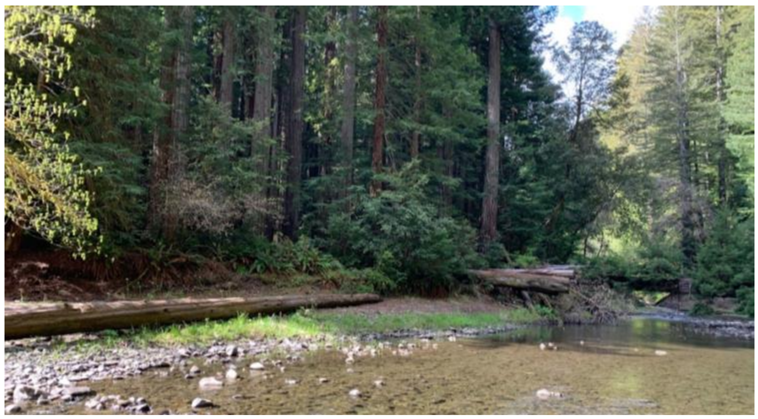
Final Report

Developing Riparian Management Goals through Validation of Assessment Tools



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Report Written by Central Coast Wetlands Group at Moss Landing Marine Labs

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

This project was made possible and successfully completed by the combined effort and contributions of many individuals and organizations. Successful completion was achieved through the dedicated work of CCWG project staff (Ross Clark, Kevin O'Connor, Cara Clark, Sarah Stoner-Duncan, and Jenny Balmagia), the CCWG Watershed Stewards from the California Conservation Corps (Maya Vavra, Alex Johanson, Jay Ryan, Ashley Baillie, Athena Lynch and Elizabeth Allen), and our partners at SCCWRP (Eric Stein, Raphael Mazor, and Jeff Brown) SFEI (Cristina Grosso), as well as staff at the State Coastal Conservancy (Evyan Borgnis-Sloane, Katie Nichols and Meghan Martinez), the technical advisory committee members, and the project manager from USEPA Region 9 (Melissa Scianni). Thank you.

Project Summary

Riparian areas throughout the state are an incredibly rich resource, providing valuable and varied ecosystem services, including diverse habitat functions, flood attenuation and climate resiliency, carbon cycling, and water quality benefits. On the central and south coast, streams and their riparian buffers improve water quality before it reaches the coastal estuaries and the Pacific Ocean. Resource managers currently face opportunities, through protection policies in development and state grant resources for protection and restoration, and new threats to these resources through destruction associated with food safety and regulatory liability concerns by landowners.

From October 2019 through December 2023 this project developed a set of riparian assessment and prioritization tools to support the protection of rivers and associated riparian habitats in California. We completed the fieldwork and data analysis necessary to validate the Riparian Rapid Assessment Method for California (RipRAM), developed and tested watershed condition estimation models, developed riparian zone protection and management recommendations statewide, improved decision maker access to watershed condition data/information, and laid the foundation to track progress towards meeting central and southern California riparian protection and enhancement goals.

The outputs and outcomes of this project will help regional stakeholders and agencies to prioritize future state investments to protect, acquire, and restore coastal stream and riparian habitats and will increase California's ability to apply the Level 1-2-3 monitoring framework in the assessment of riparian habitats.

CCWG field team conducting RipRAM validation data collection in Marin County.

Project Task Descriptions, Results, and Deliverables

Task 1. Project Administration, Reporting and formation of TAC

CCWG managed each project task, oversaw grant funds and deliverables, provided bi-annual written updates to EPA, and submitted a final report. An update to the previous EPA approved quality assurance project plan (QAPP) was completed to govern the collection of new data. CCWG formed and hosted a Riparian TAC, building off of the existing WRP Wetland Managers Group, to guide the development of the grant products, input from which was used in the development of presentations to the State Level 2 Rapid Assessment Committee and to the California Wetlands Monitoring Workgroup.

Task 1.1. Updated QAPP

CCWG updated a previous QAPP which was completed for the first round of WPD grant fund that were used for RipRAM development. The updated QAPP was submitted to USEPA. After CCWG addressed several comments, the document was approved on January 31, 2020.

Task 1.2. TAC Meetings

During the first year of this project the project team developed a potential list of TAC members, drafted a TAC invite letter and sent the letter out to the invite list. The project team then finalized the list of TAC members (Table 1) and convened the first TAC meeting on July 7, 2020. At this first TAC meeting CCWG presented background information on RipRAM development and the plan for RipRAM validation with L3 datasets. SCCWRP presented on Watershed-scale Prioritization of Management Efforts. During the second year of the project SCCWRP made several presentations on the Watershed-scale Prioritization of Management Efforts to the California Healthy Watershed Partnership, a secondary advisory group. The Project team held a second official TAC meeting in the first quarter of 2022. The meeting focused on getting feedback on the report on Watershed-scale Prioritization of Management Efforts and reporting out on RipRAM validation efforts.

Table 1. Technical Advisory Committee members

Name	Affiliation
Ali Dunne	SWAMP, Healthy Watersheds Partnership
Barry Hecht	Balance Hydrologics
Chad Loflen	San Diego RWB
Elijah Portugal	CDFW Fisheries Branch, Instream Flow and Cannabis Unit
Erik Larsen	AECOM
Katherine Pease	Heal the Bay
Lindsay Teunis	SWCA
Mark Abramson	EcoMalibu
Paula Richter	Central Coast RWB
Pete Ode	CDFW Aquatic Bioassessment Lab, SWAMP
Rebecca Payne	ICF

Name	Affiliation
Rosi Dagit	RCD of the Santa Monica Mountains
Scott Johnson	Aquatic Bioassay Consulting
Shuka Rastegarpour	State Water Resources Control Board
Stefan Lorenzato	retired

Task 1.3. Biannual status reports

Over the course of four years the project team submitted 9 status reports describing progress to date and deliverables for each reporting period.

Task 1.4. Final report

This document serves as the final report for Agreement # CD99T92901.

Grant funds were managed in an effective manner allowing for completion of all tasks and deliverables described in the work plan. All task deliverables have been made available to the Project. In addition, one grant amendment was completed, extending the completion date.

Task 2. Complete development of RipRAM

The Riparian Rapid Assessment Method for California (RipRAM) was developed on the central coast as a parallel tool to CRAM focused on the evaluation of riparian health past the upland boundaries of the CRAM riverine assessment area. RipRAM is inclusive of many riparian functions (as guided by partner agencies) and is an effective assessment tool in watersheds where riverine access is limited. Between 2013 and 2016, RipRAM was developed and verified by CCWG throughout the Central Coast, guided by a technical review team of wetland scientists from federal, state and local agencies, academia, consultants, and non-profits. The RipRAM assessment results were compared with ambient water quality and IBI data collected by the Central Coast Water Board's "Central Coast Ambient Monitoring Program". The tool development effort confirmed the utility of RipRAM to derive accurate riparian condition scores in areas with and without restricted access (from road crossings and public right of ways). This project completed development of the tool through the validation phase and worked to integrate its use within Regional Water Boards between in the central and southern regions of the State.

In compliance with state wetland assessment tool development guidelines (established by the CWMW), RipRAM was tested throughout all of California at 40 locations with existing level 3 data to ensure that the module is able to assess riparian zones across the full range of condition and ecoregions present in California.

The RipRAM field book was updated to provide additional guidance on metric narratives and scoring tables to reflect the range of riparian conditions found throughout the State. RipRAM assessment activities included evaluating level of property access (full, single side, single spot (i.e. bridge) access), preparation of field materials, travel to the site, field assessment, and data entry and QA.

RipRAM assessments were compared with available Level 3 data at selected assessment locations including biological (e.g. IBI), water quality, or faunal surveys in line with previous validation efforts for rapid assessment methods in California (see Stein et al. 2009). Sites were selected from existing locations associated with the state and regional monitoring Programs including: Surface Water Ambient Monitoring Program's (SWAMP) Perennial Stream Assessment, CCAMP, and the Southern California Stormwater Monitoring Coalition. The validation effort was completed using the RipRAM method and existing Level 3 data, a validation report was written and submitted for publication.

The project team worked with colleagues at the San Francisco Estuary Institute to create an online repository for RipRAM data, building off the great work completed for online CRAM support. This online repository allows for the scores to be displayed on **EcoAtlas.org** alongside other rapid assessment scores. Finally, training materials on the RipRAM methodology were developed and multiple trainings have been held on the central and south coast with TAC members, Regional Board and WRP member agency staff involved in stream and riparian monitoring, management, and restoration.

Task 2.1. Field data collection at 40 sites

During the first year of the project the team developed a list of potential validation datasets and available sites across the state to select 40 for the validation effort. Validation data sets included: Benthic Macroinvertebrates, stream algae, PHab (SWAMP dataset), riparian birds (MAPS dataset), and landscape measures of stress (STREAMCAT dataset). The project team then continued on with selecting 40 sites from the Perennial Stream Assessment dataset and the bird monitoring MAPS dataset which represented a range of condition based on best professional judgement. These sites were grouped by ecoregion to ensure adequate coverage across the state. They were characterized as reference or non-reference based on best professional judgement and the designations of the associated program.

Due to the COVID-19 pandemic and associated travel restrictions, it ended up taking years 2 and 3 to complete the assessments at all 40 locations across the state (Figure 1).

