generation.

A. **Large wood placement project**: The SDSF Large Wood Placement Project includes the following components: (1) installing large wood along a 0.7 mile stretch of the East Branch of Soquel Creek in four, 200-foot reaches, and (2) monitoring the large wood structures to document wood movement, aquatic habitat changes, and fish community changes. Each of the four reaches will contain from one to three large wood structures and each structure will have one to four pieces of large wood installed. There will be two unsecured sites with one to three log clusters installed per site. Additionally, there

will be two secured sites, with each site consisting of a log-vane structure with a rootwad, a log cluster, and a rootwad anchor. Logs and logs with rootwads will come from the Fern Gulch Timber Sale and from the riparian zone. The purpose of the project is to contribute to the survival and recovery of federally and State endangered coho salmon in this watershed, as well as the survival and recovery of federally threatened steelhead, by increasing habitat complexity and pool frequency.

B. **Late succession management area use**: These areas are used to promote the development and maintenance of functional old-growth habitat characteristics (and are specified under the SDSF Management Plan). They have a width of 300 feet on each side of the bankfull channel. At selected locations where conifers are lacking, Douglas-fir and coast redwood trees are to be planted to promote long-term recruitment of large wood in streams. All woody riparian (i.e., hydrophytic) vegetation is to be retained except where riparian function would be enhanced by removing such vegetation (as in prescription A. above).

C. **Hihn's Mill Road improvements**: As part of the Fern Gulch Timber Sale and THP, numerous improvements will be made to Hihn's Mill Road to reduce sediment input into the East Branch of Soquel Creek. These mitigations include building a log revetment structure at a streambank failure site impacting the road prism, constructing and reshaping rolling dips, and rocking selected road segments.

Summary

- The Soquel Creek watershed has poor large wood loading and poor off-channel/ floodplain quality, resulting in poor habitat conditions for state and federally listed anadromous salmonids.

- Riparian zones have mixed composition vegetation, under-sized conifers, and low mortality potential for coast redwood and Douglas-fir. The channel is low gradient (2-3%), unconfined, and can be classified as plane bed or forced pool riffle.

- Segment objectives include improving wood loading, maintaining shade for temperature control, protecting existing nutrient input, and reducing sediment input.

- Site prescriptions include use of Late Succession Management Areas (300 ft each side) as part of the Fern Gulch THP; a large wood placement project, testing both unanchored and anchored wood installations (outside the THP process); and road improvement work.

References

Lassettre, N. and M. Kondolf. 2003. Process based management of large woody debris at the basin scale, Soquel Creek, California. Final Report prepared for CAL FIRE. Sacramento, CA. 130 p.

Montgomery, M. and J. Buffington. 1997. Channel reach morphology in mountain drainage basins. GSA Bulletin 109: 596-611.

National Marine Fisheries Service (NMFS). 2012. Recovery plan for central California coast coho Salmon (*Oncorhynchus kisutch*) Evolutionarily Significant Unit. National Marine Fisheries Service, Southwest Region, Santa Rosa, California. Available at: http://swr.nmfs.noaa.gov/recovery/index.htm

RCDSCC (Resource Conservation District of Santa Cruz County). 2003. Soquel Creek watershed assessment and enhancement plan. Capitola, CA.

APPENDIX A-2. PATHWAY 2) SITUATIONAL SCENARIOS APPROACH

Pathway 2 presents typical situations where active riparian management will achieve specific ecological goals, such as improving instream habitat conditions through increased large wood loading, producing adequate stream temperatures with improved thermal regulation, increasing biological productivity through addition of nutrient inputs, retaining functional habitat following wildfire by creation of fire resilient riparian forests, etc. To achieve these ecological goals, criteria are listed to document where they are appropriate (i.e., suitability criteria for the site), design criteria, typical treatment options, and potential hazards to consider. A hypothetical example is also provided for each scenario.

This pathway has six main steps to follow:

STEP 1) EVALUATE EXISTING SITE CONDITIONS

As with Pathway 1, this step requires an assessment of existing site conditions from available field surveys, maps, aerial photos, GIS layers, and other data sources.

STEP 2) ASSESS WATERSHED CONDITIONS (WATERSHED CONTEXT)

Rapid watershed assessment to determine watershed-scale limiting factors should utilize existing information sources so that it can be completed cost effectively and in a reasonable time frame with limited expertise. A list of potentially useful sources of existing information for watershed context assessment is provided in Appendix E. The RPF can use third party recovery documents (e.g., NMFS 2012) to provide context and project goals where applicable.

STEP 3) DETERMINE DESIRED ECOLOGICAL FUNCTIONS

The RPF must relate how the proposed treatment types will benefit or enhance these desired ecological functions, including:

- Pool creation/increased habitat complexity with wood loading
- Sediment regulation
- Thermal regulation
- Nutrient cycling
- Structural diversity
- Habitat connectivity
- Habitat complexity (landscape scale)
- Others

The RPF must consider:

- Under what situations do we typically want to achieve these riparian functions;

- Under what situations is there a "surplus capacity" (e.g., short-term impact with long-term benefits in one variable, often in order to achieve improved conditions in another variable); and

- Is there a demonstrated deficit of one variable (e.g., lack of current instream wood loading) to substantiate justifying a site-specific proposal?

STEP 4) IDENTIFY THE APPLICABLE SITUATIONAL SCENARIO

Typical examples of common situations within the California ASP Rule geographical area that might benefit by Section V treatment options are provided in the remainder of this appendix.[13] Note that treatment options can be combined, providing greater flexibility than what is provided in the descriptions for the various situations described. Also "quid pro quo" (i.e., more-or-less equal exchange or substitution of goods or services) options may be proposed by RPFs where appropriate.

STEP 5) DETERMINE IF ADDITIONAL EXPERTISE IS NEEDED

If an RPF does not have appropriate expertise for a given type of site-specific proposal, then she or he needs to obtain that expertise (i.e., many types of proposals will require additional expertise, such as fire modeling, geology, fluvial geomorphology, fisheries biology, civil engineering, hydrology, etc.) [PRC § 752, 758]. Also, the RPF must have awareness of the state and federally listed species that may be impacted by the site-specific proposal.

STEP 6) ADDITIONAL CONSIDERATIONS

The following issues should be addressed (where appropriate) in the Section V analysis when using the situational scenarios considered in this chapter:

- Mortality balance of the riparian stand
- Silvicultural trends (predictive model or general trends)
- Growth benefits (treatment effects related to tree/stand growth response are well documented in the literature)
- Nutrient loading benefits
- Thermal risks and trends
- Instream habitat conditions and likelihood for improvement

These six steps are summarized in Figure 6.

---

[13] The geographic scope of the ASP rules is displayed in Appendix D.

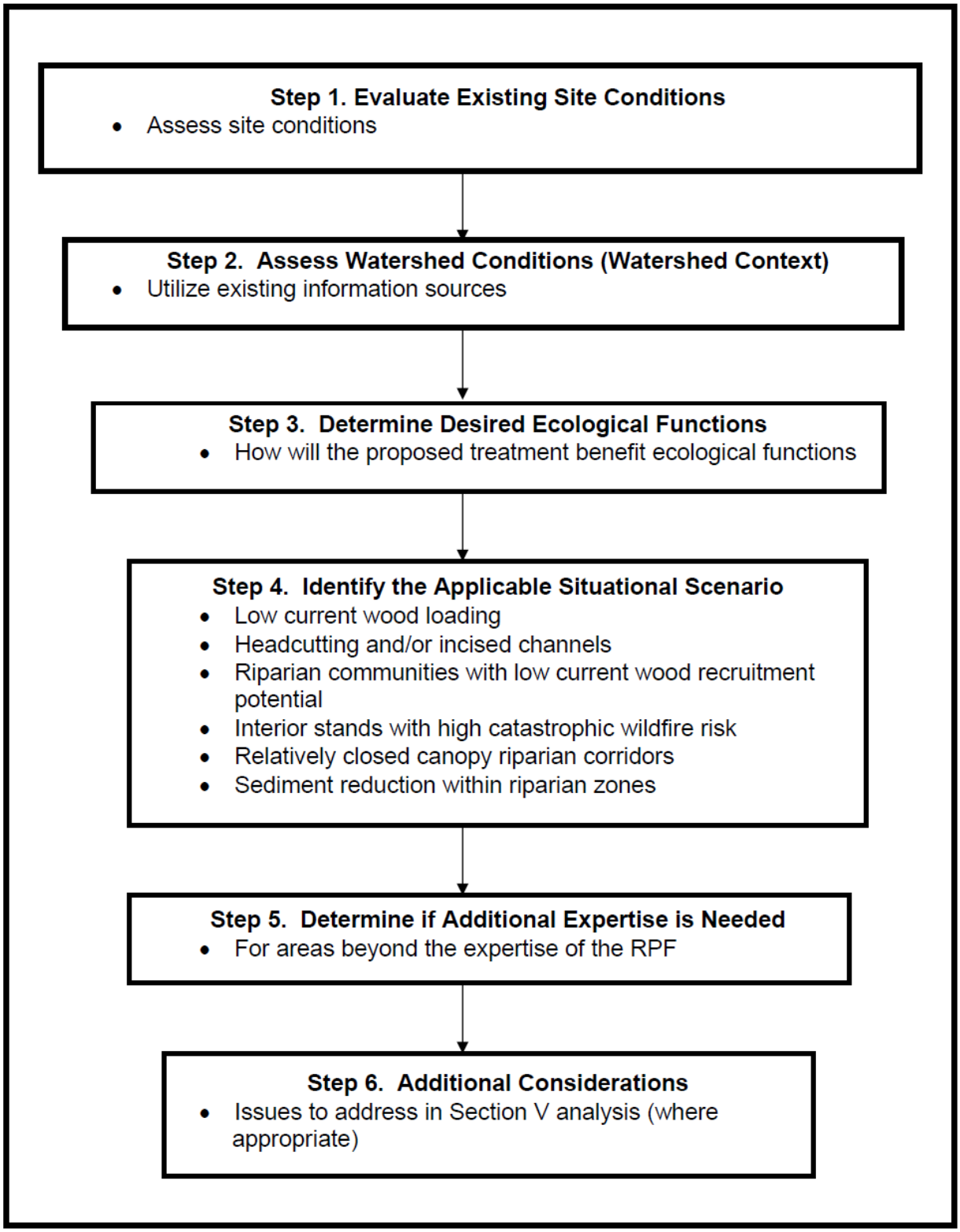


Figure 6. The six steps for Pathway 2), situational scenarios.

SITUATION 1. LOW CURRENT INSTREAM WOOD LOADING ADJACENT TO STANDS WITH LOW PROJECTIONS OF RIPARIAN MORTALITY

Instream woody material is a major component of salmonid habitat, particularly within the Coast Ranges of California (Swales 2010, Benda and Bigelow in review). Wood helps to form pools for rearing habitat, sort spawning gravels, provide overhead cover for juvenile fish, store sediment and organic matter, and partition habitat area in the water column, among other important ecological functions. Wood loading in most fish-bearing coastal streams is currently low due to historic logging practices, over-zealous stream clearance conducted from the 1960's to the 1980's, and excessive harvesting in riparian zones (Wooster and Hilton 2004). Opportunities for wood placement abound on north coastal California streams (Figure 7). Past monitoring work has shown that large wood enhancement projects can lead to higher densities of juvenile coho and other salmonids (Roni and Quinn 2001, Whiteway et al. 2010).

Typical Suitability Criteria

The following generalized criteria are intended to help identify potentially suitable site-specific proposals.

- Class I watercourses (mostly in north coastal California)
- < 3.0 % channel gradient
- Bankfull channel width = < 100 ft
- Bole lengths of conifer trees at least one and one half to two times bankfull channel width, preferably with rootwad attached (WFPB 2001)
- Functional tree diameters or grouping strategies
    - Clumps of felled/placed trees that are usually unanchored in the channel (Beneger 2011)
- Stand conditions that reflect low riparian mortality or recruitment potential
    - Examine trajectory of stand conditions
    - Evaluate recruitment potential
        - Process-based approach
        - Empirical plots
        - Mortality modeling
        - Inherent Functional Levels Table

Design Factors to Consider

- Riparian inventory (species composition, density, diameter and height)
- Watercourse channel dimensions (bankfull width and depth, slope)
- Existing instream LWD loading or pool habitat frequency by occurrence or length (habitat complexity)
- Stream LWD density/key piece loading goals or demonstrated improved wood loading/habitat complexity, potential improved pool habitat frequency

- Stand density goals (modeling or empirical analysis)[14]
- Size, number, and species composition of available riparian trees
- Source areas of felled or excavated riparian trees
- Source areas of harvested trees transported to the site(s)
- Dominant wood recruitment mechanism (e.g., bank erosion, landsliding, mortality)
- Existing and projected wood recruitment rates
- Location of trees relative to sun path and water
- Existing water temperature regime

Treatment Options

- Directional felling with/without placement by heavy equipment (Figures 8, 9, and 10)
- Excavation of tree with rootwad (i.e., toppling riparian zone dominants and co-dominants
- Engineered placement (anchored wood; e.g., log-vane structure)
- Importing logs (preferably boles with attached rootwads) from off-site (Figure 11)
- Other (including combined treatments)

Hazards (Red-Flags)

- High gradient stream channel (>3%)
- Wide channel (>100 ft bankfull width) with high stream power
- Larger streams (e.g., fourth order and higher)
- Downstream infrastructure (e.g., bridges, highways, homes, etc.) at risk [15]
- Potential for "take" of state or federally listed species (e.g., felling trees in channels with flowing water). Placing large wood in navigable waters will require a US Army Corp of Engineers permit that may lead to consultation under the federal Endangered Species Act (unless done with a DFW Fisheries Restoration Grant Program grant).
- Temperatures near biological thresholds.

Hypothetical Example

A low gradient (1.5%) Class I watercourse channel located in the northern part of the Coast Ranges within the Franciscan Formation was subjected to stream clearance work in the 1970's. The watershed is situated within the zone of coastal influence (i.e., fog zone). Bankfull channel width for this third order channel is 35 feet and the channel is located in a basin that has been identified as a high priority watershed in the NMFS Central California Coast (CCC) coho salmon recovery plan (NMFS 2012). Current large wood loading is very low, pools are shallow, and low

---

[14] Analytical modeling approaches are not required. Modeling may be appropriate for broad-scale application of a treatment.

[15] Note that the potential impacts to public safety should be addressed when considering proposed projects. In some cases, large wood structures may need to be engineered to keep the structure in place during high flows, and not to adversely impact downstream infrastructure where it exists.

shelter ratings (cover) are found within most of the habitat units. The riparian stand on the floodplain is composed of 80-year old coast redwood with little mortality expected in the next 50 to 100 years. Adequate over-wintering and over-summering habitat has been found to be problematic for coho salmon by recent DFW stream surveys. Downstream infrastructure is minimal and risk due to wood movement is rated as low.

The RPF proposes to excavate four coast redwood trees located along the channel bank within a 500 foot stream reach and place the trees with the rootwads attached into the channel. Four log clusters will be formed around these redwood trees with rootwads to mimic the location and spacing of natural wood jams (Benegar 2011). To form the log clusters, the unanchored trees with rootwads will be supplemented by felling eight redwood trees and by dragging downed trees adjacent to the stream into the active channel (also unanchored). All required federal and state permits will be obtained by the RPF prior to wood placement work. To partially offset the cost of this fisheries habitat improvement work, the RPF proposes to harvest a limited number of the 13 largest conifers per acre within the Core and Inner Zones of the Class I WLPZ. The RPF also proposes to plant a limited number of redwoods in specific open locations within the Core Zone to enhance long term recruitment potential of large wood. The RPF will provide a detailed table and map to scale showing WLPZ harvest tree size and location relative to the channel, as well as information showing that the water temperature of the stream will not be altered by this activity. Additionally, the RPF will include a discussion on how the riparian functions necessary for salmonid life stages will be more rapidly improved by this channel treatment when compared to use of the standard ASP Forest Practice Rules.

Figure 7. Placement of off-site large wood in the Little North Fork of the Gualala River (photo provided by Henry Alden, Gualala Redwoods, Inc.).

Figures 8, 9, and 10 (clockwise). Large wood enhancement project in the Clark Fork of Ten Mile River, western Mendocino County (photos provided by David Wright, CTM)—upper left: pre-project, right: immediately after construction, and bottom left: after several winter storm events).

Figure 11. Large wood structure installed in San Vicente Creek, Santa Cruz County, in 2011. Wood was transported to the site from an off-site location.

SITUATION 2. HEADCUTTING AND/OR INCISED CHANNELS (RELATIVE TO THE FLOODPLAIN)

Channels that contain large magnitude flows (exceeding about a 2-3 year recurrence interval event) without spilling onto a floodplain may have experienced, or be vulnerable to, channel incision and/or headcutting (Figures 12 and 13). Channel incision (downcutting) can generate large amounts of sediment through bed scour that is exported to downstream reaches. Incision is a self-reinforcing (positive feedback) process. It may result from of the loss of instream wood due to legacy cleaning processes, along with long periods of depressed wood recruitment. It may also result from long-term tectonic uplift or other natural variability in hydrology, erosion and sedimentation.

Channel incision associated with meadows is a greater problem in interior watersheds found in the Sierra Nevada and Cascade Range (Figure 14), and is not as significant in the Coast Ranges of California. Channel erosion in meadows adds to stream sediment loads through bank erosion and headcut retreat, adversely affecting downstream water quality and reservoir capacity (Micheli and Kirchner 2002).

A properly functioning stream channel should typically experience flooding (overbank flows) about 50-75 times each century (an average recurrence interval of 1.5 to 2 years). Such channels are capable of distributing the energy and bed stresses during large magnitude flows in ways that promote good habitat development and maintenance. These important habitat-forming processes become compromised when channels become incised (downcut) as a result of upstream-migrating headcutting processes (e.g., from poorly constructed stream crossings,

road failures, or similar processes that occur downstream of the site); from the removal of large woody debris (e.g., often associated with historic stream cleaning, splash-dams, or past harvesting practices); or from levee construction. Downcut channels typically have poor habitat conditions, cannot hold large woody debris, increase sediment production to downstream reaches, retain less water for dry season flows, and can increasingly destabilize the channel.

Incision can be especially problematic in steeper channels, where the excess shear stresses increase the rates of incision and headcutting, processes that generate excess sediment and allow it to be transported to downstream reaches. In lower gradient reaches, downcutting can also result in higher risks of spawning gravel scour, resulting in lost salmonid redds.

Reversing channel incision can be a difficult and design-intensive process. However, in many forested watersheds throughout California, the long-term success for habitat restoration and enhancement may depend on the extent that the incision problem is addressed. Proper designs for addressing headcutting and channel incision may require installing structures, reshaping channel profiles, reconnecting floodplains, locally armoring the channel bed and/or banks, and/or similar approaches. Not all of these approaches are suitable to a Section V site-specific proposal, and some may require other permit requirements. It is likely that additional expertise will be required and guidance provided in Pathway 3) Analytical Design Process may be beneficial to successful implementation.

Typical Suitability Criteria

- Gradient < 3% with an adjacent floodplain or terrace
- Channel Width < 50 ft
- Channel Cross-Sectional Area exceeds 2.5 yr flow capacity (i.e., flows with recurrence intervals greater than bankfull stage are contained within the channel).

Design Factors

The designs for improving the condition of incised channels may require experts in fluvial geomorphology, engineering geology, fisheries biology, or similar backgrounds. It is essential that such experts have direct experience with stream restoration techniques and a thorough understanding of the technical tools available in support of proper diagnosis and design. RPFs are highly encouraged to seek out such expertise when addressing this issue.

Diagnosis can be achieved using the following:

- Two year peak flow estimation using one (or more) of the following lines of evidence (in order of declining reliability):
    - Local stream gauges (either flow gauges, stage gauges or peak stage gauges)
    - Scour and/or debris lines following large storm events of a known recurrence interval (using nearby stream gauges or rainfall records)
    - Rainfall runoff modeling (HEC-HMS, MODRAT, TR-55 (NRCS Method), etc.)

- Rational Method
- Empirical USGS regional regression equations (Waananen and Crippen 1977).

- Bankfull channel width, depth, slope, type, and bed material.
  - A comparison of the existing channel capacity to the measured (or calculated) peak flow discharge
  - An evaluation of the shear stresses likely to mobilize the bed under these flows (either in the form of instantaneous peak entrainment thresholds (Shield's Curve) or volumetric sediment transport relationships (e.g., Meyer-Peter and Mueller)

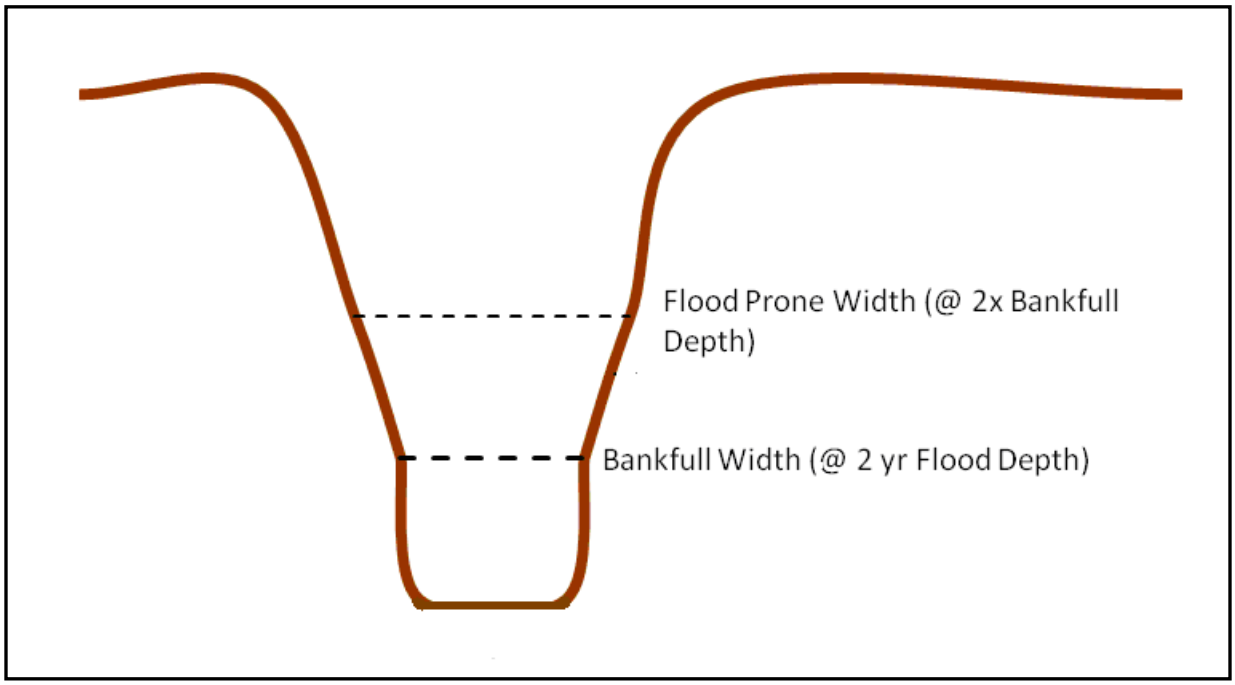


Figure 12. Diagram illustrating an incised channel with an elevated floodplain.

Figure 13. Somewhat incised or entrenched channel with a floodplain from the central part of the California Coast Ranges, where large wood addition may be used to attempt to reconnect floodplain function.

Treatment Options

- Grade control structures (rock or woody debris)
- Channel reshaping (creating inset floodplains, re-meander or channel sinuosity)
- Bed armoring
- Floodwater reconnection
- Channel diversion
- "Plug and Pond" meadow restoration (e.g., Tague et al. 2008)
- Backwater alcove construction
- Other (including combined treatments)

Figure 14. Example of an incised channel found in northeastern California.

