Effectiveness Monitoring Committee

Full Project Proposal Form

Deadline for Submission: November 16th, 2019

Project #: EMC-2013-005 **Date:** November 16, 2019

Project Title: Sediment Monitoring and Fish Habitat – San Vicente Accelerated Wood Recruitment

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Collaborators: Sempervirens Fund, Peninsula Open Space Trust, Hamey Woods Forestry Consulting, and Save the Redwoods League

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Project Duration (Years/Months): 3 Years

Background and Justification

In 2009, the California State Board of Forestry and Fire Protection approved a regulatory pathway that provides an alternative approach through the Timber Harvesting Plan (THP) process for enhancing riparian functions based on site-specific criteria (14 CCR § 916.9 (v)) referred to as "Section V" (VTAC, 2012). This pathway seeks to promote more immediate improvements to the riparian zone and aquatic habitat conditions by allowing active riparian management practices that would not otherwise be allowed under the standard Anadromous Salmonid Protection (ASP) and Watercourse Lake Protection Zone (WLPZ) rules. The Forest Practice Rules (FPRs) (CALFIRE, 2019), under Section V, allows for accelerated wood recruitment (AWR) to fish bearing streams. The AWR guidelines (Wilson et al, 2018) recognize the importance of geomorphic context and suggest projects avoid "unstable areas e.g., streamside landslide, …, inner gorge, ...". As AWR is an increasingly popular stream restoration technique, pre-project geomorphic assessment and post-project monitoring at meaningful scales will greatly contribute to understanding the geomorphic influence of these types of restoration activities.

The proposed monitoring project would study physical stream characteristics associated with the recently approved Big Jim THP (1-19-00043-SCR) which includes a FPR Section V AWR project component, the San Vicente Accelerated Wood Recruitment Project (SVAWRP). The SVAWRP implementation area in

Santa Cruz County encompasses approximately 4.2 total miles of Class I stream habitat in Big Creek and Jim Creek, ~3.2 miles and ~1 mile respectively.

The SVAWRP will recruit approximately 400 trees of various sizes and species into the upper Class I reaches of the two watercourses. The proposed effectiveness monitoring project aims to evaluate the fluvial geomorphic effects that impact the quality and functionality of anadromous fish habitats associated with AWR projects allowed by Section V. AWR projects can provide large wood inputs in a short temporal scope and are generally more cost effective than highly engineered large wood projects. Thus, AWR projects may provide important opportunities for riparian and stream habitat management enhancement, but compilations of AWR relational geomorphic monitoring data in regionally significant settings are scarce. As stated in the National Large Wood Manual Chapter 9 "Berhardt et al. (2005) reported that only 10% of more than 37,000 projects evaluated incorporated any form of project monitoring, and little if any of this information was either appropriate or available for assessing the ecological effectiveness of restoration activities." (Lentsch et al, 2016). This monitoring project may provide a scientific basis for evaluating the effectiveness of AWR and Section V.

Several distinct geomorphic settings underlie the SVAWRP treatment areas including, but not limited to, inner gorge areas with relatively steep sideslopes, moderately broad stream valleys with adjacent flood terraces, and confined bedrock-controlled settings. The array of geomorphic units resembles conditions throughout the Coast Ranges; hence, findings may be regionally informative. Monitoring of the rapidly recruited wood across geomorphic settings may generate information that would otherwise require decades of small projects. The California Geological Survey (CGS) and collaborators will monitor the effects of the SVAWRP and develop and test novel monitoring approaches against traditional methods. Three years of repeated photo-monitoring, elevation surveys, and geomorphic mapping of large-scale wood recruitment treatment sites will be reported to the Board of Forestry (BOF). The monitoring data will aid in evaluating the effectiveness of the alternative approaches for enhancing riparian functions as permissible by (14 CCR § 916.9 [936.9, 956.9](v)).

Objectives and Scope

The objectives of this project are to evaluate the effectiveness of the FPRs Section V alternative riparian management practices in enhancing the quality of the beneficial uses of water in a salmonid habitat setting, and to collect hydrogeomorphic data that aids in establishing baseline monitoring data as it relates to fluvial geomorphic effects of AWR projects in a variety of regionally significant coastal geomorphic settings.

