SOUTHERN CALIFORNIA REGIONAL RESOURCE KIT:

METRIC TRANSLATION AND PILLAR REPRESENTATION DICTIONARY

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BACKGROUND

The California Wildfire & Forest Resilience Task Force (Task Force) was created by the office of Governor Gavin Newsom to directly confront the threat of devastating wildfire and its far-reaching effects to the doorstep of nearly everyone in our state, and beyond. The Task Force is a collaborative effort to align the activities of federal, state, local, public, private and tribal organizations to support actions tailored to each region and bring the best available science to forest management and community protection efforts. The Task Force has supported the establishment of Regional Resource Kits for each of the four regions across California as delineated by the Task force for landscape management treatment planning, implementation, and tracking. The southern California ecoregion is one of the four regions, which further include the Sierra Nevada, central coast, and northern California.

Regional Resource Kits (RRK) consist of a set of core data layers pulled together to serve the basic information needs of landscape assessment and restoration planning. The southern California Resource Kit was developed in parallel with the US Forest Service's ACCEL project, which was also focused on developing data layers and decision support capacity for the 10 National Forests in the Sierra Nevada. ACCEL and the Task Force partnered in the development of the Southern California RRK, which identified 30 of the 66 ACCEL data layers for inclusion into the RRK. The ACCEL data set, as well as the RRK, is documented in the ACCEL Metric Dictionary. The metric dictionary provides detailed information on each metric: its relevance, data sources, derivation, and digital representation and location.

The raw data provided in the ACCEL data set, and the RRK by extension, provides quantitative representations of values for a given metric. However, landscape restoration is intended to improve landscape conditions through reductions in risk to valued resources and enhanced resilience to climate change and other future challenges. To evaluate the potential for management investments to achieve these benefits, managers must be able to discern favorable and unfavorable conditions and determine what management investments are most likely to accomplish their objectives.

A central objective of forest management is to increase socio-ecological resilience (LeFevre et al., 2020). The effect of past management and projected climatic change may decrease the capacity of forests to persist and recover after disturbances, adapt to shifting environmental conditions, and maintain a functional ecological structure (Churchill et al., 2013; Walker et al., 2004). Future conditions reflect climate stability as a representation of likely constraints the climate will have on maintaining existing ecosystem states. These constraints are not discernable based on current conditions, and actions based strictly on current conditions of individual metrics have the potential to be ineffective at reducing risk and improving resilience into the future. As a result, this document also describes the PROMOTE model

derivation of future stability and climate-informed management strategies to help guide management investments where they can be most effective at achieving and sustaining multiple objectives.

This document details the translation of raw data to standardized (hereafter, "translated") condition values to enable managers and stakeholders to evaluate conditions across landscapes for individual or multiple metrics and represent resilience across the levels of the framework (Element, Pillar, ecosystem) in order to inform management investments and enhance their effectiveness in accomplishing the management objectives. This document serves as an addendum to the Southern California Regional Resource Kit Metric Dictionary (SC RRK, formerly the ACCEL Metric Dictionary). SC RRK Metric Dictionary provides an in-depth description of the data source and derivation of each metric and its representation in raw values. In this companion document, we provide an abbreviated description of the metric, and then describe methods used in the PROMOTE model to translate raw values into representations of current conditions, future conditions, and climate-informed management strategies.

FRAMEWORK FOR SOCIO-ECOLOGICAL RESILIENCE

The Framework for Socio-ecological Resilience (Framework) (Manley et al. 2020, 2023) was adopted as the foundation for the ACCEL data set and the Regional Resource Kits for each Task Force region. The Framework is comprised of ten "**Pillars**" that represent the desired long-term, landscape-scale outcome to restoring resilience. Within each pillar are "**Elements**", which represent the primary processes and core functions of that pillar. Representing each element are the individual "**Metrics**" that describe the characteristics of Elements in quantitative or qualitative terms. Metrics are used to assess, plan for, measure, and monitor progress toward desired outcomes and greater resilience. The Elements representing each Pillar are relatively fixed in the Framework, but metrics are flexible and ideally consist of the best available information that provides a robust representation of each element. The constitution, derivation, and quality of metrics can improve over time as data sources and methods progress and improve. It is equally important to recognize that due to the interdependent nature of the framework, many metrics can affect conditions in multiple Elements and Pillars, but they are represented in only one place in the Framework where they best represent the fundamental character of the ecosystem.

PROMOTE MODEL

Raw values themselves do not convey information that is necessarily useful for managers to evaluate resource conditions. Raw values need to be translated into 'representations of condition' to facilitate assessments of current condition, management need, management opportunity, and the potential costs and benefits of management investments. In other words, representations of condition are necessary for assessing benefits, developing project plans, portraying the expected costs and benefits of a proposed project, and evaluating project effectiveness and landscape change toward reduced short-term risk and improved resilience into the future.

PROMOTE (Provisioning Resilience Outcomes for Management Optimization Tool) was developed to take the raw values for metrics associated with 'Elements' and the 10 Pillars in the Framework and translate them into representations of condition that can then be used by managers and stakeholders to assess conditions and evaluate management investment options.

The Southern California RRK contains over 60 metrics across the 10 Pillars. All original metrics have been translated to condition scores using the methods outlined in this dictionary. Not all of them have a particular condition interpretation, and in those cases we did not provide translated condition values. Users can select any set of metrics to represent conditions of interest to explore current landscape conditions and evaluate management options directed at current conditions represented by individual metrics. The PROMOTE model was also used to represent conditions at higher levels of the information hierarchy - the Elements and Pillars - that effectively speak to overarching resilience objectives. These additional functions provided by the PROMOTE model are described below.

PLANSCAPE WEB-BASED APPLICATION

Planscape is a planning tool built by the California Natural Resources Agency in collaboration with Google.org. and US Forest Service Pacific Southwest Research Station on behalf of the Shared Stewardship commitment between the State and Federal entities in California, and on behalf of the Task Force. The tool provides a user-friendly web-based platform that gives users easy access to the RRK raw data, the PROMOTE generated condition scores and MAPT management scores (Manley et al. In review and Povak et al. In review), and an optimization tool (ForSys; Ager et al. 2017) to help users explore landscape conditions, evaluate the outcomes of different management priorities and approaches, and ultimately help plan landscape management projects for implementation. Planscape, with the help of the RRK data, PROMOTE condition scores and MAPT management scores, and ForSys optimization functions, is designed to help stakeholders and land managers to evaluate and prioritize landscape treatments to accomplish a wide range of desired outcomes, such as mitigate fire risk, maximize ecological benefits, and help California's landscapes adapt to climate change.

DECISION SUPPORT FOR MANAGING DYNAMIC LANDSCAPES

INTRODUCTION

Landscape level assessments that leverage the availability of high-quality data, combined with decision support tools, are needed to help evaluate a complex array of management objectives across multiple and diverse interests in a rapidly changing environment. The selection of a comprehensive, spatially explicit portfolio of socio-ecological metrics is a first step, which was the objective the Regional Resource Kits for the Southern California region.

The selection of metrics to represent Elements and Pillars was accomplished by including as many of the condition-based metrics in the RRK as possible but eliminating the redundancy within and among elements. For example, the RRK contains multiple representations of some conditions with slightly different configurations (e.g., tree density by different sets of diameter classes), in those cases we represent tree density by just one of the diameter class breaks.

The next step is to provide a system where multiple metrics can be evaluated and summarized to provide quantitative representation of the Element, and similarly multiple Elements summarized to represent the Pillar. Condition scores put metrics into common units so that they can be compared and combined to make inferences over time and across Elements and Pillars. Although many different frames of reference can be generated for any given metric or suites of metrics depending on the objective, our objective was to provide a simple objective interpretation of more and less favorable conditions to support assessment and planning across the ecoregion.

In this document, we present the hierarchical framework of condition scores generated from the raw values of metrics representing each of the 10 Pillars of Resilience. The scoring approach adopted in our framework has three objectives: (1) to provide an expert-supervised, data-driven method for translating each metric's raw values into a representation of condition via fuzzy logic modeling; (2) to produce scores within a standardized scale to allow for interpretation across multiple metrics, including summation of multiple scored metrics, can be accomplished; and (3) provide a means by which metrics can be combined to make inferences about Element and Pillar conditions. Overall, the analytical capabilities of the scoring approach and the hierarchical nature of the framework allow users to create and combine scored conditions for various applications, such as landscape prioritization, evaluation of trade-offs, multi-objective planning, etc.

FUNDAMENTALS OF REPRESENTING CURRENT CONDITIONS

INTENT

The translation of raw values to a representation of condition has three elements: (1) type of data and and range of raw values; 2) a context for representing more or less favorable conditions; and (3) a

mathematical function to convert raw values to condition scores. The context for deriving condition scores can range from (1) simple representation of existing range of values; (2) broad consensus and common practices for interpreting conditions based on published literature, (3) expert opinion, when lacking scientific consensus in the literature; (4) administrative or regulatory requirements or constraints; and (5) locally determined. As one moves from broad consensus to locally determined, the burden of justification and documentation increases. In this application, most metrics were simple interpretations of range (first category), with a few falling into the second category.

PROMOTE uses fuzzy logic to evaluate the proposition that the conditions within a given cell are favorable at the metric, Element and Pillar levels of the Framework hierarchy. Instead of a binary yes/no determination of more favorable or less unfavorable, fuzzy logic evaluates the strength of evidence (i.e., condition score) for a proposition. Logic model strength of evidence output scores range between -1, representing no support for a proposition, and +1, representing full support for a proposition. Scores near 0 indicate an indeterminant representation of more favorable conditions. I

The translation from value to condition score performed by PROMOTE relies on broad consensus and common practices in order to make as few assumptions and interpretations as possible. This approach best provides a general representation and meets the needs of large landscape assessments and planning. Smaller landscapes or individual land units (e.g., an individual State Park or National Forest) may have individual administrative objectives and targets that are narrower in their interpretation of more favorable conditions (e.g., threshold of large tree density > 4/acre considered favorable); the broad representation of conditions provided by PROMOTE allows for these more local jurisdictions and interests to still interpret condition scores relative to the raw data values of interest (e.g., condition scores > 0 for large tree density may be considered favorable).

From a management context, condition scores closer to +1 indicate opportunities for conservation, and scores closer to –1 indicate opportunities for improvement or change. This context is intuitively obvious for some metrics, such as stable carbon, where areas with high scores for stable carbon would have condition scores closer to +1 and would be good candidates for conserving carbon. Similarly, areas with low scores for stable carbon would indicate areas where conserving existing stable carbon is not a major consideration, and where management investments could potentially improve conditions for stable carbon. In other cases, such as metrics of economic diversity, it is less obvious how to score raw values, and we come back to this basic objective to guide representation, that -1 values provide a guide to where management investments may result in more favorable conditions, and +1 values indicate where management investments may not be needed or where they could be designed to conserve existing conditions.

STATISTICAL APPROACH

There are five types of raw data values: continuous, percentages, proportions, ordinal, and categorical. Most metrics are continuous, percentage, or proportions, with a few falling into the other two types. Metrics with continuous values generally have a fixed minimum value of 0 and an indeterminant upper end; however, some can range into negative values. Percentages and proportions have a fixed range (0-

100 or 0-1, respectively) but otherwise are treated as continuous. Ordinal values are generally considered to be equidistant in determining condition scores. Categorical values are uncommon and take the form of binary values 0/1 or, rarely, in the form of different types of conditions which require some additional interpretation. In most cases, data can conform to a linear representation of condition that has scientific merit and management utility.

The top (+1) and bottom (-1) ends of the gradient need to be determined, and even if based on the range of values, one still needs to determine (1) what is the geographic area from which the range is derived, and (2) how to deal with outliers that can obscure the primary range of values the exist in the landscape. The geographic range could be the entire region, in this case the Southern California, or it could be associated with a subset of the region that provides a more defensible and informative context for the values. For example, species richness is a metric in the biodiversity conservation Pillar, and potential species richness is commonly a function of productivity of ecosystem types – high elevation types would be expected to have lower maximum potential overall species richness than lower elevation riparian ecosystems. So, in this example, the region would be partitioned into subregions based on major life zones or climate classes, and the value associated with +1 would be associated with the maximum observed value within the associated climate class. Some might argue that the maximum value should be the potential species richness not the observed – and there is merit to that approach. In this version of the translated continuous values, +1 was based on maximum observed values, based on the concept that it would provide a more transparent representation with fewer assumptions. In rare cases, there is strong cultural or scientific evidence to support a narrower interpretation of more favorable and less unfavorable conditions that do not span the full range of values (e.g., fire return interval, and stand density index), and in these cases endpoints for more favorable and/or less unfavorable may be established to form a narrower range of value.

The linear transformation assigns higher (or lower) scores to raw data values as they change across a positive (or negative) slope between the endpoint values, respectively. In the case of a negative slope (analogous to “lower values are more favorable”), raw data values lower than or equal to the endpoint value receive the highest score. The opposite occurs in the case of positive slope (analogous to “higher values are more favorable”): values lower than or equal to the endpoint values receive the lowest score, while those greater than or equal to the maximum get the highest score. This type of scoring based on one pair of endpoint values and monotonic slopes is termed ‘one-tailed scoring’. Equations 1 and 2 show the mathematical formulation of the scoring process with negative and positive slope, respectively; where x is the value of the metric’s current conditions, a is the lower endpoint value, and b is the upper endpoint value.

$$f(x;a,b) = \begin{cases} 1, & x \le a \\ \dfrac{a-x}{a-b}, & a < x < b \\ -1, & x \ge b \end{cases}$$ **Equation 1**

$$f(x;a,b) = \begin{cases} -1, & x \le a \\ \dfrac{x-a}{b-a}, & a < x < b \\ 1, & x \ge b \end{cases}$$ **Equation 2**

The distribution of values is the second consideration – namely how outliers are treated. The mathematical function that performs the actual scoring for continuous data can be defined as a constrained linear transformation. The constraints are endpoint values that function as cut-off data points or target values. An important aspect of interpretation-based target values is that they can be refined based on the presence of potential outliers within the statistical distribution of current conditions. This is particularly useful for metrics whose current functions have a highly skewed distribution and/or presence of outliers. From a practical standpoint, highly skewed distributions and presence of outliers can result in unrepresentative condition scores. Figure 1 shows an example of the potential effect of highly skewed distributions on the scoring process, which is explained next.

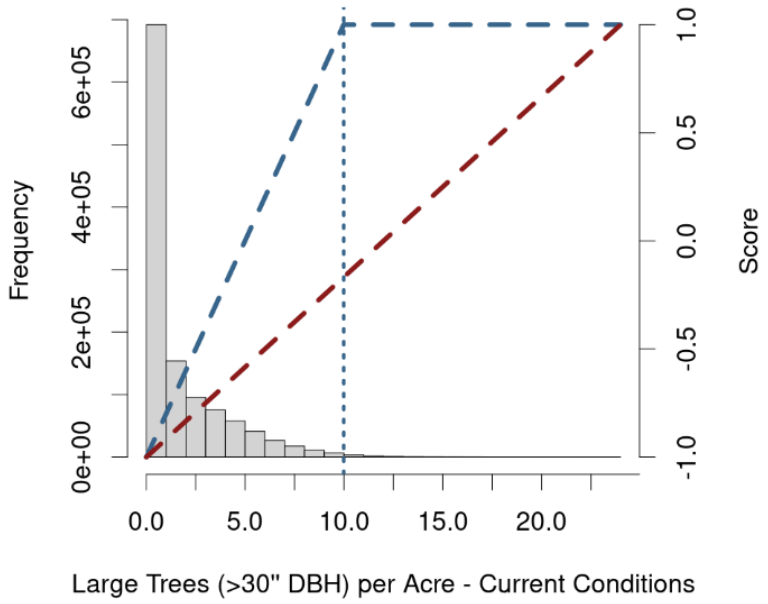

Figure 1. Statistical distribution of large trees (>30" DBH) per acre (TPA) and scoring functions. Target vertical dashed line indicates a scoring scenario where a target value of 10 TPA (dotted vertical line) was defined to mitigate the negative effect of outliers and/or skewed distributions in setting realistic condition scores. The red dashed line indicates a scoring scenario without explicitly defined endpoint values. The blue dashed line indicates a scoring scenario that reflects an upper endpoint value that is closer to the functional top end of the distribution.

In the first scenario (red dashed line), target values were not explicitly defined to evaluate the current conditions of large trees (<30" DBH) per acre (TPA) given the lack of empirical foundation. Therefore, the relationship between current and target TPA conditions was simply interpreted as "higher is more favorable". Accordingly, the minimum and maximum values from the full range of current TPA conditions were selected as targets for evaluation (0 = less unfavorable, 25 = more favorable). In the second scenario (blue dashed line), the same current-target relationship was interpreted, but 10 TPA was defined as the endpoint value considering the skewness in the distribution of current conditions. By comparing these two scenarios one may argue that the first is overly optimistic, as only current conditions of 25 TPA are considered more favorable, but they rarely occur in the landscape. On the contrary, the second scenario suggests that current conditions of 10 or more TPA are more favorable, which may be a more functional representation of condition.

Figure 2 shows the statistical distribution of current conditions for three metrics: (A) stand density index (SDI); (B) tree to shrub ratio (expressed as percent); and (3) total carbon in Megagrams per hectare (Mg/ha). The figure also shows the scoring function (dashed line), the output condition score values in the secondary y axis, and superimposed endpoint values (dotted vertical lines). The values for (A) were empirically defined based on SDI benchmarks for free competition (<0.30 more favorable) and imminent mortality (≥0.8 less favorable), as suggested by North et al., 2022. Endpoint values for tree to shrub ratio (B) were based on the existing distribution of values across the Sierra Nevada with the exclusion of outliers such that higher ratios are considered more favorable. Therefore, the linear transformation was only constrained at the minimum and 90th percentile of maximum values of current conditions. Similar to (B), higher carbon values were considered more favorable (C)

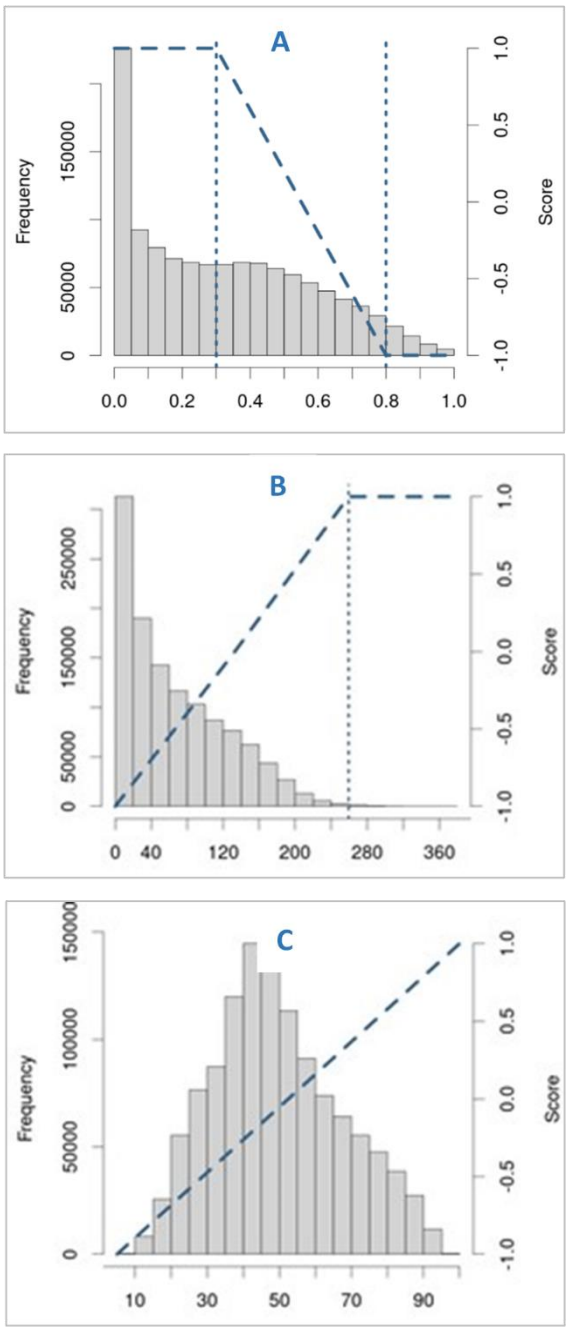

Figure 2. Histograms showing the statistical distribution of current conditions for (A) stand density index (SDI), (B) tree to shrub ratio as percent, and (C) total carbon (Mg/ha). Each inset also shows the scoring function (dashed line), the score value on the secondary y axis, and target values (dotted vertical lines, if any).

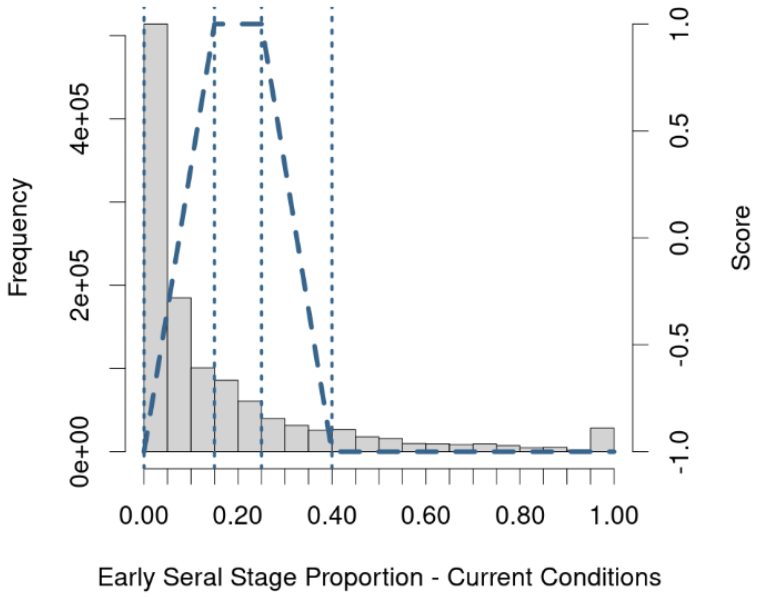

Figure 2. Statistical distribution of current early seral stage condition (D) (expressed as a proportion). The dashed line denotes a two-tailed scoring function, while the dotted vertical lines show empirical target values. The output scores are shown in the secondary y axis.

Only one-tailed scoring processes have been discussed so far. Nevertheless, the scoring can also be performed in a two-tailed fashion. In this case, more than one pair of endpoint values can be defined and both positive and negative slopes can be included in the same scoring task. A simple way to conceptualize a two-tailed scoring process is as the union of two one-tailed processes, one with a positive slope and the other with a negative slope. In this sense, the first pair of endpoint values (a, b) indicates the data point where the slope starts to climb from the lowest score (a) and the data point where it stabilizes and thus, reaches the highest score (b). The second pair of endpoint values (c, d) indicates the data point where the slope starts descending from the highest score (c), and the data point where the slope stabilizes again and thus, reaches the lowest score (d). Any data point in the range [b, c] (i.e., the plateau) will receive the highest score. Note that the selection criteria of endpoint values for one-tailed scoring still apply for the two-tailed. Also, note that (a, d) do not need to be explicitly defined. If this is the case, (a, d) will take the minimum and maximum values of the current conditions, respectively.

Figure 2 shows an example of a two-tailed scoring process, which is explained next. Current conditions of early seral stage (expressed as proportion) are scored using empirical endpoint values suggested by published literature. The first pair of endpoint values is (0, 0.15), while the second pair is (0.25, 0.40). The score of current condition values first increases between endpoint values 0 and 0.15, then stabilizes between endpoint values 0.15 and 0.25, and lastly, decreases from 0.25 to 0.40, where it stabilizes again.

REGIONAL AND SUBREGIONAL BOUNDARIES

Most metrics are translated to current condition scores based on the range of values observed across a defined area. In most cases, they reflect the full range of values across the Southern California. This regional context provides an understanding of where values are highest and lowest, and where conditions are most and least favorable. However, regional boundaries for the RRKs are derived based on a variety of criteria, and do not in all cases represent interpretable ecological or social boundaries. Also, managers are most often interested in understanding where conditions can be improved or enhanced, and maximum or minimum values at the regional scale may not be possible everywhere in the region based on intrinsic, ecological or social constraints. Translating metrics into condition scores based on the full range of values across the region may be interpreted as any location across the region can achieve the maximum or minimum values, but that not the case for all metrics. Evaluating conditions within subregions that represent areas of different intrinsic potential to achieve maximum or minimum conditions can provide a more useful management context. However, identifying appropriate and useful subregions for each metric requires thought and documentation, and some degree of consensus on how best to interpret maximum and minimum values.

This translation of the RRKs is intended to provide a generic, default representation of conditions, and as such it endeavors to take the simplest approach possible that is also meaningful and informative. There are many different approaches one could take to translating and interpreting conditions, and indeed multiple different approaches can all be useful for various applications. In this intentionally simplistic approach, ranges of values for metrics are interpreted in just one of two ways: 1) across the Southern California, or 2) for a limited set of metrics, by individual climate class. Climate class is used as the basis for subregional assessment of condition because climate is a primary driver and/or underlying influence for many of the metrics for which the range of conditions across the entire Southern California may be less useful to managers.

Climate is a main driver of ecological pattern and process interactions. These interactions may change across climate gradients making inferences among environments challenging. By identifying areas of similar climate, we can reduce the variability in ecological responses and evaluate metrics within a constrained set of environmental conditions such that these evaluations are scaled to the dominant processes influencing them. Climate classes represent discrete geographic areas of similar climate conditions that can be used to restrict metric evaluations to within a cell's climate class membership such that these evaluations capture the variability associated with a certain climatic regime.

FUNDAMENTALS OF REPRESENTING FUTURE CLIMATE STABILITY

ACCOUNTING FOR CLIMATE INFLUENCE ON ECOSYSTEM STATES

Future projected climate change will be a main driver of ecological processes moving forward, and land mangers require tools to better understand where treatments can sustain desired conditions in the long term or where transitions to alternative future states are more likely. However, quantifying potential

climate impacts on ecosystems is challenging given the number and complexity of interactions among social and ecological systems. Several studies have used a space-for-time substitution, via climate analog analysis, to identify places on the landscape that are climatically similar to the projected future climate of a given focal cell (Hamann et al. 2015, Mahony et al. 2017, Dobrowski et al. 2021). In so doing, analogues provide insight into the characteristic flora, fauna, disturbances, and other ecosystem properties of the future projected climate of a focal area.

We extend the utility of climate analog analyses to directly inform strategic and tactical management decision making by providing a representation of future prospects for each Pillar based on the magnitude of expected climate change over the next 30 years and provided in the form of a future condition score that ranges from +1 to -1 in order to facilitate the consideration of both current and future conditions into landscape restoration assessments and planning. By identifying the locations of likely climate analogue analog, the model helps quantify the likely distribution of future conditions of each Pillar. These data are then submitted to a fuzzy logic model, which translates the information gleaned from the climate analog locations to determine the level of support that future climates are compatible with maintaining existing ecosystems states associated with a given Pillar over the next 20-50 years. As such, future condition scores are intended to provide a measure of stability for each Pillar, and a frame of reference for all the Elements and metrics associated with each Pillar.

CLIMATE ANALOG METHODOLOGY

We selected a series of 9 CMIP 6 downscaled General Circulation Models (GCMs) that were recommended for regional analyses and are representative of spatial variation in model uncertainty (Mahony et al. 2022). We relied on broadly available data (i.e., North America or CONUS) to represent climate and ecosystem states to minimize constraints on the identification of analogues, and so that this methodology could be applied across all of California and across the western U.S. As such, we used ClimageNA data (Wang et al. 2016) to represent climatic conditions (temperature and precipitation), and LANDFIRE 2020 BpS data to represent ecosystem states. LANDFIRE's Biophysical Settings (BpS) represents the vegetation system that are likely to be dominant based on both the current biophysical environment and associated historical disturbance regime. BpS provides the means for interpreting the prospects of maintaining the fundamental foundation of current ecosystem states over the next several decades, with both the current and future analogues being based on BpS representations.

For each 1-km focal cell in the Southern California, we identified the top 100 climate analogues within a 1,000-km radius for each of the 9 GCMs for a total of 900 climate analogues per cell. Climate analogues were identified based on the methods of Mahony et al. (2017) and designed in consultation with climate modeling experts, including Mahony. ClimateNA (Wang et al. 2016) data were used to represent climate for the period 1971-2000 and for the future period between 2041-2070. Combined, these time periods allow for the assessment of projected climate-driven impacts on ecosystem processes and represent near-term impacts of climate change most relevant to planning timelines. Climate analog analyses was conducted using the Mahalanobis distance methods of Mahony et al. (2017) and Dobrowski et al. (2021). A total of five climate variables were selected from a set of 85 potential variables for the

analysis. Variables were selected that 1) were highly predictive of LANDFIRE BpS group vegetation patterns in the Sierras, 2) exhibited a high degree of change between the two time periods, and 3) had low multicollinearity. Variables were spring compound moisture index (CMI), mean warmest month temperature (MWMT), winter precipitation as snow (PAS), winter reference evapotranspiration (ET), and winter climatic moisture deficit (CMD).

CLIMATE-INFORMED MANAGEMENT

PROMOTE condition values and future stability values are translated into climate-informed 'management' scores, which integrate the current and future condition scores using the MAPT system (Povak et al. 2023). The MAPT system generates a composite management score that reflects the bivariate combination of current and future condition scores (Manley et al. 2023, Povak et al, 2023). The MAPT system generates a climate-informed management score that indicates which climate-adaptation strategy most closely aligns with current and future conditions: Monitor, Protect, Adapt, or Transform. These four climate-adaptation strategies are well-grounded in the climate change adaptation literature (e.g. RAD, RRT; sensu Millar et al. 2007).

1. **Monitor** – current conditions are favorable and future climate and its effects on ecosystem conditions remains relatively stable
2. **Protect** – current conditions are favorable but future climate is not expected to support current conditions, driven by substantial change and/or variability
3. **Adapt** – current conditions are unfavorable but future climate and its effects on ecosystem conditions remains relatively stable
4. **Transform** – current conditions are unfavorable and future climate is not expected to support current conditions, driven by substantial change and/or variability

MAPT scoring for landscape locations are illustrated in Figure 3, with representations of current conditions (horizontal 'x' axis) and future conditions (vertical 'y' axis), both expressed by a scale of +1 (favorable) to –1 (unfavorable). The bivariate space created by these two axes defines four climate informed management strategies based on the combination of current conditions and the expectation that the site will be able to maintain the same ecosystem characteristics in a changing climate.

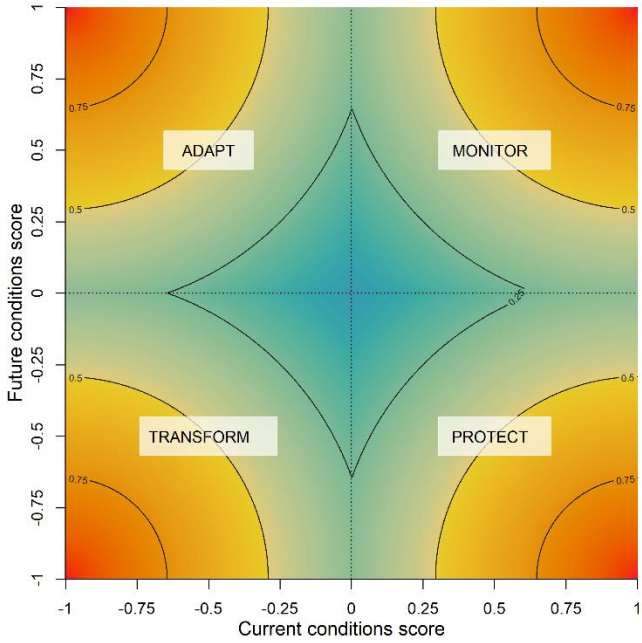

Figure 3. The MAPT system generates a composite management score that reflects the bivariate combination of current and future condition scores, reflecting a strength of association with each of four climate adaptation strategies.

The combination of current and future condition scores serves to map locations into a bivariate space that can be interpreted in terms of expectations of improving or maintaining favorable conditions. Management strategy scores can be derived for individual metrics at individual sites, and then these values can be summarized (typically averaged using a Union operator) across metrics to represent Elements, and summarized across Elements to represent Pillars, and across Pillars to represent overall ecosystem conditions. Metric scores can also be summarized across areas of interest (e.g., subwatersheds, management units, project areas) at the metric, Element, Pillar, or ecosystem level to indicate predominant climate-informed management strategies for areas of interest.

Management strategy scores are currently available in the Planscape Tool as options in all the user journeys to explore and evaluate management options and outcomes. For a more in-depth exploration of the MAPT system, associated management scores, and their utility, see Manley et al. (2023 a,b) and Povak et al. (2023).

HIGHER-ORDER RESILIENCE MEASURES: ELEMENT AND PILLAR SCORES

The set of 66 metrics in the RRK includes some highly correlated metrics to meet metric-specific interests and needs that were identified by users during the development process. However, in representing overall resilience at the Element and Pillar levels, it was important to select the strongest set of unique metrics to represent resilience. A subset of 43 metrics was selected to represent the resilience and derive climate-informed management strategies for individual Elements and Pillars. In cases where a given Element is represented by multiple metrics, the metric values are generally

averaged to represent the Element, and in cases where there are multiple Elements quantified for a given pillar, the Element values are generally averaged to represent the Pillar. Finally, Pillar values are generally averaged to represent overall ecosystem resilience. These higher-order resilience measures can be based on current conditions alone or represented by climate-informed management strategy scores. An expanded summary of the translation methods applied to the PROMOTE subset are provided in Appendix A. The translation methods applied to all metrics in the RRK are provided in Appendix B.

Table 1. Pillars of resilience, their elements, and the metrics that represent them from the Southern California Regional Resource Kit (formerly the ACCEL Resource Kit).

