Campbell Creek Planning Watershed

Pilot Project Final Report

December 31, 2019

California Natural Resources Agency
California Environmental Protection Agency

Timber Regulation and Forest Restoration Program

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Campbell Creek Planning Watershed Pilot Project Final Report

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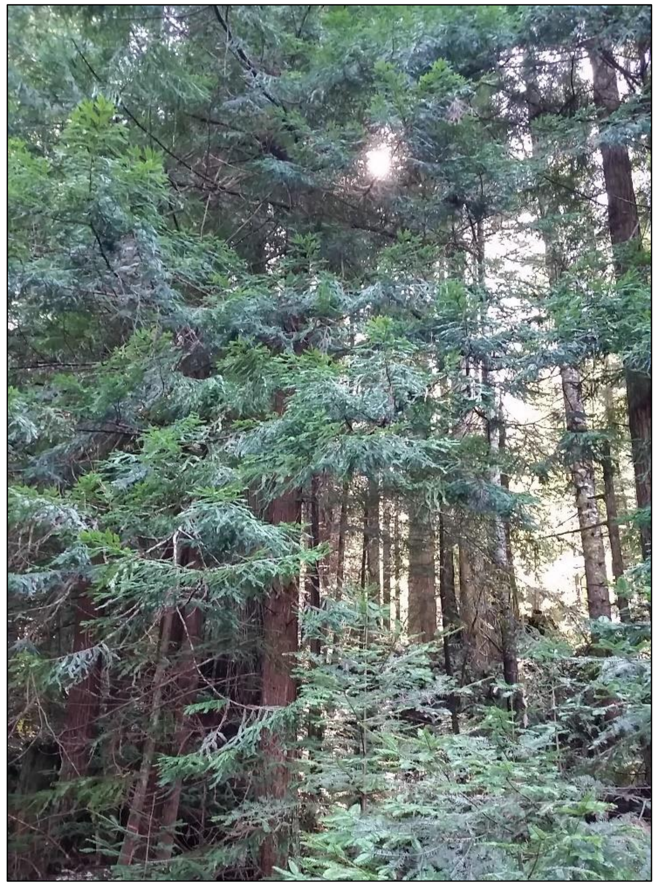
EXECUTIVE SUMMARY



State, federal, and tribal agencies, along with landowners and public stakeholders long have discussed the need for a systematic way to evaluate cumulative effects and identify restoration opportunities in California's forested watersheds. The concept of planning watershed pilot projects to study these factors has been in circulation for some time in various forms. With the passage of Assembly Bill 1492 in 2012, the state of California gained resources and staff to attempt a first planning watershed pilot project.

In order to define the collaborative nature of the pilot project, the objectives, and the processes that should be followed in its implementation, agency staff drafted a concept paper, *Forest Planning Watershed Pilot Projects Concept Paper* (Concept Paper), which was made available to the public in 2015. Two public meetings were held to receive input on the Concept Paper and after receiving public input, the draft was finalized in May 2016. The pilot project was structured with the agencies in the lead role and major guidance from the public/private Pilot Project Working Group (PPWG). In addition, the Concept Paper describes the methods used to select the initial planning watershed – Campbell Creek in Mendocino County, and the partnership with the private landowner, Lyme Redwood Forest Company. Last, the Concept Paper specifies the objective of using only existing data sources, such as Timber Harvesting Plans (THPs) and scientific reports (the exception being newly acquired LiDAR data), with a set of seven "Critical Questions" to guide the work. The work from the pilot project, especially the processes used, will inform potential future pilot projects.

After finalizing the Concept Paper, members of the PPWG were recruited, interviewed, and selected, representing government and tribal agencies, foresters, the environmental community, scientists, and timberland owners. The Pilot Project Interagency Interdisciplinary Team (PPIIT), tasked with conducting analyses for the pilot project, was formed from forestry program staff representing entities under the California Natural Resources Agency and California Environmental Protection Agency. These groups met in the first public meeting of the PPWG in December 2016. Three additional public meetings and three public webinars were held between May 2017 and January 2019. The PPIIT set up two websites to collaborate, present, and share information with the public.

While the Concept Paper contained the goals, structure, and focus of the pilot project, it was not specific on the methods. Agency and public members developed a three-track approach to test varying methods. These tracks included the approach most closely described in the Concept Paper – THP-focused data mining, but also two tracks that expanded on the concept – remote sensing rapid assessment, and modeling. These approaches were aided by the LiDAR data acquired for western Mendocino County in 2017.

The THP "mining" track was time consuming. Agency staff searched through multiple voluminous THPs to find information that might be relevant to the goals of the pilot project. Quantitative, spatially-explicit data was often not available in the THPs. Later in the process, an RPF conducted a thorough review of THPs, cataloguing the information in detail. Most of the best information available was ultimately the result of watershed studies that were appended to or referenced in THPs.

Rapid assessment of publicly-available imagery was fast and useful for determining the wood-recruitment potential (beneficial for salmon) of a stream reach. Supplementing this analysis with LiDAR data yielded an even more detailed picture of watershed conditions and wood-recruitment potential. While the LiDAR data was not obtained until late in the pilot project, its potential is promising.

Similar to the rapid assessment of imagery, modeling illustrated potential methods to assess a watershed in an office setting using pre-existing public data and off-the-shelf models. Spatial modeling has the benefit of being able to identify specific areas of a watershed in need of restoration. Additionally, modeling can narrow the scope of fieldwork, or identify other data requirements.

Each of the three tracks was largely run independently and an overall synthesis of these methods was attempted but not completed beyond the conceptual phase.

In addition to the three-track approach, agency staff presented work products through three webinars on the following:

1. A terrestrial habitat layer using Northern Spotted Owl as the resource of concern; this could potentially lead to a map or criteria for terrestrial restoration.
2. A prototyped synthesis of the three-track process (THP mining, watershed modeling, and remote sensing rapid assessment) focused on potentially restorable watercourse sites using coho salmon as the resource of concern.
3. A geology-focused assessment of erosion risk and sediment sources.

While the work completed for these webinars did not directly integrate into the three-track approach, this work complemented the three tracks and furthered the understanding of what is available in publicly available documents.

The Campbell Creek Pilot Project created many challenges for staff and the public. These included broad, conceptual issues such as the definition of "restoration," to organizational issues such as appropriate staffing levels. Despite these challenges, this report posits answers to the Critical Questions and a set of recommendations for future pilot projects, and more broadly, for forest management in California. We conclude that Timber Harvesting Plans can potentially provide the site-specific information needed to identify restoration needs and opportunities; however, the THPs reviewed as a part of this project do not, by and large, contain this information. There is an abundance of information contained within publicly available documents, including THPs, but too often that information is qualitative and not site-specific, making it difficult and time-consuming to determine the need for and potential effectiveness of restoration efforts. It is recommended that the conceptual focus of future pilot project(s) shift from obtaining data from regulatory documents to other available data sources and/or methods. Within the pilot project, these alternative methods benefited from the utilization of LiDAR, which provided a clearer picture of certain conditions in the Campbell Creek Watershed in a shorter period than the labor-intensive methods of mining THPs.

Crucial to the consideration of a future pilot project is re-examination of the overall concept. A narrow set of research questions is imperative to focus the project and staff. There are alternatives to engaging in a future pilot project, such as supporting statewide data acquisition and distribution, as well as the development of analytical tools and models to guide interpretation of the data. Similar kinds of approaches were recommended in 2001 by the University of California Committee on Cumulative Watershed Effects, led by UC Santa Barbara hydrologist and geomorphologists Dr. Thomas Dunne (Dunne, et al., 2001). With the recent improvements in LiDAR technology, there is a powerful new data source to support these kinds of spatially-based modeling approaches.

Finally, efforts that have been running parallel to the pilot project may assist future efforts. Ecological Performance Measures (EPMs) that are being developed by the TRFR Program include objectives for healthy forests that could serve as broad restoration objectives for future pilot projects. Additionally, CalTREES, the online timber harvesting plan submittal system and database, may eventually make obtaining data from THPs more efficient and include a spatial component.

SECTION 1

CAMPBELL CREEK PLANNING WATERSHED PILOT PROJECT

BACKGROUND AND GOALS

1.1 A BRIEF HISTORY

State and federal agencies, landowners, and public stakeholders long have called for a systematic way to evaluate cumulative effects and define restoration opportunities in California watersheds. For example, in the late 1990s and early 2000s, the state-led North Coast Watershed Assessment Program (NCWAP) undertook data collection and assessment of environmental conditions, cumulative effects, and potential for anadromous fisheries restoration in selected North Coast watersheds. Stakeholders were engaged in the process, and contractors were used to assist in collecting and evaluating information. Several assessments —including Redwood Creek, Mattole River, and Gualala River, were completed before declining state revenues led to cancellation of the program.[1]

Pilot projects have been components of several past Assembly Bills considered by the California Legislature (e.g., AB 2575, AB 380, AB 875). Assembly Bill 875, authored by Assemblyman Wesley Chesbro in 2013, provides a good example of related legislation introduced on this topic. Although the bill was not successful in making it to the Governor's desk, its goals and approaches were considered in development of the Campbell Creek Pilot Project. The AB 875 bill summary stated:

> The bill would require the Secretary of the Natural Resources Agency and the Secretary for Environmental Protection, by July 1, 2014, in consultation with various entities, to select a pilot project assessment team, as specified, to undertake pilot projects with the primary goal being to improve the state's collection, organization, management, use, and distribution of vital forestry-related information. The bill would require the pilot projects to accomplish certain things, including enabling restoration measures to be identified for listed anadromous salmonids, other wildlife, watersheds, and forest health issues. The bill would require the pilot projects to conclude on January 1, 2017. The bill would require the pilot project assessment team to create a report of its findings, conclusions, and recommendations and hold a public meeting to discuss the report.
> http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201320140AB875

The concept of planning watershed pilot projects has been in circulation for some time in various forms, including the previously mentioned legislative proposals as well as recommendations from forested watershed stakeholders. Assembly Bill 1492, approved by Governor Jerry Brown on September 11, 2012, established the Timber Regulation and Forest Restoration Program; among the bill's many goals are to

[1]These documents are posted on the Coastal Watershed and Planning Assessment Program website, as is the NCWAP Methods Manual (December 2003) http://www.coastalwatersheds.ca.gov/ .

"promote restoration of fisheries and wildlife habitat and improvement in water quality" and to promote "transparency … and simplify the collection and use of critical data to ensure consistency with other pertinent laws and regulations."[2] The March 2015 initiation of the current state agency-led pilot project — the Campbell Creek Pilot Project— is under the direct guidance of the Timber Regulation and Forest Restoration (TRFR) Program and its multi-agency AB 1492 Leadership Team (LT), and focuses on assembly, sharing, and analysis of existing environmental data to describe current forest conditions and identify restoration opportunities. [3]

1.2 THE CONCEPT PAPER

The *Forest Planning Watershed Pilot Projects Concept Paper* is the foundational and guiding document of the Campbell Creek Pilot Project.[4]

DRAFTING AND PUBLIC PARTICIPATION

Following the preparation of several versions of a draft pilot project template in March and April 2015, the AB 1492 Leadership Team developed a draft *Forest Planning Watershed Pilot Projects Concept Paper* (dated August 24, 2015). The draft was posted on the California Natural Resources Agency website, and public review and comment were initiated. A public workshop to review this first draft Concept Paper and receive public comments on it was held in Ukiah and webcast to the public on October 14, 2015. Written comments were accepted for a period after the workshop, and members of the AB 1492 Leadership Team completed a new draft Concept Paper in early December 2015, which included criteria for selecting the first pilot watershed (see *Selection of the Initial Pilot Project Location*). A follow-up public workshop was conducted on December 15, 2015, also in Ukiah; based on the input received, a process was developed eventually resulting in selection of the Campbell Creek Planning Watershed as the initial pilot project, as was a proposed membership structure for the Pilot Project Working Group (PPWG). These public meetings were highly interactive and well represented by environmental organizations, the timber industry, government agencies, and concerned citizens who commented upon project scope, potential location of the first pilot watershed, and the PPWG membership mix, among other issues.

After the two meetings in Ukiah, agency staff developed an implementation draft of the Concept Paper which was completed in May 2016, and the Campbell Creek Planning Watershed on the Ten Mile River in Mendocino County was chosen as the initial pilot project watershed. This version of the Concept Paper has been the guiding document for the work and contains a set of critical questions to be addressed as a part of the pilot project.

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[2] Text of AB1492 available at http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201120120AB1492 .

[3] A record of draft papers, public workshops, Pilot Project Working Group meetings, analytical work products, etc., is available on the Campbell Creek Open Data site (http://campbellcreek-calfire-forestry.opendata.arcgis.com/) as well as the forestry page of the California Natural Resources Agency website (http://resources.ca.gov/forestry/).

[4] The "Implementation Draft" of the Concept Paper can be found at http://resources.ca.gov/wp-content/uploads/2014/07/Planning-Watershed-Pilot-Projects-Concept-Paper-Implementation-Draft-May-25-2016.pdf .

The Concept Paper lays out the collaborative nature of the pilot project, the objectives, and the processes that should be followed in its implementation. It set the agencies in the lead role, with major guidance from the PPWG (see *Working Group Formation*). The Concept Paper states an objective to use only existing data sources, such as planning documents and scientific reports.

The substantive elements of the Concept Paper detail the basic approaches to conduct each of the pilot projects and provide a set of seven "Critical Questions." The Critical Questions aimed to guide the processes and analyses for the Campbell Creek Pilot Project, and each phase of the pilot project considered how the actions of the PPWG could support answering the Critical Questions. The seven Critical Questions, discussed more fully later in this document, deal with the breadth and quality of information available in public sources of information (primarily Timber Harvesting Plans [THPs]) and are:

1. *What criteria and methods can be employed, at the planning watershed scale, to identify restoration needs and priorities for watershed and biological resources based on available information in THPs and other readily available sources?*
2. *Do past THPs, collated on a planning watershed basis, contain the information needed to guide restoration at the planning watershed scale?*
3. *What are the qualitative and quantitative methods presented in THPs to analyze the potential for THPs to create or add to adverse cumulative effects on watershed and biological resources?*
4. *Is there adequate information available in past THPs and other available data sources to thoroughly and accurately characterize current biophysical and ecological conditions on the planning watershed?*
5. *Are there major gaps in the types or quality of available information, on a planning watershed scale, that would be useful for THP preparation and review, and assessment of cumulative impacts?*
6. *If there are gaps, what additional information is needed and what data are available?*
7. *What restoration needs or cumulative impacts can be identified from the planning watershed scale versus needing a different spatial context?*

The Concept Paper advances a partnership with public stakeholders and proposes the inclusion of an open, collaborative, online GIS (Geographical Information System), discussion of which can be found in the *Open Data* section of this report.

Inherent in the Concept Paper is that the *process* of working on the pilot project is paramount. If the goals of the Concept Paper are to be achieved, a standard set of processes must be arrived at to enable efficient and effective analysis in the future. As the Campbell Creek Pilot Project is proposed to be the first of up to four pilot projects, the lessons from this project are intended to inform potential future pilot projects.

The Concept Paper maps out a flow chart for the pilot project process in Figure 1.

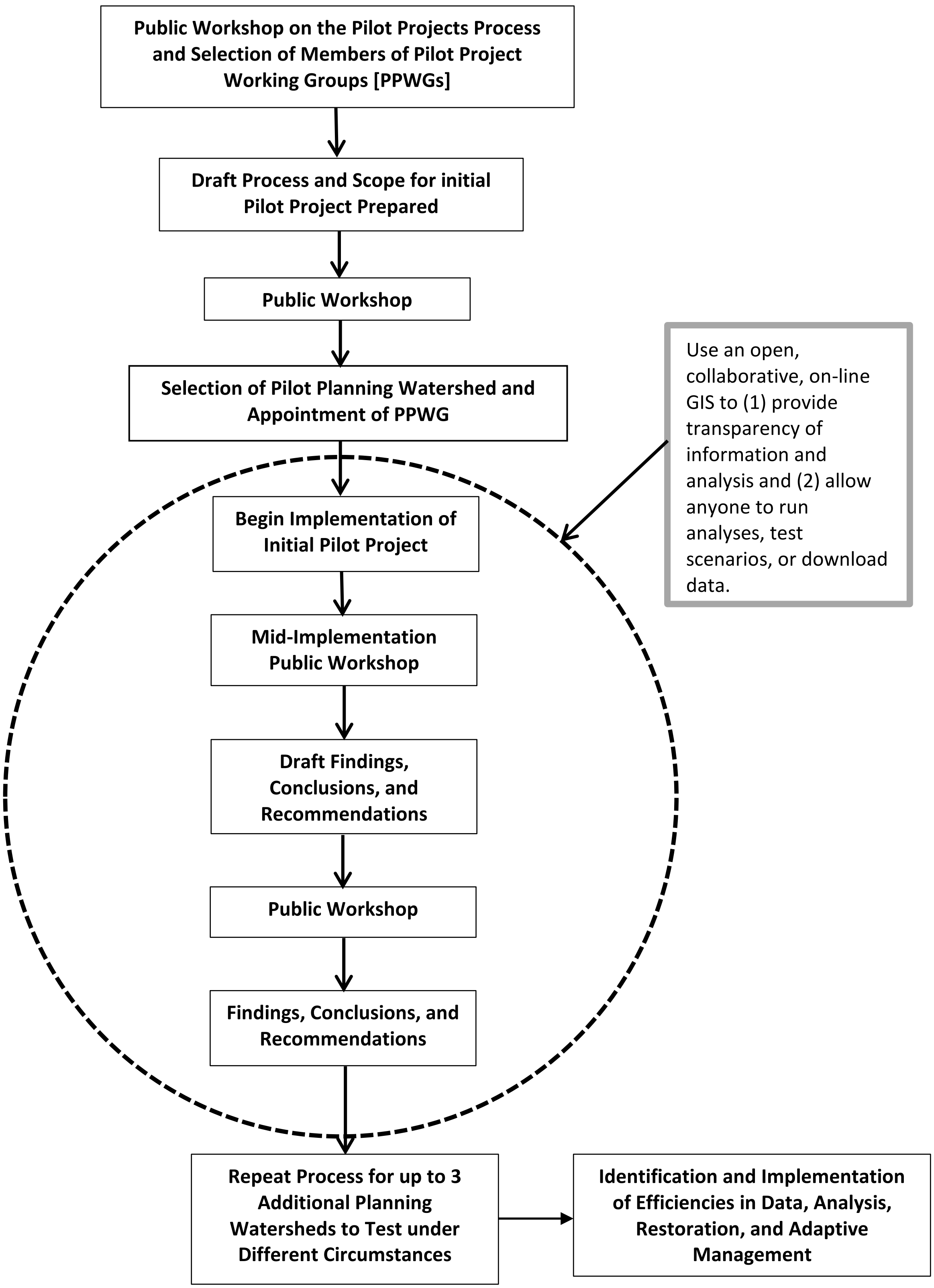


Figure 1. Pilot Projects process flow chart

The intent was to have narrowly focused pilot projects that question whether existing planning documents and other available sources could support restoration project identification and catalogue cumulative effects methods. During the drafting of the Concept Paper, agency staff received many comments with topics that were wide ranging and relevant. However, the scope of these projects was intentionally limited to enable a focused look at specific issues on a small enough piece of ground that a deep level of understanding could be attained and repeatable processes developed. As proposed in the Concept Paper, the pilot projects are intended to be one component of the overall TRFR Program. Some of the limitations to the concept and analysis are discussed in the *Challenges* section. Figure 2 places the pilot projects in the overall context of the TRFR Program.

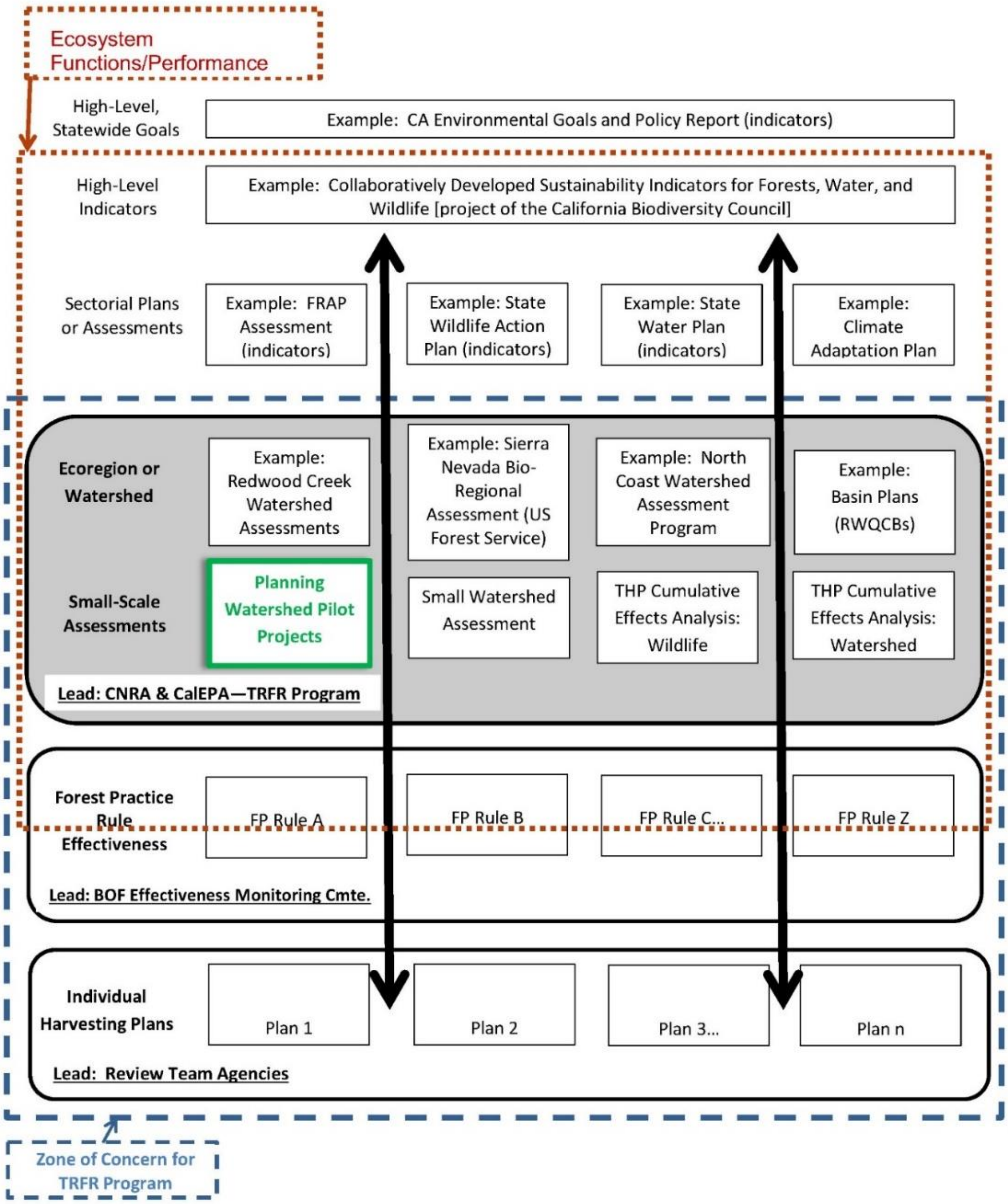


Figure 2. Pilot projects in context of Timber Regulation and Forest Restoration Program.

SECTION 2

PLANNING

2.1 SELECTION OF THE INITIAL PILOT PROJECT LOCATION

Prior to the formation of the Pilot Project Working Group (PPWG), the TRFR Program established that the initial pilot project would be in the North Coast region. Stakeholder comments regarding selection of a planning watershed for the pilot project are summarized below:

- A data-rich watershed with frequent harvest activity data (for example Timber Harvesting Plans), monitoring data, and scientific studies that provide information about current conditions
- A watershed where listed species are present and there is the potential to restore conditions for aquatic and terrestrial species
- A watershed where recovery versus highly impacted watersheds could be studied
- A watershed with multiple landowners who are supportive of the pilot project process.

The Campbell Creek Planning Watershed on the Ten Mile River in Mendocino County was selected as the watershed in which the initial pilot project would be conducted. The decision took into consideration input from stakeholders and agency GIS experts, geologists, hydrologists, foresters, environmental scientists, and wildlife biologists from the California Department of Forestry & Fire Protection, the California Geological Survey, the North Coast Regional Water Quality Board, and the California Department of Fish and Wildlife. Major factors in this selection were:

- An extensive history of timber harvesting, including recent years
- Significant amount of information available
- Critical importance as coho salmon habitat
- Strong interest from NOAA Fisheries
- A landowner who was interested in participating and has a strong commitment to restoration
- Accessibility for ground truthing information
- Attributes that addressed many stakeholder comments and interests.

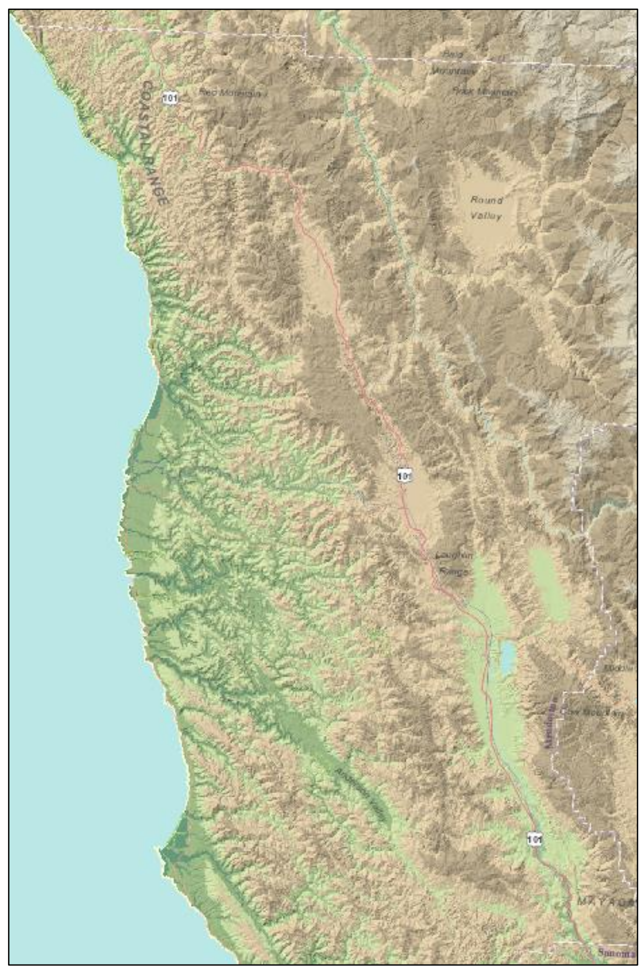


Figure 3. California Coastal Ranges.

GEOGRAPHICAL SETTING

The North Coast region (San Francisco Bay area to the Oregon border) lies within the Coast Ranges geomorphic province (CGS, 2002), an area that is characterized by a series of northwest-southeast trending mountain ranges and valleys that roughly parallel the coastline (Figure 3). The numerous active faults, folds, and complex geological

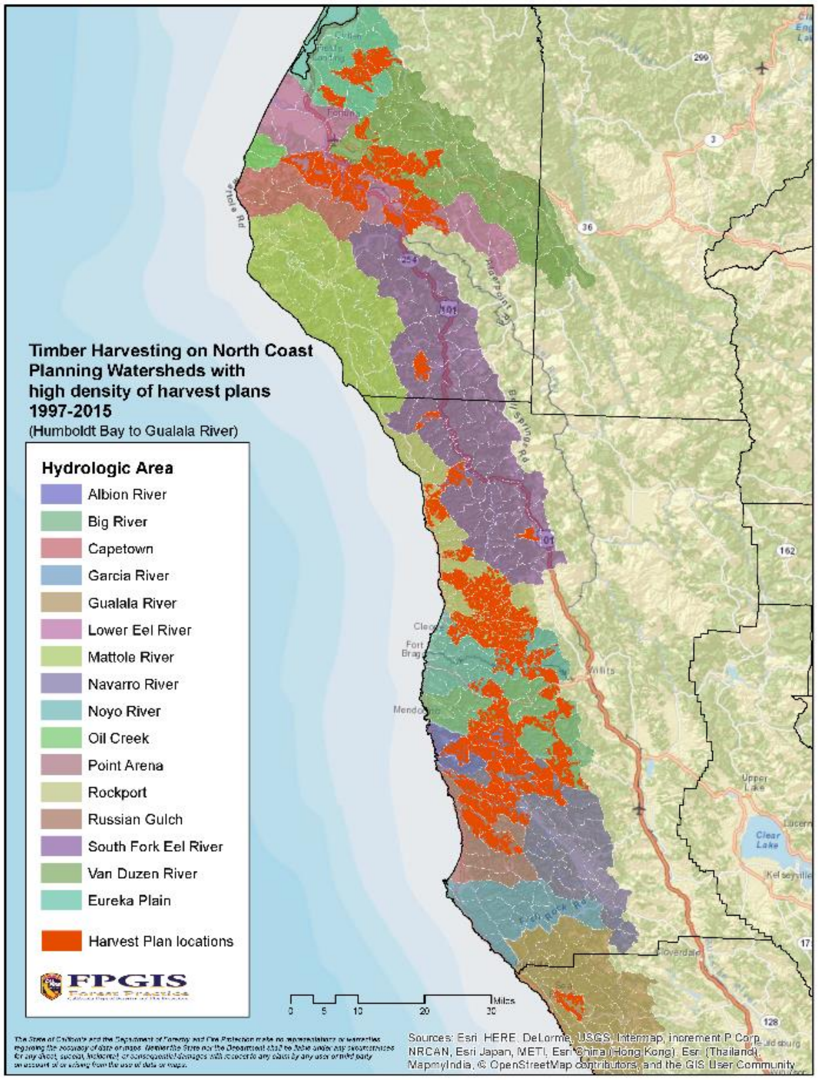


Figure 4. Hydrologic Areas reviewed for selection of the initial pilot project.

conditions in this area tell a long history of mountain building, erosion and deposition. The resulting rugged topography ultimately drains to the Pacific Ocean. Substantial annual rainfall is delivered to the seaward facing coastal mountains and drains via steep narrow valleys that contain numerous watersheds exhibiting an intricate ecology. Conditions in the coastal mountains support a largely forested landscape, and the watersheds that flow through the valleys contain habitats that support threatened or endangered species (for example, anadromous salmonids and northern spotted owl). The pilot project set out to explore the interaction of anthropogenic activities (example: timber harvesting and roads), complex geological and hydrological conditions, and habitat restoration and protection.

The following discussion briefly explains the process undertaken to determine a suitable watershed for the pilot project.

WATERSHED SELECTION PROCESS

GIS was used to analyze the Coastal CalWater Hydrologic Areas[5] from Humboldt Bay (Eureka Plain) south through the Gualala watershed for density of timber harvesting (1997-2016). This primary round of analysis resulted in the selection of 16 individual Hydrologic Areas, which included 68 individual planning watersheds (Figure 4).

Program staff crafted a preliminary set of criteria in order to compare differences among watersheds, which also provided a preliminary understanding of the types and availability of watershed data.

[5] CALWATER provides a standard nested watershed delineation scheme using the State Water Resources Control Board numbering scheme. The hierarchy of watershed designations consists of six levels of increasing specificity: Hydrologic Region (HR), Hydrologic Unit (HU), Hydrologic Area (HA), Hydrologic Sub-Area (HSA), Super Planning Watershed (SPWS), and Planning Watershed (PWS).

The planning watershed criteria included:

- Rate and area of timber harvesting in a planning watershed
- Types of silvicultural methods utilized
- Amount and complexity of available scientific data
- Amount of available imagery
- Occurrence of threatened and/or endangered species.

This was not an exhaustive process, but it fleshed out many significant, relevant categories to foster discussion and respond to stakeholder interests. Analysis that included a review of the silviculture and landownership patterns resulted in a list of 29 potential planning watersheds. A further review of each planning watershed and its topography eliminated those that were not logically delimited planning watersheds.

A visual assessment of locations further reduced the number to the 10 planning watersheds shown here in Figure 5. The resulting list of watersheds and a subset of the evaluation criteria are presented in Table 1. The full spreadsheet of information, a glossary of the information categories contained in the spreadsheet, and a set of maps are available on the TRFR Program website at: http://resources.ca.gov/forestry/.

Ultimately, through discussion and analysis, and importantly, through the willingness of Lyme Redwood Timberlands LLC (the owner of all the industrial timberlands within the watershed) and Lyme Redwood Forest Company LLC (the manager of these timberlands) to be active participants, the Campbell Creek Planning Watershed located in the Ten Mile River Hydrologic Sub Area in Mendocino County was selected (Figure 6).

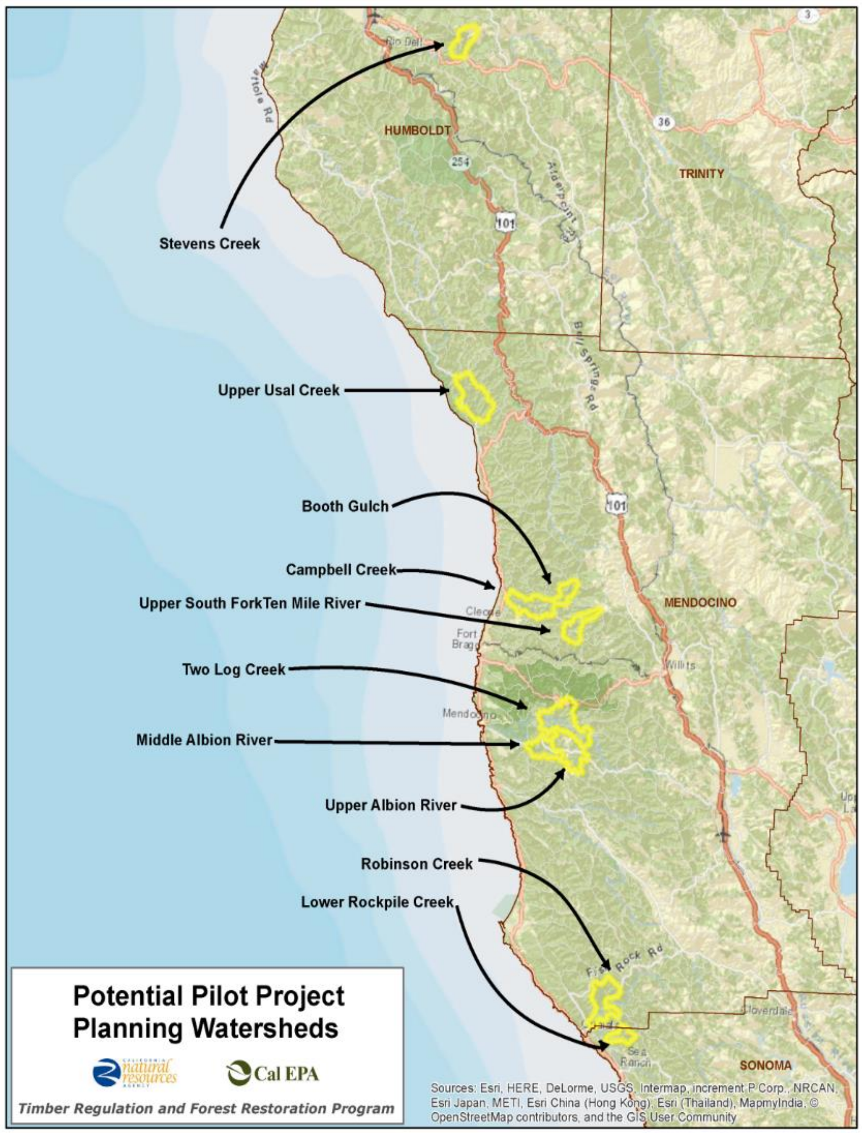


Figure 5. Ten prospective planning watersheds considered for the pilot project.

Calwater 2.2 Classification					Timber Harvesting 1997-2015			Primary Timberland Owners
Hydrologic Area	Hydrologic Sub Area	PWS Name	PWS Number	PWS Acres	THP Acres Approved for Harvesting 1997-2015	# of THPs 1997-2015	% of PWS (includes re-entry)	
Van Duzen	Bridgeville	Stevens Creek	1111.220603	4963	2848.7	37	57.4%	Green Diamond Industries, Humboldt Redwood Co, Sierra Pacific Industries
Rockport	Usal Creek	Upper Usal Creek	1113.110102	10611	1681.5	15	15.8%	Usal Redwood Forest
Rockport	Ten Mile	Booth Gulch	1113.130201	3260	2683.4	23	82.3%	Hawthorne Timber Co*
Rockport	Ten Mile	Campbell Creek	1113.130303	7904	4291.4	29	54.3%	Hawthorne Timber Co*
Rockport	Ten Mile	Upper S Fk Ten Mile River	1113.130304	5239	3900.5	34	74.5%	Hawthorne Timber Co*
Big River	Big River	Two Log Creek	1113.300406	11432	8180.1	59	71.6%	Mendocino Redwood Co, Humboldt Redwood Co, Conservation Fund, JDSF, Soper
Albion River	Albion River	Middle Albion River	1113.400001	4878	3629.6	33	74.4%	Mendocino Redwood Co
Albion River	Albion River	Upper Albion River	1113.400006	8739	3213.9	45	36.8%	Mendocino Redwood Co, Soper, Conservation Fund, Small Landowners
Gualala River	North Fork	Robinson Creek	1113.810002	8793	2607.4	23	29.7%	Gualala Redwood Timber, Conservation Fund
Gualala River	Rockpile Creek	Lower Rockpile Creek	1113.820003	2947	471.9	6	16.0%	Gualala Redwood Timber

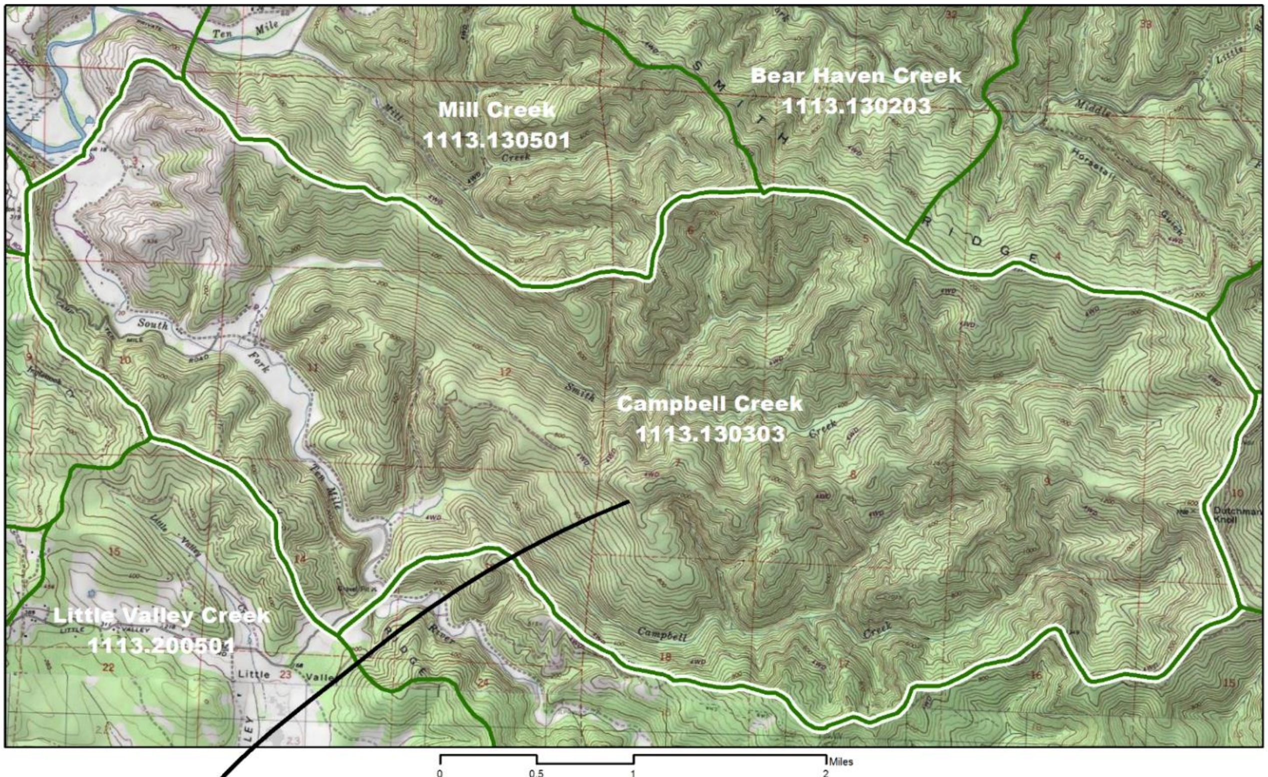
*Current Primary Timberland Owner is Lyme Redwood Timberlands

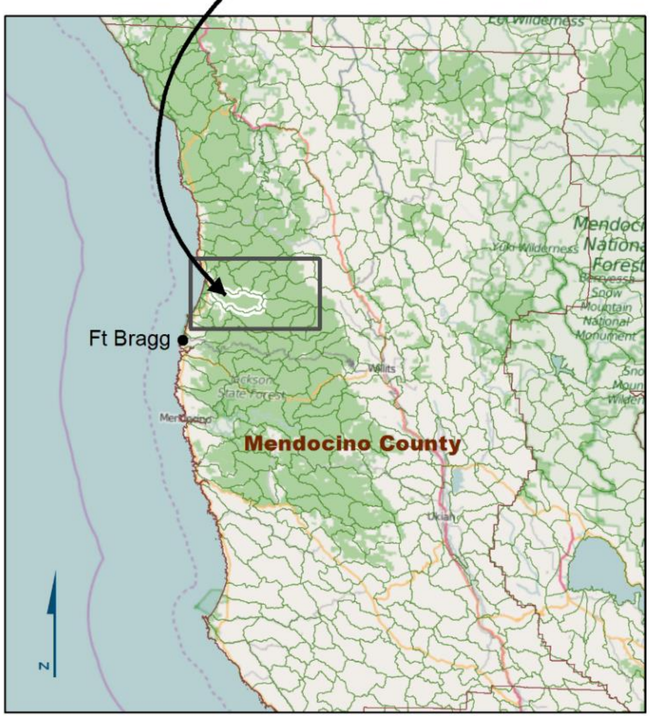
Table 1. Potential pilot project planning watersheds

The 7,904-acre Campbell Creek Planning Watershed contains approximately 14 miles of Class I (fish bearing) habitat along three main watercourses; Smith Creek (3,512 acres) to the north, Campbell Creek (2,737 acres) to the south and the South Fork Ten Mile River (1,655 acres) to the west. Both Smith Creek and Campbell Creek are tributaries to the South Fork Ten Mile River, draining from east to west through steeply incised headwater slopes into the gentler aggraded estuary of the mouth of the South Fork of the Ten Mile River. Elevation within Campbell Creek ranges from approximately 1,700 feet above mean sea level at the eastern interior headwater slopes (Dutchman's Knoll) to about 40 feet above mean sea level at the western estuary of the South Fork Ten Mile River.