Hazards (Red-Flags)

Improper diagnosis, design or construction may result in:

- Inadequate sized rock for grade control structures and/or improperly designed structures moving downstream, threatening downstream infrastructure
- Possible channel diversion or channel avulsion
- Increased downstream flooding risk
- Increased destabilization of the channel (both vertically and laterally)
- Catastrophic structural failure (both locally and downstream, threatening infrastructure resources such as culverts, bridges, etc.)
- Damage to existing habitat

Hypothetical Example

An important coho salmon stream located in the central part of the California Coast Ranges is slightly incised into its floodplain. Average channel gradient is 1.5% to 2.0% and bankfull channel width is 40 feet. Flows with recurrence intervals of greater than bankfull stage (~2 year return interval) are contained within the channel. The RPF proposes to prevent further incision by introducing large wood and rock grade control structures. Engineering expertise will be obtained from a local consulting firm to ensure that the rock and wood structures are properly designed. The RPF states that this site-specific proposal can be expected to improve both over-wintering and over-summering habitat for juvenile salmonids by increasing the likelihood that the channel will reconnect to the floodplain. All required state and federal permits will be obtained by the RPF prior to work in the channel. To partially offset the cost of these instream structural improvements, the RPF proposes to harvest a limited number of the 13 largest conifers per acre within the Core and Inner Zones of the Class I WLPZ. The RPF will provide a detailed table and map to scale showing WLPZ harvest tree size and location relative to the channel, as well as information showing that the water temperature of the stream will not be

altered by this activity. Additionally, the RPF will include a discussion on how the riparian functions necessary for salmonid life stages will be more rapidly improved by this channel treatment when compared to use of the standard ASP Forest Practice Rules, as well as an explanation of how the effectiveness of the stream headcutting mitigation will be monitored over time.

SITUATION 3. RIPARIAN COMMUNITIES WITH LOW CURRENT (OR PROJECTED) WOOD RECRUITMENT

A primary source of natural wood recruitment is generated from the toppling of trees whose fall radius intersects the stream (VanSickle and Gregory 1990). Natural toppling occurs due to bank erosion; mortality associated with competition, windthrow, wildfire, infestation, or disease; and mass wasting (landslides, debris flows) (Benda and Sias 2003, Benda et al. 2003, Benda and Bigelow in review). In stands where growth is projected to be vigorous, mortality (and associated recruitment) declines.

Competition-induced mortality is highly dependent on the species and cohort mix in the riparian stand. For example, Douglas-fir stands typically experience strong pulses of mortality associated with the stem exclusion phase (Oliver and Larson 1996), usually in the range of 40-110 years in single-cohort stands. The rate of mortality is often strongly dependent on stem density and site index (among other factors), and commercial thinning or selection harvests can affect this timing and rate of mortality. Thus, thinning can be used to increase residual diameter growth in retained trees; however, it can delay the onset of mortality that will delay the contribution of woody debris to the stream. Silvicultural approaches to improve tree growth include low thinning (thinning from below), commercial thinning (crown thinning), and variable density thinning (VDT) (Teraoka and Keyes 2011). Additional silvicultural methods may be used to establish, restore, or improve conifer site occupancy, thereby enhancing long-term wood recruitment potential (Spence et al. 1996, Ice 2000). This includes planting conifer seedlings in open riparian areas.

Typical Suitability Criteria

- Overstocked, smaller-diameter conifer stands (Figures 15 and 16)
- Excessive hardwood stocking (Figure 17)
- Poorly stocked conifer stands

Design Factors to Consider

- Retention of trees likely to recruit (e.g., leaners)
- WLPZ treatment prescriptions for the Core, Inner and Outer Zones (as defined by the ASP Rules)
- Factors affecting mortality rates

Treatment Options

One key objective of silvicultural treatments is to increase or improve wood recruitment trajectory through an increase in diameter growth over time in retained trees sufficient to meet the minimum functional diameter for instream wood (Figure 3), while retaining areas or aggregations that provide self-thinning responses in the future (i.e., to prevent entirely removing input from competition mortality). Another key objective is to restore conifer site occupancy by removing or treating evergreen hardwoods (e.g., tanoak) or to improve the condition of poorly stocked/growing conifer stands.

Generally appropriate treatment types include:

- Thinning from below (i.e., low thinning, as defined in Ligon et al. 1999)[16]
- Commercial thinning
- Variable density thinning (Chan et al. 2004, Figure 18)
- Single-tree selection (including co-dominants)
- Group selection
- Variable retention
- Alternative prescriptions
- Hardwood treatment
- Conifer tree planting
- Pre-commercial thinning
- Other (including combined treatments)

[16] This thinning involves the removal of the understory, mid-canopy, and very limited numbers of co-dominant trees. Co-dominant trees may be removed only to improve spacing and enhance growth. Dominant trees may not be removed, and average stand diameter must increase following harvest (Ligon et al. 1999).

Figures 15, 16, and 17 (clockwise). Young coast redwood plantation stand in the Eel River floodplain (photo provided by Dr. Kevin O'Hara, UC Berkeley); unthinned coast redwood stand in the Caspar Creek watershed in western Mendocino County; and a hardwood dominated stand with low wood loading in Humboldt County.

Hazards (Red-Flags)

- Existing water temperature standard issues (particularly for 303(d) water temperature impaired waterbodies).
- Water temperatures near biological thresholds.

Figure 18. Thinned riparian buffer zone in western Oregon, with the goal of accelerating development of late-successional characteristics. Thinning increased vegetative diversity, but it is unknown how long these thinning effects will last (from Mazza 2009).

Hypothetical Example

A flood prone area exists along a major tributary of a significant river in the northern part of the Coast Ranges of California that was heavily harvested in 1972 and partially cleared for grazing. Forty years ago, this area was planted with coast redwood seedlings, which are now pole-sized trees. The stand is extremely dense with close to 400 stems per acre, since no pre-commercial thinning activities were conducted within the plantation. The RPF proposes to thin the stand along a 2500 foot channel reach, reducing the density from 400 trees per acre (TPA) to approximately 200 TPA. An even density thinning will occur throughout the stand (i.e., from the watercourse transition line (WTL) to the outer edge of the flood prone area). This proposal will not meet the no-harvest requirement of the ASP rules for the Core Zone, or the overstory canopy requirements for the Inner Zone. The RPF states that this prescription is reasonable, however, since it will allow the remaining trees to grow much larger in a considerably shorter time span (diameter growth will be accelerated (Lindquist 2004)), reducing the time required for trees to reach a size appropriate for providing critical riparian functions such as large wood recruitment). The RPF states that this proposal will meet the objectives in 14 CCR § 916.9 (c)(5), creating favorable habitat in a more timely manner than would occur with the prescriptive ASP rule standard. Additionally, this type of proposal in a flood prone area must also conform with the requirements of 14 CCR § 916.9 [936.9, 956.9](v)(5).

SITUATION 4. INTERIOR STANDS WITH HIGH CATASTROPHIC WILDFIRE RISK

Unmanaged riparian stands can be sources of fire migration in fire-prone landscapes (Kobziar and McBride 2006, Murphy et al. 2007, Stone et al. 2010, Van de Water and North 2011) (Figures 19, 20, 21, and 22). North et al. (2009) report that riparian forests now have some of the heaviest ladder and surface fuel loads of any Sierran forest communities. Safford et al. (2009) state that fuel treatments that include removal of surface and ladder fuels in California yellow pine and mixed conifer forest types are highly effective management tools for reducing fire severity and canopy tree mortality. Treatments designed to reduce fire risk while improving overall riparian functions are an appropriate class of proposals under Section V of the ASP Rules (see 14 CCR § 916.9 [936.9, 956.9] (v)(6) in Appendix C) . Goals for site-specific proposals include creating fire resilient forests, promoting reduced fire intensities, and retaining functional habitat following a wildfire.

Typical Suitability Criteria

- Areas outside the zone of coastal influence (e.g., coastal fog zone) within the geographic scope of the ASP rules (high catastrophic wildfire risk is a greater problem in the interior areas of California)
- Overstocked, single-cohort stands, including in the riparian zone (Figure 23)
- Dense ladder fuels (Figure 24)
- Riparian stand surrounded by younger stands, recent harvests such that the riparian zone becomes the source of fuel relative to the surrounding forest

Design Factors to Consider

- Fire behavior models show a high risk of catastrophic wildfire (i.e., severe fire behavior and a high likelihood of stand replacing wildfire event)
- Reduction/elimination of vertical and horizontal continuity among fuel layers (surface, ladder and crown fuels)
- Increased sedimentation, possible loss of wood in watercourse channels, and possible loss of wood recruitment potential from the riparian zone.

Treatment Options

- Thinning from below (removing intermediate and co-dominant fuels)
- Single tree selection
- Group selection
- Sanitation-salvage
- Variable retention
- Alternative prescriptions
- Prescribed fire with or without silvicultural treatments (Beche et al. 2005, Arkle and Pilliod 2010)
- Other (including combined treatments)

Hazards (Red-Flags)

- Existing water temperature standard issues (particularly for 303(d) water temperature impaired waterbodies)
- Water temperature near biological thresholds
- Microclimate conditions negatively impacted
- Risk to nearby dwellings or subdivisions
- Risk to sensitive species present
- Risk to historical archeological structures

Hypothetical Example

A Class I watercourse located in the Cascade Range near a major state highway was subjected to a catastrophic wildfire 50 years ago, with a much smaller fire occurring 10 years ago. The area naturally regenerated, producing an overly dense stand both in the riparian zone and on the adjacent hillslopes. Fire behavior models and fire start data show that this area is highly prone to catastrophic wildfire (i.e., a rapidly moving crown fire). State and federally listed anadromous fish use the Class I watercourse. The RPF proposes a prescription to reduce surface fuels, intermediate fuels, and co-dominate fuels (i.e., "ladder fuels") in the stand, which reduces the overstory and understory vegetation below the required retention standards in the ASP rules. This treatment is to occur both in the Class I WLPZ Core, Inner, and Outer Zones, as well on the hillslopes beyond the WLPZ, creating a landscape-level fire hazard reduction project. The RPF will make a case for removing trees and other vegetation below the retention standards in the ASP rules, since the area has an established fire history and fire behavior models document a significant problem. In addition to describing how the stand will be improved for potential future timber production, the RPF will include a discussion of how the riparian functions necessary for salmonid life stages will be better secured and maintained by this fuel reduction treatment.

Figures 19 and 20. Angora Creek watershed following the 2007 Angora Fire in the Lake Tahoe Basin, where dense stands of trees in the Angora Stream Environment Zone (SEZ) likely contributed to the rapid fire spread upslope to Angora Ridge (Murphy et al. 2007).

Figure 21. Aerial photograph taken of the Ponderosa Fire, August 2012, in Tehama County. Note how the WLPZ riparian vegetation "wicked" the fire through irrigated pasture ground on either side of the Digger Creek channel (photo provided by Mark Lathrop, SPI).

Figure 22. Aerial photograph of an unnamed tributary of Digger Creek that was heavily burned during the 2012 Ponderosa Fire in Tehama County (photo provided by Stacy Stanish, DFW).

Figures 23 and 24. Interior California stands with high fuel loading and elevated risk of catastrophic wildfire (photos provided by Kip Van de Water, USFS, Plumas National Forest).

SITUATION 5. RELATIVELY CLOSED CANOPY RIPARIAN CORRIDORS LACKING NITROGEN-FIXING SPECIES OR WITH LOW PRIMARY PRODUCTIVITY

While physical habitat components are important, growing evidence in the scientific literature is pointing to the need to manage riparian areas for food production in the form of nutrient availability for salmonids (Liquori et al. 2008). Nutrient capacity is affected by the availability of nitrogen and sunlight-driven primary productivity that translates those nutrients into forms available to salmonids.

The biological integrity and productivity of riparian areas can benefit by managing the distribution of non-commercial nitrogen-fixing species and the amount of canopy gaps that can introduce sufficient sunlight to the aquatic communities, without contributing to excessive thermal inputs (Wilzbach et al. 2005, MacCracken et al. in press) (Figures 25 and 26).

Criteria for the extent of riparian canopy gaps depend on riparian condition throughout the entire channel network, including stream segments upstream and downstream from the treatment area. Compounding factors include:

Thermal Controls – ensuring that the treatment effects do not substantially compromise stream temperatures. Short-term effects may be appropriate if the magnitude of such effects are limited in time and/or space. Thermal heating models are widely available in the literature, and should be used in justifying broad-scale riparian designs by altering thermal controls.

Wood Recruitment – canopy manipulation treatments will affect potential wood recruitment in the local area. Such effects should be considered. For example, a short segment of variable retention may be preferable over more widespread thinning in some circumstances (and vice-versa in other circumstances). A careful, quantitative assessment will help to justify the appropriate treatment response in any given situation (the level of analysis should increase with the scale of project treatment).

Typical Suitability Criteria

- Light-limited settings where temperature gains associated with canopy openings will not significantly affect stream temperatures (e.g., zone of coastal influence)
- Watersheds with low food production and/or long nutrient cycling rates
- Watersheds where macroinvertebrate communities have not recovered from legacy practices
- Watershed where productivity is low (often limiting)
- Perennial watercourses (different criteria for intermittent watercourses).
- Others.

Design Factors to Consider

- Establishing riparian stands with the capacity to support a sufficient number of nitrogen fixing deciduous vegetation (trees or understory shrubs) distributed at key locations within the stream network
- Establishing riparian stands with a sufficient number of riparian canopy gaps that allow for sunlight to support macroinvertebrate production while balancing effects on other riparian functions (Figure 26)

Treatment Options

Strategies for improving nutrient dynamics in forested streams include:

- Clearcut
- Commercial thinning
- Single tree selection
- Group selection
- Variable retention
- Hardwood conversion (rehabilitation of understocked areas)
- Conifer conversion (using Group B Species per 14 CCR § 912.7 [932.7, 952.7] (d)
- Inter-planting with thinning
- Other (including combined treatments)

Hazards (Red-Flags)

- Areas away from the zone of coastal influence with existing water temperature issues (particularly for 303(d) temperature impaired waterbodies)
- Possible impacts to future large wood recruitment, destabilization of slopes

Hypothetical Example

A watershed located in the northern part of the California Coast Ranges, within the zone of coastal influence, has a dense second-growth coast redwood stand present along a Class I watercourse in the coastal anadromy zone (CAZ). Overstory canopy within the WLPZ averages approximately 95% and does not include red alder or other hardwood species. Current large wood loading is adequate. The RPF proposes to create a number of riparian openings in the Core and Inner Zones of the WLPZ for natural colonization by red alder, thereby improving nutrient input within the Class I watercourse and habitat diversity within the riparian zone. Creation of openings is also stated as being important to increase light reaching the channel for improvement of primary productivity (Liquori et al. 2008). The RPF will provide a map and table to show the size and locations of the openings relative to the channel. The RPF will create openings that do not produce negative watershed-related impacts (e.g., opening size will be directly related to flow to avoid excessive changes in water temperature; there will be no

openings cut on steep, landslide-prone slopes, etc.). The RPF will use a simple water temperature prediction model to show that water temperature effects from the treatment areas will be very minimal. The RPF states that this site-specific proposal in the WLPZ is appropriate, since it can reasonably be expected to improve salmonid production (Wilzbach et al. 2005).

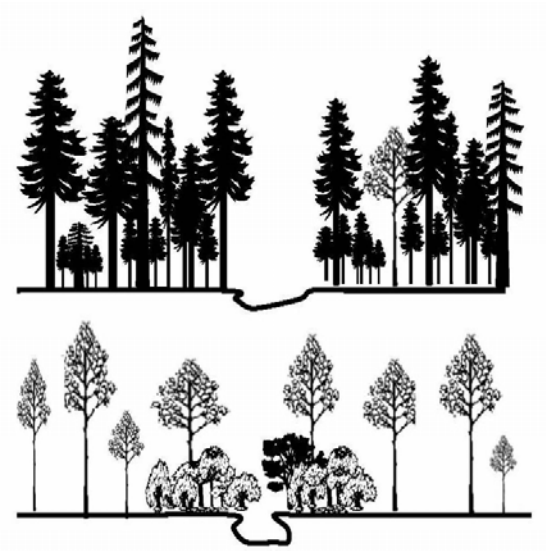


Figure 25. Diagram illustrating that riparian stands can have different mixes of conifers and hardwoods; RPFs are to determine what the optimal mix of conifers and hardwoods are for nutrient input, as well as for large wood, shading, and other riparian functions (from Liquori and Jackson 2001).

Figure 26. View of coastal riparian stand with a gap opening created to increase primary productivity (Wilzbach et al. 2005 study site). Photo provided by Dr. Lowell Diller, GDRCO.

SITUATION 6. SEDIMENT REDUCTION WITHIN RIPARIAN ZONES

Sediment production and delivery in riparian zones can result from a number of land use impacts. For example, sediment production from riparian roads, skid trails, and landings is generally much higher than that from heavily compacted areas located considerably further away from watercourse channels. Several studies in diverse geologic settings have concluded that roads located less than 200 feet of a stream channel can deliver considerably more sediment than those located further away. For example, WFPB (1997) concluded that roads located within riparian zones are especially prone to sediment delivery to stream channels. Inventories of existing or potential erosion sites often identify road, skid trail, and landings within WLPZs as appropriate legacy features that require rehabilitation. The rehabilitation work can include road decommissioning (Figure 27), including watercourse crossing removals (Figure 28); improved road, skid trail, and landing drainage or surfacing; and mechanically ripping compacted soils to improve drainage and reduce surface runoff.

Other erosion sources are common in riparian areas as well, including bank cutting, channel incision, channel diversion, unstable areas, chiseled and/or trampled streambanks associated with cattle grazing, and other areas of significant ground disturbance. These types of erosion sources can be treated by laying back over-steepened banks, using bioengineering approaches to reduce bank erosion (Figures 29 and 30), installation of properly engineered check dams, installation of sub-drains, installation of streamside corridor fencing, etc.

Operations in WLPZs to reduce sediment generation and transport to the channel are appropriate as Section V site-specific proposals, as stated in 14 CCR § 916.9 (c)(5), which includes…"abandonment and upgrading of non-functioning or high risk roads, watercourse crossings, tractor roads, and landings" as practices appropriate to restore properly functioning salmonid habitat and repair conditions detrimental to the species or species habitat.

In general, there are three treatment options available to reduce sediment production: source controls, transport controls, and mitigation controls. Examples of acceptable approaches for reducing sediment production and delivery in riparian zones are described in the following documents, as well as others: Weaver and Hagans (1994), Keller and Sherar (2003), Roads Riparian Team (2005), FishNet 4C (2004), Clary and Webster (1989), Gary and Sotir (1996), Federal Interagency Stream Restoration Working Group (1998), Lewis (2000), and DFG (2010).

Typical Suitability Criteria

- Road segments[17] located short distances from watercourses (< 200 feet).
- Riparian road segments, skid trails, and landings built on soil types with a high erosion potential (e.g., non-cohesive soils such as decomposed granitic soils).

---

[17] Note that both road segments currently in use and/or legacy roads no longer used are included in the bullet points listed in this section.

- Riparian road segments and landings with high hillslope instability and perched fill material.
- Riparian road segments and landings on steep slopes (>50%).
- Riparian road segments that are unsurfaced or inadequately surfaced and prone to surface erosion, or have ruts that prevent water from reaching the road drainage structures or facilities.
- Riparian road segments and landings that lack adequate drainage structures or are improperly drained.
- Riparian road segments and landings with road drainage structure or facility outlets close to watercourses that are delivering sediment directly to watercourse channels (i.e., hydrologically connected).
- Eroding stream channel banks.
- Downcutting, incised channels.
- Channels diverted out of their natural drainages (or potentially diverted).
- Management-related unstable areas.

Design Factors to Consider

- Soil erodibility and need for post-treatment surface erosion control (e.g., mulching, seeding, surfacing, slash treatments, etc.).
- Infiltration capacity of the soil and expected rainfall intensities.
- Slope steepness.
- Vegetative cover in the WLPZ.
- Feasible equipment access.

Treatment Options

- Pulling back perched fill and endhauling material out of the WLPZ to stable locations for road segments that will remain in the transportation network.
- Reconfiguring road prisms and installing adequate drainage structures on road segments that will remain in the transportation network.
- Upgrading properly functioning watercourse crossings to current Forest Practice Rule standards (i.e., 100 yr flood flows, passage of sediment and debris).
- Ripping compacted skid trails, landings, and abandoned roads.
- Properly decommissioning road segments, pulling crossings, outsloping, installing adequate drainage structures, and removing perched fill material for roads to be removed from the permanent road network.
- Actively revegetating and/or implementing other erosion controls on disturbed areas.
- Armoring newly excavated channel bottoms with appropriately sized rip-rap, other types of large roughness elements, or grade control structures to prevent channel incision.
- Bioengineering approaches for bank erosion stabilization.
- Installation of sub-drains for unstable areas.
- Grading on or near unstable areas to limit infiltration into the unstable area.

- Actively revegetating or other bioengineering approaches for treating and limiting erosion on unstable areas and scars.
- Other (including combined treatments).

Hazards (Red-Flags)

- Short-term sediment impacts that can adversely impact state and federally listed anadromous fish species, particularly in 303(d) impaired waterbodies.
- Possible high short-term sediment impacts to water quality from decommissioned crossings due to an inability to excavate to natural channel bottom elevations (PWA 2005, Keppeler et al. 2007).
- Critical habitat for listed fish species.

Hypothetical Example

A road located within the riparian zone was constructed along a Class I watercourse in the Santa Cruz Mountains prior to the implementation of the modern California Forest Practice Rules in 1975. The native-surfaced road is located approximately 50 feet from the channel along most of its length, with failing perched sidecast material in a position to enter the watercourse in significant quantities in numerous locations. The RPF has conducted an inventory of the road network in this watershed and concluded that a 1500 foot segment along the channel has the highest potential for adverse impact to the anadromous salmonids present in the watercourse, including state and federally listed coho salmon. Side slopes average approximately 50% and a dense unevenaged coast redwood-dominated stand is present. The RPF proposes to properly decommission this road segment by pulling back the perched fill material, ripping the road running surface, removing two watercourse crossings, outsloping the road, and installing adequate self-maintaining drainage structures. Mulching and seeding with sterile barley grass seed or a mixture specified by the local NRCS office will be used to limit surface erosion the first winters following treatment. Some conifer trees in excess of 12 inches DBH will be removed when the perched fill areas are pulled back by a hydraulic excavator. Therefore, limited harvest will occur in the Core and Inner Zones of the Class I WLPZ, but the RPF will demonstrate that this prescription is appropriate, since long-term sediment impacts to sensitive aquatic habitat will be improved with this proposal (Madej 2001).

Figure 27. Outsloped road section of riparian Road 600 decommissioned in the South Fork of Caspar Creek, Jackson Demonstration State Forest, western Mendocino County. Photograph taken in 1998.

Figure 28. Excavating a road crossing during decommissioning of the main riparian haul road in the South Fork Caspar Creek watershed (see Keppeler et al. 2007). Photograph taken in 1998.

Figure 29 and 30. Example of bioengineering as a stream stabilization technique in lieu of traditional rip-rap or rock slope protection (RSP). This site is located along Sidney Gulch in Weaverville, CA. Small test area was treated with a 6” thick willow stake brushmattress and 8” to 12” round willow fascine at the toe. The mattress is buried ~ 6” in the soil with the wattle placed over the toe. It is anchored into the bank and stream toe with wooden stakes and wiring (upper photo). The lower photo is one year post project. Bioengineering techniques are described in the FishNet 4C Manual (see Appendix A, BMP toolbox in the FishNet 4C Manual).

EXAMPLE OF PATHWAY 2) SITUATIONAL SCENARIO APPROACH: SITUATION #1—LOW CURRENT INSTREAM WOOD LOADING

East Branch of Soquel Creek, Santa Cruz County

Step 1. Evaluate Existing Site Conditions

The East Branch of Soquel Creek above the main bridge over the channel on SDSF was evaluated with field surveys, maps, and aerial photographs (Figure 31). In general, the riparian stand consists of scattered conifers with a large hardwood component. There is generally a shortage of large conifers within the 100 year floodplain for large wood recruitment. Canopy and shading can be characterized as moderate. Nutrient input to the channel from the hardwood component of the riparian stand is good. The existing conditions are limiting fish production due to inadequate summer and winter habitat, mainly related to channel incision, poor wood loading, and lack of floodplain connectivity.