Pillar	Element	Metric
Air quality	*Particulate Matter*	Potential Total Smoke Production Index Potential Avoided Smoke Production Index
Biodiversity conservation	*Species Diversity*	Wildlife species richness Threatened/Endangered vertebrae species richness
Biodiversity conservation	*Focal Species*	California Spotted Owl habitat suitability Coastal California gnatcatcher habitat suitability Mountain lion suitable habitat Mountain yellow-legged frog potential habitat Unarmored threespine stickleback Peninsular bighorn sheep California red-legged frog Joshua tree Hermes copper butterfly Laguna mountains skipper Quino checkerspot butterfly Least Bell's Vireo Nesting Habitat
Biodiversity conservation	*Community Integrity*	Functional group species richness Habitat connectivity Present Day Connectivity in California (omniscape) Full climate connectivity network
Carbon sequestration	*Storage*	Total aboveground carbon Annual biomass data 2001 and 2021, above and below ground, standing dead, and litter
Carbon sequestration	*Stability*	Aboveground carbon turnover time
Economic diversity	*Wood Product Industry*	Cost of potential treatments
Fire-adapted communities	*Hazard*	Structure Exposure Score Damage Potential Source of Ember Load to Buildings Ember Load Index Ignition Cause Fire Ignition Probability, Human-Caused Wildfire Hazard Potential

Pillar	Element	Metric
Fire dynamics	*Functional Fire*	Fire Ignition Probability, Lightning-Caused Mean Percent FRID since 1908 Mean percent FRID since 1970 FRID Condition Class for Departure Time since last fire Current FRID since 1908 Current FRID since 1970
Fire dynamics	*Fire Severity*	Annual Burn Probability Probability of High Fire Severity
Forest and Shrubland resilience	*Structure*	Density – Large Trees Canopy Layer County Canopy Vegetation Height Canopy Vegetation Cover
Forest and Shrubland resilience	*Composition*	Seral Stage – Early Seral Stage – Late Tree Cover Shrub Cover Herbaceous Cover Absolute Change in Herbaceous Cover Distribution of Obligate Resprouting, Obligate Seeding, and Facultative Seeding Shrub Species (and Tree and Herb)
Forest and Shrubland resilience	*Disturbance*	Change in average annual climatic water deficit – near future – drier Cumulative tree cover loss Cumulative shrub cover loss Risk of tree dieoff during drought Goldspotted Oak Borer Multi-stressor Refugia Shrublands with Low Natural Regeneration Potential Post-Fire in Southern California Shrub resiliency, number of disturbance events per 15 year interval since 1975 Potential Climate Refugia – Baseline (historical) conditions Potential Climate Refugia – under Modeled Climate Change (MIROC Model – Hotter and Drier) Potential Climate Refugia – under Modeled Climate Change (MIROC Model – Hotter and Drier) and CNRM-CM5 (Wetter and Warmer))
Social and cultural well-being	*Equitable Opportunity*	Poverty percentile Housing burden percentile Unemployment percentile Tribal land designations Trail density

Pillar	Element	Metric
		American Indian or Alaska Native Race alone and Multirace population concentration Hispanic/Latino population concentration Black/African American population concentration Hispanic and/or Black, Indigenous or Person of Color (HSPBIPOC) Asian population concentration Multi-race not American Indian population concentration Low income population concentration
Wetland integrity	*Composition*	Aquatic species richness Wetlands type composition Riparian Areas
Water security	*Quantity*	Actual Evapotranspiration to Precipitation Fraction during Drought Precipitation minus Actual Evapotranspiration during Normal Conditions Drought sensitivity Change in Average Climatic Water Deficit Groundwater Basin Boundaries
Water security	*Quality*	Percent impervious surface

AIR QUALITY

The goal of healthier forests is aligned with the goal of having healthier air (Cisneros et al., 2014, Long et al., 2018). Forests with sustainable fuel loads create less emissions overall, and support less rapid fire growth, which reduces emissions per day and decreases the chances that smoke from a wildland fire event will create long duration, intense smoke episodes like those we've seen at regional scales during the past decade. Key to supporting the proactive management of smoke and minimization of impacts is a granular understanding at the project scale of where the fuels are, and what potential emissions might occur under wildfire and/or Rx fire scenarios. Those emissions (e.g., from maps like those produced by F3 below) combined with estimates of daily spread can be used to inform operational or scenario-based dispersion modeling (and would be compatible with California's PFIRS smoke management system), which in turn would help fire and air managers better understand where smoke is likely to go, and help inform the public where and when it's likely to occur at potentially unhealthy concentrations.

Tradeoffs between wildfire and Rx fire smoke production (daily, or in total) could be quantified on a first order basis by summing daily or total emissions from high severity vs moderate severity over the area of the respective fire spread polygons. Note that Rx fire smoke impacts are not only different due to per acre differences in emissions, but because the per day emissions can also differ quite substantially. Those emissions numbers could also inform dispersion modeling scenarios showing the relative differences in smoke impacts between wildfire and prescribed scenarios, or even between different wildfire management scenarios.

DESIRED OUTCOME: Emissions from fires are limited to primarily low- and moderate-severity fires in wildland ecosystems. Forests improve air quality by capturing pollutants.

CURRENT CONDITIONS

PILLAR REPRESENTATION

The air quality pillar consists of the three elements, but only one is described in the current version of the Southern California RRK - particulate matter. The condition score for the air quality pillar is represented by the average of the condition scores for this element.

File Name: airQuality.tif

Data Units: Proposition, +1 to -1

Translation: Where is air quality expected to be least impacted by fire?

Translation method and outcome: Values range from +1 to -1 representing more favorable to less favorable conditions, respectively.

ELEMENT REPRESENTATION: PARTICULATE MATTER

Particle pollution represents a main component of wildfire smoke and the principal public health threat. Fine particles (also known as PM2.5) are particles generally 2.5 µm in diameter or smaller and represent a main pollutant emitted from wildfire smoke. Fine particles from wildfire smoke are of greatest health concern.

This pillar is described and represented by two metrics: potential total smoke production index, and potential avoided smoke production index (indicated by asterisks). The condition of particulate matter element is represented by the average of the condition scores for the two metrics.

Data Units: Condition score, +1 to -1

File Name: partMatter.tif

Represent pillar: Yes

Translation: None

POTENTIAL TOTAL SMOKE PRODUCTION INDEX *

Tier: 1

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: This metric is an index of the potential smoke production (represented by particulate matter that is 2.5 microns or less in diameter, or $PM_{2.5}$) that could be emitted for a given 30-meter pixel under fire weather conditions that produce high severity fire effects. By showing spatial variation in potential smoke emissions under standardized fuel moisture conditions, this index is intended to help identify potential emissions hotpots within a region if a high severity wildfire occurs in the future. It may be useful for regional scale planning and/or prioritization.

However, the actual moistures and fire weather conditions under which these fuels may convert to smoke will vary; therefore, the map does not represent actual smoke production ($PM_{2.5}$ emissions) during an actual fire event. For data users interested in near-term smoke forecasts that reflect the environmental drivers of emissions, project-specific modeling tools are recommended. For example, the BlueSky Playground (https://tools.airfire.org/playground) can tailor model inputs based on the fuel and moisture conditions observed or planned for in the project area of interest.

Potential smore emissions do not consider the probability of a fire or the transport of smoke to more distant locations; they only reflect what would happen locally if a pixel were to burn.

Data Resolution: 30m Raster

Data Units: 0 - 1**,** a unitless number serving as an index; on a per 30-m pixel basis

Data Source: LANDFIRE FCCS (LANDFIRE Program: Data Products – Fuel – Fuel Characteristic Classification System Fuelbeds) 2022

Rocky Mountain Research Station https://www.firelab.org/project/fofem-fire-effects-model

File Name: PotentialTotalSmoke_202209_scored.tif

Type and distribution of data: Right-skewed distribution representing index values. Raw data values range from 0 to 1.

Represent element and pillar: Yes

Translation: Where is potential total smoke production index the lowest?

Translation method and outcome: Raw data values translated to range +1 to -1 representing more favorable or less favorable conditions, respectively. The proposition of more favorable is based on the objective of lower potential total smoke production index (negative linear slope). More favorable (translated to +1) set at 0, less favorable (translated to -1) set at > 0.2.

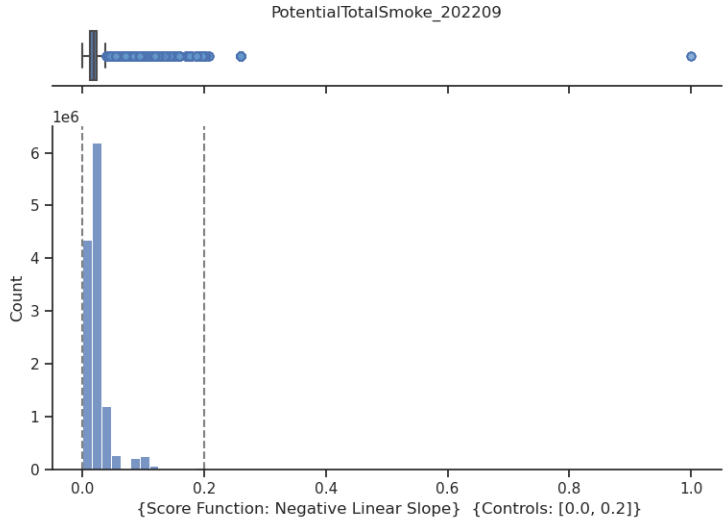

Figure 4. Histogram and scoring of potential total smoke production index in Southern California.

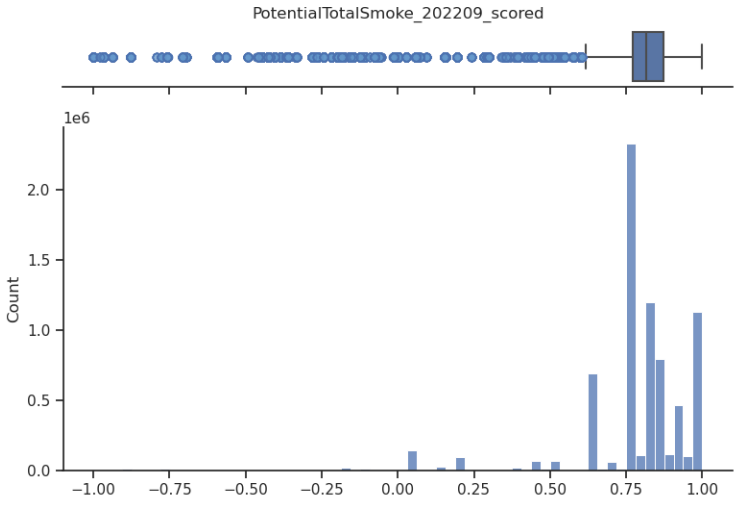

Figure 5. Histogram of translated potential total smoke production index in Southern California.

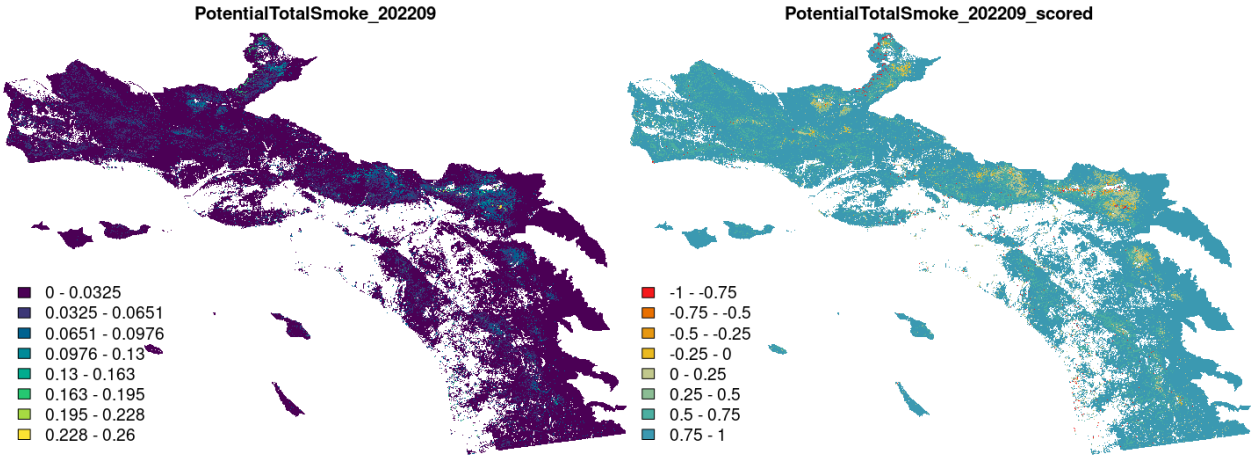

Figure 6. Maps displaying raw metric and translated metric potential total smoke production index in Southern California.

POTENTIAL AVOIDED SMOKE PRODUCTION INDEX *

Tier: 1

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: This is an index of how much *less* smoke (as defined by $PM_{2.5}$ emissions) would be produced from a given pixel by burning under moderate fire weather conditions rather than the extreme conditions that lead to high-severity smoke production. This serves as a proxy for efforts to minimize smoke emissions by allowing a given area to burn under more desirable conditions (e.g., prescribed burning conditions) vs. how it would burn under extreme conditions. Since identical fuelbeds are used as inputs in the high-severity and low-severity model runs, the index does *not* represent the effects of fuel treatments on subsequent wildfire. Rather, this metric represents the maximum potential difference between emissions under high vs. moderate fire weather conditions. Summing these reductions over large areas would be unrealistic because wildland fire burns with a mix of intensities and severities over landscapes, and does not burn everywhere in California, every year.

Wildland fire is often self-limiting in extent. In other words, wildfires may stop spreading when they reach the boundary of a recent burn. Since prescribed fire and managed wildfire can be selected to burn under moderate fire weather conditions, proactive fire use can shift high-severity-type fire emissions to low-severity-type fire emissions. This metric provides a rough index of the potential fire emissions benefits if a fire is allowed to burn under moderate weather conditions rather than in a wildfire under extreme weather. By showing the spatial variation in this potential benefit, this index is intended to help identify where fire management may have the greatest emissions benefit. It may be useful for regional scale planning and/or prioritization.

It is important to note that not all managed fire will produce an emissions benefit, because wildfire may not have otherwise burned in that location within the lifespan of the managed fire's effects, and the managed fire's footprint may not prevent a subsequent wildfire from burning in the same location.

Furthermore, actual weather conditions vary from those used in model inputs. Therefore, the map does not represent actual avoided smoke production ($PM_{2.5}$ emissions) during an actual fire event that may occur in the future. For data users interested in near-term smoke forecasts that reflect the environmental drivers of emissions, project-specific modeling tools are recommended. For example, the BlueSky Playground (https://tools.airfire.org/playground) can tailor model inputs based on the fuel and moisture conditions observed or planned for in the project area of interest.

Potential smoke emissions do not consider the probability of a fire or the transport of smoke to more distant locations; they only reflect what would happen locally if a pixel were to burn.

Data Resolution: 30m Raster

Data Units: 0 - 1**,** a unitless number serving as an index; on a per 30-m pixel basis

Data Source: LANDFIRE FCCS (LANDFIRE Program: Data Products – Fuel – Fuel Characteristic Classification System Fuelbeds) 2022

Rocky Mountain Research Station https://www.firelab.org/project/fofem-fire-effects-model

File Name: PotentialAvoidedSmoke_202209_scored.tif

Type and distribution of data: Right-skewed distribution representing index values. Raw data values range from 0 to 1.

Represent element and pillar: Yes

Translation: Where is potential avoided smoke production index the highest?

Translation method and outcome: Raw data values translated to range +1 to -1 representing more favorable or less favorable conditions, respectively. The proposition of more favorable is based on the objective of higher potential avoided smoke production index (positive linear slope). More favorable (translated to +1) set at > 0.2, less favorable (translated to -1) set at 0.

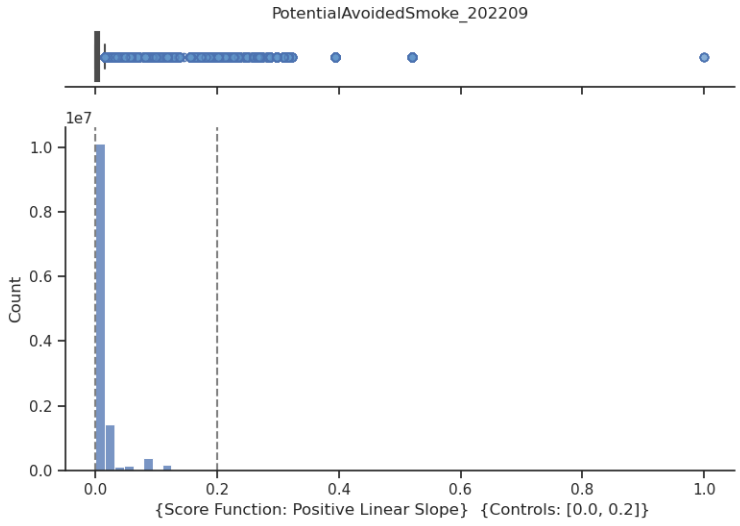

Figure 7. Histogram and scoring of potential avoided smoke production index in Southern California.

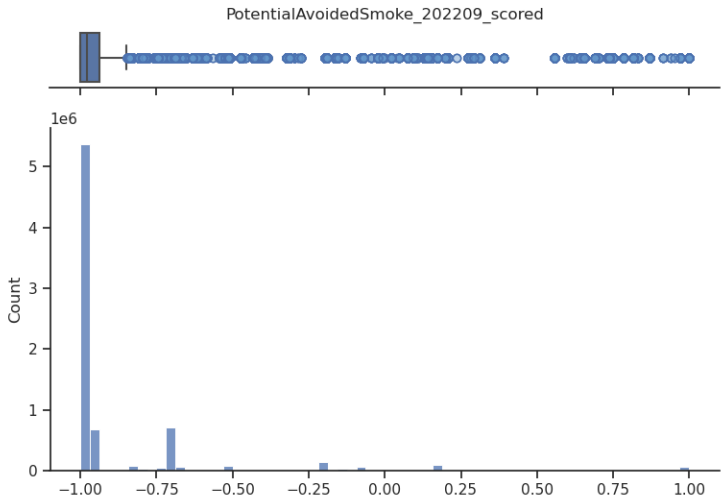

Figure 8. Histogram of translated potential avoided smoke production index in Southern California.

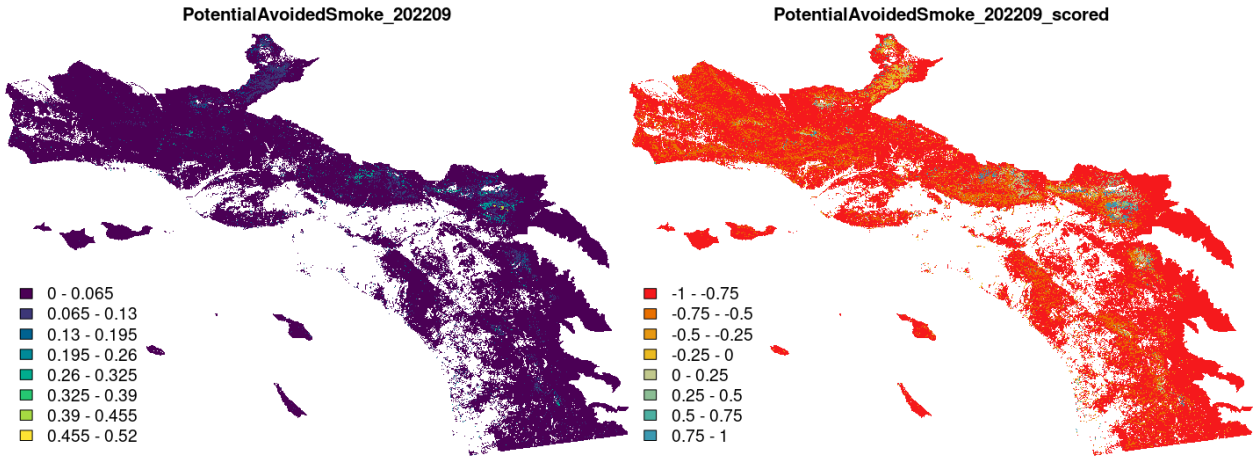

Figure 9. Maps displaying raw metric and translated metric potential avoided smoke production index in Southern California.

BIODIVERSITY CONSERVATION

The southern California landscape provides habitat for over 300 species of native vertebrates and thousands of invertebrate species and plants. Management activities over the last century have impacted most species to varying degrees and some have declined significantly in recent decades. Protecting and enhancing native biodiversity has become a management imperative under both federal and state laws and policy. Native plants and animals provide a wide array of benefits to forests and other habitats in southern California; they help forests recover after a fire, control flooding and soil erosion, cycle nutrients, and are valued by people recreating in forests. Greater species diversity promotes adaptability and helps ecosystems withstand and recover from disturbance, including those caused by climate change. The Biodiversity Conservation pillar focuses on species diversity, critical habitat for focal species and non-native species distribution.

Habitat data to model the likelihood of species presence or absence was derived from the FVEG WHR data layer.

DESIRED OUTCOME: The network of native species and ecological communities is sufficiently abundant and distributed across the landscape to support and sustain their full suite of ecological and cultural roles.

CURRENT CONDITIONS

PILLAR REPRESENTATION

The biodiversity conservation pillar has three elements: focal species, species diversity, and community integrity. Each element is represented by multiple metrics. Condition scores are calculated for all three Elements, and they are averaged to represent the Pillar. Condition scores range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of achieving the desired outcome for the pillar.

File Name: bioDiverConserv.tif

Translation: Where is biodiversity greatest?

ELEMENT REPRESENTATION: SPECIES DIVERSITY

Species diversity is a function of both the number of different species in the community and their relative abundances. Larger numbers of species and more even abundances of species lead to higher species diversity. Species diversity can be calculated in a variety of ways to represent the type and magnitude of differences among species, their number, and their abundance.

Two metrics describe and represent the species diversity element: wildlife species richness and federally threatened/endangered vertebrate species richness. The condition scores for each of the metrics are averaged to derive a condition score for the species diversity element.

Data Resolution: 30m Raster

File Name: speciesDiversity.tif

Translation: Where is species diversity the greatest?

WILDLIFE SPECIES RICHNESS *

Tier: 2

Data Vintage: 04/2023

Metric Definition and Relevance: Native species richness is estimated based on high suitability reproductive habitat for a given species. Reproductive habitat is used to represent suitability because it is critical for species persistence and for most native species it has the most limited requirements. If a habitat is identified as high for a given species, it is considered suitable (1), and habitat identified as moderate, low or not suitable, it is considered unsuitable (0). Species richness values are used as a relative measure of biodiversity value; as such, areas with lower species richness based on these criteria may still have high biodiversity value, but not as high as areas with higher richness values. The number of native species per spatial unit (30m pixel) presented as simply the total number; this can be useful for assessing change in number/composition over space. These values are specific to the southern California species and footprint for this kit.

Data Resolution: 30m Raster

Data Units: Number of species

Data source: FVEG 2023; California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: wildlife_species_richness_scored.tif

Type and distribution of data: Normal distribution representing count data. Raw data values ranged from 1 to 80 species across the Southern California.

Represent element and pillar: Yes

Translation: Where is species richness the greatest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting higher species richness (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) set based on climate regions (Table 7). Alternative approaches could be to use the maximum potential species richness as opposed to the maximum observed; however, this assumes that all species could possibly cohabitate, which is unlikely. It is possible that in the future (or past) a greater number of species could occupy the climate class and find suitable habitat within the

same 30m cell; however, the current representation is simply intended to provide a relative measure of diversity to inform where on the landscape biodiversity is currently being supported.

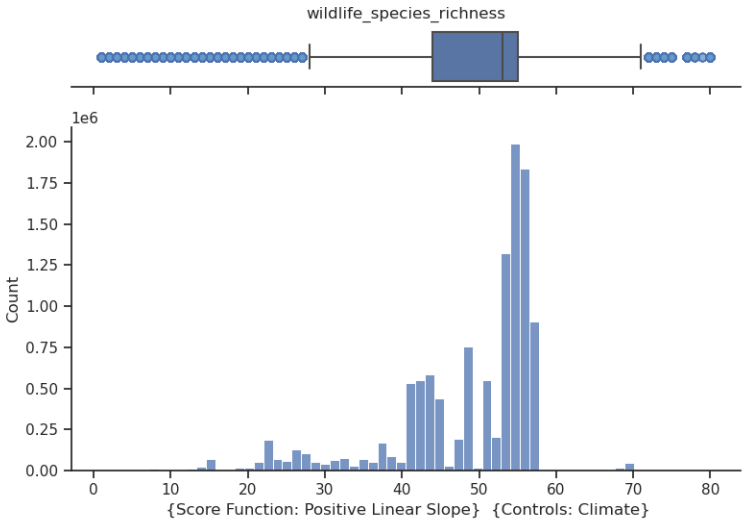

Figure 10. Histogram and scoring of wildlife species richness in Southern California

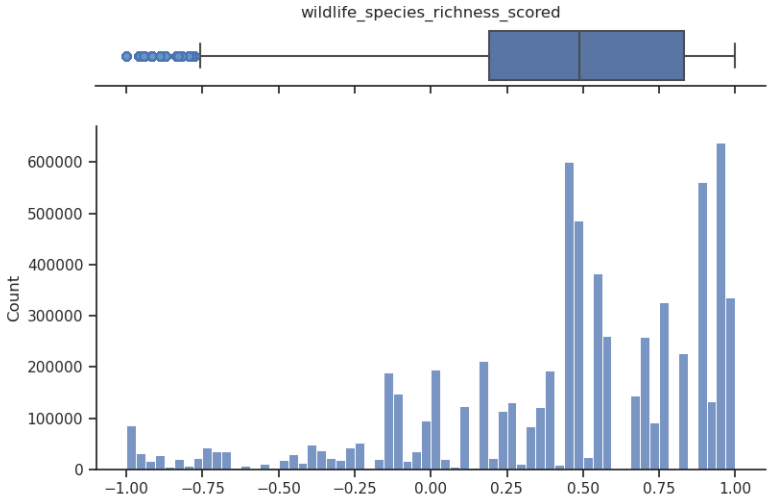

Figure 11. Histogram of translated wildlife species richness in Southern California

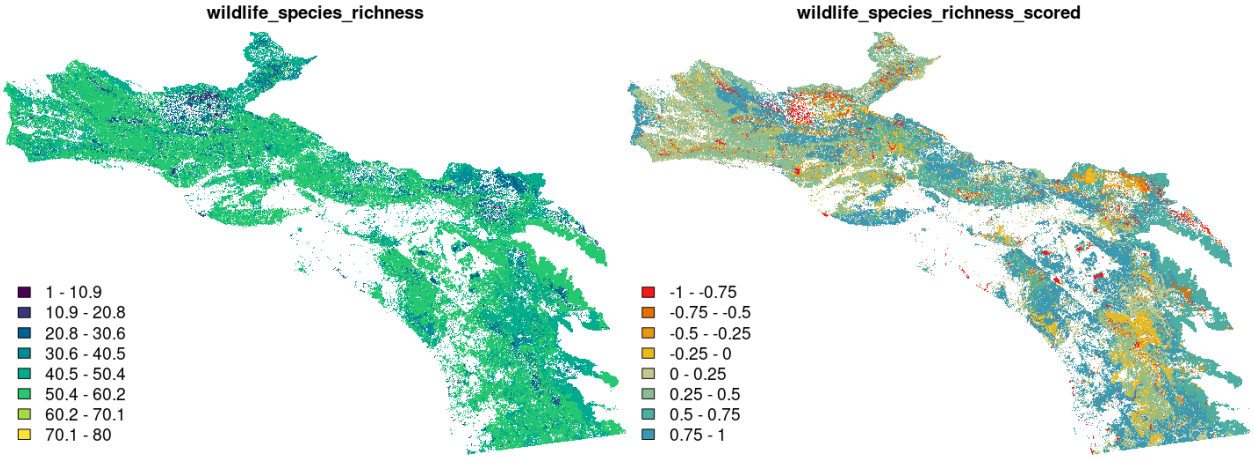

Figure 12. Maps displaying raw metric and translated metric wildlife species richness in Southern California

THREATENED/ENDANGERED VERTEBRATE SPECIES RICHNESS *

Tier: 2

Data Vintage: 04/2023

Metric Definition and Relevance: Native species richness is estimated based on high suitability reproductive habitat for a given species. Reproductive habitat is used to represent suitability because it is critical for species persistence and for most native species it has the most limited requirements. If a habitat is identified as high for a given species, it is considered suitable (1), and habitat identified as moderate, low or not suitable, it is considered unsuitable (0). Species richness values are used as a relative measure of biodiversity value; as such, areas with lower species richness based on these criteria may still have high biodiversity value, but not as high as areas with higher richness values. The total number of federally threatened/endangered native species per spatial unit (30m pixel) can be useful for assessing change in number/composition over space. These values are specific to the southern California species and footprint for this kit.

Data Resolution: 30m Raster

Data Units: Number of species

Data source: FVEG 2023; California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: t_e_species_richness_scored.tif

Type and distribution of data: Normal distribution representing count values. Raw values ranged from 0 to 10 across the Southern California. Maximum values varied among climate classes.

Represent element and pillar: Yes

Translation: Where are the number of threatened and endangered species the greatest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting a greater number of threatened and endangered species at a given point in time (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) set based on climate regions (Table 7).

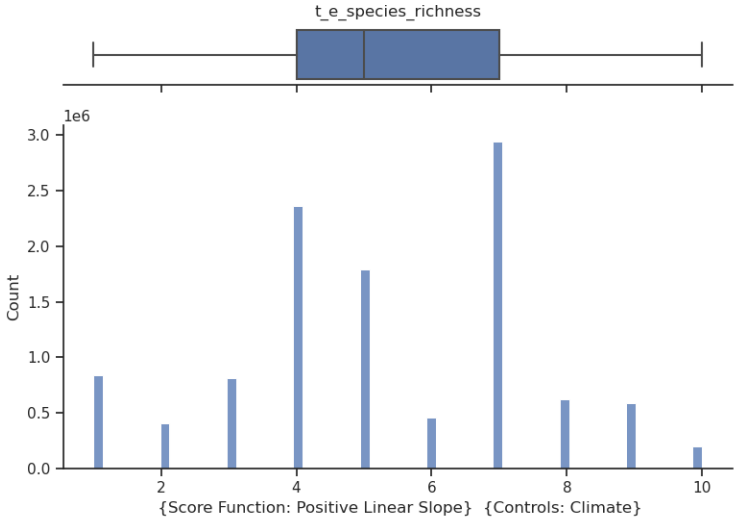

Figure 13. Histogram and scoring of threatened and endangered vertebrate species richness in Southern California

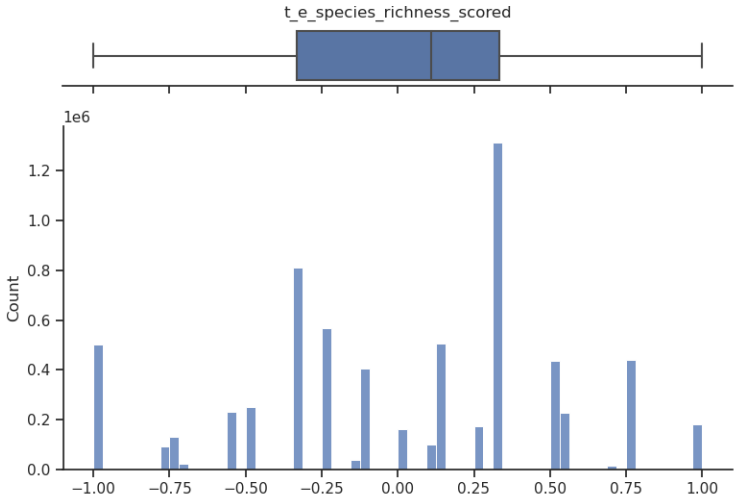

Figure 14. Histogram of translated threatened and endangered vertebrate species richness in Southern California

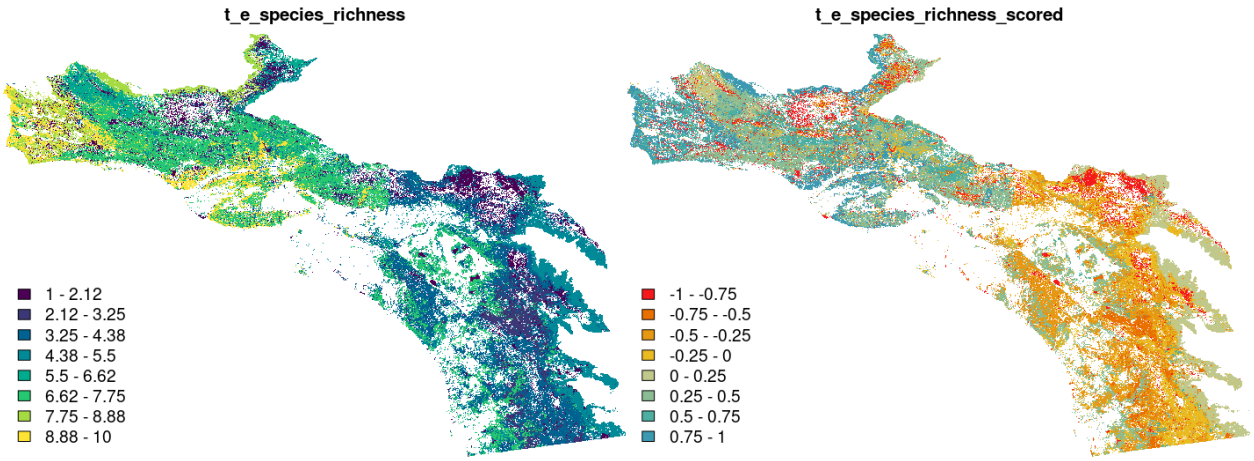

Figure 15. Maps displaying raw metric and translated metric translated and endangered vertebrate species richness in Southern California

ELEMENT REPRESENTATION: FOCAL SPECIES

For specified species listed below within the Focal Species element section of the Biodiversity Conservation pillar, the species should be considered as *Species of Interest*. It is important for the readers to understand, the listed species are not exhaustive, may be an Endangered Species Act (ESA) species, or considered Sensitive Species as they pertain to forest planning. These species are identified based on their sensitivity to impacts from restoration thinning, prescribed fire, and wildfire. The focal species are California Spotted Owl, Coastal California Gnatcatcher, Mountain Lion, Mountain Yellow-Legged Frog, Unarmored Threespine Stickleback, Peninsular Bighorn Sheep, California Red-Legged Frog, Joshua Tree, Hermes Copper Butterfly, Laguna Mountains Skipper, Quino Checkerspot Butterfly, and Least Bell's Vireo Nesting Habitat. The element representation is a sum of all of the focal species for which a given cell provides highly suitable habitat (translated value of +1) relative to the potential for species to occur in a given location given their geographic distribution.

Data Resolution: 30m Raster

File Name: focalSpecies.tif; all_sum_habitat_scored.tif

Type and distribution of data: Left-skewed, beta-like distribution representing counts. Raw data values range from 0 to 12 species.

Represent pillar: Yes

Translation: Where is habitat suitable for the most focal species?

Translation method and outcome: The potential maximum number of focal species was determined based on the overlap of species ranges. The sum of focal species with suitable habitat in a given pixel was used as the observed number of focal species. Values are translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively, based on the ratio of number of species with suitable habitat (numerator) and the potential number of focal species based on

geographic distributions (denominator). The proposition of more favorable is based on the objective of supporting habitat for the most beneficial and fewest negatively impacting species. All of the focal species are the focus of conservation, so the larger the number of species supported, the more favorable the habitat. More favorable (translated to +1) set at 1 (all habitat suitable for all potentially occurring focal species) and less favorable (translated to -1) set at 0 (no suitable habitat for potentially occurring focal species).