Like elsewhere on the North Coast, the Campbell Creek Planning Watershed is influenced by the Maritime climate of the Pacific Northwest and the Mediterranean climate of central California. Summers are characterized by cool breezes and fog along the coast and hot dry conditions inland. Winters are characterized by abundant rainfall and cool temperatures. Precipitation consists of mostly rain with an average annual rainfall of about 43 inches. Watercourse characteristics are dictated by the temporal and spatial patterns of precipitation and the topographic characteristics of the area. Stream flows can dramatically respond to rainfall fluctuations. The interior areas of higher elevation receive greater annual rainfall, and much of this precipitation occurs from relatively few intense winter storms with most of the precipitation (75 percent) occurring between November and March.

Campbell Creek Planning Watershed





Campbell Creek is a 7904 acre planning watershed within the Ten Mile River Hydrologic SubArea.

Smith Creek and Campbell Creek drain into the South Fork Ten Mile River in this Mendocino California Calwater Planning Watershed.

Dutchman's Knoll is the highest point in the watershed, at nearly 1700 feet above sea level and Lyme Redwood Timberlands manages the timberland in this planning watershed.

Figure 6. Campbell Creek Planning Watershed, Mendocino County, California

2.2 ACQUISITION OF LIDAR DATA

As a part of the Campbell Creek Pilot Project work, it was determined that remotely-sensed light detection and ranging (LiDAR) data to characterize the planning watershed and surrounding areas would be valuable. There has been a limited extent of LiDAR data publicly available for private forestlands in California. Through this effort, LiDAR data were collected on approximately 1,200 square miles of the coastal portion of Mendocino County (the western third of the County).

LiDAR data provide high-resolution resource information from a landscape scale down to individual forest stands and can provide a unique capability to view and quantify physical attributes and processes that are difficult to consistently and efficiently ascertain through ground-based or other remotely sensed observations. The LiDAR data allow automation of a broad array of applications, analyses, visualizations (e.g., geomorphology, slope stability, hydrology, forest structural attributes, and watershed models) and advanced map production. These technological advantages gained with LiDAR data have the potential to (1) reduce scientific uncertainty via a relatively robust data set, (2) provide information in areas obscured by canopy cover, (3) provide consistent regional information, and (4) provide critical framework-level, public-domain terrain information.

The level-1 quality LiDAR data collected for coastal Mendocino County can provide geospatial products for use in a variety of applications by landowners, other stakeholders, and regulatory agencies. Potential applications of these data products, which have been successfully used elsewhere, include:

- Evaluation of geomorphology, relative slope stability (landslides), terrain analysis, watershed hydrology, vegetation inventories, aquatic and terrestrial habitat typing and cumulative effects
- Identification of potential fish passage barriers (e.g., cascades, waterfalls, landslides) for salmonid distribution modeling and habitat restoration planning
- Precise mapping of stream channels, including small tributary channels previously uncaptured on USGS 1:24,000-scale quadrangles, and evaluation of watercourse classifications and transitions during timber harvesting plan (THP) review
- Precise higher resolution mapping of stream channels to inform the CA Department of Water Resources statewide National Hydrography Dataset
- Significantly improved analyses of geomorphic forms and processes at meaningful fish habitat scales (i.e., pool and riffle scale)
- Identification of roads and skid trails for evaluation of abandonment, and/or sediment delivery mitigation
- Assessment of timber stand characteristics and habitat structure and composition for use in THP and broad scale cumulative effects review
- Identification of late seral habitat and residual large old trees (habitat for many threatened and endangered species) in THP review
- Assessment of forest carbon inventories
- Identification and mapping of rare and sensitive natural communities.

LiDAR acquisition has the potential for agency staff and regional stakeholders to compare the contents of existing permitting documents and scientific studies to the LiDAR products, along with spatial representation of these products on an accurate set of base data. This comparison will allow for a more holistic and accurate understanding of the types of information permitting documents are capturing and where gaps exist. Foresters preparing timber harvesting plans and agencies or members of the public reviewing those plans may be able to use the LiDAR to support their work and provide greater efficiencies for all parties. At this time, the data are publicly available through the USGS National Map portal and the California Natural Resources Agency (CNRA) Data Center.

2.3 Formation of Working Group and Teams

The Concept Paper (see *Concept Paper*) proposed that a Pilot Project Working Group (PPWG) be formed with a broad and balanced composition like that proposed in AB 875 (2013, unchaptered), including:

Review team agencies (CAL FIRE, CDFW, CGS, Water Board)
Federal agencies
Environmental community
Timber industry
Professional foresters
Scientists
Watershed restoration practitioners
Owners or managers of forestland in the pilot watershed
Tribal representatives

The TRFR Program solicited nominations and applications for membership on the PPWG. Candidates were selected for interviews based on their qualifications and area of expertise or representation. Those selected were interviewed by a panel of TRFR staff from each Review Team Agency[6] and the California Natural Resources Agency Assistant Secretary of Forest Resources Management, who was ultimately responsible for the selection of working group members. Public stakeholder membership on the PPWG is as follows:

- Myles Anderson, Licensed Timber Operator, Anderson Logging, Inc.
- Richard Campbell, Forestry Program Manager, Save the Redwoods League
- Rob DiPerna, California Forest and Wildlife Advocate, Environmental Protection Information Center
- Walter Duffy, PhD Fisheries Scientist, formerly USGS (retired)
- George Gentry, RPF Vice President of Regulatory Affairs, California Forestry Association
- Richard Gienger, Watershed Restorationist and Forest Advocate associated with the Redwood Forest Foundation Inc. Board and Forests Forever
- Matt Greene, RPF, Matt Greene Forestry and Biological Consulting
- Vivian Helliwell, Watershed Conservation Director, Pacific Coast Federation of Fishermen’s Associations and Institute for Fisheries Resources
- Jonathan Hvozda, Hydrologist, Lyme Redwood Forest Company
- Zach Jones, RPF General Manager, Lyme Redwood Forest Company
- Cynthia LeDoux-Bloom, PhD Consulting Fisheries Scientist
- Mike Liquori, Principal, Sound Watershed
- Javier Silva Tribal Environmental Director, Sherwood Valley Rancheria
- Dan Wilson, NOAA Fisheries

[6] Departments involved in the multi-agency review and regulatory oversight of timber harvesting and include the Department of Forestry & Fire Protection, the California Geological Survey, the Regional Water Quality Control Boards, and the Department of Fish and Wildlife.

The initial intent was for the PPWG to participate in meetings, refine the scope of the pilot project, review information, assist with analysis and writing, and seek input from the public. In practice, the public members of the PPWG played more of an advisory role than a day-to-day functional one. Defining the scope and creating analytical products were the domain of the Scope of Work Team (SOW) and the agency-staffed Pilot Project Interagency Interdisciplinary Team (PPIIT). PPIIT membership has varied over time with some changes in agency staffing. Current PPIIT membership is:

- Ryan Bey, North Coast Regional Water Quality Control Board
- Steve Baumgartner, California Department of Fish and Wildlife
- Pete Cafferata, CAL FIRE
- Elliot Chasin, California Department of Fish and Wildlife
- Drew Coe, CAL FIRE
- Michael Fuller, California Geological Survey, Department of Conservation
- Russ Henly, PhD, California Natural Resources Agency (retired)
- Adam Hutchins, California Department of Fish and Wildlife
- Suzanne Lang, CAL FIRE
- Dave Longstreth, California Geological Survey, Department of Conservation
- Chris Monary, State Water Resources Control Board
- Ruth Norman, RPF, California Natural Resources Agency (Retired Annuitant)
- Will Olsen, CAL FIRE
- Francesca Rohr, CAL FIRE
- Rich Walker, PhD, CAL FIRE

The PPIIT undertook the more demanding and complex workload necessary to support the pilot project and the work of the PPWG. All agency representatives on the PPWG also served on the PPIIT. Through several public meetings and webinars with the PPWG, the direction of the project was reviewed and feedback from its members was solicited.

Per the Concept Paper, PPWG meetings were intended to have the following characteristics:

- Open to public and noticed in advance
- Public can interact and provide comments
- Meetings are webcast when technically possible
- Members use a consensus process
- Findings and recommendations are recorded in writing and posted to the TRFR Program website
- If needed, a professional facilitator is provided.

The PPWG kickoff meeting occurred on December 15, 2016 in Fort Bragg. Twenty PPWG members attended, representing agencies and a broad section of the public. During this meeting, members discussed the process issues and group structure, including the relationship between the PPWG and PPIIT. The PPWG decided to have one leader, Elliot Chasin of the California Department of Fish and Wildlife, rather than agency and public co-leads. Lyme Redwood Forest Company (Lyme) presented a robust history of the Campbell Creek Planning Watershed and surrounding areas, including the history of timber operations by Lyme and its predecessors.

Shortly after the kickoff meeting in December 2016, a smaller team convened to develop a scope of work to supplement the Concept Paper (see *Concept Paper*). The Scope of Work Team (SOW) was composed of four public and five agency members of the PPWG. In the smaller group setting, members of the public and agency staff conducted frank discussions that enabled exploration of science, data, and methods somewhat beyond the initial scope of the Concept Paper. The SOW team met regularly throughout the pilot project, typically with the same membership, but with occasional public and agency staff additions and substitutions. Over time, the SOW evolved into a small working group responsible for defining direction of the pilot project, and the group worked closely with the PPIIT on tasks and work products.

While no detailed written scope of work beyond the earlier concept paper was produced, the ongoing meetings of the SOW served to direct the work of the pilot project. During the initial phases of the SOW, a decision to prototype three methods of analytical inquiry led to the “three-track process.”

Subsequently, two additional in-person meetings of the PPWG were held in Ft. Bragg on May 23, 2017 and October 5, 2017. Webinar meetings of the PPWG, where agency staff reported on their analytical findings, were held on April 19, 2018 (*Northern Spotted Owl Terrestrial Habitat*), April 26, 2018 [*A Prototyped Synthesis of the Three-Track Process (THP Mining, Watershed Modeling, and Remote Sensing Rapid Assessment)*], and May 3, 2018 (*A Geology-Focused Assessment of Erosion Risk and Sediment Sources*).

2.4 TOOLS FOR UNDERSTANDING THE SCOPE

In an effort toward building an online system of data and information as well as the collaborations necessary to achieve that goal, members of the PPIIT representing all the Review Team Agencies—and partnering with Lyme Redwood Forest Company for use of their data—used the ArcGIS Online (AGOL) platform and created Story Maps to provide a resource overview of the Campbell Creek Planning Watershed (Figures 7, 8 a-b). Pulling existing data from across agencies and Lyme, the Story Maps delivered a publicly accessible, web-based application that presents an overview of geography, geology, biology, and timber harvesting in the Campbell Creek Planning Watershed. The Story Maps remain accessible to the public and allow the user to explore Campbell Creek through interactive maps, informative text, links to other web pages, documents, and GIS data.

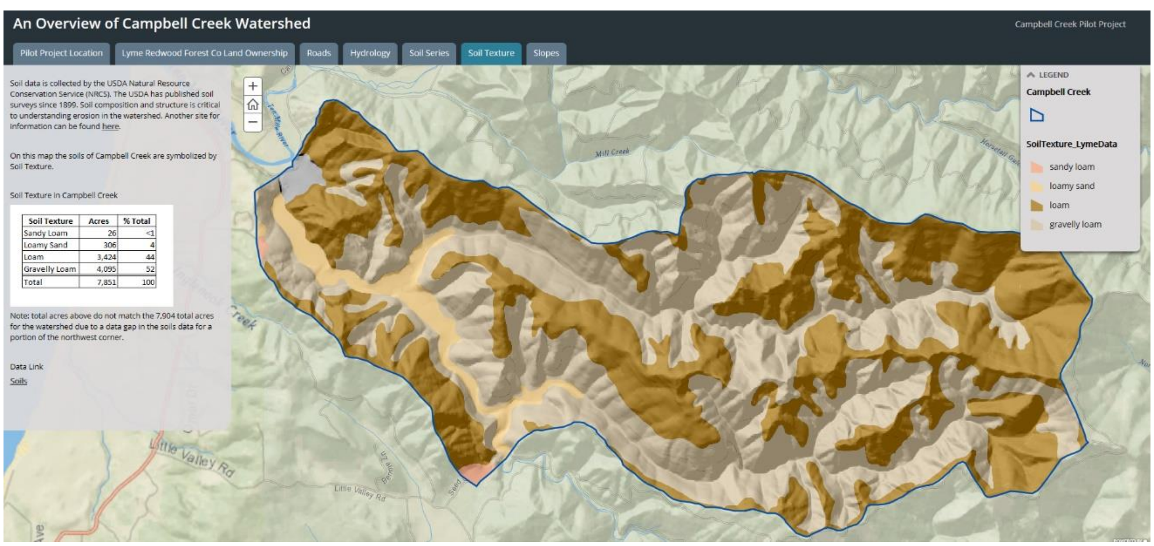


Figure 7. ArcGIS Story Maps introducing Campbell Creek; soil texture map.

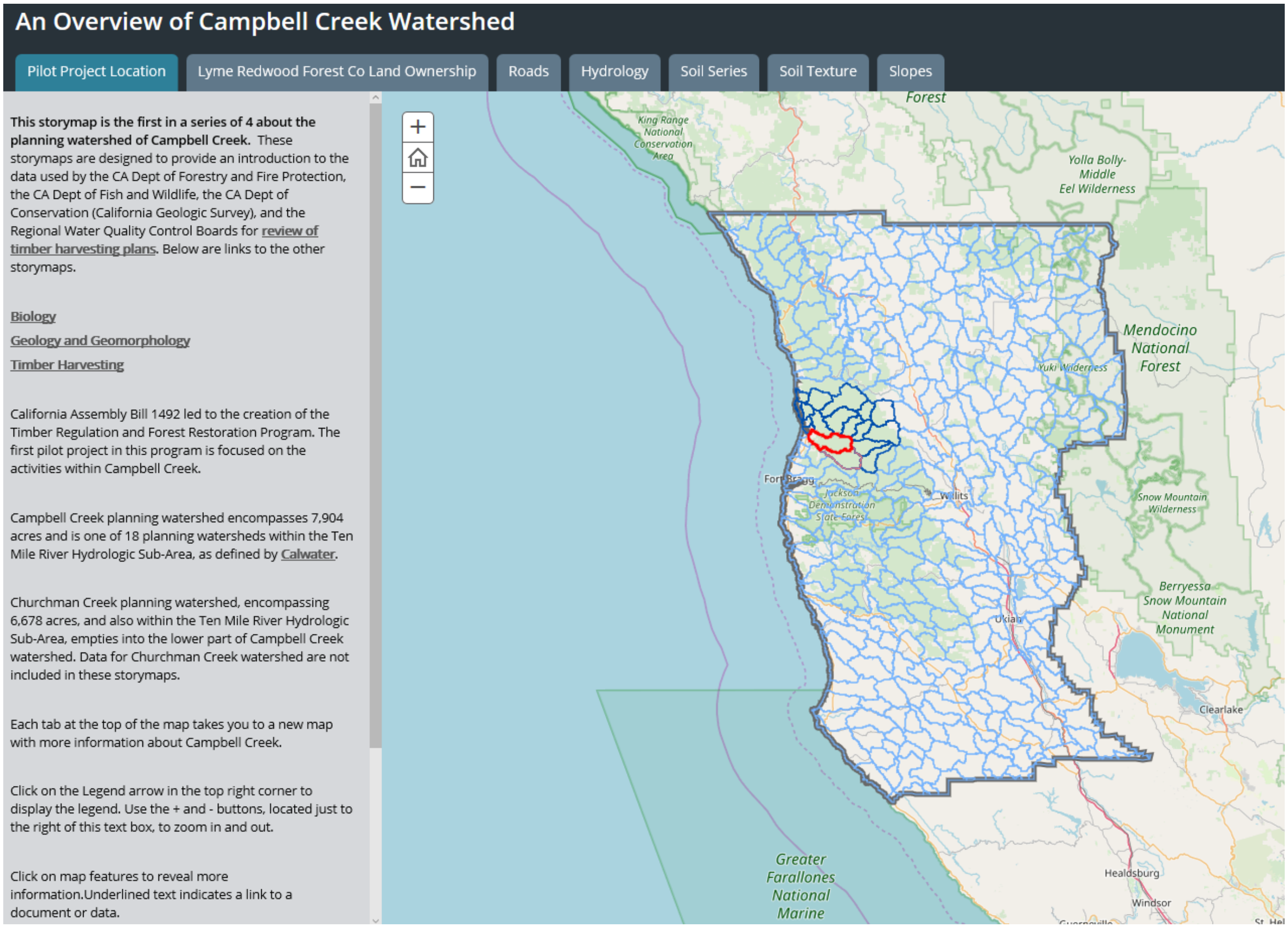


Figure 8a. ArcGIS Story Maps introducing Campbell Creek

Four Story Maps present a general introduction to the geography of Campbell Creek Planning Watershed:

An Overview of Campbell Creek Watershed (location, ownership, roads, hydrology, soils, slopes)
Biology (fish, spotted owl, vegetation, species of special concern, plants)
Geology and Geomorphology
Timber Harvesting (silviculture and yarding 1990-2015, erosion hazard ratings).

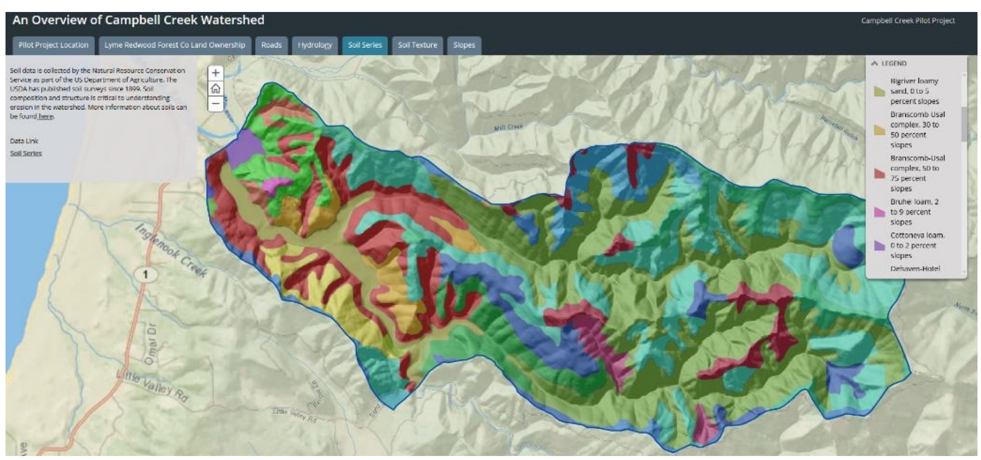


Figure 8b. ArcGIS Story Maps introducing Campbell Creek; soils map.

The AGOL Story Maps represent the first product collaboratively developed under the pilot project and made available to the public.[7]

[7] Key collaborators: Francesca Rohr, CAL FIRE; Sol McCrea, CGS; Diane Mastalir, CDFW.

SECTION 3

IMPLEMENTATION AND FINDINGS

3.1 REFINED CRITICAL QUESTIONS

An initial set of critical questions for the pilot project was developed and vetted through a series of papers and public meetings and the final critical questions were presented in the *Forest Planning Watershed Pilot Projects Concept Paper (Implementation Draft)*[8]. Table 2 below shows how the critical questions were initially numbered and then later re-sequenced into a more logical order. A theme was added to give a general sense of the focus of each critical question.

Original Critical Question Number	Logical Order of Steps	Critical Question	Theme
4	1A	What information is available in past THPs/NTMPs and other available data sources to characterize the historic and current biophysical and ecological conditions on the planning watershed scale, including cumulative effects?	Information on Historic and Current Conditions
	1B	Is this information adequate to identify restoration opportunities at the THP/NTMP scale?	Information for Restoration at Sub-planning watershed Scale
3	2	What are the qualitative and quantitative methods presented in THPs/NTMPs that analyze potential for THPs/NTMPs to create, add to, or ameliorate adverse cumulative effects on watershed and biological resources?	Cumulative Effects Methods
5	3A	Are there gaps in the types or quality of information available on a planning watershed scale that would be useful for THP/NTMP preparation and review and for the assessment of CWEs?	Information for Cumulative Effects Assessment
6	3B	If there are gaps, what additional information is needed and what data are available?	
1	4A	What information, criteria, and methods can be employed, at the planning watershed scale, to identify restoration needs and priorities for watershed and biological resources based on available information?	Restoration at planning watershed Scale
2	4B	Do past THPs/NTMPs and other available information, collated on a planning watershed basis, contain the information needed to guide restoration at the planning watershed scale?	
7	5	What restoration needs or cumulative impacts can be identified from the planning watershed scale versus needing a different spatial context?	Restoration and Cumulative Effects at a Different Spatial Scale

Table 2. Pilot project Critical Questions

[8] http://resources.ca.gov/wp-content/uploads/2014/07/Planning-Watershed-Pilot-Projects-Concept-Paper-Implementation-Draft-May-25-2016.pdf

3.2 Open Data

The Forest Planning Watershed Pilot Projects Concept Paper calls for the "development and use of a collaborative, on-line geographic information system" (Substantive Elements, page 3), which is further described as "open" (Data Collection and Characterization, page 6) i.e. publicly accessible. Data Basin was put forward as an example of such a system.[9]

The four branches of the Resources Agency already have organizational subscriptions to ESRI's ArcGIS Online, which holds similar potential to Data Basin. Therefore, a publicly accessible open data site, Campbell Creek Pilot Project, was created on ArcGIS Online as the web venue for the pilot project. The goal was to foster ease of access, transparency, and public participation. The product is a living website which is configurable, expandable, and hopefully engaging. As new data and information were developed or became available, they were immediately shared via the Campbell Creek Pilot Project Open Data site (Figure 9).

The website includes:

1. Introductory page including
   - The four Story Maps
   - Background information relevant to the pilot project
   - Downloadable data
   - A placeholder for GIS Tools related to plan submission and watershed/restoration assessment
   - A Public Comment app
2. Documents page including
   - Timber Harvesting Plans within Campbell Creek
   - Non-Industrial Timber Management Plans within Campbell Creek
   - Cumulative Watershed Effects Documents
   - Watershed Assessment and Restoration Guidance papers and articles
   - Ten Mile River Watershed documents
   - Historical Aerial Photographs (accessible only to CA Natural Resources Agency staff)
3. Analysis page including
   - Slideshows, documents and maps presented at PPWG meetings
   - Interactive maps
   - Webinars presented to the PPWG
   - LiDAR processed hillshade and canopy height
   - Road and watercourse data digitized from LiDAR processed hillshade
4. Products page which remains mostly undeveloped and serves as a placeholder in the Open Data architecture.

[9] Data Basin was created by the Conservation Biology Institute and, per the website, is "a science-based mapping and analysis platform that supports learning, research, and sustainable environmental stewardship." It allows access (with free membership) to datasets, maps and data/map galleries, and includes the ability to create maps online, create groups and host up to 1 GB of data. Further data hosting capacity and use of a limited set of analysis tools must be purchased.

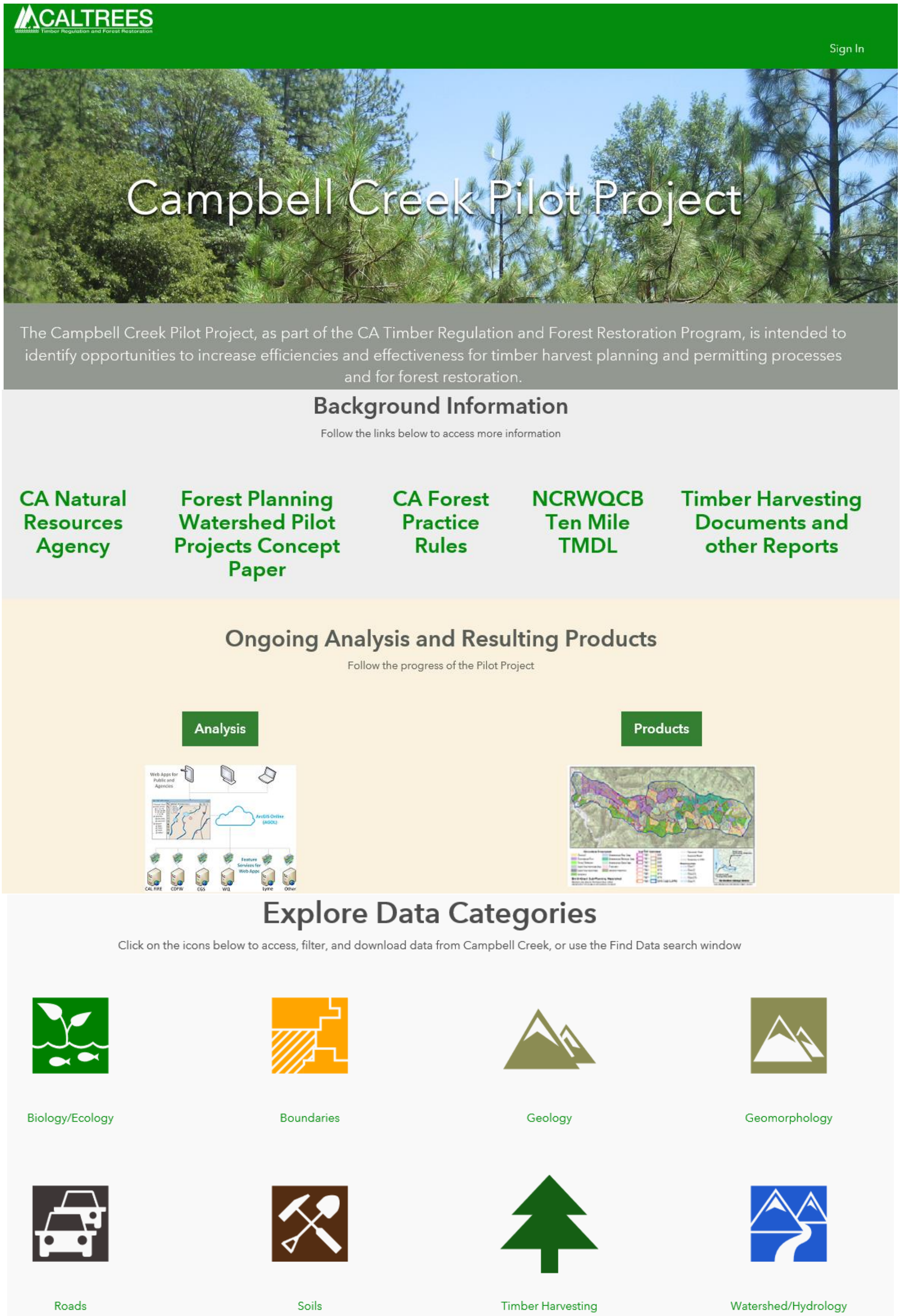


Figure 9. Campbell Creek Open Data site (http://campbellcreek-calfire-forestry.opendata.arcgis.com/).

The site is experimental in that the ArcGIS Online capability is relatively new and the skills needed to create it were acquired by staff during the course of the pilot project. No systematic approach to assess its potential and limitations was undertaken, voluntary feedback was minimal, but support staff successfully used the website as their primary source of information for the pilot project. The goal of Open Data is to publish data and information that is easy to search, easy to access, and easy to combine with other data, and also to facilitate user interaction; for instance, there is a tool within the Open Data site for users to submit comments along with the ability to map and export data. The pilot project presented an opportunity to move forward in the direction of transparency and data-driven decision support. The California Natural Resources Agency and the State Water Resources Control Board are paving the way in Open Data as a mechanism to "bring government closer to citizens and start a new shared conversation for growth and progress in our great state"[10] and useful strides were made during the pilot project.

3.3 Three-Track Approach

Having refined the Critical Questions (see *Refined Critical Questions*), the SOW Team concentrated on devising methods for the pilot project. While the focus remained understanding whether existing, publicly-available data sources could contribute to identifying restoration needs, some PPWG/SOW members questioned if concentrating only on THP-focused data was a limitation. Group members agreed that other approaches could potentially yield similar or better results in less time. Following discussions about other approaches, the SOW Team developed a three-track approach and the PPIIT took on the work. Here is the intent of each of the three tracks:

1. **THP-focused:** This method was most closely spelled-out in the Concept Paper and intended to extract elements from THPs —including narrative, tabular information, and mapped information that could be used to identify restoration opportunities.
2. **Remote sensing rapid assessment**: Air-photo series, GIS, and maps were used to create expert assessments of on-the-ground conditions on a good/fair/poor scale. Other areas have used rapid assessments with good results, including Jackson Demonstration State Forest. LiDAR was folded in as a possible tool in rapid assessment.
3. **Modeling**: Modeling in a spatial framework and building off existing methods and models held potential to create repeatable analyses that could be applied to other watersheds.

Exploring multiple methods using the data for the entire nearly eight-thousand-acre planning watershed seemed daunting, so the SOW Team promoted a phased approach by selecting a sub-watershed within Campbell Creek for prototyping each track, with iterations informed by discussions with the PPWG. Study areas in the early phases were located within the Smith Creek watershed which comprises approximately 44 percent of the Campbell Creek Planning Watershed. The initial area of interest (AOI) was an approximately 865-acre portion of the Smith Creek watershed located over steep north and south draining slopes. The area was selected to test possible approaches and assess available watershed information. This AOI includes approximately 25 percent of the Smith Creek watershed and approximately 11 percent of the Campbell Creek Planning Watershed. After experimenting with various approaches, the area of interest was then expanded to include all of the 3,512-acre Smith Creek watershed. (see Figure 10).

As was found throughout the project, determining how to evaluate for and recommend restoration in an upland managed timberland environment was challenging (see *Challenges* section), and the initial phases of work focused on riparian effects and restoration.

[10] https://data.ca.gov/

The salmonid fishery, particularly the coho fishery, is listed in the Ten Mile River Watershed Total Maximum Daily Load (TMDL) as the primary beneficial use of concern (Ten Mile River Total Maximum Daily Load for Sediment, 2000). Coho salmon were identified as a primary resource of concern for this pilot project. The Ten Mile Watershed is currently listed on the 303(d) List due to impairment and/or threat of impairment to water quality by sediment and temperature. The TMDL identifies sediment as the primary impact to the cold-water fishery beneficial uses, specifically sediment generated from high rates of historic timber harvesting and the high density of roads and skid trails supporting these activities.

The three tracks were intended to run independently and use data appropriate, initially, to the sub-watershed. Since this was a prototype and only a portion of the planning watershed, the work was completed relatively quickly (in about five weeks) in order to report to the PPWG and obtain guidance. The independence of each track was intended to enable comparing conclusions and determining if the methods would work best independently or in conjunction with each other, and what level of effort was required to complete each track. Each of the three tracks went through iterations of the work to explore and refine processes and approaches with the goal of identifying restoration opportunities.

SUB-WATERSHED GEOGRAPHY

Campbell Creek Planning Watershed (CCPWS)	Area in Acres	Miles of Class I Stream Habitat
Smith Creek	3512	5.2
Campbell Creek	2737	4.5
South Fork Ten Mile River	1655	4.3
Total	7904	14

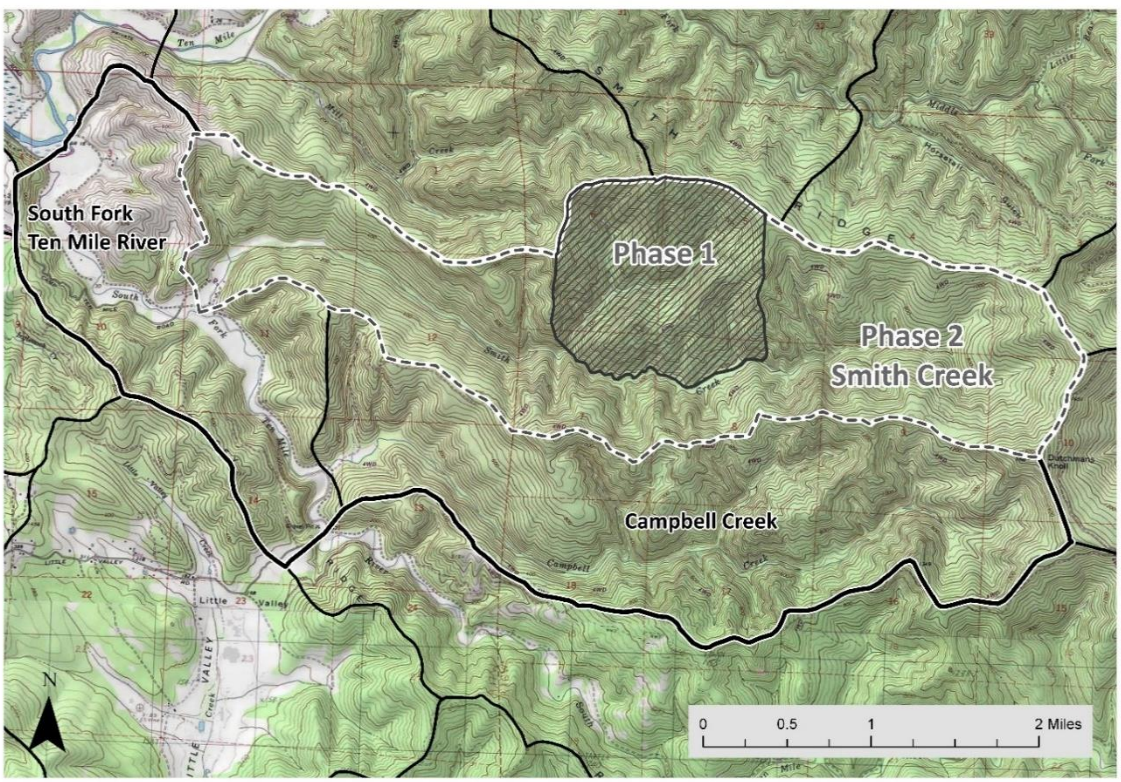


Figure 10. Sub-watersheds within the Campbell Creek Planning Watershed used as phased areas of study.

Following the second PPWG meeting, the SOW convened to discuss how to proceed with the pilot project. Finding value in each of them, the decision was made to continue with the three-track process, but attempt to better integrate them over a larger area of the Campbell Creek Planning Watershed–-the Smith Creek watershed, with a continued focus on riparian environments.

3.3.1 Track 1: Timber Harvesting Plans – Mining for Information

Methods

Initial Review

Initially, nine Timber Harvesting Plans (THPs)[11] within Smith Creek were assessed for data that addressed the pilot project's Critical Questions and how timber harvesting activities might impact resources of concern. Fine sediment is well documented as being a major threat to salmonids at all life-stages. The Ten Mile River TMDL identifies the building, use, and high density of timber roads and skid trails throughout the watershed as a major fine sediment source. While the focus of THP mining was to evaluate the potential impact timber harvesting activities might have on the resources of concern, particular attention was given to locations where sediment discharge to a watercourse was occurring and where the potential threat of discharge was greater, such as at watercourse crossings and other hydrologically connected locations. To better understand threat and threat potential, assigning a numeric value to each location would allow ranking and comparison throughout the sub-watershed. Recognizing that sediment delivery from a rarely-used seasonal road that crosses the head of a Class III watercourse on a ridge top might not be as deleterious to resources of concern as a failing culvert on a heavily-used seasonal road actively depositing sediment to a fish-bearing Class I watercourse, the value would need to consider watercourse classification and distance to a higher order watercourse. As the Registered Professional Foresters (RPFs) address existing and potential erosion sites, and controllable sediment discharge sources (CSDS) in THPs, the value would also need to address sediment savings at sites where they are to be treated as proposed in the THP by the RPF.

Based on these criteria a prototype formula was developed by Graham Brown (see Equation 1).

$$Quantifed\ Environmental\ Impact = \frac{Potential\ Discharge * Watercourse\ Classification}{Distance\ to\ higher\ order\ watercourse} - Discharge\ from\ proposed\ treatment$$

Equation 1. Prototype formula developed by Graham Brown (formerly of the NCRWQCB)

Formula inputs were located in THPs. Discharges are measured in cubic yards and distances in feet. Watercourse classification is either I, II, or III. Quantitative data was selected because it is more resilient to biases. A spreadsheet containing a list of pre-determined threats to resources of concern that were anticipated to be addressed in all THPs was generated. However, during data mining, it became apparent that this was not always the case; the THPs span three decades and were developed by different RPFs with different skill-sets and experience levels and the same inputs were not contained in all THPs. Where they were present, the data was not always presented in the same

[11] THP 1-90-180 MEN, THP 1-91-110 MEN, THP 1-91-143 MEN, THP 1-92-189 MEN, THP 1-96-274 MEN, THP 1-97-017 MEN, THP 1-01-206 MEN, THP 1-07-036 MEN, THP 1-13-031 MEN

format. For example, some RPFs provided a single sediment discharge volume at a site (e.g. 10 cubic yards), while others gave a range (10-20 cubic yards). It was unclear if the same method and protocols for measuring sediment at a site was used throughout all the THPs, or if different methods or combinations were used. Because of these data inconsistencies and gaps, it became clear the THPs could not be used with this formula.