The following more detailed information on site conditions have been documented:

- Composition of Vegetation —The riparian vegetation is primarily coast redwood, with scattered Douglas-fir trees along the East Branch. A large deciduous component exists below the Fern Gulch confluence (with good deciduous contribution to the channel).

- Relative Tree Size —The dominant WHR class in the 300 ft wide late succession management area along the East Branch of Soquel Creek is 4D (11-24 in QMD and canopy cover >60%).

- Channel Characteristics —The mean bankfull channel width is approximately 50 feet. Based on field inspection and map measurements, the channel is unconfined (valley floor width = ~ 500 ft; bankfull channel width = ~ 50 ft; valley floor width is greater than 4 bankfull channel widths). The channel gradient averages 2-3%. Using the Montgomery and Buffington (1997) classification scheme, the channel reach morphology is either plane bed or forced pool riffle. Large wood is scarce in the East Branch and recruitment is low. Only nine wood formed pools were found for 1.3 miles of stream channel (Lassettre and Kondolf 2003) (Figure 32).

- Geomorphology Information —Several mapped debris flow source areas are located along small headwater channels in this portion of the East Branch of Soquel Creek watershed in steep inner gorge areas along the channel. There is an extensive flood prone area along the East Branch of Soquel Creek. The large hardwoods in the flood prone area appear to mostly relate to the very large December 1955 flood event, which had a recurrence interval that exceeded 100 years.

Step 2. Assess Watershed Conditions

The Soquel Creek watershed is located in the Santa Cruz Mountains, near the city of Santa Cruz. The watershed covers approximately 27,000 acres (42.2 square miles). The upper portions of

the watershed are forested, are developed with rural residences, and contain reserves such as Soquel Demonstration State Forest and the Forest of Nicene Marks State Park. The lower portions of the watershed contain agricultural and grazing lands as well as the towns of Soquel and Capitola. Soquel Creek flow through the urbanized downtowns of Soquel and Capitola before emptying into Monterey Bay. A rapid watershed context assessment was conducted as part of using the situational scenario pathway prior to determining the appropriate management actions to enhance habitat for listed salmonids in Soquel Creek.

Existing watershed assessments and studies reviewed included the NMFS Central California Coast (CCC) coho salmon recovery plan (NMFS 2012), the Soquel Creek Watershed Assessment and Enhancement Plan (RCDSCC 2003), and Lassettre and Kondolf's (2003) report titled *Process Based Management of Large Woody Debris at the Basin Scale*. The NMFS (2012) coho recovery plan shows that the East Branch of Soquel Creek is the least developed portion of the basin and a priority area for coho protection and restoration (Figure 33).

The RCDSCC (2003) watershed assessment and enhancement plan reported that the highest densities of young-of-the-year steelhead, also federally listed, occur on the Soquel Demonstration State Forest (SDSF) portion of the East Branch of Soquel Creek. This part of the East Branch was stated as being the primary spawning grounds for steelhead in the Soquel Creek watershed. Low summer baseflow has been found to reduce juvenile steelhead growth rates, with conservation and preservation of baseflow one of the assessment recommendations.

Several watershed assessments have reported that the Soquel Creek basin has a long history of wood removal work, since past large flood events have produced wood jams at downstream culverts and bridges. Multiple studies and assessments have shown that large wood loading is very low in the basin (e.g., Lassettre and Kondolf 2003). The NMFS (2012) coho recovery plan lists large wood loading and off-channel/floodplain quality as poor. Three of the highest priority actions for restoration to prevent coho extinction in the Soquel Creek watershed include: (1) increasing the quantity of off-channel habitat, (2) increasing the amount of large wood in the channel, and (3) improving floodplain connectivity to provide rearing habitat (NMFS 2012).

<u>Step 3. Determine Desired Ecological Functions</u>

Based on both existing site conditions and overall watershed context information provided in several Soquel Creek watershed assessments, desired ecological functions for the East Branch of Soquel Creek include:

- Pool creation and increased habitat complexity with large wood loading, and
- Increased floodplain connectivity with large wood loading.

The RPF has determined that there is a demonstrated deficit of large wood in the channel to substantiate justifying a site-specific proposal.

Step 4. Identify the Applicable Situational Scenario

The RPF has identified Situational Scenario "**Situation 1, low current instream wood loading adjacent to stands with low projections of riparian mortality**" as appropriate for development of a Section V site-specific proposal. Adding large wood to the East Branch of Soquel Creek will create pools, increase cover for juvenile fish, and increase overall habitat complexity, benefiting state and federally listed anadromous salmonids in the basin. Coho salmon are near extinction levels in the Soquel Creek watershed (NMFS 2010). Rapidly improving wood loading by excavating 12 large conifer trees in the riparian zone and supplementing these trees with logs and rootwads transported down from THP road right-of-way work is expected to be more favorable to salmonids than waiting multiple decades for coast redwood and Douglas-fir trees to naturally recruit to the channel.

Typical Suitability Criteria

- Class I channel with listed anadromous salmonids present.
- Channel gradient ≤ 3 percent.
- Bankfull channel width equals 50 ft (less than the maximum of <100 ft).
- Bole length of conifer trees in the riparian zone approximately 120-150 ft.
- Stand conditions that reflect low riparian mortality or recruitment potential: there is active mortality for the hardwoods present, but they are of much lower value for long term wood supply to the channel. There is low mortality expected for the dominant conifer present—coast redwood.

Design Factors to Consider

- Existing large wood loading is very low, as is pool habitat frequency.
- Appropriate large conifers are available in the riparian zone for construction of a large wood enhancement project.

Treatment Options

- Excavation of conifer trees with rootwads attached.
- Engineered placement structures, partially using imported logs from THP road right-of-way construction.

Hazards

- Downstream infrastructure, including bridges and other watercourse crossings.
- Potential take of state and federally listed anadromous salmonid species.
- Potential take of protected amphibians (California red-legged frogs, etc.).

Step 5. Determine if Additional Expertise is Needed

The Soquel Demonstration State Forest staff and CAL FIRE Watershed Protection staff in Sacramento do not have the technical knowledge or experience to design a large wood placement project on SDSF. Therefore, it was determined that additional expertise from the California Geological Survey would be required to design and supervise construction of the large wood enhancement project. Mr. Stephen Reynolds, engineering geologist with the California Geological Survey, will use accepted engineering principles to design both anchored and unanchored large wood structures for the East Branch of Soquel Creek that can withstand small to moderate sized winter peak flow events without movement downstream. Mr. Reynolds has extensive experience with this type of project design and construction.

Step 6. Additional Considerations

Thermal risks and trends: Water temperatures are higher than optimal for salmonids in the East Branch of Soquel Creek. Optimal rearing temperatures for juveniles are 7.22-14.4º C for steelhead and 11.67-14.4º C for coho. In 2007, there were 86 days at Long Ridge Crossing at or above 14.4^{o} C (Figure 34). The proposed treatments (removal of approximately 12 large conifer trees) are unlikely to have a significant impact on water temperature, however, as most of the large conifer trees removed from the riparian zone will be taken from the north side of the channel.

Downstream infrastructure: The project is being designed to minimize the potential for large wood placed in the channel to block downstream watercourse crossings or otherwise adversely impact downstream urban areas.

Additional Submission Requirements for the Section V(3) Site-Specific Proposal

916.9(v)(3)(A)1. Description of the evaluation area (watershed assessment area). See Step 2.

916.9(v)(3)(A)2. Description of the current condition of the riparian zone. See Step 1.

916.9(v)(3)(A)3. Identification of beneficial functions potentially affected. See Step 4, Hazards.

916.9(v)(3)(A)4. Identification of the potential effects to beneficial functions, both positive and negative. See Table 12.

Table 12. Identification of the potential effects to beneficial functions.

	Positive Effect	Negative Effect
Beneficial Functions of Riparian Zones	(L/M/H)	(L/M/H)
Channel Zone, Channel Bed		
Streambed and flow modification by LWD	H	NA
Channel bed stabilization	H	NA
Spawning and rearing habitats	H	NA
Sediment filtration in CMZ, FPA	NA	L
Flood flow attenuation in CMZ, FPA	NA	L
Overflow channels for fish refugia	H	NA
Hyporheic zone function	NA	NA
Core Zone		
Bank stability	H	NA
Large wood recruitment potential	NA	L
Water temperature control (shade reduction)	NA	L
Nutrient production and input	L	NA
Sediment filtration	NA	L
Inner Zone		
Large wood recruitment potential	NA	L
Water temperature control (shade reduction)	NA	L
Nutrient production and input	L	NA
Microclimate control	NA	L
Structural diversity for terrestrial wildlife habitat	NA	L
Sediment filtration	NA	L
Outer Zone		
Wind resistance for riparian zone stability	NA	NA
Microclimate control	NA	NA
Large wood recruitment (esp. landslide processes)	NA	NA
Structural diversity for terrestrial wildlife habitat	NA	NA
Sediment filtration	NA	NA

916.9(v)(3)(A)5. Detailed description of the site-specific measure proposed.

The SDSF Large Wood Placement Project will include the following components: (1) installing large wood along a 0.7 mile stretch of the East Branch of Soquel Creek in four, 200-foot reaches, and (2) monitoring the large wood structures to document wood movement, aquatic habitat changes, and fish community changes. Each of the four reaches will contain from one to three large wood structures and each structure will have one to four pieces of large wood installed. There will be two unsecured sites with one to three log clusters installed per site (Figure 35 and 36). Additionally, there will be two secured sites, with each site consisting of a log-vane structure with a rootwad (Figure 37 and 38), a log cluster, and a rootwad anchor. Logs and logs with rootwads will come from the Fern Gulch Timber Sale and from the riparian zone. Logs will be excavated and/or placed in the channel with hydraulic excavators. The purpose of

the project is to contribute to the survival and recovery of federally and State endangered coho salmon in this watershed, as well as the survival and recovery of federally threatened steelhead, by increasing habitat complexity and pool frequency.

916.9(v)(3)(A)6. Schedule for implementation.

Fall 2012, Fall 2013.

916.9(v)(3)(A)7. Monitoring plan.

Upon completion of construction, a detailed as-built drawing of each structural element will be completed. The as-built drawings will require locating each log with a global positioning system (GPS) unit and taking photographs of its configuration from defined, repeatable photo point stations, which will also be mapped with the GPS.

916.9(v)(4)(A). Measures based on best available science.

Instream woody material has been found to be a major component of salmonid habitat, particularly within the Coast Ranges of California. Wood helps to form pools for rearing habitat, sort spawning gravels, provide overhead cover for juvenile fish, store sediment and organic matter, and partition habitat area in the water column, among other important ecological functions. Wood loading in most fish-bearing coastal streams is currently low due to historic logging practices, over-zealous stream clearance conducted from the 1960's to the 1980's, and excessive harvesting in riparian zones (Wooster and Hilton 2004). Past monitoring work has shown that large wood enhancement projects can lead to higher densities of juvenile coho and other salmonids (Roni and Quinn 2001, Whiteway et al. 2010).

916.9(v)(4)(B). Identification of potential significant adverse impacts to salmonids or other beneficial functions of the riparian zone.

See Step 4, Hazards.

916.9(v)(4)(C). Identification of methods to avoid or mitigate identified potential significant adverse impacts.

Use of certified biologists is required by SDSF to ensure that appropriate biological measures are implemented during construction to protect listed species.

916.9(v)(4)(D). Clear instructions and enforceable standards.

Detailed plan drawings are available upon request, providing clear instructions and enforceable standards (see SDSF contract language).

916.9(v)(4)(E). Plan implementation.

The plan submitter, SDSF, will retain an RPF and CEG to aid in interpreting the plan for the LTO.

916.9(v)(4)(F). Identification of standard prescription replaced by the proposal.

916.9(f)(3)(B) and 916.9(f)(3)(C)

Class I watercourse with flood prone areas or channel migration zones—Core Zone and Inner Zone A.

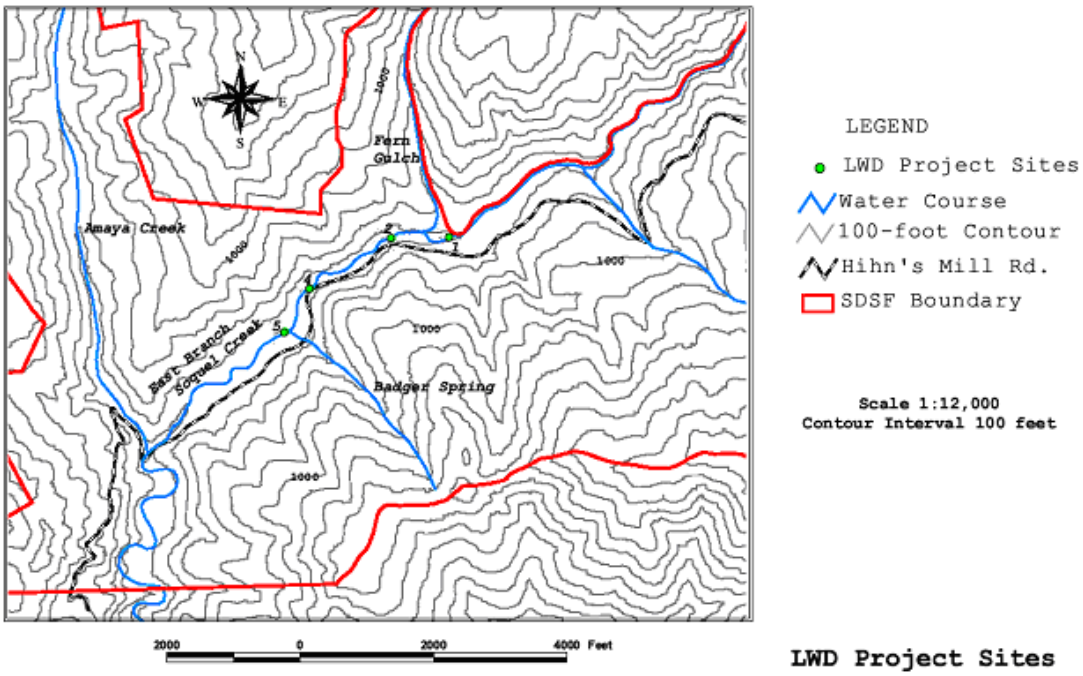


Figure 31. Large woody debris placement sites located along the East Branch of Soquel Creek.

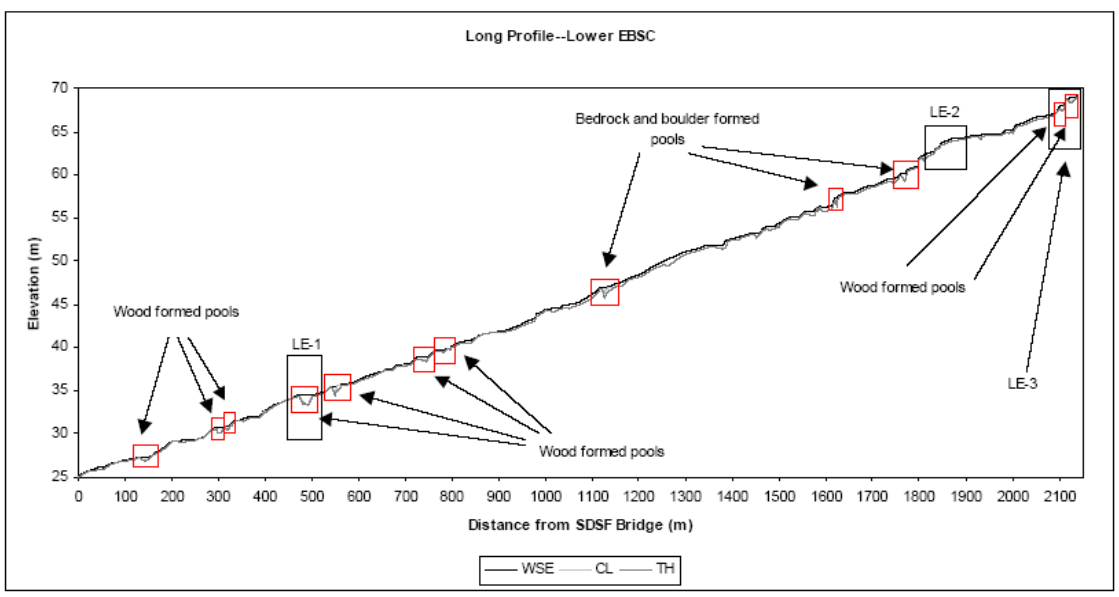


Figure 32. Long profile for the East Branch of Soquel Creek showing existing wood and bedrock/boulder formed pools (from Lassettre and Kondolf 2003).

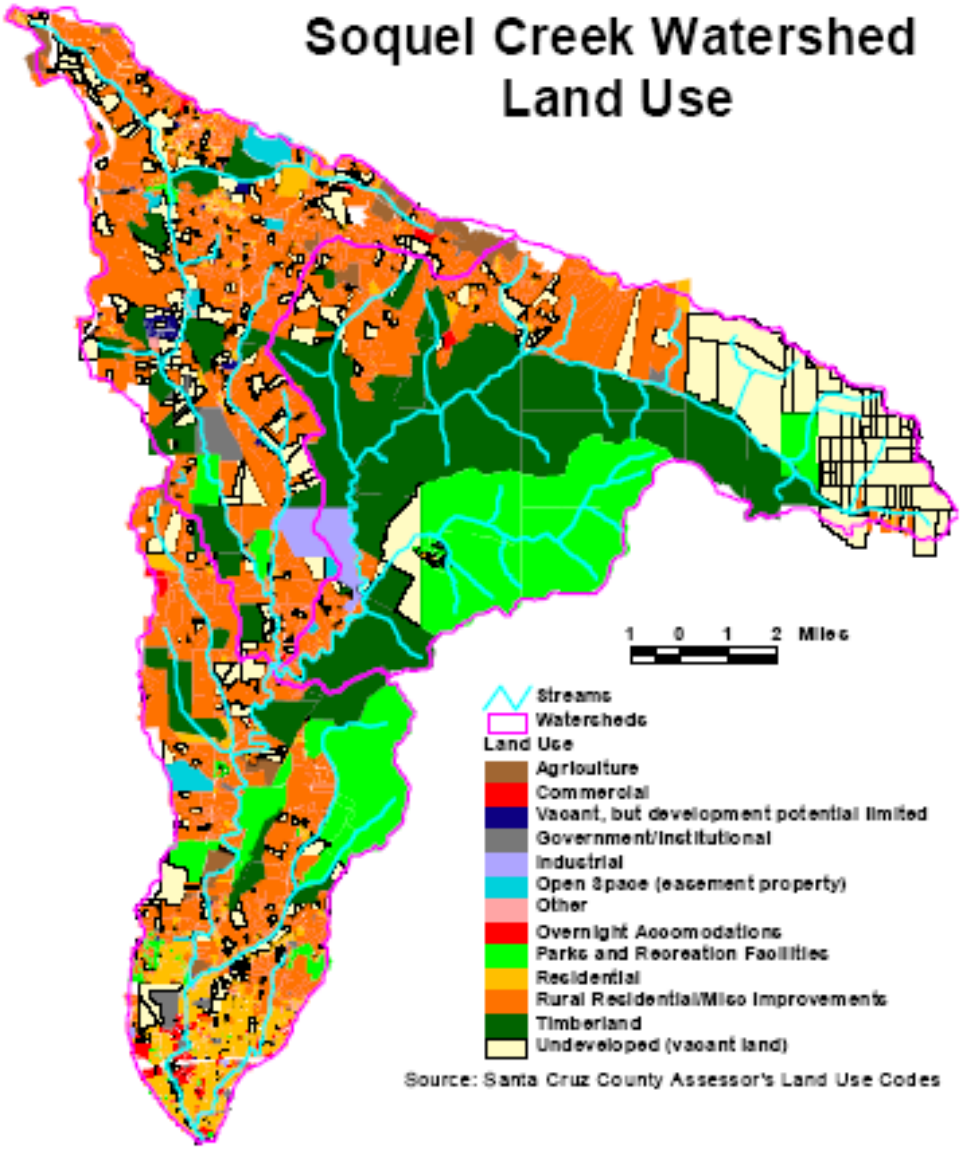


Figure 33. Soquel Creek watershed land use (from NMFS. 2012, Central California Coast Coho Salmon Recovery Plan).

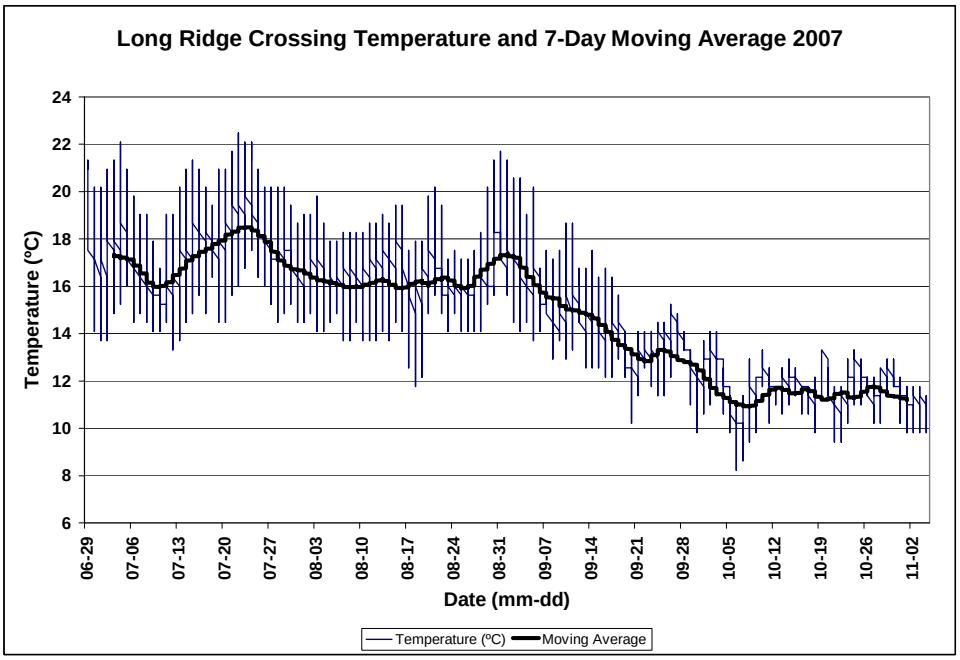


Figure 34. Plot of water temperatures from the East Branch of Soquel Creek during the summer and fall of 2007.

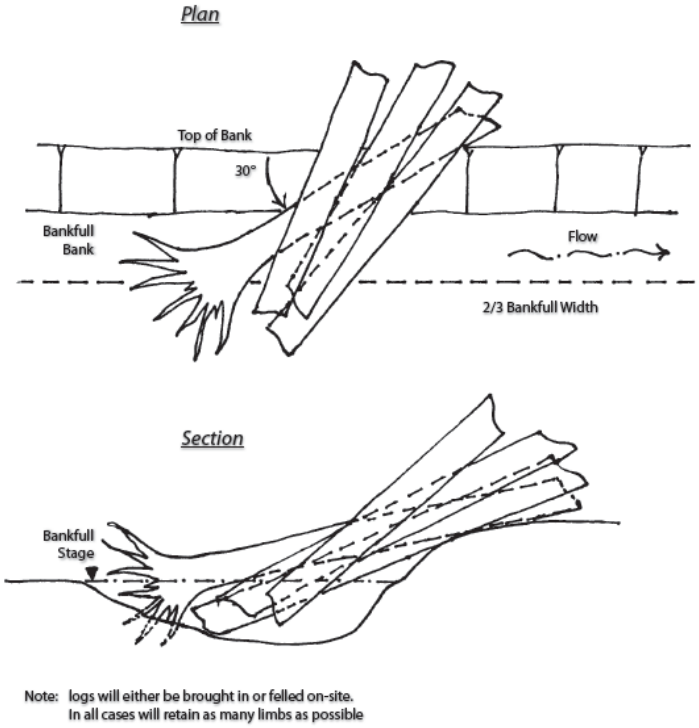


Figure 35. Diagram displaying a typical log cluster installation.