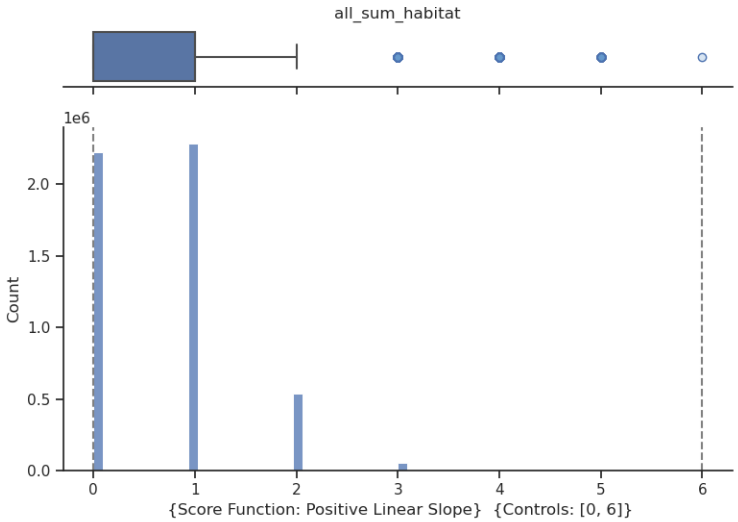

Figure 16. Histogram and scoring of all suitable habitat for focal species in Southern California

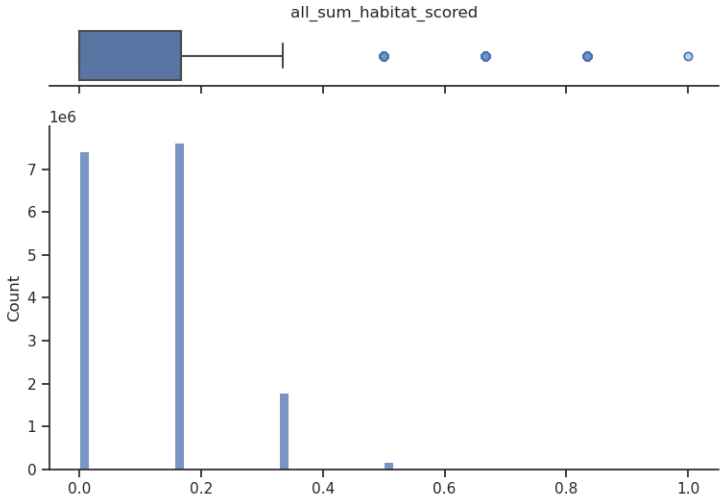

Figure 17. Histogram of translated all suitable habitat for focal species in Southern California

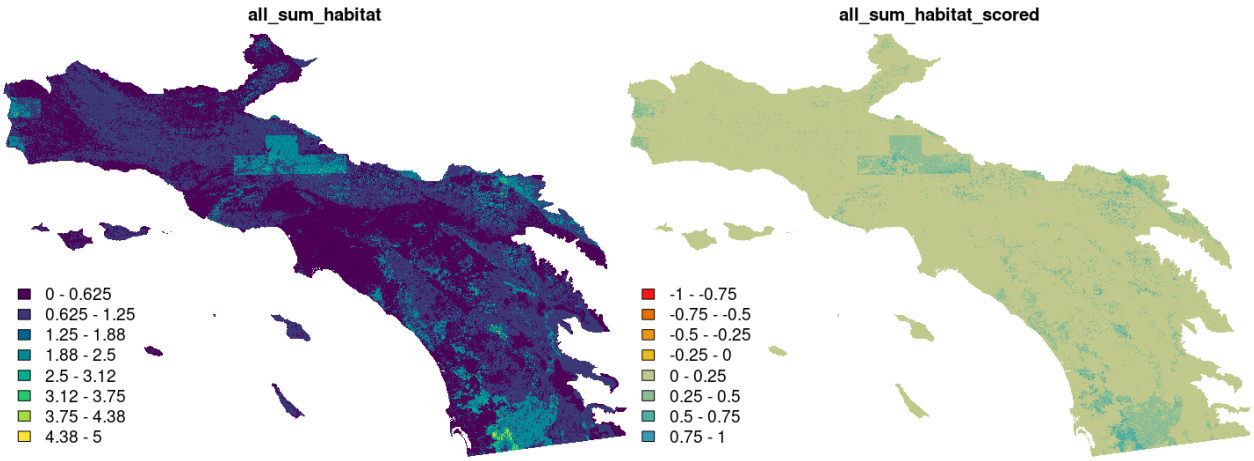

Figure 18. Maps displaying raw metric and translated metric all suitable habitat for focal species in Southern California

CALIFORNIA SPOTTED OWL HABITAT SUITABILITY *

Tier: 2

Data Vintage: 2023

Metric Definition and Relevance: California spotted owl is continuously distributed on the western slope of the Sierra and inhabits elevations ranging from 1,000 to over 7,000 feet, it is a Region 5 Forest Service "Sensitive Species" and a "Management Indicator Species" (representing late seral closed canopy coniferous forest). In November, 2019, the USFWS issued a 12-month finding on a petition to list the California spotted owl under the Endangered Species Act and determined listing to be not warranted at this time (USDI Fish and Wildlife Service 2019). Although the species is declining throughout much of its range and faces continued threats due to wildfire, habitat loss, and competition from barred owls, the USFWS determined that existing regulatory mechanisms are sufficient (USDI Fish and Wildlife Service 2019). This species is also recognized as a California "Species of Special Concern and a Species of Greatest Conservation Need."

A conservation assessment for California spotted owl was conducted in 2017 (Gutiérrez, Manley, and Stine 2017). This was followed by the development of a conservation strategy to guide habitat management on National Forest System Lands (USDA Forest Service 2019). The conservation strategy for the California spotted owl throughout its range, including southern California, aims to balance the need to conserve essential habitat elements around sites occupied by California spotted owls, while simultaneously restoring resilient forest conditions at the landscape scale (USDA Forest Service 2019).

The USDA Forest Service designates a 300-acre protected activity center (PAC) around each known nesting area or activity center. PACs are a USFS land allocation designed to protect and maintain high-quality California spotted owl nesting and roosting habitat around active sites. Territorial owls typically defend a geographic area consistently used for nesting, roosting, and foraging, containing essential habitat for survival and reproduction. The USDA Forest Service calls for an area of 1,000 acres in the

central Sierra Nevada around core use areas, including the associated protected activity center, with a minimum of 400 acres of suitable habitat.

Data Resolution: 30m Raster

Data Units: Binary, 0 (Low Suitability, Presence), 1 (High Suitability, Absence)

Data source: FVEG; California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014 Conservation Strategy for the California Spotted Owl in the Sierra Nevada, US Forest Service, 2019

File Name: CSO_suitable_habitat_scored.tif

Type and distribution of data: Binary distribution representing presences/absences.

Represent element and pillar: Yes

Translation: Where is habitat suitable for the California spotted owl?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting habitat for California spotted owl (positive linear slope). More favorable (translated to +1) set at 1 (highly suitable), less favorable (translated to -1) set at 0 (not highly suitable).

COASTAL CALIFORNIA GNATCATCHERS HABITAT SUITABILITY *

Tier: 2

Data Vintage: 2015

Metric Definition and Relevance: This habitat model was developed to delineate a sampling frame for regional monitoring of coastal California gnatcatchers (*Polioptila californica californica*) to determine: 1) percent area occupied (PAO) in high and very high suitability habitat across conserved lands and participating military lands in the U.S. range in southern California; 2) changes in PAO over time; and 3) extinction and colonization rates. One specific purpose of the model is to identify areas recovering from disturbance, such as wildfire, that may not currently support coastal sage scrub vegetation used by coastal California gnatcatchers but are otherwise highly suitable. This will enable monitoring gnatcatcher occupancy associated with habitat changes over time.

Data Resolution: 150m Raster

Data Units: Binary, 0 (Low Suitability, Presence), 1 (High Suitability, Absence)

Data source: USGS; Vandergast, A.G., Kus, B.E., Preston, K.L. and Barr, K.R., 2019. Distinguishing recent dispersal from historical genetic connectivity in the coastal California gnatcatcher. Scientific reports, 9(1), pp.1-12.

File Name: Gnatcatcher_Habitat_scored.tif

Type and distribution of data: Binary distribution representing presences/absences.

Represent element and pillar: Yes

Translation: Where is habitat suitable for coastal California gnatcatchers?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting habitat for coastal California gnatcatchers (positive linear slope). More favorable (translated to +1) set at 1 (highly suitable), less favorable (translated to -1) set at 0 (not highly suitable).

MOUNTAIN LION SUITABLE HABITAT *

Tier: 2

Data Vintage: 2023

Metric Definition and Relevance: This layer shows highly suitable habitats for the reproduction and feeding of Mountain lion (*Puma concolor*).

Data Resolution: 30m Raster

Data Units: Binary, 0 (Low Suitability, Presence), 1 (High Suitability, Absence)

Data source: FVEG 2023; California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: Mountain_lion_suitable_habitat_scored.tif

Type and distribution of data: Binary distribution representing presences/absences.

Represent element and pillar: Yes

Translation: Where is habitat suitable for mountain lions?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting habitat for mountain lions. More favorable (translated to +1) set at 1 (highly suitable, positive linear slope), less favorable (translated to -1) set at 0 (not highly suitable).

MOUNTAIN YELLOW-LEGGED FROG POTENTIAL HABITAT *

Tier: 2

Data Vintage: 2018

Metric Definition and Relevance: This dataset represents a species habitat distribution map for Southern Mountain Yellow-legged Frog (*Rana muscosa*) within the conterminous United States (CONUS) based on 2001 ground conditions.

Data Resolution: 30m Raster

Data Units: Binary, 0 (Low Suitability, Presence), 1 (High Suitability, Absence)

Data source: USGS

File Name: mountain_yellow_legged_frog_potential_habitat_scored.tif

Type and distribution of data: Binary distribution representing presences/absences.

Represent element and pillar: Yes

Translation: Where is habitat suitable for Mountain Yellow-legged frog?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting habitat for Mountain Yellow-legged frog (positive linear slope). More favorable (translated to +1) set at 1 (highly suitable), less favorable (translated to -1) set at 0 (not highly suitable).

UNARMORED THREESPINE STICKLEBACK *

Tier: 3

Data Vintage: 2021

Metric Definition and Relevance: This is a dataset representing the boundaries for the Unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*) as understood by the United States Fish and Wildlife Service.

Data Resolution: 30m Raster

Data Units: Binary, 0 (Low Suitability, Presence), 1 (High Suitability, Absence)

Data source: U.S. Fish and Wildlife Service (USFWS), Ecological Services Division

File Name: unarmored_threespine_stickleback_current_range_scored.tif

Type and distribution of data: Binary distribution representing presences/absences.

Represent element and pillar: Yes

Translation: Where is habitat suitable for unarmored threespine stickleback?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting habitat for unarmored threespine stickleback (positive linear slope). More favorable (translated to +1) set at 1 (highly suitable), less favorable (translated to -1) set at 0 (not highly suitable).

PENINSULAR BIGHORN SHEEP *

Tier: 2

Data Vintage: 2008

Metric Definition and Relevance: These data identify, in general, the areas where the final revised critical habitat for the Peninsular bighorn sheep (*Ovis canadensis nelsoni*) occurs.

Data Resolution: 30m Raster

Data Units: Binary, 0 (Low Suitability, Presence), 1 (High Suitability, Absence)

Data source: U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office.

File Name: penisular_bighorn_sheep_critical_habitat_scored.tif

Type and distribution of data: Binary distribution representing presences/absences.

Represent element and pillar: Yes

Translation: Where is habitat suitable for Peninsular bighorn sheep?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting habitat for Peninsular bighorn sheep (positive linear slope). More favorable (translated to +1) set at 1 (highly suitable), less favorable (translated to -1) set at 0 (not highly suitable).

CALIFORNIA RED-LEGGED FROG *

Tier: 1

Data Vintage: 2001

Metric Definition and Relevance: This dataset represents a species habitat distribution map for California Red-legged Frog (*Rana draytonii)* within the conterminous United States (CONUS) based on 2001 ground conditions.

Data Resolution: 30m Raster

Data Units: Binary, 0 (Low Suitability, Presence), 1 (High Suitability, Absence)

Data source: USGS

File Name: california_red_legged_frog_habitat_scored.tif

Type and distribution of data: Binary distribution representing presences/absences.

Represent element and pillar: Yes

Translation: Where is habitat suitable for California Red-legged Frog?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting habitat for California Red-legged Frog (positive linear slope). More favorable (translated to +1) set at 1 (highly suitable), less favorable (translated to -1) set at 0 (not highly suitable).

JOSHUA TREE *

Tier: 2

Data Vintage: 2003

Metric Definition and Relevance: This data set represents the digital range map of Joshua Tree (*Yucca brevifolia*) in western North America.

Data Resolution: 30m Raster

Data Units: Binary, 0 (Low Suitability, Presence), 1 (High Suitability, Absence)

Data source: USGS

File Name: joshua_tree_range_scored.tif

Type and distribution of data: Binary distribution representing presences/absences.

Represent element and pillar: Yes

Translation: Where is habitat suitable for Joshua Tree?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting habitat for Joshua Tree (positive linear slope). More favorable (translated to +1) set at 1 (highly suitable), less favorable (translated to -1) set at 0 (not highly suitable).

HERMES COPPER BUTTERFLY *

Tier: 2

Data Vintage: 2021

Metric Definition and Relevance: This is a dataset representing the boundaries for the Hermes copper butterfly (*Lycaena hermes*) as understood by the United States Fish and Wildlife Service. This species is listed as a threatened species by the USFWS.

Data Resolution: 30m Raster

Data Units: Binary, 0 (Low Suitability, Presence), 1 (High Suitability, Absence)

Data source: The U.S. Fish and Wildlife Service Region 8

File Name: hermes_copper_current_range_scored.tif

Type and distribution of data: Binary distribution representing presences/absences.

Represent element and pillar: Yes

Translation: Where is habitat suitable for Hermes Copper Butterfly?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting habitat for Hermes Copper Butterfly (positive linear slope). More favorable (translated to +1) set at 1 (highly suitable), less favorable (translated to -1) set at 0 (not highly suitable).

LAGUNA MOUNTAINS SKIPPER *

Tier: 2

Data Vintage: 2006 (critical habitat)

Metric Definition and Relevance: The current range represents the boundaries for Laguna Mountains skipper (*Pyrgus ruralis lagunae*) as understood by the United States Fish and Wildlife Service.

The critical data identifies, in general, the areas of Final critical habitat for the species. Critical habitat constitutes areas considered essential for the conservation of a listed species. These areas provide notice to the public and land managers of the importance of the areas to the conservation of this species. Special protections and/or restrictions are possible in areas where Federal funding, permits, licenses, authorizations, or actions occur or are required. This species is listed as an endangered species by the USFWS.

Data Resolution: 30m Raster

Data Units: Binary, 0 (Low Suitability, Presence), 1 (High Suitability, Absence)

Data source: U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office

File Name: laguna_mountains_skipper_current_range_and_critical_habitat_scored.tif

Type and distribution of data: Binary distribution representing presences/absences.

Represent element and pillar: Yes

Translation: Where is habitat suitable for Laguna Mountains Skipper?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting habitat for Laguna Mountains Skipper (positive linear slope). More favorable (translated to +1) set at 1 (highly suitable), less favorable (translated to -1) set at 0 (not highly suitable).

QUINO CHECKERSPOT BUTTERFLY *

Tier: 3

Data Vintage: 2009

Metric Definition and Relevance: These data identify, in general, the areas of Final critical habitat for *Euphydryas editha quino* (Quino checkerspot butterfly). This species is listed as an endangered species by the USFWS.

Critical habitat constitutes areas considered essential for the conservation of a listed species. These areas provide notice to the public and land managers of the importance of the areas to the conservation of this listed species. Special protections and/or restrictions are possible in areas where Federal funding, permits, licenses, authorizations, or actions occur or are required.

Data Resolution: 30m Raster

Data Units: Binary, 0 (Low Suitability, Presence), 1 (High Suitability, Absence)

Data source: U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office

File Name: quino_checkeredspot_butterfly_critical_habitat_scored.tif

Type and distribution of data: Binary distribution representing presences/absences.

Represent element and pillar: Yes

Translation: Where is habitat suitable for Quino Checkerspot Butterfly?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting habitat for Quino Checkerspot Butterfly (positive linear slope). More favorable (translated to +1) set at 1 (highly suitable), less favorable (translated to -1) set at 0 (not highly suitable).

LEAST BELL'S VIREO NESTING HABITAT *

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Least Bell's Vireos (LBVI) are a state and federally listed endangered species that nests exclusively in riparian areas in California. Conservation Science and Data Visualization and Aerial Information Systems co-developed a standardized mapping protocol, called VireoVegMap, with the objective of providing a comprehensive map of potential LBVI nesting habitat. Dominant vegetation map units and secondary map attributes were chosen to provide specific information relevant to LBVI ecology, conservation, and management. We then applied this protocol, using 2020 aerial imagery, to create a baseline map of riparian vegetation to support vireo recovery planning and status evaluation.

Mapping of 2020 riparian vegetation establishes a baseline for range-wide LBVI nesting habitat conditions that can be used to:

- Evaluate the range-wide status and distribution of riparian vegetation that LBVI may use for nesting.
- Develop A*rundo donax* (Giant Reed) removal strategies at the scale of HUC8 subbasins that will maintain or expand existing areas of native riparian vegetation nesting habitat. These areas, with follow-up management, will help LVBI reoccupy formerly suitable nesting habitat that has been lost to Arundo.
- Understand the extent of the threat to riparian vegetation that is imposed by the emerging stressor of shot-hole borer invasion and develop potential management strategies.
- Evaluate the potential impacts of groundwater management issues on vireo habitat across the species' potential breeding range.

- Evaluate the potential impacts of wastewater management issues on vireo habitat across the species' potential breeding range.
- Develop habitat-based management and restoration strategies.

Data Resolution: 30m Raster

Data Units: Thematic, suitable riparian vegetation types that include at least 15% shrub willow/mulefat cover and/or >15% tree willow cover.

Data source: Lott, C.A., Reyes, E., A. Glass, and D. Johnson. 2023. A Range Wide Map of Least Bell's Vireo Nesting Vegetation: Mapping Protocol. Conservation Science and Data Visualization; Boise, ID; and Aerial Information Systems, Inc.; Redlands, CA.; 111pp. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=215147

File Name: LBVireoNestingHabitat_scored.tif

Type and distribution of data: Binary distribution representing thematic values.

Represent element and pillar: Yes

Translation: Where is habitat suitable for Least Bell's Vireo nesting habitat?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting habitat for band-tailed pigeon (positive linear slope). More favorable (translated to +1) set at 1 (highly suitable), less favorable (translated to -1) set at 0 (not highly suitable).

ELEMENT REPRESENTATION: COMMUNITY INTEGRITY

Communities of species are the result of a wide array of environmental factors, and these assemblages interact, are interdependent to different degrees, and perform a range of critical ecosystem functions and services. This element reflects community conditions pertaining to species composition and co-occurrence and the implications for performing and maintaining ecosystem functions and services.

Twelve metrics are described in the community integrity element: nine functional group richness metrics, habitat connectivity, present day connectivity in California, and full climate connectivity network. Functional group richness was used to represent community integrity (indicated by asterisks); the habitat connectivity metric was not included because it could not meaningfully be translated to a condition score.

File Name: commIntegrity.tif

Represent pillar: Yes

Type and distribution of data: -1 to +1 condition score

Translation: Where is community integrity greatest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the

objective of supporting higher community integrity. The conditions scores for the six functional groups are averaged to derive the condition score for the community integrity element. More favorable (translated to +1) represents locations where functional group richness is high across most or all functional groups (positive linear slope), less favorable (translated to -1) represents locations where functional group richness is low across most or all functional groups.

FUNCTIONAL GROUP SPECIES RICHNESS *

Functional groups are sets of species that share life history characteristics that perform particular functions within an ecosystem. Nine functional groups are represented and include a range of trophic levels and ecosystem services. A primary consideration in management is to maintain conditions, adapt to changing conditions and transition to alternate but still productive conditions over time. The maintenance of ecosystem services is a primary concern with climate change.

Species list created from CWHR is divided into nine functional groups based on The Sierran All Species Information (SASI) database. The SASI database represents a combination of fields populated from the literature and fields populated from questionnaires distributed to individuals with expertise on particular Sierran taxa. The geographic distribution of each species is represented by county, and then within their range where habitat conditions are identified as highly suitable for reproduction, the species is listed as associated with the raster cell.

*HERBIVORES SPECIES RICHNESS **

Tier: 2

Data Vintage: 04/2023

Data Resolution: 30m Raster

Data Units: Count, number of species

Data source: Forest type designation (FORTYPE) from Forest Vegetation Simulator (FVS) F3, 2021; National Land Cover Database (NLCD), 2019; Existing Vegetation (CALVEG), Region 5, MARS Team, 2016; California Department of Fish and Wildlife CWHR version 9.0 (CDFW), 2014

File Name: herbivores_species_richness_scored.tif

Type and distribution of data: Left skewed distribution representing count data. Raw values range from 1 to 28 species.

Represent element and pillar: Yes

Translation: Where is herbivore species richness high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting higher species richness of the functional group (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) based on climate regions (Table 7).

Alternative approaches could use the theoretical maximum of all species in the functional group to define more favorable (+1), but that would assume that all species could cohabitate in a single location.

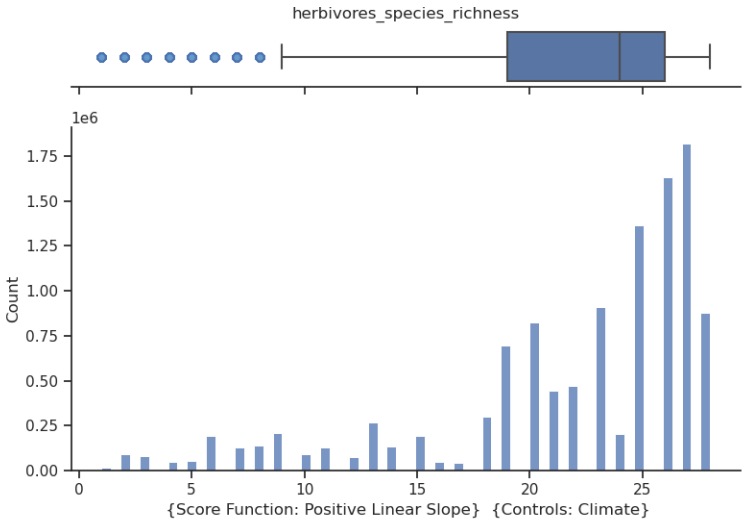

Figure 19. Histogram and scoring of herbivore species richness in Southern California

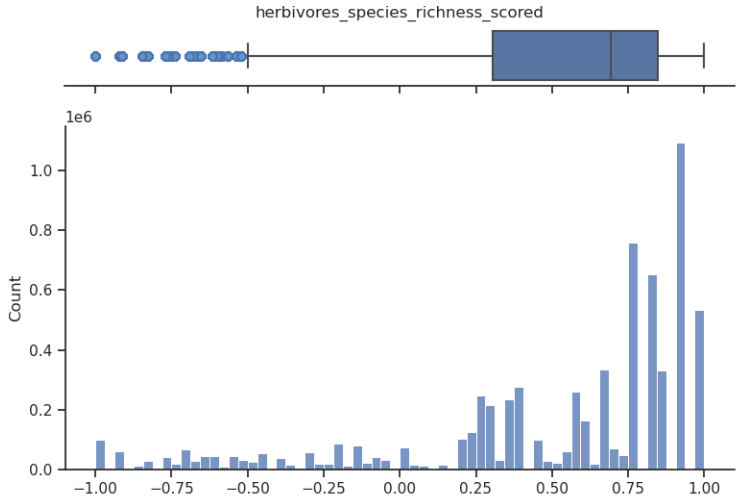

Figure 20. Histogram of translated of herbivore species richness in Southern California

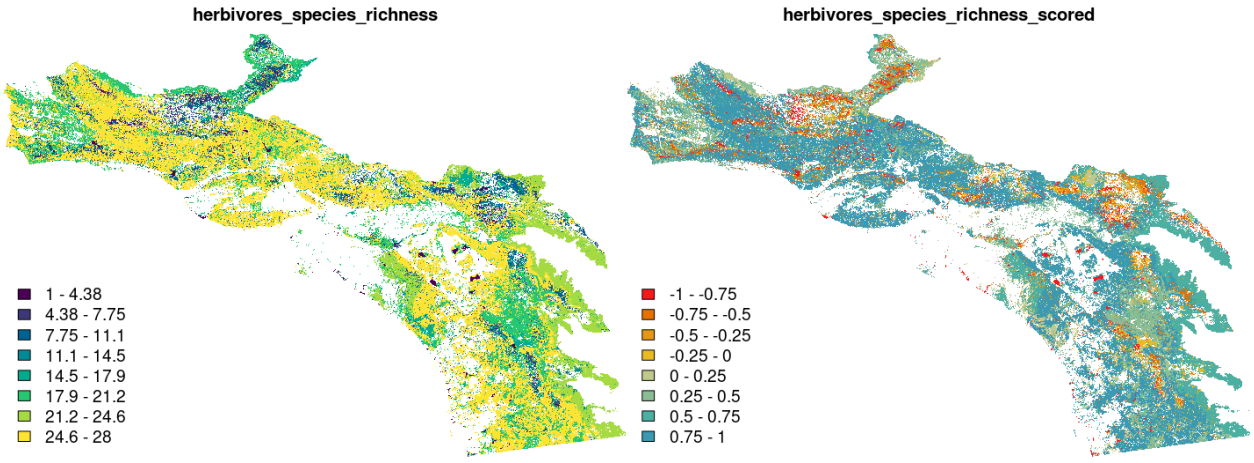

Figure 21. Maps displaying raw metric and translated metric herbivore species richness in Southern California

*PREDATORS SPECIES RICHNESS **

Tier: 2

Data Vintage: 04/2023

Data Resolution: 30m Raster

Data Units: Count, number of species

Data source: Forest type designation (FORTYPE) from Forest Vegetation Simulator (FVS) F3, 2021; National Land Cover Database (NLCD), 2019; Existing Vegetation (CALVEG), Region 5, MARS Team, 2016; California Department of Fish and Wildlife CWHR version 9.0 (CDFW), 2014

File Name: predators_species_richness_scored.tif

Type and distribution of data: Normal, skewed representing count data. Raw values range from 1 to 40 species. Maximum values varied among climate classes.

Represent element and pillar: Yes

Translation: Where is predator species richness high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting higher species richness of the functional group (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) based on climate regions (Table 7). Alternative approaches could use the theoretical maximum of all species in the functional group to define more favorable (+1), but that would assume that all species could cohabitate in a single location.

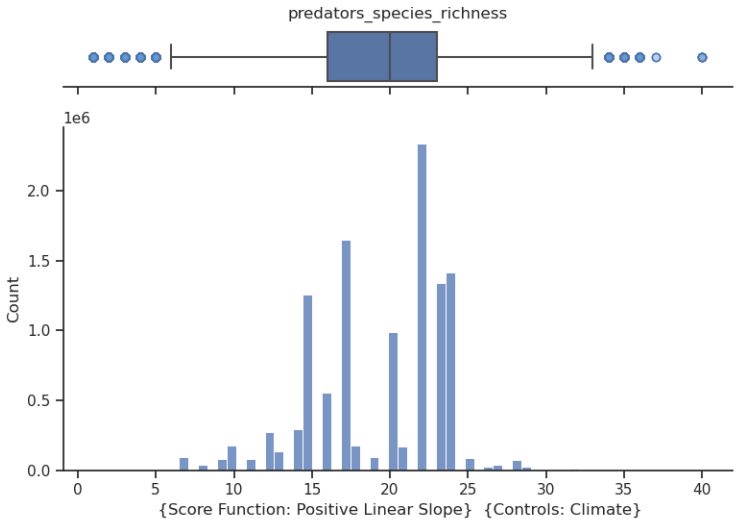

Figure 22. Histogram and scoring of predator species richness in Southern California

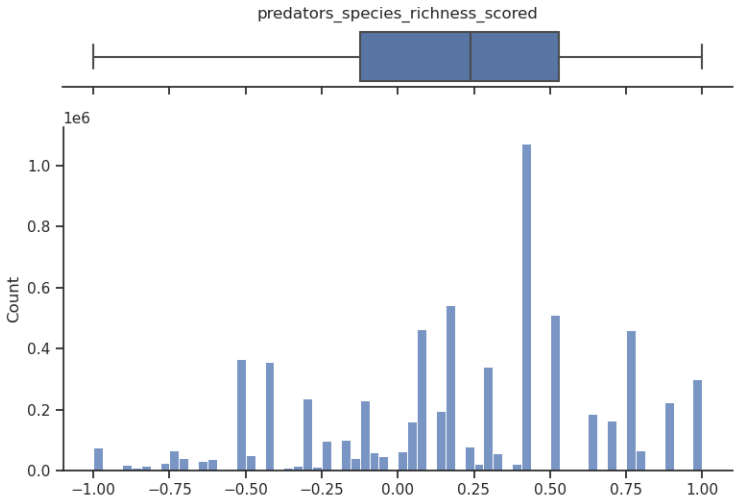

Figure 23. Histogram of translated predator species richness in Southern California

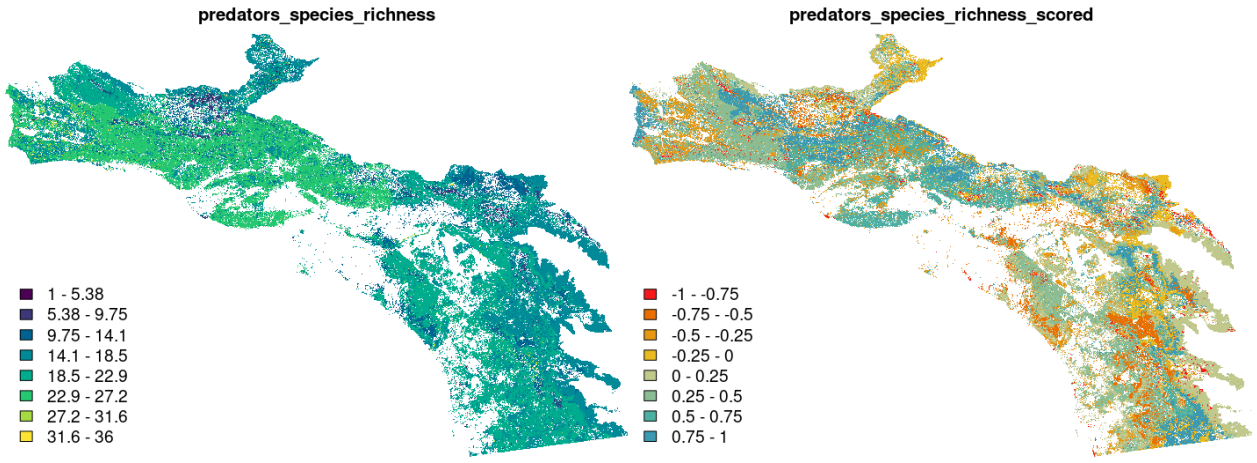

Figure 24. Maps displaying raw metric and translated metric predator species richness in Southern California

*INSECTIVORES SPECIES RICHNESS **

Tier: 2

Data Vintage: 04/2023

Data Resolution: 30m Raster

Data Units: Count, number of species

Data source: Forest type designation (FORTYPE) from Forest Vegetation Simulator (FVS) F3, 2021; National Land Cover Database (NLCD), 2019; Existing Vegetation (CALVEG), Region 5, MARS Team, 2016; California Department of Fish and Wildlife CWHR version 9.0 (CDFW), 2014

File Name: insectivores_species_richness_scored.tif

Type and distribution of data: Normal, skewed distribution representing count data. Raw values range from 1 to 47 species. Maximum values varied among climate classes.

Represent element and pillar: Yes

Translation: Where is insectivorous species richness high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting higher species richness of the functional group (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) based on climate regions (Table 7). Alternative approaches could use the theoretical maximum of all species in the functional group to define more favorable (+1), but that would assume that all species could cohabitate in a single location.

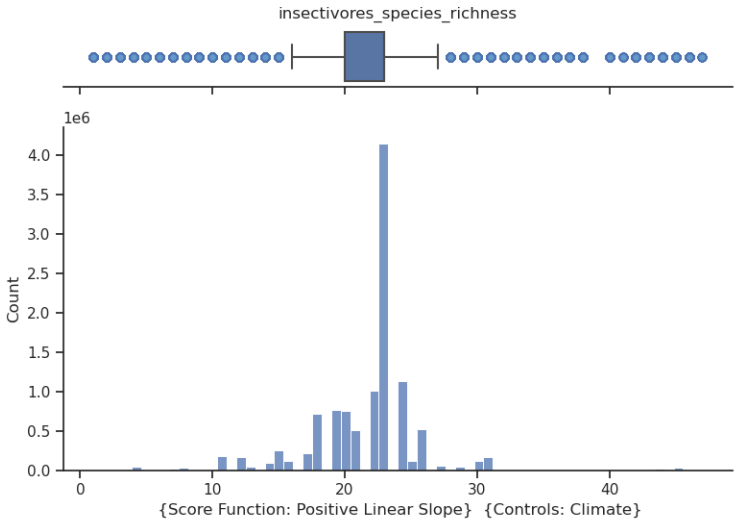

Figure 25. Histogram and scoring of insectivore species richness in Southern California

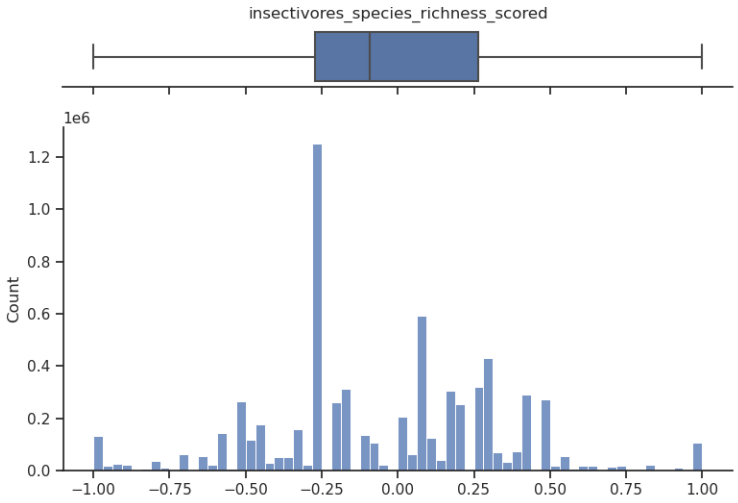

Figure 26. Histogram of translated insectivore species richness in Southern California

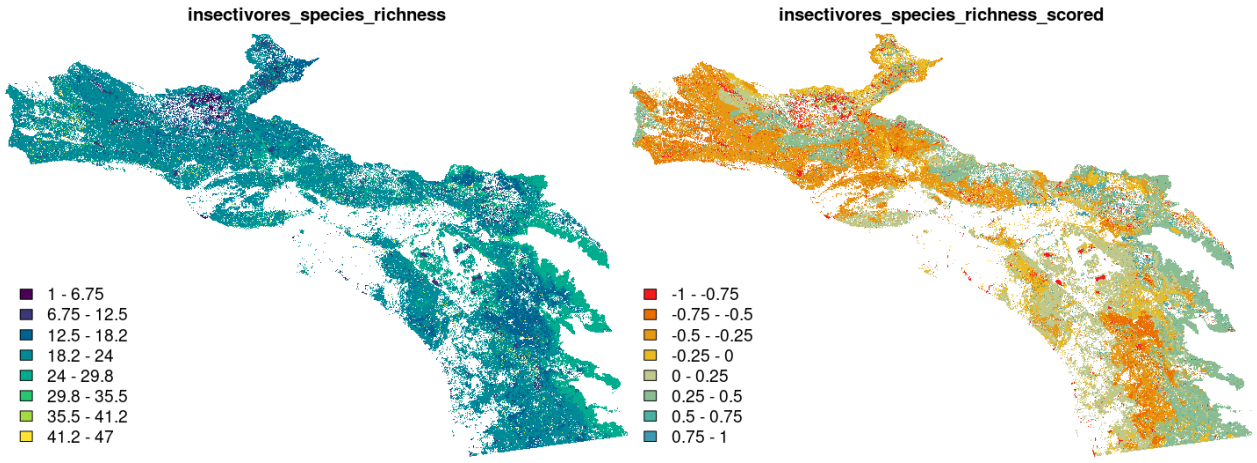

Figure 27. Maps displaying raw metric and translated metric insectivore species richness in Southern California

*SOIL AERATORS SPECIES RICHNESS **

Tier: 2

Data Vintage: 04/2023

Data Resolution: 30m Raster

Data Units: Count, number of species

Data source: Forest type designation (FORTYPE) from Forest Vegetation Simulator (FVS) F3, 2021; National Land Cover Database (NLCD), 2019; Existing Vegetation (CALVEG), Region 5, MARS Team, 2016; California Department of Fish and Wildlife CWHR version 9.0 (CDFW), 2014

File Name: soil_aerators_species_richness_scored.tif

Type and distribution of data: Normal, right-skewed distribution representing count data. Raw values range from 0 to 10 species. Maximum values varied among climate classes.