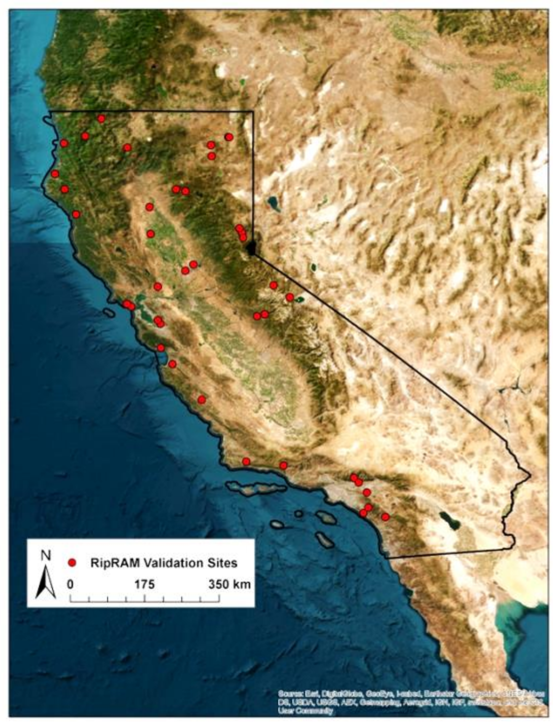

Figure 1. Locations of 40 RipRAM validation sites across California.

Task 2.2. Data analysis, validation report, finalize field book

Multiple rounds of edits were completed on the field book over the course of the grant period. Initial changes made during year 1 were based on input from the TAC and the previous verification effort in preparation for the validation data collection effort. All following updates were refinements to metric descriptions and scoring simplification following RipRAM training events. The trainees were a great sounding board on ways to enhance the metric descriptions and scoring rational. The final version of the field book is available on the CCWG RipRAM website[1] (Figure 2).

A new set of logos were developed as part of this validation effort. This allows for a clear distiction of the method from CRAM when reporting, developing advirtisements for trainings, and other uses.

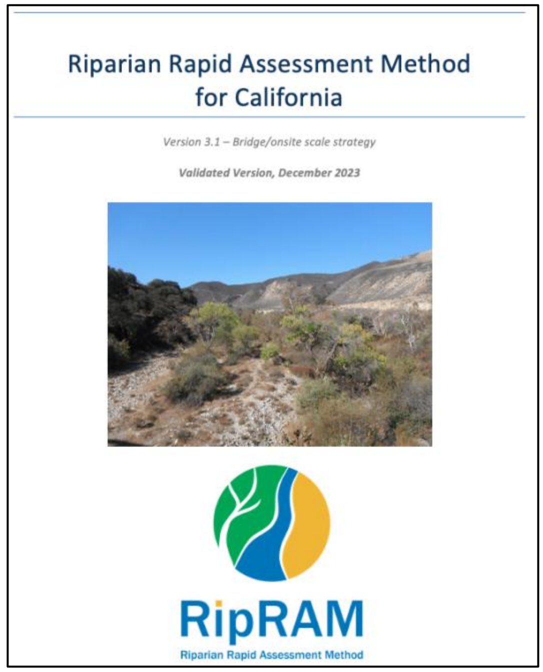

Figure 2. Cover page of the RipRAM field manual including new RiPRAM logo.

Data analysis for RipRAM validation commenced at the beginning of year 4 of this project. Th validation process used two datasets, the first being the 40 sites statewide and the second using assessments from 30 sites across three watersheds in southern California. These 30 assessments were completed in the three demonstration watersheds (Ventura, San Juan, San Diego) for the riparian management prioritization mapping effort (Task 3) at Stormwater Monitoring Coalition (SMC) monitoring stations.

A summarized version of the validation analysis is described below with a more complete description available as a manuscript.

METHODS

Validation Analysis Data Selection

Several sources of data were selected for use in validation of RipRAM: Riparian bird capture data from the Monitoring Avian Productivity and Survivorship Program (MAPS), the Hybrid Algal Stream Condition Index (H-ASCI), the Surface Water Ambient Monitoring Program's Index of Physical Integrity (IPI), the California Stream Condition Index (CSCI), the algal measure of taxonomic completeness (O/E), the algal measure of ecological structure (MMI), and measures of Physical Habitat (PHAB). Of the 40 RipRAM assessment sites, 10 sites had MAPS bird data. 18 sites had H-ASCI data, 21 sites had IPI data, 23 sites had PHAB data and 30 sites had CSCI, O/E and MMI data. In addition to conducting analyses on statewide RipRAM data, three southern California watersheds (Ventura, San Juan, and San Diego) were selected for an intensification analysis, in which 10 stations per watershed were assessed using RipRAM

[1] https://mlml.sjsu.edu/ccwg/ripram/

protocols. The SoCal Intensification RipRAM data were grouped together and analyzed in the same manner as the statewide RipRAM data.

The MAPS data were collected by the Institute for Bird Populations, an organization that collaborates nationally and internationally to determine effects of anthropogenic and natural ecological stressors on bird populations. Annual population data are collected during the breeding season using a standardized, constant-effort mist net protocol. A description of the MAPS protocol, including all data collected, can be found at www.birdpop.org/pages/maps.php. Ten of the RipRAM validation stations were selected to correspond to MAPS stations. The most recent data available in the MAPS database were used for each station. Data years ranged from 2005 to 2020, with all collections occurring during the May - August breeding season. The two MAPS metrics used for the validation effort were species richness and reproductive index. Reproductive index is calculated as the ratio of young to adult birds collected during a sampling event.

The IPI is an index that evaluates physical habitat in wadable streams using data collected with standard SWAMP protocols (Ode et al. 2016, Rehn et al. 2018). Physical habitat metrics such as substrate type, channel morphology, complexity of flow, in-stream habitat complexity, and riparian vegetative cover. The IPI was developed to enable environmental managers to evaluate how much stream conditions are influenced by anthropogenic stress, and to allow them to determine potential causes of stream disturbance, set management targets for restoration, and prioritize sites for conservation action.

The CSCI is the state of California's standard bioassessment index for interpretation of benthic macroinvertebrate data collected from wadable streams using standard SWAMP protocols. The CSCI score indicates whether and how much a stream is altered from an undisturbed state. It was developed to take advantage of the fact that living organisms such as macroinvertebrates are integrators and indicators in time and space of many different parameters of ecological condition, including sedimentation, nutrient enrichment, and riparian disturbance.

The Algal Stream Condition Index (ASCI) was modeled after the CSCI and developed to assess stream condition based on species-level data the presence of diatoms and soft-bodied algae (Theroux et al. 2020). Three indices were developed: one using diatoms, one using soft-bodied algae, and one using both assemblages. We selected the hybrid index (H-ASCI), which was found to be more accurate and responsive for statewide applications (Theroux et al. 2020).

Physical habitat, or PHAB data are grouped into categories describing physical, biological, and ecological characteristics of sites such as habitat complexity and cover, riparian vegetation cover and structure, and human influence, among others. The metrics were developed in 1999 (Kaufmann et al. 1999) and further refined in 2007 (Ode 2007), 2016 (Ode et al. 2016) and 2020 (Boyle et al. 2020). The most recent data available for each assessment site were used in our analysis. Data collection dates ranged from June 2016 to July 2021.

Range and Representativeness

Range and representativeness are measures of the ability of the RipRAM Index and RipRAM metrics to capture the range of variability found in nature (Stein et al. 2009). We examined the performance of the RipRAM Index Score across different environmental conditions using parametric (Analysis of Variance, T-tests) and non-parametric statistics (Wilcoxon signed rank test). When comparing more than two data groups, multiple comparisons tests (Tukey Studentized Range Test) or pairwise comparison tests (Tukey Honestly Significant Difference Test) were conducted when overall tests were significant. In cases where data variances were not homogeneous and residuals were not normally distributed, data were either transformed to meet assumptions or non-parametric tests were performed on signed ranked data. RipRAM Index Score was examined for significant differences across the following site characteristics. All parametric and non-parametric tests were conducted using SAS version 9.4 of the SAS System for Windows (SAS Institute Inc. 2016).

Independent assessments of site condition grouped sites according to best professional judgement, biological constraint classes (Beck et al. 2019), and site status (SWAMP). These independent assessments categorized sites from most to least disturbed and were compared to RipRAM Index Scores to demonstrate the RipRAM Index's ability to distinguish between different site conditions.

RipRAM site assessments also included characterizations of site conditions that represented the range of sites encountered statewide. These assessments included adjacent land use, hydrological flow regime, stream confinement, and presence of flowing water. We examined the relationship of these variables to RipRAM Index Score to look for biases in the site data.

Responsiveness

Responsiveness is a measure of how well the RipRAM Index distinguishes between good vs poor conditions (Stein et al. 2009). We tested this by using correlation analysis (Spearman's rho) to characterize the relationship between Level-3 data and the RipRAM Index and RipRAM metric scores. Consistent correlations between RipRAM scores and Level-3 variables are an indication of responsiveness of the RipRAM Index Score. We tested the following Level-3 variables to ensure that the RipRAM Index performed well across indices created for a range of variables encompassing watershed characteristics of habitat, physical structure, ecological communities and development, among others: California Stream Condition Index (CSCI), Hybrid Algal Stream Condition Index (H-ASCI), Index of Physical Integrity (IPI), Multi-metric Index Measuring Ecological Structure and Function (MMI), and Observed to Expected Index Measuring Taxonomic Completeness (O/E).