Figure 36. Looking downstream at site 5 (unanchored wood site).

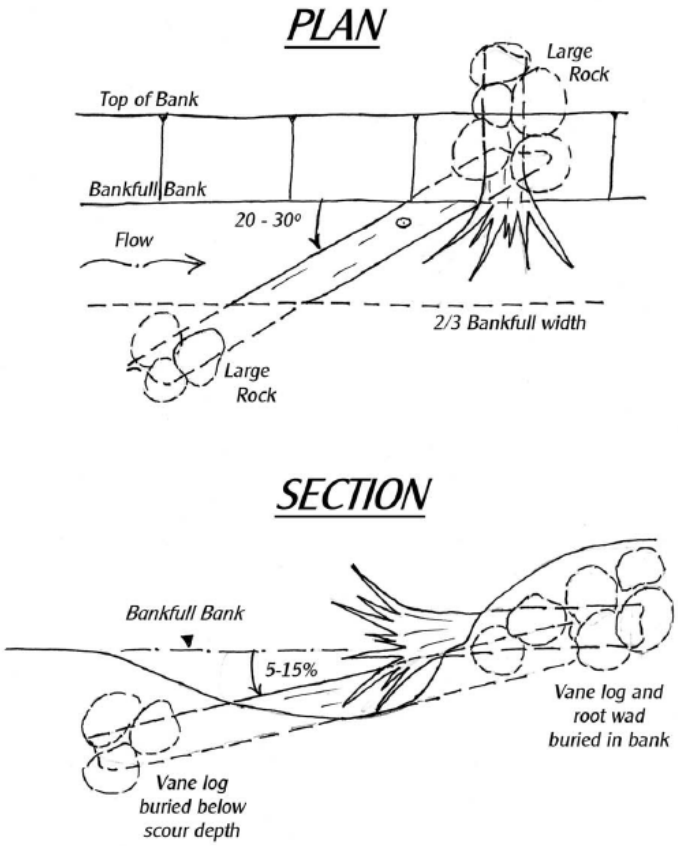


Figure 37. Diagram displaying a typical log-vane structure.

Figure 38. Looking upstream at site 2 (anchored wood site).

APPENDIX A-3. PATHWAY 3) ANALYTICAL DESIGN PROCESS APPROACH (CUSTOMIZED DESIGN)

Some landowners may opt to utilize an analytical design process that applies more detailed site-specific data and knowledge to the project site. This approach allows a landowner to customize a solution for a project site using a much wider array of tools including (but not limited to) computer models, known empirical relationships, more detailed assessment products (e.g., HCPs, Watershed Analysis), etc.

Typically, this pathway would be available to ownerships with a detailed management plan (e.g., Habitat Conservation Plans) or extensive monitoring data that would support the analysis required for this type of customized design. It therefore may not appeal to smaller landowners lacking sufficient technical expertise or data. Pathway 3 may be more applicable to unusual or complex situations, experimental approaches, or those that are not appropriate for the other pathways.

The Analytical Design procedure allows greater flexibility at the cost of more carefully crafted analysis. This approach also facilitates a broader application of riparian designs to a larger spatial area. The Analytical Design procedure requires additional data and additional design expertise from biologists, geomorphologists, ecologists, silviculturists, and/or others, similar to a formal Watershed Analysis (e.g., WFPB 1997), or other rigorous assessment methodologies. The approach is likely to result in more precise application of riparian forestry practices to the benefit of state and federally listed anadromous salmonids in ASP watersheds.

If desired, Steps 1 and 2 in the Classification Matrix (i.e., Pathway 1) can be substituted or modified for Steps A and B in the Analytical Design approach.

APPROACH OVERVIEW

The Analytical Design approach has five components (Figure 39):

1. **Riparian Functional Assessment** – is a functional evaluation and diagnosis of existing conditions that provides the technical foundation for any given project. It consists of an integrated evaluation of:
    - Stream ecological resource (i.e., aquatic habitat and water quality)
    - Dependency of ecosystem resources on riparian forest functions,
    - Future riparian forest function potential and trends, and
    - The context of the proposed project relative to watershed-scale functions, processes and conditions.

2. **Management Objectives** – defines the functional ecological intent for the riparian management area (RMA). Some examples include:

    - Reduce fire risk
    - Increase wood recruitment and habitat development
    - Improve conditional trends by using appropriate riparian silvicultural approaches
    - Promote aquatic productivity

3. **Riparian Design** – develops site-specific prescriptions that result in a forest structure and composition necessary to achieve desired riparian functions. The design should identify specific actions (e.g., harvest limits, seeding and planting, wood placement, silvicultural practices, etc.) and how these actions will vary spatially (and if appropriate, temporally).

4. **Implementation** – describes how the design will be implemented and supervised in the field, and what (if any) data will be collected (e.g., compliance monitoring).

5. **Effectiveness Assessment** – evaluates the post-treatment effectiveness of the prescriptions developed from the Analytical Design procedure t^{o} achieve agency resource protection goals (e.g., fish, wildlife, and water quality) and includes a comparison of the design to standard forest practice prescriptions to assess the relative benefits (ecological and silvicultural) of the design in relation to the default prescription. Effectiveness Assessments may be coordinated by agencies or other 3rd-parties to reduce the burden on any individual landowner, and to improve the overall learning that might come from application of the specific design.

These components combine to form a robust technical basis for proposed riparian management actions, and link that technical basis to specific actions and evaluation of consequences necessary to support regulatory permitting and programmatic evaluation of the Analytical Design.

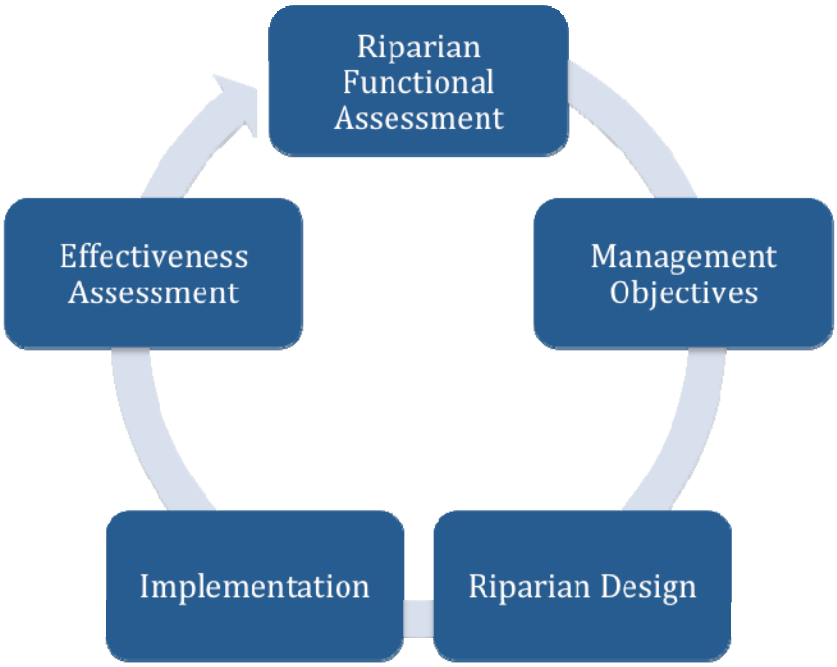


Figure 39. Conceptual framework for Analytical Design.

TOOLBOX FOR POTENTIAL RIPARIAN ASSESSMENT TECHNIQUES

The following represent a set of analytical approaches that may be used to support the technical basis for riparian design. This list is representative, and does not necessarily represent a comprehensive list of acceptable methodologies. Many of these approaches have been well developed within the technical literature. Similar methods that have been developed within the scientific and technical literature may also be appropriate. RPFs may contact Review Team agency personnel or other professionals with significant experience in riparian assessment techniques for detailed information on how to use these or other approaches. The types of assessment techniques available are displayed in Table 13.

Table 13. Analytical tools for assessing riparian function status and stream channel sensitivity.

Metric	Method	Description	Pros	Cons	References
Wood supply potential	Stand inventory	Quantifies existing stand structure (species, size, density)	Quantifies potential supply of functional size trees in riparian stand	Requires field survey	Marquardt et al. 2010
Wood supply potential	Source-distance curve	Indicates potential for riparian trees to deliver LW based on distance from channel edge (i.e., potential delivery declines with increasing distance)	Simple; input process and region-specific curves increasingly available	Delivery potential only partially based on distance. Also depends on site-specific input processes, local landform, tree height/species, and density	FEMAT 1993 (generic), Benda et al. 2002 (CA), McDade et al. 1990 (OR, WA), Martin and Grotefendt 2007 (AK), Murphy and Koski 1989 (AK)
Wood supply potential	Forest structure classification	Predicts general changes in stand structure (tree size and density) over time based on existing knowledge of stand succession	Simple; limited data needed for stand classification, regional/forest succession schemes are generally available	Prediction of stand structure changes over time are highly variable and depend on multiple factors (e.., landform, site productivity, ecoregion)	Oliver and Larson 1996
Wood recruitment sources	Wood recruitment budget	Delineates locations and relative importance of all LW input processes	Identifies all wood sources (includes disturbance processes) and provides context for their relative importance by input process and source locations; basin scale assessment	Requires network-scale field survey and data analysis	Benda et al. 2003, Martin and Benda 2001, O'Connor and Ziemer 1989, O'Connor Environmental 2000

Metric	Method	Description	Pros	Cons	References
Wood recruitment potential	Modeling stand dynamics and LW recruitment	Simulation modeling of riparian forest dynamics, LW input, and inchannel storage/movement	Can simulate LW input and storage/movement under various riparian management schemes	Requires computer modeling, plus information on stand structure and site characteristics (e.g., soil moisture, landform). Applicability based on validity of modeling assumptions(e.g., random tree fall, directed fall, chronic stand mortality as only input processes). Disturbance sources of LW generally not modeled.	Benda et al. 2007, Meleason et al. 2003, Welty et al. 2002, Beechie et al. 2000, Bragg et al. 2000, Van Sickle and Gregory 1990
Shade potential	Site inventory	Quantifies existing shade (e.g., canopy density, effective shade, spatial distribution)	Direct measure of all shade producing elements (i.e., understory, tree canopy, and topography)	Requires field survey	Teti and Pike 2005
Shade potential	Thermal loading	Quantifies site-specific thermal loading potential given topography, aspect, and stand characteristics	Can determine the relative contribution of shade from riparian stand versus shade from topography given the solar path. Can be evaluated at the site or watershed scale. Allows for gaming of scenarios	Requires riparian stand information (height, density, width) and topography data. Analysis usually performed using GIS, but can be hand calculated for site	Allen et al. 2007, Benda et al. 2007, DeWalle 2010

Metric	Method	Description	Pros	Cons	References
Water temperature	Temperature modeling	Predicts stream temperature as a function of riparian condition	Can predict steam temperature, depending on model, at reach and network scales under various riparian management schemes	Requires computer modeling with GIS plus information on stand structure, topography, and stream characteristics (e.g., flow, width, depth, substrate, groundwater input)	Allen et al. 2007, Sridhar et al. 2004, Boyd and 2003, Cafferata 1990, Amaranthus 1984, McGurk 1989
Microclimate				Requires field survey	James 2003, Ledwith 1996
Erosion potential	Erosion hazard rating	Identifies potential erosion hazard from soil survey maps	Simple; only need location info to look-up published soil erosion hazard rating	Map rating accuracy varies by location and is not based on existing ground cover or disturbance history	NRCS Web Soil Survey http://websoilsurvey.nrcs.usda.gov/app/
Erosion potential	Erosion hazard assessment	Identifies potential erosion hazard based on site characteristics (soil, slope, and ground cover)	Can identify site-specific hazards and sediment delivery potential	Requires field survey and hazard classification using suitable protocol	Brake et al. 1997, WDNR 1997

Metric	Method	Description	Pros	Cons	References
Erosion potential	Erosion modeling	Predicts surface erosion hazard level or sediment delivery potential as function of soil, slope, and ground cover	Can predict sediment delivery potential at reach or network scales (depends on model) under various riparian management schemes	Requires computer modeling plus information on ground cover, soils, and topography	USDA Water Erosion Prediction Project (WEPP) http://www.ars.usda.gov/Research/docs.htm?docid=10621, Benda et al. 2007
Organic litter and nutrient supply	Site inventory	Quantifies or classifies existing litter supply potential	Direct measure of litter/nutrient supplying elements (e.g., shrub cover, canopy cover, conifer/deciduous ratio)	Requires field survey	Richardson et al. 2005
Windthrow potential	Windthrow hazard assessment	Identifies withthrow prone terrain and vulnerability of various stand retention schemes	Provides guidance for unit layout to minimize windthrow potential	Site-specific guidance should be supplemented with local knowledge and watershed-scale hazard assessment requires modeling	Rollerson et al. 2009, Kramer et al. 2001, Mitchell et al. 2001, Steinblums et al. 1984
Landslide and debris flow potential	Unstable slope hazard assessments, slope stability models, aerial photograph analysis, field surveying	Identifies potential unstable slopes, debris flow channels, sediment delivery potential	Can use published hazard maps or slope stability models to assist in identifying general areas of higher or lower potential for slope instability	May require certified professional and/or modeling expertise for watershed-scale assessment	Burnett and Miller 2007, Benda et al. 2007, Dietrich et al. 2007, WFPB 1997

Metric	Method	Description	Pros	Cons	References
Channel response potential	Geomorphic stream classification	Identifies channel response potential to riparian inputs (wood, heat, sediment, litter)	Methods widely accepted; classification schemes well defined and can be delineated from maps or field information	Classification accuracy and interpretation can vary based on map quality, availability of site-specific information, and user knowledge/experience	Montgomery and Buffington 1997, WFPB 1997, Rosgen 1994, Paustian et al. 1992
Floodplain function	Aerial photo assessment				WFPB 1997

I. Riparian Functional Assessment

The purpose of the assessment is to: (1) evaluate the relative importance of riparian function inputs (wood, heat, sediment, litter/invertebrates) for forming aquatic habitat and to affect water quality in the adjacent stream reach, and (2) to assess the potential connectivity (i.e., transport) of riparian inputs to downstream channels. The sensitivity or response of aquatic resource condition to riparian inputs and the potential downstream connectivity are indicators of stream dependency on riparian functions.

Functional Ecological Resource Evaluation

Channel response potential and downstream connectivity are strongly influenced by channel geomorphology (gradient, confinement, bed composition), stream size/flow, and position in the stream network. Although channel morphology and flow vary along the stream network, a stream may be subdivided into reaches with distinct channel forms that are reflective of watershed topography and channel forming processes (e.g., Paustian et al. 1992, Montgomery and Buffington 1997). Such geomorphic stream classification provides a qualitative tool for assessing response potential to changes in riparian function inputs (e.g., WFPB 1997). This approach is adopted by applying a typing system that combines stream size (based on channel width or regionally calibrated basin areas) with the Montgomery-Buffington classification. The response potential is described below for riparian function inputs (Table 14). More rigorous evaluation of response potential can be facilitated by quantititive modeling of channel conditions and watershed processes (Benda et al. 2007).

Large Wood

Channel sensitivity to large wood is influenced by channel morphology and stream size. For example, large wood has a stronger influence on the formation of pools in moderate gradient, unconfined channels (plan bed, pool riffle, alluvial fan) compared to that in either steeper gradient, confined channels or in low-gradient channels (Montgomery et al. 1995, Beechie and Sibley 1997, Martin 2001, Gomi et al. 2005). The cobble-boulder-bedrock substrate in steeper high-energy channels control bedform (e.g, step pool, cascade) and pool formation is independent of large wood; although large wood may function to trap sediment in step-pool channels (Montgomery and Buffington 1997). In low gradient meandering channels (e.g., dune ripple) the dependency on large wood is limited, as free-formed pools are common (Beechie and Sibley 1997). The relationship between large wood and pool frequency is also dependent on channel width. As channel width increases, pool frequency is more strongly influenced by changes in large wood abundance (Montgomery et al. 1995, Martin 2001).

Table 14. Generalized channel sensitivity/response potential to changes in exchange function inputs in relation to stream size and channel type.

		Function input (channel response metric)			
Channel type	**Stream size**	**Large wood (pool formation)**	**Shade (temperature)**	**Sediment (grain size)**	**Litter (retention)**
colluvial	small	M	H	M	H
bedrock	all	L	H	L	L
cascade	all	L	M	M	L
step pool	all	M	H	M	M
plane bed	all	H	H	H	L
pool riffle	small	H	H	H	H
	medium	H	M	H	H
	large	H	L	H	M
dune ripple	small	M	H	L	M
	medium	M	M	L	L
	large	L	L	L	L
alluvial fan	all	H	M	H	H

Downstream connectivity for large wood is a function of transport processes (fluvial, debris flow), which are based on stream size, channel morphology, and disturbance risk. The travel distance of large wood by fluvial transport is a function of stream size (i.e., distance increases with increasing channel width) and the size of mobile large wood is generally less than or equal to the channel width (Martin and Benda 2001). For example, Martin and Benda (2001) estimated the mean transport distances for mobile large wood over the lifetime of individual pieces ranged from about 200 m in small (3-5 m wide) jam-rich streams to about 2,500 m in larger channels (20-30 m wide). Because large wood by definition ranges from 2-3 m long, there is essentially no fluvial export of large wood from small streams. However, episodic debris flows can transport large wood, including pieces longer than channel width, from small steep headwater channels (e.g., colluvial channels) to downstream low-gradient channels (May and Gresswell 2003). Debris flows originate on unstable landforms that commonly occur near headwater streams and may deliver sediment and debris, including large wood to downstream channels which may begin on steep gradients around 25 percent and may extend downstream to gradients less than 3 percent (Benda 2005). A study by by Burnett and Miller (2007) found that in one area of Oregon, the likely initiation point and transverse distance of debris flows could be estimated.

Water Temperature

Solar radiation is the primary driver of stream temperature in most streams. Stream temperature sensitivity to shade is influenced by a suite of site characteristics. Stream size is a key driver, with sensitivity decreasing in relation to increasing depth, velocity, and discharge (Moore et al. 2005). Velocity influences exposure duration which decreases with increasing

velocity in steeper channels (cascade channels). Stream depth has significant influence because it affects both the magnitude of the stream temperature fluctuations and the response time of the stream to changes in environmental condition (Adams and Sullivan 1989). Also, sensitivity declines with increasing stream width as the channel becomes too wide for shading. The temperature response to heat input may be dampened somewhat by hyporheic exchange rate which is a function of bed composition. Streams with alluvial gravel/cobble bed material (pool riffle, alluvial fan channels) enables increased hydraulic retention (promotes conductive cooling) and are less sensitive to shade loss compared to streams with less-permeable boulder/bedrock substrate (e.g., cascade, bedrock channels) (Johnson 2004, Dent et al. 2008). The relative sensitivity of a stream and the contributing factors may be examined by analytical modeling (e.g., Heat Source; Boyd and Kasper 2003)

The effect of heat input on downstream water temperature in the same stream depends on factors controlling heat exchange in the downstream reach, including heat exchanges across the air–water surface, cooling from groundwater inflow, and hyporheic exchange (Story et al. 2003, Moore et al. 2005). Stream depth and velocity control the rate of heat exchange and response distance. Because depth and velocity generally increase with discharge, the sensitivity of a downstream reach to heat inputs decreases with increasing discharge (Moore et al. 2005). The temperature sensitivity of a stream with tributary heat input is a function of the temperature differences between streams and the flow ratio between contributing and receiving streams (Brown 1980).

General guidelines for assessing temperature connectivity are limited because of the large variability in conditions that are best evaluated with modeling (e.g., Heat Source; Boyd and Kasper 2003). However, a regional guide was developed for western Washington by Caldwell et al. (1991). They found that headwater streams had minimal influence on the downstream water temperature because of the large size difference between headwater tributaries and receiving (typically fish-bearing) waters. Using the stream flow mixing equation, assumed tributary and receiving stream temperatures, and the relationship between distance from divide and minimum stream discharge, they determined that a headwater stream could not affect the temperature in a typical fish-bearing stream by more than 0.49° C if the confluence of the receiving stream is more than 7 km (4.5 miles) distance from the watershed divide. Caldwell et al. (1991) reported that small streams are very responsive to localized conditions and that the longitudinal effect of any one headwater stream on downstream temperatures is limited to 150 meters (~500 ft) or less. Longer distances have been reported for larger streams. For example, Zwieniecki and Newton (1999) found in low gradient streams averaging ten feet width and 0.5 cfs, within buffered clearcuts, increased temperatures cooled to trend line temperatures within 150-300 meters (492-984 feet) downstream. On the other hand, Sullivan et al. (1990) reported a cooling effect extending 3 km downstream of the confluence of two streams. They suggested for larger streams that 600 meters (1,969 feet) be the minimum length for streams to equilibrate to background temperatures. In any case, the temperature resulting from two streams merging can be accurately predicted by the weighted average of the two stream temperatures. Similarly, the distance required for the receiving stream to reach equilibrium downstream of a tributary can be estimated based on velocity and channel dimensions,

recognizing that equilibrium is generally achieved in two hours of travel time (Sullivan et al. 1990).

Sediment

The effects of fine sediment supply on streambed particle size is governed by geomorphic and fluvial controls on sediment transport capacity. Therefore, channel sensitivity is associated with the spatial distribution of source, transport, and response segments in the stream network (Montgomery and Buffington 1997). Small steep headwater channels are transport limited and may store sediment for decades to centuries until an episodic event (debris flows, debris floods, or gully erosion) transports the material to larger channels (Benda 2005). Downstream, the larger transport segments (i.e., confined; bedrock, cascade, and step-pool channels) are morphologically resilient channels that rapidly convey sediment loads to lower gradient response segments. The response segments (i.e., moderate to unconfined channels; plane-bed, pool-riffle, alluvial fan) are sensitive to sediment deposition (Montgomery and Buffington 1997). The sand and silt beds of dune-ripple channels are insensitive to deposition of fines.

Downstream connectivity for sediment is a function of fluvial and episodic (debris flow) transport processes, which are governed by stream size, channel morphology, and disturbance risk. As described above, fluvial transport potential increases with increasing stream size and debris flow export is associated with small channels in headwaters that occur near unstable hillslopes. Published hazard maps or slope stability models can be used to assist in identifying general areas of higher or lower potential for slope instability, but field evaluation will be necessary to determine specific areas susceptible to debris flow events (Dietrich et al. 2001, Burnett and Miller 2007, Dietrich et al. 2007). MacDonald and Coe (2007) state that delivery of sediment from headwater channels to downstream reaches depends on the transport process, channel type, transport capacity, and sediment particle size.

Organic Litter

The retention and subsequent biological processing of organic litter is a major trophic resource for biological communities in small streams. The retention of organic litter (i.e., reach sensitivity) is dependent on channel morphology and flow regime (Richardson et al. 2009). Retention of detrital particles increases with increasing channel roughness which is associated with complex channels consisting of an intermingling of rock and debris (stones, twigs, logs, wood jams, pool riffle, step pool, alluvial fan). Channel types with low roughness (plane-bed, cascade, bedrock) have low retention of litter. Litter transport increases rapidly with discharge as particles become entrained and are transported downstream (Richardson et al. 2009).

Riparian Forest Function Assessment

The riparian assessment involves evaluations of riparian function status and delivery of functions to the stream. The analysis of function status ranks the suitability of the current riparian forest to supply large wood, provide shade, minimize surface erosion, and supply organic litter/terrestrial invertebrates. The function delivery analysis evaluates the amount of connectivity between riparian forest functions and the adjacent stream. The riparian forest functional potential is derived from the function status and delivery analyses (Table 15).

Function potential ratings indicate the relative capacity of the existing riparian forest to deliver riparian functions. (Note, changes in function potential are based on the feasibility of changing either function status or function delivery, or both. The Analytical Design approach will mostly focus on silviculture to influence function status, although it is conceivable that unit layout can influence delivery; e.g., affect windthrow risk).