Represent element and pillar: Yes

Translation: Where is soil aerator species richness high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting higher species richness of the functional group (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) based on climate regions (Table 7). Alternative approaches could use the theoretical maximum of all species in the functional group to define more favorable (+1), but that would assume that all species could cohabitate in a single location.

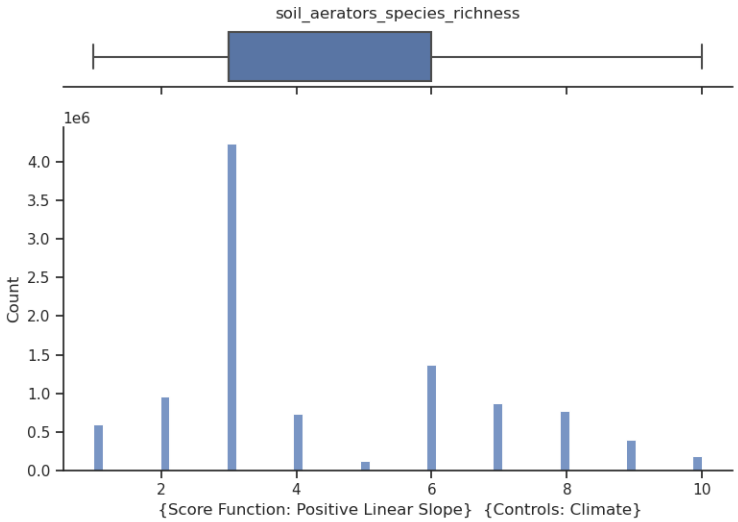

Figure 28. Histogram and scoring of soil aerators species richness in Southern California

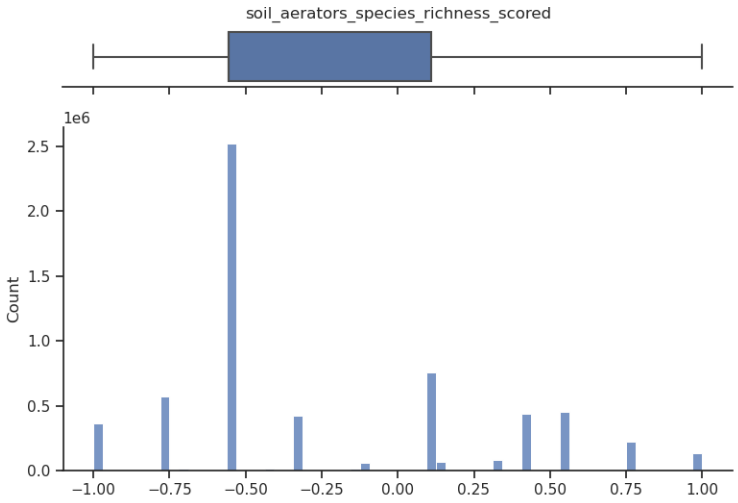

Figure 29. Histogram of translated soil aerators species richness in Southern California

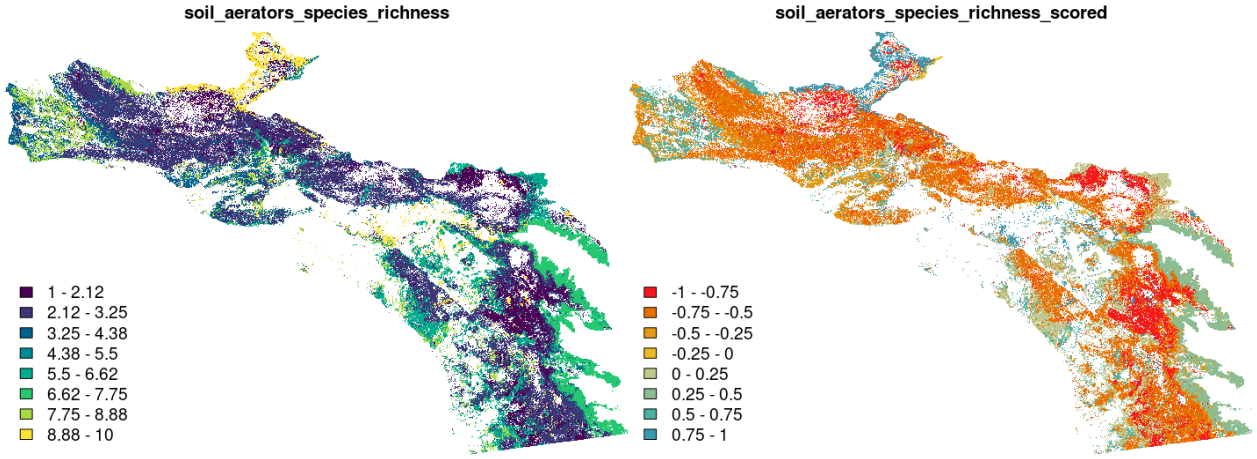

Figure 30. Maps displaying raw metric and translated metric soil aerators species richness in Southern California

*SEED/SPORE DISPERSERS SPECIES RICHNESS **

Tier: 2

Data Vintage: 04/2023

Data Resolution: 30m Raster

Data Units: Number of species

Data source: Forest type designation (FORTYPE) from Forest Vegetation Simulator (FVS) F3, 2021; National Land Cover Database (NLCD), 2019; Existing Vegetation (CALVEG), Region 5, MARS Team, 2016; California Department of Fish and Wildlife CWHR version 9.0 (CDFW), 2014

File Name: seed_spore_dispersers_species_richness_scored.tif

Type and distribution of data: Left skewed distribution representing count data. Raw values range from 0 to 15 species. Maximum values varied among climate classes.

Represent element and pillar: Yes

Translation: Where is seed and spore dispersing species richness high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting higher species richness of the functional group (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) based on climate regions (Table 7). Alternative approaches could use the theoretical maximum of all species in the functional group to define more favorable (+1), but that would assume that all species could cohabitate in a single location.

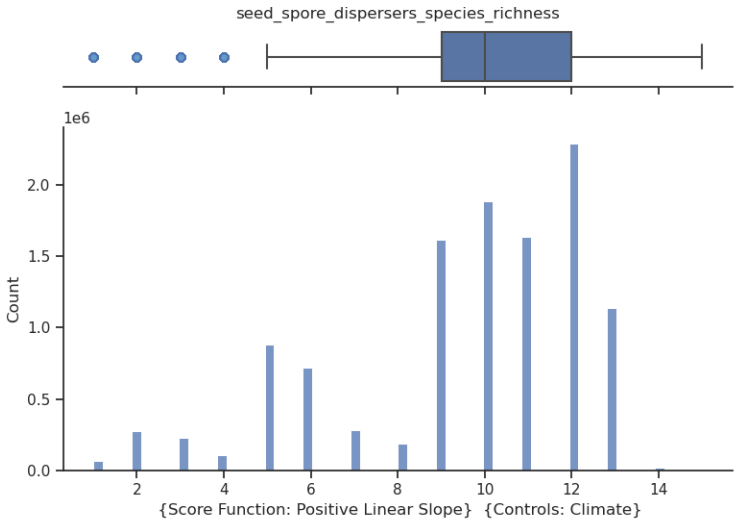

Figure 31. Histogram and scoring of seed spore dispersers species richness in Southern California

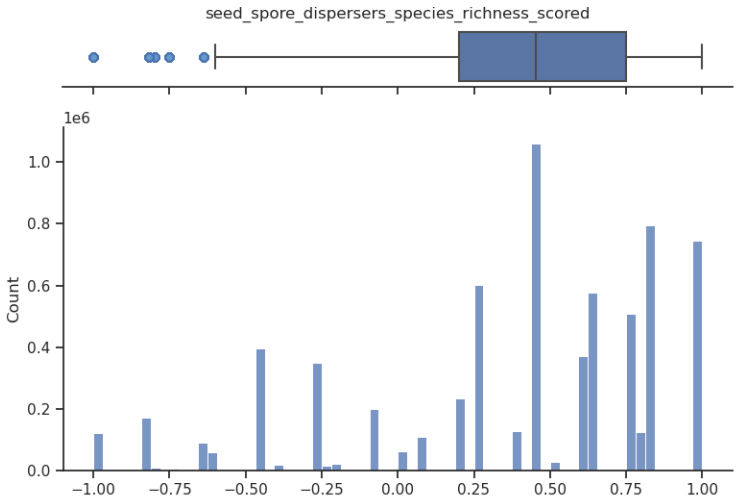

Figure 32. Histogram of translated seed spore dispersers species richness in Southern California

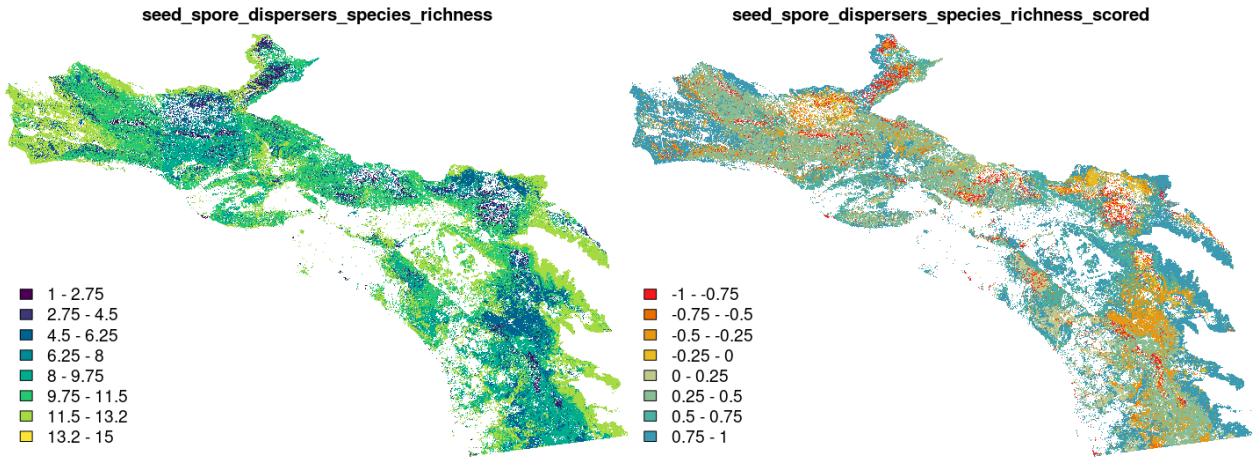

Figure 33. Maps displaying raw metric and translated metric seed spore dispersers species richness in Southern California

*CAVITY NESTERS/EXCAVATORS SPECIES RICHNESS **

Tier: 2

Data Vintage: 04/2023

Data Resolution: 30m Raster

Data Units: Number of species

Data source: Forest type designation (FORTYPE) from Forest Vegetation Simulator (FVS) F3, 2021; National Land Cover Database (NLCD), 2019; Existing Vegetation (CALVEG), Region 5, MARS Team, 2016; California Department of Fish and Wildlife CWHR version 9.0 (CDFW), 2014

File Name: cavity_nesters_excavators_species_richness_scored.tif

Type and distribution of data: Right skewed distribution representing count data. Raw values range from 0 to 16 species.

Represent element and pillar: Yes

Translation: Where is cavity nesting species richness high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting higher species richness of the functional group (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) based on climate regions (Table 7). Alternative approaches could use the theoretical maximum of all species in the functional group to define more favorable (+1), but that would assume that all species could cohabitate in a single location.

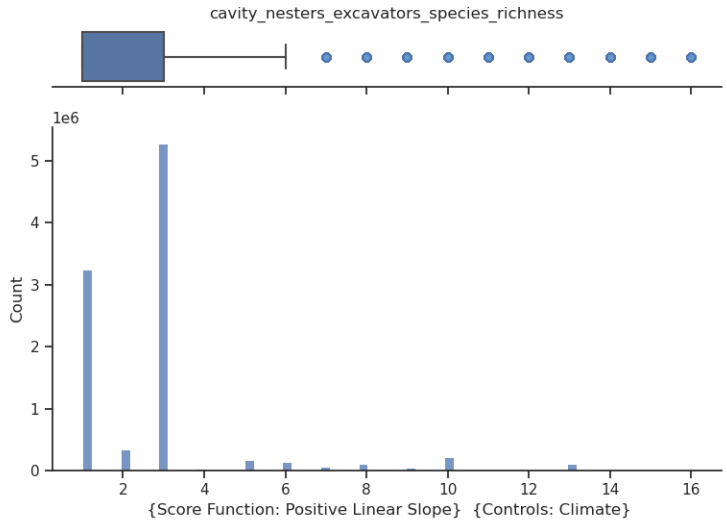

Figure 34. Histogram and scoring of cavity nesters excavators species richness in Southern California

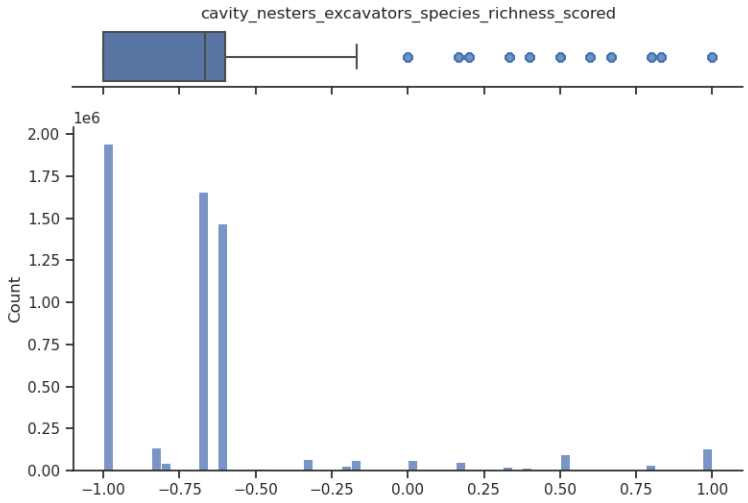

Figure 35. Histogram of translated cavity nesters excavators species richness in Southern California

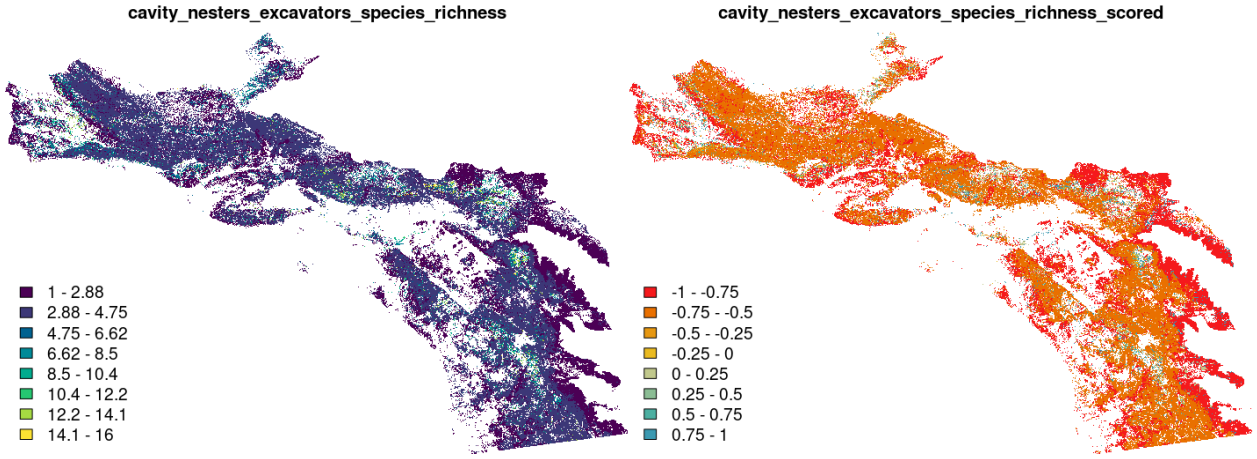

Figure 36. Maps displaying raw metric and translated metric cavity nesters excavators species richness in Southern California

*FOREST RAPTORS SPECIES RICHNESS **

Tier: 2

Data Vintage: 04/2023

Metric Definition and Relevance: Native species richness is estimated based on high suitability reproductive habitat for a given species. Reproductive habitat is used to represent suitability because it is critical for species persistence and for most native species it has the most limited requirements. If a habitat is identified as high for a given species, it is considered suitable (1), and habitat identified as moderate, low or not suitable, it is considered unsuitable (0). Species richness values are used as a relative measure of biodiversity value; as such, areas with lower species richness based on these criteria may still have high biodiversity value, but not as high as areas with higher richness values. The total number of federally threatened/endangered native species per spatial unit (30m pixel) can be useful for assessing change in number/composition over space.

Data Resolution: 30m Raster

Data Units: Number of species

Data source: FVEG 2023; California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: forest_species_richness_202304_scored.tif

Type and distribution of data: Right skewed distribution representing count data. Raw values range from 1 to 10 species.

Represent element and pillar: Yes

Translation: Where is forest raptors species richness high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting higher species richness of the functional group (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) based on climate regions (Table 7). Alternative approaches could use the theoretical maximum of all species in the functional group to define more favorable (+1), but that would assume that all species could cohabitate in a single location.

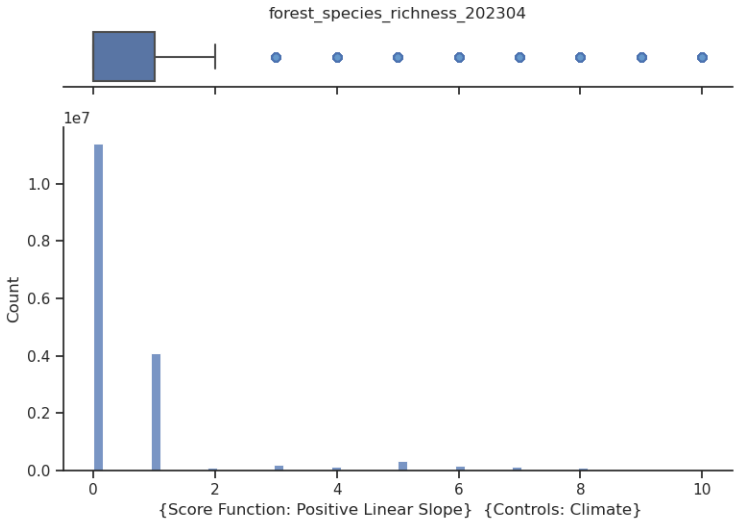

Figure 37. Histogram and scoring of forest raptors species richness in Southern California

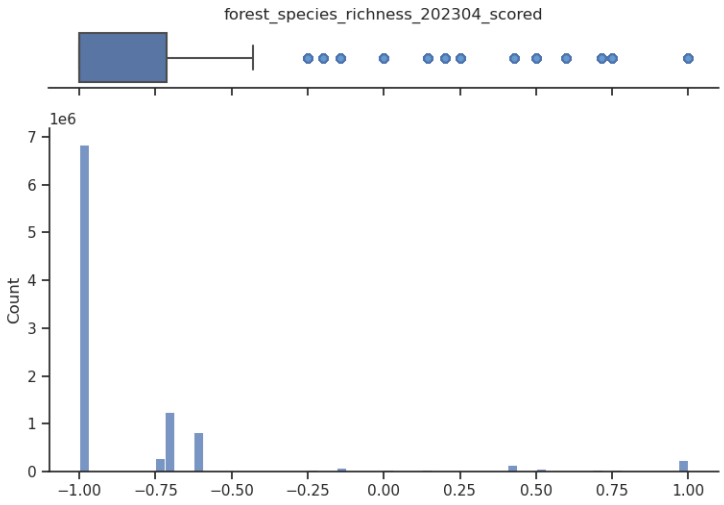

Figure 38. Histogram of translated forest raptors species richness in Southern California

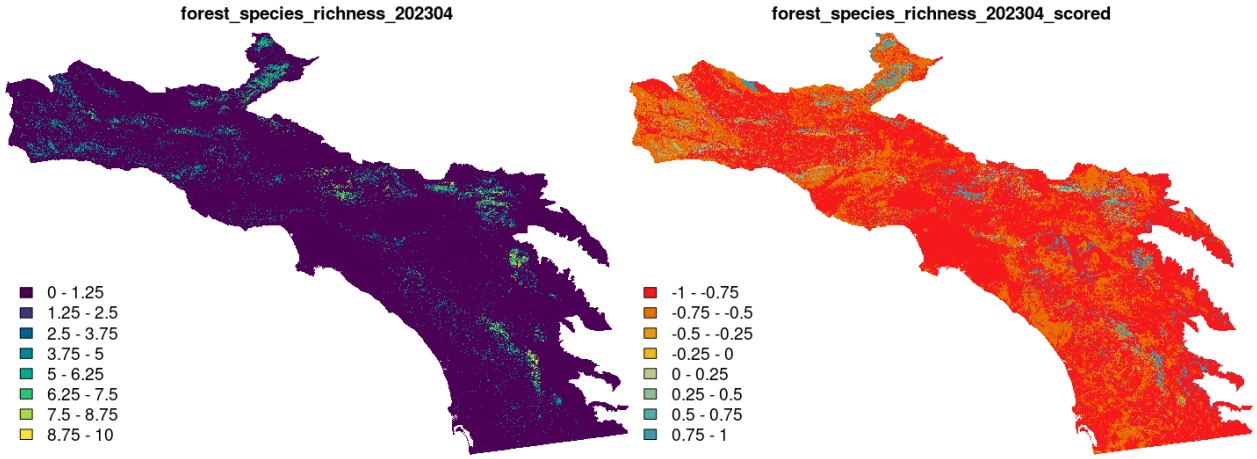

Figure 39. Maps displaying raw metric and translated forest raptors species richness in Southern California

*OPEN HABITAT RAPTORS SPECIES RICHNESS **

Tier: 2

Data Vintage: 04/2023

Metric Definition and Relevance: Native species richness is estimated based on high suitability reproductive habitat for a given species. Reproductive habitat is used to represent suitability because it is critical for species persistence and for most native species it has the most limited requirements. If a habitat is identified as high for a given species, it is considered suitable (1), and habitat identified as moderate, low or not suitable, it is considered unsuitable (0). Species richness values are used as a relative measure of biodiversity value; as such, areas with lower species richness based on these criteria may still have high biodiversity value, but not as high as areas with higher richness values. The total number of federally threatened/endangered native species per spatial unit (30m pixel) can be useful for assessing change in number/composition over space.

Data Resolution: 30m Raster

Data Units: Number of species

Data source: FVEG 2023; California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: open_species_richness_202304_scored.tif

Type and distribution of data: Right skewed distribution representing count data. Raw values range from 1 to 8 species.

Represent element and pillar: Yes

Translation: Where is open habitat raptors species richness high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the

objective of supporting higher species richness of the functional group (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) based on climate regions (Table 7). Alternative approaches could use the theoretical maximum of all species in the functional group to define more favorable (+1), but that would assume that all species could cohabitate in a single location.

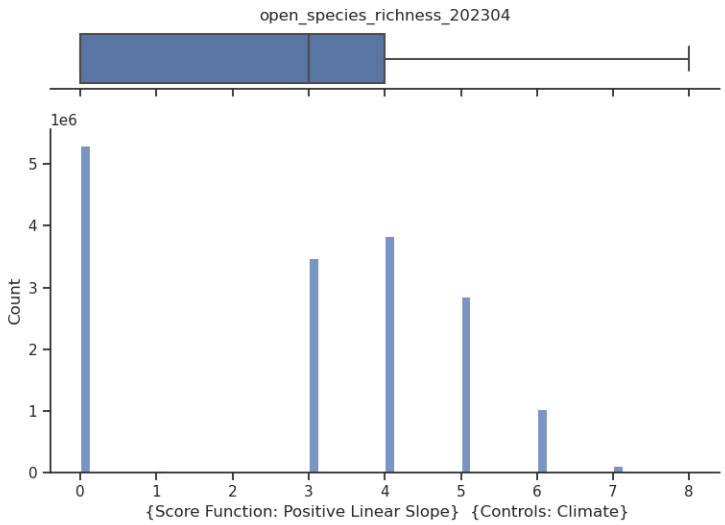

Figure 40. Histogram and scoring of open habitat raptors species richness in Southern California

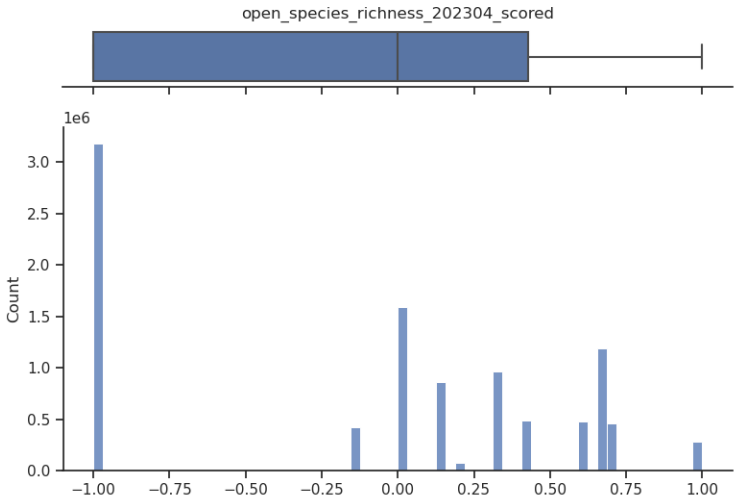

Figure 41. Histogram of translated open habitat raptors species richness in Southern California

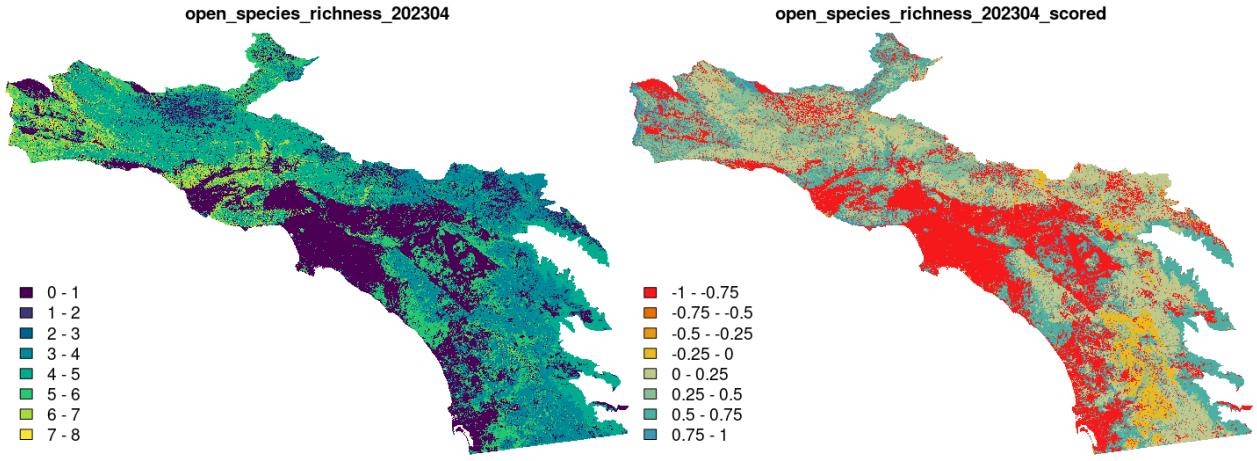

Figure 42. Maps displaying raw metric and translated metric open habitat raptors species richness in Southern California

*HUMMINGBIRDS SPECIES RICHNESS **

Tier: 2

Data Vintage: 04/2023

Metric Definition and Relevance: Native species richness is estimated based on high suitability reproductive habitat for a given species. Reproductive habitat is used to represent suitability because it is critical for species persistence and for most native species it has the most limited requirements. If a habitat is identified as high for a given species, it is considered suitable (1), and habitat identified as moderate, low or not suitable, it is considered unsuitable (0). Species richness values are used as a relative measure of biodiversity value; as such, areas with lower species richness based on these criteria may still have high biodiversity value, but not as high as areas with higher richness values. The total number of federally threatened/endangered native species per spatial unit (30m pixel) can be useful for assessing change in number/composition over space.

Data Resolution: 30m Raster

Data Units: Number of species

Data source: FVEG 2023; California Department of Fish and Wildlife CWHR version 9.0 (CDFW); 2014

File Name: hummingbirds_species_richness_202304_scored.tif

Type and distribution of data: Right skewed distribution representing count data. Raw values range from 1 to 3 species.

Represent element and pillar: Yes

Translation: Where is hummingbirds species richness high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of supporting higher species richness of the functional group (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) based on climate regions (Table 7). Alternative approaches could use the theoretical maximum of all species in the functional group to define more favorable (+1), but that would assume that all species could cohabitate in a single location.

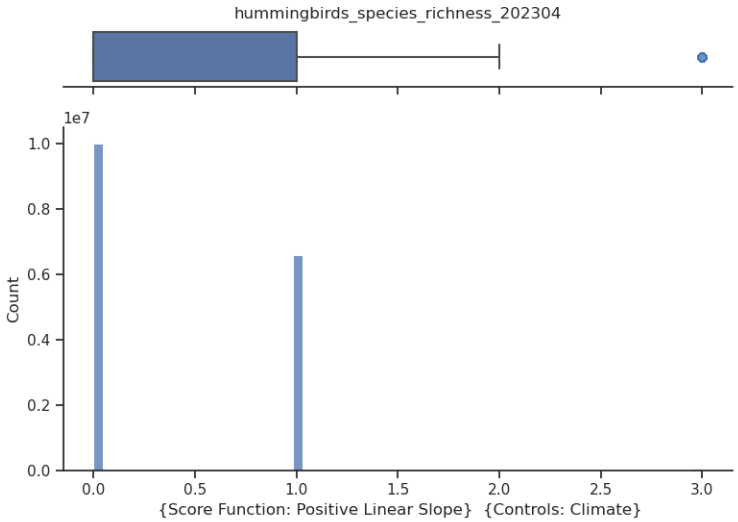

Figure 43. Histogram and scoring of hummingbirds species richness in Southern California

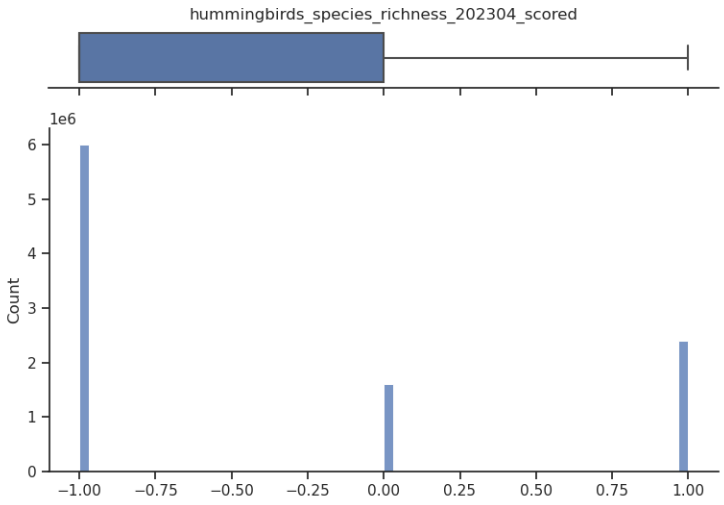

Figure 44. Histogram of translated hummingbirds species richness in Southern California

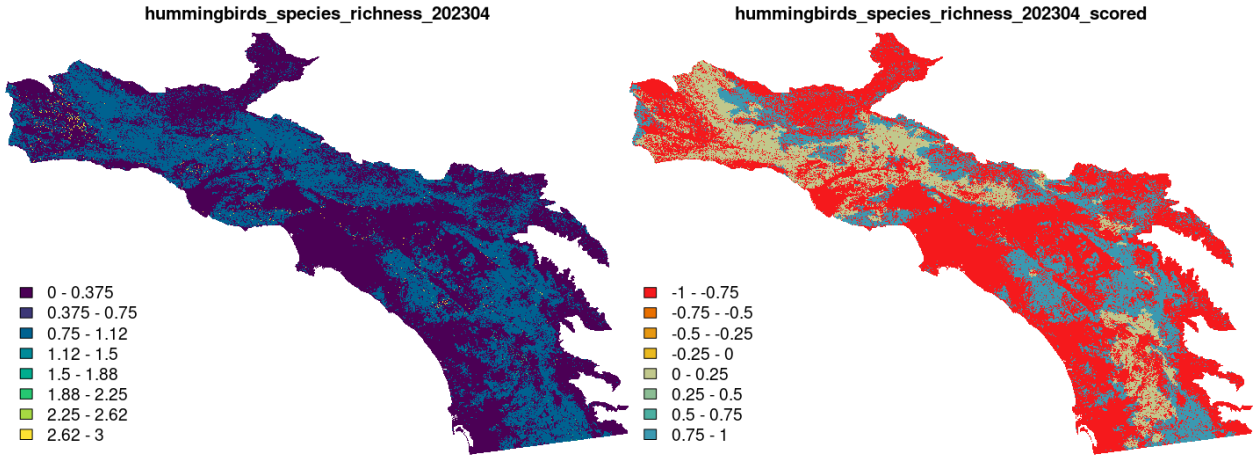

Figure 45. Maps displaying raw metric and translated hummingbirds species richness in Southern California

HABITAT CONNECTIVITY

Tier: 1

Data Vintage: last updated 08/21/2019

Metric Definition and Relevance: The Terrestrial Connectivity dataset is one of the four key components of the California Department of Fish and Wildlife's (CDFW) Areas of Conservation Emphasis (ACE) suite of terrestrial conservation information. The dataset summarizes the relative ability of a species to move across the landscape between patches of suitable habitat. It shows a compilation of linkages, corridors, and natural landscape blocks identified in statewide and regional connectivity studies. Each hexagon (2.5 mi^2) is ranked into one of the following categories based on the identification of corridors and linkages in statewide, regional, and species-movement studies:

- 5: *Irreplicable and Essential Corridors* – The Nature Conservancy's (TNC) Omniscape model identifies channelized areas and priority species movement corridors. The mapped channelized areas are those areas where surrounding land use and barriers are expected to funnel, or concentrate, animal movement. These areas may represent the last available connection(s) between two areas, making them high priority for conservation.
- 4: *Conservation Planning Linkages* – Habitat connectivity linkages are often based on species-specific models and represent the best connections between core natural areas to maintain habitat connectivity. Linkages have more implementation flexibility than irreplaceable and essential corridors; any linkage areas not included in rank 5 are included here.
- 3: *Connections with Implementation Flexibility* – Areas identified as having connectivity importance but not identified as channelized areas, species corridors or habitat linkage at this time. Future changes in surrounding land use or regional specific information may alter the connectivity rank. Included in this category are areas mapped in the TNC Omniscape study as 'intensified', core habitat areas, and areas on the periphery of mapped habitat linkages.

- 2: *Large Natural Habitat Areas* – Large blocks of natural habitat (> 2000 acres) where connectivity is generally intact. This includes natural landscape blocks from the 2010 CEHC and updated with the 2016 Statewide Intactness dataset. Areas mapped as CEHC NLB and not include in the previous ranks, are included here.
- 1: *Limited Connectivity Opportunity* – Areas where land use may limit options for providing connectivity (e.g., agriculture, urban) or no connectivity importance has been identified in models. Includes lakes. Some DOD lands are also in this category because they have been excluded from models due to lack of conservation opportunity, although they may provide important connectivity habitat.