The geographic scale of the SVAWRP provides an opportunity to simultaneously document the effects of various AWR designs in multiple geomorphic settings representative of many restorable Class I streams. We will demonstrate innovative, efficient, and useful monitoring approaches. Traditional stream monitoring methods, as CGS currently uses at Soquel Demonstration State Forest, will be supplemented with and compared to novel methods aimed at improved repeatability, efficiency, accuracy, and scientific relevance. Geomorphic context, change detection, and regional applicability will be emphasized.

The project will establish a set of discrete monitoring reaches where analytical data will be collected and analyzed to evaluate the effects and impacts of the AWR practices in a variety of geomorphic settings. The geographic extent of each monitoring reach will be determined based on site specific geomorphic characteristics and will encompass areas that may exhibit potentially substantive geomorphic change.

Favorable site characteristics include responsive geomorphic features representative of sediment dynamics and sites that are amenable to sub-canopy drone navigation. Approximately 5 -10 monitoring detailed stations will be identified and designated within the monitoring reaches based on distinct geomorphic settings and feasibility of conducting the monitoring activities in the stream reaches. Additionally, less detailed monitoring will occur annually along the entire reaches of Big and Jim Creeks within the AWR project area to assess overall channel changes.

Critical Questions and Forest Practice Regulations Addressed

This proposed Class I watercourse AWR sediment monitoring and fish habitat study relates the following EMC Themes; Theme 1 (WLPZ Riparian Function), Theme 2 (Watercourse channel sediment), Theme 4 (Mass Wasting Sediment), and Theme 5 (Fish Habitat).

This study would provide essential data for answering the following critical questions

1) Theme 1: Are the FPRs and associated regulations effective in…(c) retaining predominant conifers in WLPZs and large woody debris input to watercourse channels?
    - The Theme 1 Critical Question will be addressed by quantifying the number and volume of primary wood pieces input into the watercourse at the selected monitoring stations.

2) Theme 2: Are the FPRs and associated regulations effective in minimizing management-related sediment delivery from forest management activities to watercourse channels … (b) for individual Plans at the project level to evaluate channel response to forest management prescriptions and additional mitigation measures?
    - The Theme 2 Critical Question will be addressed by repeated surveys including thalweg long profiles, channel cross-sections, and pebble counts to quantify channel response to the AWR treatment at the monitoring stations. Repeated LiDAR and photogrammetric surveys will be used to document and quantify sediment delivery and storage related to the AWR project by identifying and monitoring conditions such as any potential bank scour occurring due to the AWR inputs.

3) Theme 4: Are the FPRs and associated regulations effective in minimizing sediment delivery to maintain water quality from … (a) existing chronic unstable geologic features? (b) mass wasting during episodic rare events and/or large storms?
    - The Theme 4 Critical Questions will be addressed by repeated LiDAR, photogrammetric, and pebble count surveys used to identify and document changes to identified unstable features within the monitoring station vicinity and to document bed-load material and distribution changes related to the AWR inputs.

4) Theme 5: Are FPRs and associated regulations effective in … (b) maintaining and restoring the distribution of foraging, rearing and spawning habitat for anadromous salmonids?
    - The Theme 5 Critical Question will be addressed by repeated thalweg long profile and channel cross-section surveys to document and monitor channel changes such as pool development including repeated pebble counts and photogrammetric surveys to document changes to bed-load material and distribution as well as overall sediment storage related to the AWR inputs.

The Board adopted an option (14 CCR § 916.9 [936.9, 956.9] Section (v)) that supports more site-specific decision making in the design of riparian prescriptions that can be applied during the time of adjacent timber harvest. This regulatory pathway offers an alternative to prescriptive uniform buffers and may be more protective of ecological functions (VTAC, 2012). This proposed study aims to evaluate the interactions of various geomorphic and habitat conditions as they relate to the FPRs active riparian stand manipulation practices outlined in (14 CCR § 916.9 [936.9, 956.9](v)). The project would evaluate and characterize the change in fluvial geomorphic dynamics, and the potential impacts to geomorphology and beneficial uses of the watersheds as they relate to the Section V practices. The project will monitor and evaluate annual changes in sediment deposition, transport, and corresponding fluvial geomorphic processes and flow dynamics in each of the discrete monitoring reaches as the watershed responds to the THP activities. Additionally, less detailed monitoring will be conducted annually along the entire reaches of Big and Jim Creeks within the AWR project area and will note significant changes within the channel system.