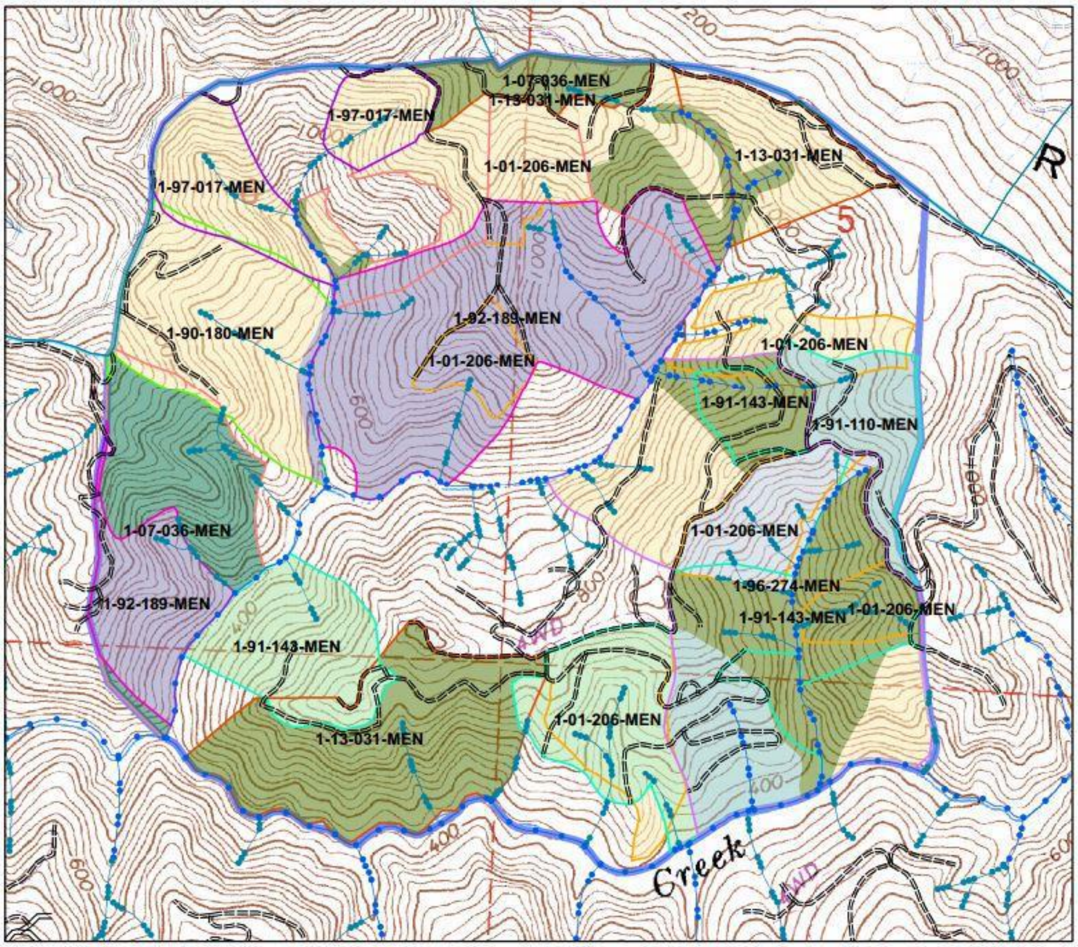


Figure 11. Timber Harvesting Plans (THPs) located within Smith Creek sub-watershed.

Results of this initial exercise were presented at the PPWG public meeting in Fort Bragg on May 23, 2017. Subsequently, it was determined that information derived from THPs might be more useful in the GIS where it could be illustrated for better understanding and serve as components of spatial analyses that might examine current conditions within areas that have been harvested. PPIIT members developed a framework to extract spatial data from the four most recent THPs in the Campbell Creek Planning Watershed.[12] The narrower set of plans was chosen because they were submitted after the Forest Practice Rule Anadromous Salmonid Protections (ASP) came into effect (2010) and are more likely to have information pertinent to salmonid habitat. Only two of the plans had harvest units within the Smith Creek watershed, so the scale was expanded to the whole of Campbell Creek.

[12] THPs 1-15-107 MEN, 1-15-094 MEN, 1-14-126 MEN, 1-13-031 MEN all had some proposed operations in Campbell Creek.

Spatial information was extracted from THP Sections II, III, and V and includes:

- THP Map Points predominantly consisting of road, watercourse crossing, and erosion locations
- Plan attached Geologic features (Geology Maps in Sections II & V)
- In-Lieu Practices map points (Reviewers Maps in Section III)
- Landing locations (Reviewers Maps in Section III)
- Water Drafting Sites (Appurtenant Road Maps Section II, Water Drafting Locations Maps Section V)
- Anadromous Fish Habitat (Aquatic Habitat Assessment in Section V)
- Erosion Hazard Ratings (EHR Maps in Section V or Operators Maps Section II).

Attribute information assigned to these features include:

- THP Map Points – THP Map Points table and Erosion Control Plan (ECP) table
- Plan attached Geologic Points - Point, line and polygon geomorphic features from the plan attached geology reports and maps
- In-Lieu Practices - WLPZ skid trails (lines) and WLPZ landings (points) had no attributes. Felling of WLPZ trees was purely narrative and contained no spatial data
- Landings - limited attributes found in THP map legends (proposed, existing, WLPZ)
- Water Drafting Sites – found in tables in Sections II & V
- Anadromous Fish Habitat - attributes included on the maps: spawning and rearing; restorable
- Erosion Hazard Ratings – attributes included on the maps: high, moderate, low.

Note: almost all the attribute information is *qualitative*, not *quantitative*.

THP Amendments were evaluated for any additional relevant information or changes to the plan. It was found that the only significant additional data was contained in changes to 1600 agreements, specifically regarding Water Drafting Site locations, which are discussed below.

Data Acquisition

A geodatabase was created with fields designed to allow for data filtering and calculations where appropriate. Attribute data was gathered from all relevant areas within the THP.

Specific challenges were encountered:

- THP Map Points - one map point may refer to 2 separate features (2 points added to the GIS).
- Geologic Points - the points refer to larger geomorphic features; the geo-points table has description and treatment information; the geomorphic features have the spatial extent; the two are not linked.
- Landings – only oversize and WLPZ landings are required by the Forest Practice Rules (FPRs) to be mapped.

The geodatabase identifies features and attributes throughout the Campbell Creek Planning Watershed (Figure 12). Feedback on this process or the value of the data extracted from plans was minimal. A rate-of-harvest analysis could add to the overall understanding of cumulative effects and combined with data and analysis developed in the other two analysis tracks (see *Track 2: Rapid Assessment with Imagery Analysis* and *Track 3: Hydrologic Modeling*) might identify potential “hotspot” locations for restoration activities.

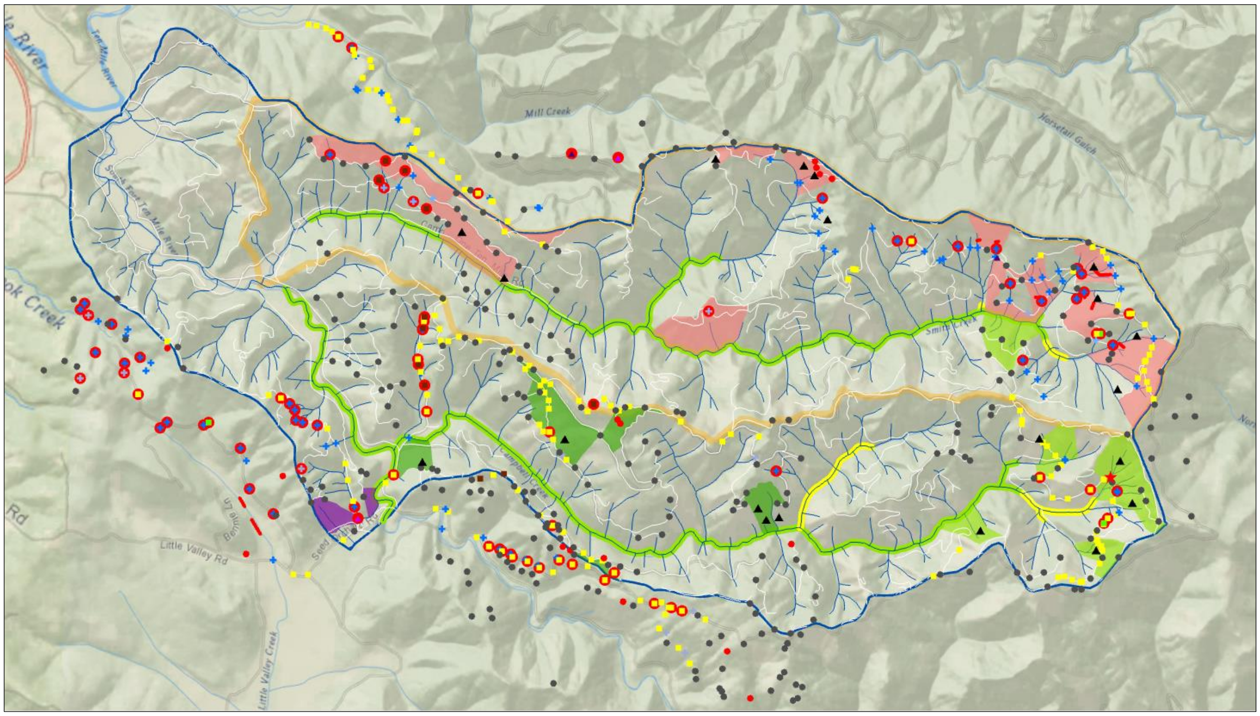


Figure 12. Mapped features gathered from THPs in Campbell Creek; data available at http://campbellcreek-calfire-forestry.opendata.arcgis.com/.

Additional Information

The following information was found in the THPs but was not captured:

- TMDLs were generally referenced in the plans. The TMDL does contain targets: sediment, temperature, LWD, pools etc. THPs contribute to achieving those targets, but how much depends on THP size, location, current conditions, silviculture, number of crossings, number of watercourses, geology, time etc. The Ten Mile TMDL was established in 2000, so its instream data are dated. There is some information on Smith Creek but little of it is spatially explicit.

- 2012 CDFW Stream Survey on Smith Creek includes: reach lengths, tables, graphs, pie charts, lengthy narratives.

Deeper Analysis of Plan Contents

Deriving spatial information from a THP requires the information to either have explicit coordinates or be mapped within the plan. The notion persisted among the SOW Team and the PPIIT that the THP must contain information that was not contained in maps, was relevant to restoration, and eluding the non-Foresters engaged in the data mining exercises, and that a deeper examination with the expertise of a Registered Professional Forester (RPF) was required.

A systematic, supplementary review process of newer THPs within Campbell Creek was undertaken by an experienced RPF[13], beginning with a focus on Section IV (the cumulative impact analysis); the thought was that the most recent THPs might yield information useful in guiding restoration. The aim was to categorize the

[13] Ruth Norman, RPF #2474

information, describe analytical methods, detail whether the information is qualitative or quantitative, and whether the information is spatial. (See Appendix 2 for overview, see Appendix 3 for workbook)

The exercise disclosed that seven of the eight most recent THPs described more than one planning watershed in the Cumulative Impacts Assessment (THP Section IV). This potentially obscured data specific to the Campbell Creek Planning Watershed. Several of the THPs concluded "… There are no known recent trends which have produced significant cumulative impacts upon biological resources within the assessment areas."

There was a change in formatting of the Cumulative Impacts Assessment between 2010 and 2013. More information is provided in the newer plans. However, other information was moved from the Cumulative Impacts Assessment to other parts of the plan. For example, descriptions of historic land-use were moved to the Erosion Control Plan in Section V in THPs from 2013 forward. There were also periodic changes to plan formatting, either because of rule/regulation/direction changes or because of plan submitter preferences, which means extracting information from THPs, even in the same watershed with the same landowner, cannot necessarily be standardized.

There are two Nonindustrial Timber Management Plans[14] in Campbell Creek submitted in 1994 and 1996. They contained little quantitative information. However, of note was restoration work conducted by The Nature Conservancy and occurring on 1-94NTMP-002 MEN in 2018 as documented in a recent Notice of Timber Operations (NTO). However, The Nature Conservancy's permits associated with the in-stream restoration work are not part of the NTMP or NTO. Disclosure of the project indicates that The Nature Conservancy has the data necessary to inform a restoration project on the South Fork of Ten Mile River within the Campbell Creek Planning Watershed. For NTMPs, the original document may be old and of little use, but there is the possibility that recent NTOs, as in this case, or plan amendments could contain information of interest. Older THPs (mid-1980s) were also evaluated (see Appendices 13 and 14). Like the Nonindustrial Timber Management Plans, data provided was limited and has become outdated by the passage of 30+ years.

Further examination of the 2007-2015 THPs found the most detailed information associated with the pilot project's objectives appears to be stream surveys, specifically, as incorporated from the 2012 California Department of Fish and Wildlife Stream Inventory Reports for the South Fork Ten Mile River, for Campbell Creek and for Smith Creek (Draft). These reports were relied upon in the preparation of THPs through:

- Incorporation by reference with data summarized in the Aquatic Habitat Assessment in Section V of the THP
- Inclusion of the complete CDFW Stream Inventory Reports (South Fork Ten Mile River and Campbell Creek) as Addendums 1 and 2 of the Aquatic Habitat Assessment in THP 1-14-126 MEN in Section V of the THP
- Inclusion of the complete CDFW Draft Stream Inventory Report for Smith Creek as an addendum to the Aquatic Habitat Assessment in Section V of THP 1-13-031 MEN.

[14] 1-94NTMP-002, 1-96NTMP-008

Where the CDFW Stream Inventory Reports presented gaps, only short (approximately 600, 1,000, 1,500 or 2,000 feet) stretches of watercourses were independently surveyed by the plan submitter. In the discussion of the survey methods in those harvest plans it is stated that the intent was to survey at least 30% of the of the Class I stream habitat adjacent to the plan, not the full length of these stream segments. These stream surveys were identified as “Level II” surveys. The level of stream survey conducted by the CDFW (“Level IV” surveys) was more thorough and generally included the entire length of a major drainage, as opposed to the partial survey on the plan submitter’s property as described above. Where a wider view (scale at the drainage level) is discussed in the most recent harvest plans (2013-2015), the 2012 CDFW reports found in THPs 1-14-126 MEN and 1-13-031 MEN are cited. The summary of CDFW Stream Inventory Reports found in THPs/NTMPs may be too general (providing only averages for entire drainages) for the purposes of guiding restoration work, and supplemental data gathered by the plan submitter is focused on too small an area to help form a picture at the watershed scale (see Appendices 4 and 12). A fisheries or watershed restoration specialist might determine the usefulness of the contents of the Aquatic Habitat Assessment found in the 2007-2015 THPs and whether the CDFW Stream Inventory Reports are superior and should be accessed directly.

Some outcomes of timber harvesting and subsequent actions are simply not knowable at the time of THP/NTMP submission and approval. How many, if any, seedlings will need to be planted and/or whether herbicides will need to be used, as examples, depend on conditions following the harvest operations. There may be adequate natural seedlings post-harvest and competing vegetation may not pose an impediment to seedling growth, eliminating the need for planting or herbicide use. Within five years of the completion of harvest operations stocking reports are required to be filed certifying that adequate numbers of healthy trees (planted and/or natural) are in place and free to grow, to meet the requirements of the Forest Practice Rules. For herbicide use, there is no THP/NTMP related post-harvest paperwork. However, reports of past herbicide use can be generated from a California Department of Pesticide Regulation (www.cdpr.ca.gov) database. The database includes industrial uses of herbicide on non-timberland as well as timberlands (see Appendix 6).

A summary of maps, data bases, literature and other sources used by THP and NTMP preparers was mined from several harvest documents. Some of these sources may speak to the larger pilot project objectives but they were not further researched regarding answering the Critical Questions from the perspective of THP/NTMP mining. (See Appendix 5) This is something that could be examined in greater detail.

Findings

THPs contain more qualitative data than quantitative data.

THP narratives typically describe ecological conditions for geographic areas larger than the planning watershed scale. The Aquatic Habitat Assessments in Section V of the THPs from the past eleven years vary (see Appendix 4) —addressing stream segments within the Campbell Creek Planning Watershed, only discussing stream segments outside of the watershed, or a combination of both. It was beyond the scope of this project to assess if this information can be scaled up or down.

Timber harvesting activities in this area occurred over multiple decades. The THPs for these activities were written by different RPFs. Qualitative components in each THP vary in content and style. They reflect each RPF’s unique skill set and expertise level, and likely contain elements where best professional judgment was used. While valuable information is contained in these narratives, there is no agreed-upon protocol to compare them.

Even when the time was spent to delve deeply into each plan and with all THPs under one ownership, specifically locating like data across plans was an effort. One THP may reference a report in a different THP (for example THP 1-15-107 MEN references “South Fork Ten Mile River and Campbell Creek Aquatic Habitat Assessment” found in THP 1-14-126 MEN) making the “mining” of one THP into the “mining” of two.

THPs and NTMPs are a permit to harvest timber; they function in part as a sort of contract for the Licensed Timber Operator (spelling out the operational requirements of the harvest), they are not organized to provide “data” in a format that allows for easy collation, even when there was data that may have addressed the pilot project objectives and/or Critical Questions. THPs/NTMPs must be submitted on standardized forms. These forms do not require that information specific to identification of restoration opportunities be in any one specific place in the plan, or in most cases in any particular format (narrative, table, graph, map). Lack of clear criteria for what constitutes a restoration opportunity for this pilot project also made identifying where such information might be found in a THP or NTMP difficult.

It was the opinion of some PPIIT members that Section 14 CCR § 916.4(a)(2) of the Forest Practice Rules (FPRs), which states that “The opportunity for habitat restoration shall be described within the plan for each Class I watercourse, and for each Class II watercourse that can be feasibly restored to a Class I”, appears to not have been fully implemented in the THPs examined. If timber harvesting activities included a requirement to assess existing large wood volumes using standardized, agreed-upon methods and protocols, analyzed data and findings could be compared to recovery targets identified in state and federal recovery plans. An RPF could then identify specific restoration opportunities for the Class I or restorable Class II adjacent to their timber operations. (See Appendix 7 for thorough discussion of 14 CCR § 916.4(a))

THP mining is time-consuming, and the information contained in them can be outdated and inaccurate. Some THPs contain over 800 pages and reference over 50 sources for just the Cumulative Impacts Assessment portion. Some references are several decades old and on-site conditions have likely changed, perhaps considerably. A watershed resource specialist or fisheries biologist might better evaluate the value of older information and data.

Deriving GIS data from hardcopy documents is tedious and time consuming; without a firm concept and agreed upon methodology to describe and assess conditions in a planning watershed there was no targeted outcome. Stronger identification of what resource elements in a harvesting plan are of value and to what type of analytical scenario, would allow for more strategic data capture.

Some members of the PPWG suggested a process referred to as mixed method analysis, which synthesizes qualitative and quantitative methods of research and analyses. This approach might be well-suited to natural resource management, but was beyond the scope of the pilot project.

THPs and NTMPs contain passive restorative elements, such as the Core Zone for Class I WLPZs, but do not contain the information needed to directly target restoration at the planning watershed scale or systematically identify site-specific restoration needs and opportunities.

3.3.2 Track 2: Rapid Assessment with Imagery Analysis

The second track assessment methods were to determine if the riparian stand composition indicates a current and continued supply of functional large wood[15] for anadromous salmonids utilizing this watershed.[16] The work was done in three phases: (1) air photo and Google Earth imagery for a small Class I watercourse subsection of the Smith Creek watershed, (2) Google Earth imagery and LEMMA[17] data analysis for the entire Class I portion of the Smith Creek watershed, and (3) LiDAR analysis for the entire Class I portion of Smith Creek.

The main goals and objectives for this rapid assessment were to:

- Rapidly determine the species, size, and density of riparian trees in Class I watercourses located in the Smith Creek watershed
- Determine if Google Earth imagery offers a reasonable rapid check for LEMMA riparian stand data
- Determine how well LiDAR data compare to Google Earth imagery and LEMMA riparian stand data
- Determine if these rapid imagery assessment approaches are helpful for assessing where the potential for large wood recruitment from the riparian zone is adequate, and where large wood enhancement projects may be appropriate (given additional field information is obtained).

Methods

NAIP Imagery and Google Earth

The primary rapid assessment data sources for the small Class I watercourse subsection of the Smith Creek watershed (Figures 12 and 13) were 2014 Google Earth imagery and 2014 NAIP[18] photos. Slightly more than a mile of Smith Creek and approximately a half mile of the unnamed tributary draining into it were assessed. An office stereoscope was used to view pairs of 2010 Lyme Redwood Forest Company air photos, while Google Earth imagery was used online.

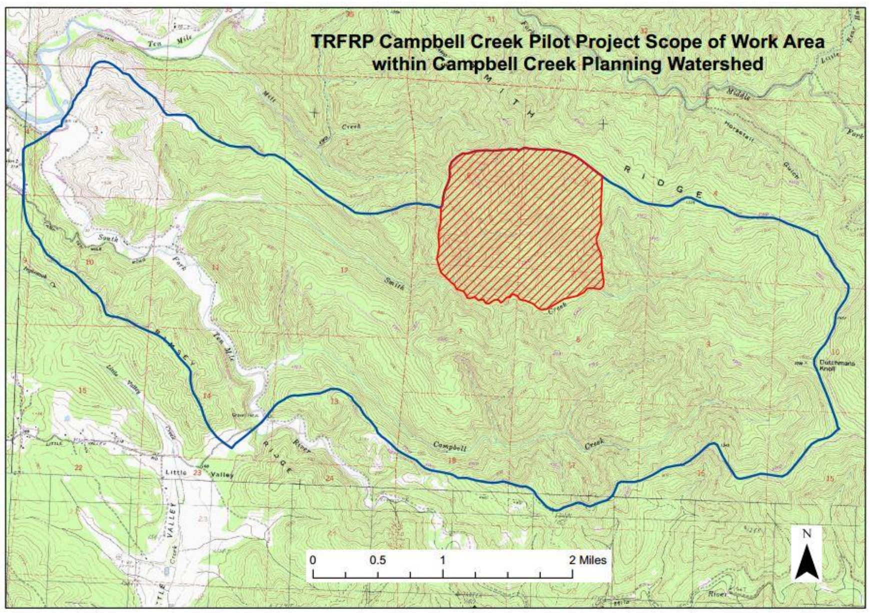


Figure 12. Sub-watershed of the Smith Creek basin used for the initial assessment.

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[15] "Supply of functional large wood" refers to standing trees of suitable size, species, and stream proximity such that, if they were delivered to the stream channel through natural process (e.g., streambank collapse, windfall, or decay) or through intentional felling they would provide desirable in-stream habitat (such as pools and cover) for salmonids.

[16] Geomorphic analyses using rapid aerial imagery assessment is covered in *Section III-IV: Beyond the Three Track: Additional Inquiry, Geology-Focused Assessment of Erosion Risk and Sediment Sources* of this report.

[17] LEMMA is an abbreviation for Landscape Ecology, Modeling, Mapping and Analysis; LEMMA data have over 150 different attributes available for querying (see: https://lemma.forestry.oregonstate.edu/).

[18] National Agriculture Imagery Program, images downloaded from https://earthexplorer.usgs.gov

The methodology was patterned after the large wood recruitment component of the Washington Watershed Analysis Riparian Function Module (WFPB 2011). This approach involves using aerial imagery to determine the dominant vegetation along both sides of Class I fish-bearing channels in terms of type (conifer, hardwood, or mixture), size (large, moderate, or small), and density (dense or sparse). Recruitment potential was based on mortality, not bank erosion or landslide input, even though these recruitment processes are known to be important in this watershed (Benda 2011).

Codes used to classify riparian vegetation for identified segments were as follows:

CLD	**C**onifer (>70%), **L**arge DBH (>20"), **D**ense (>33% cover)
CMD	**C**onifer (>70%), **M**edium DBH (12-20"), **D**ense (>33% cover)
MLD	**M**ixed Hardwood/Conifer, **L**arge DBH (>20"), **D**ense (>33% cover)
MMD	**M**ixed Hardwood/Conifer, **M**edium DBH (12-20"), **D**ense (>33% cover)
HMD	**H**ardwood (>70%), **M**edium DBH (12-20"), **D**ense (>33% cover)

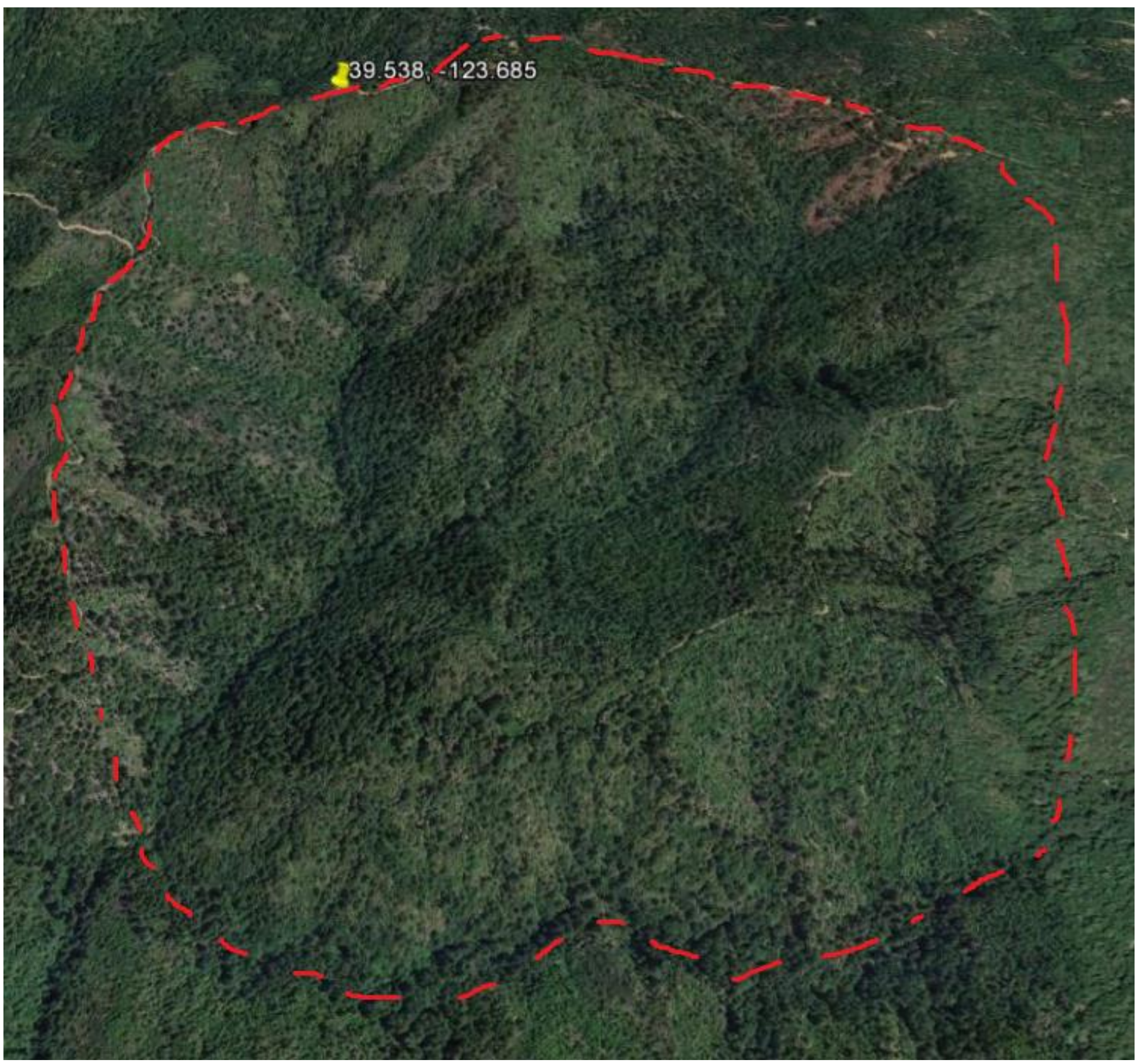


Figure 13. Google Earth image of the Smith Creek sub-watershed

LEMMA Vegetation Data

The initial analysis was expanded beyond the sub-watershed into the Smith Creek watershed, comprising most of the northern half of the Campbell Creek Planning Watershed. Availability of 2010 air photos was not adequate, so the aerial imagery assessment of riparian vegetation relied on Google Earth 2014 and NAIP 2016 photos. Approximately five miles of Smith Creek and approximately a half mile of the unnamed tributary draining into it were assessed as Class I watercourses (Figure 14).

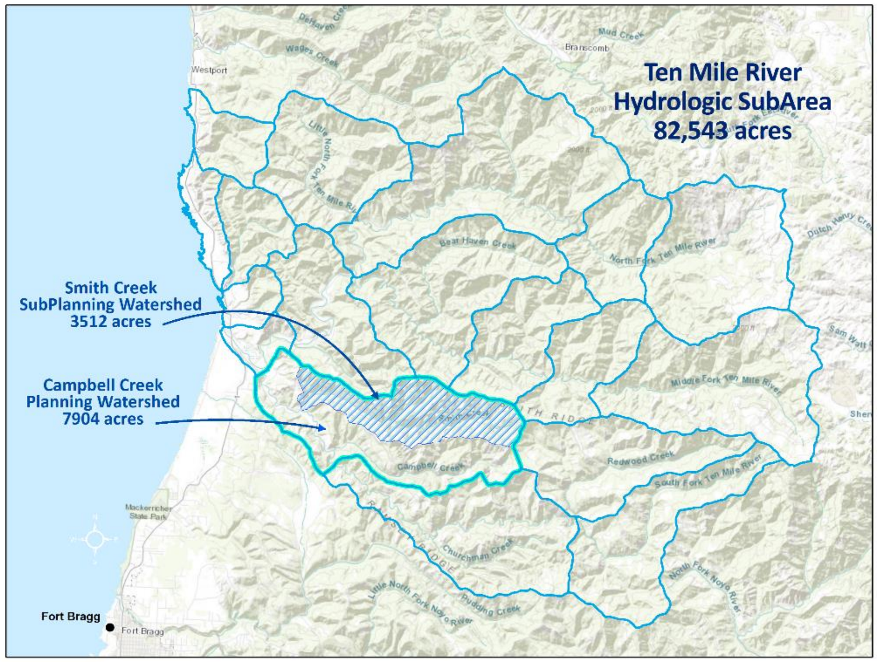


Figure 14. Smith Creek sub-watershed assessed in second phase.

Similar methods were used for the larger extent as with the initial sub-watershed, except that air photo analysis with an office stereoscope was not utilized [i.e., Washington Watershed Analysis Riparian Function Module (WFPB 2011)]. Google Earth imagery results were compared to LEMMA riparian stand data to determine if LEMMA data offer a reasonable characterization of riparian stand data.

LiDAR

In 2018, LiDAR data became available for the Campbell Creek Planning Watershed as part of a state-funded effort to provide LiDAR covering approximately 1200 square miles in Mendocino County. Analysis of these data has revealed that LiDAR holds promise for providing several types of quantitative information for assessing current riparian conditions (and by extension, function). A key advantage of the LiDAR data is that it is objective, repeatable, and can serve as the basis of a long-term monitoring process. Riparian (and upland) canopy cover data are continuous and can be summarized at whatever reporting spatial unit(s) are desired. Additionally, riparian canopy height estimates are largely continuous at high spatial resolution and can be used in relation to the distance from the channel for a repeatable metric of large wood recruitment potential. A downside of LiDAR, however, is its high cost. The TRFR Program's Mendocino County LiDAR acquisition cost was $656,000 for approximately 786,000 acres (including the cost share from the U.S. Geological Survey), or about $0.84/acre.

As stated above, several tree and vegetation parameters are required for the Washington Forest Practices Board (WFPB) manual (2011) riparian condition methods. The three parameters used for this work were dominant vegetation type (conifer, hardwood, or mixed), average tree size class (small, medium, large), and stand density class (sparse or dense). Reasonable and spatially precise estimates of all three of these parameters can be obtained from the LiDAR data collected. Thresholding of the intensity image data was used to determine the dominant vegetation type[19] (hardwood, conifer or other); thresholding of the LiDAR first return minus bare earth for canopy height to estimate dense versus sparse vegetation; and best-fit functions to estimate average tree diameter at breast height (DBH) from tree (canopy) height (by dominant species) for tree size class estimation.

In the redwood region, dominant hardwood tree species often found in riparian areas include red alder, willow, and bigleaf maple (Welsh et al. 2000, Bolsinger 1988). Redwood and Douglas-fir also occur as dominants in this zone. Given the apparent marked difference in the LiDAR intensity images between hardwood and conifer dominated riparian areas, for this study simple empirical thresholding was used to create a binary image of riparian hardwood-dominated pixels (values < 60) and two other vegetation types—open non-forest (intensity >= 60 and canopy height < 2 feet), and assumed conifer-dominated (intensity >= 60 and canopy height > 2 feet). This was performed after a 3-by-3-pixel (~1-meter-square) window mean filter was applied to the original data, to smooth some of the high spatial frequency variation. Each riparian segment (created using the Washington Manual methods above) was then summarized as to the percentage area of riparian hardwood, conifer, or other that occurred within it (Figure 15).

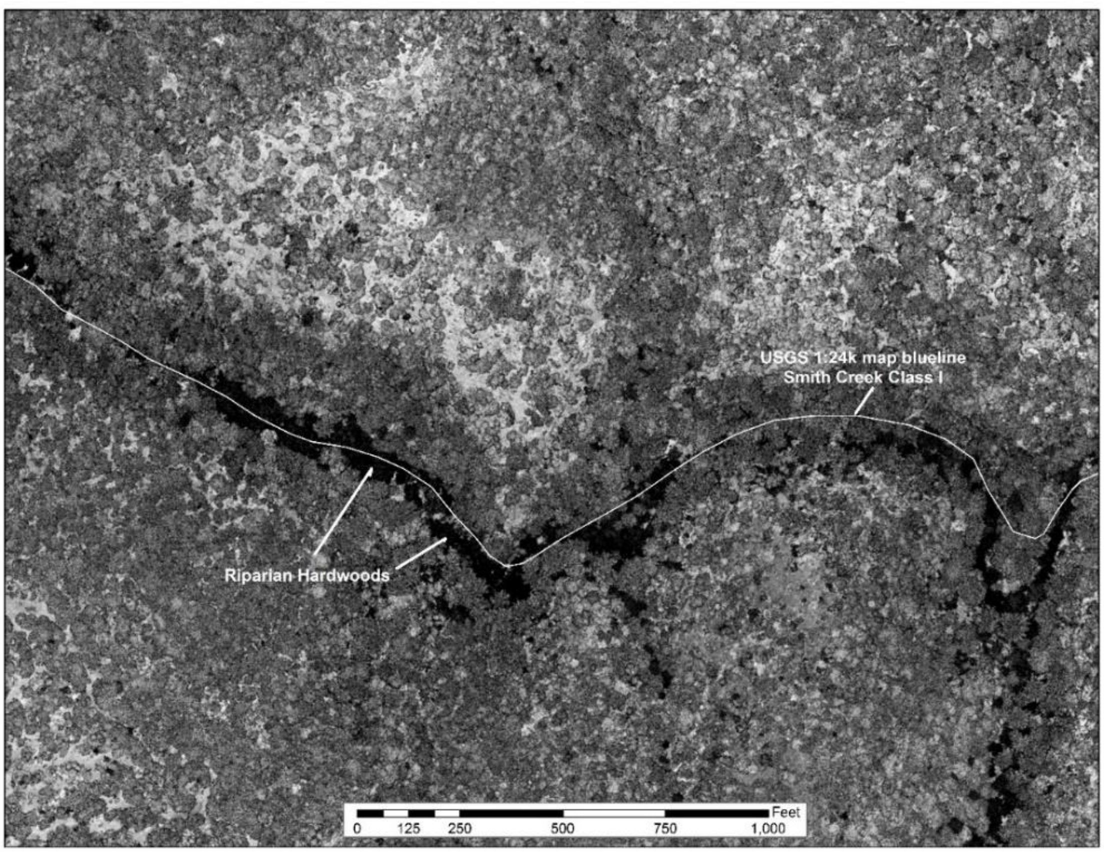


Figure 15. LiDAR intensity data, smoothed by a 3-pixel-by-3-pixel mean filter, Smith Creek. Areas along the creek that are highly absorptive (dark in image) of the 1064 nm laser light are most likely vegetation with high leaf water content (Carter 1991), often hardwood dominant tree species such as red alder (*Alnus rubra*). These data were used to separate canopy dominated by hardwoods from other cover types for parameter Dominant Vegetation Type.

[19] Thresholding is a term used to describe a value above which the data is either selected, and/or lumped into a different category.

The density parameter was determined by using thresholds of LiDAR-estimated vegetation height, canopy of > 2 feet, as estimated using the difference between the first return and bare earth return, was set to dense, and lesser values were set to sparse (Figures 16, 17).

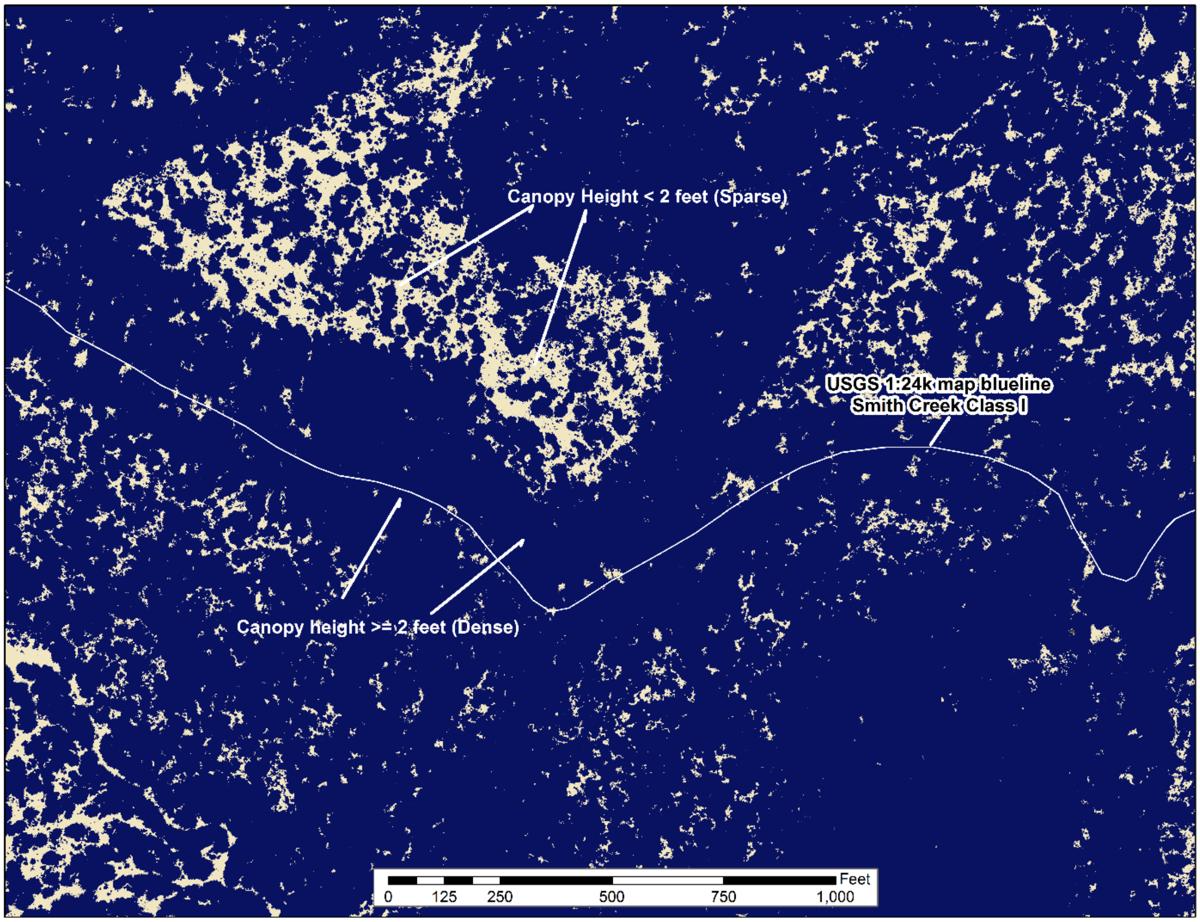


Figure 16. LiDAR first return minus bare earth (canopy height) data, Smith Creek (same area as Figure 15). These data were used to separate dense (dark in image) from sparse (light color) vegetation cover, using a canopy height of 2 feet as the threshold.