Data Resolution: 30m Raster

Data Units: Categorical; 5 (listed above)

Data source: California Department of Fish and Wildlife; Terrestrial Connectivity, Areas of Conservation Emphasis (ACE), version 3.1 last updated 08/21/2019

File Name: HabitatConnectivity_2019.tif

Translation: None

PRESENT DAY CONNECTIVITY IN CALIFORNIA (OMNISCAPE)

Tier: 1

Data Vintage: last updated 01/2023

Metric Definition and Relevance: This data represents a wall-to-wall characterization of regional habitat connectivity potential in California for plant and animal species whose movement is inhibited by developed or agricultural land uses.

This model of present-day connectivity assumes there will be more 'current flow', representing wildlife movement, coming from and going to areas that are less modified. Wildlife may encounter barriers and land uses that are not conducive to movement en route. They may avoid moving through these areas entirely or these areas will increase their risk of harm. Land use, energy infrastructure, roads, and night lights are some of the factors that affect the 'resistance' to movement in this analysis.

Present Day Connectivity is partitioned into 11 classes (and the code used in the data):

1) 3 - Land use may restrict movement:
2) 4 - Permeable lands that contribute little to regional connectivity
3) 19 - Impeded
4) 25 - Diffuse - Med
5) 29 - Diffuse - High
6) 31 - Intensified - Low
7) 35 - Intensified - Med

8) 39 - Intensified - High
9) 41 - Channelized - Low
10) 45 - Channelized - Med
11) 49 - Channelized - High

Connectivity classes are assembled into categories based on whether an area had more or less flow than would be expected in the absence of barriers. For example, when animal movement is restricted by surrounding land uses, it channelizes into a single movement pathway, or a linkage. These **Intensified** and **Channelized** linkages are areas with more flow and far more flow, respectively, than would be expected in the absence of nearby barriers to movement. **Diffuse** connectivity areas are broadly, permeable areas with as much flow as is expected. Roads and intensive development can cause complete or partial barriers to animal movement, impeding their ability to traverse the landscape. **Impeded** areas are areas where there is less flow than is expected.

The Omniscape output 'current flow' was classified into high, medium and low classes and further categorized by the amount of flow compared to what would be expected in the absence of barriers. The 'Channelized' class has 1.7 times more flow than expected in the absence of barriers and represents the last remaining natural pathway through a modified landscape. The 'Intensified' class has 1.3-1.7 times more flow than expected and represents areas where there are a few remaining natural pathways. The 'Diffuse' class has as much flow as expected and represents lands that have many or unlimited movement options.

Data Resolution: 30m Raster

Data Units: Categorical; 11 (listed above)

Data source: The Nature Conservancy (TNC) Omniscape

c.k.stanley@tnc.org

The Nature Conservancy: A World Where People & Nature Thrive

File Name: PresentDayConnectivity_Omniscape_202301.tif

Translation: None

FULL CLIMATE CONNECTIVITY NETWORK

Tier: 3

Data Vintage: 2021

Metric Definition and Relevance: This linkage network is designed to allow for local movements among individual preserves while supporting landscape-scale regional connectivity. Habitat connectivity is the most frequently recommended strategy to support adaptation to climate change, habitat fragmentation, and post-disturbance recolonizations. In southern California, conservation planning efforts have resulted in protected area networks to address widespread habitat fragmentation across the region. These plans are designed to protect biodiversity by establishing networks of core habitats.

Connectivity is essential if these networks are to support the long-term goals of protecting biodiversity, particularly as species' ranges are likely to shift in response to climate change.

Data Resolution: polygon

Data Units: Categorical, 4 - See metadata for field definitions

Data Source: San Diego State University CWC Project Team

File Name: Full_climate_connectivity_network.shp

Translation: None

FUTURE CONDITION

Metric definition and relevance: Potential future biodiversity was evaluated using the USGS GAP Analysis Species Range Maps (USGS 2018). Range maps were downloaded for 1,719 species (284 amphibians, 327 reptiles, 459 mammals, 649 birds), which were distributed across the conterminous US. These data were rasterized to 1,000-m cells where each cell received a separate species richness score for each of the four classes of species. Species richness was then compared for each focal cell within the Sierras to their respective climate analogues.

Data resolution: 1-km, resampled to 30-m to match current conditions data

Data Units: Translated strength of evidence score. Values near -1 indicate large changes in the fire regime are likely, while values near +1 indicate little to no change is expected.

Data source: USGS GAP Analysis Species Range Maps (USGS 2018)

File Name: bioDiverConserv030_future.tif

Translation: Where is future climate most stable for biodiversity?

Future climate stability interpretation: Species richness scores for each GCM were combined using a Union operator (i.e., averaged). For a given focal cell, a weighted empirical distribution was developed for each class of species from the 100 climate analogues for each of the 9 GCMs, separately. The weight of each analog was determined by the Sigma score, where lower weights were given to analogues that were not a good match to the focal cell's future climate. Current richness for the cell was evaluated to determine its percentile according to these distributions (Figures 5B). Percentiles close to 100% indicated that current richness is high compared to its analogues and suggested future biodiversity will decrease under climate change leading to a score of -1. This score was combined with the mean Sigma climate score using the And (minimum) operator to help account for a preponderance of analogues not representative of future climate conditions for a given focal cell.

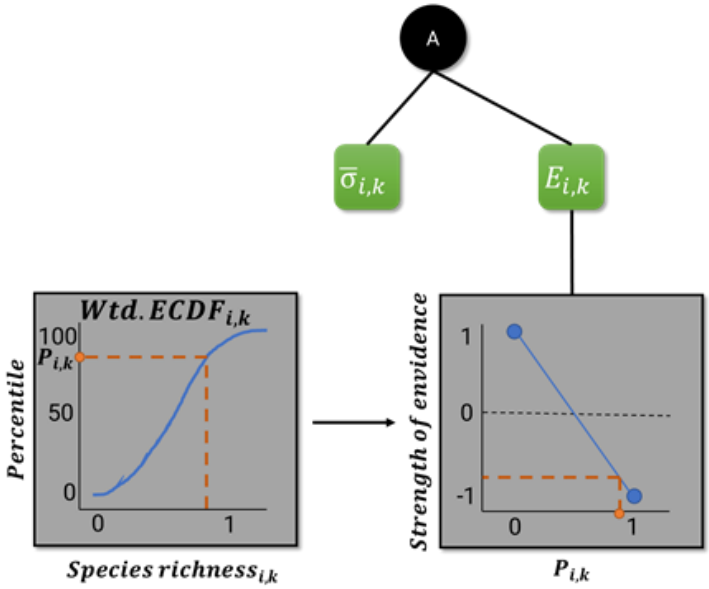

Figure 46. Level 1 biodiversity logic. Subscripts indicate: i, cell (n = 9,000); k, climate model (n = 9).

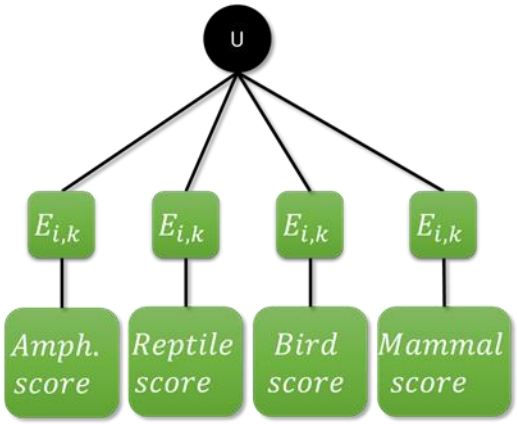

Figure 47. Level 2 biodiversity logic. Subscripts indicate: i, cell (n = 9,000); k, climate model (n = 9).

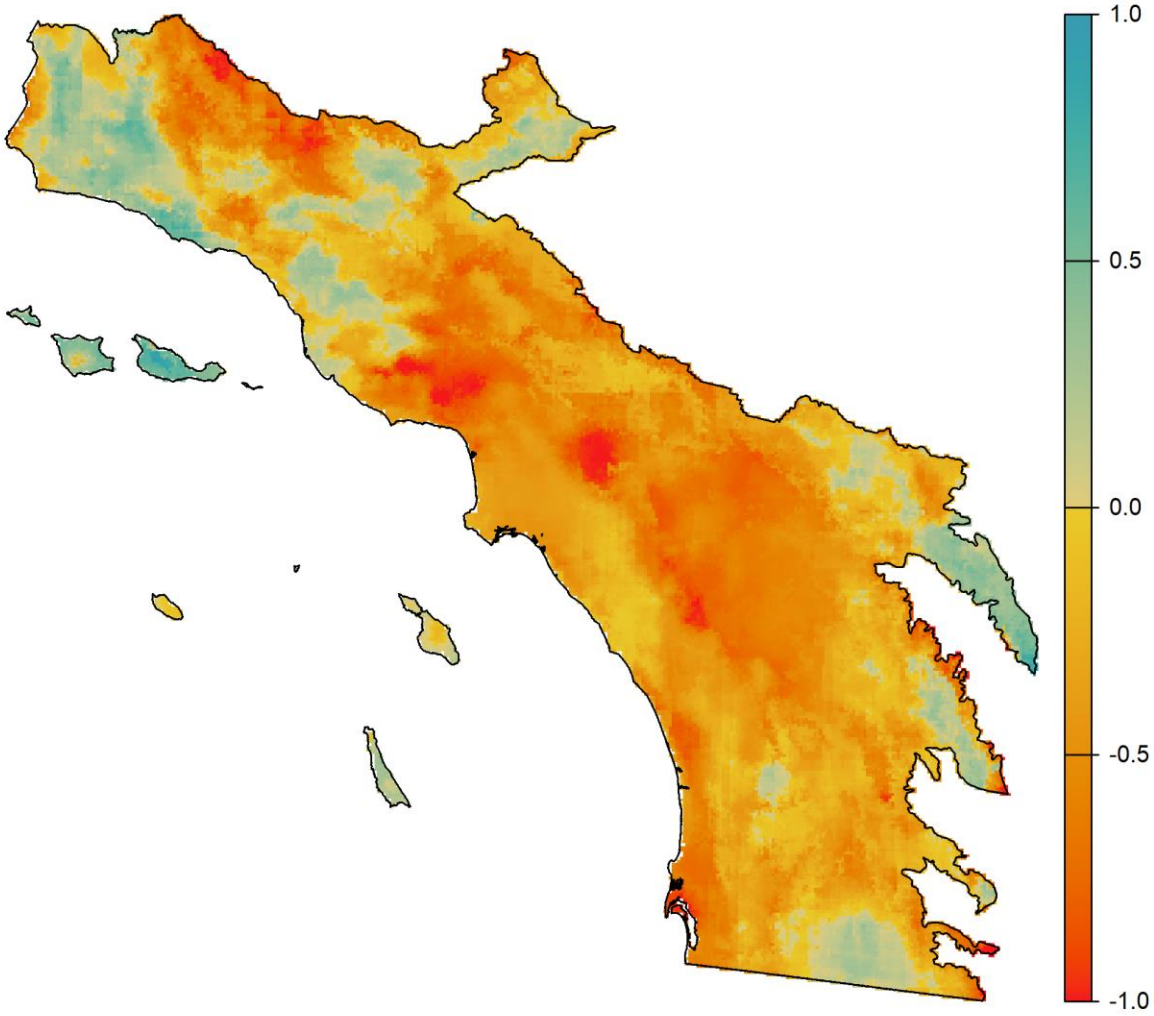

Figure 48. Images of future condition scores for biodiversity across the Southern California

CARBON SEQUESTRATION

Forests play an important role in mitigating climate by sequestering and storing large amounts of carbon. However, forests are at risk of losing carbon because of rates of decay and disturbance, especially with high severity wildfires. Knowing where carbon exists provides a context for where changes in forest conditions will have the greatest impact on carbon storage and sequestration objectives.

DESIRED OUTCOME: Carbon sequestration is enhanced in a stable and sustainable manner that yields multiple ecological and social benefits.

Note that all values for carbon have been expressed in Mg C/ha, the international standard for how carbon is measured. If needed, to convert back to the native short tons per acre, divide the Mg/ha by 2.2417023114334.

CURRENT CONDITIONS

PILLAR REPRESENTATION

The carbon sequestration pillar consists of two elements: carbon storage element and carbon stability. The carbon sequestration pillar condition score is derived by averaging the condition scores of the storage and stability elements.

File Name: carbonSeq.tif

ELEMENT REPRESENTATION: CARBON STORAGE

Carbon storage in forest biomass is an essential attribute of stable forest ecosystems and a key link in the global carbon cycle. After carbon dioxide is converted into organic matter by photosynthesis, carbon is stored in forests for a period of time before it is ultimately returned to the atmosphere through respiration and decomposition or disturbance (e.g., fire). A substantial pool of carbon is stored in woody biomass (roots, trunks, branches). Another portion eventually ends up as organic matter in forest floor litter and in soils. Soil carbon does not change very quickly and is difficult to measure directly.

Carbon storage is described by two metrics: total aboveground carbon and annual biomass data. The total aboveground carbon data source is the primary source of vegetation metrics for the Southern California kit, and as such, it is selected as the source to represent this metric and element to provide greater internal data consistency across the kit.

Data Units: Condition score, +1 to -1

File Name: storage.tif

Represent pillar: Yes

Translation: Where is total carbon the highest?

TOTAL ABOVEGROUND CARBON *

Tier: 1

Data Vintage: 09/2020

Metric Definition and Relevance: Identifying ecosystem carbon is essential to land managers and the Total Carbon (F3) metric provides an estimate of the amount of existing carbon (live and dead) and its location on California's landscape. It is primarily useful for carbon accounting – how much carbon is where – but in combination with other metrics (stable carbon), it provides a valuable context for understanding where and how much of the carbon on the landscape is vulnerable and where there are opportunities to enhance carbon sequestration and stable storage.

Data Resolution: 30m Raster

Data Units: Grams dry matter/m2

Data Source: CECS; https://california-ecosystem-climate.solutions/

File Name: CStocks_Total_Above_202009_scored.tif

Type and distribution of data: Normal, right-skewed distribution representing continuous values. Raw data values range from 0 to 100000.

Represent element and pillar: Yes

Translation: Where is total aboveground carbon high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of higher total aboveground carbon (positive linear slope). More favorable (translated to +1) set at 0, less favorable (translated to -1) set at > 45741.002. Alternative approaches could be to set -1 at the top value, but that would result in a more favorable interpretation of damage potential.

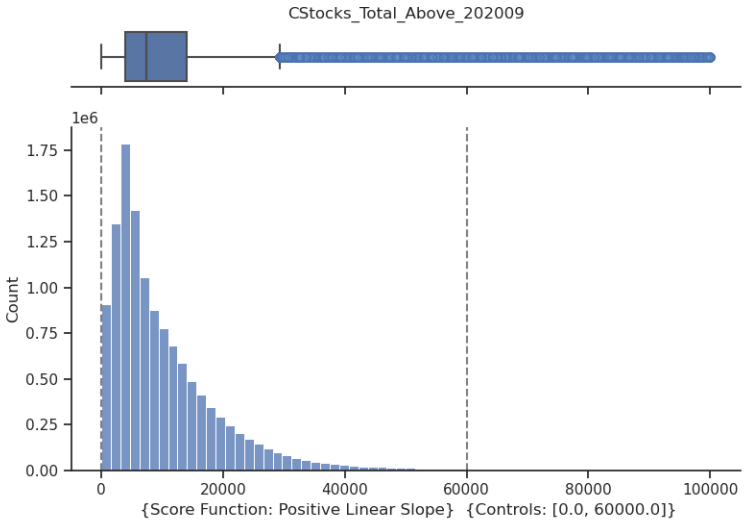

Figure 49. Histogram and scoring criterion of current condition of total carbon across the Southern California, based on F3 data

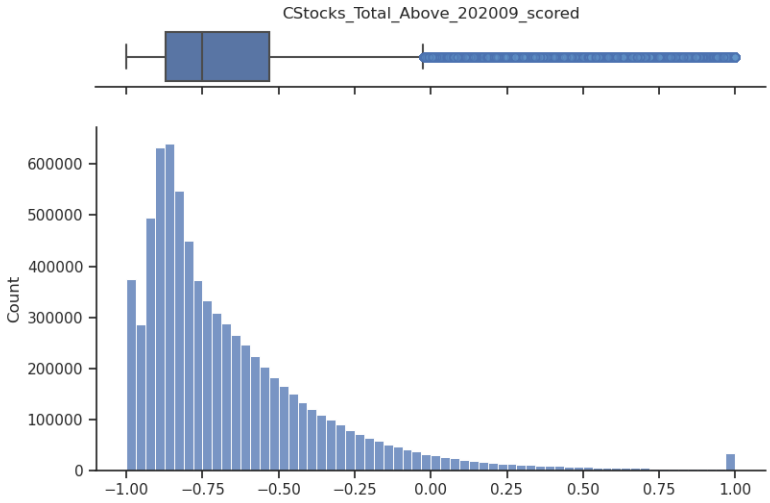

Figure 50. Histogram of translated current condition of total carbon across the Southern California, based on F3 data

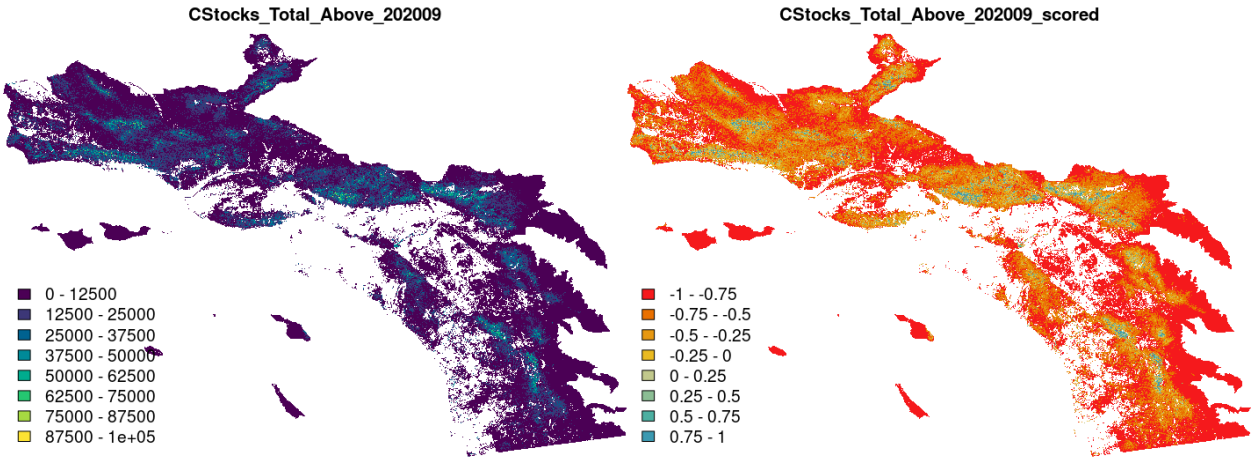

Figure 51. Maps displaying raw metric and translated metric of current condition of total carbon across the Southern California, based on F3 data

ANNUAL BIOMASS DATA 2001 AND 2021 – ABOVE AND BELOW GROUND, STANDING DEAD, AND LITTER

Tier: 2

Data Vintage: 2001 and 2021

Metric Definition and Relevance: Biomass estimates for shrubland-dominated ecosystems in southern California have, to date, been limited to national or statewide efforts which can underestimate the amount of biomass; are limited to one-time snapshots; or estimate aboveground live biomass only. These data were developed using a consistent, repeatable method to assess four vegetative biomass pools from 2001-2021 for the southern California study area (totaling 6,441,208 ha), defined by the Level IV Ecoregions (Bailey 2016) that intersect with USDA Forest Service lands (Figure 1). Aboveground live biomass estimates were developed first (Schrader-Patton and Underwood 2021), and then belowground, standing dead, and litter biomass pools were calculated using field data in the peer-reviewed literature (Schrader-Patton et al. 2022). Over half (52.3%) of the study area is shrubland, and the method accounts for different amounts of carbon associated with three post-fire shrub regeneration strategies: obligate resprouting, obligate seeding, and facultative seeding. Biomass estimates were also generated for trees and herbs, giving a total of five life form post-fire regeneration strategy types. These data provide an important contribution to the management of shrubland-dominated ecosystems to assess the impacts of wildfire and management activities, such as fuel management and restoration, and for monitoring carbon storage over the long term.

The biomass data are a key input into the online web mapping tool SoCal EcoServe, developed for US Department 0f Agriculture Forest Service resource managers to help evaluate and assess the impacts of wildfire on a suite of ecosystem services including carbon storage. The tool is available at https://manzanita.forestry.oregonstate.edu/ecoservices/ and described in Underwood et al. (2022).

Data Resolution: 30m Raster

Data Units: kg/m2

Data Source:
Schrader-Patton, C.C., E.C. Underwood, and Q.M. Sorenson. 2023. Annual biomass spatial data for southern California (2001–2021): Above- and belowground, standing dead, and litter. *Ecology* e4031.

Schrader-Patton, C.C. and E.C. Underwood. 2022. Annual biomass data (2001-2021) for southern California: above- and below-ground, standing dead, and litter. Dryad, Dataset, https://doi.org/10.5061/dryad.qz612jmjt

Underwood, E.C., Q.M. Sorenson, C.C. Schrader-Patton, N.A. Molinari and H.D. Safford. 2023. Resprouting, seeding, and facultative seeding shrub species in California's Mediterranean-type climate region. *Frontiers in Ecology and Evolution* 11:1158265. doi: 10.3389/fevo.2023.1158265

Data available in RRK for 2001 and 2021 (year in file name changes accordingly). The full set of data for intervening years can be downloaded from: https://doi.org/10.5061/dryad.qz612jmjt .

File Name: WWETAC_UCD_above_ground_2021_g_m2_v22.tif; WWETAC_UCD_below_ground_2021_g_m2_v22.tif; WWETAC_UCD_litter_2021_g_m2_v22.tif; WWETAC_UCD_standing_dead_2021_g_m2_v22.tif; WWETAC_UCD_above_ground_2001_g_m2_v22.tif; WWETAC_UCD_below_ground_2001_g_m2_v22.tif; WWETAC_UCD_litter_2001_g_m2_v22.tif; WWETAC_UCD_standing_dead_2001_g_m2_v22.tif

Translation: None

ELEMENT REPRESENTATION: CARBON STABILITY

Carbon stability is an important feature in carbon sequestration calculations because carbon turnover – high levels of loss, even if followed by high rates of sequestration – are not as ecologically beneficial as high residency rates for carbon and larger pool values, particularly when stored in large live trees which have many other ecological benefits. The carbon in dead biomass is considered a more unstable component of the carbon pool itself, and a potential destabilizing factor for the live carbon pool in fire-adapted forest ecosystems, especially where it exceeds certain thresholds (e.g., over 46 Mg (total biomass)/ha, Stephens et al., 2022).

The carbon stability element is described and represented by a single metric, aboveground carbon turnover time (indicated by asterisk).

Data Units: Condition score, +1 to -1

File Name: stability.tif

Represent pillar: Yes

Translation: Where is carbon stability the highest?

ABOVEGROUND CARBON TURNOVER TIME *

Tier: 1

Data Vintage: 09/2020

Metric Definition and Relevance: The average lifetime of aboveground live and dead carbon in years. Locations where the lifetime or turnover time is longer have more carbon in more stable pools, such as large trees or large coarse woody debris. Locations where the lifetime or turnover time is shorter have more carbon in labile pools, such as live or dead leaves.

Data Resolution: 30m Raster

Data Units: Years

Data Source: CECS; https://california-ecosystem-climate.solutions/

File Name: CStocks_Turnovertime_202009_scored.tif

Type and distribution of data: Right-skewed distribution representing relative index values. Raw data values range from 0 to 200.

Represent element and pillar: Yes

Translation: Where is aboveground carbon turnover time high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of higher aboveground turnover time (positive linear slope). More favorable (translated to +1) set at 0, less favorable (translated to -1) set at > 60. Alternative approaches could be to set -1 at the top value, but that would result in a more favorable interpretation of damage potential.

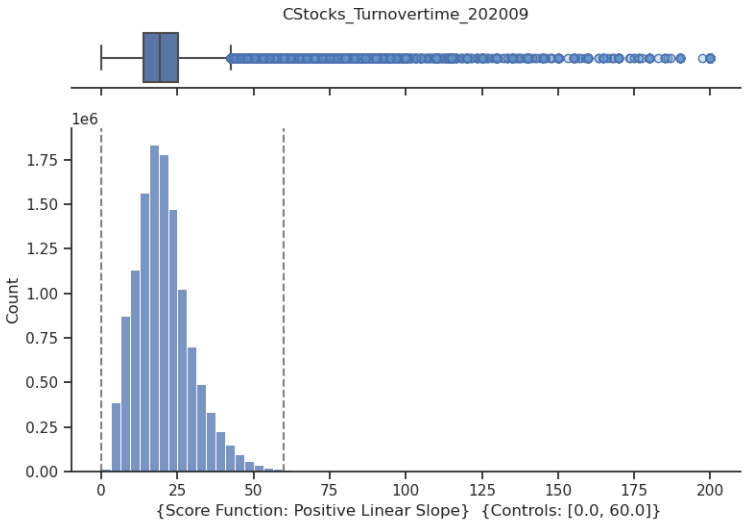

Figure 52. Histogram and scoring of aboveground carbon turnover time in Southern California

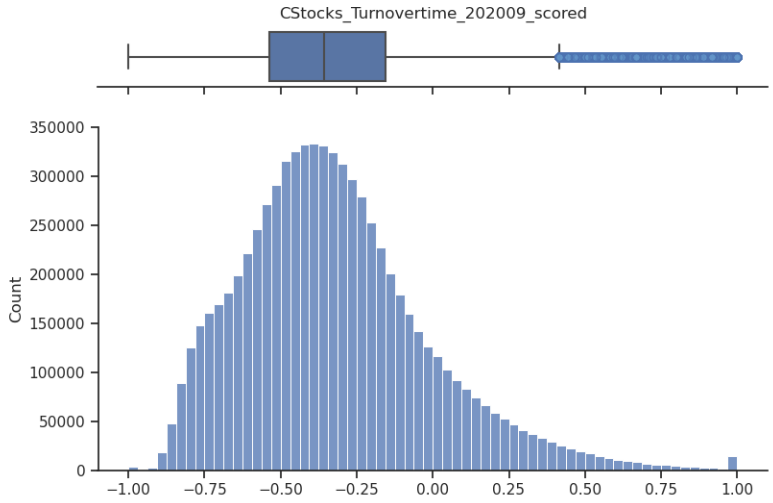

Figure 53. Histogram of translated aboveground carbon turnover time in Southern California

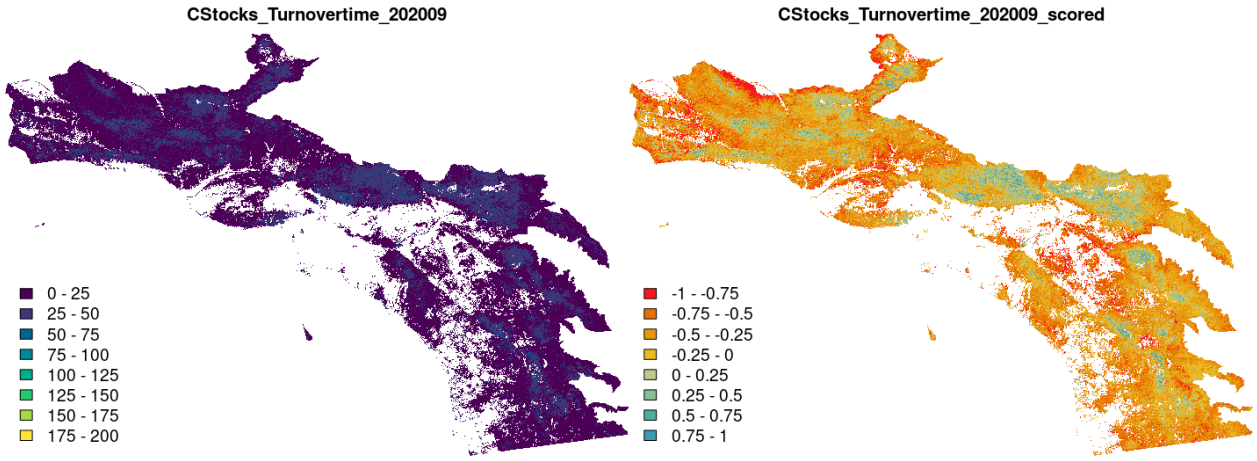

Figure 54. Maps displaying raw metric and translated metric aboveground carbon turnover time in Southern California

FUTURE CONDITION

Metric definition and relevance: Aboveground live carbon (Mg ha^{-1}) was evaluated using a global dataset (300-m) representing conditions for the year 2010 (Spawn et al. 2020; https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=1763). Methods for estimation of C densities varied by lifeform, but the dataset resulted in a consistent wall-to-wall coverage across North America. We eliminated from the analysis all climate analogues that experienced a stand replacing disturbance between 2000 – 2010 using the Hansen et al. (2013) Global Forest Change dataset (https://glad.earthengine.app/view/global-forest-change). This removed incidences of recent disturbance and skewed the distribution of carbon at climate analogues sites towards those that have not experienced near-term disturbances and therefore

are representative of later stages of successional development and higher relative accumulations of carbon.

Data resolution: 1-km, resampled to 30-m to match current conditions data

Data Units: Translated strength of evidence score, +1 to -1.

Data source: Aboveground live carbon; Spawn et al. (2020). Disturbances; Hansen et al. (2013)

File Name: carbon030_future.tif

Translation: Where is future climate most stable for carbon sequestration?

Future climate stability interpretation: Values near -1 indicate large changes in the fire regime are likely, while values near +1 indicate little to no change is expected. For a given focal cell, a weighted empirical distribution was developed from the 100 climate analogues for each of the 9 GCMs, separately. The weight of each analog was determined by the Sigma score, where lower weights were given to analogues that were not a good match to the focal cell's future climate. Current carbon levels for the cell were evaluated with respect to this distribution to determine its percentile condition (Figure 55). Percentiles close to 100% indicated that current carbon levels were high compared to its analogues and suggested carbon levels will decrease in the future under climate change leading to a score of -1. This score was combined with the mean Sigma climate score using the And (minimum) operator to ensure cells with no analogue analogere given lower scores.

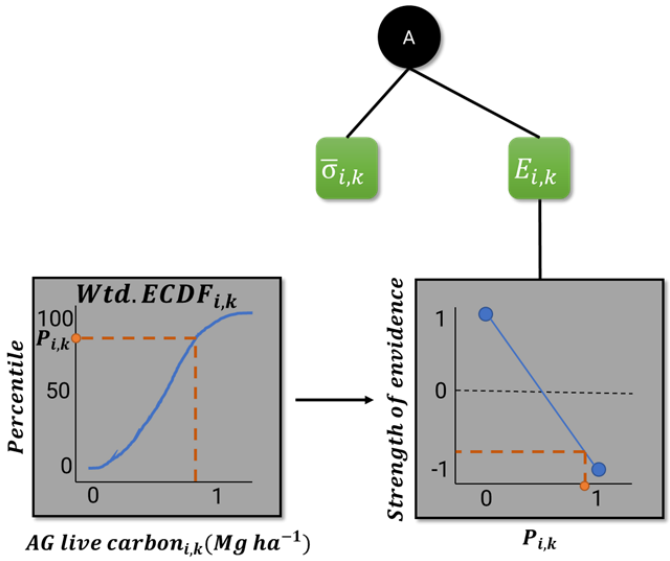

Figure 55. Logic model for carbon. Subscripts indicate: i, cell (n = 9,000); k, climate model (n = 9).

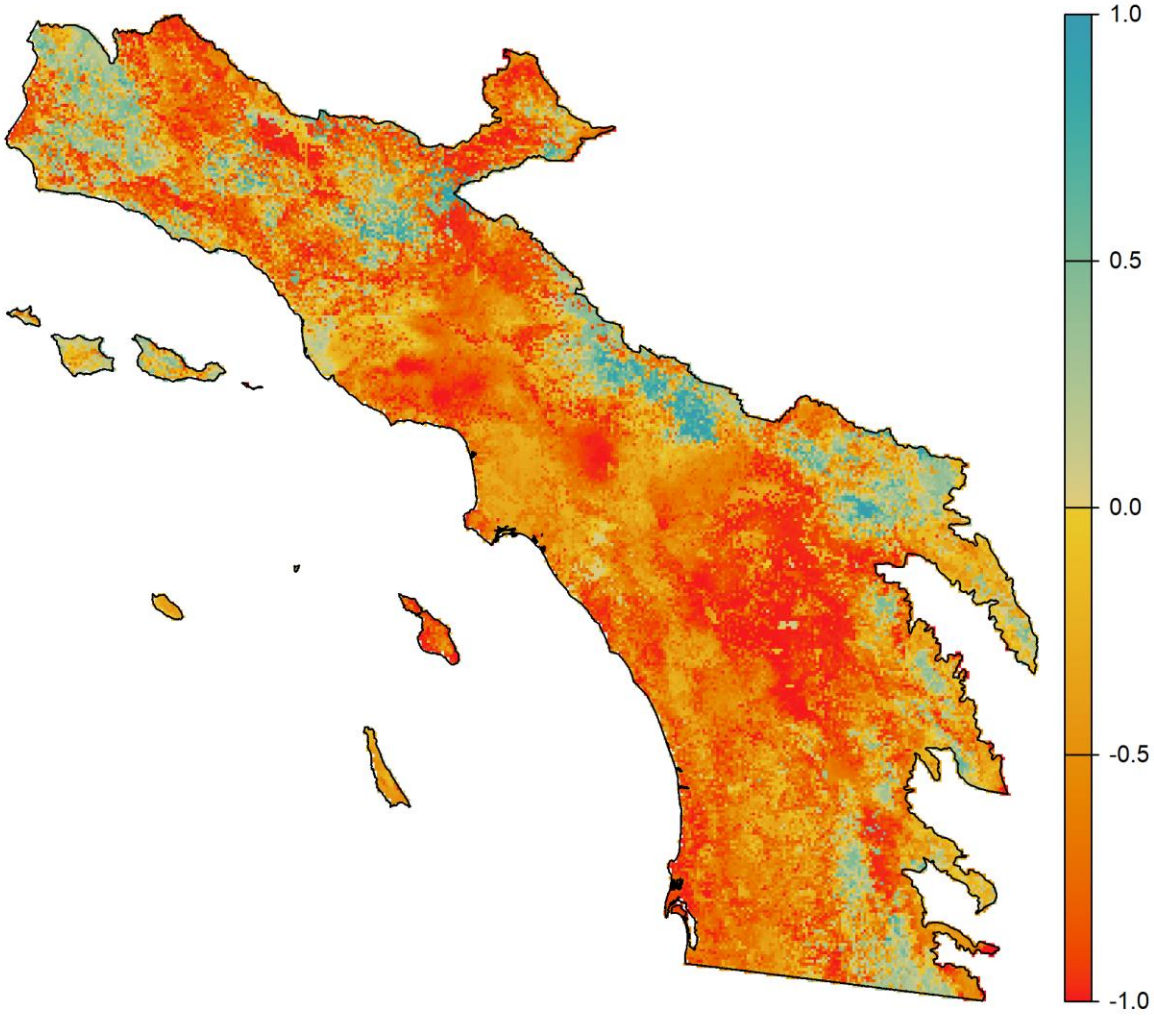

Figure 56. Images of future climate stability scores for the carbon sequestration pillar across the Southern California

ECONOMIC DIVERSITY

Economic Diversity increases business opportunities that provide regional economic vitality and additional benefits to rural and vulnerable populations. Ecosystem services and forest products provide a foundation for many local and regional economic activities and employment opportunities. Forest management should support a sustainable natural resource-based economy.