Research Methods

The monitoring project consists of an empirical approach to observe and document physical changes in, around, and directly related to the recruitment of wood into the stream channel. Five to ten monitoring stations will be selected across the AWR project. Two complementary data collection methods will operate in tandem. The primary method, a proven technology, consisting of annual, traditional elevation cross-sections, thalweg profiles, and pebble counts will produce familiar 2-dimensional representations of channel conditions. The secondary method, a promising application, aims to produce 3-dimensional representations of the physical conditions, specifically via classified digital elevation models (DEM), through photo-monitoring that will consist of 1) time-lapse photography and 2) photogrammetry. The annual monitoring and the time-lapse photography will add time as another dimension.

Spatial Data

Ground-based GPS may be problematic due to multipath interference and poor signal caused by topographic features and dense forest. Elevations and elevation models will be determined as follows.

1. Prior to or as soon as practical after AWR implementation and before winter runoff, a vendor will fly a low-altitude supra-canopy lidar survey with a very high laser pulse rate. As part of the process, licensed surveyors will establish survey control and spatially accurate elevation data. The data is intended to determine a topographic baseline prior to geomorphic response to the wood recruitment. DEMs of the canopy surface and "bare earth" (BE) will be constructed using the first and last returns of the laser pulses. We acknowledge uncertainty regarding the density and character of last returns that can be achieved given the dense forest; however, we anticipate that enough pulses will reflect off the ground surface to provide an array of elevation points sufficient to interpolate a BE model adequate to recognize and map reach-scale geomorphic features.

2. At each station, local benchmarks will be established and fitted to a) the survey control established by the vendor and b) the array of ground elevations derived from the lidar. As needed, a licensed surveyor will be retained to establish benchmarks at monitoring stations. We will scrutinize the last-return elevations in the field to verify that ground elevations are accurate within specifications. At each station, we will scrutinize the BE model and reclassify non-ground returns appropriately.

3. The primary monitoring method will consist of annual thalweg profiles and channel cross-sections that will be tied into the local benchmarks established at each monitoring station. Elevations along the profiles and cross-sections will be determined by using a total station, levelling rods, and measuring tape or hip-chain. Visual monitoring will also be conducted annually along the entire reaches of Big and Jim Creeks within the AWR project area, significant sites of change will be assessed in more detail as above.

4. The secondary method will use photogrammetric modelling to create a 3-dimensional model that will be fitted to the array of measured elevations and the BE model. At each station, we will determine an area of interaction between AWR wood and the stream bed and bank. We will place a set of weatherproof targets across the area, determine the elevation of the center of each target, and take many overlapping photographs of the interaction area (IA). Photographs will be taken in a dense array encompassing the IA. Photographs will be taken from above the interaction area using drone or balloon platforms if feasible. The photographs will be processed using a Structure from Motion or similar algorithm that automatically generates tie points between overlapping images and utilizes measured coordinates to produce a georeferenced photomosaic and 3-dimensional model. The photogrammetric model may be cartographically adjusted as needed to correct deviations from the array of measured elevations and the LiDAR-derived BE model.

Geomorphic Classification

1. Fluvial and non-fluvial geomorphic features will be identified via on-the-ground inspection and examination of the BE model. The coupling of the channel and adjoining slopes will be characterized.

2. Geomorphic features will be monitored and mapped at two scales: reach-scale and station-scale.

3. Maps will utilize classifications and terminology as provided in the Forest Practice Rules (CALFIRE, 2019), the California Geological Survey's Note 50 (CGS, 2013) and the North Coast Watershed Assessment Program (NCWAP) Manual (CGS, 2003). Hence, our results will be documented in terms consistent with the extant collection of published watershed and landslide maps.