The Washington method uses the metric average diameter at breast height (DBH) to classify the size of the trees present. Trees of DBH < 12" are considered to be small, trees from 12" to 20" are typed as medium, and above 20" DBH average tree stands are considered as large.

LiDAR does not produce standard data products of tree DBH per se. It is possible, however, to use the height data to infer average tree DBH, depending on the species of tree and the age of the stands. Vuong (2014) showed that LiDAR height estimates can be processed to approximate tree DBH in second growth redwoods and Douglas-fir. In other publications, tables have been produced also showing the relationship between ground-measured DBH and tree height, for example among second-growth redwoods (Bruce 1923), and similar relationships for red alder and bigleaf maple (Snell and Little 1983).

Using the above data, the LiDAR height data for riparian hardwood-dominated areas were transformed into estimated average DBH [i.e., using red alder and bigleaf maple curves (Figure 18)]. Similarly, for conifer-dominated areas height was converted into DBH estimates using data for redwood and Douglas-fir. From the output, and using the hardwood-conifer classified intensity image, the 12" and 20" DBH thresholds were used to classify the riparian trees into small, medium, and large size classes. For example, the 12" DBH second-growth redwood class was estimated to be about 67.9' tall on average, whereas the 20" DBH class was 101.4' tall (based on Eng 2012, Figures 19 and 20).

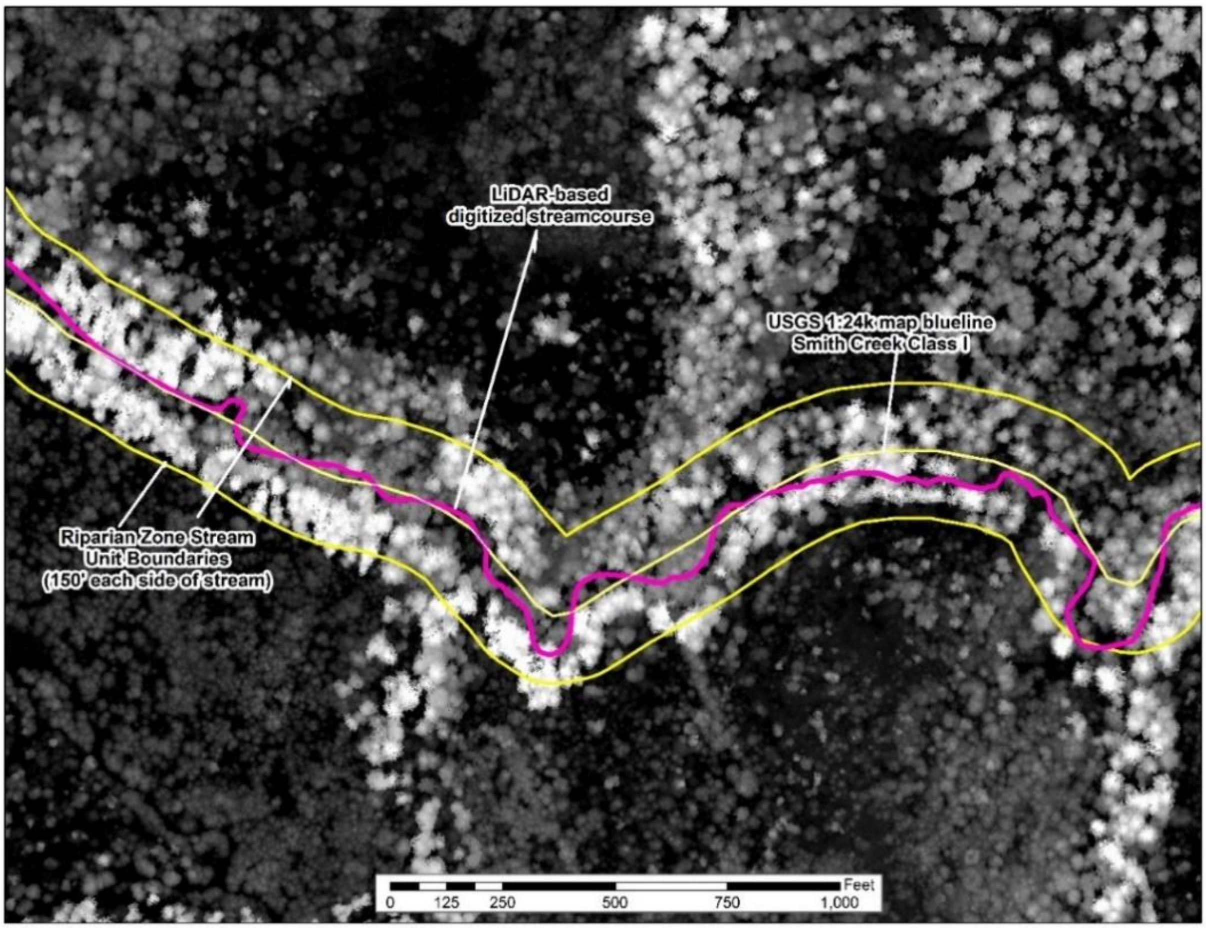


Figure 17. Raw LiDAR canopy height image (first return minus bare earth). Lighter tones are proportional to taller trees. Individual tree crowns and even large limbs are clearly discernable. USGS and LiDAR watercourse locations, and USGS riparian buffers, shown for reference.

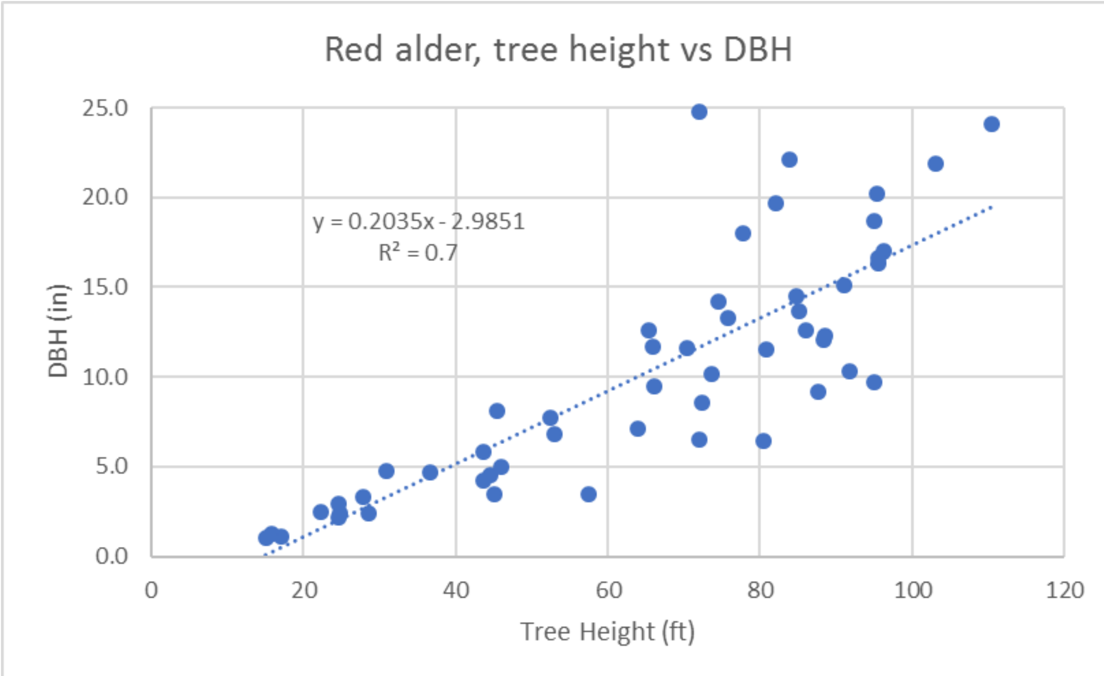


Figure 18. DBH in relation to height of riparian hardwood species red alder. Each point represents an individual tree. A linear regression resulted in an r-squared value of 0.7. The curve was used to determine size class breakpoints for riparian hardwoods (data from Snell and Little, 1983).

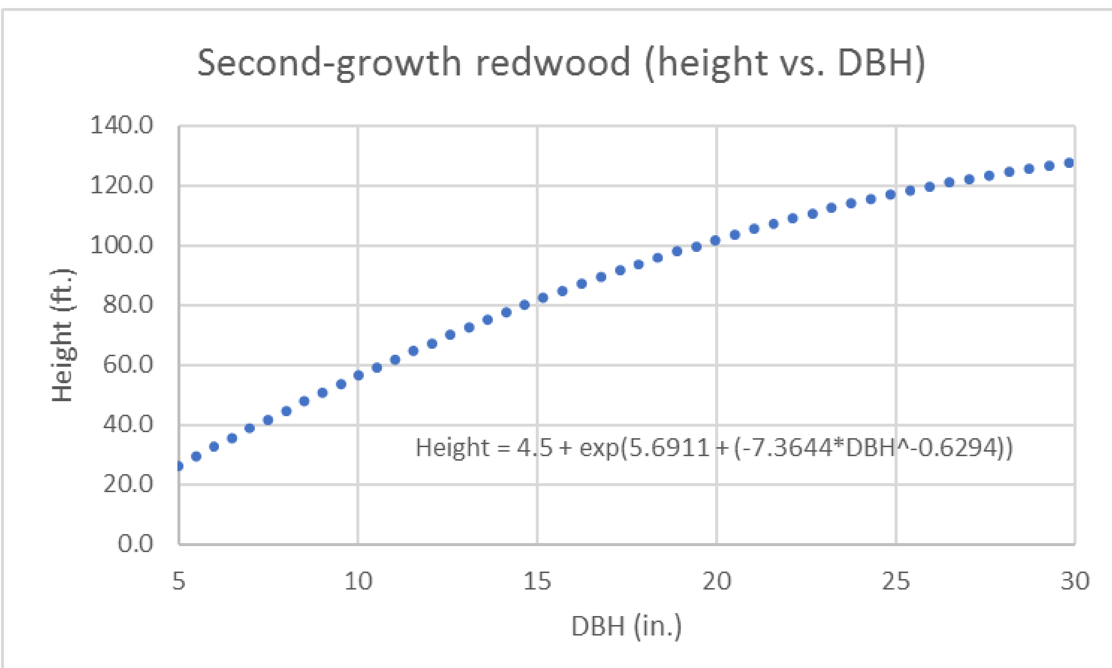


Figure 19. DBH in relation to height of second-growth redwoods. Graph shows best-fit of equation 1 from Eng (2012), which used 2,235 redwood trees in western Mendocino County, and had an r-squared value of 0.969. This equation was used to determine breakpoints using LiDAR height data for 12” DBH and 20” DBH size classes, used for conifer size class assignment.

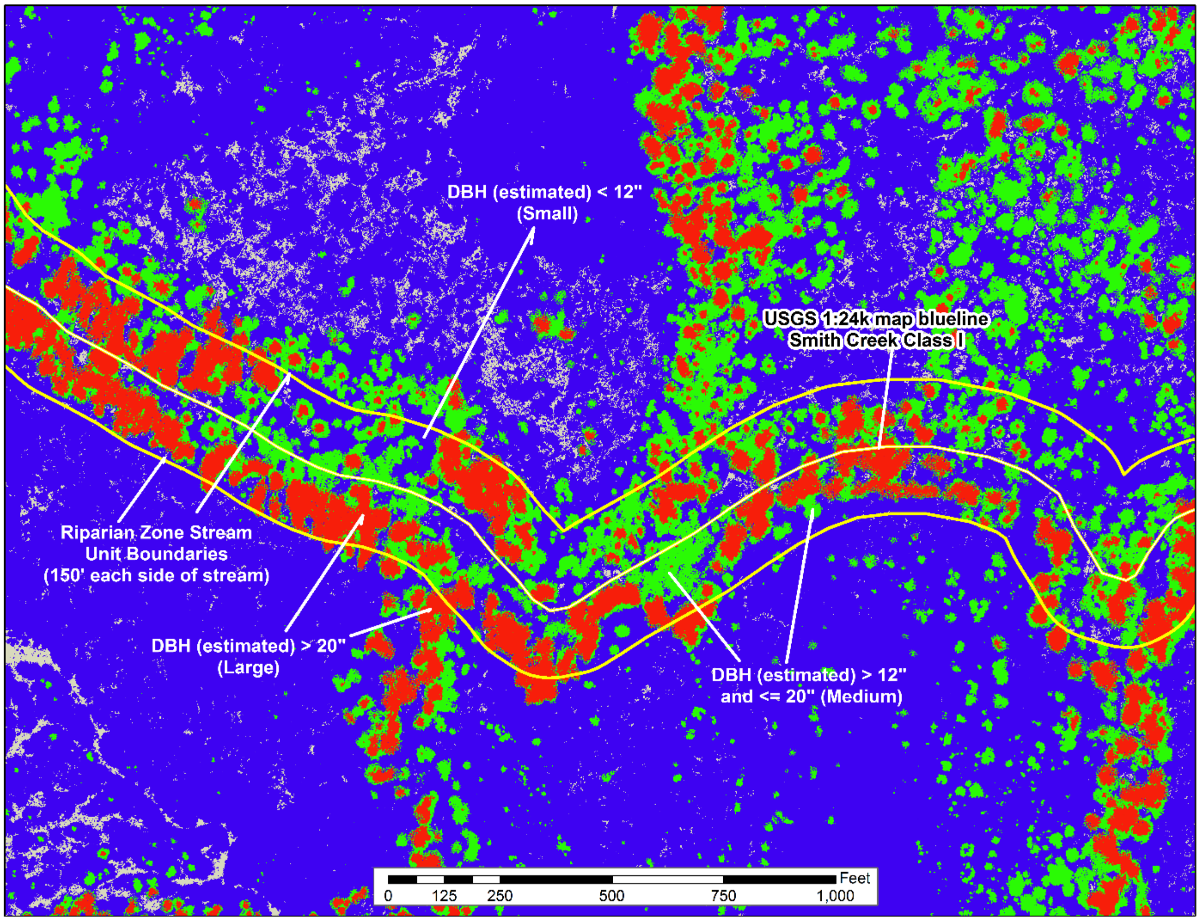


Figure 20. Size Class derived from canopy height data—example area of Smith Creek Class I. Size classes of trees are shown as follows: Large (red) -- > 20" DBH, Medium (green) -- > 12" and <= 20" DBH, and Small (blue) --> trees of less than 12" DBH. DBH was estimated for hardwood and conifer areas using the curves from red alder and redwood, respectively. The 150-foot buffer on each side of the USGS stream vector (assumed center of watercourse) is also shown.

Field verification work took place in lower Smith Creek and Campbell Creek watersheds on October 10, 2018 (Figure 21). The main objectives of the field survey were to:

1) Collect a set of tree height measurements with which to compare to the same trees in LiDAR canopy height data (DSM – DTM);
2) Compare tree information on the ground with an experimental point GIS layer of apparent tree locations (and their LiDAR maximum heights);
3) Collect the DBH of those same trees to compare to modeled DBHs derived from tree height using data from the literature (Eng 2012, Snell and Little 1983); and
4) Obtain a sense of the main physiological driver(s) of the areas of vegetation in the LiDAR that have significantly darker reflectance than average, in the 1064 nm laser intensity data product.

Preparations were made for informed field-based data collection by processing data derived from LiDAR, creating custom field survey forms, and loading them for field use in mobile GIS application software. The applications employed for navigation/data querying were Avenza, and Explorer for ArcGIS. Tree measurements were collected using the Survey123 for ArcGIS field app. Tree locations were collected using a sub-meter GPS unit.

Data prepared and taken into the field included:

- LiDAR intensity (single-wavelength laser reflectance) images
- Points defining the tops of trees and their maximum heights, as derived from LiDAR
- LiDAR hillshaded bare earth images for terrain viewing
- NAIP imagery (high resolution color aerial photography) from 2016
- Forms custom made to enter data on the tablet.

The field apps allowed for GIS data querying and the real-time GPS ground location shown on whichever GIS base layer had been selected for display. The latter assisted the interpretation of the local surroundings in terms of visible tree crowns, local trees and species, and LiDAR reflectance data.

Figure 21. Field team in the Smith Creek planning watershed on October 10, 2018 comparing measured tree heights to LiDAR derived tree heights.

Field personnel assumed the tasks of taking accurate GPS location readings, locating trees in GIS data, and tree measurement recording on pre-loaded GIS data mobile applications, DBH measurements, species identification, and tree height measurements using laser rangefinders.[20] Nineteen (19) trees were selected non-randomly that offered clear view to their tops, and crews worked to include a variety of hardwood and conifer species, as well as tree sizes. One tree of the 19 could not be confidently located in the LiDAR data.

[20] Field checks for tree heights were made with a logger’s tape and clinometer.

FINDINGS

Rapid Assessment, Google Earth, LEMMA

In total, it was estimated that there were approximately 6000 feet of MLD (mix of conifer and hardwood, large size, dense stand), 6000 feet of MMD (mix of conifer and hardwood, moderate size, dense stand), 4000 feet of CSD (conifer, small size, dense stand), and 4000 feet of CLD (conifer, large size, dense stand) (Figure 22).

The Washington watershed analysis method presumes that conifer mortality rates are much higher for Douglas-fir than for coast redwood (M. Liquori, Sound Watershed, personal communication).[21] Therefore, these categories were modified so that large and moderate tree sizes went from high to moderate large wood recruitment potential. With this modification, the majority of this Class I watercourse reach was assigned an estimated moderate large wood recruitment potential, with a smaller component having a low potential.

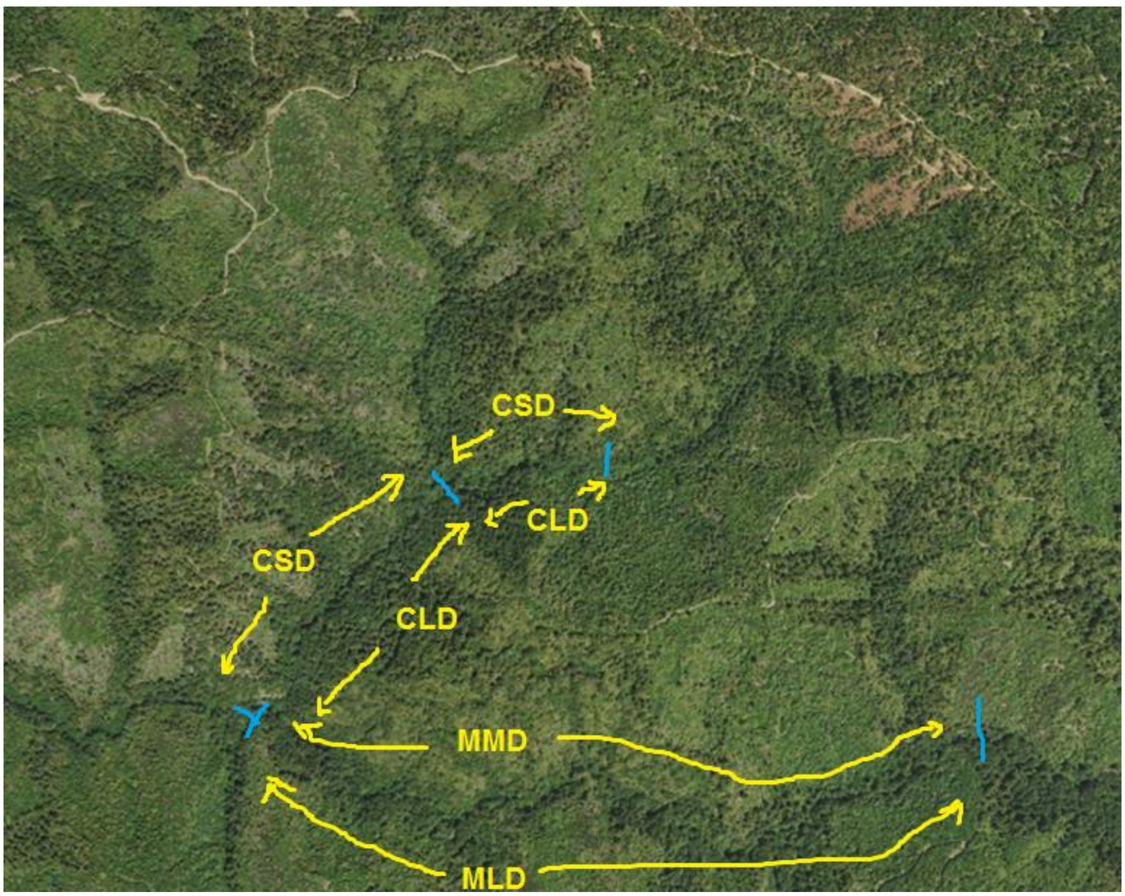


Figure 22. Riparian tree size, species, and density classifications made for the Smith Creek sub-watershed.

After expanding the Area of Interest beyond the sub-watershed and into Smith Creek, approximately two-thirds of the classified segment length was found to be mixed (hardwood and conifer), or hardwood

[21] Douglas-fir is the dominant westside conifer species in Washington and is not the dominant species in the Campbell Creek Planning Watershed.

dominated (Figures 23 and 24). This equates to a moderate large wood recruitment potential for these segments, partly due to these WLPZs having been thinned in the past. In general, the lower watershed has a higher hardwood component, particularly on the south facing slopes (Figures 25 and 26). The upper watershed was found to have a greater conifer component compared to the lower basin (Figure 25).

The second phase of the effort was to compare LEMMA data to aerial imagery assessment information obtained with the Google Earth photos. Higher hardwood canopy cover was observed on south facing slopes (Figure 26). Other attributes used for the LEMMA analysis included conifer canopy cover, quadradic mean diameter (QMD) for the dominant and codominant hardwoods, QMD for the dominant and codominant conifers, and hardwood trees per hectare. The LEMMA data for the lower watershed indicated lower conifer QMD, with higher QMD in the upper half of the basin. In general, there seems to be some agreement with the aerial imagery assessment work. However, LEMMA data for the Smith Creek basin, specifically the red alder basal area values (as surrogate for riparian vegetation), may significantly overpredict its presence away from known streams in the watershed. LEMMA hardwood canopy cover percentage also may underestimate the riparian vegetation along the larger mainstems.

Limited ground truthing data were obtained from (1) the CDFW (2012) Smith Creek stream survey, and (2) field observations and photos of the lower Smith Creek channel and riparian zone associated with the Mill-Smith THP large wood enhancement project. For the lower half of Smith Creek, the CDFW survey reported conifer canopy 40%, hardwood canopy 53%, and open 6%.

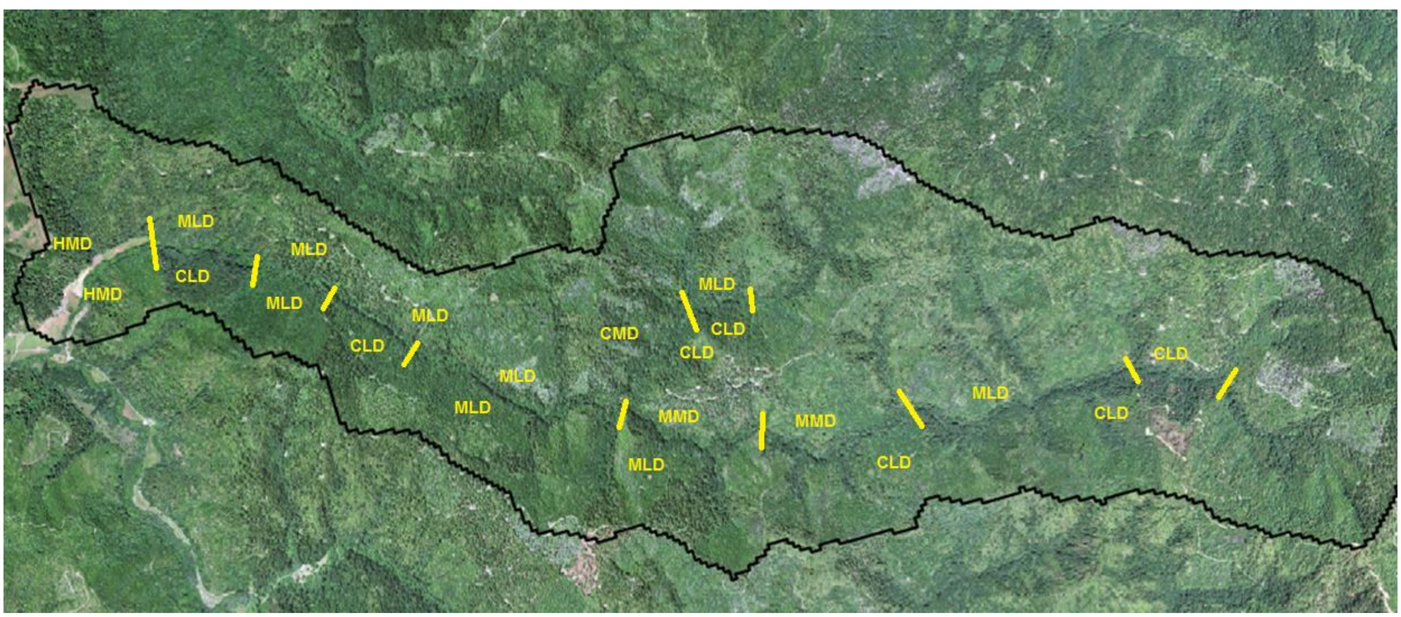


Figure 23. Riparian classifications for the Smith Creek watershed using the WFPB (2011) methodology. Smith Creek Class I watercourses were divided into 22 units, a left and right bank unit per each stream "reach."

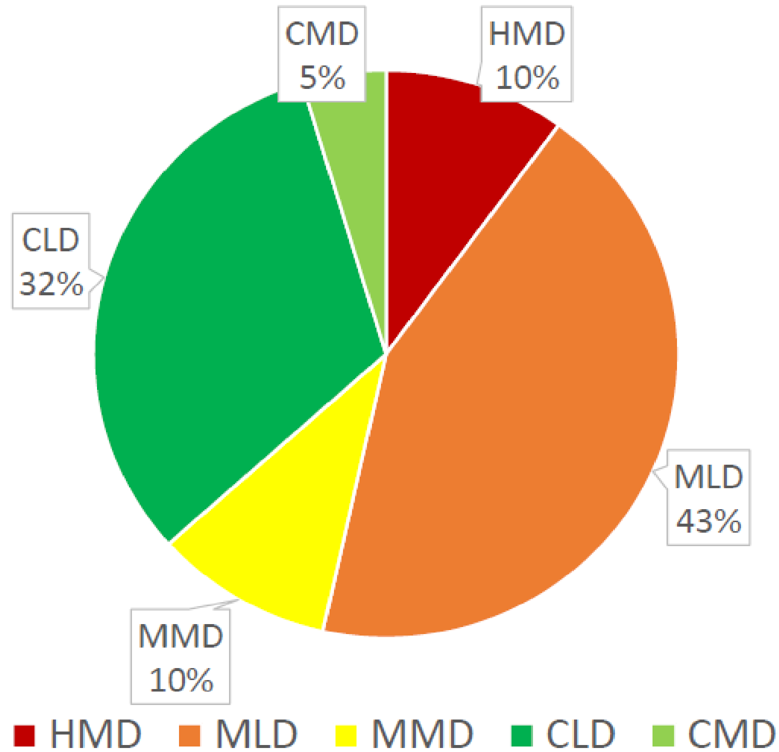


Figure 24. Percentages of the five riparian vegetation classification types in the Smith Creek sub-watershed.

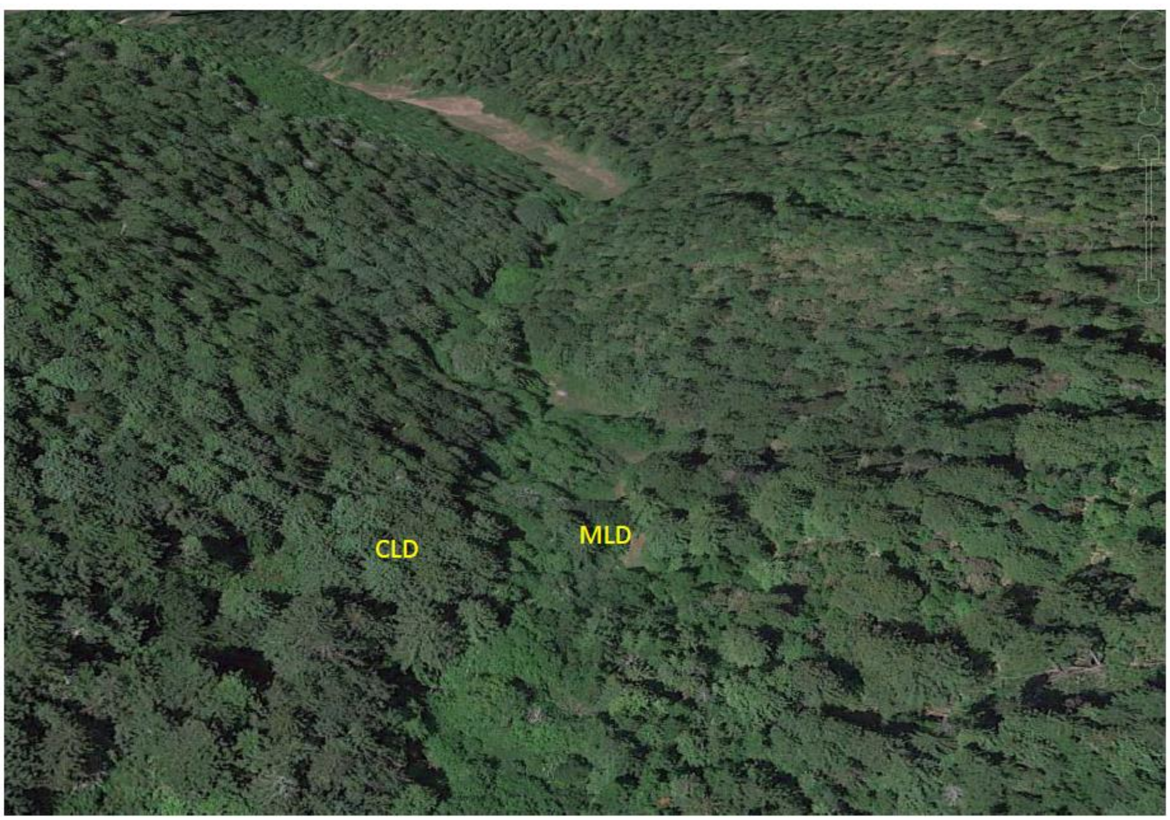


Figure 25. Mixed hardwood/conifer riparian stand on south facing slope (MLD) and larger conifers on north facing slope (CLD) in the lower part of the Smith Creek watershed.

Figure 26. Close-up of Smith Creek riparian stand dominated by larger conifers on north facing slope; hardwoods on south facing slope.

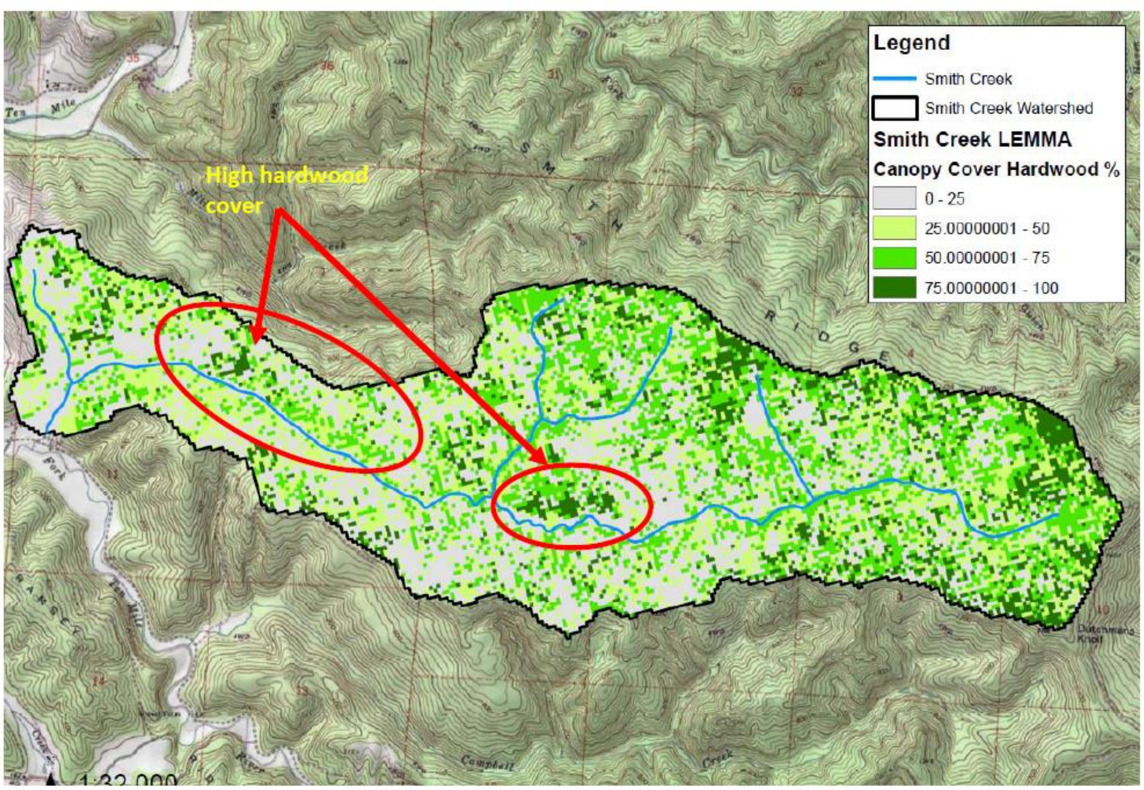


Figure 27. LEMMA hardwood canopy cover for the Smith Creek sub-watershed.

The primary conclusions from the second phase work were as follows:

- There is a moderate large wood recruitment potential for Class I segments in the Smith Creek watershed. This conclusion supports the value of large wood enhancement projects in the appropriate locations for restoration, due to the need for rapid improvement in habitat conditions for the CCC coho salmon ESU.

- Google Earth and NAIP imagery are available to all analysts, they are relatively current, and they are easy to use.

- Google Earth and NAIP imagery provide rapid information on riparian stand conditions that generally are in agreement with LEMMA data.

- Adequate ground truthing, along with LEMMA data, Google Earth and NAIP imagery, and air photo analysis, can provide information on riparian stand conditions. These data can inform project proponents about appropriate locations for large wood enhancement projects (i.e., restoration).

Comparison with LiDAR-Derived Riparian Condition Parameters

The metrics for Smith Creek Class I watercourse riparian zones that were determined using the WFPB methods were compared with analogous LiDAR-derived metrics for the same spatial units. In all, Smith Creek Class I watercourses were divided into 22 units, a left and right bank unit per each stream "reach." The size of the units ranged from 4.1 to 17.6 acres, with the mean size of 9.8 acres. LiDAR metrics at the 1 foot scale (or 1 m (mean of 3 x 3 filter) for dominant vegetation type) were summarized for each of the units. The number of grid cells for each class per unit were computed, and these were then normalized to percentages per unit. In the dominant vegetation type classes, only those cells with either hardwood or conifer were used in the normalization, i.e. bare ground or low vegetation cells were excluded from the cover statistics.

Table 3 compares the results of the two methods for the combined metrics (dominant vegetation type, size class and density class). There was complete agreement between the methods on all assigned density class units (all were "dense", or > 33% vegetation cover). For dominant vegetation type, the agreement was at 55%, and for the size class the methods yielded the same results for 45% of the units.

Density, with only two classes, was never close to the WFPB 33% threshold in the LiDAR data, with the average for the 22 units at above 93%. The main differences between the methods for the dominant vegetation typing were between the mixed hardwood/conifer and the conifer types, with the LiDAR making more calls for conifer than ocular estimates of air photos found to be mixed hardwood/conifer (8 units). For the size class parameter, the two methods were in the least agreement. For 8 out of 22 units, the LiDAR types the size class as small (dominated by trees < 12" DBH), whereas the air photo analysis for the Washington method called them large (> 20" DBH). This is a particularly difficult metric to determine from either method, as DBH is not easily measured or inferred from remotely sensed data. Allometric (a mathematical relationship between two different physical tree characteristics) relationships derived from published tables for redwood and red alder were used for approximating DBH from LiDAR measured canopy height (conifers and hardwoods), but these results may be biased in unknown ways. Field checking should be used to determine the actual average tree diameters and clarify which data source may be the more accurate.

	LiDAR-derived metrics							
WFPB method	HMD	MSD	MMD	MLD	CSD	CMD	CLD	WA totals
HMD	0	1	0	0	0	0	0	**1**
MSD	0	0	0	0	0	0	0	**0**
MMD	0	1	0	0	2	0	0	**3**
MLD	0	3	0	0	4	0	2	**9**
CSD	0	0	0	0	0	0	0	**0**
CMD	0	0	0	0	0	1	0	**1**
CLD	0	0	0	1	1	0	6	**8**
LiDAR totals	**0**	**5**	**0**	**1**	**7**	**1**	**8**	**22**

Table 3. Direct comparison matrix between WFPB method results and LiDAR-derived results for 22 riparian units. Diagonals are those in complete agreement. Three letter abbreviations are for dominant vegetation type (H: Hardwood; M: Mixed hardwood/conifer; C: Conifer), size class (S: Small; M: Medium; L: Large) and density class (D: Dense; S: Sparse). See definitions for breaks in text.

LiDAR reflectance data were found to offer a reasonable approximation of where broadleaf, conifer, and grassland/shrub vegetation exist on the ground. Adequate results were obtained for the study area without knowing the exact species present (e.g., redwood vs. Douglas-fir). This indicates that LiDAR reflectance data in combination with canopy height can provide good information about large wood recruitment potential along fish-bearing streams, likely better than ocular analyses of air photos. Even with LiDAR data, however, Google Earth imagery and ground truthing should be used as verification, confirming that the results are reasonable.