RESULTS

Range and Representativeness-Statewide

RipRAM Index Scores were collected from 40 assessment sites distributed throughout 30 watersheds statewide. Twenty-five watersheds were represented by a single station, while the remaining 15 stations were divided amongst the Eel River (2), Sacramento River (2), Redwood Creek (2), Klamath River (3) and Sacramento (6) (Figure 1). RipRAM Index Scores ranged from 6.25 to 100, with a mean of 72.8. The sites with the lowest RipRAM Index Scores were in San Francisco Bay and Trabuco Creek while three sites in Klamath River, Matilija Creek and Redwood Creek had RipRAM Index Scores of 100. A frequency distribution of RipRAM Index Scores showed a skewed distribution to higher scores (Figure 3A), with 10 stations falling into the 81-100 range. Individual RipRAM metrics also skewed to the left, mostly strongly for Metric 1 (Total Riparian Cover), Metric 2 (Vegetative Cover Structure), Metric 7 (Macroinvertebrate Habitat Patch Richness) and Metric 8 (Anthropogenic Alterations to Channel Morphology).

Analyses comparing the performance of the RipRAM Index Score to site assessments based on best professional judgement (Figure 3B), adjacent land use (Figure 3C), biological constraint class, and site status (SWAMP) all revealed significant differences among RipRAM sites (Table 2). In general, the RipRAM Index was able to distinguish between sites in good condition (i.e., sites with characteristics closer to reference conditions) and bad condition (i.e., sites with more human disturbance). When comparing the RipRAM Index Score to site assessments based on characteristics unexpected to differ across a disturbance spectrum (stream confinement, hydrologic flow regime, presence of flowing water), analyses revealed no significant differences (Figure 3D, Table 2). In total, these range and representative results demonstrated both lack of bias in RipRAM validation site selection and demonstration of the RipRAM Index Score's ability to reflect the variability of site conditions found in the validation data.

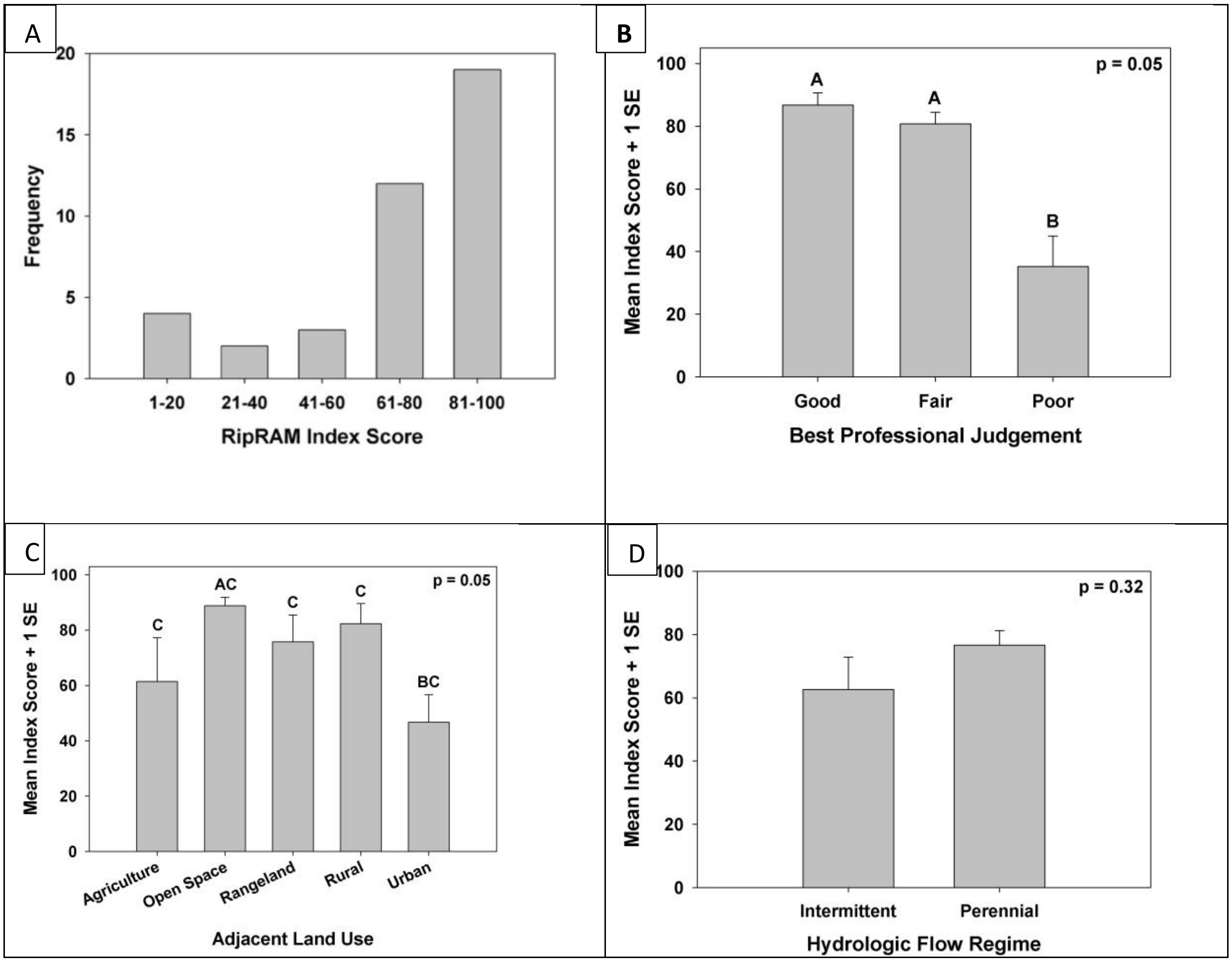

Figure 3. Graphs of RipRAM index score range and representativeness statewide. (A) Frequency distribution of index scores, (B) Mean Index score grouped by best professional judgment of condition, (C) Mean Index score grouped by adjacent land use, and (D) Mean index score grouped by stream hydrologic flow regime.

Table 2. Range and representativeness statistical results for the statewide dataset

		Overall Test				Comparison Test (when needed)			
Independent Variable	**Dependent Variable**	**Test**	**Test Statistic**	**DF**	**p value**	**Test**	**Test Statistic**	**DF**	**p value**
Best Professional Judgement	Index Score	Wilcoxon signed rank test	Kruskal-Wallis chi square - 16.08	2	p = 0.0003	Dwass, Steel, Critchlow-Fligner Pairwise Multiple Comparisons	Z = -1.68 Z = 3.27 Z = 2.49	1 1 1	0.21 0.003 0.001
Biological Constraint Class	Ranked Index Score	ANOVA	F = 24.57	3	<0.0001	Tukey Studentized Range Test	t = 3.8	36	0.05
Site Status (SWAMP)	Index Score	ANOVA	F = 18.07	2	<0.0001	Tukey Studentized Range Test	t = 3.5	28	0.05
Adjacent Land Use	Reflected LN Index Score	ANOVA	F = 4.57	4	0.0045	Tukey Honestly Significant Difference Test		35	0.05
Hydrologic Flow Regime	Index Score	Wilcoxon signed rank test	Kruskal-Wallis chi square = 0.97	1	0.324				
Stream Confinement	Index Score	Wilcoxon signed rank test	Kruskal-Wallis chi square = 1.23	1	0.27				
Flowing Water	Index Score	T-test	t = -1.15	38	0.25				

Range and Representativeness-Southern California Intensification

The SoCal Intensification dataset was comprised of data from 30 assessment sites. Index Scores at these sites ranged from 6.25 to 100, and as with the statewide data, a frequency distribution of the RipRAM Index Scores skewed to the left, with a mean Index Score of 72 (Figure 4A). The site with the lowest Index Score was found in the San Juan watershed, while the highest Index Scores came from sites in Ventura and San Diego watersheds. Individual RipRAM metrics skewed to the left also, in particular Metric 5 (Riparian Vegetation Width), Metric 7 (Macroinvertebrate Habitat Patch Richness) and 8 (Anthropogenic Alterations to Channel Morphology).

The SoCal intensification site assessments showed a lack of bias for site conditions involving hydrologic flow regime (Figure 4D), stream confinement and presence of flowing water, with no significant differences found in the RipRAM Index Scores when grouped according to these variables (Table 3). As with the statewide data, there were differences in adjacent land use between SoCal sites, with Forestland Index Scores being significantly greater than other land use categories (Figure 4C). There were no differences between different levels of developed sites, and Index Scores of sites with lower levels of development were not significantly different than open space scores.

Analysis of variance demonstrated significant differences in RipRAM Index Scores among SoCal constraint classes (F = 4.5, df = 3, p = 0.01, Figure 4B). Only 1 assessment site was classified as Likely Unconstrained, and therefore it was eliminated from the pairwise comparisons analysis. For the Index Scores of the other 3 constraint classes, Possibly Unconstrained scores were not different than Possibly Constrained scores, but they were significantly greater than Likely constrained Index Scores. Likely and Possibly Constrained Index Scores were not significantly different from each other (p = 0.05).