4. Reach-scale maps are critical to identifying geomorphic response beyond and between monitoring stations. Reach-scale classification allows comparison to similar reaches in the region. Modifiers will be added to terminology, as appropriate, to describe trends identified through the monitoring period. For example, a mid-channel bar that appears to have enlarged will be assigned a modifier such as "aggrading" or "aggraded".

5. Station-scale maps will be scaled to illustrate to IAs in their entirety and to delineate grain-size distribution. Modifiers will be added to terminology, as appropriate, to describe patterns of grain size distribution following the Unified Soil Classification schema. For example, a mid-channel bar consisting of silty-sand may be assigned a modifier such as "sandy" or "gravelly". Modifiers such as "coarsening" and "fining" may be added to indicate trends.

6. Pressure transducers will be placed upstream and downstream of the overall project area in both Big Creek and Jim Creek to continuously record local stream hydrologic conditions through the monitoring reaches.
7. Where applicable and appropriate, the CRAM methodology (CWMW, 2013) may be applied for documenting site conditions.

Station Selection

1. Stations will be selected to represent the spectrum of geomorphic reaches present. Given the limited geographic scope, geomorphic mapping may not provide a sufficiently large population of distinct geomorphic reaches to allow for rigorous stratified sampling methods.
2. Favorable site characteristics include responsive geomorphic features sensitive to treatment both representative of sediment dynamics and amenable to inter-canopy drone navigation.
3. We will not select stations a) that may be excessively difficult to access, or b) affected by extraneous variables, or c) with sensitive values as determined by the land owner.

Station Set-up

1. Stations will consist of a set of benchmarks for photo-monitoring points, elevations, channel cross-sections and profiles, and other transects.
2. Stations, if feasible, will consist of an array of time-lapse cameras arranged with overlapping fields of view to document key events affecting the IAs. Each of the cameras will be set to capture one photograph per day.
3. As needed, identifier tags and markers may be affixed to pieces of wood or monumented in the ground.

Scientific Uncertainty and Geographic Application

1. Uncertainties
    a. The scale of the AWR project is well beyond most similar projects.
        i. The collective experience and the scientific literature of such large implementations are limited in California. No models exist that relate large-scale AWR to reach-scale geomorphic response.
        ii. The possibility exists that one or more extreme events (i.e., wind, fire, flood, rain, and slope movement) may occur during the monitoring period and may confound the monitoring and interpretations in unanticipated ways.
        iii. The natural range of variability for the specific project area is poorly defined and based on extrapolations from other areas.
        iv. The natural LWD load for the specific area is unknown. Although the AWR may, in certain ways, mimic a watershed disturbance, the implementation and rate of LWD input will likely exceed the natural range of variation.
        v. The potential for complex interactions among the hundreds of trees to be felled may result unpredictable sediment and flow dynamics that may challenge efforts

to quantitatively link AWR-stimulated geomorphic process to mappable geomorphic features. This uncertainty may limit the development of a regionally applicable model but also justifies the need for geomorphic monitoring.

vi. Detailed hydrological measurement of flow rates is out-of-scope. Hydrological parameters are acknowledged to potentially have significant bearing on sediment dynamics. Instead this project relies on limited hydrologic data and geomorphic mapping as a proxy for detailed hydrological measurement and to characterize sediment dynamics.

b. Data Gaps

  i. Incomplete Data Capture

    a. Equipment failure during data acquisition
    b. Prohibitive conditions that may preclude complete data collection
      i. No-fly days for the drone
      ii. Corrupt or lost data
      iii. GPS signal loss
      iv. Impassable road conditions
      v. Terms and Conditions of the Special Use Permit
    c. Logistical or unintended failure to collect data

  ii. Out-of-scope Confounds

    1. Unobserved/unrecorded Physical Influences
      a. Manipulation of LWD structures due to hydraulics and sediment transport
      b. Manipulation of LWD structures by other agents
        i. Humans, wildlife, fire, windthrow, landslides
      c. Changes that occur between annual data collections
        i. Automated time-lapse photography will capture site conditions daily but events that occur between photographs may remain insufficiently known or unknown.

c. Bias

  i. Visibility Bias

    1. Detection and documentation of conditions may vary due to visibility constraints.

  ii. Methodological Bias

    1. Traditional stream monitoring methods record a minimalistic set of conditions along predefined transects.
    2. Ancillary photogrammetric observation and modeling can provide the basis for a more comprehensive data collection of variable conditions at

each LWD site. However, inexperience, miscommunication, and/or uncontrolled methodological complexities may result in biased or unusable data.