Desired Outcome: Forest management and outdoor activities support a sustainable, natural-resource-based economy, particularly in rural communities.

CURRENT CONDITIONS

PILLAR REPRESENTATION

The economic diversity pillar in this kit consists of only one of the four elements in the Framework: the wood product industry element.

Data Units: Condition score, +1 to -1

File Name: econDiversity.tif

Translation: Where is economic diversity most resilient?

ELEMENT REPRESENTATION: WOOD PRODUCT INDUSTRY

The wood product industry plays an important role in the Southern California social and ecological realm. The industry provides jobs, income, and local wood products from natural resources as well as being an integral player in managing ecosystems. Restoration activities depend on the wood product industry to be involved in the removal of fuels to appropriate processing facilities as opposed to leaving materials as additional fuel on the landscape.

The wood product industry element is described and represented by one metric: cost of potential treatments (indicated by asterisk).

Data Units: Condition score, +1 to -1

File Name: woodProdInd.tif

Represent pillar: Yes

Translation: Where is the wood product industry most resilient?

COST OF POTENTIAL TREATMENTS *

Tier: 2

Data Vintage: 2023

Metric Definition and Relevance: The principle method for maintaining or restoring resilience to the southern California landscape involves vegetation treatments. There are many variations on treatments involving different kinds of equipment and different activities of managing vegetation. The metric has gathered available information on the costs of the major treatment methods and incorporated this information into a geospatial database.

There are no treatments of vegetation in southern California that generate revenue. All treatments included here are represented simply as costs per acre.

Data Resolution: 30m Raster

Data Units: Continuous, dollars per acre

Data source: CALFIRE, USDA Forest Service

File Name: cost_per_acre_vegtype_scored.tif

Represent element and pillar: Yes

Type and distribution of data: Right-skewed distribution on continuous values. Raw values range from 3 to 13.

Translation: Where is cost of potential treatments the lowest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of identifying lower biomass removal costs. More favorable (translated to +1) set at $3/ac, the least cost observed (negative linear slope), and less favorable (translated to -1) set at $13/ac, the maximum cost observed. Alternative approaches could evaluate costs using a positive linear slope, such that management would be directed toward areas with -1 values (low cost) and away from areas with +1 values (high cost).

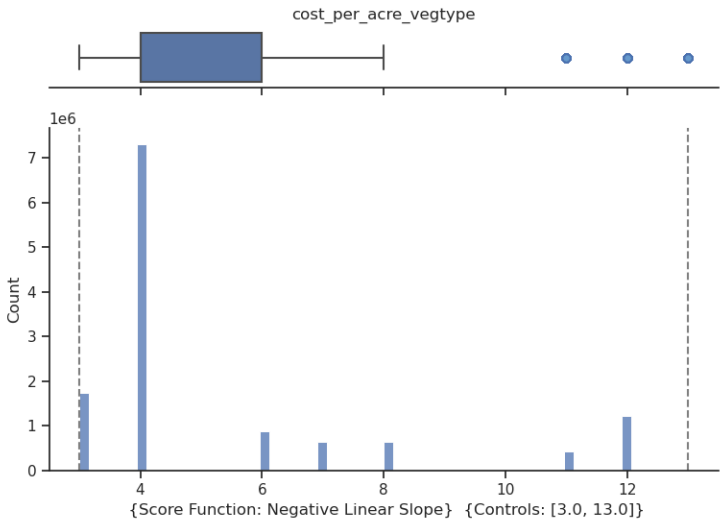

Figure 57. Histogram and scoring criterion of current condition scores for mobilization costs to saw facilities across the Southern California

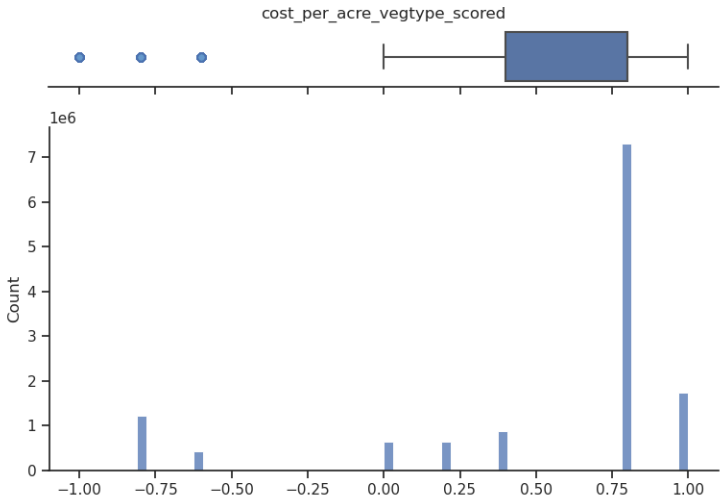

Figure 58. Histogram of translated current condition scores for mobilization costs to saw facilities across the Southern California

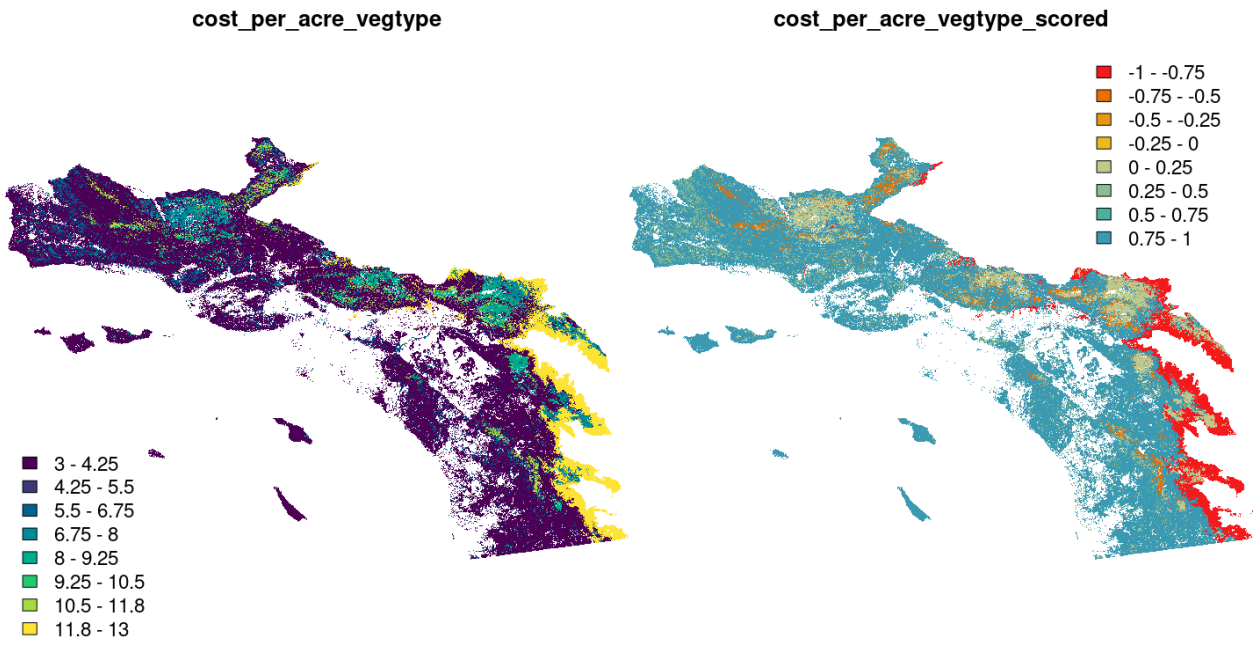

Figure 59. Maps displaying raw metric and translated metric of current condition scores for mobilization costs to saw facilities across the Southern California

FUTURE CONDITION

Metric definition and relevance: Future climate constraints on economic diversity was represented as the average of the Forest Resilience (stability in vegetation type), Water Security (stability in current levels of drought), and fire severity (stability in amount of high severity fire) future condition Pillars. This was designed to identify areas with high certainty of maintaining current vegetation with predictable levels of drought- and fire-related mortality. Large transitions to alternative vegetation types, particularly from forest to non-forest, may have implications not just on wood industry, but on recreation, tourism, and other expected ecological benefits. This Pillar accounts for the potential of these shifts occurring directly through the Forest Resilience Pillars, and indirectly through the Water Security (drought disturbances) and percent replacement severity (fire disturbances).

Data resolution: 1-km, resampled to 30-m to match current conditions data

Data Units: Translated strength of evidence score. Values near -1 indicate large changes in the fire regime are likely, while values near +1 indicate little to no change is expected.

Data source: USGS GAP Analysis Species Range Maps (USGS 2018)

File Name: econDiversity030_future.tif

Translation: Where is future climate most stable for wood products?

Climate constraint interpretation: The average of the probability of stand replacing fire score (Fire dynamics pillar), likelihood of transition to alternative vegetation type (Forest Resilience Pillar), and likelihood of increasing drought conditions (Water Security Pillar).

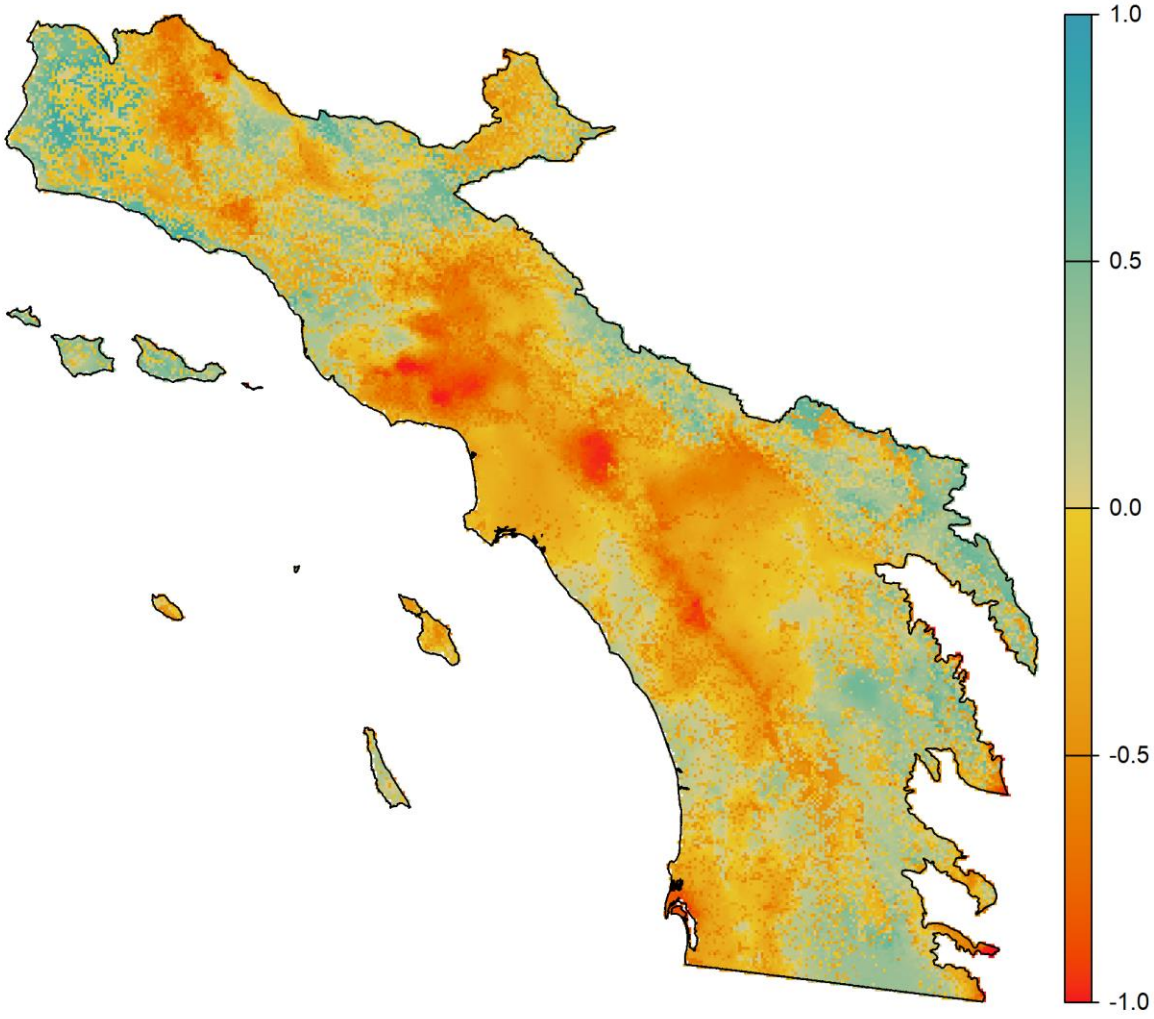

Figure 60. Images of future climate stability for the economic diversity pillar across the Southern California

FIRE ADAPTED COMMUNITIES

Wildfires are a keystone disturbance process in western US forests. However, the capacity for humans to coexist in the wildland urban interface (WUI) requires different restoration strategies aimed at the protection of life and property. This pillar evaluates the degree to which communities are living safely with fire and are accepting of management and natural ecological dynamics. It also evaluates the capacity for communities to manage desired, beneficial fire and suppress unwanted fire.

The definition of WUI used here, from Carlson et al 2022, adopts the definitions of interface and intermix WUI developed for previous census-based WUI mapping efforts based on U.S. Federal Register definitions (Radeloff et al., 2005; USDA & USDI, 2001). According to the definitions used for the building-based maps and for the census-based maps, WUI is where building density exceeds 6.17 units/km2 and where land cover is either (1) at least 50% wildland vegetation (intermix) or (2) under 50% wildland vegetation but within 2.4 km (1.5 miles) of a patch of wildland vegetation at least 5 km2 in area that contains at least 75% vegetation (interface). The distance selected for the interface definition is based on research from the California Fire Alliance suggesting that this is the average distance firebrands can travel from an active wildfire front (Stewart et al., 2007).

Desired Outcome: Communities have adapted to live safely in forested landscapes and understand the significance of fire to maintaining healthy forests. They have sufficient capacity to manage desired fire and suppress unwanted fire.

CURRENT CONDITIONS

PILLAR REPRESENTATION

The Fire-adapted Communities Pillar is represented in the RRK by metrics in a single Element – Hazard – so the Pillar condition score is the same as the Hazard Element score, which in turn is represented by a single metric, damage potential. Condition scores range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of achieving the desire outcome for the pillar.

Data Units: Condition score, +1 to -1

File Name: fireAdaptComm.tif

Translation: Where are communities most fire-adapted?

ELEMENT REPRESENTATION: HAZARD

The fire hazard element characterizes the fire risk in the wildland urban interface (WUI) defense and threat zones.

In the RRK, this Element is described by seven metrics: structure exposure score, damage potential, ember load index, housing unit density, ignition cause, fire ignition probability (human-caused), and

wildfire hazard potential. The current condition of the Hazard Element is represented by two metrics, damage potential and fire ignition probability, human-caused (indicated with asterisks). The condition scores for each of the metrics are averaged to derive a condition score for the hazard element.

Data Units: Condition score, +1 to -1

File Name: hazard.tif

Translation: Where is fire hazard the lowest?

STRUCTURE EXPOSURE SCORE

Tier: 1

Data vintage: 08/2023. Includes disturbances through the end of 2022

Metric Definition and Relevance: This metric combines two data layers; one is the Wildland Urban Interface (WUI) as defined by Carlson et al. 2022, and a second data layer, Structure Exposure Score (SES), developed by Pyrologix LLC. The WUI includes the intermix and interface zones which collectively identify areas where structures occur. The distance selected for the interface definition is based on research from the California Fire Alliance indicating the average distance firebrands can travel from an active wildfire front. Structure Exposure Score is an integrated rating of wildfire hazard that includes the likelihood of a wildfire reaching a given location along with the potential intensity and ember load when that occurs. SES varies considerably across the landscape. The data are current through 2021. Not included in the element representation because it is included in the calculation of damage potential.

Pyrologix uses a standard geometric-interval classification to define the ten classes of SES, where each class break is 1.5 times larger than the previous break. So, homes located within Class X are 1.5 times more exposed than those in Class IX, and so on. This metric represents SES for WUI areas only.

Data Resolution: 30m Raster

Data Units: Relative index, 10 classes, low to high exposure

Data Source: Pyrologix, LLC, WUI (USGS)

File Name: StructureExposureScore_WUI_2023_scored.tif

Type and distribution of data: Asymmetric distribution representing index values. The raw data range from 3 and 30.

Represent element and pillar: No

Translation: Where is structure exposure to fire low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of lower structure exposure (negative linear slope). More favorable (translated to +1) set at 1.0, less favorable (translated to -1) set at > 30. Alternative approaches could be to set -1 at the top value, but that would result in a more favorable interpretation of structure exposures.

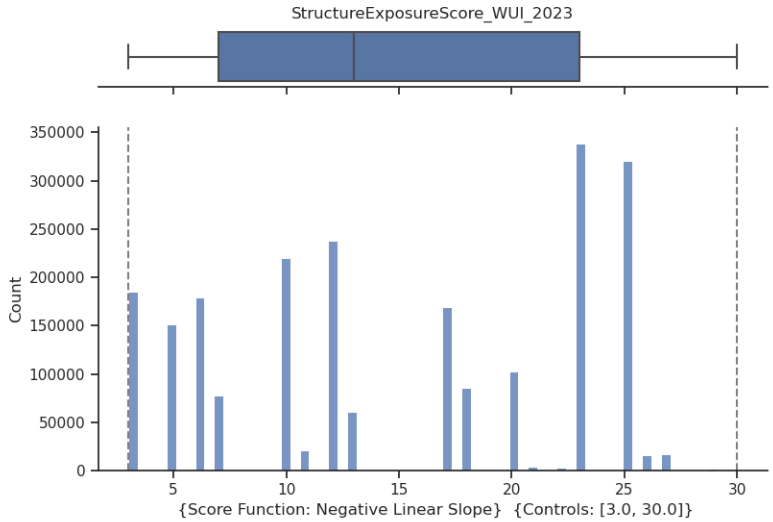

Figure 61. Histogram and scoring criterion of structure exposure score across Southern California

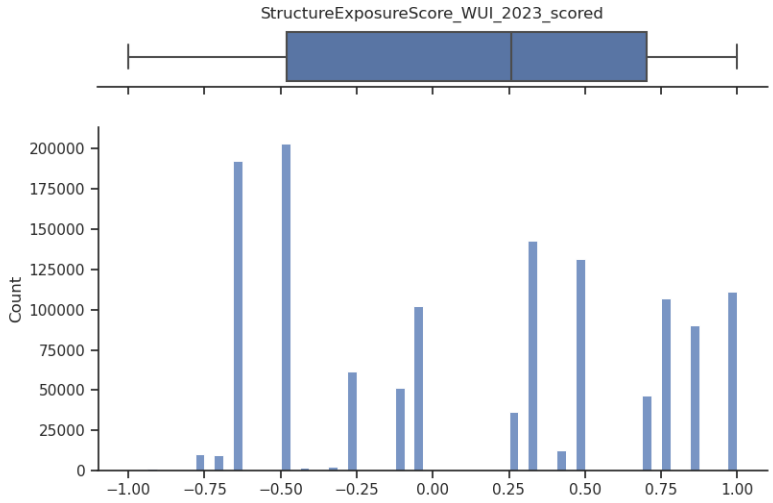

Figure 62. Histogram of translated structure exposure score across Southern California

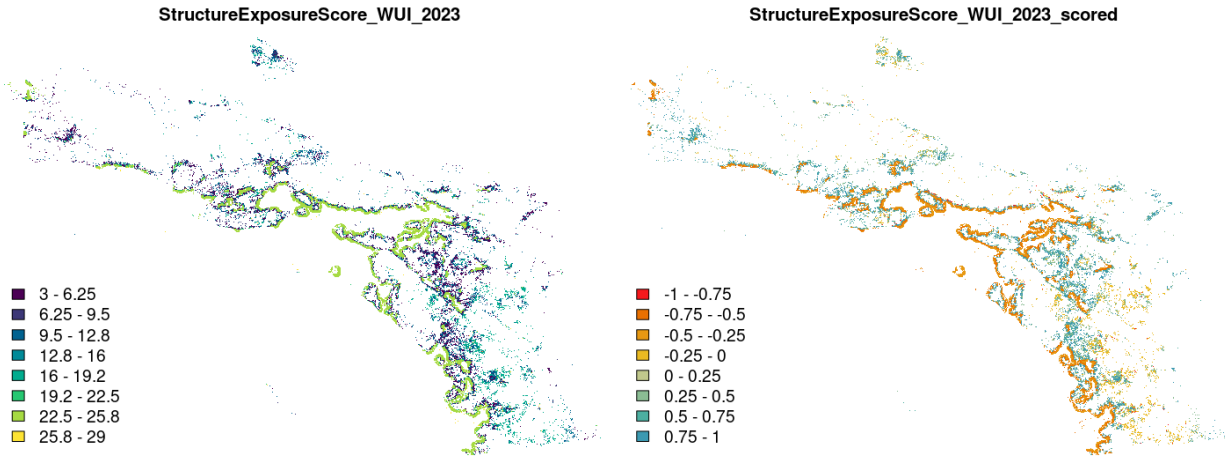

Figure 63. Maps displaying raw metric and translated metric structure exposure score across Southern California

DAMAGE POTENTIAL *

Tier: 1

Data Vintage: 08/2023. Includes disturbances through the end of 2022

Metric Definition and Relevance: This metric combines two data layers; one is the Wildland Urban Interface (WUI) as defined by Carlson et al. 2022, and a second data layer, Damage Potential (DP), developed by Pyrologix LLC. The WUI includes the intermix and interface zones which collectively identify areas where structures occur. The distance selected for the interface definition is based on research from the California Fire Alliance suggesting that this is the average distance firebrands can travel from an active wildfire front. The composite Damage Potential (DP) dataset represents a relative measure of wildfire's potential to damage a home or other structure if one were present at a given pixel, and if a wildfire were to occur (conditional exposure). It is a function of ember load to a given pixel, and fire intensity at that pixel, and considers the generalized consequences to a home from fires of a given intensity (flame length). This index does not incorporate a measure of annual wildfire likelihood. The data are current through 2021.

Data Resolution: 30m Raster

Data Units: Relative index, low to high potential

Data source: Pyrologix, LLC; WUI (USGS)

File Name: DamagePotential_WUI_2023_scored.tif

Type and distribution of data: Right-skewed distribution representing relative index values. Raw data values range from 3 to 13.

Represent element and pillar: Yes

Translation: Where is fire damage potential low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of lower damage potential (negative linear slope). More favorable (translated to +1) set at 1.0, less favorable (translated to -1) set at > 13. Alternative approaches could be to set -1 at the top value, but that would result in a more favorable interpretation of damage potential.

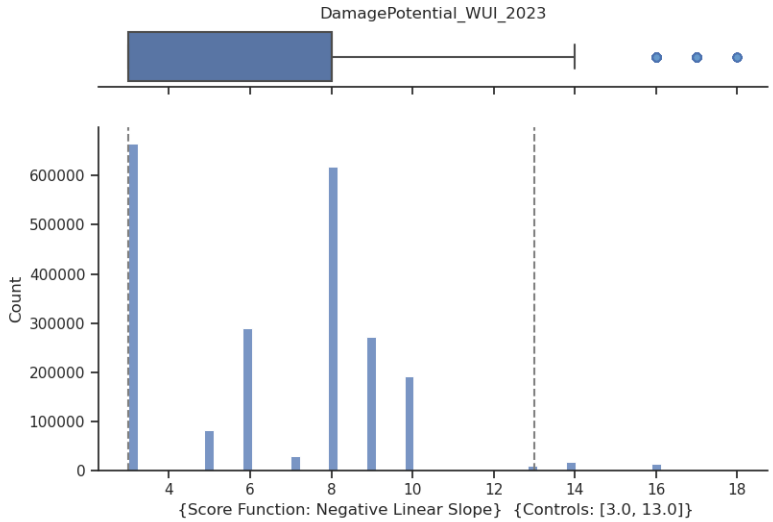

Figure 64. Histogram and scoring criterion of current damage potential from fire across the Southern California

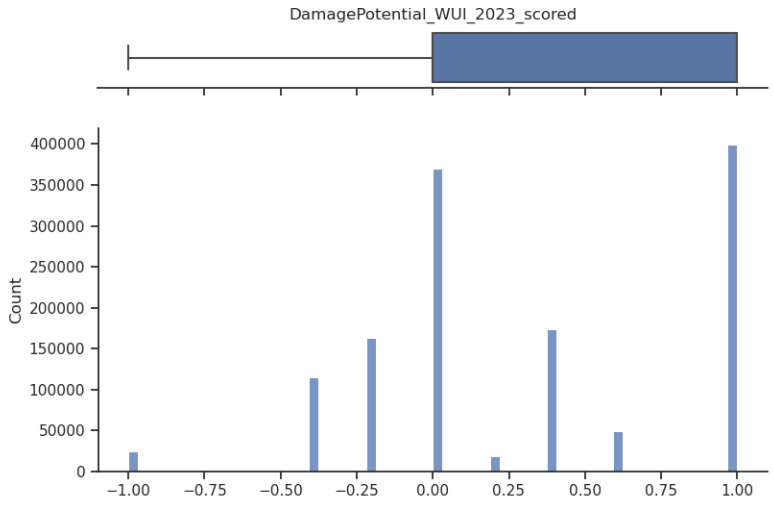

Figure 65. Histogram of translated current damage potential from fire across the Southern California

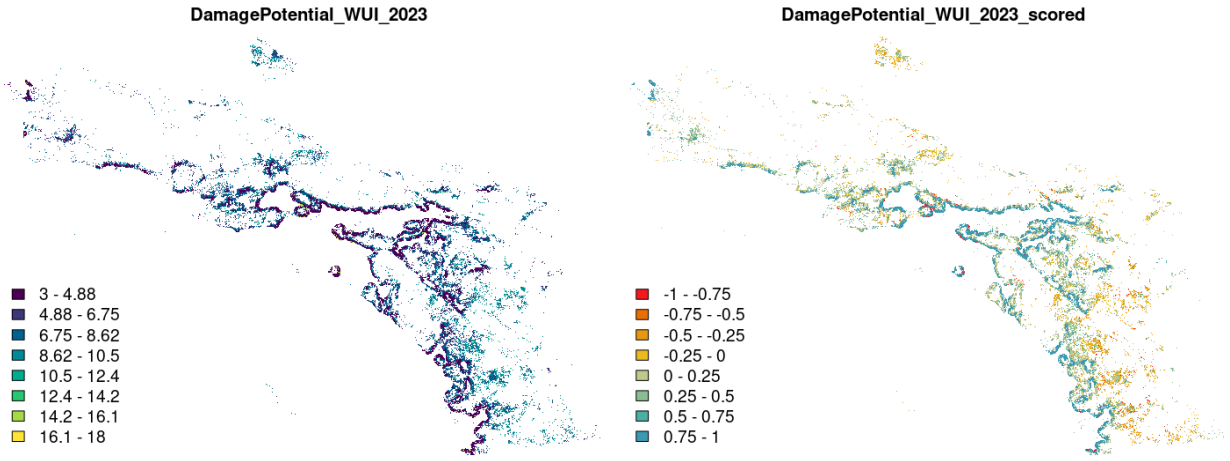

Figure 66. Maps displaying raw metric and translated metric current damage potential from fire across the Southern California

SOURCE OF EMBER LOAD TO BUILDINGS

Tier: 1

Data vintage: 08/2023. Includes disturbances through the end of 2022

Metric Definition and Relevance: The ember transport model used in WildEST tracks the travel of embers from each source pixel to downwind receiving pixels. The relative number of embers landing on a given receiving pixel is summed across all potential source pixels. If the receiving pixel has a nonzero WRC Building Cover value (meaning the pixel is within 75 m of a qualifying building), then we separately sum the relative number of embers from the source pixel. The final SELB raster represents the expected annual relative ember production that lands on building cover across all weather types.

Data Resolution: 30m Raster

Data Units: Relative index

Data Source: Pyrologix, LLC

File Name: SourceEmberLoadToBuildings_2023_scored.tif

Type and distribution of data: Right-skewed distribution representing index values. Raw data values range from 0 to 0.5.

Represent element and pillar: No

Translation: Where is source of ember load to buildings lowest?

Translation method and outcome: Raw data values translated to range +1 to -1 representing more favorable or less favorable conditions, respectively. The proposition of more favorable is based on the objective of lower source of ember load to buildings (negative linear slope). More favorable (translated to +1) set at 0, less favorable (translated to -1) set at > 0.5.

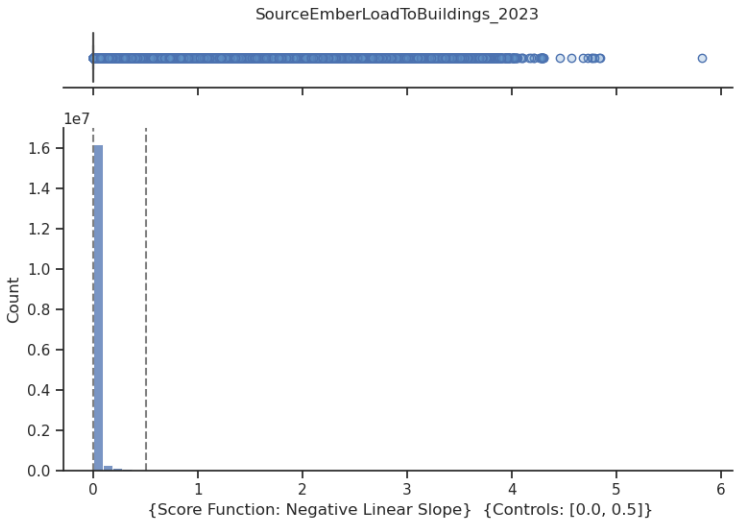

Figure 67. Histogram and scoring of source of ember load to buildings in Southern California.

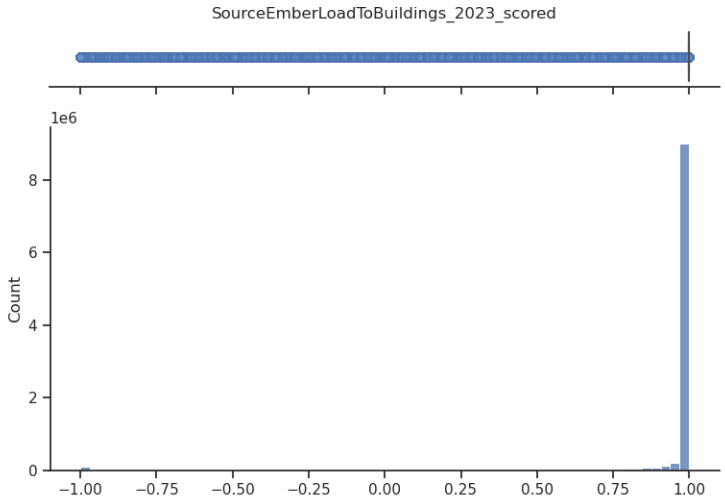

Figure 68. Histogram of translated source of ember load to buildings in Southern California.

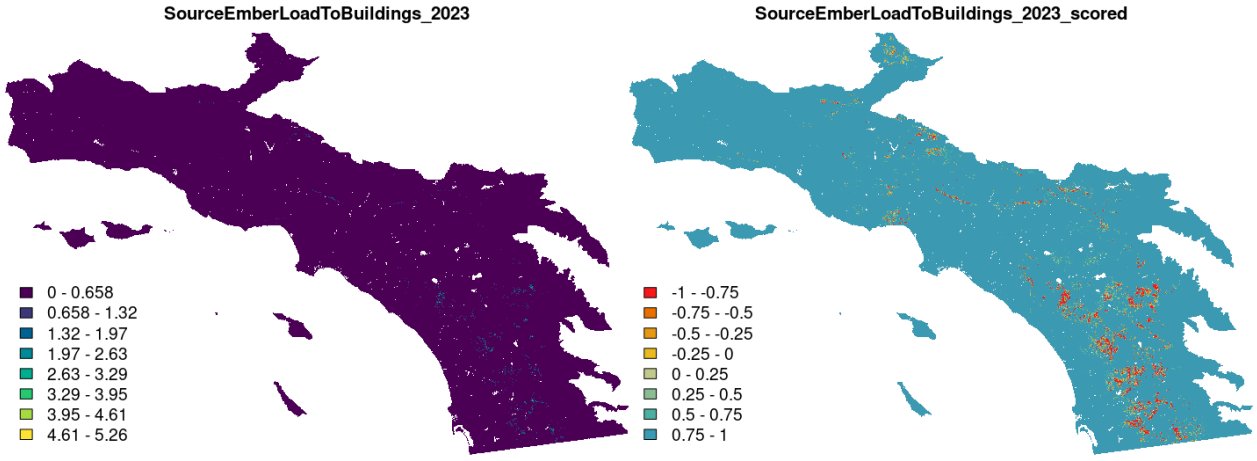

Figure 69. Maps displaying raw metric and translated metric source of ember load to buildings in Southern California.

EMBER LOAD INDEX

Tier: 1

Data vintage: 08/2023. Includes disturbances through the end of 2022

Metric Definition and Relevance: This ember load dataset represents the ember load index (ELI) per pixel, for a given pixel, based on surface and canopy fuel characteristics, climate, and topography within the pixel. The Ember Load Index (ELI) incorporates burn probability (BP). BP is incorporated into calculations of the ember production before the distribution of embers across the landscape to determine ember load. Given that ELI incorporates burn probability, this index can be used to identify where on the landscape hardening buildings may be needed to resist ignition and the priority for doing so according to the likelihood of the area being visited by fire.

Data Resolution: 30m Raster

Data Units: Relative index, number of embers

Data Source: Pyrologix, LLC

File Name: EmberLoadIndex_2023_scored.tif

Type and distribution of data: Zero-inflated, right-skewed distribution representing relative index values. Raw data values range from 0 to 6.

Represent element and pillar: No

Translation: Where is the Ember Load Index low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of lower damage potential (negative linear slope). More favorable (translated to +1) set at 1.0,

less favorable (translated to -1) set at > 6. Alternative approaches could be to set -1 at the top value, but that would result in a more favorable interpretation of ember load index.