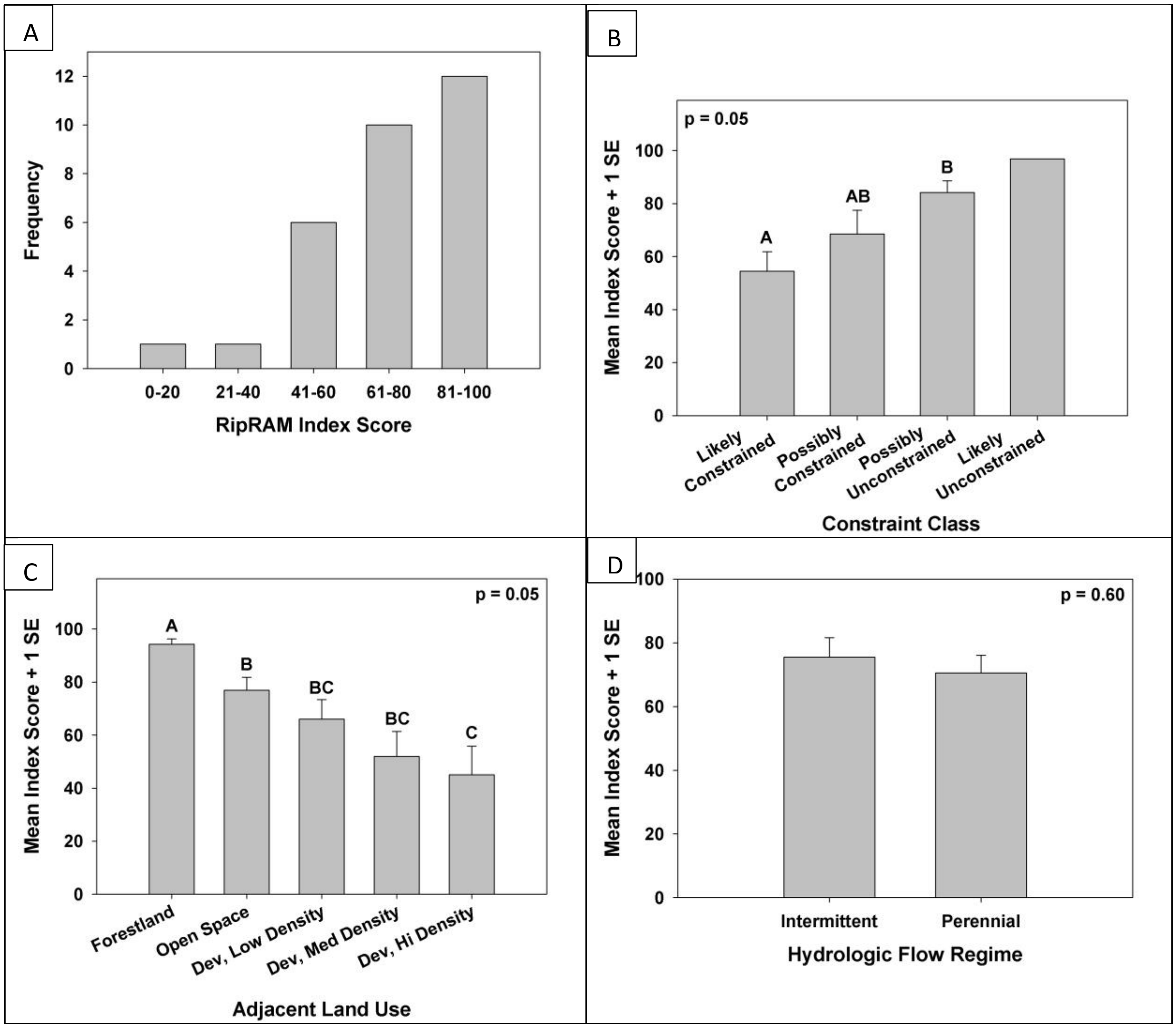

Figure 4. Graphs of RipRAM index score range and representativeness for southern California intensification. (A) Frequency distribution of index scores, (B) Mean Index score grouped by modeled constraint class, (C) Mean Index score grouped by adjacent land use, and (D) Mean index score grouped by stream hydrologic flow regime.

Table 3. Range and representativeness statistical results for the southern California intensification dataset

		Overall Test				Comparison Test (when needed)			
Independent Variable	**Dependent Variable**	**Test**	**Test Statistic**	**DF**	**p value**	**Test**	**Test Statistic**	**DF**	**p value**
Biological Constraint Class	Index Score	ANOVA	F = 4.5	3	0.01	Tukey's studentized range test	t = 3.88	26	0.05
Adjacent Land Use	Index Score	Welch's ANOVA	F = 10.8	4	0.002	Tukey's studentized range test	t = 4.15	25	0.05
Hydrologic Flow Regime	Index Score	Wilcoxon signed rank test	Kruskal-Wallis chi square = 0.97	1	0.32				
Stream Confinement	Index Score	Wilcoxon signed rank test	Kruskal-Wallis chi square = 1.23	1	0.27				
Flowing water	Index Score	T-test	t = 0.56	28	0.58				

Responsiveness- Statewide

In general, the RipRAM Index Score performed well when correlated with various PHAB Level 3 metrics (Table 4). In particular, it was positively and significantly correlated with PHAB metrics measuring Habitat Complexity and Cover and Riparian Vegetation Cover and Structure. As expected, Index Score was negatively and significantly correlated with the SWAMP Combined Riparian Human Disturbance Index and with the PHAB Aquatic Macrophytes/Emergent Vegetation Cover Present metric. The RipRAM Index Score was also negatively and significantly correlated with several PHAB metrics involving channel sinuosity and slope and substrate particle size. Individual RIpRAM metrics 1 (Total Riparian Cover), 3 (Vegetation Cover Quality), and 4 (Age Diversity and Natural Regeneration) were also positively and significantly correlated with PHAB metrics which assessed Riparian Vegetation Cover and Structure, Metric 5 (Riparian Vegetation Width) was significantly negatively correlated with multiple SWAMP and EMAP riparian and non-agricultural riparian human disturbance indices (Table 3). All RipRAM metrics except Metric 6 (Riparian Substratum Condition and Vertical Connectivity) were significantly negatively correlated to Mean Herbs/Grasses Groundcover.

Table 4. Responsiveness statistical results for the statewide dataset

Independent Variable	Dependent Variable	Spearman's Rho	p-value	Direction of Relationship
Big Shelters Cover (PHAB)	RipRAM Index	0.70	0.0004	Positive
Mean Upper Canopy Trees and Saplings (PHAB)	RipRAM Index	0.62	0.003	Positive
Aquatic Macrophytes/ Emergent Vegetation Cover Present (PHAB)	RipRAM Index	0.56	0.003	Negative
Combined Riparian Human Disturbance Index (SWAMP)	RipRAM Index	0.59	0.003	Negative
Mean Mid-channel Shade and Canopy Cover (PHAB)	RipRAM Index	0.51	0.012	Positive

Independent Variable	Dependent Variable	Spearman's Rho	p-value	Direction of Relationship
Mean Lower (Mid-Layer) and Upper Canopy Cover (PHAB)	Metric 1 - Total Riparian Cover	0.46	0.042	Positive
Riparian Vegetation All 3 Layers Presence (PHAB)	Metric 3 - Vegetation Cover Quality	0.63	0.0022	Positive
Mean Herbs/Grasses Ground Cover (PHAB)	Metric 4 - Age Diversity and Natural Regeneration	0.75	0.0001	Negative
Combined Riparian Human Disturbance Index (EMAP)	Metric 5 - Riparian Vegetation Width	0.87	0.0001	Negative
MAPS	RipRAM Index	0.65	0.04	Positive
CSCI	RipRAM Index	0.70	< 0.0001	Positive
H-ASCI	RipRAM Index	0.57	0.01	Positive
IPI	RipRAM Index	0.65	0.002	Positive
MMI	RipRAM Index	0.73	< 0.0001	Positive
O/E	RipRAM Index	0.57	0.0009	Positive

The RipRAM Index also correlated well with various statewide indices measuring wildlife support, stream condition, physical habitat, and macroinvertebrate communities (Figure 5). The RipRAM Index was positively and significantly correlated with CSCI (Figure 5A), H-ASCI (Figure 5B), IPI (Figure 5C), MMI (Figure 5D) and MAPS species richness (5E), demonstrating that the RipRAM Index Score was able to perform well statewide in riparian habitats of varying levels of disturbance and represent other measures of condition. The RipRAM Index was particularly highly correlated with the CSCI and the MMI, measures of stream condition and algal ecological structure.