3. Transformation of 1-dimensional point data to 2-dimensional surfaces requires mathematical interpolation that may systematically simplify or misrepresent actual conditions.

iii. Classification Bias

1. Classification schema may introduce systematic bias due to pigeon-holing and ambiguity.
2. Interpreters may vary in the application of the schema.
3. Inconsistent classification or misclassification may bias the data.

iv. Confirmation Bias

1. The endeavor to formulate interpretations of geomorphic processes may overlook the significance of non-geomorphic processes.
2. CGS staff that approved the AWR project are also involved in the monitoring project. The PI was part of the field review team that approved the AWR project and so favorably prejudged the AWR outcome. Internal peer review should minimize the effect, if any.

v. Sample Bias

1. Logistical constraints may interfere with comprehensive data collection in absolute conformance with the study design.
2. The sampling strategy is deliberately selective not random. This monitoring project is targeted to reveal geomorphic change due to AWR and to test methodological improvements.
3. The data collected during the three-year monitoring period may be skewed toward weather or climatic events that may be temporally over-represented.

vi. Publication Bias

1. A project goal is the submission of a paper to a peer-reviewed journal. A publisher's interest in the project may be contingent on the scientific significance of the findings which is not guaranteed.

2. Geographic applications

Several distinct geomorphic settings underlie the SVAWRP treatment areas and the array of geomorphic units resemble conditions throughout the Coast Ranges; hence, findings may be regionally informative.

a. Spatial Scale

i. Jim Creek and Big Creek

1. The location of AWR project defines the monitoring reaches in Big Creek and Jim Creek. However, it is infeasible to monitor the entirety of the AWR project at a detailed level.

2. Instead, the extent of the AWR project will be stratified by gross geomorphic character following NCWAP methods. A set of key sites will be selected based on both the feasibility to conduct field operations and the geomorphic character.
3. Visual monitoring will also be conducted annually along the entire reaches of Big and Jim Creeks within the AWR project area, significant sites of change will be assessed in more detail as described above.

b. Temporal Scale

i. Three years starting with a survey of baseline conditions prior to or as soon as practical after AWR implementation, and then 3 cycles of annual data collection.

c. Scale of Controlling Processes

i. Stochastic Processes

1. It is not feasible to design project timelines to capture a representative sample of controlling processes i.e., hydrologic events. Sediment transport operates over continuous to highly punctuated timelines regulated by watershed runoff which cannot be reliably predicted to define an appropriate temporal scale for monitoring. The geomorphic response may evolve in a single water-year or over decades and one event could reset the entire system.
2. Instead, project timelines are constrained by the implementation of the AWR and the three-year limit for EMC projects.
3. Annual data collection will document the net geomorphic effects of the preceding water-years but cannot capture the dynamics of controlling processes at higher temporal resolutions. Daily time-lapse photography will be used to reconstruct a gross timeline of observable events that likely contribute to the net geomorphic effects but will not support irrefutable linkage between the data and the controlling, stochastic processes. Pressure transducers will aid in estimating flow depths.

Collaborations and Project Feasibility

Project Principal Investigators from CGS include:
Cheryl Hayhurst, Long term large wood habitat restoration monitoring expertise;
Michael Fuller, Terrain modeling and watershed studies expertise; and
Peter Roffers, Remote sensing expertise.

Current project collaboraters include:
Sempervirens Fund;
Peninsula Open Space Trust;
Save the Redwoods League; and
Nadia Hamey, Hamey Woods Forestry Consulting.

The project collaborators have developed the SVAWRP, are granting property access to CGS, and provide site background, history, and information that is useful for this project. CGS's expertise and focus for this project is in the physical channel changes and geomorphology. Additional collaborations of in-kind surveys or data collection outside our area of experise, such as associated biological surveys, are welcome.