Table 15. Ratings for riparian forest function potential.

Function Delivery	Function Status		
	Poor	Fair	Good
Low	L	L	M
Medium	L	M	H
High	L	M	H

Functional Status

Riparian forest structure and composition define riparian function status (Table 16). The large wood supply potential of a riparian forest is based on the density of functional size trees that may be recruited to the channel within a defined source distance (e.g., one site-potential-tree-height). Functional size is determined by the diameter and length of wood pieces that are large enough to influence channel forming processes and is directly related to channel width (Bilby and Ward 1989 (Figure 3), Beechie and Sibley 1997). Potential tree recruits must be tall enough to intersect the channel after falling down and the portion in-channel must be of functional size. Therefore, the size of potential recruits varies with tree distance from the channel and channel width. The composition of recruited large wood (conifer or deciduous) influences the longevity and structural strength of wood formed habitat (Cederholm et al. 1997, Bilby et al. 1999) and could be used as a qualifier of the large wood supply potential for riparian forests.

Table 16. Stand characteristics that influence the potential of riparian forest to provide exchange functions. Symbols indicate direction of characteristic effect on function: + = positive, - = negative, +/- = depends on specific condition, blank cells = not linear.

	Exchange Function			
Forest Characteristics	**large wood**	**shade**	**sediment retention**	**litter and invertebrates**
tree size (dia. and ht.)	+		+	
stand density	+/-	+	+	+/-
dominant tree species	+/-			+/-
riparian stand height		+		
riparian stand width	+	+		
ground cover (shrubs, wood)			+	+

The shade potential of a riparian forest is based on stand height, canopy density, and stand width characteristics that effectively attenuate direct beam solar radiation (DeWalle 2010). Stand height is based on the shadow length that is required to shade a stream of given width and is determined from the relationship between solar altitude and shadow length for a given site during summer (e.g., at solstice). Canopy density and buffer width affects the attenuation of direct beam radiation as it passes through the canopy along the daily solar path for a given site during summer. Attenuation by the canopy is directly related to tree leaf area index (varies by species) and stand density (Sridhar et al. 2004, DeWalle 2010).

The sediment retention within a riparian forest is based on vegetative ground cover, hillslope gradient, and soil erodibility (WFPB 1997). Ground cover, including roots, stems, and debris (logs, branches, needles), binds soils and creates roughness elements that minimize surface runoff and trap soil particles (Liquori et al. 2008). Ground vegetation is probably more effective than forest cover for reducing surface erosion, but trees and associated root mass are important for enhancing bank and hillslope stability.

The riparian stand composition, especially the presence of deciduous trees, has a strong influence on the quality of detrital litter and the supply of terrestrial invertebrates to streams (Liquori et al. 2008). Stream adjacent trees and shrubs, especially overhanging vegetation, are considered the most important contributors of litter and terrestrial insect fallout (Liquori et al. 2008). Litter derived from riparian vegetation is the dominant base of food chains in forested streams of orders 0 through 3 (Cummins et al. 1989, Cummins 2002).

Riparian Function Delivery to Streams

The landform and network position of a riparian stand influences the delivery of riparian functions to streams by directly controlling function input processes (e.g., tree fall direction, topographic shading, surface erosion) and by indirectly controlling the probability (frequency) and type of natural disturbance at the site (Table 17).

Landform and network position have a large influence on large wood recruitment processes which govern the source area and frequency of wood delivery to streams (Benda et al. 2003, Swanson 2003). Tree fall in riparian stands tends to be directional and fall direction toward the stream increases in relation to slope steepness (Sobota 2003). Consequently, large wood input (i.e., stream connectivity) from chronic mortality is greater for riparian trees on steep terrain than for riparian trees on low-gradient landforms (e.g., floodplain, terrace). Wood input from bank erosion increases with stream size and is strongly associated with riparian stands on unconfined landforms (e.g., floodplain, alluvial fan) (Martin and Benda 2001). The influence of bank erosion on riparian-stream connectivity declines in smaller streams and is limited on confined landforms (e.g., canyon, hillslope confined channel). The probability of large wood recruitment by episodic processes is more strongly associated with steeper landforms in headwater areas than with low-gradient lower-valley landforms. There is an increasing probability of windthrow in riparian stands that are located along the edges of gullies or in the upper more wind-exposed portions of a basin (Rollerson et al. 2009). Basin aspect in relation to the prevailing storm direction also influences the probability of wind disturbance (Kramer

Table 17. Riparian function delivery potential (low, medium, high) as influenced by landform and network position. Unconfined/low valley landforms have valley floor width (VW) > 4 bankfull channel widths (CW), confined/headwater landforms have valley floor width (VW) < 2 bankfull channel widths (CW)], and moderately confined/mid valley landforms have valley floor width < 4 bankfull channel widths (CW)] and > 2 bankfull channel widths (CW).

		Landform/Network Position		
Affected function	**Process**	**Unconfined/ low valley**	**Mod confined/ mid valley**	**Confined/ headwater**
		Chronic Processes		
Large wood	chronic mortality	L	M	M
Large wood	bank erosion	H	M	L
Shade	direct solar radiation	H	M	L
Sediment	surface erosion	M	M	H
Litter and invert	fallout/entrainment	M	M	H
		Episodic Processes		
Large wood	windthrow	L	M	H
Large wood	landslide/debris flow	L	M	H
All functions	fire	L	M	H

et al. 2001, Mitchell et al. 2001). The probability of large wood input from landslides is highest in steep convergent landforms (1st and 2nd order channels) and declines downstream with the transition to lower gradient, wider valley landforms (May and Gresswell 2003). Wood input from landslides may dominate wood loading in headwater channels. However the frequency of landslides at a particular site can range from a few decades to millennia (Nakamura and Swanson 2003). Similarly, windthrow may dominate wood inputs in low- to mid-order channels and event frequency ranges from decades to centuries. These episodic disturbances of riparian forests, as well as wildfire, are not only influenced by landform characteristics, but may be sensitive to adjacent timber harvest activity (Martin and Grotefendt 2007, Rollerson et al. 2009).

Potential direct beam solar radiation varies by location in relation to topographic shading, channel morphology, and stream orientation (Sridhar et al. 2004, Moore et al. 2005, Allen et al. 2007). Stream exposure to incident solar radiation decreases with increasing shadow from ridges in steep headwater terrain. Similarly, exposure decreases with increasing channel incision and with decreasing channel width (bank shading), which is common in small headwater streams. Channel orientation influences the duration of high angle exposure to direct beam radiation, which decreases with east-west orientation; hence streams having a north-south orientation tend to be warmer than those with an east-west orientation.

Surface erosion is influenced by hillslope gradient, ground cover vegetation, soil erodibility, and precipitation intensity (WFPB 1997). Sediment delivery potential increases with slope. Therefore, the sediment retention function of riparian ground cover is most important in steeper terrain.

Biotic inputs (litter and invertebrates) from the riparian forest to streams are more tightly connected for smaller (headwater) streams as a result of the closed canopy and the high edge-to-area ratio (Richardson et al. 2005). Biotic connectivity is also influenced by riparian flooding, which would increase with stream size and in unconfined landforms. Confined channels would have the least biotic connectivity.

The frequency of fire in riparian forest is associated with valley morphology and stream size. Small first order streams with incised channels in headwaters have shorter fire return intervals than second and third order, low gradient streams in wide valleys (Everett et al. 2003, Van de Water and North 2010). The relative influence of fire on riparian function also varies with stream order/landform; the potential for fire disturbance declines with increasing stream size and the increased presence of floodplain landforms, which are more frequently disturbed by floods (Charron and Johnson 2006).

Watershed Context

The purpose of the watershed assessment is to determine the relative contribution of ecological services (e.g., aquatic habitat, fish potential) that are provided by the project reach compared to that in the project watershed. Knowing the ecological service potential of the project reach facilitates ranking of reach importance relative to a desired ecological value (e.g., conserve fish populations). Such ranking is useful for prioritizing management concerns and for judging the relative benefits of different management options for the Analytical Design approach.

Geomorphic channel typing, fish habitat, and fish distribution information are typical indicators of ecological service potential. Spatial patterns of fish distribution and habitat use by life phase are strongly influenced by channel morphology and flow regime (Montgomery et al. 1999, Steel et al. 2004, Isaak and Thurow 2006). One way to objectively quantify the integrated functions of channel morphology, fish habitat and distribution is to develop an “intrinsic potential” index (Burnett et al. 2007). The Intrinsic Potential (IP) score can identify potential stream reaches throughout the landscape where restoration can result in improved salmonid population status and risk. IP scores may be available for some regions or can be calculated for stream reaches in a watershed using channel geomorphology and flow data (e.g., NetMap; Benda et al. 2007). The IP ranking of the project reach can be evaluated by comparing IP quality (e.g., categorical ranking of IP scores) among reaches or by determining the percentile rank from a cumulative frequency distribution of IP scores for the watershed (Table 18).

Table 18. Ranking of ecological service potential of project reach relative to that in the watershed.

Ecological resources	Reach value	Reach quality	Rank in watershed
Intrinsic potential			
salmon	IP score	H,M,L	percentile
steelhead	IP score	H,M,L	percentile
other	IP score	H,M,L	percentile
Habitat			
pools	pct area	H,M, L	percentile
spawning gravel	pct area	H,M, L	percentile

Surveys of fish habitat (spawning and rearing habitat) and species distribution in the stream network can provide an index of habitat quality, fish use, and spatial distribution which can be used to evaluate the relative importance of the project reach compared to that in the watershed (e.g., WFPB 1997).

II. Management Objectives

Specific management objectives should be established for each project based on an analysis of the existing deficiencies associated with each project watershed. Opportunities for active riparian management should be established based on these deficiencies, and not necessarily driven solely by a desire to extract timber values. In general, the primary riparian management objectives may include one or more of the following:

- Enhancement and/or recovery of natural wood recruitment processes (e.g., competition mortality, windthrow, bank recruitment)
- Sufficient heat regulation to minimize mortality risk and optimize growth conditions that support fish populations (e.g., Sullivan et al. 2000)
- Sufficient nutrient cycling processes that support food supply and desirable growth conditions for salmonids (e.g., Wilzbach et al. 2005, Kiffney and Roni 2007, Modenke and Ver Linden 2007, Poor and McDonnell 2007)
- In-stream habitat conditions that provide sufficient rearing, spawning and passage
- Dynamic geomorphic stability where channels are hydrologically connected to their floodplains; incision from legacy practices are recovered or improved
- Lateral and longitudinal diversity in habitat functions and conditions along the entire watershed network
- Emphasis of ecological hotspots and geomorphically dynamic reaches that leverage the unique benefits of those reaches to support a broad habitat matrix across multiple reaches

III. RIPARIAN DESIGN

The riparian design is a description of the stand characteristics (i.e., design criteria) and management actions (i.e., prescriptions) that are estimated to put the riparian stand on trajectory to achieve the management objectives. The design is derived through an iterative process of evaluating and comparing:

- The probable future stand characteristics and growth schedule for various treatment alternatives, including no-treatment of the existing stand,
- The effectiveness and time frame of each alternative to improve the riparian function potential,
- The potential to produce a harvestable surplus,
- The relative importance (ecological service potential) of improved riparian functions for the stream and watershed, and
- Feasibility (cost effectiveness, operational constraints) of implementing different options.

The detail and intensity for this evaluation is dependent on the stand prediction capability and the complexity of the management objectives. Growth and yield models offer the most flexibility and would be essential for comparing a range of alternatives. However, simple forest stand development schemes are effective predictors of stand characteristics and can be used for planning riparian prescriptions (Oliver and Hinckley 1987).

The evaluation for effectiveness of each alternative to improve riparian functions is based on the relationships between riparian stand characteristics and riparian functions (see Function Status section). In this evaluation the stand characteristics are converted to function-metrics and the function potential is compared among treatments. For example, the density of functional size trees (accounting for stream width and tree distance to stream) is used to determine the large wood supply potential. Similarly, the stand height and crown density are an effective predictor of shade potential.

The harvestable surplus evaluation is based on the knowledge that forest structure can be manipulated to improve ecological functions, as well as, to produce opportunities for timber harvest. For example, timber harvest may be associated with stand conversion (e.g., hardwood to conifer), partial-harvests to create fire breaks or patch-cuts to emulate disturbance patterns, or multi-stage strategies of thinning to optimize yield as well as ecological functions. The timber yield for conversions and partial-cuts are straight-forward (i.e., based on existing stand data), but the evaluation for complex multi-stage harvests will rely on modeling.

The evaluation of aquatic habitat and ecological services that results from the riparian design is based on a comparison of the existing habitat condition to potential habitat when the riparian-dependent functions have been improved. The prediction of habitat potential is based on the relationship between channel sensitivity/response potential and riparian function inputs (Table 14). In sensitive reaches (i.e., where response is moderate to high), the effectiveness of adding large wood or changing shade levels on rearing habitat and water temperature, respectively,

can be estimated from existing habitat response curves or from modeling (e.g., Beechie and Sibley 1997, Allen et al. 2007).

The feasibility of implementing the riparian design is dependent on a host of factors, including the overall ecological contribution to the stream and watershed, potential timber yield, site access, and potential coordination with adjacent upland silviculture operations.

STEP A) EVALUATE EXISTING SITE CONDITIONS

With the Analytical Design approach, analysis of the existing site conditions is conducted by qualified experts trained to evaluate the functional impacts associated with riparian forestry. There are three fundamental assessments that should occur: geomorphic, riparian, and disturbance regimes.

Geomorphic Surveys

Geomorphic surveys should consider the ecological and geomorphic condition of streams within the THP area and associated contributing sub-watersheds. The analysis should evaluate the channels, and we recommend using criteria similar to those presented in WFPB (1997, Tables E-3a, b, c) to establish the existing condition and sensitivity of stream channels. Such factors can include more intensive analysis combining field investigations, models, maps, aerial photos, empirical data, and/or other credible analytical tools. The analysis should consider:

- Seasonal vs. perennial flow
- Aquatic habitat availability, abundance, and resilience
- Functional importance for key inputs (wood, heat, nutrients)
- Bank and channel stability assessment

Key analytical inputs may include:

- Bed substrate conditions, including embeddedness
- Habitat surveys
- Wood inventories
- Sediment supply investigations
- Geomorphic mapping
- Channel cross-sections and longitudinal profiles

Riparian Growth Analysis

The analyst will evaluate the existing and future site potential to deliver wood, thermal protection, and nutrient supply from the existing stand. This information can be used to

diagnose specific site deficiencies and identify opportunities for site treatments to improve long-term riparian conditions. The analysis should consider:

- Wood recruitment sources from bank erosion, treefall (mortality), streamside landsliding (including debris flows) (of various wood size categories)
- Thermal loading, including topographical and vegetative shade
- Nutrients/litter/food sources
- Erosion, landsliding, and sediment delivery to streams
- Channel migration potential and likely bank erosion rates
- Growth potential and expected dynamic stand responses

Key analytical inputs may include:

- Growth models
- Empirical growth plots
- Spatial mapping tools
- Wood recruitment models

Disturbance Regimes

The design process should consider specific disturbance regimes that help refine the process domains for each stream segment. Identifying specific disturbance regimes will allow the riparian design to adjust to specific risks that may affect the delivery rates and processes associated with each key function. Specific criteria can be established to define and map these areas. Disturbance regimes include:

- **Fire regimes** – riparian areas with high fuel loads and fire ladders in fire-prone landscapes. In such areas, prudent strategies may be employed, including fire breaks, ladder treatments, or similar prescriptions.
- **Disease and infestation zones** – riparian areas with significant disease or infestation conditions for which thinning treatments could prevent transmission.
- **Channel migration potential** – low gradient active floodplains prone to channel migration processes.[18]

[18] Note that specific guidance on development of site-specific plans for flood prone areas is provided in 14 CCR § 916.9 [936.9, 956.9] (v)(5) in Appendix A, as well as in Cafferata et al. (2005).

- **Windthrow risk zones** – riparian areas with high risk of windthrow, including species present, height of the stand, etc.
- **Debris Flows** – the influence of debris flow risk is accommodated within the Geomorphic Typing procedure. However, watershed-scale risk-based approaches may be applied in landscapes with high debris flow risk concentrations or in other unique circumstances.

Disturbance regimes identify special considerations that should be applied to specific stream segments to accommodate processes that have the potential to substantially alter the dominant functional processes. These disturbance regimes require onsite investigation, design adjustment and justification using appropriate management tools and strategies (see Analytical Toolbox, Table 13).

Spatial Analysis

The design process should consider the spatial distribution of site conditions in its analysis and design. Such analysis may extend beyond the limits of the THP to include upslope contributing watersheds as well as downstream receiving areas. The spatial analysis should consider connectivity between stream segments, by recognizing the downstream transport potential of each key functional input (wood, sediment, heat, nutrients, and water) (see MacDonald and Coe 2007).

STEP B) DIAGNOSE FUNCTIONAL OBJECTIVES

In this step, the analysis should identify specific functional deficiencies and opportunities provided by the site's existing (and potential future) conditions described in Step A. Such analysis will require some understanding of riparian ecology, and should specifically address each key riparian exchange function (wood supply, nutrient supply, thermal regulation, and sediment). The analysis should consider credible qualitative and quantitative methods of analysis.

STEP C) DEVELOP A TECHNICAL BASIS FOR DESIGN

As with any engineering design, a technical basis is an analysis that provides the technical support that specifically describes and justifies the feasibility of the design. The technical basis should outline how the functional objectives provided by the design can be achieved at the treatment site, and why they can be effective at providing the necessary functions. The technical basis should also describe how prescriptions should be implemented.

The specific components in the technical basis should depend on the unique conditions associated with each site and its associated design. As such, they should be determined by the RPF. However, each technical basis should meet specified standards defined by regulation, which should document and justify how the riparian design will achieve the necessary site functions.

The Decision Matrix defined in the Classification Matrix procedure (Pathway 1) can guide the level of technical justification and analysis required within the Analytical Design procedure's technical basis. For example (in increasing order of required justification):

- **Generally Available** – these sites offer the greatest opportunity for management activities with the least risk to functional impacts. As such, limited analytical justification is required to develop treatments in these areas.
- **Protect** – such sites reflect areas that are highly functional within sensitive areas. Any treatments in these areas should therefore require substantial technical justification.
- **Maintain** – these sites suggest the need to maintain existing functions with minor (modest) treatments directed to promote future "good" conditions.
- **Improve** – these sites offer the best opportunities to improve site conditions with limited risk of impacts. Such locations may benefit by aggressive treatments with appropriate analytical support required.

Compare the Expected Response for Design Alternatives

As part of the technical basis, the Analytical Design should include both a spatial and temporal comparison of the standard rules verses the proposed design that justifies the proposed actions. Such comparisons may be provided in the form of maps, model output, or other credible and objective analytical procedures. Such comparisons can also be used iteratively to develop and refine the site design.

IV. Implementation

The implementation phase in this pathway describes the actions taken during treatment and the information that may be collected to evaluate project compliance and effectiveness. Typically, implementation monitoring activities and effectiveness monitoring activities rely on different information. Implementation monitoring measures *actions* against the *standard* identified in the design or permit requirements (e.g., was the action implemented to specifications). By contrast, effectiveness monitoring measures the *results* of actions against the *objectives* of the design (e.g., was the design effective in achieving desired results). Careful considerations of these two different types of monitoring can lead to cost-effective data collection that can inform both implantation and effectiveness questions.

V. Effectiveness Assessment

See Section IV (above) and Chapter VIII for possible effectiveness monitoring strategies.

Recommended ASP Rule Section V Pre-Consultation Guidance

[This document will be compiled into an instruction sheet and a separate form that can be printed and used in the field. The instructions will also indicate that the form is optional, and that users can alter or modify it as needed]

Purpose: The purpose of Pre-Consultation activities is to:

1) Evaluate the site-specific proposal in the context of restoration and recovery objectives of the Anadromous Salmonid Protection (ASP) rules (i.e., consistent with requirements in 14 CCR Section 916.9 v (1)),[19]
2) Identify potential issues of concern that may require additional considerations for the site-specific proposal, and
3) Give the landowner and/or RPF the ability to determine the potential acceptance of proposed actions.

The intent is to quickly identify issues of potential controversy to allow for a more efficient application of resources during the planning period. The benefit of using this (or a similar) form is that it can:

- Facilitate the preparation of documentation required for an evaluation pursuant to 14 CCR 916.9 [936.9, 956.9] (v)(3).
- Organize and document the preparation and outcomes of pre-consultation discussions with agency representatives.
- Help evaluate the level of effort needed to develop the information and analysis to comply with agency needs.

---

[19] *See the recommendations included in the Recovery Strategy for California Coho Salmon (DFG 2004) at the following weblinks:*

http://www.dfg.ca.gov/fish/documents/SAL_SH/SAL_Coho_Recovery/ReportToCommission_2004/07.RangewideRecommendations.pdf

http://www.dfg.ca.gov/fish/documents/SAL_SH/SAL_Coho_Recovery/ReportToCommission_2004/08.WatershedRecommendations.pdf

- Ensure a common understanding between the landowner (plan proponent) and the agencies to minimize any mis-communication.
- Help identify permitting requirements that may be necessary.

The enclosed form is optional. It is provided solely for the benefit of the landowner/RPF in the planning of a Section V site-specific proposal. The documented outcomes of discussions with agencies do NOT represent formal agency approval, but this information is intended to provide timely feedback to the RPF during the planning process. CAL FIRE will NOT rely on this form, but will confirm forest practice rule (FPR) conformance through evaluation of documentation included in the timber harvesting plan (THP) and through the Review Team process, regardless of the content in this form. However, a completed pre-consultation form can be submitted with the THP application to ensure that discussions with agencies or other stakeholders are part of the public record.[20] Any changes from the proposal discussed in this pre-consultation form that are included in the final THP should be clearly described in the THP submittal.

It is incumbent on the plan proponent to determine the level of effort appropriate for this pre-consultation form. Only those sections applicable to the site-specific proposal should be completed.

During the Pilot Phase, we request that all pre-consultation forms, ***regardless of the outcome***, be submitted to the Section V Technical Advisory Committee (VTAC) to help understand where roadblocks are occurring. CAL FIRE will take the lead in facilitating a process so that these forms are compiled, after removing landowner names, and submitted to the VTAC.

---

[20] *According to CEQA laws, the general public has the right to pertinent information that the lead agency (CAL FIRE) or Responsible Agency (other state agencies) use to make their determinations. Such information will be made public upon submission to the THP process, and thus the documentation submitted with the THP should be sufficiently complete as to be in compliance with CEQA.*

Part I) Pre-Consultation Information

SUMMARY OF SITE-SPECIFIC PROPOSAL

To be prepared prior to the pre-consultation.

PROPOSAL OBJECTIVES:

List as bullets

ABSTRACT: (ALSO SEE PROPOSAL CONTEXT):

Briefly summarize the site-specific proposal, including references to graphics (where appropriate). Summarize the who, what, where, when, why, and how sufficient to provide agency staff with enough context to understand the issues before the field site visit. Also, the plan proponent should outline the initial justification for the site-specific proposal.

SITE-SPECIFIC PROPOSAL CONTEXT

To be prepared prior to the consultation to provide agency staff with basic information about the proposal.