The field verification work that took place on October 10, 2018 revealed that the ground-based observations of tree heights concurred closely with those obtained with LiDAR. For the most part the trees examined were either of dominant or co-dominant crown class. Anecdotally, most of the trees measured appeared as distinct points in the GIS layers, and the height attribute of these points were used to assign their "LiDAR height." Figure 28 shows the relationship between the tree heights as observed from the ground versus the LiDAR for the same tree. The linear regression resulted in an r^2 value of 0.94,[22] but significance cannot be inferred, given that criteria for statistical rigor were not met. The results are encouraging, as the LiDAR height data in the limited areas studied matched ground observations well (Figure 29). This approach appears to have merit, and with further development could serve for analysis in a larger and more thorough study.

[22] Standard error of prediction equals 7 feet.

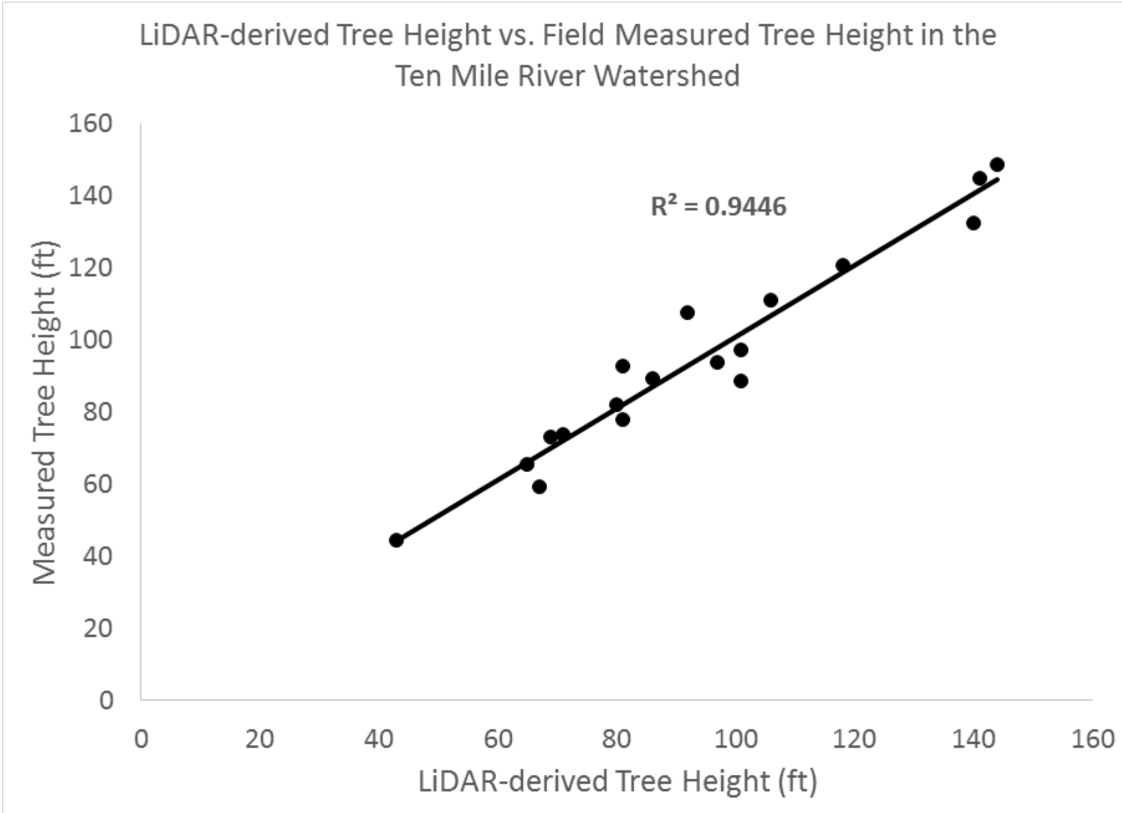


Figure 28. Relationship between tree heights measured on the ground versus LiDAR-derived tree heights.

Regression curves fitting tree height to their DBH measurements were used to approximate DBH for trees. For conifers, equations for second-growth redwood data from Jackson State Demonstration Forest were taken from Eng (2012). For hardwoods, data published by Snell and Little (1983) for red alder were used to regress DBH from hardwood heights. Thus, second-growth redwood characteristics were used as a proxy for all conifers, and red alder was used as a proxy for hardwood growth. The models used for deriving tree DBHs from their heights did not match the measured DBHs for the few trees sampled, conifer or hardwood. In general, modeled values of DBH were much lower than those measured in the field. On average the redwoods were about 15.9” larger DBH than the model predicted, and the non-redwoods were approximately 6.4” larger DBH. Several trees had unusual growth forms.

Preliminary observations suggest that the extent of hardwood cover in the riparian function units spatially defined for Smith Creek was larger than that determined by the LiDAR method that attempted to isolate hardwoods. This is due to that fact that hardwood species other than red alder and willow could also be present in these areas – and these trees would not have shown up as “dark” in the intensity image (used to distinguish hardwoods). A preliminary conclusion is that some property unique to alder and willow (and perhaps other species in the poplar or willow plant families) makes them very absorptive of the 1064 nm laser light and appear dark.

LiDAR offers data of high quality for forestry and watershed analyses for numerous applications. While not perfect, the high spatial resolution, wall-to-wall coverage, and locational precision achievable with the pointable laser are likely to allow for analyses not possible from other sensors or ground-based equipment.

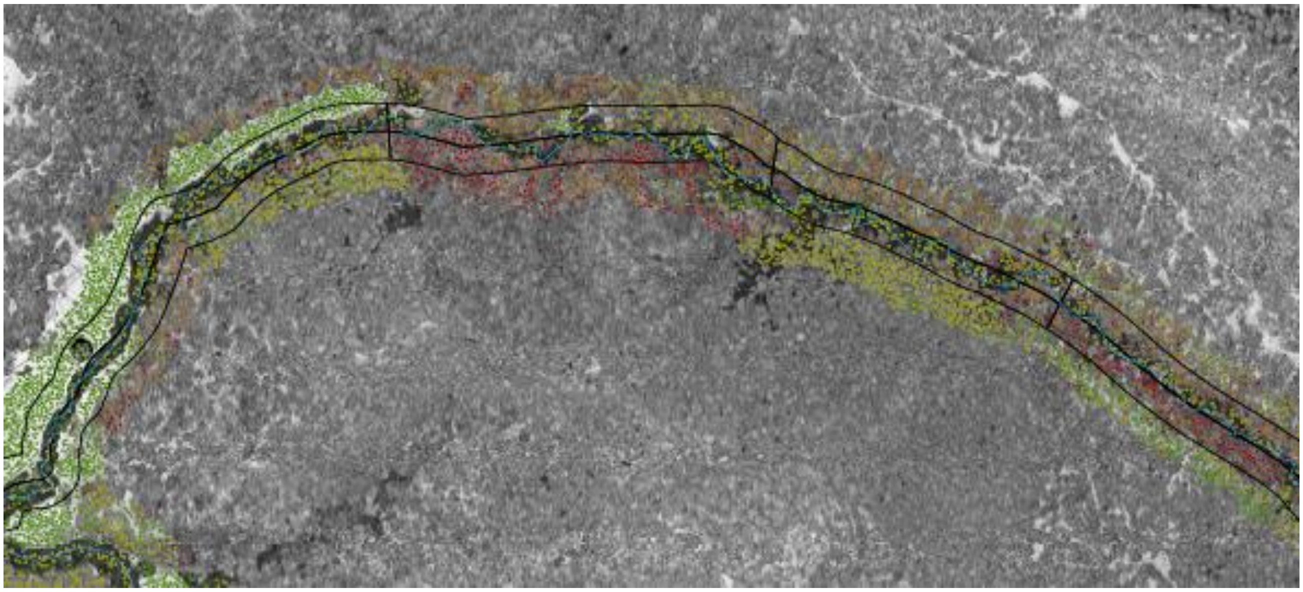


Figure 29. LiDAR-derived tree heights for the lower Smith Creek riparian zone (300 feet on each side of the channel). Green dots are vegetation <50 ft tall; yellow are trees 50 to 100 ft, orange 100-150 ft, and red are >150 ft in height. Segment breaks correspond to breaks shown in Figure 23.

While air photo and LiDAR data provide important information for screening potential restoration sites, adequate field information is critical for determining the most appropriate site-specific locations for large wood projects. Two prominent fisheries scientists with considerable local experience in the Campbell Creek planning watershed were queried to determine the key field data necessary to locate large wood enhancement sites. This type of information is necessary to complement remotely sensed data obtained at the watershed or sub-watershed scale.

Mr. David Wright, currently with The Nature Conservancy, worked as a fisheries biologist for Campbell Timberland Management for many years and provided considerable input in their THPs regarding fisheries conditions and the need for restoration through accelerated large wood input. Wright (2018) documented the process used to select the Mill-Smith THP (01-13-031 MEN) large wood enhancement site located on lower Smith Creek (Figure 30). This was the first large wood project conducted as part of a THP using Section V, site-specific riparian management component of the 2010 Anadromous Salmonid Protection Rules, and illustrates that this type of work can be completed as part of a plan. Key determinations included (1) identifying coho salmon as the target species and documenting their presence; (2) locating a reach with suitable stream gradient and width; (3) documenting with water temperature data that the aquatic thermal regime was suitable; (4) using habitat survey information to document that large wood loading was low, pool habitat was deficient, and shelter values were poor.

Ms. Anna Halligan, Trout Unlimited North Coast Coho Project Director, provided detailed information on how Trout Unlimited determines where to develop instream enhancement projects using grant funding. They rely on fish presence, existing wood counts, current channel characteristics (e.g., substrate, channel width, flows), and guidance from recovery and watershed plans when planning and prioritizing projects. Additionally, a recently formed Large Wood Augmentation Technical Advisory Committee developed a suite of project selection criteria to assist with project selection/prioritization for grant proposals (TU 2017). These criteria include coho salmon presence, having a willing landowner, wood availability, existing watershed conditions (e.g., water temperature, streamflow, land use, large wood data), history of previously implemented projects, downstream infrastructure, physical access, and feasibility of the project (e.g., engineering required, implementation method, wood transport).

The types of field data described above should be included in any evaluation of potential large wood enhancement sites selected for instream restoration work, whether LiDAR data are available or not.

Figure 30. Mill-Smith THP large wood enhancement site 1 before treatment (top) and after treatment (bottom). Photos provided by Lyme Redwood Forest Company.

3.3.3 TRACK 3: HYDROLOGIC MODELING

A modeling-based approach was used to illustrate potential methods to assess a watershed in a rapid, office-based approach that relied on publicly available data sources. The initial test of a rapid modeling approach was based heavily on the use of digital elevation models (DEM) obtained from the USGS National Elevation Dataset.[23] All modeling methods used the standard ArcGIS Spatial Analyst toolbox processes, or for hydrologic modeling, the use of TauDEM (Terrain Analysis Using Digital Elevation Model, online at http://hydrology.usu.edu/taudem/taudem5/) toolboxes within ArcGIS.[24]

METHODS

The initial approach delineated the sub-watershed of Smith Creek (Figure 31), and within that watershed eleven catchments were delineated based on a threshold of 24.7 acres (10 hectares) to create individual contributing areas (Figure 32). To delineate these hydrologic areas, individual DEM cells were classified in ArcGIS by the direction of flow downslope; a second algorithm determined the downslope accumulation of cells using the direction of flow. A threshold was applied to the flow accumulation product, which in turn defined how many cells were needed to initiate a flow line and create a subsequent catchment. As stated above, a 10-ha or 1000-cell threshold was used to delineate individual catchments within the watershed, while the flow lines were delineated using a 100-cell threshold—1 ha or approximately 2.5 acres (Figure 33).

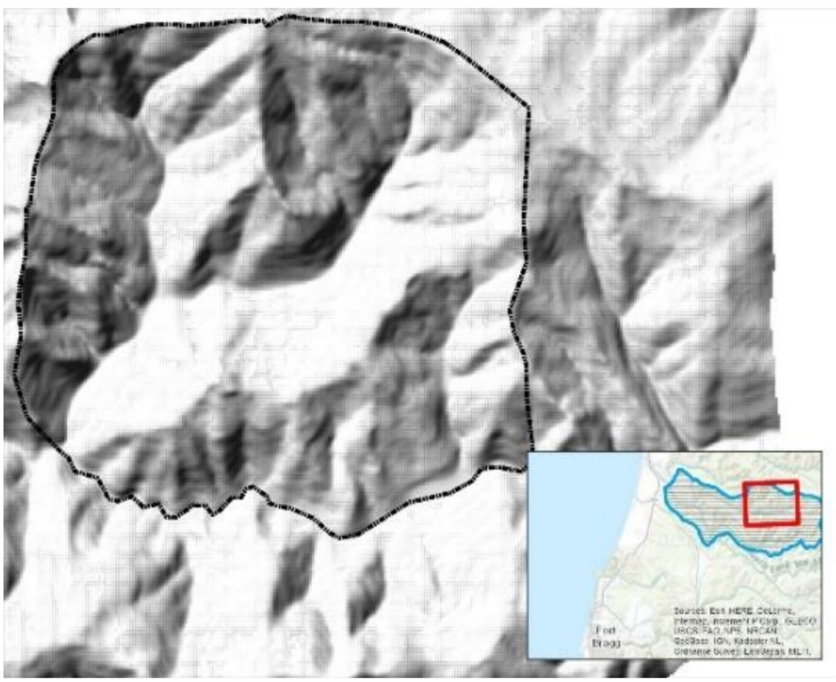


Figure 31. Initial scoping area.

The flow lines were further classified based on individual segment mean slope, categorized by 0 to 5%, 5 to 20%, and over 20% slope, with each category relating to depositional, transition/delivery, and erosional/source reaches, respectively. These categories were based on the Washington State Watershed Analysis guide (2011) and work in Benda et. al. (2005). Additionally, percent slope of hillslopes was calculated in ArcGIS, and all areas with a gradient of 65% or higher were extracted, serving as an indicator for potential shallow mass wasting.

[23] The National Elevation Dataset (NED) is a seamless raster product primarily derived from USGS 10- and 30-meter Digital Elevation Models (DEMs). U.S. Geological Survey DEM (10 m) available at: https://nationalmap.gov/elevation.html
[24] ArcGIS is a geographic information system (GIS) for creating maps and analysis of spatial data; distributed by ESRI.

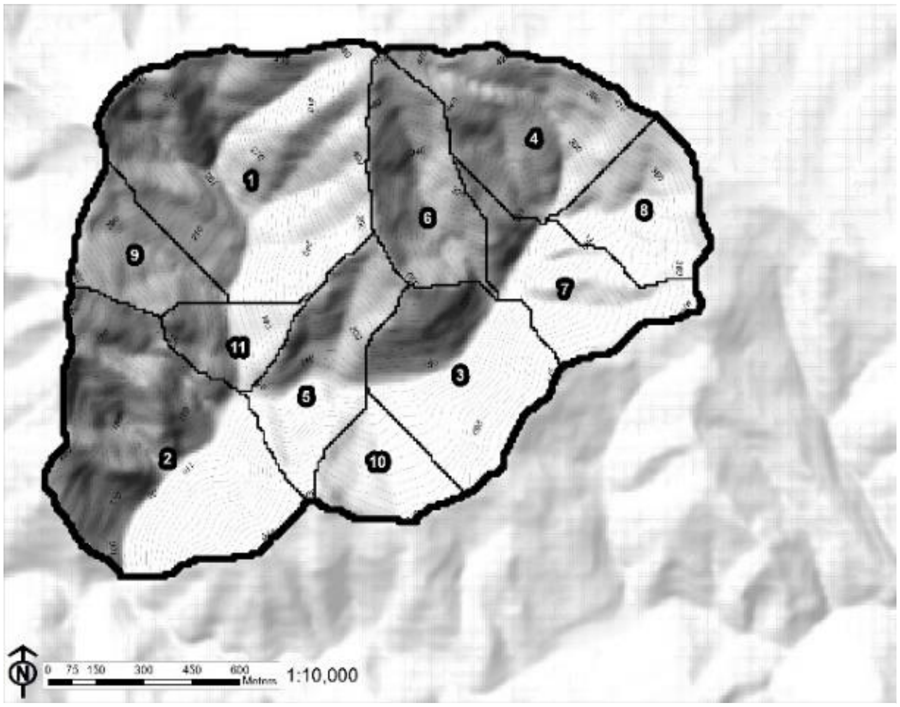
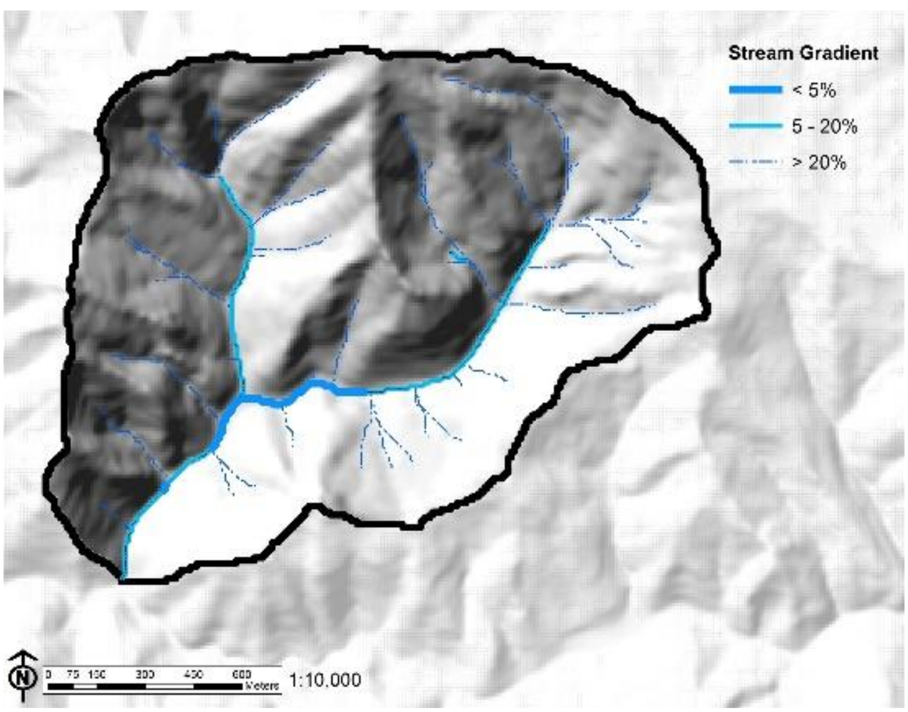


Figure 32. Individual catchments (above).

Figure 33. The stream network delineated based on the 100-cell threshold, classified by average segment slope. (below).



The land use component of this rapid modeling approach was derived using various years (1998, 2005, 2009, 2010, 2012, 2014) of georeferenced NAIP images, which were used to identify and digitize road segments within the watershed. These data were combined with footprints of timber harvesting plans from 1990 to 2013 to identify areas with past management activity.

These individual layers gleaned from the modeling allowed for an overlay and identification of past or present road crossings on watercourses, the ability of watercourses to erode, transport, and deliver sediment, hillslope instability, and areas where past management may have induced in-stream or hillslope-based changes.

Building upon these modeling approaches, a second phase attempted to show how a model based in ArcGIS and technical field measurements from peer-reviewed literature could be used to answer questions about a specific resource of concern, large wood habitat potential. In the example presented to the Pilot Project Working Group, areas were identified where large wood recruitment opportunities might exist to improve coho salmon habitat. A model was built that processed publicly available, remotely sensed vegetation and coho intrinsic habitat potential data, a 10-meter DEM, and calculated watercourse attributes based on empirical relationships from peer-reviewed papers. The goal of the model process was to spatially identify potential locations where large wood abundance could be purposefully increased to improve in-stream coho habitat.

The exercise was designed to model stream characteristics and determine if the surrounding riparian trees were large enough to form pools if recruited into the stream, thereby increasing complexity and habitat for coho salmon. The model approach was consistent with Appendix A of the Section V guidance manual (VTAC 2012)[25] and intended to demonstrate a simple method to assist landowners with their efforts for large wood restoration in coho habitats. The modeling approach was comprised of:

- Determining the stream power index (SPI), a function of stream slope and upstream drainage area, calculated as:
  - **SPI =** $\boldsymbol{Upstream\ drainage\ area\ (km^2) \times \frac{Stream\ slope\ m\,m^{-1}}{100}}$
- Calculate bankfull width (BFW, see Faustini et al. 2009):
  - **BFW =** $\boldsymbol{3.05 \times Upstream\ drainage\ area\ (km^2)^{0.36}}$
    - This equation, developed for the Coast Ranges and Cascade Range of the west coast. While not explicit to the California North Coast, it was used in order to make a first order determination of bankfull width for modeling purposes, absent local data to improve estimates.
- Determining the necessary diameter of large wood pieces required to form a pool in the stream (DPF, see Bilby and Ward 1989 and Beechie 1998), and if the trees within 50 meters of the stream met that requirement:
  - **DPF (cm) =** $\boldsymbol{2.5 \times BFW}$

Assessing stream segments for restoration opportunity based on the SPI, DPF, riparian tree diameter, and NOAA intrinsic habitat potential (IP) for coho. Data sources used in the model were a 10-meter digital elevation model (DEM) from the USGS, NOAA Fisheries intrinsic potential for coho on the central California coast (Agrawal et al. 2005), and vegetation structure information from the Landscape Ecology, Modeling, Mapping and Analysis group (LEMMA) (Ohmann et al. 2014).

The watershed was modeled in ArcGIS using the DEM to derive a digital stream network utilizing the first phase methods previously outlined. For each 10 m x 10 m DEM “cell” under the digital stream network, the stream power index (SPI) was derived. The SPI was averaged for each stream segment, and stream segments were separated by SPI values above and below 0.5, the threshold at which large wood is typically able to form pools in northern California (Benda and Bigelow 2014) (Figure 34).

[25] http://bofdata.fire.ca.gov/board_committees/vtac/vtac_guidance_document_/vtac_guidancedocument_dec21-2012_final.pdf

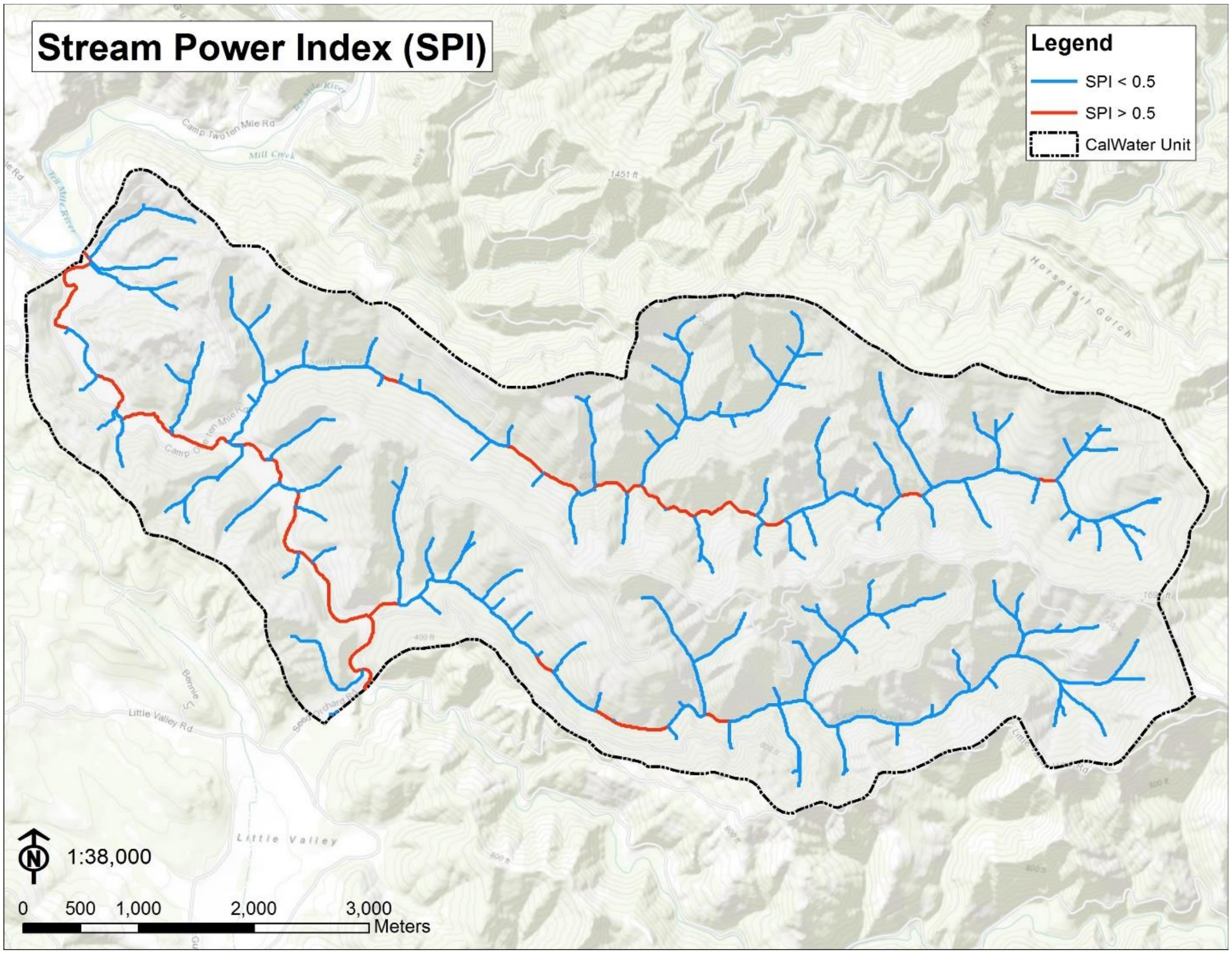


Figure 34. The stream network derived from the DEM, and separated by the SPI threshold of 0.5.

The regional regression equation indicated above was used to determine the channel bankfull width, from which the diameter necessary for large wood to form a pool (DPF, also shown above) was calculated. The LEMMA data were used to assess if the quadratic mean diameter (QMD) of trees within 50 meters of the stream met the required DPF (see above *Track 2: Rapid Assessment with Imagery Analysis* for further analysis of LEMMA data for riparian vegetation assessment). The stream network was classified into segments with low and high SPI and sufficient or insufficient riparian tree diameter size to form pools. These results were overlaid on the NOAA Fisheries IP data, which were classified into areas of 0.4 to 0.7 (moderate rating) and over 0.7 (high rating), determining potential areas to field verify for restoration opportunities. These areas were not field verified as part of this project to determine if they were suitable locations for active wood placement, so the relative effectiveness of the model for identifying LWD-related restoration opportunities in the Campbell Creek Planning Watershed remains unknown.[26]

[26] See Campbell Global (2015) and Mackey and Blencowe Watershed Management (2018) for locations where large wood enhancement projects have been recently implemented in the Campbell Creek Planning Watershed following field verification using the accelerated wood recruitment method (Carah et al. 2014).

Findings

Based on the methodology used for Track 3, there is an ability to rapidly assess a watershed in an office-based setting using pre-existing public data and off-the-shelf and/or customized predictive models. In both phases, the emphasis was placed on the ability of a modelling approach to identify discrete locations on a landscape, based on explicit criteria or resources of concern, that could be evaluated and validated in the field.

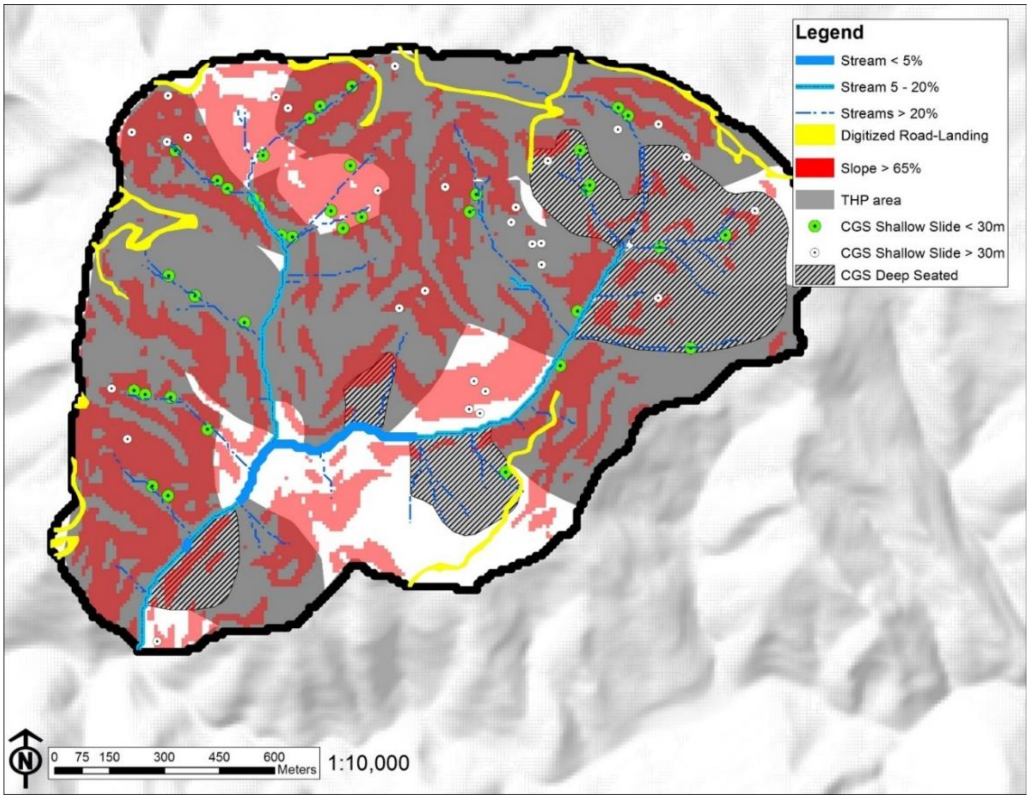


Figure 35. Overlay results showing past timber harvest areas, watercourses by geomorphic function, roads and landings from aerial photos, potentially unstable slopes, and historic mapped unstable features.

The initial modeling effort for the first phase presented an example where the different model outputs were layered to show the intersections of past timber harvests, historic and current roads, potentially unstable slopes, and geomorphologically similar stream reaches within individual catchments in the watershed. Assuming that restoration of the sediment regime was a key objective, one approach was to use this layering to identify potential sediment source reaches and sediment transport reaches that were spatially linked to unstable slopes, past timber harvests, or road construction. Figure 35 shows the overlay results, with additional data points on shallow and deep-seated landslides (data which may vary in quality and quantity across watersheds and ownerships).

By screening areas where high magnitudes of sediment could be routed downstream to fish-bearing watercourses, this would allow a focused field investigation, and potentially, identification of specific areas where removal of anthropogenic sediment sources could be targeted.

Further modeling development illustrates coho habitat restoration through the use of large wood enhancement projects. Again, the methodology and process provide an example of how to narrow the potential scope of field work to discrete landscape locations using GIS-based spatial modeling. Then, technical experts can identify where targeted watershed restoration may in fact create the greatest benefit relative to explicit goals.

This modeling exercise revealed, not unexpectedly, that reliance on remotely-sensed data cannot be taken as absolute fact. Delineated stream networks may not follow exactly where flowing water and/or bed, bank, and channel morphology exists, and the LEMMA vegetation data required verification both due to being remotely sensed and having only a 30-meter pixel resolution. However, absent detailed, field-based surveys and data, the model approach served as a basic estimate of ground conditions. The availability of high quality LiDAR data, which provides a more accurate and detailed view of topographic and vegetative characteristics, would further refine this modeling exercise.

The second phase results for the large wood recruitment modeling exercise indicated that within the focused watershed, a majority of the stream network likely has sufficiently sized riparian trees to form in-channel pools, and a low enough stream power index to allow for a successful restoration project (Figure 37). The observed coho range indicated by the CalFish database[27], coupled with the model results, illustrates how the lower reaches of the Ten Mile River watershed are where stream reaches exist with the necessary stream power index under 0.5 and coho presence (Figure 36).

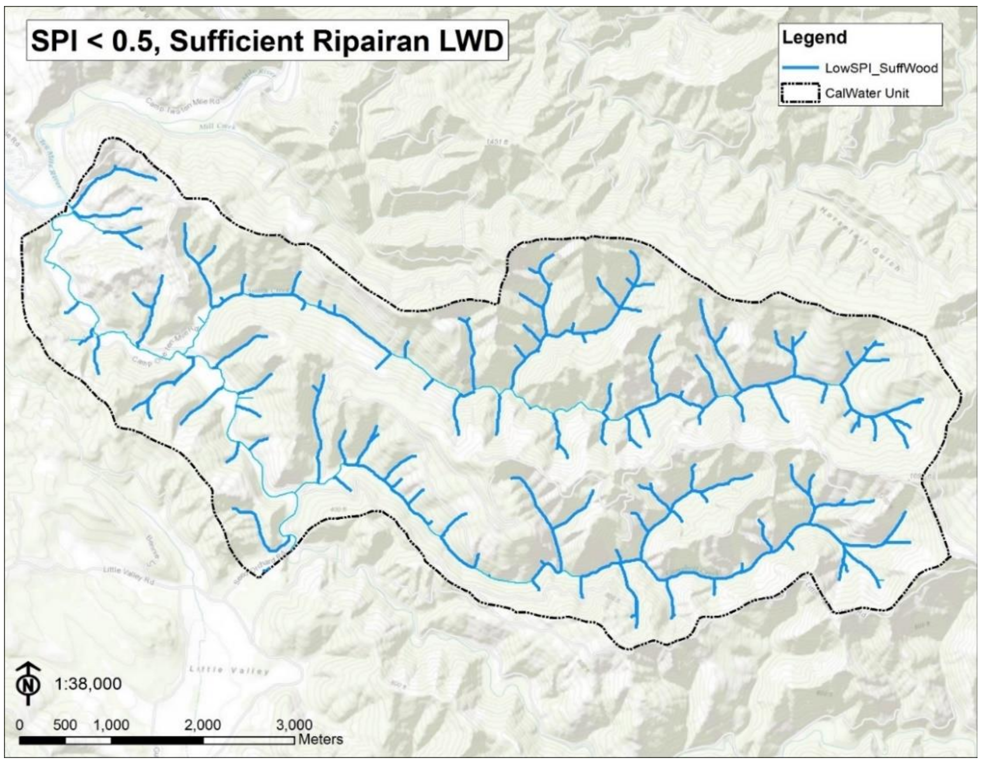


Figure 36. Model results within the Campbell Creek Planning Watershed illustrating where the riparian stands had large enough trees to form in-channel pools and a stream power index below 0.5, indicating areas where restoration projects may be more likely to succeed.

The model results, when finally overlaid with the intrinsic habitat potential for coho salmon, are an example of using the remote sensing data and modeled results to identify the spatially explicit reaches where wood recruitment restoration projects could occur, either due to adequately sized trees or a lack of adequately sized trees (such as in the lower reaches that exhibit floodplain dynamics). Figure 38 illustrates these overlay results.

27 https://www.calfish.org/

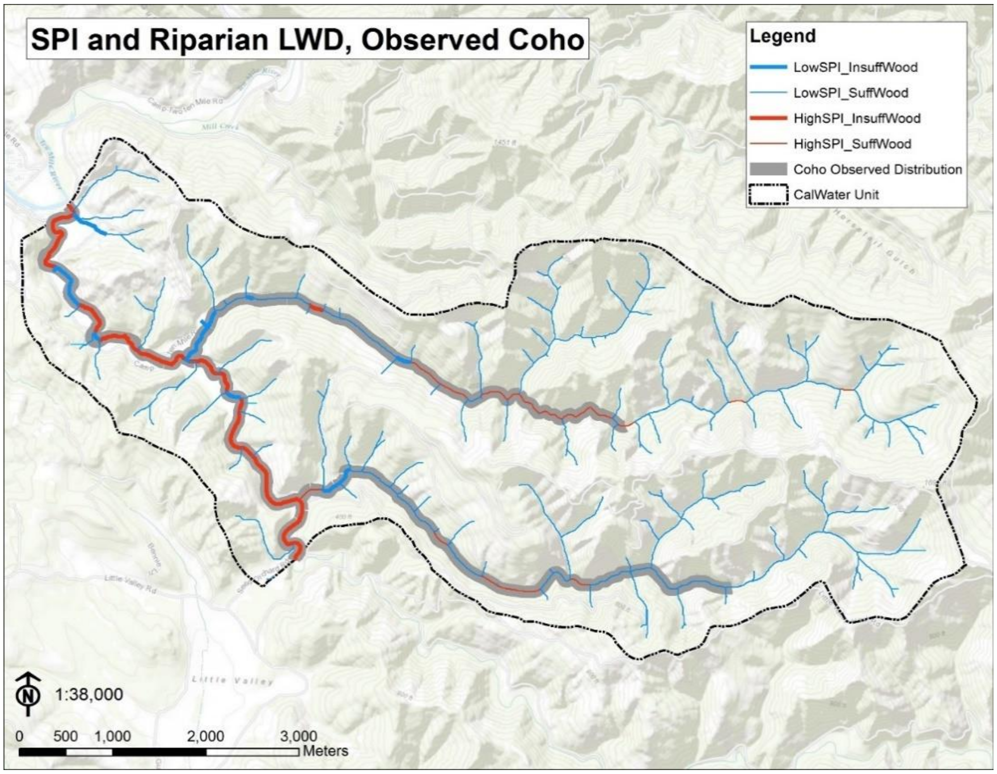


Figure 37: Observed coho presence, reaches above and below an SPI of 0.5, and reaches with sufficiently sized riparian trees to form in-channel pools.

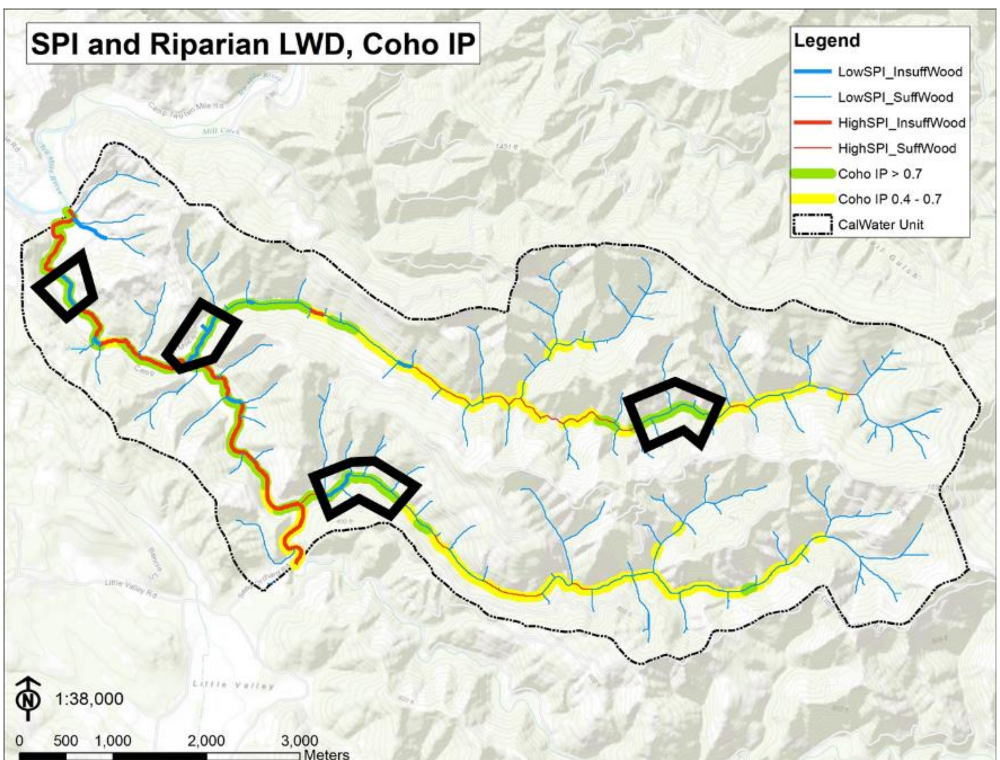


Figure 38. Results from the model built to calculate areas best suited to large wood recruitment and coho habitat improvement, to help guide field-based surveying. SPI refers to the stream power index, a measurement of slope and upstream contributing area within the stream channel, LWD refers to if the remotely sensed stand structure would meet requirements to form a pool or backwater, and IP stands for the modeled habitat Intrinsic Potential for coho salmon.