The overall project feasibility is good. The SVAWRP will provide ample locations for favorable monitoring station selection that will facilitate successful data collection by all intended methods. We have year-round access to the property and monitoring stations.

Project Deliverables

1. Periodic Updates to the BOF
2. Field Tours as requested (and with landowner approval)
3. Annual tabulations
4. Final report to BOF
5. Scientific paper submitted to a peer-reviewed journal
6. Conference presentations

Project Timeline

- Supra-canopy lidar acquisition to capture pretreatment or as-built conditions of the entire SVAWRP to map geomorphic reaches from which 5-10 study sites will be selected.
- Year 1 fall: Upon completion of the SVAWRP timber management activities the identified monitoring reaches will be occupied to conduct field data collection including finalizing and preparing, permanent photographic monitoring locations, permanent geographic and reference points, geomorphic characterization of reaches.
- Year 1 winter-spring: Office based data compilation and processing.
- Year 1 spring: Annual progress reports submitted to the BOF.
- Year 2 fall: Annual monitoring and data collection to be conducted at each selected monitoring reach each year through the duration of the project during maximum low flow conditions
- Year 2 winter: Office based data compilation and processing.
- Year 2 spring: Annual progress reports submitted to the BOF.
- Year 3 fall: Annual monitoring and data collection to be conducted at each selected monitoring reach each year through the duration of the project during maximum low flow conditions
- Year 3 winter: Office based data compilation and processing.
- Year 3 spring: A final supra-canopy LiDAR, comprehensive data compilation and final report composition; products to include data evaluation, analysis, and recommendations.

Requested Funding

To facilitate the intended scope of the proposed monitoring project, the Principle Investigators are requesting $56,200 from the Effectiveness Monitoring Committee. The cost estimates and breakdown are provided in the table below.

References

CALFIRE, 2019, California Forest Practice Rules 2019, Title 14 CCR, Ch. 4, 4.5, and 10 Department of Forestry and Fire Protection.

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CGS, 2003, Manual for Regional or Watershed Scale Mapping of Landslide and Fluvial Geomorphic Conditions, dated October 2003.

CGS, 2013, Factors Affecting Landslides in Forested Terrain, California Geological Survey Note 50, dated January 2013, 6pp.

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

Wilson, D., Warmerdam, J., Cafferata, P., Stanish, S., Simpson, N., Hendrix, J., and Wright, D., 2018, Accelerated Wood Recruitment and Timber Operations: Process Guidance from the California Timber Harvest Review Team Agencies and National Marine Fisheries Service (NMFS). Paper prepared for the Wood for Salmon Working Group, an informal group of California state, county, federal agency staff, representatives from environmental non-profits, and private landowners and consultants, that promotes actions in state and federal recovery plans for improved habitat for listed anadromous salmonids by accelerating the pace and scale of instream restoration projects, especially large wood enhancement.

Category	Description	Year 1	Year 2	Year 3	Total
Personnel *Identify all personnel costs a including field technicians, graduate students, Principal Investigators, etc.* ***Show these values as individual rates per unit of time.***					
Fringe Benefits *Cite as actual benefits or a percentage of personnel costs.*					
Other					
Operating Expenses *Include rent, supplies, and equipment costs as separate line items*	LiDAR Drone Services	$15,000	$15,000	$15,000	$45,000
	Licensed Surveyor	$2,000			$2,000
	Ground Control Targets	$200			$200
	Pressure Transducers (4 @ $500/ea)	$2,000			$2,000
	Game Cameras (20 @ $350/ea)	$7,000			$7,000
Indirect Cost *Not to exceed 15%*					
Travel *Express as per diem rates specified by CalHR, or verification that such rates area not available to you.*					
Total Cost		$26,200	$15,000	$15,000	$56,200
Matching or In-Kind Contributions	CGS staff time for 4 staff working 8 weeks	$150,000	$150,000	$150,000	$450,000
EMC Funding Requested		$26,200	$15,000	$15,000	$56,200