GENERAL PROPOSAL INFORMATION

Forest Practice Rule Location (Geographic Scope)

- Coastal Anadromy Zone –
  - Confined
  - Flood Prone Area or Channel Migration Zone
  - Southern Subdistrict (SSD)
- Outside Coastal Anadromy Zone –
  - Confined
  - Flood Prone Area or Channel Migration Zone
- Upstream of an ASP Planning Watershed

Watercourse Class/Type

Length of Class I Watercourse (ft) _____

Length of Class II-L Watercourse (ft) _____

Length of Class II-S Watercourse (ft) _____

Length of Class II-SSD Watercourse (ft) _____

Length of Class III Watercourse (ft) _____

Proposal Types

☐ Instream Large Wood Enhancement

☐ Fire Hazard Reduction

☐ Flood Prone Area Management

☐ Core Zone WLPZ Vegetative Management

☐ Inner Zone WLPZ Vegetative Management

☐ Outer Zone WLPZ/ ELZ Management

☐ Sediment Reduction Related to Logging Roads, Crossings, Landings and/or Skid Trails

☐ Channel Bank Stabilization

☐ Barrier Modification/Removal

☐ Other (explain) _____

Applicable Rule Goal – 14 CCR 916.9(a)

☐ Comply with terms of TMDL

☐ Prevent significant sediment load increase

☐ Prevent significant channel instability

☐ Prevent significant blockage of aquatic migratory routes

☐ Prevent significant adverse impacts to streamflow

☐ Protect, maintain, and restore conifer trees that can provide LWD recruitment

☐ Protect, maintain, and restore canopy needed for shade and nutrient inputs

Applicable WLPZ Objective – 14 CCR 916.9(c)

☐ Bank stability (core zone) [(c)(1)]

☐ Large wood recruitment/placement (core, inner, outer zones) [(c)(1), (c)(2), (c)(3), (c)(5)]

☐ Canopy retention (core, inner, outer zones) [(c)(1), (c)(2)]

☐ Vertical structural diversity (inner, outer zones) [(c)(2)]

☐ Species diversity for nutrient input (inner zone) [(c)(2)]

☐ Wind resistance where windthrow is likely (outer zone) [(c)(3)]

☐ Microclimate control (outer zone) [(c)(3)]

☐ Habitat for terrestrial wildlife species dependent on riparian areas (outer zone) [(c)(3)]

☐ Sediment filtration (outer zone) [(c)(3)]

☐ Water and nutrient supply (CII-L) [(c)(4)]

☐ Sediment storage and transport rate (CII-L) [(c)(4)]

☐ Functional wood supply for fish habitat (CII-L) [(c)(4)]

☐ Implementation of practices to maintain, protect, and contribute to restoration of properly functioning habitat [(c)(5)]

Improvement of Beneficial Functions

☐ Bank Stability

☐ Large Wood Recruitment

☐ Water Temperature

☐ Nutrient Input

☐ Upslope Stability

☐ Habitat Improvements (e.g., pools, cover, etc.)

☐ Vegetative Structure Diversity for Fish and Wildlife Habitat

☐ Microclimate, Sediment Filtration

☐ Fish Passage Improvements

☐ Other (_____)

Evaluation Type (circle one)

CDFW Concurrence (14 CCR 916.9(v)(2)) OR Full Justification (14 CCR 916.9(v)(3))

Proposed Standard Rule Modifications (list applicable rules)

PROPOSAL SPECIFIC INFORMATION

Landowner Contact Information

Proposal Location (including maps)

Proposal Partners or Collaborators

Additional Information (site photos, data, maps, etc.)

List here and include as attachments

TECHNICAL JUSTIFICATION FOR PROPOSED MANAGEMENT MEASURES

To be prepared prior to the consultation to the extent that information is available.

PROPOSAL RATIONALE - INTERPRETATION OF EXISTING FUNCTIONAL OPPORTUNITIES/DEFICIENCIES

Summarize the status of key riparian functions (wood supply, temperature, sediment, nutrient loading, etc.) that the proposed action will address. Use of the Riparian Risk Assessment Process may substitute for the descriptions below (include results here).

Brief Summary of Resource Conditions at the WATERSHED SCALE from Existing Watershed Analyses, Assessments, TMDL Documents, NOAA listed species recovery plans, and other information sources (including personal knowledge).[21]

Key Assumptions of Proposal Benefits

[21] Note that a more comprehensive list of watershed scale documents for context assessment is available in the VTAC Guidance Document, Chapter 10.

Outline Preliminary Rationale for Consistency with Requirements in 14 CCR Section 916.9 v (1) (p.97 of CA Forest Practice Rule Book 2012)

EXISTING CONDITION SUMMARY

Complete only the questions below that apply to the proposal. Narrative discussions are acceptable and supporting data or graphics may be desirable. These issues will be formally addressed in the THP, and this section can be used in the plan. Additional issues may be discussed.

1. *Briefly outline the existing riparian structure (species, structure, function) and how proposed treatments will affect vegetative structure diversity for fish and wildlife habitat.*
2. *Describe how the existing and/or trending conditions of channel types are affecting fish habitat functions and how proposed treatments will improve habitat conditions.*
3. *Describe the vegetative structure, canopy closure, and potential wood recruitment conditions under existing and future conditions in the absence of the site-specific proposal, and how the proposed treatment will affect the trajectory and development of functional tree sizes available for potential wood recruitment.*
4. *Describe the existing water temperature patterns and how the proposed treatments are likely to affect future temperature regimes.*
5. *Describe the existing and/or trending instream sediment conditions and how upslope sediment sources affect habitat conditions and how proposed treatments will affect upslope stability and sediment delivery.*
6. *Describe how the existing vegetative structure is producing a high risk of catastrophic wildfire in both the riparian zone and on the upland area of the watershed, and how the proposed treatment will reduce this risk.*
7. *Briefly describe how the existing vegetative structure is affecting hydrologic, geomorphic, and biological functions in flood prone areas/overflow channels and how the proposed treatment will likely affect these functions.*
8. *Briefly describe how the existing vegetation in the riparian zone is affecting biotic diversity and nutrient input, and how the proposed treatment will likely affect these functions.*

Proposed Design Elements/Metrics/Standards

Proposed Monitoring

Assessment of Potential Impacts - Methods of Analysis

List the sources of data, analysis methods used, or other analytical information used to arrive at your interpretation.

PART II) Pre-Consultation Results

This section can be used to summarize the outcome of the pre-consultation.

It provides a place for the landowner/ RPF/RPF designee to informally document a list of potential issues of concern, documentation or information needs, questions, preliminary findings, and preliminary levels of support from each agency or individuals that participated in the pre-consultation. This form is NOT intended to imply that agency approval is required prior to proceeding with the THP. Nor does it imply that ALL agencies must be consulted for all issues.

The plan proponent is encouraged to engage in discussions with agencies and individuals participating in the pre-consultation and to document such interactions. Agencies that participate in the review are encouraged to provide a written summary of their initial concerns. This section is voluntary, but documentation will help support the THP submission.

This summary could be derived from written documentation provided from participants that attended the pre-consultation field meeting or otherwise provided written responses to pre-consultation discussions.

NOTE: CAL FIRE will use the THP record (not this form) to make regulatory determinations. The pre-consultation results are for the benefit of the landowner/landowner representatives in preparing the THP, and thus only need to be documented sufficiently to satisfy that need.

CONTACT LIST

List the names of all persons contacted and/or consulted, including contact information.

PRELIMINARY ISSUE TRACKING TABLE

The table below is for use by the RPF to informally track potential issues and agency support for proposed actions. It need not be submitted with the THP.

S – Support
CS – Conditional Support (describe likely conditions)
JS – Justification Needed
IR – Additional Information Requested (please describe specific data needed)
SC – Substantive Concerns
U – Unlikely Support as presented
N/A – Agency did not participate in pre-consultation
N/C – Agency did not comment

Potential Issue (list)	**CDFW***	**RWQCB***	**CAL FIRE***	**CGS***	**NMFS**	
(e.g., elevated water temperature)	*IR*	*SC*	*N/A*	*N/A*		

** Agency notification is required, other agencies are optional at the discretion of RPF or landowner, but likely should include NOAA Fisheries (NMFS). Others include US Fish and Wildlife Service (USFWS), US Army Corps of Engineers (USACE), Department of Parks and Recreation (DPR), and Counties.*

Potential Issue Descriptions

Outline or briefly describe each potential issue of concern, outstanding question/information request etc. listed in the summary table.

Associated Permitting Action Items

Outline any permitting actions discussed.

Attachments and Other Documents

Attach any letters, discussions, or other appropriate written documentation.

Recommended ASP Rule Section V Pre-Consultation Guidance

NOTE: The example provided below comes from a data-rich watershed: the Soquel Creek basin located in the Santa Cruz Mountains. Abundant information existed prior to describing the site-specific proposal described below due to heavy state and federal agency input on proposal design. Most proposals will start the pre-consultation process with a smaller amount of information.

It took approximately 8 hours to prepare this document.

No direct economic benefit will result for the landowner, CAL FIRE, from implementation of this proposal; it is provided as an example of the pre-consultation process.

Part I) Pre-Consultation Information

SUMMARY OF THE SITE SPECIFIC PROPOSAL

To be prepared prior to the pre-consultation.

PROPOSAL OBJECTIVES:

List as bullets

- Enhance large wood loading within the East Branch of Soquel Creek.

- Contribute to the survival and recovery of federally and State endangered coho salmon and the survival and recovery of federally threatened steelhead, by increasing habitat complexity and pool frequency within the East Branch of Soquel Creek.

ABSTRACT: (ALSO SEE PROPOSAL CONTEXT):

Briefly summarize the site specific proposal, including references to graphics (where appropriate). Summarize the who, what, where, when, why, and how sufficient to provide agency staff with enough context to understand the issues before the field site visit. Also, the plan proponent should outline the initial justification for the site specific proposal.

The proposed Large Woody Debris (LWD) and Habitat Complexity Proposal is located along the East Branch of Soquel Creek within the boundaries of Soquel Demonstration State Forest (SDSF), managed by the California Department of Forestry and Fire Protection (CAL FIRE). The SDSF large wood placement proposal includes the following components: (1) installing large wood along a 0.7 mile stretch of the East Branch of Soquel Creek in four, 200-foot reaches, and (2) monitoring the large wood structures to document wood movement, aquatic habitat changes, and fish community changes. Each of the four reaches will contain from one to three large wood structures and each structure will have one to four pieces of large wood installed. There will be two unsecured sites with one to three log clusters installed per site. Additionally, there will be two secured sites, with each site consisting of a log-vane structure with a rootwad, a

log cluster, and a rootwad anchor. Heavy equipment will be used to input large wood into the East Branch of Soquel Creek channel. Large wood will come from two sources: (1) trees excavated in the riparian zone with their roodwads attached, and (2) trees excavated with their rootwads attached (25 ft tree lengths), along with longer logs without rootwads attached, located along new road right-of-way in the Fern Gulch Timber Sale and trucked down to the designated reaches. The purpose of the proposal is to contribute to the survival and recovery of federally and State endangered coho salmon in this watershed, as well as the survival and recovery of federally threatened steelhead, by increasing habitat complexity and pool frequency. The proposal will take place in the late summer and fall of 2012 and 2013.

SITE SPECIFIC PROPOSAL CONTEXT

To be prepared prior to the consultation to provide agency staff with basic information about the proposal.

GENERAL PROPOSAL INFORMATION

Forest Practice Rule Location (Geographic Scope)

- Coastal Anadromy Zone –
  - Confined
  - Flood Prone Area or Channel Migration Zone
  - Southern Subdistrict (SSD)
- Outside Coastal Anadromy Zone –
  - Confined
  - Flood Prone Area or Channel Migration Zone
- Upstream of an ASP Planning Watershed

Watercourse Class/Type

Length of Class I Watercourse (ft) 800 ft (4 – 200 ft reaches spanning 0.7 mi)

Length of Class II-L Watercourse (ft) _____

Length of Class II-S Watercourse (ft) _____

Length of Class II-SSD Watercourse (ft) _____

Length of Class III Watercourse (ft) _____

Proposal Types

x☐ Instream Large Wood Enhancement

☐ Fire Hazard Reduction

☐ Flood Prone Area Management

☐ Core Zone WLPZ Vegetative Management

☐ Inner Zone WLPZ Vegetative Management

☐ Outer Zone WLPZ/ ELZ Management

☐ Sediment Reduction Related to Logging Roads, Crossings, Landings and/or Skid Trails

☐ Channel Bank Stabilization

☐ Barrier Modification/Removal

☐ Other (explain)

_____

Applicable Rule Goal – 14 CCR 916.9(a)

☐ Comply with terms of TMDL

☐ Prevent significant sediment load increase

☐ Prevent significant channel instability

☐ Prevent significant blockage of aquatic migratory routes

☐ Prevent significant adverse impacts to streamflow

x☐ Protect, maintain, and restore conifer trees that can provide LWD recruitment

x☐ Protect, maintain, and restore canopy needed for shade and nutrient inputs

Applicable WLPZ Objective – 14 CCR 916.9(c)

☐ Bank stability (core zone) [(c)(1)]

x☐ Large wood recruitment/placement (core, inner, outer zones) [(c)(1), (c)(2), (c)(3), (c)(5)]

☐ Canopy retention (core, inner, outer zones) [(c)(1), (c)(2)]

☐ Vertical structural diversity (inner, outer zones) [(c)(2)]

☐ Species diversity for nutrient input (inner zone) [(c)(2)]

☐ Wind resistance where windthrow is likely (outer zone) [(c)(3)]

☐ Microclimate control (outer zone) [(c)(3)]

☐ Habitat for terrestrial wildlife species dependent on riparian areas (outer zone) [(c)(3)]

☐ Sediment filtration (outer zone) [(c)(3)]

☐ Water and nutrient supply (CII-L) [(c)(4)]

☐ Sediment storage and transport rate (CII-L) [(c)(4)]

☐ Functional wood supply for fish habitat (CII-L) [(c)(4)]

x☐ Implementation of practices to maintain, protect, and contribute to restoration of properly functioning habitat [(c)(5)]

Improvement of Beneficial Functions

☐ Bank Stability

x☐ Large Wood Recruitment

☐ Water Temperature

☐ Nutrient Input

☐ Upslope Stability

x☐ Habitat Improvements (e.g., pools, cover, etc.)

☐ Vegetative Structure Diversity for Fish and Wildlife Habitat

☐ Microclimate, Sediment Filtration

☐ Fish Passage Improvements

☐ Other (_____)

Evaluation Type (circle one)

CDFW Concurrence (14 CCR 916.9(v)(2)) OR Full Justification (14 CCR 916.9(v)(3))

Proposed Standard Rule Modifications (list applicable rules)

916.9(f)(3)(B) and 916.9(f)(3)(C)

Class I watercourse with flood prone areas or channel migration zones—Core Zone and Inner Zone A

PROPOSAL SPECIFIC INFORMATION

Landowner Contact Information

California Department of Forestry and Fire Protection

Soquel Demonstration State Forest

4750 Old San Jose Road

Soquel, CA 95073-9611
(831) 475-8643

Angela Bernheisel, Forest Manager

Proposal Location (including maps)

Soquel Demonstration State Forest (see Figure 31)

Proposal Partners or Collaborators

California Geological Survey

California Department of Fish and Wildlife

Resource Conservation District of Santa Cruz County

NOAA National Marine Fisheries Service

NOAA Southwest Fisheries Science Center

Santa Cruz County

Alnus Ecological

Additional Information (site photos, data, maps, etc.)

List here and include as attachments

[see photos, maps, diagrams included in Appendix A-2 for the Situational Scenarios Approach example—Figures 31-38]

TECHNICAL JUSTIFICATION FOR PROPOSED MANAGEMENT MEASURES

To be prepared prior to the consultation to the extent that information is available.

PROPOSAL RATIONALE - INTERPRETATION OF EXISTING FUNCTIONAL OPPORTUNITIES/DEFICIENCIES

Summarize the status of key riparian functions (wood supply, temperature, sediment, nutrient loading, etc.) that the proposed action will address. Use of the Riparian Risk Assessment Process may substitute for the descriptions below (include results here).

The proposed action will address very low large wood loading in the East Branch of Soquel Creek. NMFS staff recommended that CAL FIRE initiate a large wood installation project to help address low wood loading here, one of the highest priority recovery actions included in their Central California Coast (CCC) Coho Recovery Plan.

CCC coho salmon (*Oncorhynchus kisutsch*) in the Santa Cruz Mountains are extremely endangered and Soquel Creek likely maintains one of the southern most populations of coho salmon in North America. The hope is that placement of large wood will contribute to the survival and recovery of federally and State endangered coho salmon in this watershed, as well as the survival and recovery of federally threatened steelhead (*Oncorhynchus mykiss*). This work will lead to increased habitat complexity, as well as an increase in pool frequency and shelter rating. Additionally, it will provide the local Santa Cruz community with an opportunity to observe functional large wood placement structures.

Large wood that will be input into the East Branch of Soquel Creek channel will come from two sources: (1) trees excavated in the riparian zone with their roodwads attached, and (2) trees excavated with their rootwads attached (25 ft tree lengths), along with longer logs without rootwads attached, located along new road-right-of-way in the Fern Gulch Timber Sale and trucked down to the designated reaches.

Brief Summary of Resource Conditions at the WATERSHED SCALE from Existing Watershed Analyses, Assessments, TMDL Documents, NOAA listed species recovery plans, and other information sources (including personal knowledge).[22]

At the watershed scale, limiting factors were assessed with the NOAA Central California Coast Coho Recovery Plan (NOAA 2012), which includes Soquel Creek as one of its 28 focus watersheds. The Recovery Plan shows the East Branch of Soquel Creek as a Core Area for coho recovery in this basin. Large wood frequency and off-channel/floodplain quality are listed as in poor condition. Increasing the amount of large wood in the channel is shown as a key mechanism to prevent coho salmon extinction in the Soquel Creek watershed.

Other watershed assessments have also found that Soquel Creek is lacking sufficient volumes of large wood and that the scarcity of large wood limits juvenile salmonid production throughout the watershed. For example, Lassettre and Kondolf (2003) reported only 9 wood formed pools in 1.3 miles of stream channel. The channel gradient is generally 2-3%, the channel is unconfined, and characterized as plane bed/forced pool riffle. The scientific literature supports adding large wood to stream channels with these

[22] Note that a comprehensive list of watershed scale documents for context assessment is available in Appendix E.

types of characteristics to improve conditions for federally and State listed anadromous salmonids.

Large wood loading in Soquel Creek and its tributaries is low due to extensive log removal efforts by Santa Cruz County from the 1950's to the 1990's. The watershed has a long history of wood removal due to problems associated with the creation of woody debris jams during large flood events at watercourse crossing structures (Lassettre and Kondolf 2003).

Sources include:

NMFS. 2012. Central California Coast Coho Salmon Recovery Plan.

http://swr.nmfs.noaa.gov/recovery/index.htm

RCDSCC. 2003. Soquel Creek Watershed Assessment and Enhancement Project Plan.

http://www.rcdsantacruz.org/media/watershed_plans/SCWEP.pdf

Lassettre and Kondolf. 2003. Process Based Management of Large Woody Debris at the Basin Scale, Soquel Creek, California.

http://www.fire.ca.gov/resource_mgt/downloads/reports/LWDinSoquelCreek.pdf

Key Assumptions of Proposal Benefits

Adding large wood to the East Branch of Soquel Creek will create pools, increase cover for juvenile fish, and increase overall habitat complexity, benefiting listed anadromous salmonids in the basin.

Outline Preliminary Rationale for Consistency with Requirements in 14 CCR Section 916.9 v (1) (p. 97 of CA Forest Practice Rule Book 2011)

Coho salmon are near extinction levels in the Soquel Creek watershed (NMFS 2012). Rapidly improving wood loading by excavating 12 large conifer trees in the riparian zone and supplementing these trees with logs with rootwads transported down from road right-of-way work is expected to be more favorable to salmonids than waiting multiple decades for coast redwood and Douglas-fir trees to naturally recruit to the channel.

EXISTING CONDITION SUMMARY

Complete only the questions below that apply to the proposal. Narrative discussions are acceptable and supporting data or graphics may be desirable. These issues will be formally addressed in the THP, and this section can be used in the plan.

1. Briefly outline the existing riparian structure (species, structure, function).

The riparian stand consists of conifers with a large hardwood component. There is generally a shortage of large conifers within the 100 year floodplain for large wood recruitment. Canopy/shade is moderate. Nutrient input to the channel is good.

2. Describe how the existing and/or trending conditions are affecting fish habitat functions.

The existing conditions are limiting fish production due to inadequate summer and winter habitat, mainly related to channel incision, poor wood loading, and lack of floodplain connectivity.

3. Describe the vegetative structure, canopy closure, and wood recruitment conditions under existing and future conditions in the absence of the site specific proposal, and how the proposed treatment will improve conifer growth for shading and wood recruitment potential.

As stated above, the current wood loading in the East Branch of Soquel Creek is poor. While there is a mixture of hardwoods and larger conifers along the channel with adequate canopy closure, the expectation is that it would take multiple decades for extensive input of large wood due to landsliding, bank erosion, and tree mortality. The proposed treatment will greatly accelerate wood loading at four reaches of the channel. The proposed treatment will remove a limited number of large conifers in a few locations, but will not significantly impact longer term recruitment of large wood into the channel or significantly affect conifer stocking, particularly on the south side, for shading.

4. Describe the existing water temperature patterns and how the proposed treatments are likely to affect future temperature regimes.

Water temperatures are higher than optimal for salmonids. Optimal rearing temperatures for juveniles are 7.22-14.4º C for steelhead and 11.67-14.4º C for coho. In 2007, there were 86 days at Long Ridge Crossing at or above 14.4º C. The proposed treatments are unlikely to have a significant impact on water temperature, as most of the large conifer trees removed from the riparian zone will be taken from the north side of the channel.

5. Describe how the existing and/or trending instream sediment conditions and sediment sources affect habitat conditions.

Numerous sediment sources exist along the East Branch of Soquel Creek. Abundant landslide features are present, directly related to the location of the San Andreas Fault along the channel. Unstable areas are mapped and included as part of the Fern Gulch THP. Fine sediment from landslide features reduces the quality of spawning and rearing habitat for anadromous salmonids.

6. Describe how the existing vegetative structure is producing a high risk of catastrophic wildfire in both the riparian zone and on the upland area of the watershed, and how the proposed treatment will reduce this risk.

N/A

7. *Briefly describe how the existing vegetative structure is affecting hydrologic, geomorphic, and biological functions in a flood prone area, and how the proposed treatment will likely affect these functions.*

The East Branch of Soquel Creek has an unconfined channel (bankfull channel width is 50 feet; valley floor width is approximately 400 ft wide) with a flood prone area. In several areas, the channel is somewhat incised and the floodplain is not well connected to the channel. The proposed treatment will aid in reconnecting the channel with its floodplain, improving over-wintering habitat for listed salmonid species. Poor over-wintering habitat is a key limiting factor in this watershed.

8. *Briefly describe how the existing vegetation in the riparian zone is affecting biotic diversity and nutrient input, and how the proposed treatment will likely affect these functions.*

The extensive hardwood component in the riparian stand is currently inputting abundant nutrients for primary productivity. The proposed treatment is unlikely to affect nutrient input, since very few of the hardwood trees will be impacted at the large wood enhancement sites.

Proposed Design Elements/Metrics/Standards

The proposal entails placing LWD along a 0.7 mile stretch of the East Branch of Soquel Creek in four, 200-foot reaches. Each reach will contain one to three LWD elements, and each element will include one to four large pieces of LWD. Placement of LWD in all four reaches will result in a total of approximately 300 cubic yards of new woody material in the stream system.

Proposed Monitoring

Upon completion of construction, a detailed as-built drawing of each structural element will be completed. The as-built drawings will require locating each log with a global positioning system (GPS) unit and taking photographs of its configuration from defined, repeatable photo points (stations), which will also be mapped with the GPS. Each log will be fitted with metal tags stamped with unique identification number consisting of the date, site number, and piece number. Each LWD structure will be located and mapped with GPS and incorporated into a data dictionary, where it will be transferred and stored in a geographic information system (GIS) database for future reference. Monitoring will be conducted on an annual basis. LWD structures will be photographed from the previously identified photo stations and inspected for damage and function.

In addition to the physical monitoring described above, NOAA's Southwest Fisheries Science Center (SWFSC) will conduct pre-wood addition sampling of fish and invertebrate prey communities at treatment and control sites, conduct post wood addition sampling of fish communities at treatment and control sites annually for five years and at

periodic intervals thereafter, conduct annual surveys to document habitat changes associated with wood additions and movement of structures, and prepare annual reports.