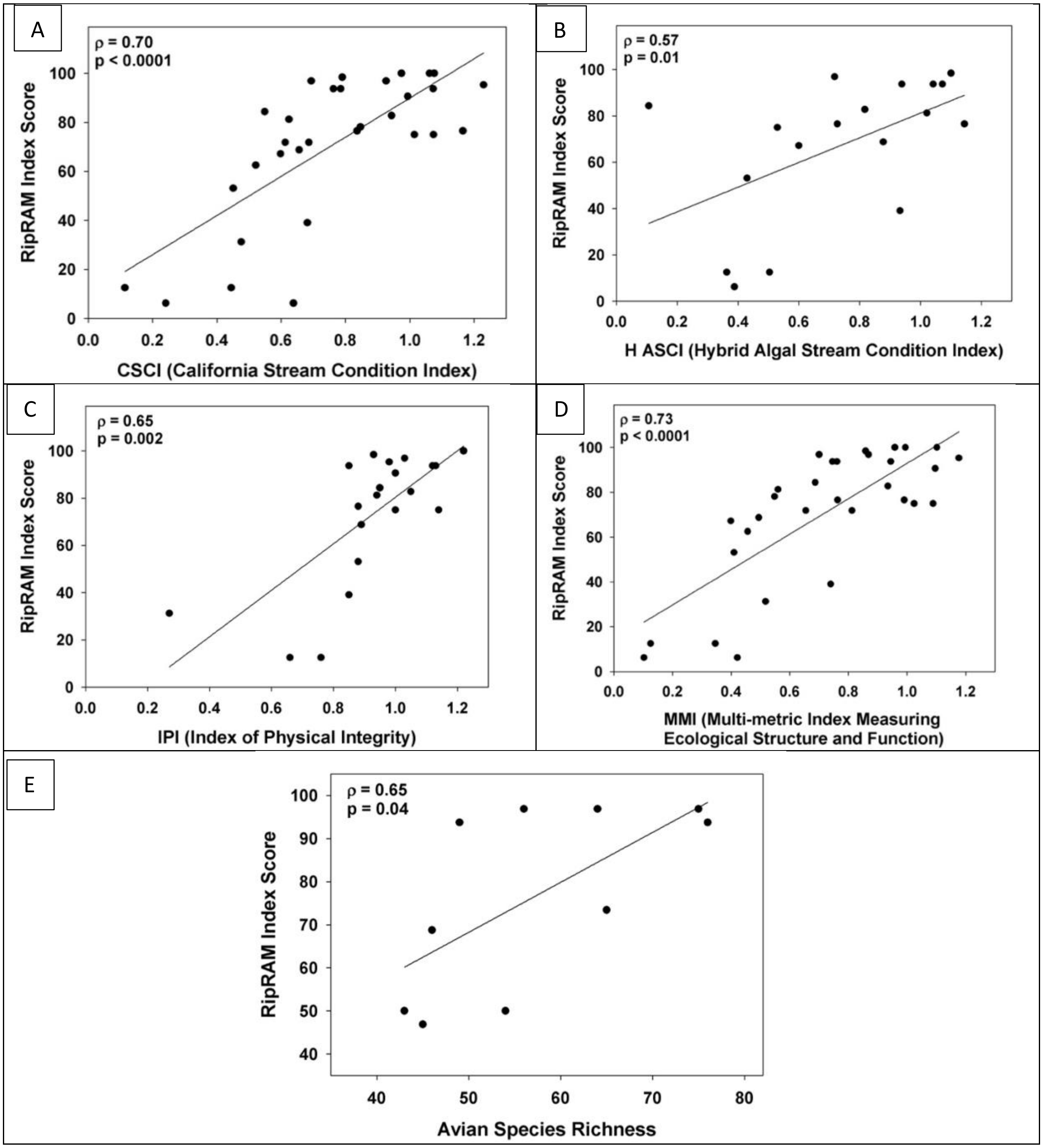

Figure 5. Graphs of RipRAM index score responsiveness for the statewide dataset. (A) RipRAM Index score compared to CSCI score, (B) RipRAM Index score compared to H ASCI score, (C) RipRAM Index score compared to IPI score, (D) RipRAM Index score compared to MMI score, and (E) RipRAM index score compared to MAPS Avian Species Richness.

Responsiveness-Southern California Intensification

Many of the significant correlations between SoCal RipRAM Index Scores and PHAB metrics involved substrate (including a negative correlation with percent hardpan), disturbance indices, and water quality. SoCal RipRAM Index Score was most positively correlated with Big Shelters and Mean Boulders

Cover, two metrics describing Habitat Complexity and Cover, and most negatively correlated with human influence PHAB metrics (Landfill/Trash Riparian Human Disturbance and the SWAMP and EMAP Combined Riparian Human Disturbance indices) (Table 5). Other significant correlations involved metrics categorizing substrate size and composition and water quality (specific conductivity, salinity).

Metric 1 (Total Riparian Cover) was most significantly and negatively correlated with water quality (conductivity and salinity), human disturbance and presence of artificial structures. Metric 3 (Vegetation Cover Quality) was most highly correlated with substrate size (positively) and disturbance (negatively). Metric 4 (Age Diversity and Natural Regeneration) was most strongly correlated with several measures related to water velocity and flow, with velocity correlations being significant and negative and flow correlations being significant and positive. Metric 5 (Riparian Vegetation Width) was also correlated with PHAB water quality metrics (negatively and significantly), as well as several PHAB disturbance metrics.

Table 5. Responsiveness statistical results for the southern California intensification dataset

Independent Variable	**Dependent Variable**	**Spearman's Rho**	**p-value**	**Direction of Relationship**
Epifaunal Substrate/Available Cover (Rapid Bioassessment Protocol)	RipRAM Index	0.83	<0.0001	Positive
Big Shelters Cover	RipRAM Index	0.67	0.0005	Positive
Landfill/Trash Riparian Human Disturbance	RipRAM Index	0.57	0.005	Negative
Natural Shelter Cover (sum LW, brush, overhang, boulders, undercut, live tree roots, macrophytes)	RipRAM Index	0.57	0.006	Positive
Combined Riparian Human Disturbance Index (SWAMP)	RipRAM Index	0.54	0.009	Negative
Mean Water Salinity	RipRAM Index	0.51	0.022	Negative
Mean Water Specific Conductivity	Metric 1 - Total Riparian Cover	0.60	0.005	Negative
Overhanging Vegetation Cover Present	Metric 3 - Vegetation Cover Quality	0.42	0.050	Negative
Mean Water Velocity (m/s)	Metric 4 - Age Diversity and Natural Regeneration	0.65	0.006	Negative
Combined Riparian Human Disturbance Index (EMAP)	Metric 5 - Riparian Vegetation Width	0.59	0.004	Negative
CSCI	RipRAM Index	0.41	0.03	Positive
H-ASCI	RipRAM Index	0.46	0.02	Positive
IPI	RipRAM Index	0.22	0.35	N/A

As with PHAB metrics, the SoCal RipRAM Indices were not as strongly correlated with indices for stream condition and algal stream condition, although both were positively and significantly correlated (Table 5, Figure 6A, 6B). The IPI did not significantly correlated with the RipRAM Index Score (Figure 6C).

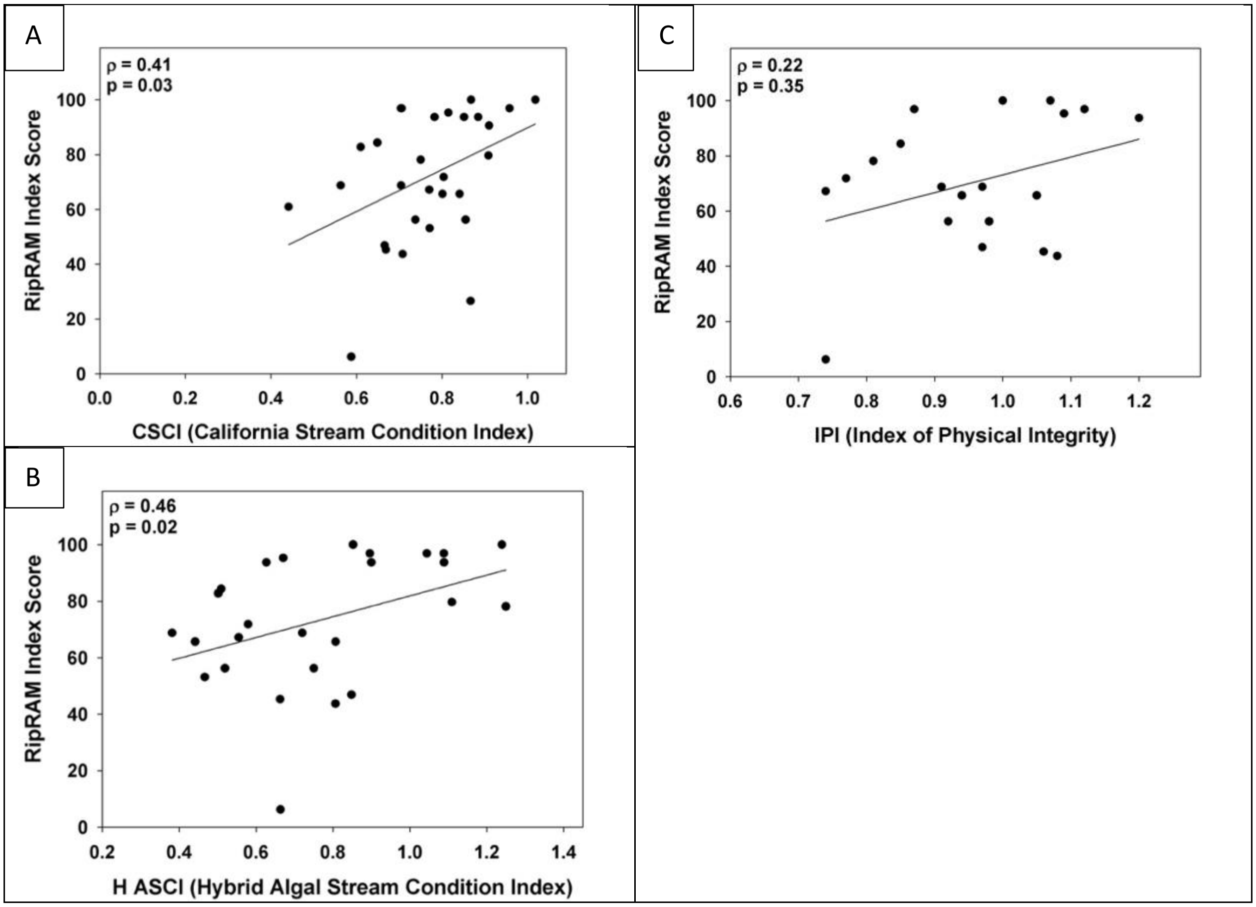

Figure 6. Graphs of RipRAM index score responsiveness for the southern California intensification dataset. (A) RipRAM Index score compared to CSCI score, (B) RipRAM Index score compared to H ASCI score, and (C) RipRAM Index score compared to IPI score.