This modeling approach illustrates that the ability to identify discrete portions of the landscape using pre-existing, publicly available data to narrow the scope of field work, or identify other data needs, is possible. The modeling approach requires technical experts with knowledge of physical processes and geospatial modeling techniques, and concise, targeted questions or objectives. The methodology outlined in the methods sections serve as an example of an initial approach, which can be modified and targeted further based on ecological/physical setting, landowner objectives, or reviewing agency needs.

3.4 Beyond the Three Tracks: Additional Inquiry

Agency staff undertook additional routes of inquiry in an effort to further explore conditions in Campbell Creek using existing information, to examine terrestrial habitat with information from THPs, and to build upon the pilot project's earlier work by prototyping synthesis through spatial analysis. This work was presented in a series of three webinars which aimed to share results and receive PPWG and public feedback. The topics of the three webinars were:

1. A terrestrial habitat layer using Northern Spotted Owl as the resource of concern; this could potentially lead to a map or criteria for terrestrial restoration.
2. A prototyped synthesis of the three-track process (THP mining, watershed modeling, and remote sensing rapid assessment) focused on potentially restorable watercourse sites using coho salmon as the resource of concern.
3. A geology-focused assessment of erosion risk and sediment sources.

All three webinars are available at http://campbellcreek-calfire-forestry.opendata.arcgis.com/pages/campbell-creek-analysis and are summarized below.

3.4.1 Terrestrial Habitat and Restoration Using Northern Spotted Owl (*Strix Occidentalis Caurina*) as a Resource of Concern

Northern Spotted Owl analysis for the Smith Creek watershed

The Northern Spotted Owl (NSO) was chosen to be the resource of concern when addressing terrestrial habitat restoration and potential assessment of cumulative impacts. The focus here is using THPs and other resources to identify opportunities for forest restoration to improve NSO habitat. Restoration measures to improve NSO habitat can be either passive (e.g., allow trees to grow into larger sizes that provide better habitat elements for nesting or roosting) or active (e.g., thinning dense, mid-sized trees to allow the residual trees to more rapidly grow to a larger size that provides better habitat elements for nesting or roosting).

The special status of the NSO at both the state and federal level has resulted in extensive scientific inquiry into the owl's biology and habitat requirements across the California portion of its range. Timber harvesting plans include data on past survey efforts, as well as present and projected habitat suitability. The publicly available data for NSO associated with the Smith Creek watershed was compiled from THPs and records in the CDFW BIOS Spotted Owl database and presented spatially and graphically across the breadth of those records. Additionally, Lyme provided their most recent NSO habitat designations for the Campbell Creek watershed. This information was presented to the Campbell Creek Pilot Project Working Group in a public webinar on April 19, 2018. The presentation included the Northern Spotted Owl habitat time series database, spatial depictions of the Spotted Owl database detections by various attribute fields, summaries of detection history, and conclusive summaries on the available data.

Habitat Time Series Database Development

CDFW staff assessed the Northern Spotted Owl data included in THPs from 2005 through 2015. The 0.7 mile home range for seven known NSO activity centers (MEN0118, MEN0137, MEN0149, MEN0150, MEN0243, MEN0312, and MEN0313) overlap portions of the Smith Creek watershed (see Figure 39). Core areas associated with MEN150, MEN0312, and MEN0313 were identified to be completely in the Smith Creek drainage (see Figure 40). NSO habitat as identified in Section V NSO habitat typing analysis of THPs 1-05-181 MEN, 1-07-036 MEN, 1-08-015 MEN, 1-13-031 MEN, 1-15-107 MEN, and 1-15-094 MEN were digitized and displayed in a time series to demonstrate changes in assigned typing related and unrelated to harvesting under the plans (see *NSO* Appendix 8, slides 35 through 44).

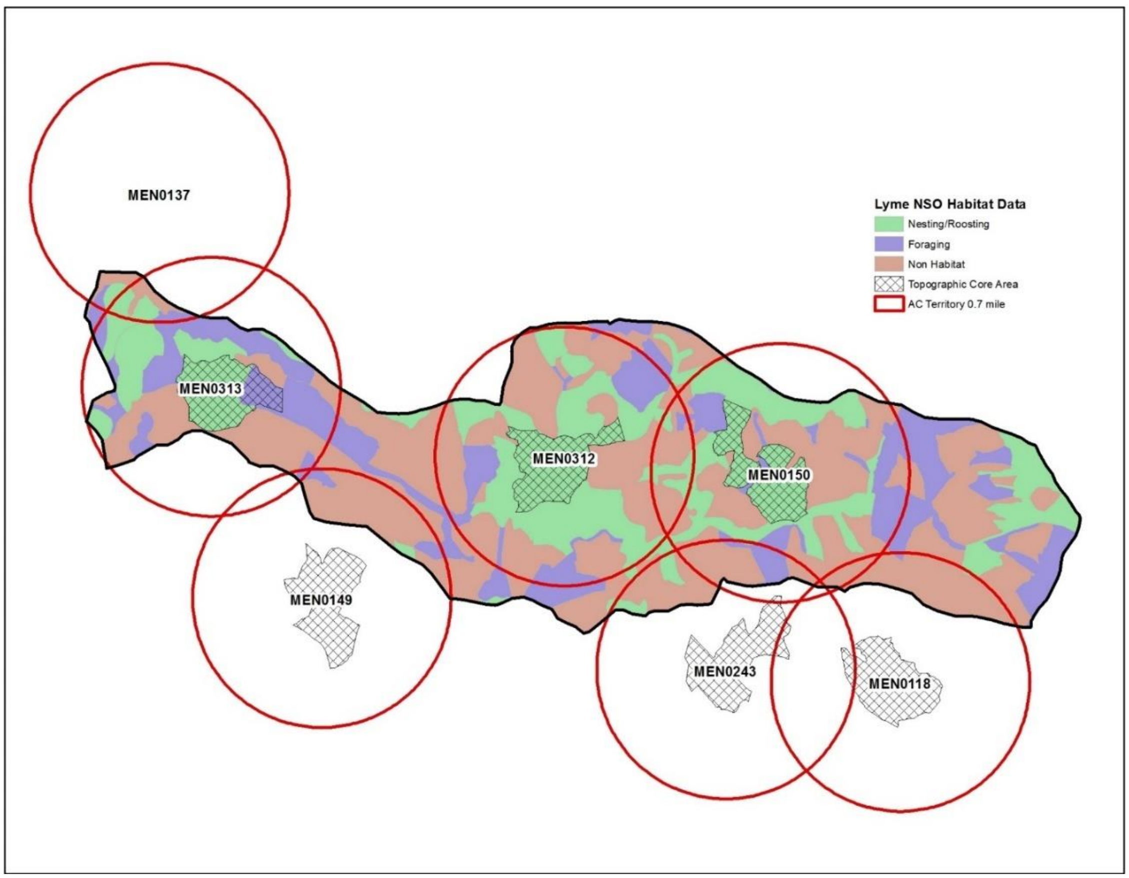


Figure 39. Terrestrial habitat and core areas of NSO activity centers within the Smith Creek sub-watershed

To create the habitat time series database, the NSO habitat maps were extracted from Section V of the THPs and georeferenced in the GIS to a basemap using ground control points, and then the habitat units were digitized. Data were created from the earliest representation to the latest, digitizing any new habitat polygons as well as delineating changes in habitat that occurred since the previously mapped date. This was done for each year in which NSO maps were available within the watershed.

Generally, the NSO maps for any particular year covered only part of the watershed. Harvest units might be clustered at one end of the watershed or there might be large gaps between units. In areas with no new THPs and therefore no new NSO habitat maps for a given year, it was assumed there was no change in habitat from the previously mapped date.

Spotted Owl Database

Additionally, the assessment included Northern Spotted Owl survey and detection data provided by Lyme (or preceding land managers) to the CNDDB Spotted Owl database. The history of NSO survey information for activity centers in the Smith Creek watershed associated to MEN0150 begins in 1989, and 1991 for activity centers MEN0312 and MEN0313 (see Appendix 8, slides 53 through 72). Location data for many detections in the Spotted Owl database for activity centers within 0.7 miles of the Smith Creek watershed are attributed to the accuracy of a quarter-section centroid.

The mapped representation of the Spotted Owl database includes a “Spider” line tool associating detections to activity centers based on a number of criteria. Figure 40 depicts the seven activity centers and multiple detections associated to activity centers beyond the 0.7-mile home range perimeter, including positive no-pair data, pair-detections, and no-detections locations with the Lyme-provided NSO habitat typing and topographic core areas.

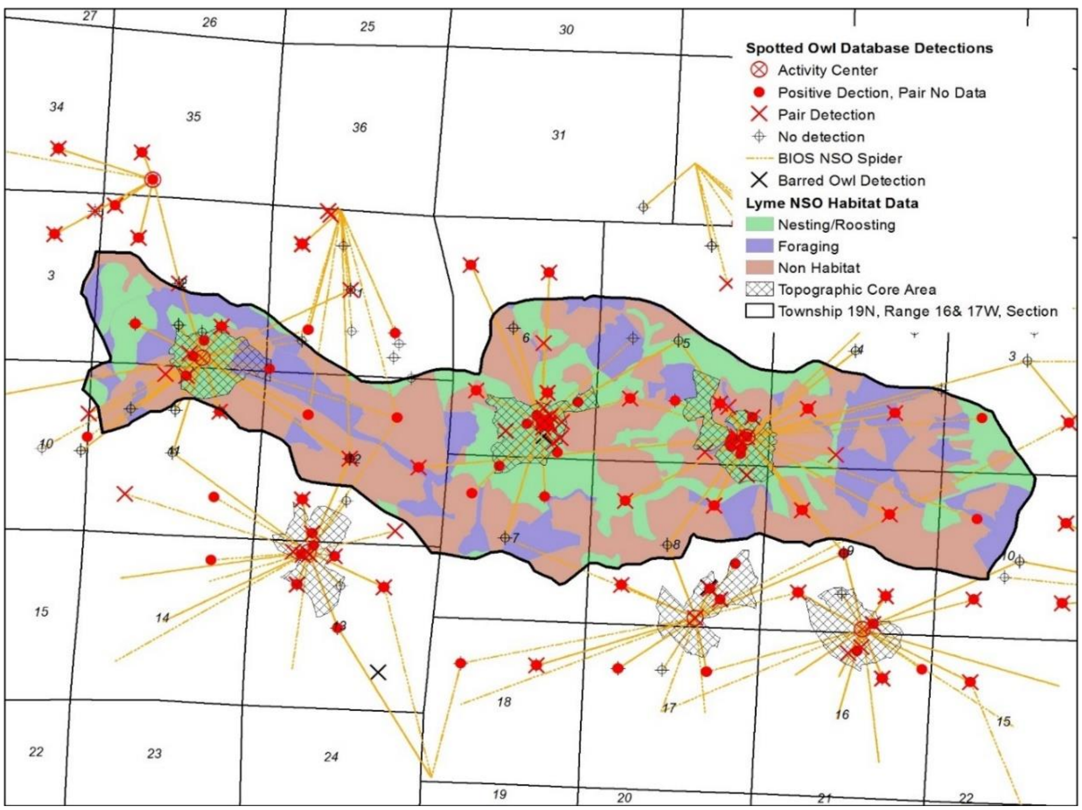


Figure 40. Seven NSO activity centers and multiple detections associated with them beyond the 0.7-mile home range.

The Spotted Owl database detections associated with each activity center identified in the Smith Creek watershed, activity centers MEN0150, MEN0312, and MEN0313 (see Appendix 8, Slide 53 through 72), are represented with 4 maps for each activity center illustrating:

1. The home range and detections associated to the activity center with the Lyme-provided NSO habitat typing and topographic core area;

2. The detections identified as nest (nest = yes) and depicted using accuracy as either contributor-provided coordinates or quarter section centroids with the Lyme provided NSO habitat typing and topographic core areas and the location, date, and type of silviculture for harvest units in the proximity of the detections ;

3. The *date labelled* detections identified as nest (nest = yes) and depicted using accuracy as contributor-provided coordinates or quarter section centroids with the Lyme-provided NSO habitat typing and topographic core areas;

4. The detections identified as a nest detection and locations identified as "contributor" coordinates or "quarter section centroid" with the Lyme-provided NSO habitat typing and topographic core areas, and CAL-FIRE- provided silviculture (even age or uneven age) prescription labeled by year of plan filing.

Additionally, two charts for each activity center and the entirety of the associated detections summarize the Spotted Owl database detections. For each activity center the summary chart includes the annual detections (number of activity center, positive/negative detection by year of survey effort), and annual pair occupancy nesting detections (pair detections and the related nesting status as provided).

The timber harvesting plans used for this exercise contain large amounts of spatial and tabular data. The spatial data are available at varying levels of resolution and accuracy (from plotted maps, GIS-generated coordinates, to quarter-section centroids (center of a 160-acre square)). Because forests are dynamic and methods for collecting stand data may change over time, stand data are not always consistent in polygon shape and habitat typing from THP to THP across years. NSO survey information and habitat designation are designed to avoid take of the species. Data generated to facilitate management objectives do not necessarily support robust statistical study of population and demographic trends for NSO. An analysis of these trends would be essential to instituting a restoration project aimed at maintaining the population of NSO at a multi-watershed scale—the scale necessary to support foraging, nesting, roosting, and dispersal of NSO. The Spotted Owl database is not designed to support analysis of nesting and/or reproductive trends, and does not facilitate reliable calculation of productivity, fecundity (# of female young produced per adult female), or survival. As stated in CDFW's NSO Status Review[28] (emphasis added):

> Activity center sites may not represent the actual number or density of owls across the range in California due to the nature of how the data are collected and reported. **Data are often collected inconsistently based on local project-level monitoring needs and not all data are reported to the Department's database.** Also, activity centers are generally retained in the database over time regardless of annual occupancy status (see Status and Trends section of this report).

[28] See http://www.fgc.ca.gov/CESA/index.aspx#nso for the CDFW Status Review Report

Further, the habitat typing definitions used to demonstrate that timber operations are avoiding impacts to Northern Spotted Owl rely on the minimum functional habitat definitions (see Appendix 10) rather than classifying habitat by quality (such as habitats modeled to result in higher productivity, fecundity, and survival). A discussion of higher quality habitat in the Status Review includes (emphasis added):

> Overall, **Northern Spotted Owls require some minimum level of old forest within their core area and broader home range to optimize survival and reproductive output**. **It is also apparent that older forest mixed with other forest types (excluding non-habitat) benefits Northern Spotted Owl fitness in California** and southern Oregon, **at least partially due to the increased foraging opportunities along transitional edges**. In spite of inconsistencies in methods used and minor differences in amount of old forest and edge that provide the highest habitat fitness for owls, the literature points to the benefits of a **mosaic of forest types that contain sufficient older forest, especially around the core area, while limiting the amount of nonhabitat in the home range**. Based on the studies in the Northern Spotted Owl range in California and southern Oregon, **management that maximizes late-seral forest in the core area (at least 25% to support survival but ideally about 50% to maintain high habitat fitness potential) while limiting the amount of nonforest or sapling cover types throughout the home range (no more than about 50%) would likely result in high quality Northern Spotted Owl territories.**

Figure 41. Northern spotted owl (*Strix occidentalis caurina)*.

Findings

More information about NSO is contained within THPs than for any other species. This exercise focused on determining whether that information, while voluminous, is appropriate for informing restoration activities. While THPs include the acreage of suitable and non-suitable habitat, these acreages use minimum functional habitat definitions according to CDFW's NSO Status Review. Absent a more detailed habitat delineation that enabled setting tiered restoration objectives, restoration practitioners would be required to survey habitat prior to restoration activities to adequately characterize the existing habitat. Thus, the THPs do not contain the appropriate habitat delineations necessary to create a restoration regime focused on increasing populations of NSO in the Smith Creek watershed. The information contained in THPs is not designed for identifying opportunities for restoration.

Further complicating factors include: different habitat definitions, future harvesting and natural forest growth. The Campbell Creek Planning Watershed has a single large timberland owner in Lyme Redwood Timberlands; this is not the case in many other planning watersheds. It should be noted that not all landowners use the same habitat definitions, and some provide no NSO data in their plans (e.g., landowners with an Incidental Take Permit from the U.S. Fish and Wildlife Service). NSO maps at the Planning Watershed scale would have to be updated with each new THP and Nonindustrial Timber Management Plan (NTMP), preferably following harvest operations to confirm harvest had occurred, to be useful for future THP/NTMP plan preparation, review, and/or identification of restoration opportunities. Also, forest characteristics change over time absent timber harvesting. Tree diameter growth will change non-habitat into foraging habitat and foraging habitat into nesting/roosting where there is adequate stocking over time.

3.4.2 USING OVERLAY ANALYSIS AS A TOOL TO IDENTIFY RESTORATION OPPORTUNITIES FOR COHO SALMON

Each of the three tracks of analysis explored in the pilot project work from a foundation of spatial information. An attempt to prototype a synthesis of the three tracks and further identify potential restoration sites was undertaken. The goals were to stimulate discussion among the PPWG and perhaps solidify methods of determining impacts and restoration opportunities at the planning watershed scale in a formulaic and repeatable process.

Overlay analysis is "used for optimal site selection or suitability modeling. It is a technique for applying a common scale of values to diverse and dissimilar inputs to create an integrated analysis." (See Understanding Overlay Analysis.) Suitability models identify the best or most preferred locations for a specific phenomenon.

General steps outlined in Understanding Overlay Analysis

1. Define the problem = what is the objective?
This can be defined directly from the *Forest Planning Watershed Pilot Projects Concept Paper* of May 2016: two of the "substantive areas to be addressed by the pilot projects" are the "description of current forest conditions" and the "identification of restoration opportunities in forested landscapes".

It is important to note that the Concept Paper also states the following: "To define 'restoration' in the context of the pilot projects, we borrow from the Society for Ecological Restoration: 'Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.'"

2. Break the problem into sub-models.

Most overlay problems are complex, and this one is no different. Breaking it down into sub-models helps to organize the process and the data, which in turn helps more effectively to answer the spatial question. Two sub-models were identified for this analysis: ASSETS and THREATS.

Specifically, using the data collected during the three-track analysis, Assets could be, in alphabetical order:

- Adequate riparian function
- Coho intrinsic potential
- Existing and restorable coho habitat
- Pool formation potential from large wood recruitment
- Watercourses and WLPZs

Threats could be:

- Extreme, high, or moderate erosion hazard ratings
- Instream water temperature (not part of the analysis but deemed a missing piece)
- Landings
- Roads
- Timber harvesting activities
- Watercourse crossings

3. Determine significant layers

This step is where expert knowledge becomes critical in terms of choosing the inputs and deciding which attributes from those inputs are important. Some inputs are simple—for example coho habitat—which would belong to the Asset group. The data to be valued is straightforward: For the Class I watercourses in Smith Creek, either the habitat exists (spawning and rearing), or it is restorable (Figure 42).

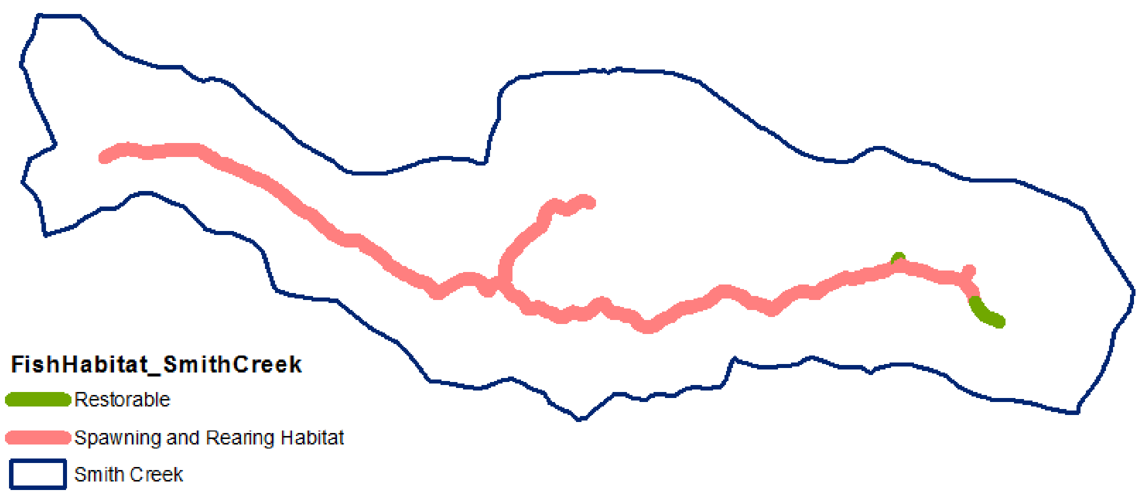


Figure 42. Coho habitat in Smith Creek

Other inputs to the sub-model might be more complex, e.g. timber harvesting as an input to Threats. What attributes of timber harvesting contribute Threats to coho? Should silviculture be included by type (e.g., clearcut or selection), by number and timing of entries, proximity to a road, proximity to a watercourse, slope, or a combination of factors? These same questions can be asked about yarding. Should time decay be included? Previous studies can be used as a guide to this process. Ultimately, subject matter experts need to make these decisions within the limits of the existing GIS data.

4. Reclassification/transformation

Once all the attributes of the Assets and Threats have been identified they may need to be converted to rasters[29] and then reclassified and valued. This is all "geoprocessed" in the GIS. Interval or ordinal value scales are, in this case, probably the best fit[30].

Using the example of the Track 2 riparian function assessment, which is illustrated below as presented at the October 2017 PPWG meeting (Figure 43), it was captured in the GIS as a polygon of the Watercourse Lake Protection Zone (WLPZ) or riparian area, using the maximum 150' protection defined in the Forest Practice Rules. The entire area was given a "moderate" rating (value = 2), per the assessment. (Figure 44)

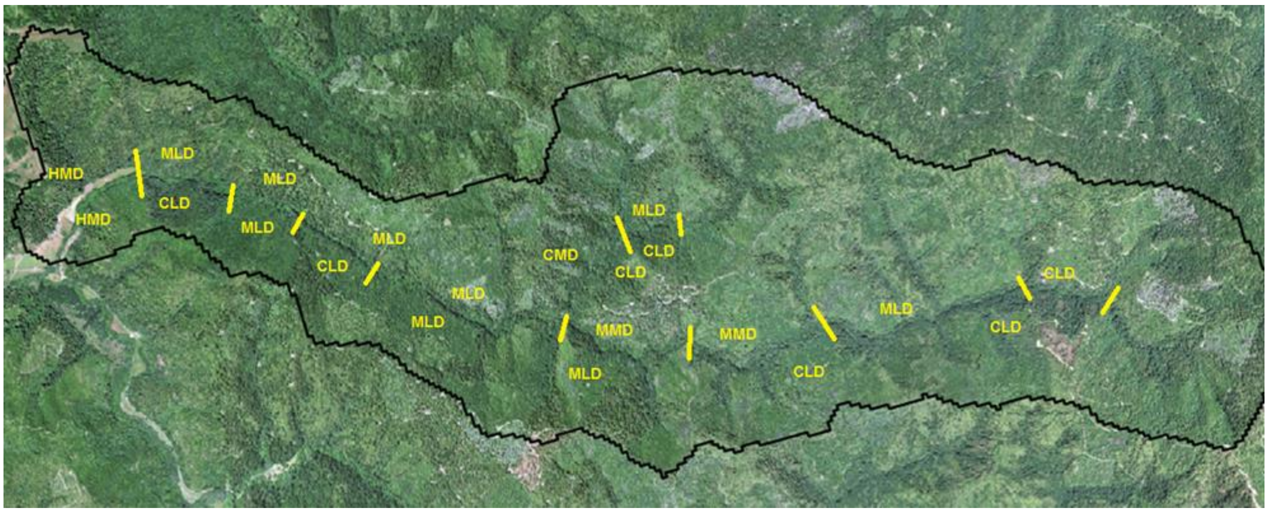


Figure 43. Riparian classifications for the Smith Creek watershed using the WFPB (2011) methodology

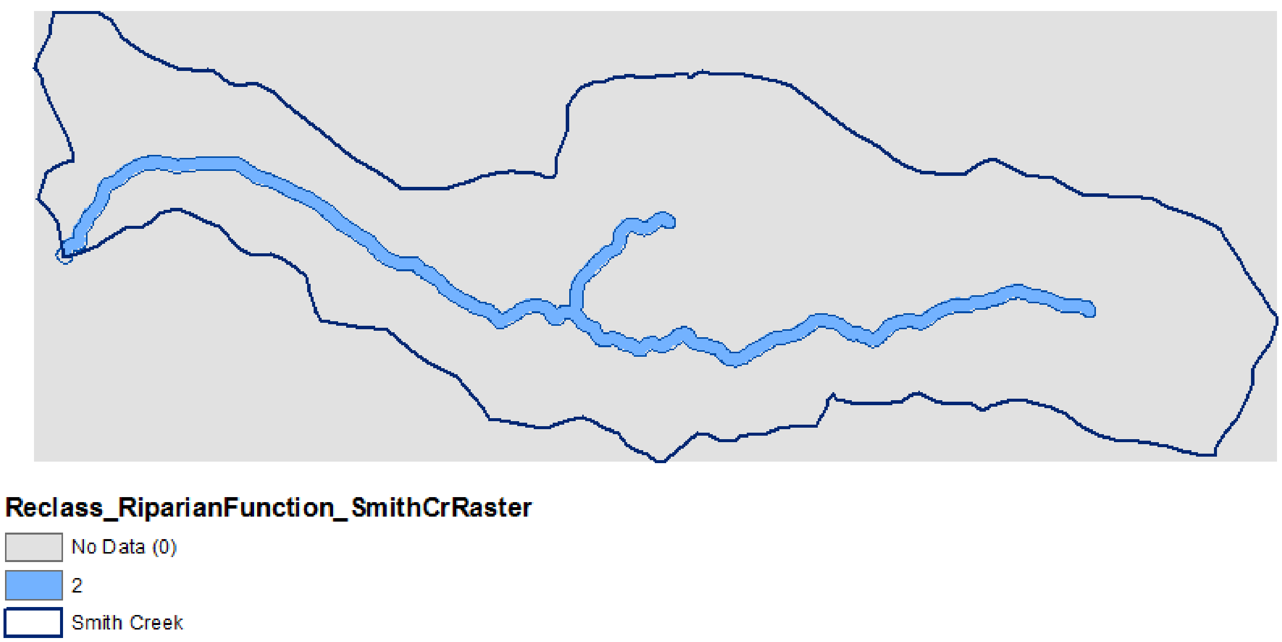


Figure 44. Riparian classifications rendered as polygons for analysis

[29] See: what is a raster?

[30] See page 3 Understanding Overlay Analysis

This polygon was then converted to a raster creating a rectangular grid. This raster or grid, can be reclassified so that grid "cells" are given the following values:

No Data	0
Low	1
Moderate	2
High	3

This process is repeated for each Input item in both the Assets and the Threats sub-model.

5. Weight

Once all the inputs for the Assets and Threats have been established, with their respective attributes and reclassified values, it is time to consider weighting the factors based on importance. For example, if Input 1 is considered to be twice as important as Input 2, then Input 1 values would be multiplied by 2. The ratio between these two items would always be 2:1. The bottom grid illustrates exactly this. The top grid in Figure 45 is showing a ratio of 3:1.

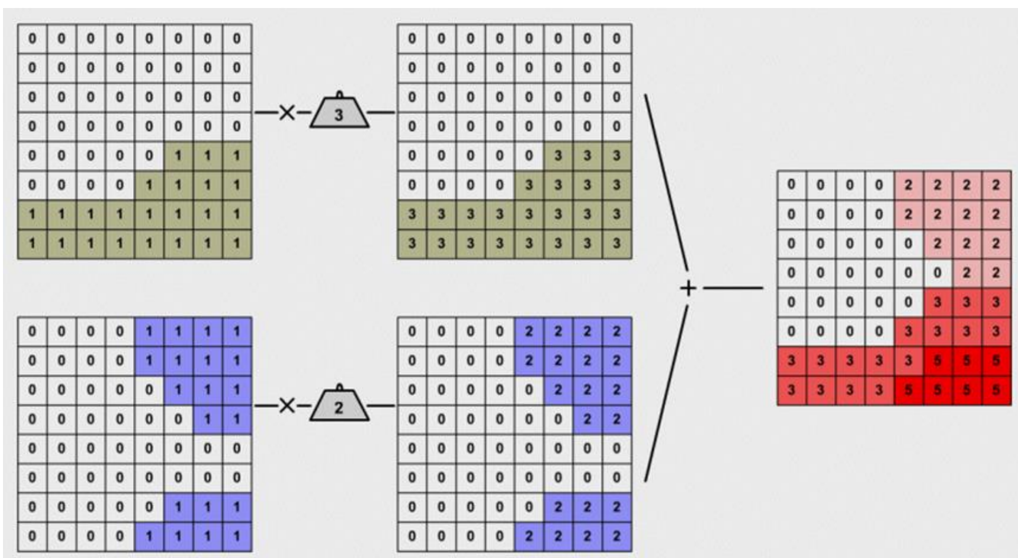


Figure 45. Illustration of weighted values in grid-based analysis

Weighting is not a requirement as all inputs in a sub-model may be considered of equal impact. Expert knowledge is needed to answer the questions: should the inputs be weighted? And if so, how should they be weighted?

6. Add/Combine

The data are now in a more uniform format which means that:

- All data layers are rasters with each grid cell of the individual Assets and Threats exactly overlapping the cells of the other inputs – imagine them stacked perfectly on top of each other.
- Each cell also has a value based on the attribute of interest, and the values have potentially been weighted by relative importance.
- A simple math calculation can sum the Assets and the Threats for each cell.

The results of this step can show the spatial distribution of low to high Assets and low to high Threats. (Figures 46 and 47)

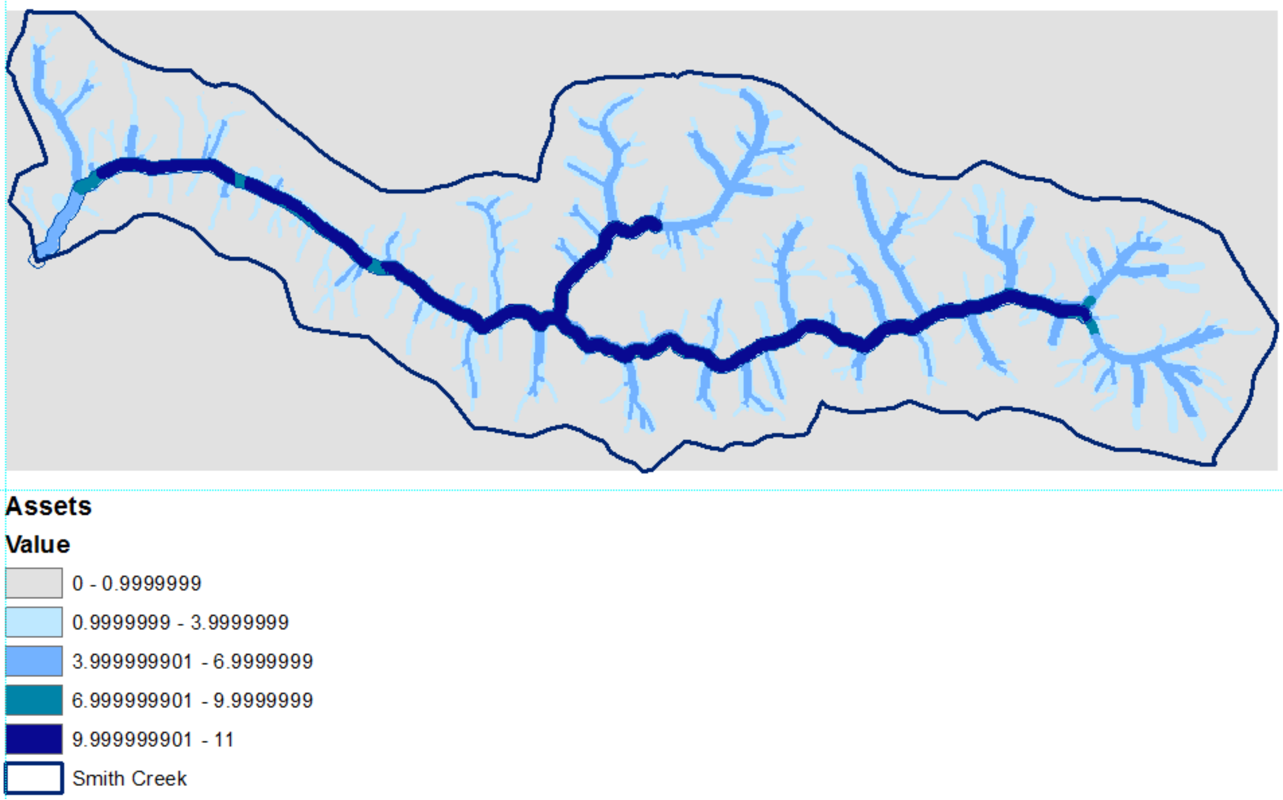


Figure 46. Combined Assets

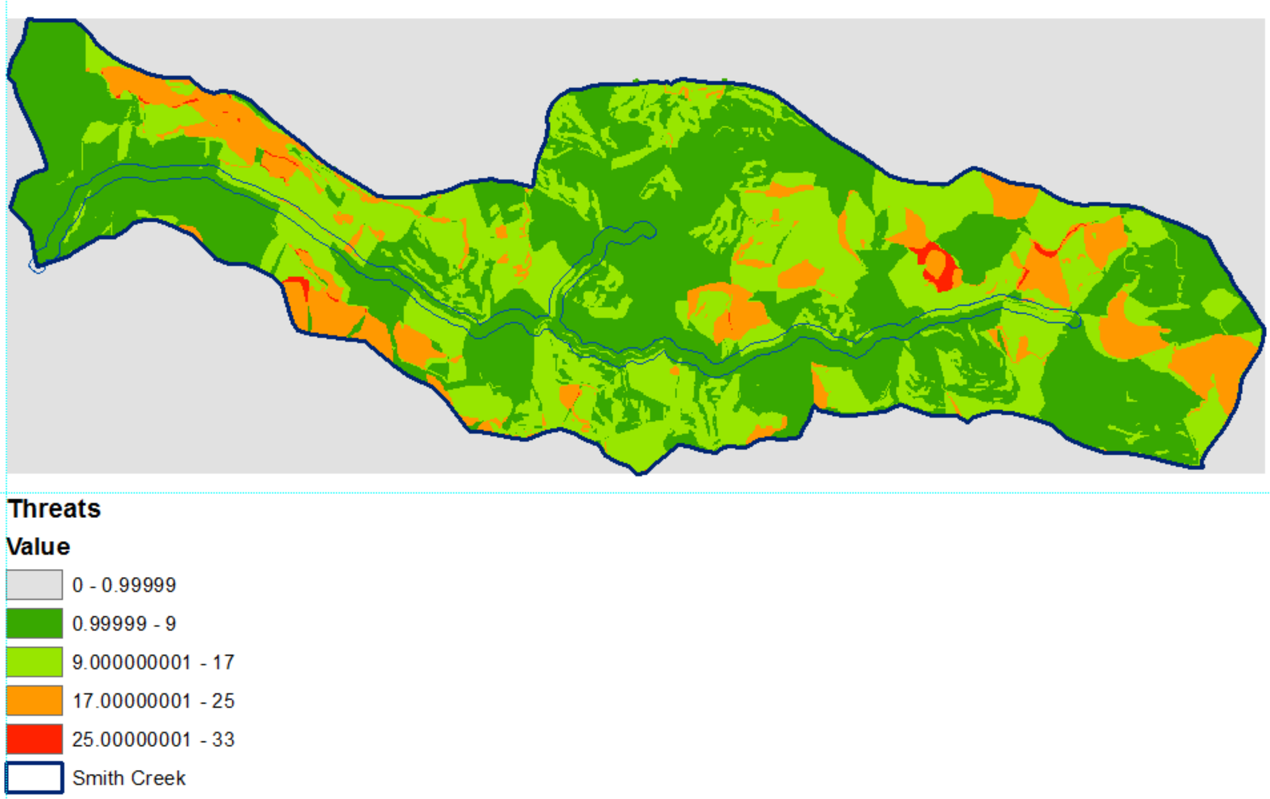


Figure 47. Combined Threats

7. Analyze

How are potential areas for restoration identified from these results? The values can be regrouped into High, Medium, and Low to make the Assets and Threats values more digestible. (Figures 48 and 49)

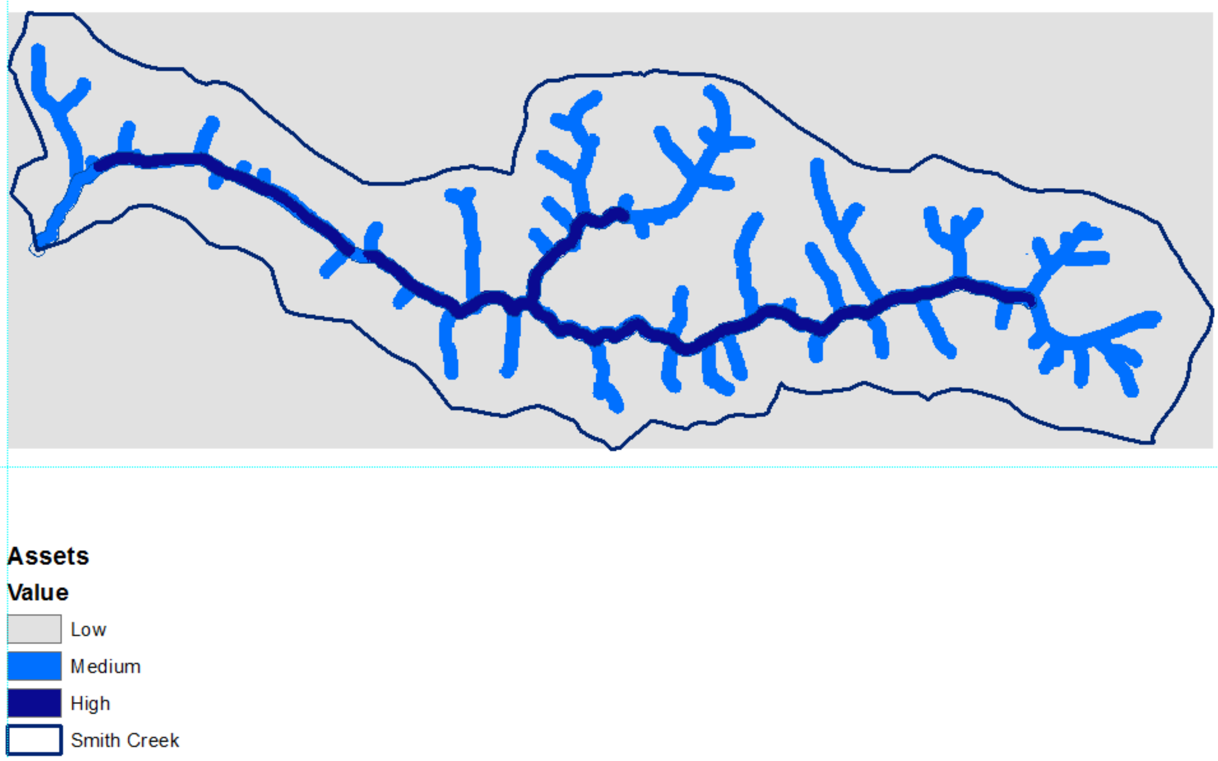


Figure 48. Assets grouped into High, Medium, and Low

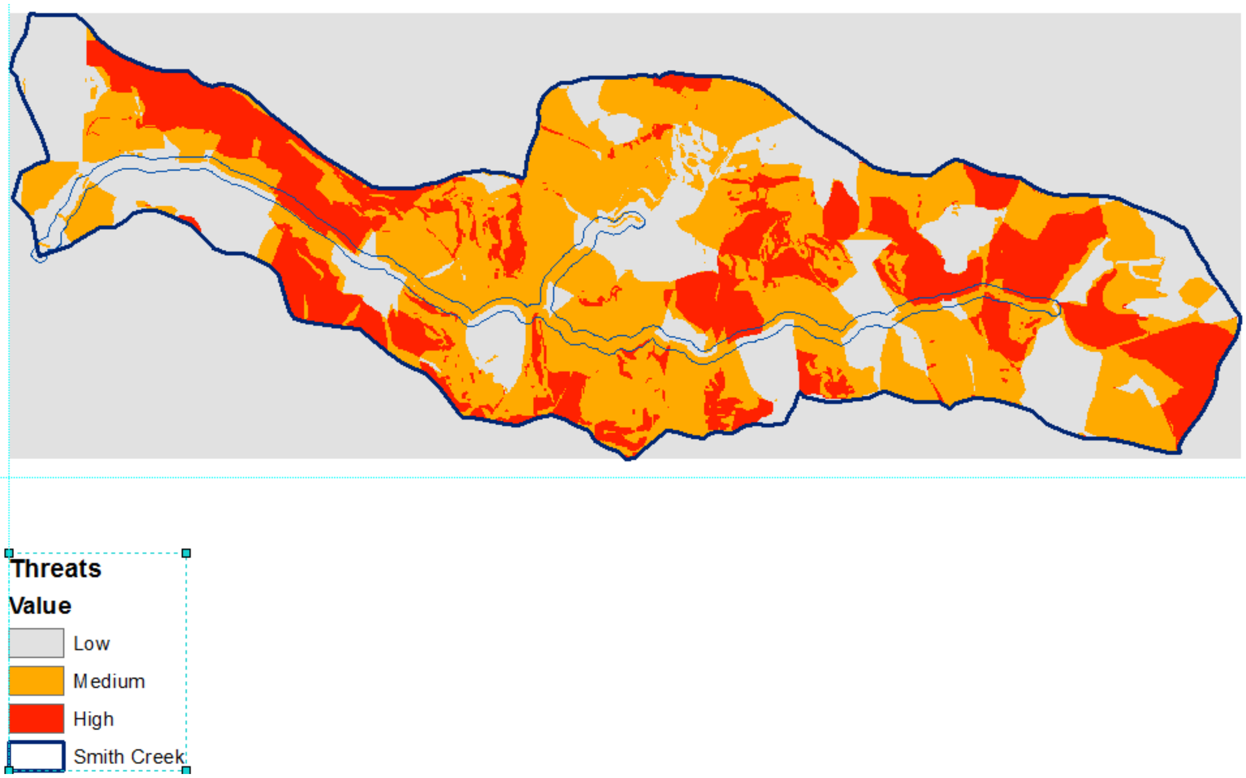


Figure 49. Threats grouped into High, Medium, and Low

Thinking in terms of risk, the following question can be asked: where are the Assets at greatest risk? In other words, where are high Assets overlapped by medium or high Threats?