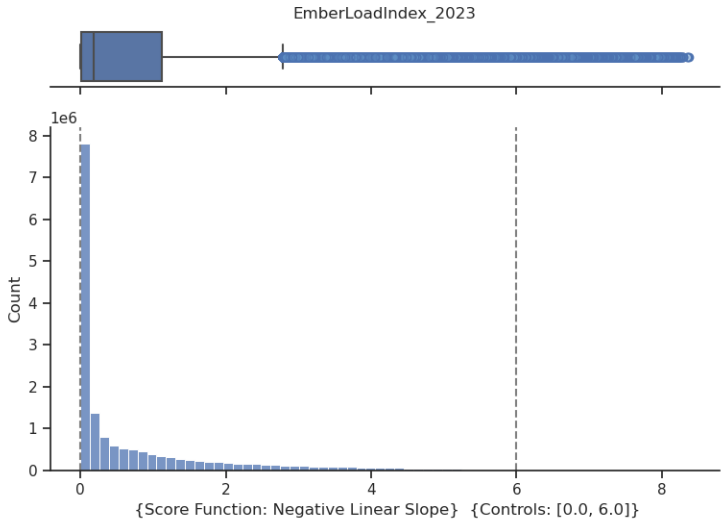

Figure 70. Histogram and scoring of ember load index in Southern California

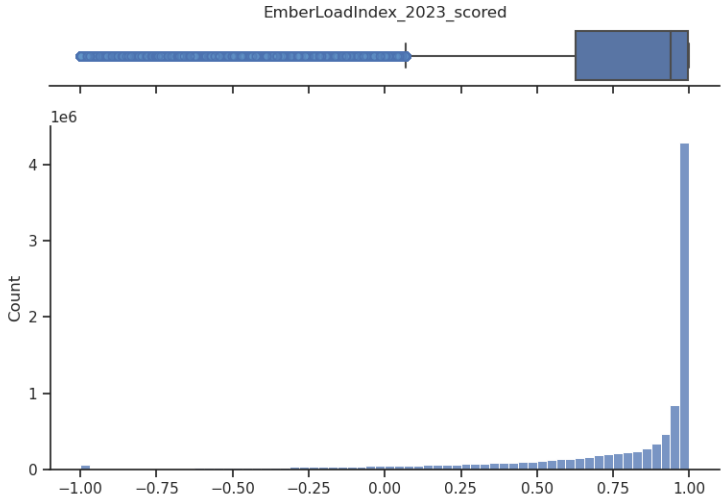

Figure 71. Histogram of translated ember load index in Southern California

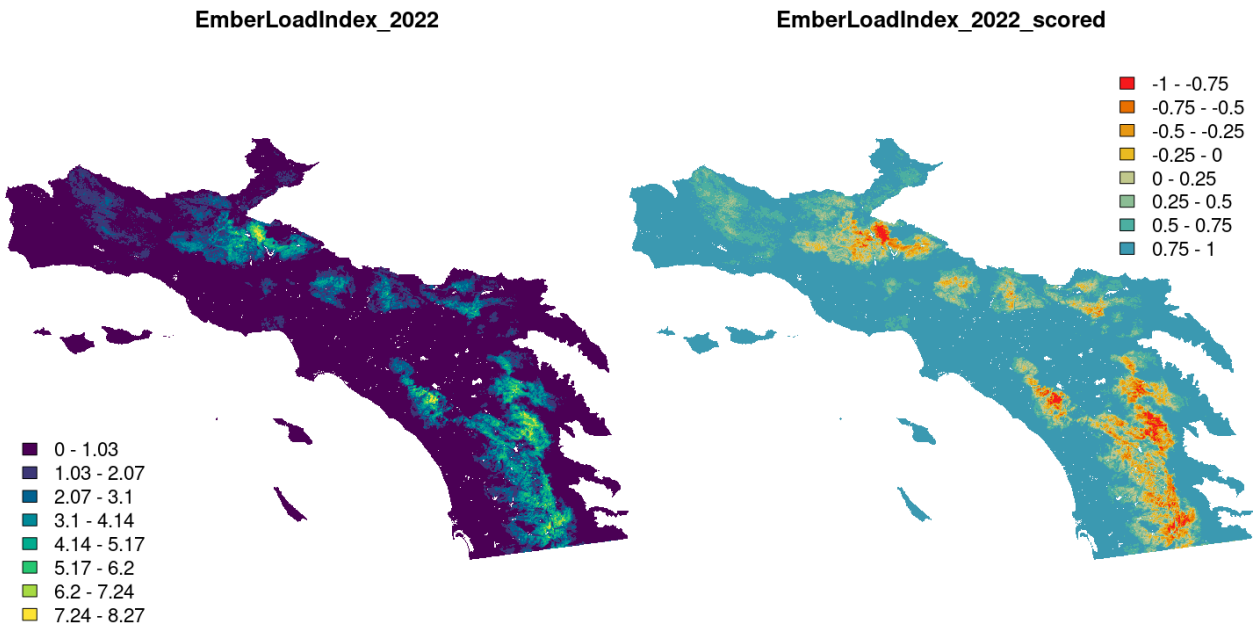

Figure 72. Maps displaying raw metric and translated metric ember load index in Southern California

IGNITION CAUSE

Tier: 1

Data vintage: 1992 - 2020

Metric Definition and Relevance: The original point layer (WildfireOccurrence_CA_1992_2020.shp) contains a spatial database of wildfires that occurred in the United States from 1992 to 2020. It is the fifth update of a publication originally generated to support the national Fire Program Analysis (FPA) system. The wildfire records were acquired from the reporting systems of federal, state, and local fire organizations. The following core data elements were required for records to be included in this data publication: discovery date, final fire size, and a point location at least as precise as a Public Land Survey System (PLSS) section (1-square mile grid). The data were transformed to conform, when possible, to the data standards of the National Wildfire Coordinating Group (NWCG), including an updated wildfire-cause standard (approved August 2020). Basic error-checking was performed and redundant records were identified and removed, to the degree possible. The resulting product, referred to as the Fire Program Analysis fire-occurrence database (FPA FOD), includes 2.3 million geo-referenced wildfire records, representing a total of 180 million acres burned during the 29-year period. Identifiers necessary to link the point-based, final-fire-reporting information to published large-fire-perimeter and operational-situation-reporting datasets are included. Short, Karen C. 2022. Spatial wildfire occurrence data for the United States, 1992-2020 [FPA_FOD_20221014]. 6th Edition. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2013-0009.6

Data Resolution: Vector (points) and 30m Raster

Data Units: Count

Data Source: Rocky Mountain Research Station, U.S. Forest Service

File Name: WldFireOccCause_Human_1992_2020_scored.tif, WldFireOccCause_Natural_1992_2020_scored.tif

Type and distribution of data: Zero-inflated, right-skewed distribution representing continuous values. Raw data values range from 0 to 105.

Represent element and pillar: No

Translation: Where did wildfires occur in Southern California?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of lower damage potential (negative linear slope). More favorable (translated to +1) set at 1.0, less favorable (translated to -1) set at > 105. Alternative approaches could be to set -1 at the top value, but that would result in a more favorable interpretation of ignition cause.

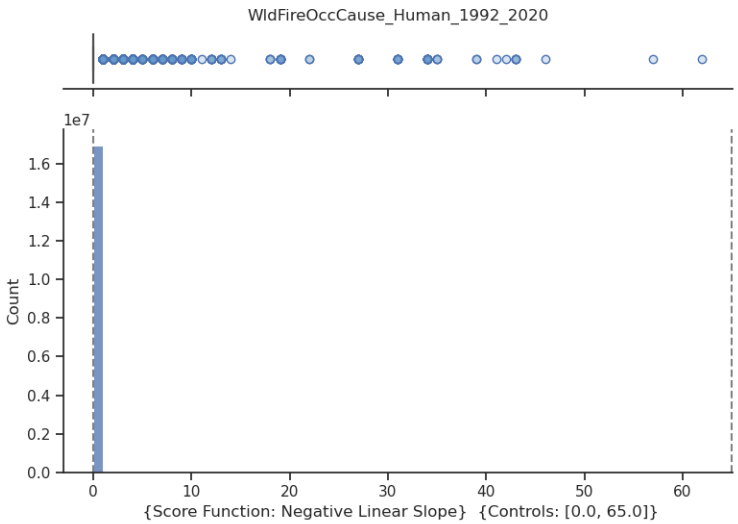

Figure 73. Histogram and scoring of wildfire occurrence, human-caused, 1992-2020 in Southern California

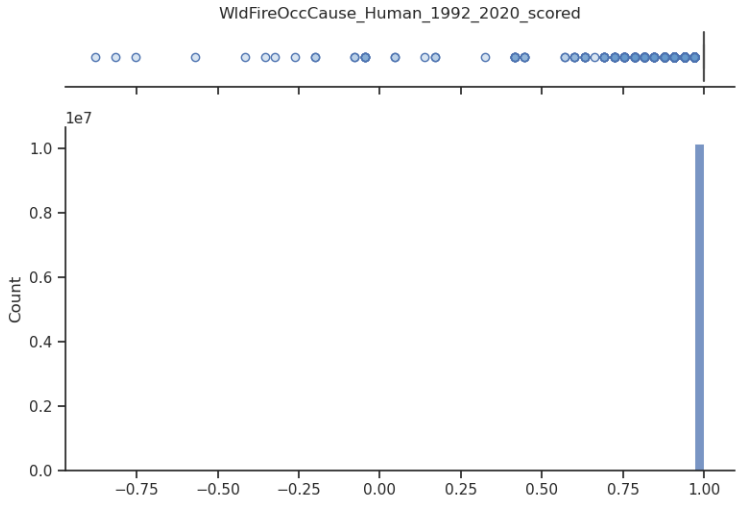

Figure 74. Histogram of translated wildfire occurrence, human-caused, 1992-2020 in Southern California

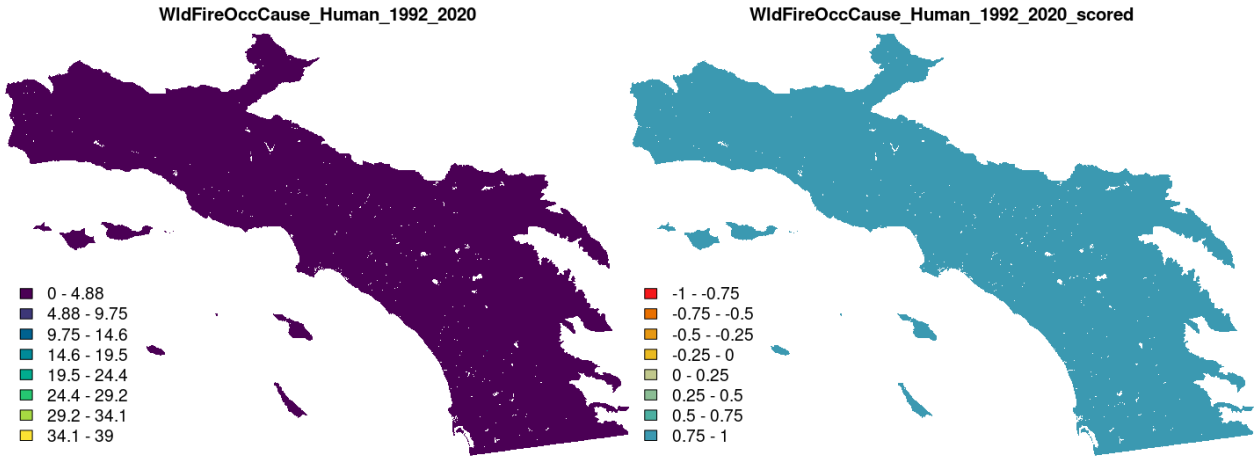

Figure 75. Maps displaying raw metric and translated metric wildfire occurrence, human-caused, 1992-2020 in Southern California

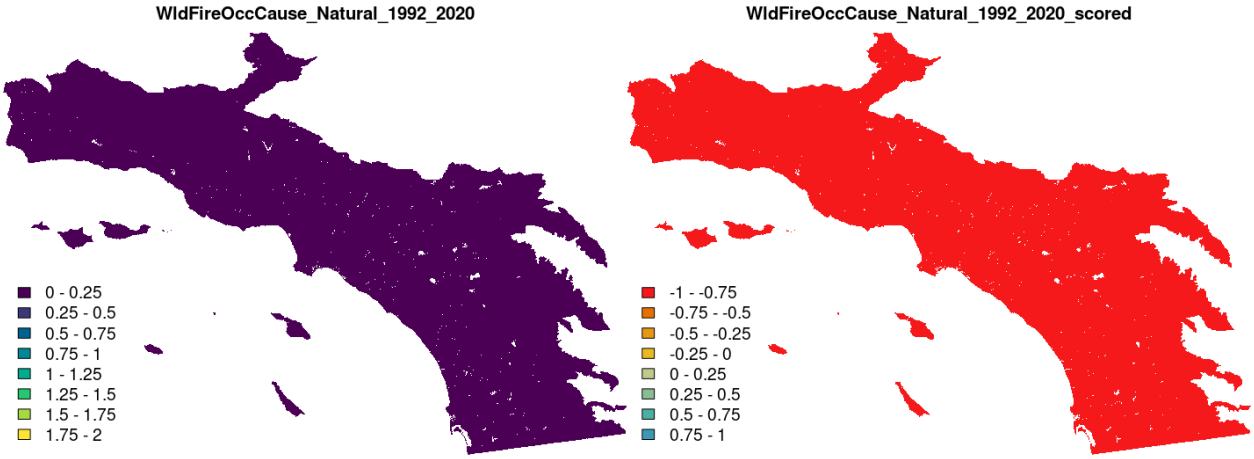

Figure 76. Maps displaying raw metric and translated metric wildfire occurrence, natural-caused, 1992-2020 in Southern California

FIRE IGNITION PROBABILITY, HUMAN-CAUSED *

Tier: 3

Data Vintage: 1992 to 2015

Metric Definition and Relevance: The rasters depicts the predicted human-caused ignition probability for the state of California.

Data Resolution: 1km Raster

Data Units: Probability, 0-1

Data Source: Bin Chen and Yufang Jin, University of California Davis, bch@ucdavis.edu

File Name: PredictedHumanIgnitionProb_1km_scored.tif

Type and distribution of data: Bimodal distribution representing probability. Raw data values range from 0.001 to 0.713.

Represent element and pillar: Yes

Translation: Where is human-caused fire ignition probability low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of lower human-caused fire ignition probability (negative linear slope). More favorable (translated to +1) set at 0.001, less favorable (translated to -1) < 0.713 for human-caused fire ignition probability. Alternative approaches could be to set -1 at the top value, but that would result in a more favorable interpretation of human-caused fire ignition probability.

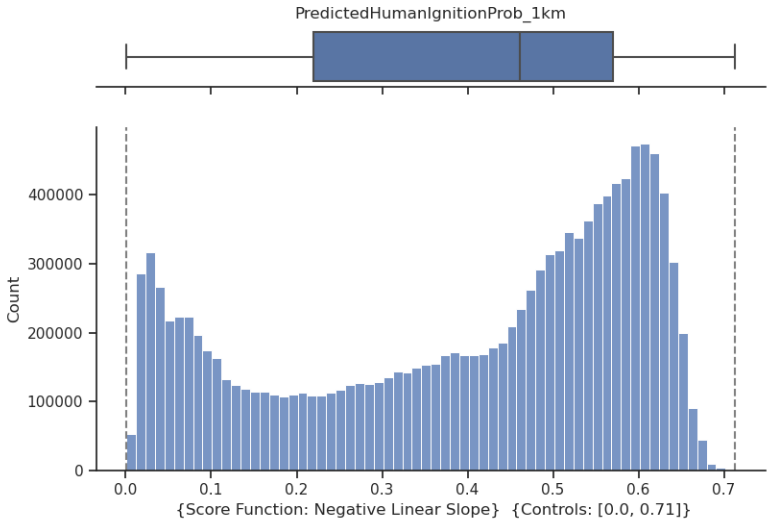

Figure 77. Histogram and scoring of predicted human fire ignition probability in Southern California

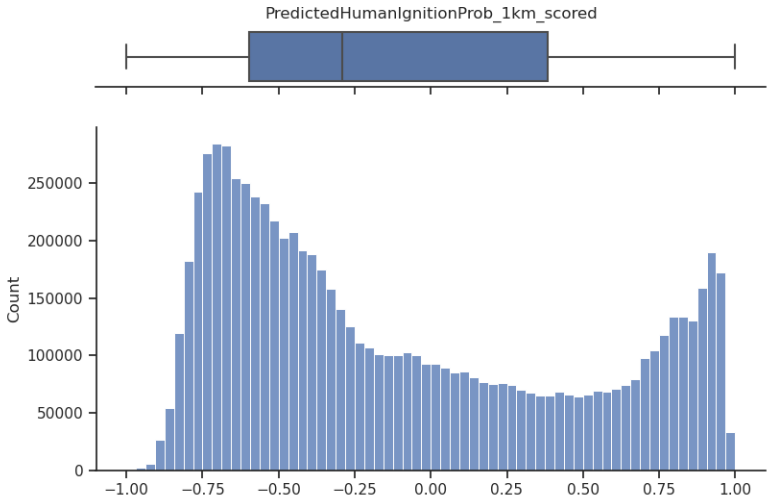

Figure 78. Histogram of translated predicted human fire ignition probability in Southern California

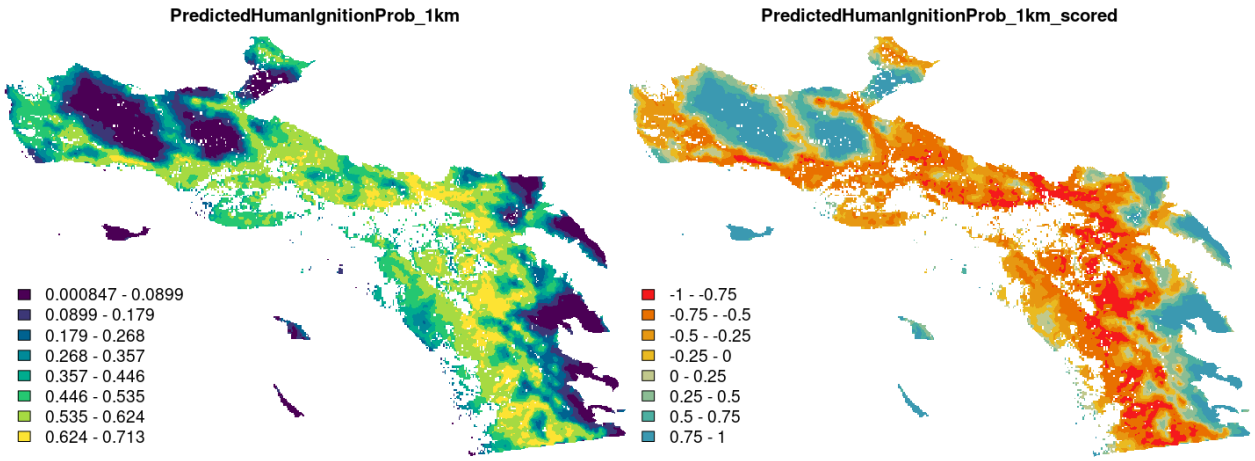

Figure 79. Maps displaying raw metric and translated metric predicted human fire ignition probability in Southern California

WILDFIRE HAZARD POTENTIAL

Tier: 1

Data Vintage: 08/2022. Includes disturbances through the end of 2021.

Metric Definition and Relevance: Wildfire Hazard Potential (WHP) is an index that quantifies the relative potential for wildfire that may be difficult to control. WHP can be used as a measure to help prioritize where fuel treatments may be needed.

Data Resolution: 30m Raster

Data Units: Relative index

Data Source: Pyrologix, LLC

File Name: WildfireHazardPotential_2022_scored.tif

Type and distribution of data: Right-skewed distribution representing index values. Raw data values range from 0 to 86220.

Represent element and pillar: No

Translation: Where is wildfire hazard potential low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of lower wildfire hazard potential (negative linear slope). More favorable (translated to +1) set at 0, less favorable (translated to -1) < 50000.

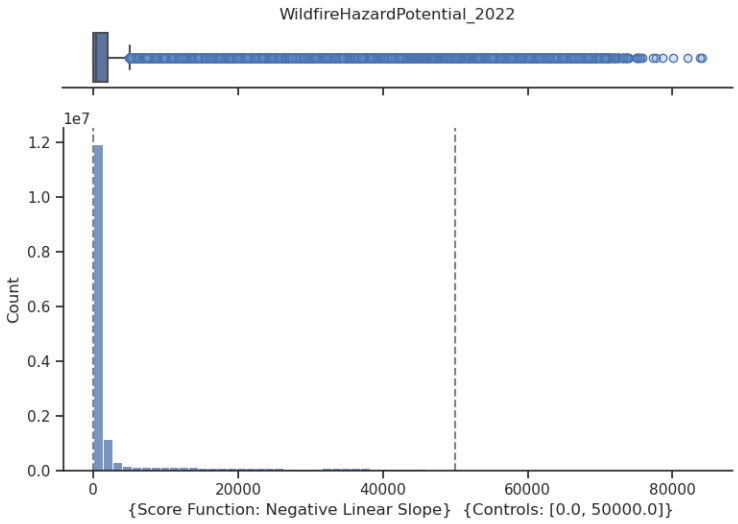

Figure 80. Histogram and scoring of wildfire hazard potential in Southern California

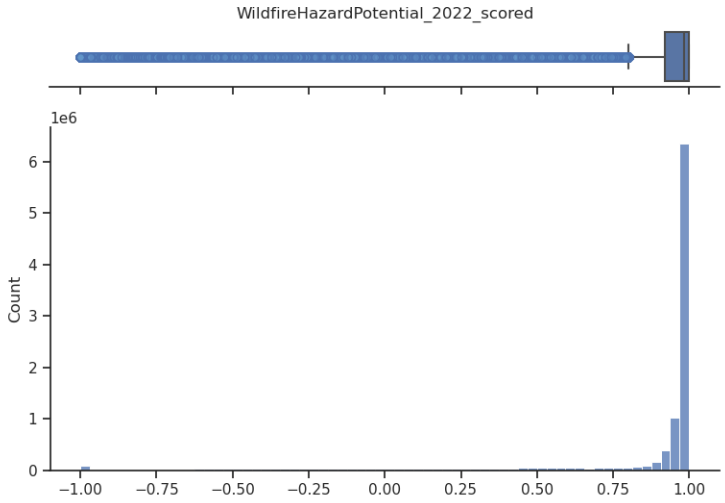

Figure 81. Histogram of translated wildfire hazard potential in Southern California

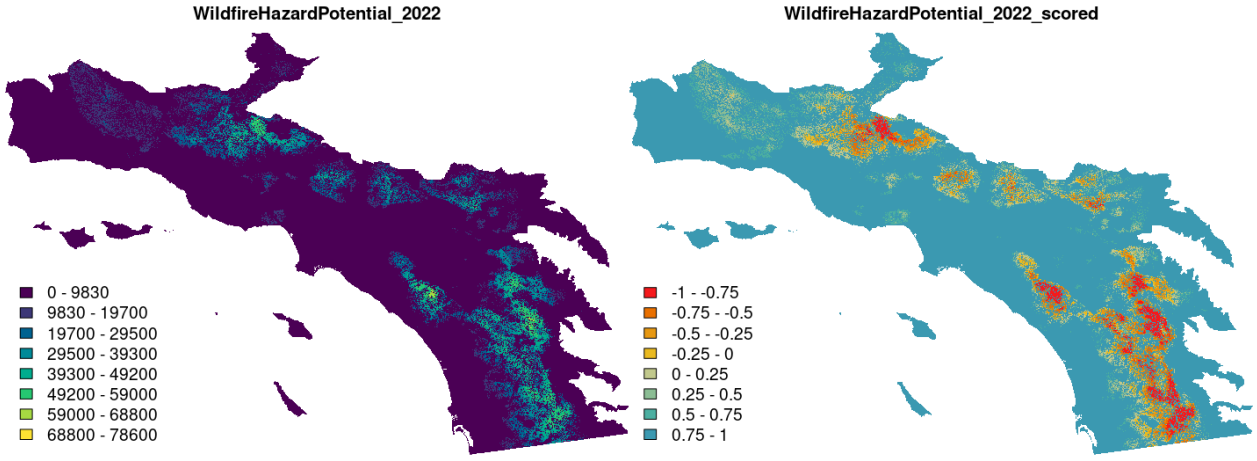

Figure 82. Maps displaying raw metric and translated metric wildfire hazard potential in Southern California

FUTURE CLIMATE STABILITY

Metric definition and relevance: Fire-adapted Community future climate stability was evaluated the same as Fire Dynamics (see below). The model evaluates the potential changes in fire return interval (FRI) and percent replacement severity (PRS) under climate change. The LANDFIRE Biophysical Setting (BpS) data were used represent natural potential fire regime characteristics for a given cell based on its biophsyiscal setting and subjected to a "natural" disturbance regime (LANDFIRE 2020). This was chosen over existing disturbance regimes to remove the influence of recent disturbances on focal and climate analog cells and to represent potential differences in anticipated fire regime characteristics due to changes in climate. Data and methods for this pillar were similar to those of Parks et al. (2018) who used BpS FRI and PRS to explore potential climatic shifts in fire regimes across the western US using a climate analog approach.

Data resolution: 1-km, resampled to 30-m to match current conditions data

Data Units: Climate stability score, continuous, -1 to 1

Data source: LANDFIRE Biophysical Setting (BpS) (LANDFIRE 2020).

File Name: fireAdaptComm030_future.tif

Translation: Where is future climate stability greatest for fire-adapted communities?

Future climate stability interpretation: Values near -1 indicate a less stable climate, where large changes in the fire regime are likely, while values near +1 indicate a more stable climate, where little to no change in the fire regime is expected. FRI and PRS scores for each GCM were combined using a Union operator (i.e., averaged). For a given focal cell, a weighted empirical distribution was developed for FRI and PRS data from the 100 climate analogues for each of the 9 GCMs, separately. The weight of each analog was determined by the Sigma score, where lower weights were given to analogues that were not a good match to the focal cell's future climate. The current FRI and PRS levels for the cell were evaluated

to determine its percentile according to these distributions. For PRS, percentiles close to 100% indicated that the current PRS levels were high compared to its analogues and suggested future PRS will decrease under climate change leading to a score of +1. For FRI, the scoring was agnostic to direction, and low scores were given to cells where the current FRIs were in the tails of the analog distribution, indicating current FRI was either much higher or much lower than the analogs). This score was combined with the mean Sigma climate score using the and (minimum) operator to help account for a preponderance of analogues not representative of future climate conditions for a given focal cell. See Figure 47 in the 'Fire Dynamics' pillar, future conditions section.

FIRE DYNAMICS

Fire dynamics reflect fire as an ecological process and the function that it performs. It can be broken into two key elements: functional fire and fire severity. Although fire dynamics pertain to the entire landscape, the ecological role of fire is most relevant to landscapes outside of the wildland urban interface (WUI). Within the WUI, protection of life and property takes priority over the role of fire as a process. As a result, this fire dynamics pillar pertains to areas outside of the WUI while the fire-adapted communities pillar pertains to areas inside the WUI.

DESIRED OUTCOME: Fire burns in an ecologically beneficial and socially acceptable way that perpetuates landscape heterogeneity and rarely threatens human safety or infrastructure.

CURRENT CONDITIONS

PILLAR REPRESENTATION

The Fire Dynamics pillar is comprised of two elements: functional fire and severity. These elements relate to the character, location, and frequency of fire across the landscape. The condition scores of these two elements are averaged to represent the condition of the Fire Dynamics Pillar. Condition scores range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of achieving the desire outcome for the pillar.

File Name: fireDynamics.tif

ELEMENT REPRESENTATION: FUNCTIONAL FIRE

Increasing the pace and scale of restoration on the landscape will require using a variety of tools to accomplish restoration targets. The use of prescribed fire and managed wildfires, where appropriate, can contribute to the restoration need. This is particularly true where fires burn at low and moderate severity, which we are referring to as “functional fire”. Functional fire is when fire burns in an ecologically beneficial and socially acceptable way, perpetuating landscape heterogeneity and rarely threatening human safety or infrastructure.

The Functional Fire Element is described by seven metrics in the RRK, many of which are highly related. Resilience at the element level is represented by the average condition scores of two metrics (indicated by asterisks): mean percent fire return interval departure (FRID) since 1970 and time since last fire, and the condition scores for each of the metrics are averaged to derive a condition score for the species diversity element.

Data Units: Condition score, +1 to -1

File Name: funcFire.tif

Translation: Where is fire functioning as a constructive disturbance process?

FIRE IGNITION PROBABILITY, LIGHTNING-CAUSED

Tier: 3

Data Vintage: 1992 to 2015

Metric Definition and Relevance: The raster depicts the predicted lightning-caused ignition probability for the state of California.

Data Resolution: 1km Raster

Data Units: Probability, 0-1

Data Source: Bin Chen and Yufang Jin, University of California Davis, bch@ucdavis.edu

File Name: PredictedLightningIgnitionProb_1km_scored.tif

Type and distribution of data: Bimodal distribution representing probability. Raw data values range from 0 to 0.957.

Represent element and pillar: No

Translation: Where is lightning-caused fire ignition probability high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of higher lightning-caused ignition probability (positive linear slope). More favorable (translated to +1) > 0.957, less favorable (translated to -1) set at 0.

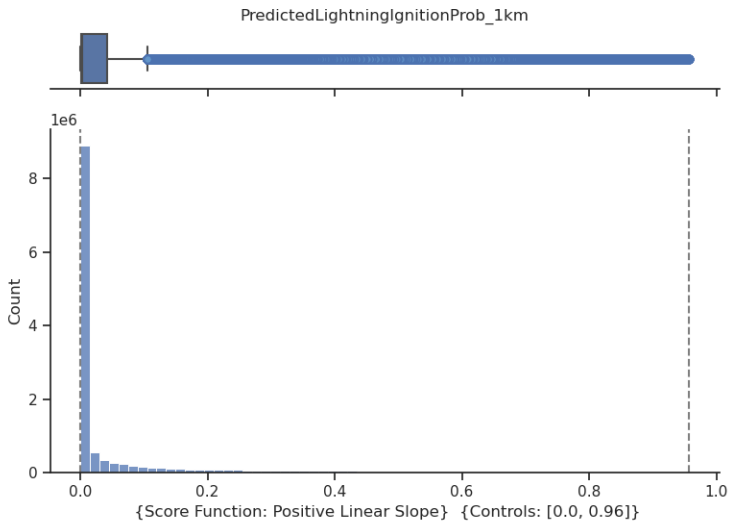

Figure 83. Histogram and scoring of wildfire occurrence, natural-caused, in Southern California

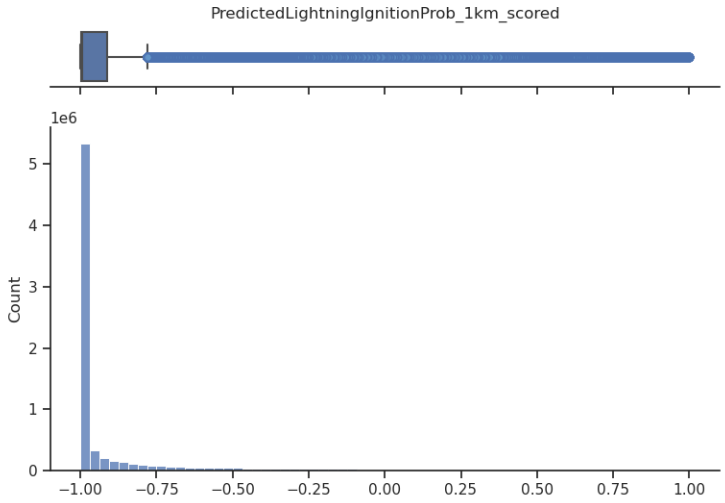

Figure 84. Histogram of translated wildfire occurrence, natural-caused in Southern California

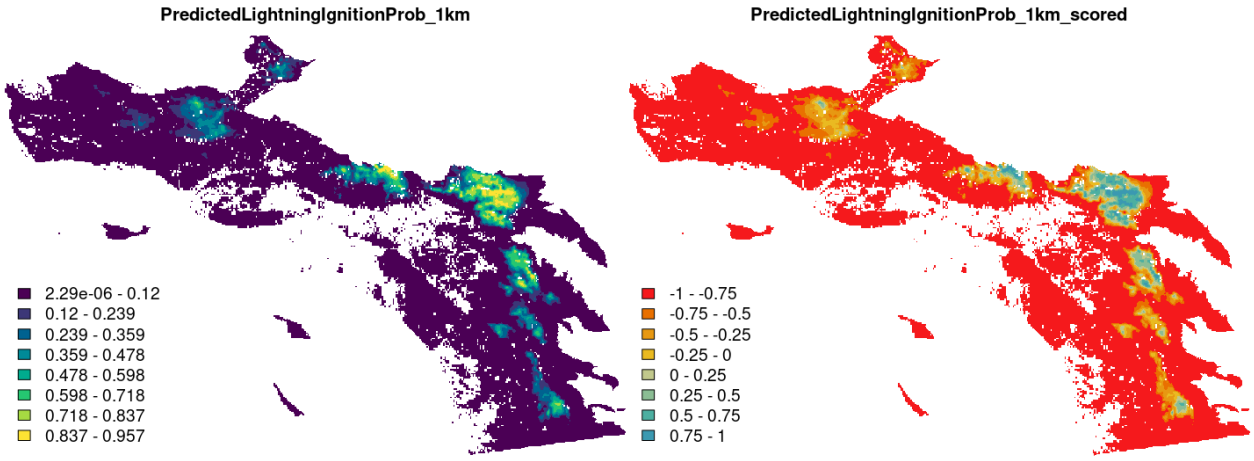

Figure 85. Maps displaying raw metric and translated metric predicted lightning fire ignition probability in Southern California

FIRE RETURN INTERVAL DEPARTURE

Metric Definition and Relevance: The fire return interval departure (FRID) analysis quantifies the difference between current and pre-settlement fire frequencies, allowing managers to target areas at high risk of threshold-type responses owing to altered fire regimes and interactions with other factors.

Data Source: USDA Forest Service, Region 5, MARS Team

MEAN PERCENT FRI DEPARTURE, SINCE 1908

Tier: 3

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: This metric, mean percent FRID, is a measure of the extent to which contemporary fires (i.e., since 1908) are burning at frequencies similar to the frequencies that occurred prior to Euro-American settlement, with the mean reference FRI as the basis for comparison. Mean PFRID is a metric of fire return interval departure (FRID) and measures the departure of current FRI from reference mean FRI in percent.

Data Resolution: 30m Raster

Data Units: Percent (-100% to 100%), departure from mean FRI

Data Source: Fire History (2022), CAL FIRE Existing Vegetation (CALVEG 2011), USDA Forest Service, Region 5, MARS Team

File Name: meanPFRID_2022_scored.tif

Type and distribution of data: Normal distribution representing percentages.

Represent element and pillar: No

Translation: Where is the fire return interval within the historical range?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of being within 33% (more or less frequent) of the average historical fire return interval. The raw data range from -98.44 to 90.35. More favorable (translated to +1) set at –33 to +33% of fire return interval, less favorable (translated to -1) set at < -67% for too frequent fire, and >67% for too infrequent fire, based on FRID condition classes.

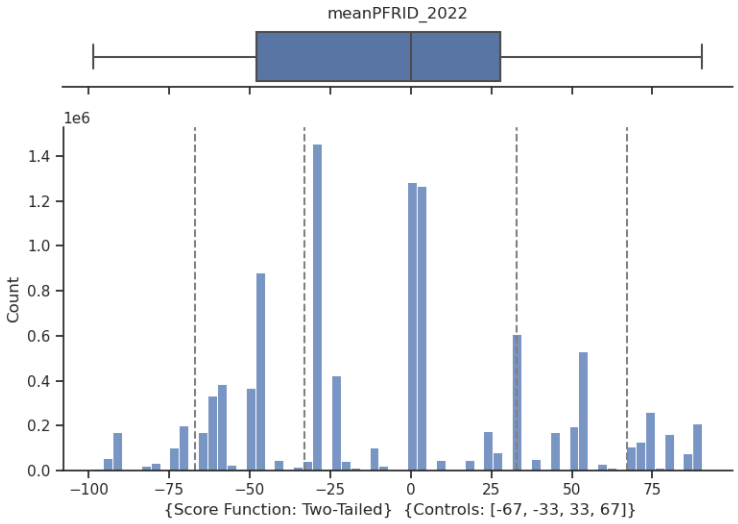

Figure 86. Histogram and scoring criterion of mean percent fire return interval departure, since 1908 across the Southern California.