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Task 2.3. Create eRipRAM, link with EcoAtlas

A subaward to SFEI was set up in year three of the project with the task of construction an eRipRAM interface (similar to eCRAM) and linking the interface with EcoAtlas.org so that RipRAM scores can be displayed along CRAM scores. Meetings we held over several months to decide on how the interface would look, operate, and how scores will be displayed on EcoAtlas.org.

Work on the online interface began in earnest in year 4 of the project when staff at SFEI completed development of RipRAM database, populated lookup tables, and developed various database functions for loading the metric information on the data entry forms, calculating scores, and saving assessment data to the database. In addition, staff researched and identified a newer tech stack than what is used for eCRAM (developed in 2013) for developing the online data entry forms. The newer tech-stack was selected for use. It is well supported, open-source software that is being used by other organizations, such as the React framework that is developed by Meta and the Mui.com component design that has several out of the box components that can be used for the RipRAM data entry tool without additional code development. The staff at SFEI then went on and developed detailed documentation on the technical requirements, database Entity Relationship (ER) Diagram, and functions used in the RipRAM tool.

After completing the background framework for eRipRAM SFEI moved into the forward-facing portion of the work. They developed the online mapper for submitting RipRAM AA polygons (Figure 7A), and the Basic Information and metric worksheet forms (Figure 7B), including data validation code for checking data and issuing error messages when appropriate. The final step included modifying the CRAM Data

Entry landing page to include a link to RipRAM Data Entry (Figure 7C). Various rounds of testing were conducted to confirm that new data and edits were saving to the database properly.

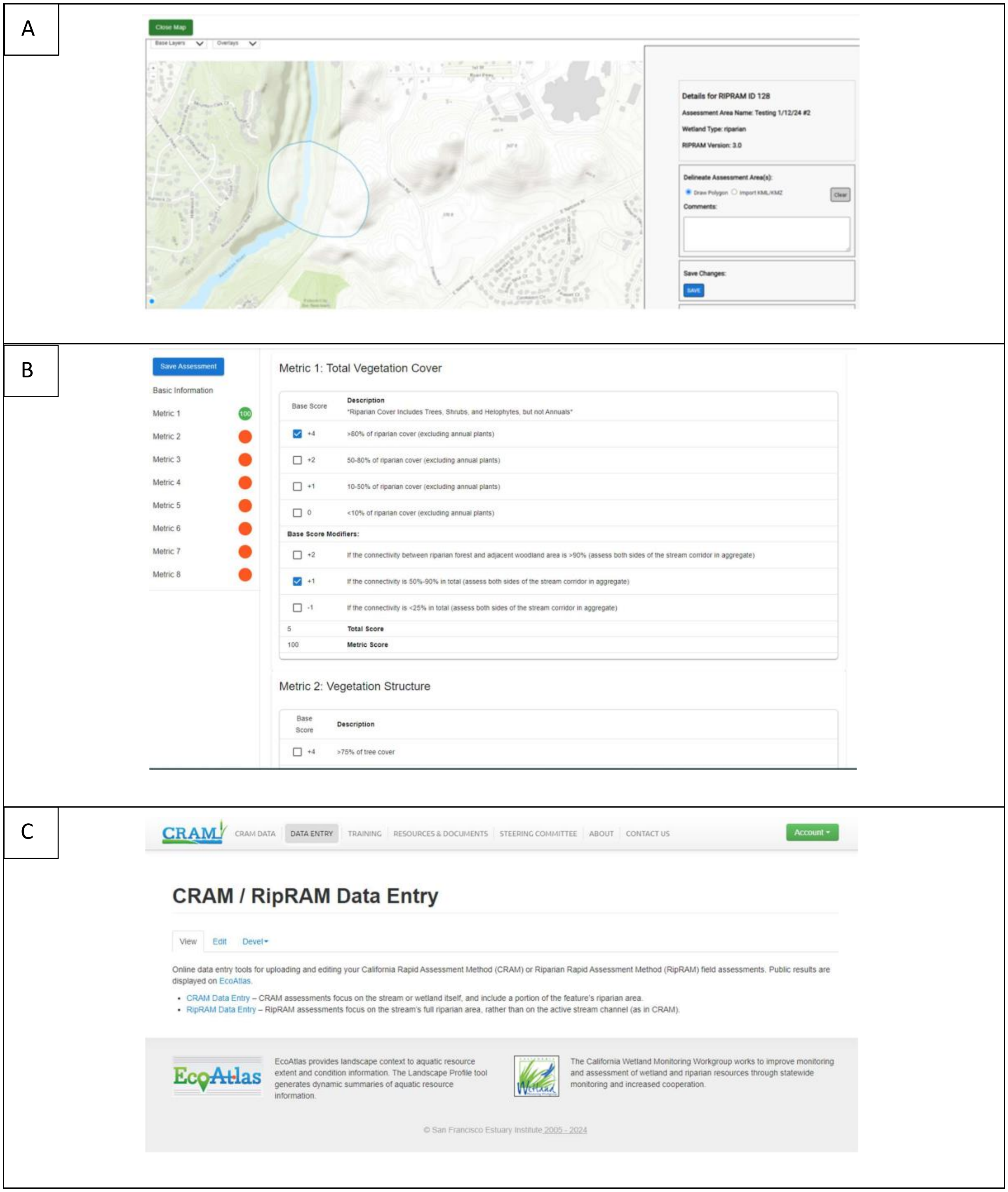

Figure 7. Screenshots of eRipRAM development. (A) Assessment Area polygon mapper, (B) RipRAM metric data sheets, and (C) CRAM/RipRAM data entry landing page

Task 2.4. Integrate RipRAM use with Regional Water Boards and WRP member agency staff through RipRAM Trainings

Over the course of years 1 and 2 the project team developed a training curriculum based heavily on the CRAM training curriculum. Several presentations were crafted to explain to the trainees the development process of RipRAM, how to conduct an assessment, and how to interpret the results. Key to the training curriculum is that it:

- Provide an understanding of the conceptual structure and approach of RipRAM;
- Provide hands-on experience with RipRAM in the office and field;
- Build capacity for the use of RipRAM by providing a solid technical grounding in the method so that practitioners can reliably perform assessments

The general schedule is a 2.5-day training course. Day 1 is a half day on zoom giving the presentations (Intro, Conducting an Assessment, Interpreting scores). Day 2 and 3 are in the field conducting a total of seven assessments. The trainers start off by walking step by step through an assessment with the trainees at the initial sites. By the end of the second day the trainees conduct the assessments on their own in groups of 2-4.

Figure 8. Photo of trainers and trainees during the April 2022 RipRAM training in the Monterey Bay area.

Four trainings were put on by the projects team over the course of 2022 and 2023 (Figure 8). The dates, locations and number of participants are listed in Table 6. The two final RipRAM trainings had a long waiting list due to an abundance of people expressing interest in taking the course. The CCWG team plans to offer a RipRAM training in Spring 2024 to address this need.

Table 6. Number of participants in RipRAM Trainings by region and location.

Date	**Region**	**Location**	**Number of Participants**
April 2022	Central Coast	Monterey Bay area	10
May 2023	South Coast	San Juan watershed	11
October 2023	Central Coast	Monterey Bay area	20
November 2023	Central Coast	San Luis Obispo area	21

Task 3. Map and prioritize healthy watersheds

This task synthesized information from multiple tools and data sets to identify stream reaches for protection and management. Data sets related to both watershed condition and vulnerability were compiled for the state and utilized in 6 watersheds within central and southern California to guide watershed management decisions in those watersheds. These assessments can serve as demonstration efforts that can be expanded with support from local partners to other watersheds as the tools are adopted.

The team developed example data visualization products that illustrate output of the assessment and how the products can be used to inform and prioritize restoration and management decisions on the central and south coasts. These stream reach watershed condition/management recommendations were then verified using RipRAM at 10 locations in each watershed (a total of 60 condition assessments). In effect, we integrated RipRAM data with other watershed condition and vulnerability indicators to establish an assessment framework for healthy watersheds. A tech memo and manuscript were drafted describing the specific data sets and methods used to develop the assessment and management framework.

Task 3.1. Synthesize information from multiple tools and datasets to assess 6 watersheds based on condition and vulnerability

Six watersheds in central and southern California were selected to use as demonstration areas for the riparian assessment tools. The three central coast watersheds were: Salinas, Santa Maria, and San Lorenzo, while the three south coast watersheds were: Ventura, San Juan and San Diego. The watersheds represent a range of size, land use and stressor impacts along the California coastline.

Figure 9. Location of the six test watersheds used to ground truth the watershed prioritization methods.

The project team the investigated the availability of stressor data and tradeoffs associated with different strategies for mapping watershed integrity (including the Riparian Condition Assessment tool, Index of Watershed Integrity, and Stream Classification and Priority Explorer). A collaboration was developed with the State Water Board's Healthy Watershed's Partnership (HWP) to align the project tea's general approach with their goals. The HWP's efforts focused on prioritizing across watersheds whereas this project focused on prioritizing management actions within watersheds. The collaboration allowed for the technical approaches to be co-developed in a way to allow both efforts to support each other.