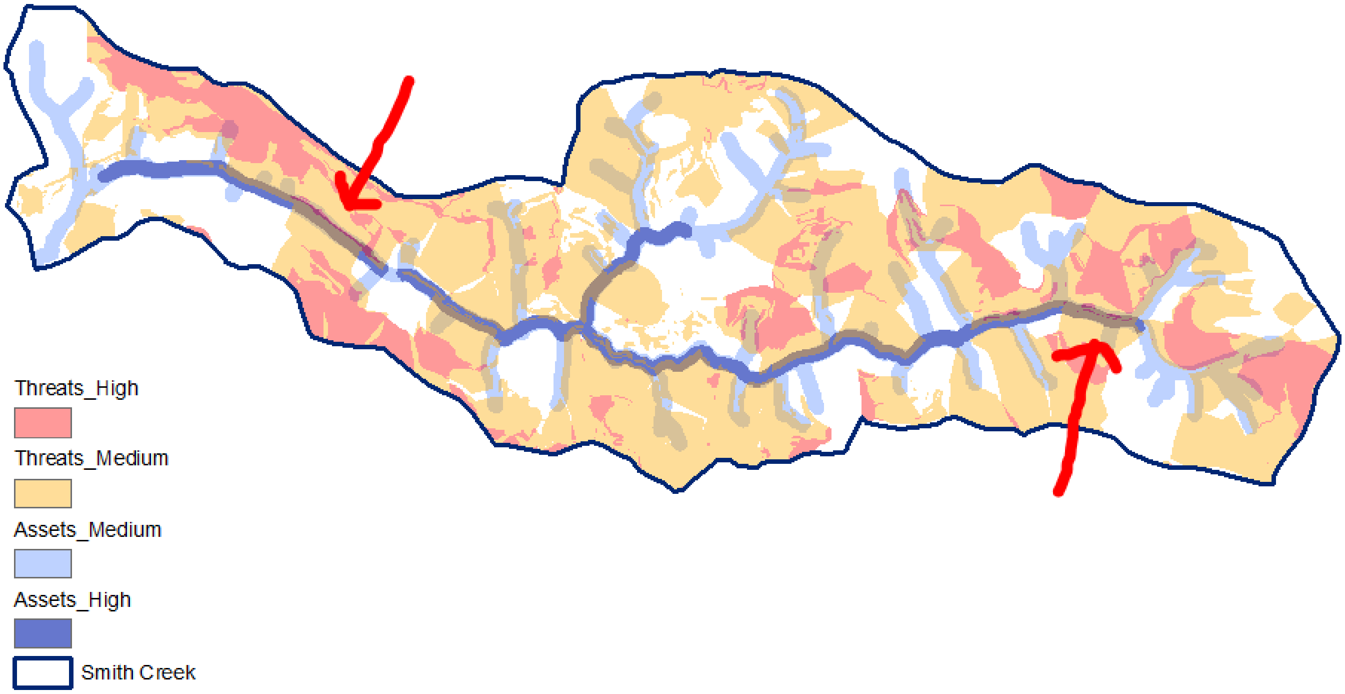


Figure 50. Overlaying Assets and Threats to target areas with potential for restoration

The red arrows in Figure 50 point to two areas where high and medium Threats overlap high Assets. That is, where high value areas for the resource of concern are potentially at greater risk from impacts. These locations are where potential restoration activities could have the greatest effect. Once potential restoration sites have been identified, these locations MUST be visited to validate the analysis. Before this analysis can be run, a final list of Inputs to the Assets and Threats sub-model would need to be agreed upon; including determination of which attributes should be valued and whether the inputs should be weighted.

From the data that were collected during the three-track analysis on the Smith Creek sub-watershed:

Assets could include:

- Adequate riparian function
- Coho intrinsic potential
- Existing and restorable coho habitat
- Pool formation potential from large wood recruitment
- Watercourses and WLPZs

Threats could include:

- Extreme, high, or moderate erosion hazard ratings
- Instream water temperature (not part of the analysis but deemed a missing piece)
- Landings[31]
- Roads
- Silviculture
- Watercourse crossings

[31] However, the Forest Practice Rules do not require landings to be mapped if they are outside of a WLPLZ.

Instream water temperature, deemed a missing piece, was included under Threats. Additional inputs could include slope or sediment.

Data Refinements

When determining the significant layers and attributes to be valued, some inputs are complex and expert knowledge is critical. Roads and timber harvesting fall into this category, with each having potential options regarding how the data are used.

Multiple aspects of roads (distance from watercourse, slope, in WLPZ, density, proximity to watercourse crossings, crossing density), timber harvesting (silviculture, yarding, multiple entries, distance to roads/watercourses, time decay), or any feature, can be included in an overlay analysis. One way to do this is to put the individual inputs into a sub-model. They can be valued separately and then weighted by importance in relation to each other. Then the sub-model can be combined with the other inputs in either the Threats (in this case) sub-model.

Feedback from PPWG

The webinar which presented these analytical scenarios was created to stimulate conversation, scientific and practical reflections on methods and repeatable processes, and illustrate how analytical characterizations can be synthesized to answer questions. The remarks and feedback from the PPWG are summarized below:

1. Include Best Management Practices as an input
2. Use the term “Activities” instead of “Impacts”
3. Add tribal cultural resources to Assets
4. EEMS—Environmental Evaluation Modeling System might be a good approach to modeling; authored by Conservation Biology Institute
5. Mass wasting should be included under Threats (Is there access to these data?)
6. Include legacy impacts to the landscape that will not recover on their own, e.g. incised channels
7. Include a routing element to indicate flow
8. Reach consensus on weighting factors for inputs
9. A literature review would be beneficial; this is a very difficult process in which to reach agreement on the modeling
10. Analysis would be more meaningful as a watershed-to-watershed comparison, rather than within a single watershed
11. Project 201 undertaken in the 1980s by Department of Fish & Game cleared large woody debris from watercourses; this would be a good place to start with restoration by restoring LWD
12. Employ the Delphi method[32] – process of consolidating expert knowledge input. This could help manage the subject matter opinions about inputs and weighting.

Ultimately, using an overlay process to synthesize inputs demands thoughtful consideration on how to value the model inputs and how to interpret and use the outputs; requires consensus among practitioners and acceptance by stakeholders; and warrants further structured exploration, which was not undertaken in this pilot project.

[32] The Delphi Method is an interactive technique, relying on experts’ anonymous judgements, which eventually distill into a decision.

3.4.3 GEOLOGY-FOCUSED ASSESSMENT OF EROSION RISK AND SEDIMENT SOURCES

The California Geological Survey created a findings document, *Geologic and Geomorphic Information Review for Smith Creek*, dated March 7, 2018 that can be found in Appendix 9. Below is a summary and update of some aspects of that document. The May 3, 2018 webinar was a visual tour of this summary.

Brief Overview of Methods

The draft *Geologic and Geomorphic Information Review for Smith Creek Basin* (geological document) explained in detail the process and results of augmenting data available in the Timber Harvesting Plan (THP) administrative record with specific land attributes as identifiable via remote sensing using the best-available digital elevation model (DEM) and available aerial photography. The draft review painstakingly articulated the inadequacy of the available geologic information for the purposes of identification of sediment yield, transport, and storage parameters to inform cumulative effects analyses and landscape restoration planning and projects.

In the geological document, CGS evaluated the following topics: Bedrock Geology, Hillslope Erosion, Roads, Large Woody Debris (LWD), and Channel Conditions. Additionally, for each topic the following subsections are provided: Key Concerns, Key Findings, and Explanation. Some topics are broken down into subtopics.

Overarching Findings

The following overarching findings apply across each of the topics:

- Readily available data exist and provided a limited, somewhat blurry view of the geologic dynamics within the Smith Creek watershed and the encompassing Campbell Creek Planning Watershed.
- Numerous data gaps and data quality issues adversely impact the confidence in interpretations of the watershed conditions and processes.
- To guide restoration activities, data requires supplementation to address questions brought up herein.

THP documentation provide snapshots in time and space of various reaches of Smith Creek and tributaries. The documentation referred to includes submitted THPs with PHI and pre-consultation reports, prepared by either CALFIRE foresters or CGS geologists. CGS PHI reports dating from 1987 to 2013 and THPs dating from 1991 to 2015 were referenced for information on channel conditions. The documents reflect both spatial and temporal variability beyond the general impressions made by the Cumulative Watershed Effects discussions and the CDFW stream surveys, and apparently contradict them. Generalizations of conditions over the entire basin tend to lose important details that pertain to impacts and restoration potential. Methods and terminology of characterizing channel conditions have remained essentially the same across the ~25-year span of these observations. This apparent consistency, if assumed, allows the observations to be grouped together as a set that spans the lower, middle, and upper reaches. The CDFW surveys fill in several gaps in the industry stream data.

On the other hand, the cumulative effects conclusions made in the geological document, if one accepts the data used at face value, substantially differ from the findings in THPs. The picture that emerges, if data are valid, true, and sufficient is the following interpretation which due to low confidence in the data should be considered as a working hypothesis.

Working Hypothesis

The stream system is out of equilibrium (Simon and Rinaldi, 2006) and shifting, possibly irreversibly to a new state which possibly may be within the long-term natural range of variation and has experienced:

a. episodes of channel incision that necessitated morphological reclassification between 1994 and 2012 in the lower reach and between 2012 and 2015 in the upper reach
b. ongoing sediment delivery to Smith Creek from a population of landslides that are thought to have initiated recently to almost 90 years ago
c. intermittent spikes in harvest-related and road-related landslide activity, especially in the early 1970s and the 1990s
d. ongoing aggradation caused by a persistent presence of debris jams that break-down and reform in the middle reach of Smith Creek, implying continual resupply of woody debris and sediment most likely due to ongoing bank erosion and channel incision in the middle reach and its tributaries.

In the geological document (Appendix 9), Table 1 shows the features, detailed in separate sections, used to develop the above scenario and how the various approaches agreed or disagreed. Detail for the individual processes are provided in separate sections. Tables 2, 3, and 4 in the referenced appendix provide a timeline of significant watershed events derived from the available data.

The working hypothesis and other questions raised here provide a basis for restoration planning which includes monitoring to determine trends and corrective measures.

Throughout the geological document (Appendix 9), CGS described data issues as (1) data gaps, 18 times; (2) omissions, twice; (3) misclassification, once; (4) misrepresentation, once; (5) perishable, outdated, or obsolete, once each; (6) contradictory, once; (7) bias, three times and (8) generally lacking in important detail, many times. To illustrate the uncertainty about data and the importance of data gaps, CGS included 50 unresolved questions regarding the specific topic of sediment-related cumulative watershed impacts, some of which cannot be accurately answered without decades of quality data, which are not readily available and may not exist.

Update to the Geological Document

In the geological document, *Geologic and Geomorphic Information Review for Smith Creek Basin*, CGS posited a working hypothesis that portions of Smith Creek are in geomorphic disequilibrium which may be partially due to a history of landslides that dammed the creek. Land use, seismicity, and storms may have contributed to the evolving disequilibrium. Additional corroboration has since emerged because improved elevation data became available for the project area.

The data was collected during the spring of 2017 using airborne Light Detecting and Ranging (LiDAR) procedures. During the first week of April 2018, CGS received preliminary deliverables of the data for inspection to verify that technical specifications were met. The data for the Smith Creek area was processed as part of the inspection and cursorily reviewed for significance to the Campbell Creek Pilot Project. Preliminary results that corroborate the hypothesis were provided to the working group on July 26, 2018. As of September 21, 2018, the higher resolution elevation data became publicly available.

This update summarizes the significance of the new LiDAR data to the geological document. The examination of the new data focused strictly on data quality and any significance to the hypothesis. The new data in part confirm and in part corroborate the hypothesis put forth in the original review. The new data revealed eight landslides that have, in the past, apparently dammed Smith Creek and display possibly persistent impacts on aquatic habitat characteristics and channel stability. The effects of damming can extend both upstream and downstream of the landslides and produce a collection of observable geomorphic features (Figure 51). Thus, the residual effects of the landslides may have significance to stream restoration activities. For example, sediment conditions within the flood-prone zone along approximately 75% of the lower reach of Smith Creek appear (based on the new elevation data) to be dominated by two landslides that occurred, perhaps one to several centuries ago.

For the Smith Creek basin as a whole, the presence of eight breached landslide dams revealed in the new elevation data represents perhaps the most direct evidence of the potentially major role that individual deep-seated landslides have had and possibly continue to have in Smith Creek in shaping aquatic habitat. Rare events such as landslide dams may be significant anomalies that are not easily modeled. No hypothesis-driven field investigation has been conducted by CGS. However, on-the-ground observations were separately documented in the administrative record for one of the landslide sites (Figure 51) for which a stream restoration project was designed, reviewed, and implemented in 2013.

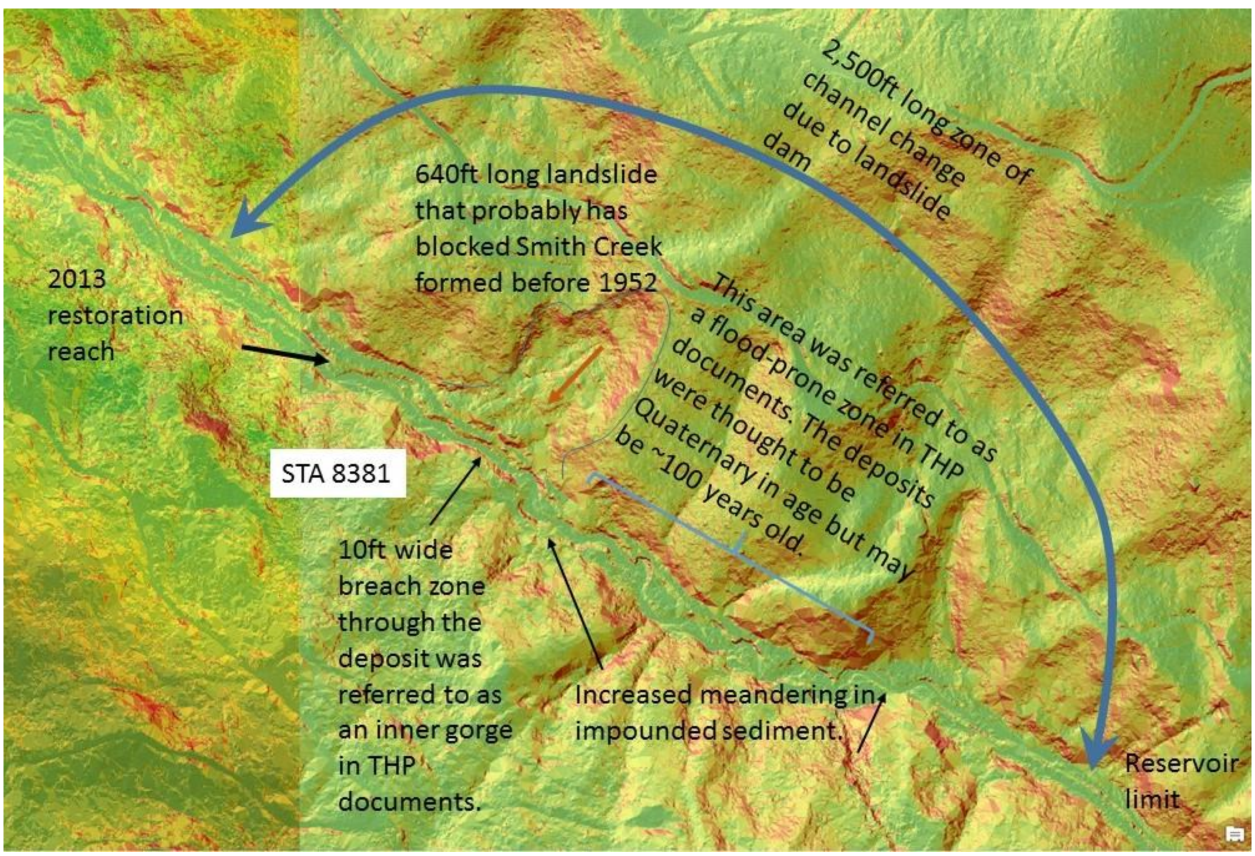


Figure 51: Map of a landslide at 8,381 feet upstream of the mouth of Smith Creek. In 2013, a channel restoration project involving large wood augmentation was conducted at the base of the landslide (indicated by the orange arrow) that may have temporarily dammed the creek until it eventually breached. Annotations indicate the locations of various observations that provide supporting evidence. The landslide dam scenario was not recognized during the evaluations of the restoration project.

3.5 Process Challenges

Negotiating Expectations

The intent of the pilot project process was to be a public process. The concept originated in discussions between agency staff and the public, with input during two public workshops and periods of open public comment. The composition of the Pilot Project Working Group (PPWG) represented a broad spectrum of the regulated and interested public, and there were up-front challenges in defining the scope of the pilot project versus the broader scope of forest regulation in California. During the process, agency staff reminded members of the public that the scope of the pilot project was narrower than some of their preferences. Public meeting participants and public working group members alike were interested in seeing California's forests managed differently, and to many pilot projects are an avenue to encourage systemic change.

In retrospect, deeper examination of what seemed to be conflicting goals —(a) looking for a way to systematically target restoration opportunities through the THP process and (b) review of the application of the Forest Practice Rules vis-à-vis cumulative impacts— might have been fruitful in understanding the broader picture of forest regulation and forest restoration in California. Looking at the FPRs in context of restoration goals has the potential of yielding actionable results. Striving for resiliency of forest health and aquatic and terrestrial habitats must co-exist and incorporate the ongoing goals of a sustainable timber industry in California. The Campbell Creek Pilot Project was unable to bridge these disparate viewpoints and tended to steer away from regulation and policy discussions.

Defining Restoration

Restoration was defined broadly in the Concept Paper using the Society for Ecological Restoration's definition: "Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed." Numerous members of the public, the PPWG, and the PPIIT expressed concern throughout the process that tangible restoration objectives were lacking in this pilot project. Without a more focused objective, all tracks of inquiry were somewhat self-directed by agency staff, working from the framework of their own expertise and experience, but not necessarily well-integrated with each other nor aiming for a synthesized conclusion about restoration in Campbell Creek.

PPWG Member Participation

Over the course of two-plus years, participation among members of the PPWG was inconsistent. Communication between and attendance by some members of the PPWG waned or even ceased. The low meeting frequency of the PPWG contributed to an overall lack of engagement, as did the lack of regular communication. The process aimed to be inclusive, but essentially became agency driven without regular substantive input from the entire PPWG.

Many public members of the PPWG desired more frequent communication and would have welcomed greater exchange and levels of participation; the absence of calendared meetings and conference calls or other methods of regularized communication diffused any functional integration amongst members. Stronger and more predictable cycles of communication between agency staff and public members might have generated higher expectations and greater collaboration between them.

The intent of agency leadership was to communicate with the PPWG members between meetings when there was substantive information to share. Work products tended to come in infrequent large pieces rather than frequent incremental pieces, and inter-meeting communications were limited. The autonomous functioning of the Pilot Project Interdisciplinary Implementation Team (PPIIT) along with the lack of a well-articulated operating structure within the PPWG served to stymie participation. The formation of the Scope of Work Team was not intended to neutralize the whole of the PPWG, but its existence unwittingly had that effect. Lacking clarity on mutual expectations or with roles and responsibilities, a reduced sense of ownership manifested.

Further, agency staff, though accommodating many extra tasks into their daily workloads, are compensated for their contributions. Public members of the PPWG, in many cases conducting their own private businesses, are expected to volunteer most or all their time without remuneration. Perhaps it is unfair to expect the public members—who possess expertise, interest, and a will to serve—to perform their critical professional work with little or no compensation.

LIMITED TRIBAL PARTICIPATION

Public agencies and tribal entities have forged practices of working together to protect cultural resources, and this must continue to expand and incorporate tribal environmental perspectives. The dominant perspectives held within agencies and the scientific community need to incorporate tribal values into a more synergistic and practical place in discourse and planning. There are many examples of land management choices designed to derive benefit from forest resources while adhering to traditional values.

The Yurok Tribe's Cultural Fire Management Council provides one example of a functional partnership whose landscape goals transcend a singular perspective to meet societal ecological goals, while enhancing tribal ones. Their mission is to "facilitate the practice of cultural burning on the Yurok Reservation and Ancestral lands, which will lead to a healthier ecosystem for all plants and animals, long term fire protection for residents, and provide a platform that will in turn support the traditional hunting and gathering activities of Yurok".[33] "Using modern technology and sound scientific principles tempered with cultural values the (Yurok) Program will work with the environment to provide current and future Tribal members financial revenue while preserving the integrity of those resources needed to maintain strong links to traditional cultural practices."[34]

The Campbell Creek pilot project would have benefited from greater tribal involvement throughout the process. No tribal-sensitive data were addressed in the project and a tribal perspective is largely missing. Beyond future pilot projects, state agencies must continue inviting tribal participation in all endeavors and work toward an intersection of science, cultures, and policy, that integrates Traditional Ecological Knowledge (TEK) into the process. Tribal partnership in forest restoration and resiliency, whether on tribal lands or not, is warranted and should be collegial and deliberate.

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[33] http://culturalfire.org/our-mission/

[34] https://www.yuroktribe.org/departments/forestry/

Terrestrial Restoration in Managed Timberlands

Throughout the pilot project process, the PPWG struggled with how to address upland terrestrial restoration on privately managed timberlands. Conversely, riparian and aquatic restoration practices were a practical goal, as streams and riparian areas are largely protected by various laws (WLPZ rules in the Forest Practice Rules, Fish and Game Code Section 1600, Waste Discharge Requirements in the Porter-Cologne Water Quality Act, etc.). Harvesting trees in riparian areas is limited, and the amount of harvest permissible with site-specific riparian management prescriptions under 14 CCR § 916.9(v) may benefit riparian habitats through restorative practices that allow for greater conifer growing space, enhanced light and nutrients for greater primary productivity leading to more salmonid production, bank stabilization, or large woody debris placement for improved habitat complexity. In general, active restoration methods to protect salmonids and aquatic habitat are well-defined, well-understood, and have well established infrastructure of agency grant programs, non-governmental organizations, supportive forest landowners, and experienced crews available to implement projects.

One goal of upland forest restoration could be to create a natural range of variation that supports a variety of species, while reducing sediment discharge and creating natural runoff regimes into streams, benefitting aquatic species and their habitat. An avenue of restoration in upland environments might focus on retention of large swaths of forest where the natural progression through all seral stages is promoted. Over time, this could create a forest composed of large, old trees with late-successional features, medium-age trees, tree fall gaps allowing space for early successional features, young trees, and a variety of wildlife associated with this heterogeneous forest.

Allowing a large area of forest to age without harvesting is not compatible with the financial goals of many timberland owners who reasonably expect income generation from timber harvesting. It is also in conflict with the intent of the zoning of most of the Campbell Creek Planning Watershed — Timber Production Zone (TPZ), per the California Timberland Activity Act of 1982.[35] However, there are potential scenarios where the objectives of upland terrestrial restoration and sustainable timber harvesting could align (e.g., with conservation easements), but this was not in scope for this pilot project. The Campbell Creek Planning Watershed is almost entirely owned by Lyme Redwood Timberlands, and areas in this watershed historically have been managed using evenaged silviculture, and more recently under a mix of evenaged and unevenaged practices. Other upland forest restoration goals could focus on eliminating invasive species, reducing fire risk, recruiting snags, etc. There are both passive and active restoration prescriptions to achieve goals such as these and warrant further study.

Establishing a Hypothesis

The partnership with Lyme Redwood Forest Company brought with it a trove of spatial data and decades of timber harvesting plans to explore. In the end, data mining without a clear hypothesis created a time-consuming, frustrating experience with far too many potential paths to follow. This was further

[35] See sections 51100-51155 of the Government Code. (http://leginfo.legislature.ca.gov/faces/codes_displayexpandedbranch.xhtml?lawCode=GOV&division=1.&title=5.&part=1.&chapter=6.7.&article=1.&goUp=Y)

complicated by trying to characterize THP contents that are often qualitative descriptions rather than quantitative measurements. The more data that were collected and the more paths explored, the more difficult it became to analyze.

This outcome was foreseen in the early phases of the project by a member of the public (who later became a member of the PPWP). A suggestion was also made that deserves consideration should additional pilot projects be undertaken:

> "… I strongly suggest that the Program consider developing specific working hypotheses driven by known understanding of the dynamics between forest ecology and forest management practices.
>
> … I suggest starting with first principles based on watershed process and function FIRST. Then look for various sources of information needed to explore those functions (which may or may not be found in the THPs)."[36]

The intent of this pilot project was to inform future pilot projects and to enable efficient and effective analysis in the future (see *The Concept Paper*). Subsequent pilot projects need to operate with stronger focus.

3.6 PUBLIC MEETINGS

After the initial meeting in December of 2016, the PPWG was convened again in May of 2017 in Fort Bragg. During this meeting, PPWG agency staff reported on the progress that had been made since the kickoff meeting. This included discussion of the refined critical questions, the resources of concern, and the rationale for scaling-down to a sub-watershed. The primary focus of this meeting was an elaboration of the three-track approach and the progress that had been made to that point. In the afternoon, representatives from Lyme Redwood Forest Company led the PPWG and public attendees on a tour of Lyme's property near Fort Bragg. Tour participants were able to observe Campbell Creek channel conditions near the entrance to South Fork Ten Mile River, extensive observations of

Figure 52. (right above) Zach Jones, Lyme Redwood Forest Company, leading a field tour of the Campbell Creek planning watershed on May 23, 2017.

Figure 53. (right below) Observation of the Smith Creek channel during the May 23, 2017 field tour of the Campbell Creek planning watershed.

[36] Comments made by PPWG member Mike Liquori, October 21, 2015.

seasonal road conditions, recent “fuzzy” clearcuts and tanoak treatments (Figure 52), and a large wood enhancement project in Smith Creek implemented in 2016 (Figure 53).

PPWG MEETINGS

In October of 2017, the PPWG met again in Fort Bragg. During this meeting, the following was accomplished:

- Recapped the previous work of the three-track approach
- Presented the Campbell Creek Pilot Project Open Data site (see Section 3.2 *Open Data*)
- Presented an in-depth summary of the further work completed with the three-track process, including an initial synthesis of the three tracks
- Discussed issues and limitations with the work to that point
- Began a discussion on answering the Critical Questions.

As previously mentioned, additional public meetings were held via webinar on April 19th, April 26th, and May 3rd of 2018 and are summarized above in *Beyond the Three Tracks: Additional Inquiry.*

3.7 ANSWERING THE CRITICAL QUESTIONS

The set of seven critical questions contained in the May 2016 Concept Paper were intended to guide the process and analyses for the Campbell Creek Pilot Project. In October of 2017 the discussion on answering the Critical Questions began. First responses, from the December 18, 2017 meeting notes of the PPIIT THP Mining Subgroup indicated that difficulties answering the Critical Questions had been identified below in Table 4.

Question	Step	Critical Question	First Responses (12/18/2017)
4	1A	What information is available in past THPs/NTMPs and other available data sources to characterize the historic and current biophysical and ecological conditions on the planning watershed, including cumulative effects?	THPs and other sources have been gathered but have not adequately brought this information together in a synthetic fashion, so the tasks involved in answering the question are incomplete. A stronger subject matter expert (Forester or RPF) would be helpful and importantly, a framework to organize the data. It would be best to create this framework before collating the information from these various sources.
	1B	What information is available in past THPs/NTMPs and other available data sources to characterize the historic and current biophysical and ecological conditions on the planning watershed, including cumulative effects?	If restoration criteria for a given element is well defined, prescriptive measures should be able to be defined and opportunities identified. The plans themselves use outside information and collaborations to address issues within their plans.
3	2	What are the qualitative and quantitative methods presented in THPs/NTMPs that analyze potential for THPs/NTMPs to create, add to, or ameliorate adverse cumulative effects on watershed and biological resources?	We need more work on this. Much information in a plan employs language from the rules; other studies are cited; there are strong descriptions of the watersheds and their condition and if active restoration has occurred.
5	3A	Are there gaps in the types or quality of information available on a planning watershed scale that would be useful for THP/NTMP preparation and review and for the assessment of CWEs?	We have not done enough work to establish this. A lot more THPs need to be evaluated to make that determination.

6	3B	If there are gaps, what additional information is needed and what data are available?	See above.
1	4A	What information, criteria, and methods can be employed, at the planning watershed scale, to identify restoration needs and priorities for watershed and biological resources based on available information?	The model described in Section 3.3.3 is useful and targets areas of concern. The EHR Mapper is another resource and there are other tools that can be helpful as well. More work is needed to identify or create them.
2	4B	Do past THPs/NTMPs and other available information, collated on a planning watershed basis, contain the information needed to guide restoration at the planning watershed scale?	Yes, though the organization of this has not been established. A ranking system that quantifies narrative descriptions might be helpful but would rely on SMEs to agree upon parameters.
7	6	What restoration needs or cumulative impacts can be identified from the planning watershed scale versus needing a different spatial context?	This depends on what you're examining. If the planning watershed contains the uplands and is a logical hydrologic unit, then the PWS can yield information, and certainly when looking at spawning and rearing habitat, the planning watershed can be a functional scale, though there may still be downstream impacts that aren't apparent at the PWS.

Table 4: December 18, 2017 responses to the Critical Questions

Several of the Critical Questions focus primarily on information available in THPs and NTMPs (see Table 4 above or the numbered items below). Some PPWG/SOW members, as the project progressed, questioned if concentrating only on THP-focused data was a limitation (see *Three-Track Approach*). This may have further complicated responding to the Critical Questions.

The answers to the critical questions were further refined at the end of the pilot project:

1. ***What information, criteria and methods can be employed, at the planning watershed scale, to identify restoration needs and priorities for watershed and biological resources based on available information?***

   a. THP mining – reading through past harvest documents (see *Track 1: Timber Harvesting Plans – Mining for Information Methods*). THPs in the Campbell Creek Planning Watershed have identified CDFW Stream Inventory Reports as a significant source of information used to describe watershed/biological resources for aquatic species habitat, which has been useful in identifying restoration needs and could continue to be so in the future. The conclusion of the Aquatic Habitat Assessment found in THP 1-13-031 MEN (plan pages 497-498) provides an example of this:

   "… Structural pool complexity and LWD loading were found to be less than ideal in both creeks, and LWD introduction was recommended in both CDFW 2012 Habitat Inventory Reports ..."

   It should be noted that where recent THPs in the pilot project area have provided new data, they have done so with a less detailed survey and targeted a percentage (30%-50% of the stream reach) in the immediate vicinity of proposed harvest units, not at the planning watershed scale. The CDFW Stream Inventory Reports are a much better source and are closer to a planning watershed scale than THPs/NTMPs; while mining of harvest documents might occasionally be useful in supplementing CDFW Stream Inventory Reports. (See Appendices 4 and 12.)

With respect to one of the small landowners (Smith Ranch, holder of 1-94NTMP-002 MEN) in the planning watershed, information is dated and priorities confined to that ownership, not the entire Campbell Creek Planning Watershed. However, a Notice of Timber Operations (NTO #22) for the Smith Ranch NTMP utilized an evaluation done by The Nature Conservancy to identify restoration needs and priorities. Unfortunately, the information, criteria and methods associated with identifying those needs and setting priorities for the Smith Ranch was not part of the NTMP or the NTO. The Nature Conservancy utilized a permitting process other than the NTMP to get approval for the restoration project.

For the majority of the Campbell Creek planning watershed there has been a succession of owners: Rex Timber, Inc. [1982-1988], Georgia Pacific West [1989-1999], Hawthorne Timber Company LLC [2000-2015] and Lyme Redwood Timberlands Forest Company, LLC [2016 to present]). Their priority when doing restoration work appears to be related to the proximity of active harvest operations. When priority sites are identified, they are generally treated, removing them as "restoration needs." Several THPs cite past work with Trout Unlimited that has led to watershed improvement. Also, while information of a limited scope may be gleaned from existing harvesting documents, the time required to gather it is disproportional to the value of the information, which tends to be qualitative rather than quantitative and not spatially-explicit to enable the identification of site-specific restoration needs. Restoration needs may be relatively lower in this watershed as the result of restoration that has already occurred.

b. Northern spotted owl (NSO) habitat maps in THPs/NTMPs and database reports from CDFW (summarized in THPs/NTMPs), when combined, can provide information about owl occupancy and habitat distribution (see Appendix 10 and *Terrestrial Habitat and Restoration*).

c. Remote sensing rapid assessment of existing imagery and LEMMA data (see *Track 2: Rapid Assessment with Imagery Analysis*).

d. Modeling – using existing modeling tools and physical characteristics (i.e., elevation, slope, past harvest, road locations) to identify discrete locations on the landscape, however, these models provide only an initial office level screening method to narrow the scope of the field work necessary to accurately locate restoration opportunities (see *Track 3: Modeling* and *Using Overlay Analysis*). Not based on available information, was the collection of new data using LiDAR completed as a part of this pilot project (see *LiDAR)*

2. *Do past THPs/NTMPs and other available information, collated on a planning watershed basis, contain the information needed to guide restoration at the planning watershed scale?*

For THPs and NTMPs, when considered in isolation, the answer is "no." Landscape scale information found in THPs and NTMPs is primarily qualitative and often not confined to a single planning watershed. A THP/NTMP often has harvest units in two or three planning watersheds, with general descriptions for this larger area. More specific information tends to be confined in harvest units and the immediately surrounding areas. THPs/NTMPs from different time periods have different levels of information due to changes in the requirements of the Forest Practice Rules and other regulations. Also, different RPFs provide different qualities of information. See Appendices 2, 3, 4, 11 and 12 for in depth reviews of the contents of various sections of THPs.

THPs and NTMPs do not provide digital spatial data, which is increasingly necessary for modern restoration planning and cumulative effects analysis. There have been some discussions about the potential for CalTREES to provide a means by which THP and NTMP submitters could provide spatial data pertaining to the harvest area, ownership (in the case of NTMPs), and cumulative effects assessment units (which might extend beyond ownership boundaries). However, this capacity has not yet been built into CalTREES, and some landowners and RPFs have expressed a wariness or unwillingness to provide digital spatial data into the public domain of harvesting documentation.

In the Campbell Creek Planning Watershed, the NTMPs that were available for review were over 20 years old (1994 and 1996). Therefore, they provided little or no information that might be useful to guide restoration at this time. In the THPs the information that appeared to be most useful was often derived from other sources, most notably CDFW 2012 Stream Inventory Reports. The CDFW Stream Inventory Reports contain more of the kind of information needed to guide stream restoration, especially where entire watercourses have completed surveys (i.e., Campbell Creek was fully surveyed, but Smith Creek was not). (See Appendix 4.) Gaps in the CDFW reports are not fully filled by surveys done by plan submitters and summarized in THPs/NTMPs. For the pilot project area the most recent CDFW Stream Inventory Reports do not cover all of the Class I watercourses in the planning watershed – so, unless there is information other than CDFW Stream Inventory Reports and THP Aquatic Habitat Assessments (Appendices 4 and 12) it seems likely the answer to the question of whether adequate information exists to guide stream restoration at the planning watershed scale is “No.” It should also be noted that, like THPs/NTMPs, a drainage may cross more than one planning watershed.

THP/NTMP and CDFW northern spotted owl status information sections were not found to contain the appropriate habitat delineations necessary to create a restoration regime focused on increasing populations of NSO in the Campbell Creek Planning Watershed (see *Terrestrial Habitat and Restoration*).

Other available information may include existing remote sensing, as used in the rapid assessment and modeling described in detail elsewhere in this document. These sources contain different information needed to guide restoration at a planning watershed scale than either THPs or NTMPs, but also appeared to be reliant on a need for field verification. Google Earth, NAIP, and LEMMA imagery are readily available, relatively current, and easy to use. They can be used together to provide rapid information on riparian stand conditions, including large wood recruitment potential along fish-bearing streams. Similarly, combined LiDAR reflectance and canopy height data can provide good information about large wood recruitment potential that is likely better than that obtained from aerial photos. Ground-based observations of tree heights concurred closely with those obtained with LiDAR. Where the data are available, LiDAR-based analysis could rapidly assess large wood potential over large areas, at the planning watershed scale or larger. The pilot project team’s experience with using LiDAR indicated that it provides high quality data for forestry and watershed analysis for numerous applications. The data’s high spatial resolution, continuous coverage, and locational precision allows for analyses not possible from other sensors or ground-based technology.