Assessment of Potential Impacts - Methods of Analysis

List the sources of data, analysis methods used, or other analytical information used to arrive at your interpretation.

Mr. Stephen Reynolds, engineering geologist with the California Geological Survey, used accepted engineering principles to design both anchored and unanchored large wood structures for the East Branch of Soquel Creek that can withstand small to moderate sized winter peak flow events without movement downstream.

Sources of data on current wood loading within the East Branch of Soquel Creek include: Lassettre and Kondolf (2003), Resource Conservation District of Santa Cruz County (2003), and NMFS (2012).

PART II) Pre-Consultation Results

This section can be used to summarize the outcome of the pre-consultation.

It provides a place for the landowner/ RPF/RPF designee to informally document a list of potential issues of concern, documentation or information needs, questions, preliminary findings, and preliminary levels of support from each agency or individuals that participated in the pre-consultation. This form is NOT intended to imply that agency approval is required prior to proceeding with the THP. Nor does it imply that ALL agencies must be consulted for all issues.

The plan proponent is encouraged to engage in discussions with agencies and individuals participating in the pre-consultation and to document such interactions. Agencies that participate in the review are encouraged to provide a written summary of their initial concerns. This section is voluntary, but documentation will help support the THP submission.

This summary could be derived from written documentation provided from participants that attended the pre-consultation field meeting or otherwise provided written responses to pre-consultation discussions.

NOTE: CAL FIRE will use the THP record (not this form) to make regulatory determinations. The pre-consultation results are for the benefit of the landowner/landowner representatives in preparing the THP, and thus only need to be documented sufficiently to satisfy that need.

CONTACT LIST

List the names of all persons contacted and/or consulted, including contact information.

Stephen Reynolds: California Geological Survey

Stephen.Reynolds@conservation.ca.gov

Terris Kasteen, Jennifer Nelson: California Department of Fish and Wildlife

TKASTNEEN@dfg.ca.gov; JENELSON@dfg.ca.gov

Sooni Gillett: Resource Conservation District of Santa Cruz County

sgillett@rcdsantacruz.org

Jonathan Ambrose: National Marine Fisheries Service

Jonathan.Ambrose@NOAA.GOV

Dr. Sue Sogard, Joe Pecharich: NOAA Southwest Fisheries Science Center

Susan.Sogard@noaa.gov; Joe.Pecharich@NOAA.GOV

Jim Robins: *Alnus* Ecological

JROBINS@ALNUS-ECO.COM

Ryan Switzer: Central Coast Regional Water Quality Control Board

RSwitzer@waterboards.ca.gov

Ian Liffmann: US Army Corps of Engineers

Ian.Liffmann@usace.army.mil

Chad Mitcham: US Fish and Wildlife Service

(805) 644-1766, extension 335

Dr. Neil Lassettre: Cardno Entrix

neil.lassettre@cardno.com

PRELIMINARY ISSUE TRACKING TABLE

The table below is for use by the RPF to informally track potential issues and agency support for proposed actions. It need not be submitted with the THP.

S – Support
CS – Conditional Support (describe likely conditions)
JS – Justification Needed
IR – Additional Information Requested (please describe specific data needed)
SC – Substantive Concerns
U – Unlikely Support as presented
N/A – Agency did not participate in pre-consultation
N/C – Agency did not comment

Potential Issue (list)	**CDFW***	**RWQCB***	**CAL FIRE***	**CGS***	**NMFS**	
(e.g., elevated water temperature)	*IR*	*SC*	*N/A*	*N/A*		
Potential impacts to terrestrial listed species (e.g., CRLF)	S	N/A	N/A	N/A	N/A	
Water temperature increases	CS	N/A	N/A	N/A	CS	
Stability of large wood placed in the channel and potential downstream impacts to infrastructure	S	S	S	S	S	
Riparian area and channel/streambank disturbance	CS	S	S	S	CS	

** Agency notification is required, other agencies are optional at the discretion of RPF or landowner, but likely should include NOAA Fisheries (NMFS). Others include US Fish & Wildlife Service (USFWS), US Army Corps of Engineers (USACE), Department of Parks and Recreation (DPR), and Counties.*

Potential Issue Descriptions

Outline or briefly describe each potential issue of concern, outstanding question/information request etc. listed in the summary table.

Potential impacts to terrestrial listed species (e.g., CRLF)

- Will disturbance with heavy equipment and dewatering of the channel at two of the four reaches cause significant impacts to listed terrestrial wildlife species?

Water temperature increases

- Will removal of 12 large conifer trees, some of which will be on the south side of the channel, cause adverse impacts to stream temperatures?

Stability of large wood placed in the channel and potential downstream impacts to infrastructure

- Will wood structures installed move downstream during moderate to large flood events, causing damage to bridges, roads, etc.?

Riparian area and channel/streambank disturbance

- Will inputting the wood, either with rootwad excavation or movement of imported logs with heavy equipment, cause unacceptable soil disturbance in the riparian area and at streambanks?

Associated Permitting Action Items

Outline any permitting actions discussed.

- Federal Coho ITP
- DFW Consistency Determination
- US Army Corps of Engineers 404
- Water Board 401 Certification
- DFW 1600 (part of THP)

Attachments and Other Documents

Attach any letters, discussions, or other appropriate written documentation.

(v) Site-specific measures or nonstandard operational provisions

(1) In consideration of the spatial variability of the forest landscape, the RPF may propose site-specific measures or nonstandard operational provisions in place of any of the provisions contained in this section. Site specific plans may be submitted when, in the judgment of the RPF, such measures or provisions offer a more effective or more feasible way of achieving the goals and objectives set forth in 14 CCR § 916.9 [936.9, 956.9], subsections (a) and (c), and would result in effects to the beneficial functions of the riparian zone equal to or more favorable than those expected to result from the application of the operational provisions required under 14 CCR § 916.9 [936.9, 956.9].

(2) Measures or provisions proposed pursuant to 14 CCR § 916.9 [936.9, 956.9], subsections (v) shall only be approved when the plan incorporates an evaluation of the beneficial functions of the riparian zone as set forth in subsection (3) below. In the event of measures limited in applicability to specific sites, the submitter may instead of an evaluation, obtain written concurrence from DFG prior to plan submittal. RPFs may request a preconsultation for the site specific plan and the Director may agree and request staff from responsible agencies.

(3) The evaluation of the beneficial functions of the riparian zone shall be included in addition to any evaluation required by all other District Forest Practice Rules, may incorporate by reference any such evaluation, and shall include the following components scaled appropriately to the scope of the proposed measure(s) or provision(s) and the beneficial functions potentially affected.

(A) The following are required components of an evaluation conducted pursuant to 14 CCR § 916.9 [936.9, 956.9], subsection (v)(3):

1. A description of the evaluation area. If the evaluation area is different than the watershed assessment area described pursuant to Technical Rule Addendum No. 2, the RPF shall briefly explain the rationale for establishing the evaluation area.

2. A description of the current condition of the riparian zone within the evaluation area related to the beneficial functions. The RPF may incorporate by reference any conditions described in the plan pursuant to 14 CCR § 916.4 [936.4, 956.4], subsection (a). The RPF shall use the best available information, at the appropriate scale, to describe the existing vegetation, timber stand characteristics, roads, skid trails, landings, channel types, unstable areas, flood prone areas, and overflow channels.

3. An identification of the beneficial functions that may potentially be affected by the proposed measure(s) or provision(s).

4. An identification of the potential effects to the beneficial functions, both positive and negative. The RPF may use a reasoned analysis to describe the effects and may assign ratings of high, moderate and low to those effects that may individually or cumulatively limit anadromous salmonid distribution and abundance in the watershed.

5. A detailed description of the site-specific measure(s) or nonstandard operational

provision(s) proposed. The description should address at a minimum the relationships between the riparian stand characteristics and ecological functions, the relative importance of the beneficial functions of the riparian zone to the watercourse, the cost effectiveness of the measure(s) or provision(s), and the predicted consequences.

6. A schedule for implementing proposed management practices.

7. A plan for monitoring consistent with 14 CCR § 916.11 [936.11, 956.11].

(4) Measures or provisions proposed pursuant to 14 CCR § 916.9 [936.9, 956.9], subsections (v) shall only be approved when they meet the following additional standards:

(A) They must be based upon the best available science, and explained and justified in the plan.

(B) They must identify potential significant adverse impacts that may occur to listed salmonids or the beneficial functions of the riparian zone as a result of the proposed measure(s) or provision(s).

(C) They must identify feasible systems, methods, procedures or approaches proposed to avoid or mitigate identified potential significant adverse impacts to a level of insignificance.

(D) They must be written so they provide clear instructions and enforceable standards for the timber operator;

(E) They must provide that, where appropriate for implementation of the measure(s) or provision(s), the plan submitter is responsible for retaining an RPF to aid in interpreting the plan to the timber operator and timberland owner on a continuing basis to help assure compliance with the measure(s) or provision(s).

(F) They must identify each standard prescription that would be replaced by the measure(s) or provision(s) proposed.

(5) Guidance is provided below for site specific plans for flood prone areas:

(A) Site-Specific Plans for watercourses with flood prone areas or channel migration zones:

This section is an optional approach to be used at the discretion of the plan submitter. When used, this section replaces requirements found in 14 CCR § 916.9 [936.9, 956.9], subsection (f)(3). The goal of this approach is to allow RPFs to develop a site specific plan for salmonid habitat protection on a flood prone area. Site specific plans are to lead to development of properly functioning salmonid habitat and can include active management to restore the beneficial uses of the riparian zone.

(B) Timber operations are limited to the flood prone areas beyond the outer margin of a CMZ.

(C) RPFs are to propose riparian protection zones and management practices that are

designed for local conditions.

(D) Site specific assessments shall include:

1. Identifying the issues that need to be considered for watercourse and riparian protections [refer to Table 1 of "Flood Prone Area Considerations in the Coast Redwood Zone "(Riparian Protection Committee Report, Cafferata et al 2005)].

2. Describing processes that need to be considered for the issues identified above.

3. Developing a method to define a desired trajectory for watercourse and riparian conditions in the context of the goals of 14 CCR § 916.9 [936.9, 956.9], subsection (a).

4. Defining how the proposed operations will aid reaching the desired trajectories.

5. Disclosing assumptions being made at each step and limits to both the science and the proposed management activities.

6. Identifying how to determine what needs to be monitored and how to conduct the monitoring.

7. Supporting documentation is required including but not limited to field data, NetMap analysis, large wood modeling results, etc.

(E) As described in the "Flood Prone Area Considerations in the Coast Redwood Zone" (Cafferata et al 2005), the site-specific plan for Class I flood prone area management shall include:

1. an inventory of the flood prone area for all hydrologic, geomorphic, and biological functions present that can be affected by timber operations;

2. a determination of the category of inundation where management is proposed [i.e., very frequent (1-5 yr recurrence interval or RI), frequent (5-20 yr RI), moderately frequent (20-50 yr RI), or infrequent (50+ yr RI)]; and

3. an appropriate analysis for functions present in light of possible significant adverse impacts from management. Analysis for hydrologic functions may include how the flood prone area vegetative roughness will change with timber operations. Analyses for geomorphic functions may include how proposed operations will change bank stabilization, amount of soil disturbance on the flood prone area, and the potential for channel avulsion. Analyses for biological functions may include how harvesting will affect overflow channels, large wood recruitment, stream shading, riparian microclimate, organic matter input, and terrestrial wildlife habitat.

(F) Disclosure and analysis requirements increase with increased risk associated with the proposed level of activity and the increased frequency of inundation in the flood prone area. In particular, management proposed within the 20 year recurrence interval flood prone area in a watershed with coho salmon habitat or restorable habitat requires detailed analysis.

(G) In addition to considering how proposed prescriptions will affect flood prone area functions at the project level, site specific plans must consider a larger watershed perspective that includes consideration of the stream network and past activities in the watershed. Also, consideration must be given to the current condition of the flood prone area.

(H) Information provided in the "Flood Prone Area Considerations in the Coast Redwood Zone " (Cafferata et al 2005) is to be used for guidance in the coast redwood zone.

(I) The site-specific plan for Class I riparian management must: (1) have Review Team agencies pre-consultation and receive concurrence from the Review Team agencies, including DFG, and (2) include a monitoring component.

(6) Guidance is provided below for site specific plans for fire hazard reduction:

(A) For site specific plans that address WLPZs having conditions where catastrophic, stand replacing wildfire will result in significant adverse effects to salmonid species, riparian habitat or other wildlife species, the site specific plan shall address measure(s) or provision(s) that create fire resilient forests, promote reduced fire intensities, and retain functional habitat following a wildfire. Site specific plans proposed for fuel hazard reduction shall contain information demonstrating the potential for severe fire behavior and likelihood of stand replacing fires. Fuel reduction measure(s) or provision(s) shall be designed to reduce fire behavior to levels appropriate for the region and riparian area. Measure(s) or provision(s) include, but are not limited to, activities that eliminate the vertical and horizontal continuity among all vegetative fuel layers (surface fuels, ladder fuels and crown fuels), focus on reducing surface and ladder fuel hazards, and simultaneously meet goals and objectives of 14 CCR § 916.9 [936.9, 956.9] subsections (a) and (c).

(7) No site-specific measure(s) or nonstandard operational provision(s) proposed pursuant to 14 CCR § 916.9 [936.9, 956.9], subsection (v) may be prescribed by an RPF or approved by the Director in lieu of the following rules:

(A) The rules contained in Subchapter 2 (Application of Forest Practice Rules); Article 2 (Ratings and Standards) and Article 11 (Coastal Commission Special Treatment Areas) of Subchapter 4 (Coast Forest District Rules); Article 2 (Ratings and Standards) of Subchapter 5 (Northern Forest District Rules); Article 2 (Ratings and Standards) and Article 11 (Coastal Commission Special Treatment Areas) of Subchapter 6 (Southern Forest District Rules); and Subchapter 7 (Administration) of Chapter 4, Division 1.5 of Title 14 of the *[California Code of Regulations]*; or

(B) Any Forest Practice Rule pertaining to the width of the special treatment area adjacent to a wild and scenic river declared pursuant to PRC 5093.50, et seq.; or

(C) Any Forest Practice Rules or parts of rules that incorporate practices or standards specified in the Forest Practice Act.

(8) The Director shall not accept for inclusion in a plan any site-specific measures or non-standard operational provisions as described in this section where the Department of Fish and Game or where two or more agencies listed in PRC § 4582.6 and 14 CCR § 1037.3 have submitted written comments which lead

to the Director's conclusion that the proposed measures or provisions will not meet the goal of this section and the agencies participated in the review of the plan, including an on-the-ground inspection.

(9) Site-specific measures or nonstandard operational provisions proposed pursuant to 14 CCR § 916.9 [936.9, 956.9], subsection (v) shall not be considered alternative practices pursuant to 14 CCR §§ 897 or 914.9 [934.9, 954.9], in lieu practices or site specific practices pursuant to 14 CCR § 916.1 [936.1, 956.1], or alternative prescriptions for the protection of watercourses or lakes pursuant to 14 CCR § 916. 6 [936.6, 956.6].

(10) Board staff and the Department shall work with agencies, stakeholders, and appropriate scientific participants (e.g., Monitoring Study Group, Technical Advisory Committee) in a transparent process to: (1) describe and implement two pilot projects, including monitored results, using site-specific or non-standard operational provisions; and (2) provide recommendations to the Board for consideration for adoption to provide detailed guidance for the application of site-specific or non-standard operational provisions. The pilot projects and guidance shall address cumulative and planning watershed impacts, and the guidance may address the appropriate standards the site-specific or non-operational provisions shall meet. A report on the progress of the pilot projects and implementation guidance shall be presented to the Board within 18 months of the effective date of this regulation.

(w) Except when expressly required by 14 CCR § 916.9 [936.9, 956.9], subsections (w)(1)-(5) below, the provisions of 14 CCR § 916.9 [936.9, 956.9] shall not apply to a plan that is subject to:

(1) a valid incidental take permit issued by DFG pursuant to Section 2081(b) of the Fish and Game Code that addresses anadromous salmonid protection; or

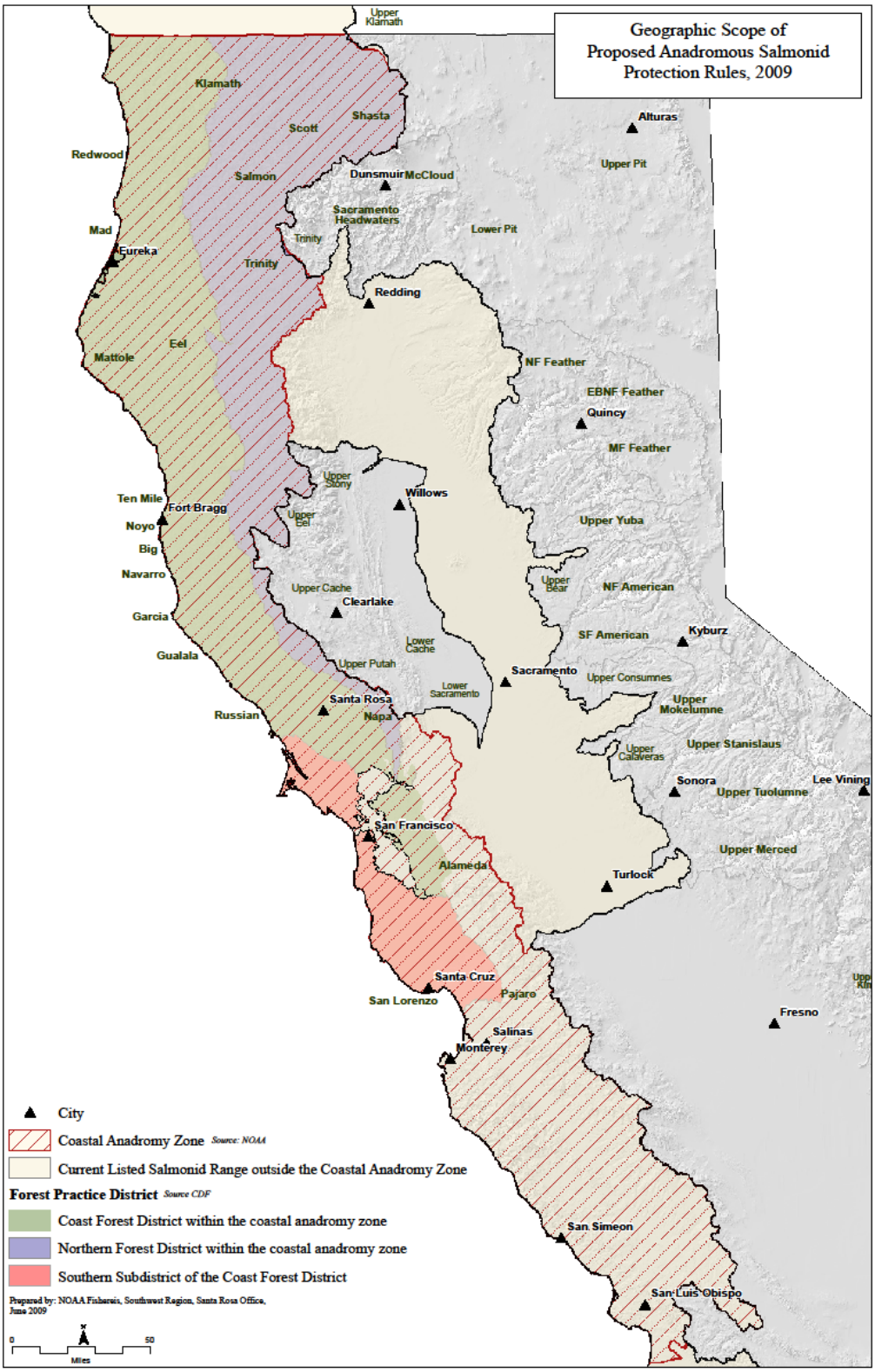
(2) a federal incidental take statement or incidental take permit that addresses anadromous salmonid protection, for which a consistency determination has been made pursuant to Section 2080.1 of the Fish and Game Code; or

(3) a valid natural community conservation plan that addresses anadromous salmonid protection approved by DFG under section 2835 of the Fish and Game Code; or

(4) a valid Habitat Conservation Plan that addresses anadromous salmonid protection, approved under Section 10 of the federal Endangered Species Act of 1973; or

(5) project revisions, guidelines, or take avoidance measures pursuant to a memorandum of understanding or a planning agreement entered into between the plan submitter and DFG in preparation of obtaining a natural community conservation plan that addresses anadromous salmonid protection.

APPENDIX D. MAP OF THE ASP RULE GEOGRAPHIC SCOPE



APPENDIX E. WATERSHED CONTEXT INFORMATION

Existing sources of watershed context information include:

- Anadromous salmonid recovery plans (e.g., Central California Coast (CCC) coho salmon, Southern Oregon-Northern California Coast (SONCC), including bibliographies listed within the documents)

    - State recovery plans

http://www.dfg.ca.gov/fish/Resources/Coho/SAL_CohoRecoveryRpt.asp

    - Federal recovery plans

http://swr.nmfs.noaa.gov/recovery/soncc_draft/SONCC_Coho_DRAFT_Recovery_Plan_January_2012.htm

http://swr.nmfs.noaa.gov/recovery/index.htm

- Private timberland company Habitat Conservation Plans (HCPs)

    - Humboldt Redwood Company

http://www.mrc.com/Reports-HCP.aspx

    - Mendocino Redwood Company (draft)

http://www.mrc.com/Reports-HCP.aspx

    - Green Diamond Resource Company

http://swr.nmfs.noaa.gov/ahcp.htm

- North Coast Watershed Assessment Program (NCWAP) reports

http://coastalwatersheds.ca.gov/Home/tabid/54/Default.aspx)

Redwood Creek
Van Duzen River
Lower Eel River
Salt River
Mattole River
Outlet Creek
Noyo River

Big River
Albion River
Navarro River
Garcia River
Gualala River

- Resource Conservation District (RCD) watershed assessments
    - Examples include: Cow Creek (Western Shasta Co. RCD, Soquel Creek (RCD of Santa Cruz Co., Pescadero-Butano Creeks (San Mateo Co. RCD)

http://www.water.ca.gov/fishpassage/docs/clover.pdf

http://www.rcdsantacruz.org/media/watershed_plans/SCWEP.pdf

http://www.sanmateorcd.org/pesc-butanoassess.pdf

- Sediment and temperature TMDL studies

http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/303d/)

- Other individual watershed studies (e.g., Redwood National/State Parks reports).

Additional websites:

- UC Davis Natural Resources Project Inventory (NRPI)

http://ice.ucdavis.edu/project/nrpi)

- CalFish website for watershed condition data

http://www.calfish.org/)

- KRIS watershed online sites for watershed condition data

http://www.krisweb.com/

APPENDIX F. CHANNEL TYPE DEFINITIONS AND DIAGRAMS

The channel types used in Appendix A-1: Pathway 1) Classification Matrix Approach, Table 4, are those described in Montgomery and Buffington 1993 and Montgomery and Buffington 1997. There are seven main reach-level channel types in this classification scheme, as illustrated in Figures 40, 41a, 41b, and described in Tables 19 and 20 below.

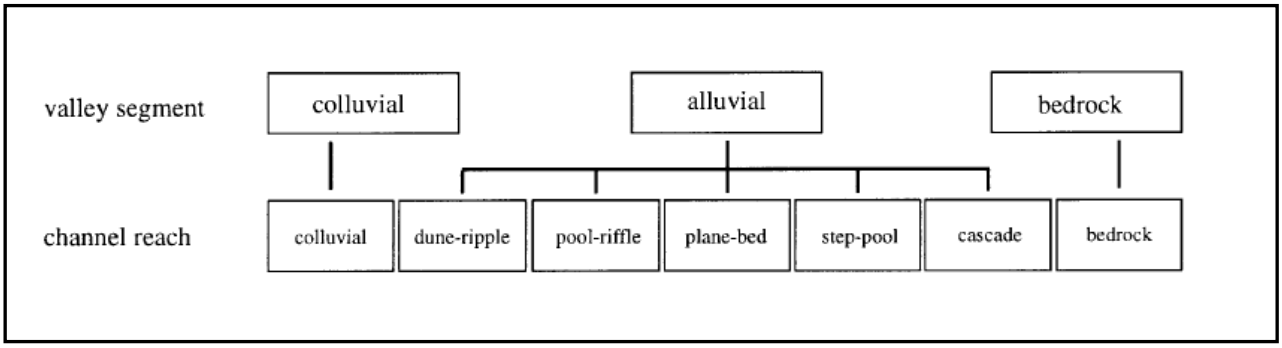


Figure 40. Diagram illustrating the relative transport capacities of reach-level channel types (Figure 11 from Montgomery and Buffington 1997).