Data compilation

The team went through a process of data compilation to inform and build the condition and vulnerability models and associated tool. Sources included StreamCat for stressors, CalEnviroScreen data set to identify potential data layers that could be used as part of the phase of prioritizing management areas based on community interests and environmental justice, and Watershed health as measured by CSCI, ASCI and CRAM scores.

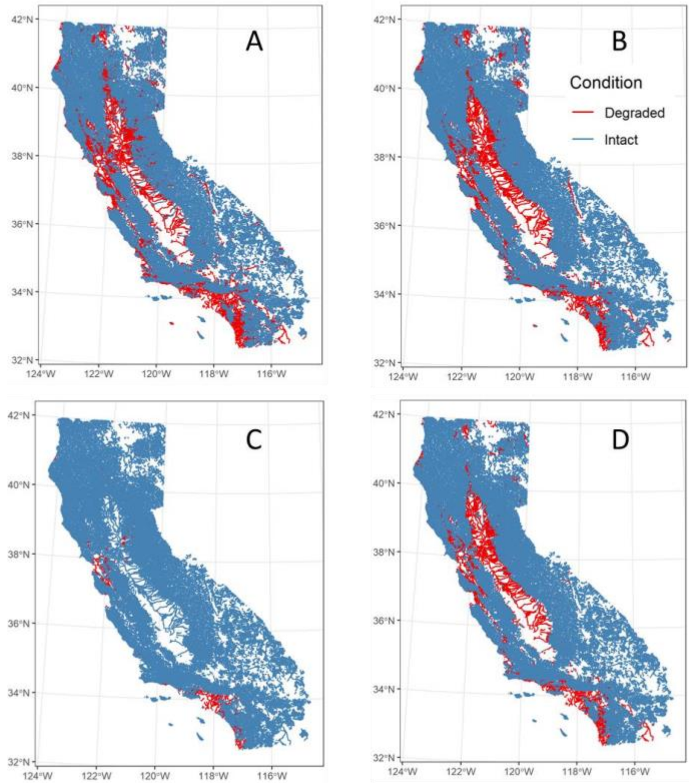

Figure 10. Predicted condition index results based on random forest model outputs for statewide stream reaches in California. Panels A, B, C, and D refer to the ASCI, CSCI, CRAM biotic structure, and CRAM physical structure indices, respectively. For each index, stream reaches were classified as "degraded" if the normalized index score was less than the 10th percentile value from reference sites.

Tool Development:

With input from the Healthy Watersheds Partnership, a strategy was developed to help prioritize potential management actions to address specific watershed scale stressors. The team then compared different modeling processes (random forest and maximum entropy) as extrapolation approaches to conduct the assessment across the entire state. Based on a review of literature and past applications, we concluded that random forest appeared to be the best way forward. The StreamCat dataset of stressors was then paired with CSCI and ASCI metrics to determine sensitivity of different condition indicators to specific stressors. This helped inform the random forest model of statewide conditions.

The team completed the statewide models for CSCI, ASCI, CRAM index scores, CRAM attribute scores, and RipRAM (Figure 10). These models provide modeled condition scores for all stream reaches in California. Together they were then used to categorize streams into candidates for protection vs. restoration.

A preliminary rule set was developed for prioritizing candidate reaches for restoration or protection based on the condition and StreamCat stressor datasets. Rules were developed using a combination of variable importance analysis from the statewide CSCI, ASCI, and CRAM random forest models, sensitivity analysis, and best-professional judgement. The preliminary rules were tested, reviewed by the project TAC, and iteratively refined (Figure 11). Following input from the HWP and TAC, SCCWRP completed development of watershed prioritization approach, including pilot testing in the six watersheds.

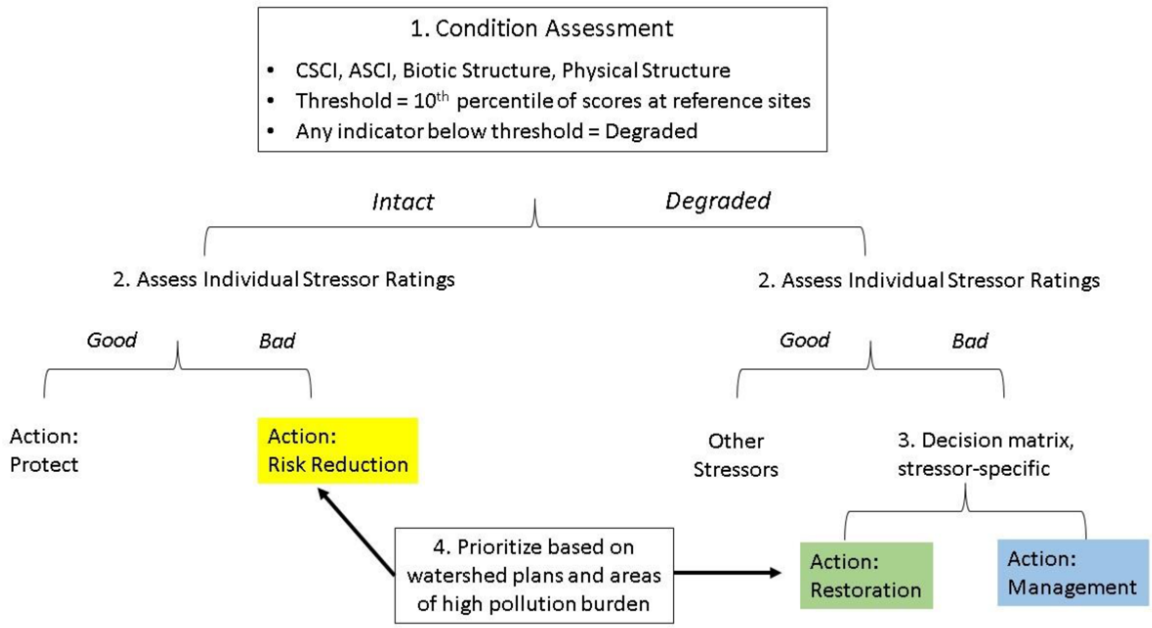

Figure 11.Process used to prioritize stream reaches for protection, restoration, or management. Intact sites with low stress should be protected and monitored. Degraded sites where median stress values did not exceed thresholds should be monitored and investigated for other stressors.

Task 3.2. Define and map the reference riparian width for central and south coast watersheds

Efforts to define and map reference riparian width on the central and south coast took a back seat to the watershed condition/vulnerability/management assessment and modeling task. The project team felt this was a much more important deliverable to finalize and get integrated into EcoAtlas.org over a riparian width map. Tools for mapping riparian width (i.e. RipZET) moved forward during the course of this project making this task not necessary.

Task 3.3. Use RipRAM to verify stream reach watershed condition estimates

CCWG conducted an assessment of the Salinas watershed in fall 2021 (using 30 locations) to verify stream reach watershed condition estimates and support the watershed assessment prioritization tool.

CCWG then worked with SCCWRP to identify RipRAM monitoring locations in the 3 southern California watersheds which were assessed in spring 2022 (Figure 12). The assessment locations were located at Southern California Stormwater Monitoring Coalition sites, allowing for the comparison of RipRAM scores to other measures of condition. The data were be used to support the watershed assessment analysis and the RipRAM validation analysis.

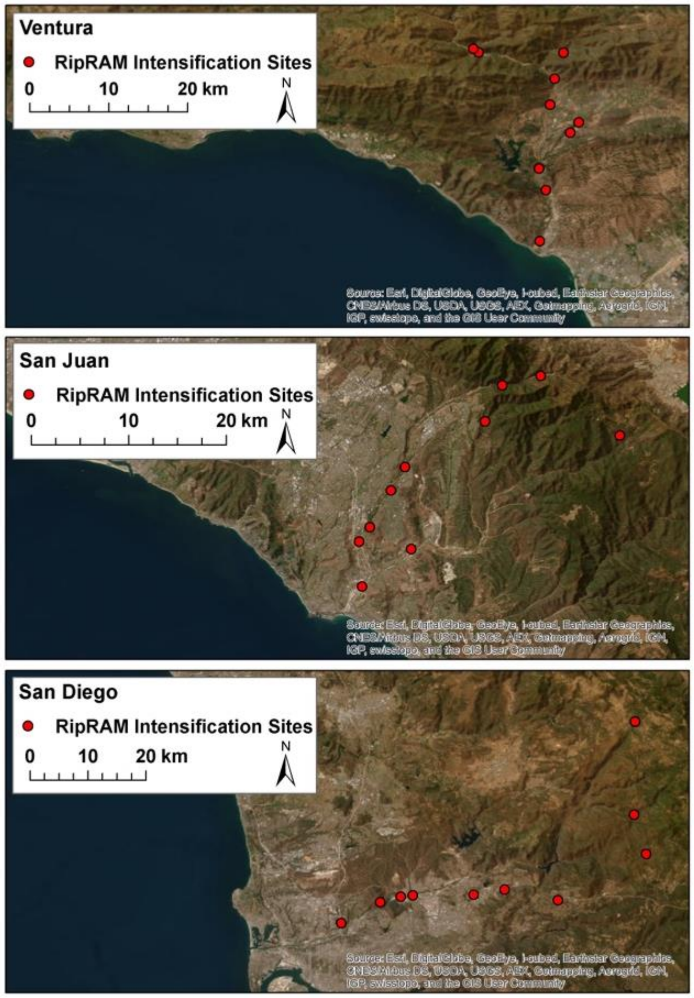

Figure 12. Locations of RipRAM assessments in the three southern California demonstration watersheds.