Other modeling efforts were able to screen for areas where large amounts of sediment could be susceptible to being routed downstream to fish-bearing watercourses. These areas could then be investigated in the field and specific areas identified where anthropogenic sediment sources should be removed or otherwise mitigated.

In summary, the use of spatial data and modelling tools illustrates the ability to identify discrete portions of the landscape using pre-existing, publicly available data to narrow the scope of field work to identify site-specific restoration needs. The modeling approach requires technical experts with knowledge of physical processes and geospatial modeling techniques, and concise, targeted questions or objectives. The methodology outlined in the methods sections serve as an example of an initial approach, which can be modified and targeted further based on ecological/physical setting, landowner objectives, or reviewing agency needs. The use of these kinds of methods incorporating spatial data with analysis and modeling is consistent with the recommendations of Dunne et al.[37] in their examination of scientific approaches to the prediction of cumulative watershed effects.

Not evaluated in detail in this pilot project were the CDFW Stream Inventory Reports themselves (aside from noting the inclusion of this information in THPs), except for the work that CGS provided in the *Geologic and Geomorphic Information Review for Smith Creek Basin* (Appendix 9) and in the webinar. Several separate surveys along Smith Creek were compared. Substantial differences were noted in the descriptions of the physical environment. The combined information was insufficient to derive confident conclusions but sufficient to pose working hypothesis that Smith Creek may be in geomorphic disequilibrium - possibly due to residual landslides impacts.

3. ***What are the qualitative and quantitative methods presented in THPs/NTMPs that analyze the potential for THPs/NTMPs to create, add to, or ameliorate adverse cumulative effects on watershed and biological resources?***

The Forest Practice Rules do not specifically require cumulative effects assessment methods to be disclosed in THPs/NTMPs (See, e.g., 14 CCR sections 912.9, 932.9, and 952.9; as well as Technical Rule Addendum No. 2, Cumulative Impacts Assessment). See Appendices 2, 3, 4, 11 and 12 for in depth reviews of the contents of various sections of THPs, including what content might be useful to analyze the potential for THPs/NTMPs to create or add to adverse cumulative effects on watershed and biological resources. The contents of THPs are primarily narrative in nature. It should be noted that the intent of the Board of Forestry in the development of the Forest Practice Rules is that: "… [N]o THP shall be approved which fails to adopt feasible mitigation measures or alternatives from the range of measures set out or provided for in these rules which would substantially lessen or avoid significant adverse impacts which the activity may have on the environment." [14 CCR section 896(a)] Where a THP/NTMP is in conformance with the Forest Practice Rules the presumption is that significant adverse impacts have been avoided.

Appendix 5 summarizes qualitative and quantitative information used in the preparation of THPs/NTMPs including, but not limited to: soils maps, geology maps, natural diversity databases, northern spotted owl databases and, CDFW Stream Inventory reports. Where necessary specialists are employed to address specific issues. Examples include employing a Certified Engineering Geologist to review unstable slopes, a wildlife

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[37] Dunne., T., J. Agee, S. Beissinger, W. Dietrich, D. Gray, M. Power, V. Resch, and K. Rodrigues. 2001. A scientific basis for the prediction of cumulative watershed effects. Report No. 46. Wildland Resources Center, Division of Agriculture and Natural Resources, university of California, Berkeley. 103p.

biologist for sensitive species and/or a botanist for sensitive plants. Reports by specialists are generally found in Section V of a THP (Supporting Documentation) and summarized where appropriate in other sections of the plan.

Section IV (the Cumulative Impacts Analysis) of THP 1-15-107 MEN is representative of the contents of recent THPs submitted in the Campbell Creek planning watershed in stating the standard practice of this landowner is not creating or adding to adverse cumulative effects in designing and implementation timber harvest operations. Discussed are several strategies used to deal with negative environmental effects from implementation of forestry projects including: avoidance (avoid the impact altogether by not taking actions or parts of actions), minimization (minimize impacts by limiting the degree or magnitude of the action and its implementation) and mitigation (repair, rehabilitation or restoration environmental degradation).

Several types of practices to achieve avoidance, minimization and mitigation are identified including: Best Management Practices (employing a pre-determined suite of management practices that are known to minimize or avoid adverse impacts), site specific practices (employing individual or combinations of practices or techniques that are tailored to avoid, minimize or mitigate adverse impacts that are specific to the project or portions thereof), on-site mitigation (mitigation implemented within the footprint of the proposed project, or very closely associated), off-site mitigation (mitigation that is implemented outside of the footprint of the proposed project and is expected to address impacts that could be associated with the proposed project).

The methods and practices used in designing and implementing THPs such as 1-15-107 MEN to address cumulative effects include the strategies and practices described above. The selection of the final suite of practices varies by resource requiring protection and is an iterative process with feedback and adaptation of final selected practices being provided by the cumulative effects analysis itself, a circular feedback process that may be done many times during the course of project design. The end goal of the project proponent is to achieve the initial project objectives and not only prevent adverse cumulative environmental effects, but also achieve a positive cumulative environmental outcome. Significant effort is made to compare the current condition with that of the known desired condition of the affected resource. From this comparison understanding can be gained as to whether a cumulative impact from past, present, and future projects will occur, and whether it can be expected to improve or degrade an affected resource. THP 1-15-107 MEN acknowledges that cumulative effect analysis is an imperfect science.

The following observations speak to other ways in which THPs/NTMPs avoid adverse cumulative effects (these examples focus mainly on aquatic habitat):

- Quantitative and qualitative methods include summarizing the CDFW Stream Inventory Reports where available and gathering a subset of similar data for a portion of the stream reaches where data is missing.
- Reference to existing studies on sediment delivery, etc. for planning harvest operations is a qualitative (and sometimes quantitative) method of assessing potential impacts.

- Professional judgement is a qualitative method. Many RPFs have been working in the same watershed or watersheds for 10 or even 20+ years. They are familiar with historic conditions, elements of past harvest plans that may not have been labeled "restoration" but that have reduced sediment delivery to watercourses, improved access for fish (like when a culvert that is a barrier is replaced with a larger one, a bridge, or simply removed and the road abandoned), etc. (See Appendix 4)
- Compliance with the Forest Practice Rules. The Rules have been designed to avoid the creation or addition to adverse cumulative watershed effects, and to ameliorate existing negative impacts. There may be qualitative and quantitative information on file with the Board of Forestry and Fire Protection regarding how each new rule is expected to avoid/ameliorate potential cumulative impacts.
- The Nature Conservancy involvement in restoration with one of the NTMPs (1-94NTMP-002 MEN), Trout Unlimited's involvement with Lyme Redwood Timberlands Forest Company LLC (LWD enhancement project associated with THP 1-13-031 MEN) may be considered qualitative methods to avoid creating or adding to existing conditions and to ameliorate adverse effects as current and past restoration projects are mentioned in THPs/NTMPs.

Although questions about what restoration has already occurred were not among the Critical Questions for this Pilot Project they do have a bearing on amelioration of adverse existing cumulative effects. For the majority of this planning watershed there has been a series of owners, as noted earlier. By focusing on only the most recent harvest plans the history of restoration work already performed has not been fully revealed. Below is text from THP 1-96-003 MEN disclosing that even 20+ years ago the landowner (at that time, Georgia Pacific West) was actively undertaking stream enhancement (page 42, emphasis added):

> "Initially stream restoration activities undertaken by the Department of Fish and Game in the late 1960's focused on the removal of logjam barriers which partially or completely blocked access by anadromous fishes into important spawning and nursery tributaries. Recent restoration efforts in the Ten Mile basin during the last 10 years have focused mainly upon habitat enhancement projects (as opposed to restoration projects) in effort to increase available spawning rearing habitat for juvenile fish. This work has included placement of scour logs, cover logs, barrier modification, boulder placement, and rip-rapping of stream banks. **These enhancement projects were initially completed in November of 1992**, by the Center for Education and Manpower Resources, INC. (CEMR). Preliminary results reported by the director, William Kidd, indicate a 50% success rate of 36 placement sites on the North Fork. **This year the CEMR has several enhancement projects are scheduled within the Ten Mile basin, including the south fork and its main tributaries**.
>
> Currently Georgia-Pacific is conducting the following watershed monitoring/enhancement and biological studies within the assessment areas: …
>
> … Fisheries habitat inventorying was implemented in the SFTM in 1994. Field survey have been completed for the south fork and its tributaries, analysis is scheduled for completion by January 1996. Inventory data will be focused on identifying areas critical to future monitoring and enhancement work.
>
> … **Stream enhancement projects within the Ten Mile basin are focused on high impact areas and 'open sores' identified by the biologists during instream monitoring and habitat inventorying activities. These enhancement projects are designed to enhance and create spawning and nursery habitat for the anadromous fishery in the Ten Mile River basin**."

Species other than those associated with watercourses also are addressed in THPs, including methods used in THP to avoid creating or adding to adverse cumulative effects (THP 1-15-107 MEN):

> With respect to the forestry staff, the Company's current practice of assessing the presence or absence of raptors and plants in proposed timber harvest areas is to visually inspect the area during plan layout or note incidental species occurrence during other wildlife surveys in the plan or assessment areas.
>
> For plants, the area searched includes seasonal roads, tractor roads, logging/tractor road watercourse crossings, road cut banks, wet areas, seeps, watercourses, and harvest unit perimeters. For those plant species that prefer hydric or mesic conditions, protection is expected to be provided through implementation of watercourse and lake protective measures (refer to Item 26). For other plants, such as those that usually invade/occupy disturbed sites, harvest operations are expected to be beneficial.
>
> For raptors, company foresters note presence of feathers, whitewash, plucking posts, snags, green wildlife trees (trees with decadence, structural deformities, cavities, broken and or bayonet tops, mistletoe brooms, evidence of internal rot) and potential platform nests during plan layout. The company foresters also listen and look for raptors during field preparation. Raptor calls are usually very easy to detect and distinguish. Given the extent to which foresters inspect the entire plan area during layout, this allows for a reasonable expectation that when a raptor is heard/seen or a platform nest, snag with cavities, green wildlife tree with nest potential, feathers, whitewash, or plucking post does occur it will be detected. When potential raptors or their nests are located by foresters, the Company wildlife department is contacted to identify the species and determine appropriate mitigation to insure that the active nest of raptors will not be taken or destroyed as per 3503.5 of the California Department of Fish and Game Code of regulations. [THP 1-15-107 MEN, page 120]
>
> NSO habitat classification was done by different means for different stands. On the Hawthorne ownership, stand types have been correlated with habitat classifications. This is supplemented by aerial photo review and field work by foresters and biologists on the ownership. These efforts result in updates to habitat classifications over time to best reflect current conditions. [THP 1-15-107 MEN, page 121]

Each northern spotted owl activity center has a requirement for habitat retention which is described and mapped in the plan (unless the landowner has an Incidental Take Permit). For most harvesting plans, like the ones in this planning watershed, the qualitative and quantitative requirements found in THPs/NTMPs are included in guidelines provided by the U.S. Fish and Wildlife Service (USFWS, see Appendix 10).

Mapping and summary tables of habitat pre-/post-harvest and the thresholds in the USFWS guidelines are used to analyze the potential for THPs/NTMPs to create, add to, or ameliorate adverse cumulative effects on this biological resource. Where the plan meets the criteria in the USFWS guidelines the presumption is that significant adverse impacts have been avoided. (See Appendix 10)

4. ***What information is available in past THPs/NTMPs and other available data sources to characterize the historic and current biophysical and ecological conditions on the planning watershed, including cumulative effects? Is this information adequate to identify restoration opportunities at the THP/NTMP scale?***

Historic information is provided in THPs/NTMPs as a narrative of land use, generally beginning with initial harvest entries (sometimes as far back as 1900). This is usually for the planning watershed or larger area. In current THPs in the pilot project planning watershed (plans from 2013 forward) this discussion is found in the Erosion Control Plan in THP Section V. In earlier THPs (2010 and earlier) the information is found at the beginning of the Cumulative Impacts Assessment in THP Section IV. Caution: most of the harvest plans reviewed in detail (plans from 2007-2015) are not confined to the Campbell Creek Planning Watershed so the discussion of early history and land use patterns must be read carefully to exclude non-applicable material.

The history of much of the pilot project planning watershed begins with Union Lumber Company construction of a railroad network along the Ten Mile River's main stem and up the larger tributaries around 1900. Burning occurred two or three times in association with the harvests. Significant disturbance and adverse effects to watercourses and near-stream areas, some effects of which linger to this day, is acknowledged. Railroad logging continued in the late 1930s to 1949, likely including Smith and Campbell Creek watersheds. Early road construction was typically immediately adjacent to the stream channels and impacted nearby and downstream watercourse channels. Non-timber operations during this time, included grazing (there is pasture and cultivation along the banks of Smith Creek for about its first ½ mile), stream clearance in the 1960s (exact location may not be in the Campbell Creek Planning Watershed) and gravel mining (probably not in the pilot project watershed). Prior to the 1970s the tax structure encouraged removal of high value overstory trees and leaving hardwoods, altering the natural stand structure and composition. In the 1970s, cable yarding moved many roads away from drainage bottoms but construction across drainages increased sidecast into watercourses and increased diversion potential. In the 1980s substantial changes in the Forest Practice Rules were instituted to improve stream protection, erosion control, road and landing construction and maintenance. From 1990 to 1997, with more protection from rules, road construction techniques improved, and between 1997 and 2007, roads were constructed mainly to replace tractor yarding with cable systems. Silviculture and yarding methods became less intensive.

Discussion of current conditions may include a general discussion of the assessment area as relatively diverse, containing redwood and mixed evergreen coniferous forest. The coniferous forest having a range of ages and stand compositions resulting from disparate initial harvests and a broad range of subsequent regeneration and silviculture techniques being utilized. Suitably sized hard snags and soft snags are present. A network of WLPZ corridors link NSO habitats to form an interconnected reserve area. The extent of this reserve exceeds 10% of the area and the proportional set asides (0.25 acres reserve /5 acres clear-cut= 5%) advocated in CDF&G's "Snag Resource Evaluation" (Snag Resource Evaluation, page 10, David J. Richter, CDF&G, 1993). WLPZ areas are buffered by the lower-slope selection systems being adopted under the plan submitter's Enhanced Riparian Management Scheme.

Information provided in THPs/NTMPs can include discussion of research and data collected for Section 303(d) listing of the Ten Mile drainage for sediment (data that is now approximately 20 years old). THPs from 2010 forward contain a characterization of historic conditions/cumulative impacts compared to current conditions/cumulative impacts (quotes are from the Cumulative Impact Assessment [Section IV] of THP 1-10-033 MEN)(Figure 54):

Research Related: Past non-timber harvesting projects completed and/or on-going during the past 10 years are generally noted for their positive strides toward understanding, protecting and enhancing watershed and biological resources. Currently, HTC is conducting the following watershed monitoring/enhancement and biological studies within the assessment areas:

- Northern Spotted Owl studies/surveys with the necessary Department of Fish and Game permit(s).
- Continued stream monitoring within selected sub-watersheds (including temperature and fish presence).

1.

Miscellaneous: HTC is constantly upgrading and maintaining its rocked, all-weather mainline haul routes within the Campbell Creek assessment area and throughout their Ten Mile River ownership which includes the Little Valley Creek area. Recent past improvements and upgrades, which have occurred in the last couple of years, include several miles of rock re-surfacing and chip sealing, addition of relief culverts and upgrading several crossings through replacement of undersized/damaged/or not functioning properly culverts and rocking approaches. This and other upgrades and general maintenance will substantially lessen the potential for significant adverse sedimentation effects.

According to the technical TMDL for the Ten Mile River Watershed, the overall average sediment input rate has significantly decreased over the period of record (1933-1999). For example, the average input rate for the 1989-1999 period (628 tons/mi2/yr) is far from the historic inputs observed in the periods 1933-1942(1569 tons/mi2/yr) and 1953-1965 (1683 tons/mi2/yr). Campbell does recognize that even though the overall rate of delivered sediments continues to decline over the time, the percent contribution of sediment from forest roads (surface erosion) has increased in the last several decades (see figure below).

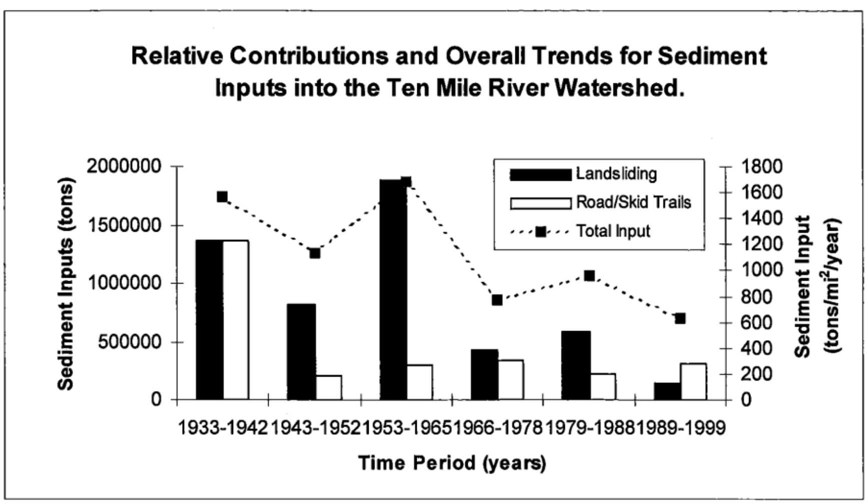

Figure 54. Sediment chart from THP 1-10-033 MEN

Historic conditions and cumulative effects are identified but this information is generally not adequate to identify restoration opportunities at the THP/NTMP scale.

Another available data source would be the CDFW Stream Inventory Reports, which contain more quantitative information than THPs typically do. For Campbell and a portion of Smith Creek surveys were completed in 2012 (CDFW 2012). Historic context could be gained by looking at the previous survey (CDFW 1994) to see what changes (adverse or beneficial) occurred during the period that elapsed between surveys. This was not evaluated in detail as part of this pilot project but may have the potential to identify restoration opportunities at the THP/NTMP scale. In any case, the 2012 stream inventories are now somewhat dated, given the dynamic nature of streams whether due to natural or anthropogenic disturbance or recovery processes.

Supplemental surveys conducted by the plan submitter's biologists may not be suitable for characterizing any but the small area surveyed. For example, THP 1-10-033 (page 389) states: "… Due to the length of stream requiring surveying on the South Fork Ten Mile River (approximately 3,000 feet), we divided the segments of the Valley Gate THP class I habitat into three reaches each measuring approximately 1,000 feet in length. We then systematically selected one of the survey reaches in order to sample at least 30% of the total instream distance." The segment of the South Fork Ten Mile River that was surveyed was not depicted on the single map found in the Aquatic Habitat Assessment (in THP Section V). But, because the survey functioned as reconnaissance to determine watercourse Class I/II transitions its general location can been approximated.

The current (2015 forward) Forest Practice Rules require that at the THP/NTMP scale, sensitive conditions be identified that have the potential to directly impact watercourses. These conditions are to be considered for inclusion in the harvest document, along with measures needed to maintain and restore (to the extent feasible) values described in the rules for the protection of fish and wildlife habitat (code section 14 CCR § 916.4). See Appendix 7 for an extensive discussion of this rule. The restoration opportunities identified at the THP/NTMP scale are required to be considered for remediation, where feasible, as part of the THP/NTMP in which they are described.

There are temporal and spatial problems with using "… information … available in past THPs/NTMPs … to characterize the historic and current biophysical and ecological conditions on the planning watershed, including cumulative effects." This problem speaks to whether the information available: "Is … adequate to identify restoration opportunities at the THP/NTMP scale." At the Campbell Creek Planning Watershed scale there have been eight plans in the past eleven years. They are widely scattered over the landscape and when they provide detailed information it is generally confined to the immediate surroundings of the plan area leaving large areas without current information. The wider the area being discussed the more general the information is. By going back further in time there are more THPs to examine but the information is dated. With time, trees have become established, grown in diameter and height, provided stability and erosion protection to areas that may have been exposed at an earlier time, etc. Restoration work may have been done outside of the THP process and not captured in discussions in current plans. Also, the further back one goes, the less information was required by earlier versions of the Forest Practice Rules. I.e., in the 1980s harvest plans were not required to include any cumulative impacts assessment. Listed species (salmonids, NSO, etc.) were addressed only in general terms, if at all, prior to being listed under state or federal endangered species acts.

Historic and current biophysical and ecological conditions may be gathered from northern spotted owl information in harvesting plans. Each northern spotted owl activity center has a requirement for habitat retention that is described and mapped in the plan (unless the landowner has an Incidental Take Permit). For the Campbell Creek Planning Watershed, the qualitative and quantitative requirements are the requirements of the U.S. Fish and Wildlife Service guidelines and are addressed in the THPs/NTMPs. Where a harvest plan meets the criteria in the USFWS guidelines the presumption is that significant adverse impacts have been avoided. (see Appendix 10) However, THP/NTMP and CDFW northern spotted owl status information were not found to contain the appropriate habitat delineations necessary to create a restoration regime focused on increasing populations of NSO in the Campbell Creek Planning Watershed (see *Terrestrial Habitat and Restoration*).

Is information derived solely from THPs/NTMPs adequate to identify restoration opportunities at the THP/NTMP scale? The answer seems to be “yes” and “no.” Yes, some information is provided in a THP with respect to the opportunity, however, it may be as simple as reference to a CDFW Stream Survey citing a LWD shortage in a certain drainage or reach of a stream. The “Catch 22” is that these opportunities are often not simply identified in the THP yet are treated as part of the THP operations. By the time “THP mining” takes place they are no longer opportunities. In this instance, the answer to the above question is “no.”

It is possible that the Campbell Creek Planning Watershed simply does not have significant restoration opportunities available to provide a more definitive answer to this Critical Question.

5. ***Are there major gaps in the types or quality of available information, on a planning watershed scale, that would be useful for THP/NTMP preparation and review, and assessment of CWEs?***

A gap identified involved recent (relative to the submission dates of the THPs) CDFW Stream Inventory Survey reports. The gap was composed of those stream segments without recent past stream surveys. Instream water temperature was identified as a gap in *Using Overlay Analysis*, but is not often required for THP/NTMP preparation or review. Geology data were found to range between moderate and poor with temporal and spatial coverage being spotty (see *Geology-Focused Assessment of Erosion Risk and Sediment Sources*).

There are two recent (2012 and 2017) Forest Practice Rules specific to restoration; (1) the restoration of aspen areas and (2) management of white and black oak woodlands to restore and conserve resources (code sections 14 CCR 913.4(e), 933.4(e), 953.4(e) Aspen, meadow and wet area restoration and 14 CCR 913.4(f), 933.4(f), 953.4(f) White and Black Oak Woodland Management). These rules are too recent to have been considered in most of the plans in the Campbell Creek Planning Watershed so THPs are an unlikely source of information. Consideration needs to be been given to what outside sources could identify suitable sites for the use of these prescriptions.

Regarding herbicide use, THPs provide a general statement that herbicide may be used, though this is not a reliable predictor. A large landowner will know where on their property herbicides have been used in the past, but they may not know of herbicide use on other ownerships. Non-timberlands may be using herbicides, and this would not be discoverable in THPs/NTMPs.

Some data have a finite life. Most notably are surveys for plant and animal species. Over time there may be complete coverage at the planning watershed scale, but portions of that data could be 5 years old, 10 years old or older, and no longer reflecting current conditions. For northern spotted owl, surveys are required for every THP/NTMP with few exceptions. There may be gaps where no surveys have ever occurred or where none have occurred recently. For northern spotted owl, survey information required by the U.S. Fish and Wildlife Service for THP/NTMP approval is not available elsewhere at this time. If the protocols are followed no additional information should be needed for preparation, review or assessment of NSO CWEs for harvest documents. (see Appendix 10)

Given that THPs have been reviewed with the level of information found in the existing Cumulative Impacts Assessment (Section IV, discussion that varies little between THPs in the Campbell Creek Planning Watershed) there do not appear to be any significant gaps in the types or quality of information available for the majority landowner in this watershed to use in future THP preparation. If the most recent past harvest document passed the review process the next one in the same planning watershed should be able to use much, if not all, of the information and even same text. The most recent THPs include these findings: "... There are no known recent trends which have produced significant cumulative impacts upon biological resources within the assessment area." and "In Summary, watershed conditions today are improving and over time continued improvement of stream conditions [within] the watershed is anticipated." (text found in both of the 2015 THPs) (also see Appendix 2). Possible exceptions could include listing of a previously unlisted wildlife or plant species and a natural disaster that impacts a large portion of the planning watershed (i.e., wildland fire, wind damage). In the wake of such exceptions major gaps in types and/or quality of information may arise.

Regarding this question, the fact that most of the Campbell Creek planning watershed has been in a single industrial timberland management status for decades means that useful information for THP preparation is part of the owner's archives. Their databases are likely to contain more useful and site-specific information than can be obtained from other sources. But even this would have gaps in some areas, such as time sensitive information (i.e. wildlife and plant surveys).

6. ***If there are gaps, what additional information is needed and what data are available?***

Gaps were identified in stream, wildlife and plant survey information. The timberland owner conducts their own surveys specific to the proposed harvest areas, but not at the planning watershed scale. There do not appear to be currently available, ready to use, alternative sources of information to fill these gaps. To aid the small landowner, it would seem preferable for CDFW to pursue completing habitat inventory surveys for major watercourses, particularly in areas with anadromous salmonids. This would provide consistency and fill gaps in parts of watersheds where there have not been recent harvest plans and where harvest plans are not likely in the near future.

Data gaps associated with geology-focused assessments were characterized "… sediment related cumulative impacts some of which cannot be accurately answered without decades of quality data which is not readily available and may not exist." (See *Geology-focused Assessment of Erosion Risk and Sediment Sources*, working hypothesis)

Additional information that can fill the gap concerning past use of herbicides at the watershed scale is available from the California Department of Pesticide Regulation (www.cdpr.ca.gov). Reports of past herbicide use can be generated by township or sections. A more useful format for the purposes of the pilot project would be Planning Watershed. (see Appendix 6)

The discussion about LiDAR indicated a potential for use in identification of gaps. However, the assessment of LiDAR associated with this pilot project did not specifically look for gaps, and at present, LiDAR data has not been fully field verified nor processed in a manner to fill significant gaps on its own. See the *LiDAR* section; for example, models used for deriving tree DBH from tree heights did not match field measured DBHs and issues with modelling hardwood cover values from LiDAR were identified (associated with reflectance values). In the future LiDAR may be able to produce the type of additional information necessary to fill many gaps in existing data. To fill gaps using LiDAR derived information would likely need detailed analysis by a qualified individual, with field verification.

7. ***What restoration needs or cumulative impacts can be identified from the planning watershed scale versus needing a different spatial context?***

This question was open to too much interpretation to be able to provide a definitive answer. "Restoration needs" would need a clear definition to pursue an answer further. However, water flowing from many planning watersheds can combine at the mouth of a river so focus on the planning watershed scale may not acknowledge downstream impacts. Example, generally an estuary receives input from more than one planning watershed. Maybe there are unintended consequences approaching analysis one planning watershed at a time or independent of others in the same larger draining system. Things that improve headwater or mainstem conditions might not be beneficial for out-migrating salmonids when they pass through the lower stream reaches and the estuary. The fact that CDFW Stream Inventory Reports aren't confined to a single planning watershed but are tied more to a drainage, regardless of whether it flows through one or more than one planning watersheds, seems to speak to this question. Nothing in the Forest Practice Rules requires a THP/NTMP to be in a single planning watershed so the assessment areas are often two or more planning watersheds simply because the harvest units are in two or more planning watersheds (see Appendix 4). Non-aquatic restoration needs/cumulative impact identification often will reach beyond the boundaries of a single planning watershed. If the habitat being restored is northern spotted owl habitat then it often crosses ridges, straddling the boundary of two or more planning watersheds. THPs/NTMPs assess NSO habitat by the distance from owl activity centers, not by planning watershed. Restoration of a sensitive vegetation type closely tied to a given soil or parent material type would be unlikely to respect watershed boundaries.

The planning watershed scale may or may not be the best scale for timber harvest cumulative impacts evaluation and review, but it is the standard identified in the Forest Practice Rules. There is no apparent reason that the planning watershed scale would be the most appropriate for the focus of future pilot projects with respect to restoration, particularly watercourse or salmonid habitat restoration. Some watercourses, like the South Fork Ten Mile River, cross planning watershed boundaries, rising in Churchman Creek Planning Watershed before flowing through Campbell Creek Planning Watershed and going through at least one more planning watershed before reaching the Pacific Ocean. Planning watershed boundaries were crossed when CDFW did the South Fork Ten Mile River Survey (see Appendix 4).

Section 4 Recommendations

Overview

Timber Harvesting Plans have the limited potential to provide the site-specific information needed to identify restoration needs and opportunities, though the THPs reviewed as a part of this project do not, by and large, contain this information. There is an abundance of information contained within publicly available documents, including THPs, but too often that information is qualitative and not site-specific, making it difficult to determine the need for and potential effectiveness of restoration efforts. This is not surprising given that the THP acts as a CEQA-equivalent document, and the primary goal is procedural compliance with CEQA by assessing, disclosing, and mitigating potential significant environmental impacts from timber harvesting activities. This goal is not entirely consistent with that of process-based restoration, which seeks to establish normative rates and magnitudes of ecosystem processes (Beechie et al., 2010).

Further, locating the specific information relevant to potential restoration among the large quantity of information within THPs is time-consuming. CalTREES (the new online timber harvesting system) may be able to serve as a mechanism for increasing the quality, consistency, and site-specificity of data across THPs and other harvesting documents, though at this point, CalTREES lacks GIS capabilities and is not capturing a full suite of site-specific resource information, nor do the Forest Practice Rules necessarily require this information.[38] CalTREES was developed as a form-based system and was not scoped for how it might capture and produce critical resource information; the system is not well equipped to capture information that will easily lend itself to watershed analysis or specifically locating restoration opportunities.

Figure 55. Stream restoration project; Clark Fork of Standley Creek.

Despite the volume of existing information included in THPs, the primary focus on procedural adherence to CEQA requirements limit the ability of these documents to identify opportunities for scientifically sound restoration projects. On-the-ground monitoring data that provides detailed measurements of the physical and biological condition of stream reaches and their surroundings is necessary for restoration and is not typically available in THPs. The CGS review of the potential value of LiDAR in detecting landslides and their impact on sediment dynamics underscores the point that remote sensing, modeling, and ground-level monitoring and observation are needed to better characterize and predict the benefits of sediment reduction-related restoration activities. Another successful example is the work of CAL FIRE to use aerial photos, LEMMA data, process models, and LiDAR, combined with on-the-ground confirmation, to identify the availability of large wood for recruitment into streams. These approaches provided a clearer picture of certain conditions in the Campbell Creek Watershed in a shorter period of time than the labor-intensive methods of mining THPs.

[38] The Wood for Salmon Working Group's efforts identifying ways to better incorporate restoration activities into timber harvests, including using THPs as the primary permitting mechanism, along with ways to deliver restoration grant funding to such restoration activities, serves as positive examples.

Recommendations

1. The overall concept of the pilot projects should be re-examined before moving forward with one or more further projects. The goals of this pilot project were to determine if existing, publicly available data sources (focusing primarily on the contents of THPs) could identify specific needs for restoration efforts and to catalogue cumulative impacts information. These goals were broad and lacked definition. More narrowly focused research questions or hypotheses would result in a more focused outcome.

2. The focus of future pilot project(s) should shift from obtaining data from THPs and NTMPs to other available data sources and/or methods, as many of the analytical methods used in this pilot project have proved promising.

3. As an alternative or complement to focusing on a specific planning watershed for a future pilot project, identify what data can be used for restoration planning and cumulative effects analysis that could be compiled at a statewide scale from existing sources. Focus on building spatially explicit analytical tools for RPFs, agencies, and the public. Possible benefits include standardized datasets to be used by RPFs, providing a common information framework for harvesting plan submitters along with agency reviewers and regulators. This is consistent with the current CalMAIN[39] (California Multi Agency Information Network) effort and could serve to prototype online information resources specific to resource management. It also could provide data needed to support Ecological Performance Measures (see Recommendation #10).

4. It would be helpful if a future pilot project more specifically defined "restoration" in both the ecological and legal senses, with the goal of all participants working from a well-articulated understanding of the CEQA-based legal requirements of mitigation versus restoration.

5. Basic measurements of Class I watercourse channel physical parameters are not required in THPs, hindering the identification of trends that could help estimate and predict environmental change and the type of restoration needs, if any. A future pilot project might evaluate how such data could be collected routinely (e.g., large wood loading and whether data could be collected via remote sensing or field techniques), reported (whether by agency or landowners), and analyzed.

6. Section 14 CCR § 916.4(a)(2) of the Forest Practice Rules (FPRs), which states that "The opportunity for habitat restoration shall be described within the plan for each Class I watercourse, and for each Class II watercourse that can be feasibly restored to a Class I," is an important mechanism for identifying aquatic habitat restoration needs, such as placement of

[39] Under the lead of the Central Valley Water Board, and with broad participation from Review Team agencies and other resource managers (e.g., State Parks, Sierra Nevada Conservancy), there is movement for a consolidated effort that brings data together into a common framework: CalMAIN, an agile, transparent multi-agency technology platform to inform natural resource-based management questions in oak woodland and forested watersheds (timber harvesting, cannabis, water rights, flow assessment, and forest health initiatives), and other closely related focus areas.

large wood in streams. This sometimes leads to restoration projects being conducted on an opportunistic basis, while crews and equipment are on site for harvesting activities; the overall THP process (along with Lake or Streambed Alteration Agreements and Waste Discharge Requirements being met) addresses most of the permitting requirements. This approach, while achieving restoration, does so on a piecemeal basis, not necessarily part of a systematic or priority-based approach.

A systematic evaluation of needs and opportunities —for example of LWD placement, should be performed on a watershed-by-watershed and on a stream reach basis using the kinds of data, analyses, and modeling tools explored as part of this pilot project, or possibly as CDFW conducts its systematic stream surveys, to establish strategic priorities for accomplishing restoration work, as well as to provide guidance for watershed stakeholders. State restoration grant programs could provide a source of funding for implementation.

7. Existing programs and partners are already conducting restoration work in several North Coast watersheds, including the Campbell Creek Planning Watershed. Their expertise and published guidelines for how restoration work can be accomplished can help define criteria for instream restoration opportunities. Below are some examples associated with the Campbell Creek Planning Watershed area (and the larger Ten Mile River basin):
    - Trout Unlimited (TU) identified many miles of streams in eight major drainages on the North Coast that need large wood augmentation.
    - The Nature Conservancy (TNC) has developed a methodology for identifying locations for large wood placement.
    - The Wood for Salmon Working Group (WFSWG) has developed a reference document for RPFs and agency personnel providing guidance on placing large wood in fish-bearing stream using a low-cost approach denoted as accelerated wood recruitment (WFSWG 2018).

8. Many California watersheds have not had the high level of restoration focus that there has been over many years in the Campbell Creek Planning Watershed and other North Coast watersheds. A future pilot project might investigate restoration needs on a watershed that has not been significantly assessed and where no substantial restoration projects have been implemented.

9. It is recommended that the State continue its efforts to develop and implement a strategy to obtain high quality LiDAR across forested portions of California to be used in conjunction with other imaging and ground-truthing. Although the Campbell Creek Pilot Project didn't receive LiDAR outputs until late in the process, agency staff found the datasets to have considerable potential. LiDAR has the advantage of being current, objective, spatially referenced, and spatially continuous. It can also be used in variety of geomorphic and ecological applications. LiDAR data should be made easily available to agency staff, the public, NGOs, landowners, RPFs preparing harvest plans, and agencies reviewing those harvesting plans.

Airborne LiDAR can be helpful in representing elements of the landscape that otherwise are difficult to obtain due to terrain, vegetation, and site access. However, airborne LiDAR is not widely available due to collection costs. Consequently, LiDAR provides data with high spatial resolution but very low temporal resolution as many years may pass between data collections. Unless repeatedly collected at regular intervals, the ability to detect environmental change in a timely manner may not be sufficient for restoration and monitoring.

The value this pilot project found in the use of spatial data for analysis and modeling is consistent with the recommendations of Dunne et al. (2001),[40] when they examined scientific approaches to the prediction of cumulative watershed effects. Where available, LiDAR should become standard spatial data source used for identifying restoration needs and assessing cumulative impacts.

A future pilot project could:

- evaluate the best ways to optimize the current investment in LiDAR-derived elevation data in addition to traditional survey methods and document review, which suffered from problematic data gaps and data quality,
- develop and propose data standards and further explore analytical uses of LiDAR to support restoration and cumulative effects assessment,
- develop a method for using LiDAR-derived elevation data to map large scale erosion sites along forest roads and landings which can be used to identify sediment-reduction restoration opportunities, and
- determine (1) the capacity to combine existing stream surveys with new landslide mapping using LiDAR-derived elevation data, (2) the means for effective data visualization, and (3) the means for efficient data sharing and updating.

Developing data products could facilitate restoration planning and may also support cumulative impacts analysis. Timelines of watershed disturbances and restorations could provide a basis for predicting the long-term performance of restoration projects and for assessing cumulative impacts.

10. One consideration regarding the future of the pilot projects is the Ecological Performance Measures (EPMs) that are being developed by the TRFR Program. Inherent in these EPMs and their proposed "indicator" approach[41] would be objectives for healthy forests that could serve as broad restoration objectives for future pilot projects and potentially help address terrestrial wildlife/habitat issues. An alternative approach to indicators is using an ecological modeling

[40] Dunne., T., J. Agee, S. Beissinger, W. Dietrich, D. Gray, M. Power, V. Resch, and K. Rodrigues. 2001. A scientific basis for the prediction of cumulative watershed effects. Report No. 46. Wildland Resources Center, Division of Agriculture and Natural Resources, university of California, Berkeley. 103 p. http://resources.ca.gov/docs/forestry/Richard%20Gienger%20Comment%203%20Attachment%201.pdf

[41] See the EPM background paper at http://resources.ca.gov/wp-content/uploads/2019/04/AB-1492-Ecological-Performance-Measures-Methodology-White-Paper-April-2019-Final.pdf.

approach to quantify the status and trend of ecological processes and functions. A future pilot project could evaluate the potential utility of the EPMs in an ecological modeling framework.

11. A future pilot project should consider changes to the working group composition, including the possibility of a dual-leadership role – one agency leader and one public leader. This might allow the respective leaders to focus their attention on their peers, potentially enabling greater participation. Project leaders should have the skills to implement standard project management approaches, or a consultant should be considered to assist with framing the project and facilitating communication and meetings. The working group may benefit from land managers outside of the planning watershed planning area. The public leader may need to be monetarily compensated for their time, and other experts may need to be brought in to fill in gaps in workload capacity or resource-specific knowledge.

12. Tribal participation should be regarded as that of an equal government agency (i.e., state, federal, tribal) rather than a public stakeholder, facilitating greater tribal involvement and information sharing. Tribal data and Traditional Ecological Knowledge should be well integrated into analyses and determinations, with efforts made by the agencies and scientific communities to break down cultural barriers and understand the implications to managed forest resources across the landscape.

13. The potential capacity of CalTREES should be evaluated to increase the quality, consistency, and site-specificity of data across harvesting documents, including the capacity for submission of digital spatial data (GIS), as well as aligning current GIS data with CalTREES. This could lead to more site-specific information and better understanding of potential restoration opportunities, as well as improved cumulative impacts analyses.

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