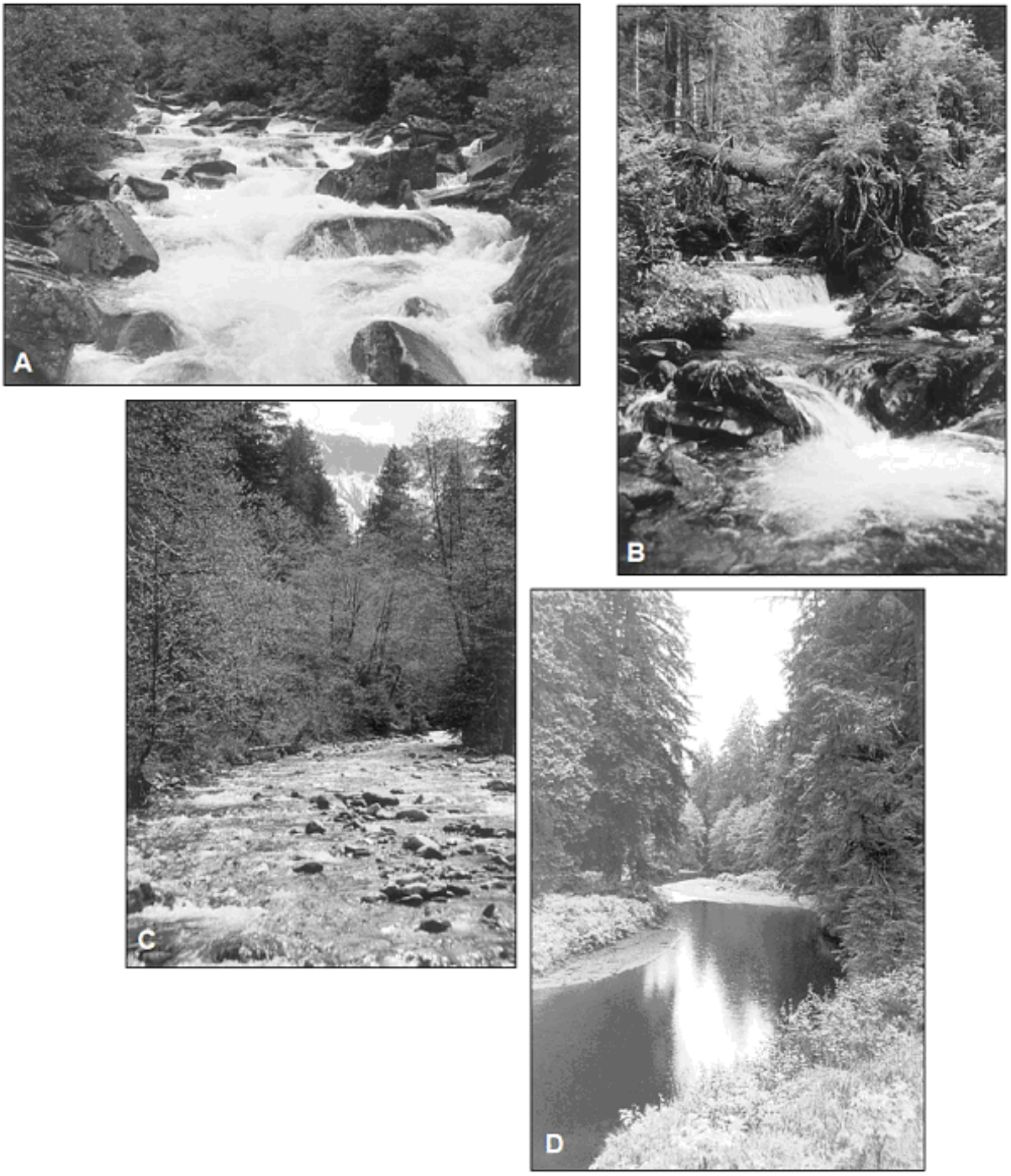


Figure 41a. Photographs of Montgomery and Buffington channel types (Figure 1 in Montgomery and Buffington 1997). Alluvial channel-reach morphologies: (A) cascade, (B) step pool, (C) plane bed, and (D) pool riffle.

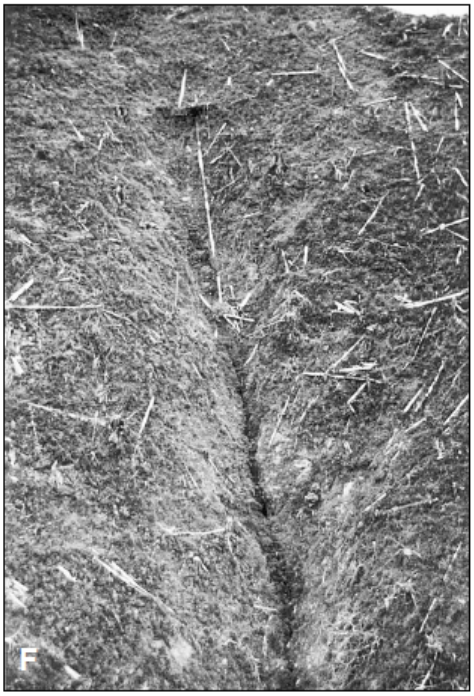


Figure 41b. Photographs of Montgomery-Buffington channel types (Figure 1 in Montgomery and Buffington 1997). Alluvial channel-reach morphologies: (E): dune ripple, (F) colluvial (channel in photo is 0.5 m wide), and (G) forced pool riffle.

Table 19. Reach-level channel type characteristics (Figure 19 from Montgomery and Buffington 1997).

TABLE 1. DIAGNOSTIC FEATURES OF EACH CHANNEL TYPE

	Dune ripple	Pool riffle	Plane bed	Step pool	Cascade	Bedrock	Colluvial
Typical bed material	Sand	Gravel	Gravel-cobble	Cobble-boulder	Boulder	Rock	Variable
Bedform pattern	Multilayered	Laterally oscillatory	Featureless	Vertically oscillatory	Random	Irregular	Variable
Dominant roughness elements	Sinuosity, bedforms (dunes, ripples, bars) grains, banks	Bedforms (bars, pools), grains, sinuosity, banks	Grains, banks	Bedforms (steps, pools), grains, banks	Grains, banks	Boundaries (bed and banks)	Grains
Dominant sediment sources	Fluvial, bank failure	Fluvial, bank failure	Fluvial, bank failure, debris flows	Fluvial, hillslope, debris flows	Fluvial, hillslope, debris flows	Fluvial, hillslope, debris flows	Hillslope, debris flows
Sediment storage elements	Overbank, bedforms	Overbank, bedforms	Overbank	Bedforms	Lee and stoss sides of flow obstructions	Pockets	Bed
Typical confinement	Unconfined	Unconfined	Variable	Confined	Confined	Confined	Confined
Typical pool spacing (channel widths)	5 to 7	5 to 7	None	1 to 4	<1	Variable	Unknown

Table 20. Additional Montgomery-Buffington channel type characteristics. Figure 7.11 in FISRWG 1998.

	Braided	Regime	Pool-Riffle	Plane-Bed	Step-Pool	Cascade	Bedrock	Colluvial
Typical Bed Material	Variable	Sand	Gravel	Gravel, cobble	Cobble, boulder	Boulder	N/A	Variable
Bedform Pattern	Laterally oscillary	Multi-layered	Laterally oscillary	None	Vertically oscillary	None	•	Variable
Reach Type	Response	Response	Response	Response	Transport	Transport	Transport	Source
Dominant Roughness Elements	Bedforms (bars, pools)	Sinuosity, bedforms (dunes, ripples, bars) banks	Bedforms (bars, pools), grains, LWD, sinuosity, banks	Grains, banks	Bedforms (steps, pools), grains, LWD, banks	Grains, banks	Boundaries (bed & banks)	Grains, LWD
Dominant Sediment Sources	Fluvial, bank failure, debris flow	Fluvial, bank failure, inactive channel	Fluvial, bank failure, inactive channel, debris flows	Fluvial, bank failure, debris flow	Fluvial, hillslope, debris flow	Fluvial, hillslope, debris flow	Fluvial, hillslope, debris flow	Hillslope, debris flow
Sediment Storage Elements	Overbank, bedforms	Overbank, bedforms, inactive channel	Overbank, bedforms, inactive channel	Overbank, inactive channel	Bedforms	Lee & stoss sides of flow obstructions	•	Bed
Typical Slope (m/m)	S < 0.03	S < 0.001	0.001 < S and S < 0.02	0.01 < S and S < 0.03	0.03 < S and S < 0.08	0.08 < S and S < 0.30	Variable	S > 0.20
Typical Confinement	Unconfined	Unconfined	Unconfined	Variable	Confined	Confined	Confined	Confined
Pool Spacing (Channel Widths)	Variable	5 to 7	5 to 7	none	1 to 4	< 1	Variable	Variable

Source: Montgomery and Buffington, 1993.

APPENDIX G. GLOSSARY

Alluvial fan: A fan-shaped sediment deposit formed where a fast flowing stream flattens, slows, and spreads, typically at the exit of a canyon onto a flatter plain.

Anadromous salmonid: Fish species in the family Salmonidae that divide their lives between freshwater and the ocean; juveniles are born in freshwater, mature at sea, and return to their natal streams to spawn a new generation.

Avulsion: A rapid channel shift during flood flows from a main channel into side channels, occurring in response to reductions in channel capacity (typically due to sediment deposition and/or large wood) that forces the streamflow out of the existing channel. New channels are cut or older ones are reoccupied.

Backwater alcove: Waterbody that maintains a downstream connection to the main channel at summer low flow, but has no upstream connection during low flow.

Bankfull stage: The stage that occurs when discharge fills the entire channel cross section without significant inundation of the adjacent floodplain, and has a recurrence interval of 1.5 to 2.0 years (see 14 CCR § 895.1).

Bankfull width: The channel width at bankfull discharge.

Beneficial uses of water: Those uses of water as defined by Section 13050(f) of the Water Code and as described in the applicable Water Quality Control Plan (see 14 CCR § 895.1). "Beneficial uses" of the waters of the state that may be protected against quality degradation include, but are not limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves.

Biotic diversity: The number of different species in a defined area (also know as biodiversity).

Buffer strip: An area of land maintained in permanent vegetation that helps to protect or restore water quality and aquatic habitat by trapping sediment, enhancing filtration of nutrients and pesticides, supplying shade and large wood in forested areas, and providing bank stability through retention of riparian trees near the stream channel.

Cascade channel: A channel in which energy dissipation is dominated by continuous tumbling and jet-and-wake flow over and around individual large clasts (rock fragments such as boulders) (see Montgomery and Buffington 1997).

Channel geomorphic classification: The categorization of river channels that is based on the degree of sinuosity and braiding, and the type of sediment load (suspended, mixed, or bedload), since this controls the relative stability of a channel which, in turn, affects channel pattern. The most basic categories are: straight, meandering, and braided.

Class II watercourse transition: Larger Class II watercourses functionally connected to or extending upstream from the end of Class I watercourses, as defined by the California Forest Practice Rules.

Colluvial channel: A small headwater stream located at the head of a channel network that flows over a colluvial valley fill and exhibits weak or ephemeral fluvial transport (see Montgomery and Buffington 1997).

Confluence angle: The angle formed by the junction of two streams. High confluence angles (typically exceeding about 70%) are generally prone to deposition at or near the confluence. Lower confluence angles typically carry debris into downstream reaches.

Confluence zones: The area surrounding where a tributary channel joins a larger watercourse (i.e., main stem), or where two tributaries meet to form the source of a larger watercourse.

Conifer: Cone-bearing seed plants with vascular tissue; all conifers are woody plants, the great majority being trees with just a few being shrubs. Typical examples of conifers found in California include coast redwood, Douglas-fir, grand fir, western hemlock, ponderosa pine, sugar pine, incense cedar, white fir, Jeffrey pine, lodgepole pine, giant sequoia, and red fir.

Core zone: In areas where the Anadromous Salmonid Protection Forest Practice Rules apply in California, a 30 foot wide area in the WLPZ measured from the watercourse transition line extending upslope to the beginning of the Inner Zone for Class I watercourses. The Core zone for Class II watercourses varies from 0 to 30 feet depending on Class II type and slope class. The Core Zone provides streambank stability, wood recruitment, and stream shading for the watercourse channel (see 14 CCR § 916.9 [936.9, 956.9]).

Debris flow: Fast moving, liquefied landslides of mixed and unconsolidated water and debris.

Debris flow source area: Channels that link steep, unstable hillslopes prone to generating debris flows (defined by a Certified Engineering Geologist (CEG) or Professional Geologist (PG)) to downstream fish-bearing channels.

Deciduous litter: Dead plant material, such as leaves, bark, needles, and twigs, that has fallen to the ground and originates from trees or shrubs that lose their leaves seasonally.

Floodplain: The flat area adjoining a river channel constructed by the river in the present climate and overflowed at times of high discharge.

Fire ladder fuels: Live or dead vegetation that allows a fire to climb up from the forest floor into the tree canopy. Common fuel ladders include tall grasses, shrubs, and tree branches, both living and dead.

Flood prone area: An area contiguous to a watercourse channel zone that is periodically flooded by overbank flow. Indicators of flood prone areas may include diverse fluvial landforms, such as overflow side channels or oxbow lakes, hydric vegetation, and deposits of

fine-grained sediment between duff layers or on the bark of hardwoods and conifers. The outer boundary of the flood prone area may be determined by field indicators such as the location where valley slope begins (i.e., where there is a substantial percent change in slope, including terraces, the toes of the alluvial fan, etc.), a distinct change in soil/plant characteristics, and the absence of silt lines on trees and residual evidence of floatable debris caught in brush or trees. Along laterally stable watercourses lacking a channel migration zone where the outer boundary of the flood prone area cannot be clearly determined using the field indicators above, it shall be determined based on the area inundated by a 20-year recurrence interval flood flow event, or the elevation equivalent to twice the distance between a thalweg riffle crest and the depth of the channel at bankfull stage. When both a channel migration zone and flood prone area are present, the boundaries established by the channel migration zone supersede the establishment of a flood prone area (see 14 CCR § 895.1).

Forced pool riffle channel: A channel in which most pools and bars are forced by obstructions such as large woody debris (see Montgomery and Buffington 1997).

Fuel loading: Amount of woody fuels present on a forested site, inventoried by fuel volume, height, and cover.

Fully stocked: Forested stands that may not be experiencing active competition-induced mortality, but that are experiencing a sufficient reduction in growing space as to expect mortality to begin before the next anticipated harvest cycle.

Functional priority ratings: A rating scheme that estimates the probable riparian function dependence on any given exchange function for a given channel type.

Gap conversion: A hole in the forest canopy caused by the loss or removal of multiple trees that is regenerated with conifer or hardwood species.

Habitat Conservation Plan (HCP): A long-term, landscape-level document that is a required part of an application for an Incidental Take Permit, issued under the United States Endangered Species Act (ESA) to private entities undertaking projects that might result in the destruction of an endangered or threatened species. It is a planning document that ensures that the anticipated take of a listed species will be minimized or mitigated by conserving the habitat upon which the species depend, thereby contributing to the recovery of the species as a whole.

Hardwood: Angiosperm (non-monocot) trees that are usually broad-leaved; in temperate and boreal latitudes they are mostly deciduous. Typical examples of hardwoods found in California include tanoak, red alder, Pacific madrone, coast live oak, canyon live oak, interior live oak, blue oak, Oregon white oak, California black oak, white alder, bigleaf maple, giant chinkapin, cottonwood, aspen, and California buckeye.

Headcutting: A fluvial erosion process that lengthens a stream channel at its head and also enlarges its drainage basin.

Headwater channel: The smallest tributary with a defined bed and banks that carries water from the upper reaches of the watershed to the main channel of the river (often referred to as a first order channel).

Hyporheic zone: The region beneath and adjacent to streams and rivers where surface and groundwater mix.

Incised channel: A vertically contained stream that has abandoned previous floodplains due to a lowering of local base level and is characterized by high streambanks bounded by alluvial terraces.

Inherent functional levels: Estimate of the probable riparian function dependence on any given exchange function for a given riparian condition.

Inner zone: In areas where the Anadromous Salmonid Protection Forest Practice Rules apply in California, a zone in the WLPZ adjacent to the Core zone that provides a large number of trees for large wood recruitment, shading, vertical structural diversity, and nutrient input. For Class I watercourses in the Coastal Anadromy Zone (CAZ), the Inner Zone is 70 feet wide; in non-CAZ areas, it is 40 feet wide (flood prone areas have variable width Inner Zones for both CAZ and non-CAZ areas). The Inner Zone for Class II watercourses varies from 35 to 80 feet in width depending on Class II type and slope class (see 14 CCR § 916.9 [936.9, 956.9]).

Nitrogen fixing species: Plants that convert nitrogen from a form they cannot use into a form they can use; they utilize an enzyme to catalyze the conversion of atmospheric nitrogen (N_2) to ammonia (NH_3).

Nutrient supply: Litter input from the riparian zone of a watercourse, which provides an important food source for benthic macroinvertebrates, and thus indirectly supports salmonid production.

Off-channel habitats: Bodies of water adjacent to the main channel that have surface water connections to the main watercourse at higher discharges; they include overflow channels, side channels, and backwater alcoves. Off-channel habitats provide valuable refugia for salmonids during high discharge winter storm events.

Organic litter: Dead plant material, such as leaves, bark, needles, and twigs, that have fallen to the ground.

Outer zone: In areas where the Anadromous Salmonid Protection Forest Practice Rules apply in California, a zone in the WLPZ adjacent to the Inner zone that reduces buffer strip windthrow; and provides wood recruitment, microclimate control, and terrestrial wildlife habitat. For Class I watercourses in the Coastal Anadromy Zone (CAZ), the Inner Zone is 50 feet wide and is only required where even-aged regeneration methods will be utilized adjacent to the WLPZ; in non-CAZ area, it is 30 feet wide and mandatory. In both cases, only commercial thinning or single

tree selection can be used and 50% post-harvest overstory canopy is required (see 14 CCR § 916.9 [936.9, 956.9]).

Perched fill material: Loose, uncompacted, excessive sidecast soil material in unstable locations (often on oversteepened slopes).

Plane bed channel: A planar gravel and cobble-bed channel that encompasses glide (run), riffle, and rapid morphologies; they lack discrete bars (see Montgomery and Buffington 1997).

Pool-riffle channel: A channel that has an undulating bed that defines a sequence of bars, pools, and riffles (see Montgomery and Buffington 1997).

Prescriptive uniform buffers: Fixed-width buffers of native vegetation along watercourses dictated by state or federal regulations or guidelines.

Plug and pond meadow restoration: Method used to prevent headcut gully migration by filling or plugging gullies, routing surface flows over the meadow surface, and raising the meadow water table.

Relative stand density: A measure of inter-tree competition that combines the effects of stocking level (number of trees per acre) and average tree size. Stand density sub-classification describes a generalized condition of stand growth and mortality dynamics. Relative stand density conditions vary by species and stand age assemblages.

Resource Conservation Districts (RCDs): Special districts of the state of California, set up under California law to be locally governed agencies with their own locally appointed or elected independent boards of directors. California RCDs implement projects to protect land and water resources on public and private lands and educate landowners and the public about resource conservation.

Modified Timber Harvesting Plan (THP): A special category of Timber Harvesting Plan that can be submitted for approval by the California Department of Forestry and Fire Protection for ownerships of 100 acres or less of timberland when several specific criteria can be met (see 14 CCR § 1051, Modified THP).

Riparian area: The part of the landscape adjoining rivers and streams that has a direct influence on the water and aquatic ecosystem. They have unique soil and plant characteristics that are strongly influenced by free and unbound water in the soil. Riparian ecosystems occupy the transitional area between the terrestrial and aquatic ecosystems.

Riparian function: Functions known to affect ecological processes between streams and their adjacent forests, including shading/heat exchange, water exchange, nutrient and biotic exchange, wood exchange, and sediment exchange (see Liquori et al. 2008).

Riparian management: Practices prescribed for the riparian area that will more rapidly improve aquatic habitat conditions for listed anadromous salmonids when compared to the use of the standard California Forest Practice Rules.

Ripping: Mechanical process whereby a winged subsoiler or large chisel teeth mounted on the back of a crawler tractor are used to break up compacted soil by lifting and shattering the soil profile.

Side channels: See the definition for off-channel habitat (above).

Silvicultural activities: Practices involved with the establishment and management of trees for wood production.

Source distance curves: Curves showing the effectiveness of riparian processes as a function of distance from stream channels. They have been used as the basis for aquatic conservation strategies and state forest practice rules.

Spatially explicit riparian management: Riparian management tailored to site-specific conditions to better protect ecological processes.

Spatial resolution: The scale required for identifying the relative benefit of habitat factors for anadromous salmonid fish species appropriate to the scale of the proposed site-specific proposal (as used in this document).

Step pool channel: A channel characterized by longitudinal steps formed by large clasts (rock fragments such as boulders) organized into discrete channel-spanning accumulations that separate pools containing finer material (see Montgomery and Buffington 1997).

Thermal loading: Input of heat to a forest stream, mainly occurring due to exposure of the stream surface to solar radiation, which produces elevated water temperatures.

Total Maximum Daily Load (TMDL): A regulatory term in the U.S. Clean Water Act (Sec. 303(d)), describing a value of the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards.

Tributary junction: The location where a tributary channel joins a larger watercourse (i.e., main stem), or where two tributaries meet to form the source of a larger watercourse.

Under stocked: Forest stand density characterized as open with active growth and very limited mortality.

Unevenaged management: Management of a specific forest, with the goal of establishing a well stocked stand of various age classes and permits the periodic harvest of individual or small groups of trees to realize the yield and continuously establish a new crop (see 14 CCR § 895.1).

Waste Discharge Requirements (WDRs): The order adopted by the Regional Water Quality Control Boards in California that regulates discharges of waste to surface water and discharges of waste to land. WDRs are often synonymous with "permits."

Watercourse: Any well-defined channel with distinguishable bed and bank showing evidence of having contained flowing water indicated by deposit of rock, sand, gravel, or soil, including but not limited to, streams as defined in PRC 4528(f). Watercourse also includes manmade watercourses (see 14 CCR § 895.1).

Watercourse and lake protection zone (WLPZ): A strip of land, along both sides of a watercourse or around the circumference of a lake or spring, where additional practices may be required for protection of the quality and beneficial uses of water, fish and riparian wildlife habitat, other forest resources and for controlling erosion (see 14 CCR § 895.1).

Watershed context assessment: A rapid watershed assessment process that can be completed cost effectively in a reasonable time frame with limited expertise, mainly utilizing existing information sources to determine watershed-scale limiting factors (see Appendix D).

Watershed scale: Information collected and analyzed for an entire watershed, rather than data processed at a site or stream reach scale.

Water Quality Control Plan: Document prepared by a California Regional Water Quality Control Board (sometimes referred to as a Basin Plan) that designates beneficial uses for waterbodies in the Region, and establishes water quality objectives and implementation plans to protect those beneficial uses.

Windthrow: Trees uprooted or broken by wind damage.

Wood loading: The weight or volume of wood per square meter of stream channel (kg/m^2 or m^3/m^2).

Wood supply: Input of large woody debris from the riparian zone (or farther upslope with landslide processes) into a watercourse channel from various wood recruitment mechanisms, including bank erosion, mortality, landslide processes, and wildfire.