Task 3.4. Technical report on the watershed assessment technique

A technical report was completed in April 2022 (SCCWRP Tech Report 1246), along with an associated journal article published in *Water*[2]. The report documents the process the team went through to develop and test:

- watershed condition estimation models based on bioassessment data,
- use of the EPA's StreamCat dataset to identify stressors and develop reach-specific models to prioritize actions,
- riparian zone protection and management goals,
- improved decision maker access to watershed condition data, and

[2] https://doi.org/10.3390/w14091375

- incorporation of environmental justice concerns.

The project team applied the watershed prioritization methods statewide and in six pilot watersheds in central and southern California[3]. Statewide, the team was able to identify 18% of stream reaches that are in good condition but that are most vulnerable to existing stressors and an additional 19% of stream reaches that are degraded and are highest priority for restoration and management. The remaining 63% of stream reaches were prioritized for protection and periodic monitoring or minor remedial actions. The results of this project can help regional stakeholders and agencies prioritize hundreds of millions of dollars being spent to protect, acquire, and restore stream and riparian habitats (Figure 13). The methods are directly transferable to any regional condition and stress data that can be readily obtained.

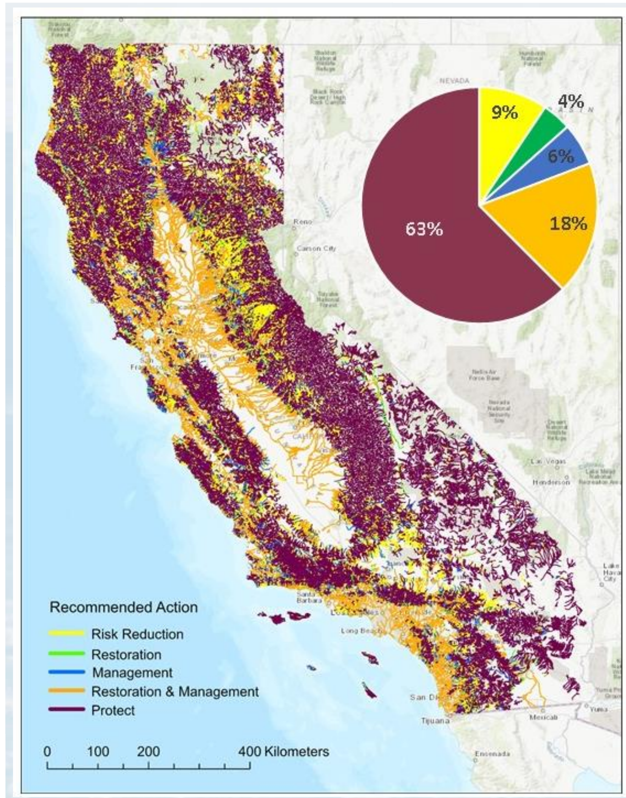

Figure 13. Recommended actions for all stream reaches in California based on outputs of the watershed prioritization analysis. An interactive map is available online.

Task 4. Development of watershed prioritization and regional protection objectives

This task demonstrated application of the tools developed in the prior tasks to establish watershed management priorities and restoration goals for the southern California and Central Coast regions.

Building on a decade of new research data and tools, the Southern California Wetlands Recovery Project began the process to update their Regional Strategy in 2012. The Regional Strategy (2018) includes quantifiable and spatially-explicit goals for *coastal wetlands* that can ultimately be used by WRP member agencies and partners for reference in designing projects, reviewing project proposals, and making funding decisions. This task supported team members to integrate coastal watershed condition results into the RSU planning process.

We expanded this effort to the central coast region, working with regional partners to ensure their visions and strategies for wetland, stream and watershed management are included and addressed.

[3] https://dataportal.sccwrp.org/

Finally, we compared the results of the south coast and central coast watershed assessments and prioritizations, providing insight regarding habitat condition, variability, vulnerability, in reference with regional priorities.

Task 4.1. Demonstrate application of the tools to establish watershed priorities and restoration/management goals for the 6 southern California and Central Coast watersheds

The project team worked with staff at the State Coastal Conservancy to demonstrate application of the tools to establish watershed priorities and restoration/management goals. Meetings were held with SFEI, SCCWRP, and SCC about how best to incorporate the modeled riparian condition and management layers into EcoAtlas.org. In response, modifications were made to the Southern California Wetlands Recovery Project EcoAtlas Dashboards, including:

- switched the order of visualizations so they are displayed in sequential order based on the objective number
- updated the caption text
- added a new Event Type code to Project Tracker for entering WRP projects

SFEI then completed a draft display of riparian management actions layer on the EcoAtlas.org development site. Feedback was provided by the project team and the final display of the riparian management actions layer was made available on the EcoAtlas website (Figure 14).

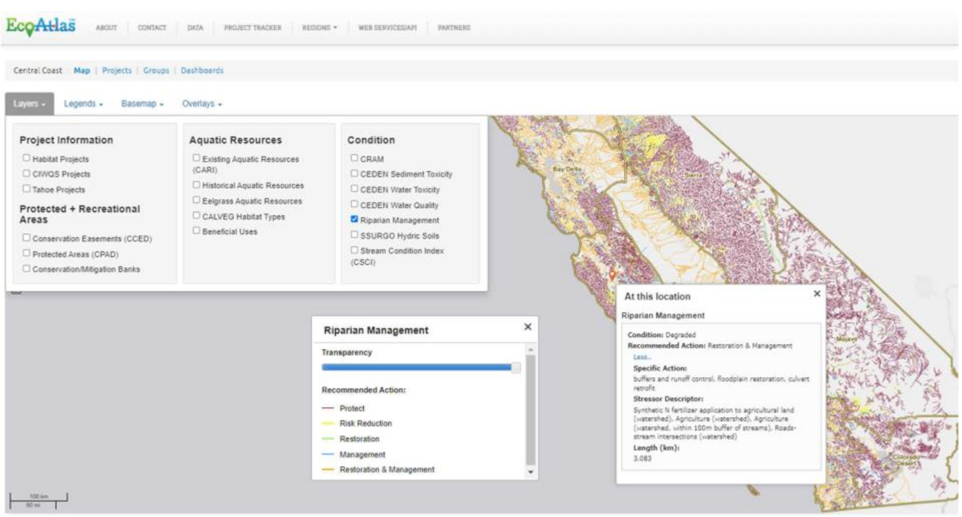

Figure 14. Riparian management actions layer on the EcoAtlas.org website.

Task 4.2. Technical report on the prioritization technique

A technical report was completed in April 2022 (SCCWRP Tech Report 1246), along with an associated journal article published in *Water.*

Task 5. Enhance platform for data dissemination and output tracking

This task integrated riparian condition data into currently available user-friendly data exploration tools to allow easy exploration of combinations of condition and vulnerability to develop watershed prioritizations. The project team uploaded condition assessment and management prioritization maps to the existing user-friendly data exploration tool (EcoAtlas).

Task 5.1. Upload condition assessment and management prioritization maps to EcoAtlas

All RipRAM assessments completed as part of this project were uploaded to the new eRipRAM online interface and then displayed on the EcoAtlas.org website.

Task 5.2. Expand functionality of EcoAtlas for use by regional partners to track progress on watershed protection goals and actions

The Riparian Management layer was added to the EcoAtlas database and interactive map under the Condition category. A new Riparian Management summary was developed and added to the EcoAtlas Condition Profile allowing for summaries by condition and recommended action (Figure 15). Finally, a section was added to the EcoAtlas Data page to provide more information on the Riparian Management layer[4].

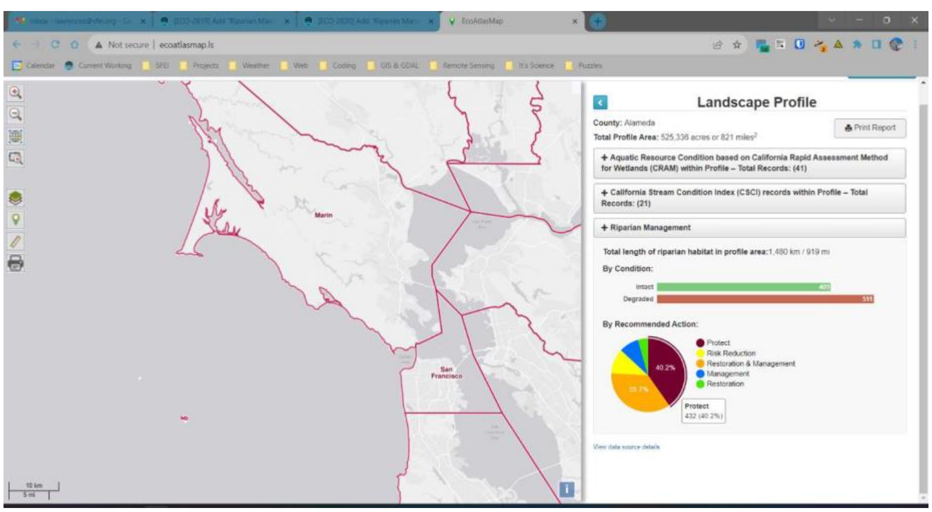

Figure 15. EcoAtlas.org webpage showing the Riparian Management summary profile.

[4] https://ecoatlas.org/data/