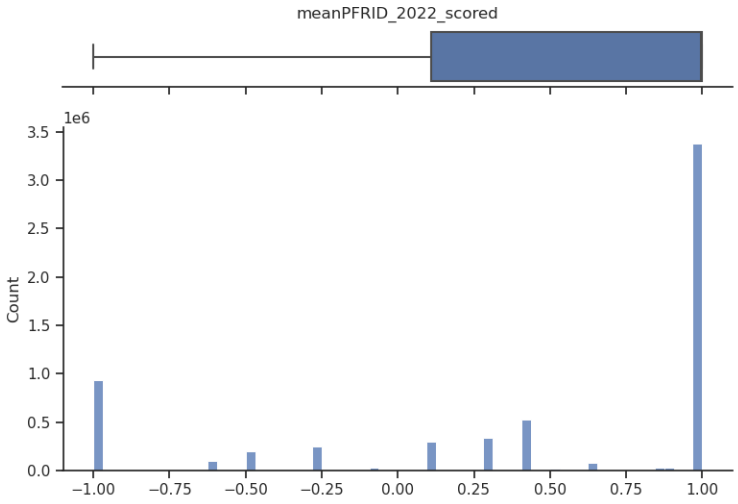

Figure 87. Histogram of translated mean percent fire return interval departure, since 1908 across the Southern California.

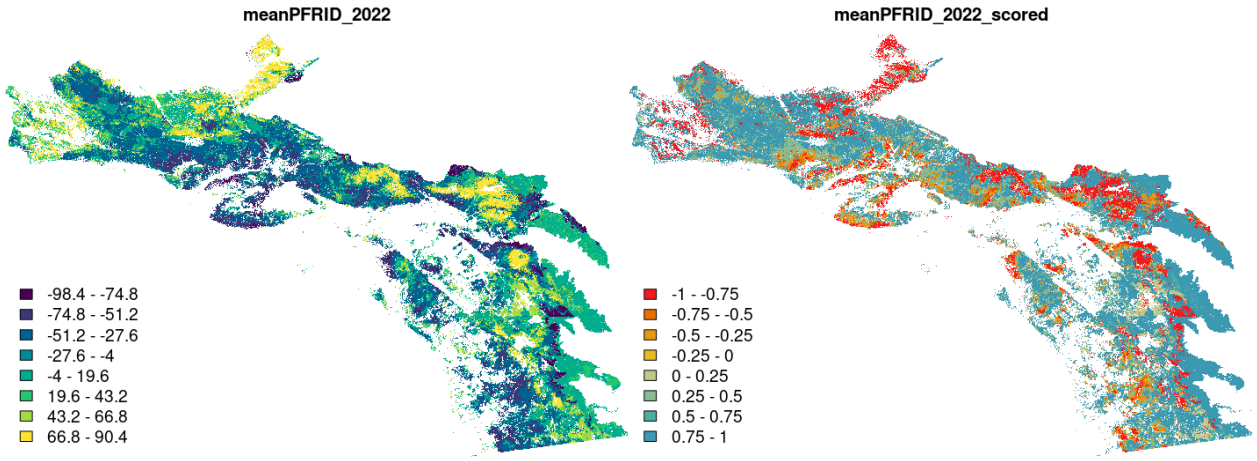

Figure 88. Maps displaying raw metric and translated metric of mean percent fire return interval departure, since 1908 across the Southern California.

*MEAN PERCENT FRI DEPARTURE, SINCE 1970 **

Tier: 2

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: Percent FRID (PFRID) quantifies the extent ~~in percentage~~ to which recent fires (i.e., since 1970) are burning at frequencies similar to those that occurred prior to Euro-American settlement, with the mean reference FRI as the basis for comparison. Mean PFRID measures the departure of current FRI from reference mean FRI in percent.

Data Resolution: 30m Raster

Data Units: Percent (-100% to 100%), departure from mean FRI

Data source: Fire History (2022), CAL FIRE Existing Vegetation (CALVEG 2011), USDA Forest Service, Region 5, MARS Team

File Name: meanPFRID_1970_2022_scored.tif

Type and distribution of data: Bimodal distribution representing percentages.

Represent element and pillar: Yes

Translation: Where is the fire return interval within the historical range?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of being within +/-33% (more or less frequent) of the average historical fire return interval. More favorable (translated to +1) set at –33 to +33% of fire return interval, less favorable (translated to -1) set at < -67% for too frequent fire, and >67% for too infrequent fire. These interpretations correspond to well-established FRI condition classes (see below). FRID itself is an interpretation of conditions that are expected to be more resilient based on historical fire regimes. Alternative approaches could be to

broaden the interpretation of less favorable (-1) out to <-100% sand >100%, but then they would not correspond to FRI condition classes. FRID average values and condition classes based on empirical data (see metric dictionary for raw data for citations).

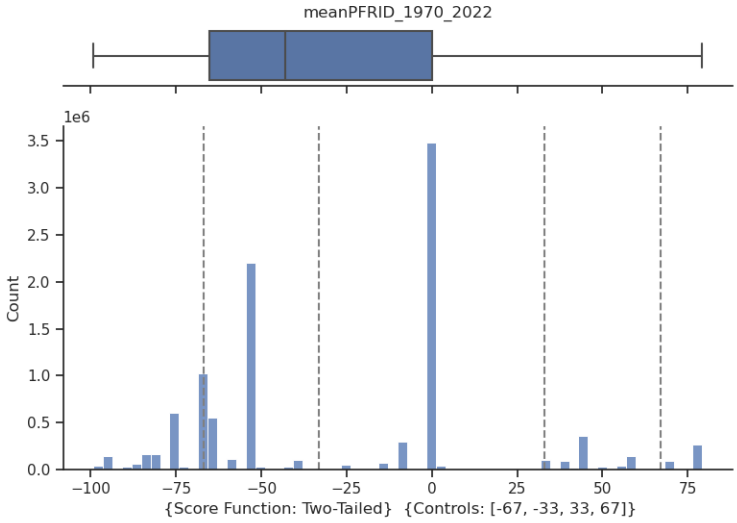

Figure 89. Histogram and scoring criterion of mean percent fire return interval departure, since 1970 across Southern California.

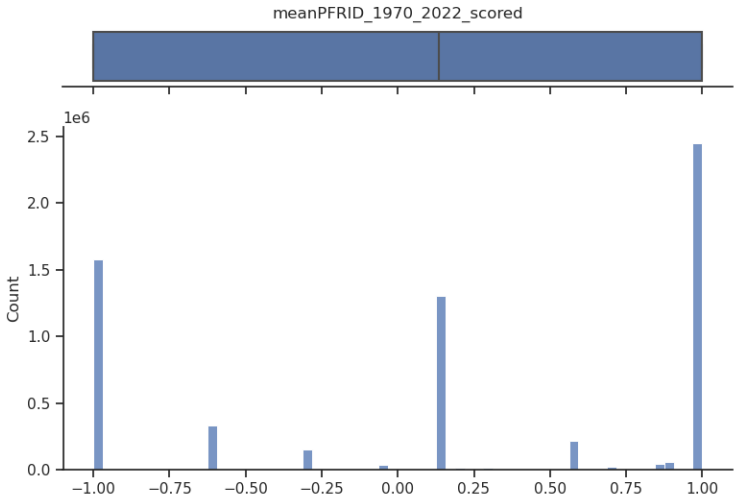

Figure 90. Histogram of translated current mean percent fire return interval departure, since 1970 across Southern California.

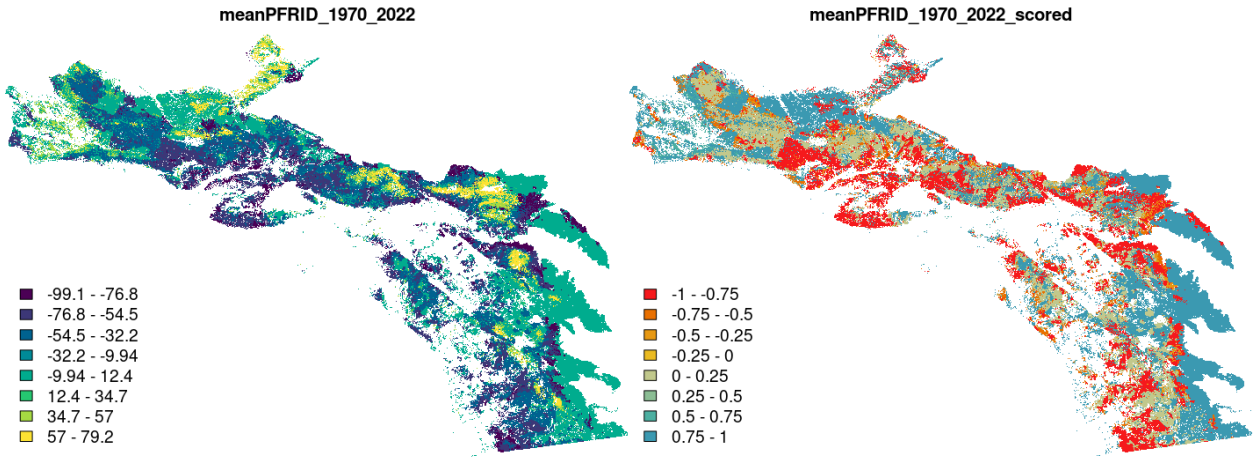

Figure 91. Maps displaying raw metric and translated metric of mean percent fire return interval departure, since 1970 across Southern California.

FRID CONDITION CLASS FOR DEPARTURE

Tier: 3

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: This metric uses the mean percent FRID to a measure of the extent to which contemporary fires (i.e., since 1908) are burning at frequencies similar to the frequencies that occurred prior to Euro-American settlement, with the mean reference FRI binned into another basis for comparison. Mean PFRID is a metric of fire return interval departure (FRID) and measures the departure of current FRI from reference mean FRI in percent.

Data Resolution: 30m Raster

Data Units: Categorical, departure condition

Data Source: Fire History (2022), CAL FIRE; Existing Vegetation (CALVEG 2011), Region 5, MARS Team

File Name: meanCC_FRI_2022_scored.tif

Type and distribution of data: Bimodal distribution representing categorical values. Raw data values range from -3 to 3.

Represent element and pillar: No.

Translation: Where is the fire return interval within +/-33% of the historical range?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of being within 33% (more or less frequent) of the average fire return interval. More favorable (translated to +1) set at –1 to +1 condition class (corresponding to -33% to 33% of the average fire return interval), and less favorable (translated to -1) set at -3 condition class for too frequent fire, and 3

for too infrequent fire. FRID itself is an interpretation of conditions that are expected to be more resilient based on historical fire regimes.

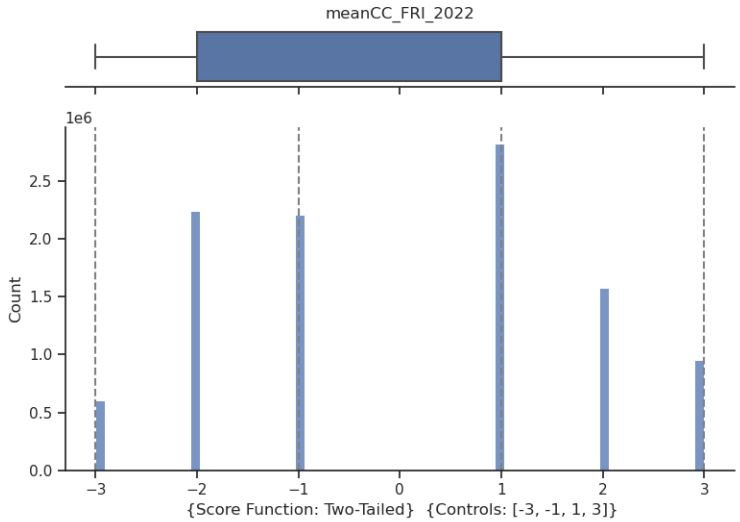

Figure 92. Histogram and scoring criterion of mean condition class fire return interval departure, across Southern California.

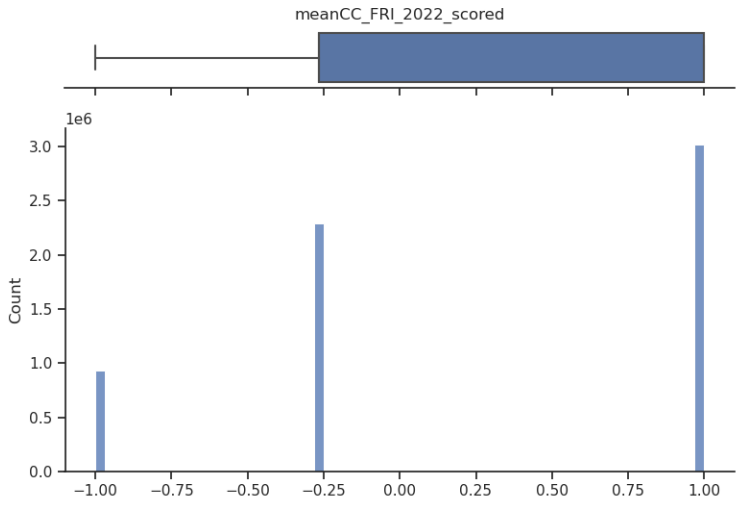

Figure 93. Histogram of translated mean condition class fire return interval departure, across Southern California

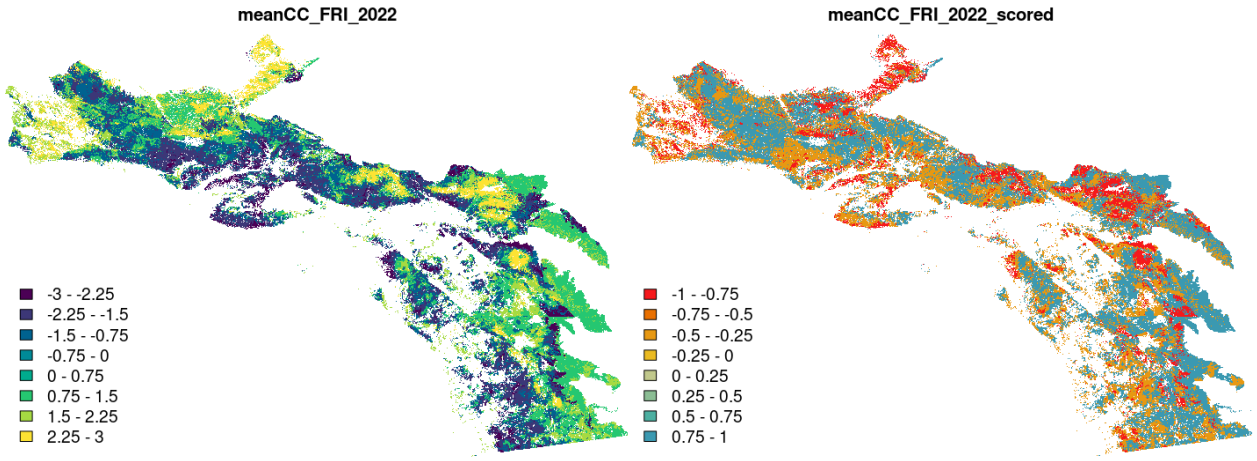

Figure 94. Maps displaying raw metric and translated metric mean condition class fire return interval departure, across Southern California

*TIME SINCE LAST FIRE **

Tier: 2

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: Time Since Last Fire (TSLF), from the Fire Return Interval Departure (FRID) map, provides information (in years) to indicate the length of time since an area last burned. The raw values of this data could not be translated to condition scores for current conditions.

Data Resolution: 30m Raster

Data Units: Years

Data Source: Fire History (2022), CAL FIRE; Existing Vegetation (CALVEG 2011), Region 5, MARS Team

File Name: TSLF_2022_scored.tif

Type and distribution of data: Left-skewed, beta-like distribution representing percentages. Raw data values range from 0 to 113 years.

Represent element and pillar: Yes

Translation: Where has fire occurred within the fire return interval?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of being ~~within~~ < 133% of the average fire return interval (i.e., mean FRI + (0.333 * mean FRI)). More favorable (translated to +1) set at time since last fire being no more than 33% longer than the average fire return interval, less favorable (translated to -1) set at > 67% longer than the average fire return interval.

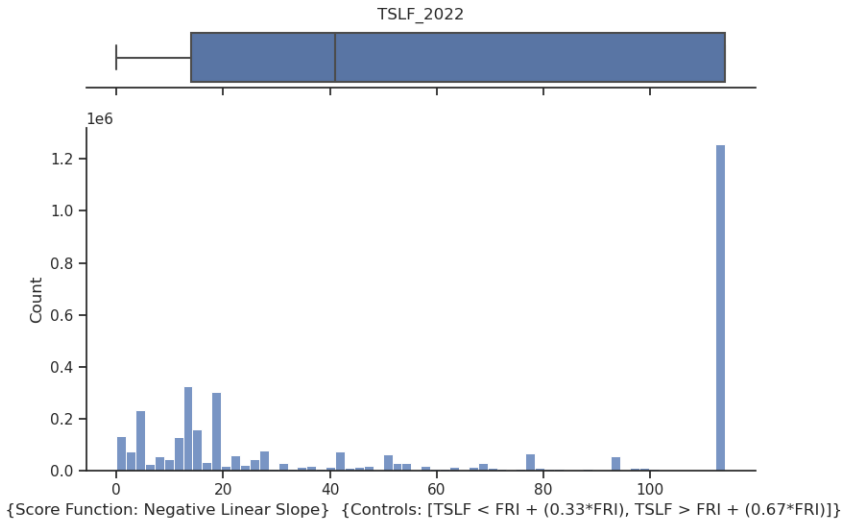

Figure 95. Histogram and scoring of time since last fire in Southern California

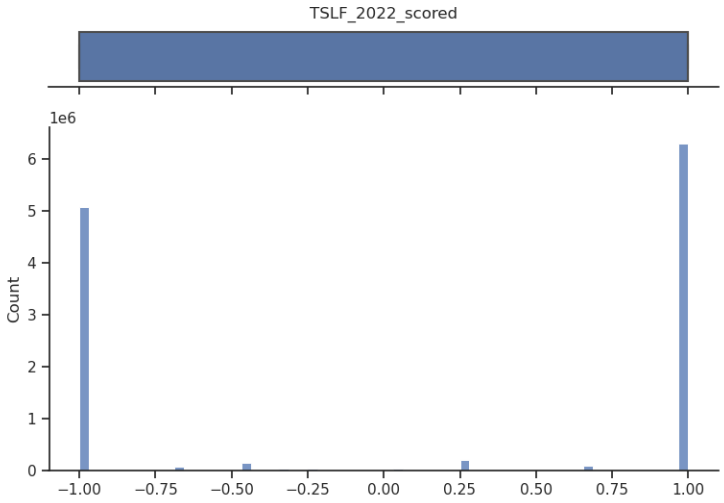

Figure 96. Histogram of translated time since last fire in Southern California

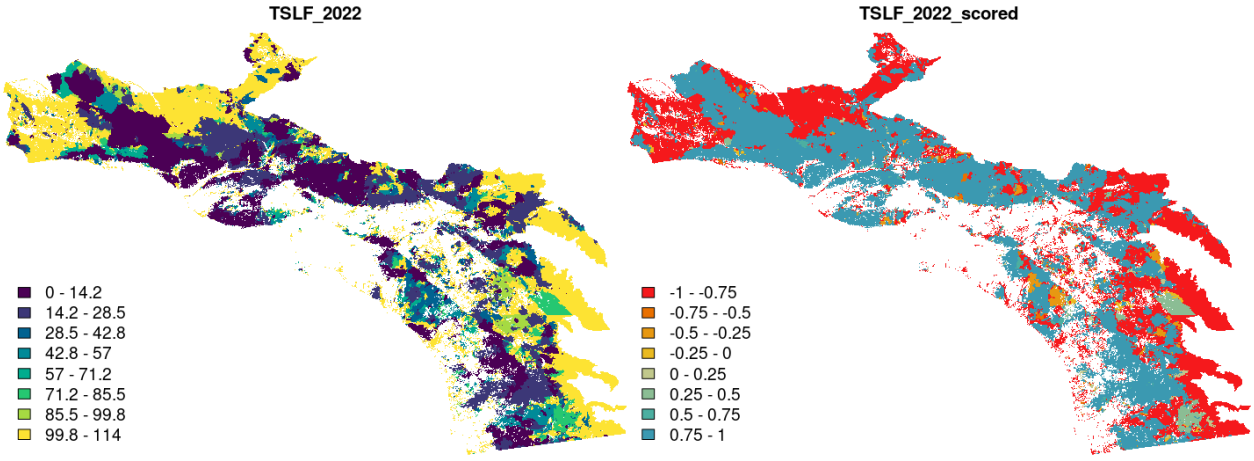

Figure 97. Maps displaying raw metric and translated metric time since last fire in Southern California

CURRENT FIRE RETURN INTERVAL DEPARTURE, SINCE 1908

Tier: 3

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: The fire return interval departure (FRID) analysis quantifies the difference between current and pre-settlement fire frequencies, allowing managers to target areas at high risk of threshold-type responses owing to altered fire regimes and interactions with other factors. This is a measure of the extent to which contemporary fires (i.e. since 1908) are burning at frequencies similar to the frequencies that occurred prior to Euro-American settlement.

Data Resolution: 30m Raster

Data Units: Average Years

Data Source: Fire History (2022), CAL FIRE Existing Vegetation (CALVEG 2011), Region 5, MARS Team

File Name: currentFRI_2022.tif

Translation: None

CURRENT FIRE RETURN INTERVAL DEPARTURE, SINCE 1970

Tier: 2

Data Vintage: 2022. Includes disturbances through the end of 2022.

Metric Definition and Relevance: The fire return interval departure (FRID) analysis quantifies the difference between current and pre-settlement fire frequencies, allowing managers to target areas at high risk of threshold-type responses owing to altered fire regimes and interactions with other factors. This is a measure of the extent to which contemporary fires (i.e. since 1970) are burning at frequencies similar to the frequencies that occurred prior to Euro-American settlement, with the mean reference FRI

as the basis for comparison. With this metric, mPFRID_1970, the same formulas are used as with meanPFRID but with 1970 as the baseline rather than 1908. Important note: because 1970 is the baseline for this measure, no fires before 1970 are taken into account and all PFRs start at a PFRID of zero beginning in 1970.

Data Resolution: 30m Raster

Data Units: Average Years

Data Source: Fire History (2022), CAL FIRE Existing Vegetation (CALVEG 2011), Region 5, MARS Team

File Name: currentFRI_1970_2022.tif

Translation: None

ELEMENT REPRESENTATION: FIRE SEVERITY

Uncharacteristic proportions of high severity fire over the area burned, particularly in the last decade, has been a common theme in the megafires that have occurred throughout the Sierra recently. The following metrics characterize, map, and quantify some of the factors that contribute.

The RRK has two metrics that describe the Severity Element: annual burn probability and probability of high fire severity. The current condition of the Hazard Element is represented by one metric, probability of high fire severity (indicated with an asterisk). The Element condition score is the same as the probability of high fire severity score.

Data Units: Condition score, +1 to -1

File Name: severity.tif

Translation: Where is fire severity lowest?

ANNUAL BURN PROBABILITY

Tier: 1

Data Vintage: 08/2023. Includes disturbances through the end of 2022

Metric Definition and Relevance: Annual Burn Probability represents the likelihood of a wildfire of any intensity occurring at a given location (pixel) in a single fire season. In a complete assessment of wildfire hazard, wildfire occurrence and spread are simulated in order to characterize how temporal variability in weather and spatial variability in fuel, topography, and ignition density influence wildfire likelihood across a landscape. In such cases, the hazard assessment includes modeling of burn probability, which quantifies the likelihood that a wildfire will burn a given point (a single grid cell or pixel) during a specified period of time. Burn probability for fire management planning applications in this case is reported on an annual basis - the probability of burning during a single fire season.

Data Resolution: 30m Raster

Data Units: Probability, 0 to 1

Data Source: Pyrologix, LLC

File Name: AnnualBurnProbability_2023_scored.tif

Type and distribution of data: Zero-inflated, right-skewed distribution representing probability. Raw values range from 0.0 to 0.101 for any given year.

Represent element and pillar: No

Translation: Where is burn probability low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of burn probability being low (negative linear slope). More favorable (translated to +1) set at 0.0 probability, less favorable (translated to -1) set at the highest observed value of 0.101 probability.

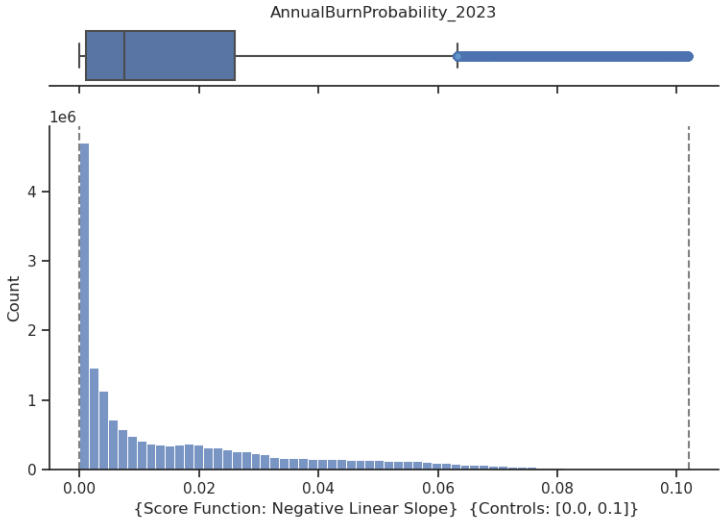

Figure 98. Histogram and scoring of annual burn probability in Southern California

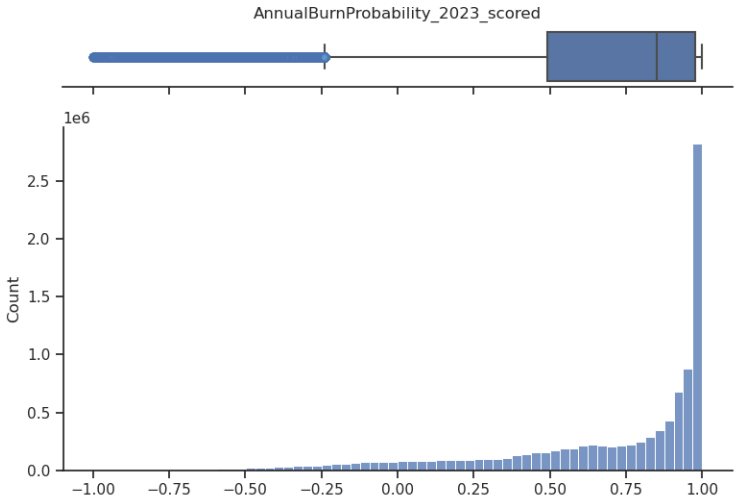

Figure 99. Histogram of translated annual burn probability in Southern California

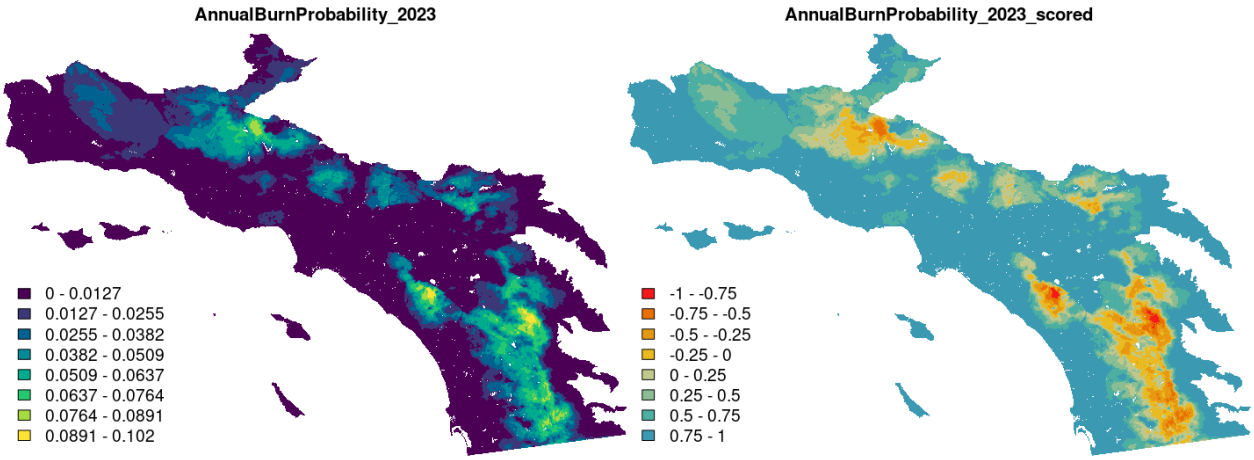

Figure 100. Maps displaying raw metric and translated metric annual burn probability in Southern California

PROBABILITY OF HIGH FIRE SEVERITY *

Tier: 1

Data Vintage: 08/2023. Includes disturbances through the end of 2022

Metric Definition and Relevance: These metrics depicts the probability of high severity fire as constructed by Pyrologix LLC. This operational-control probability raster indicates the probability that the headfire flame length in each pixel will exceed 8 foot flame lengths, the threshold that defines fires that would exceed manual control.

Data Resolution: 30m Raster

Data Units: Probability, 0 to 1

Data Source: Pyrologix, LLC

File Name: ProbabilityHighFireSev_2023_scored.tif

Type and distribution of data: Zero-inflated bimodal distribution representing probabilities. Raw values range from 0 to 1 probability.

Represent element and pillar: Yes

Translation: Where is the probability of high severity fire low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of high severity fire probability being low (negative linear slope). More favorable (translated to +1) set at 0.0 probability, and less favorable (translated to -1) set at 1.0 probability, and intermediate conditions (0 score) at 0.5 probability. In some cases there may be a very low tolerance for the probability of high severity fire (e.g., score of -1 set lower than a probability of 1) and in some instances, there may be a desire for some high severity fire (score of -1 set at probabilities greater than *and* less than certain values). These alternative interpretations can be derived from the translated values provided.

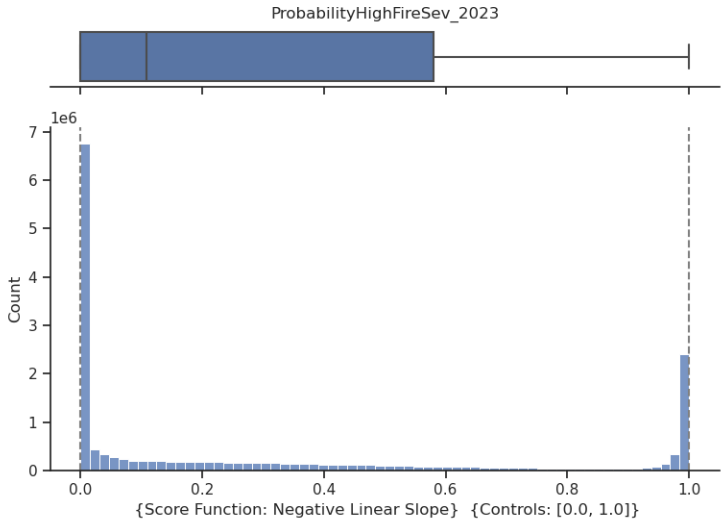

Figure 101. Histogram and scoring criterion of probability of high severity fire across the Southern California.

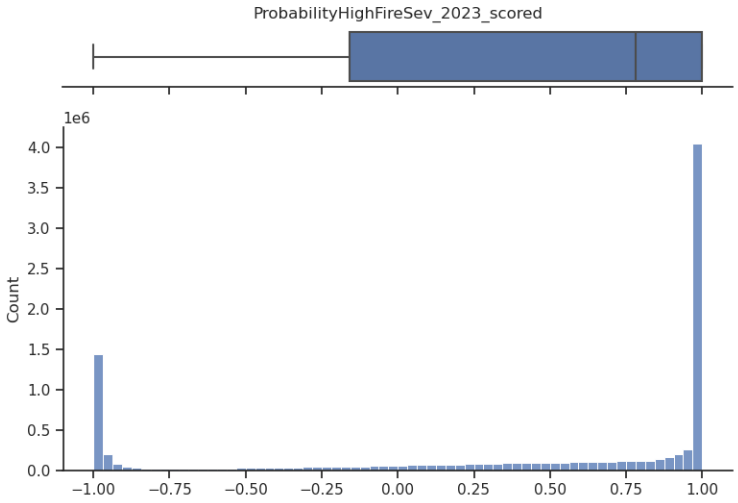

Figure 102. Histogram of translated current probability of high severity fire across the Southern California.

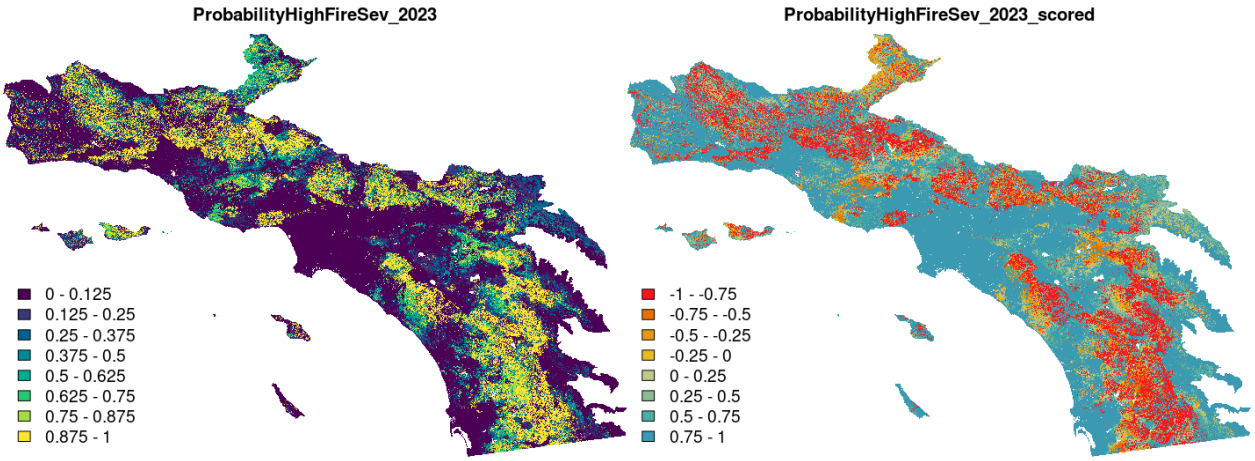

Figure 103. Maps displaying raw metric and translated metric of current condition of probability of high severity fire across the Southern California.

FUTURE CLIMATE STABILITY

Metric definition and relevance: The model evaluates the potential changes in fire return interval (FRI) and percent replacement severity (PRS) under climate change. The LANDFIRE Biophysical Setting (BpS) data were used represent natural potential fire regime characteristics for a given cell based on its biophysiscal setting and subjected to a "natural" disturbance regime (LANDFIRE 2020). This was chosen over existing vegetation to remove the influence of recent disturbances on focal and climate analogue cells and to represent potential differences in anticipated fire regime characteristics due to changes in climate. Data and methods for this pillar were similar to those of Parks et al. (2018) who used BpS FRI

and PRS to explore potential climatic shifts in fire regimes across the western US using a climate analogue.

Data resolution: 1-km, resampled to 30-m to match current conditions data

Data Units: Climate stability score, continuous +1 to -1.

Data source: LANDFIRE Biophysical Setting (BpS) (LANDFIRE 2020).

File Name: fireDynamics030_future.tif

Translation: Where is future climate stability greatest for resilient fire dynamics?

Climate stability interpretation: Values near -1 indicate a less stable climate, where large changes in the fire regime are likely, while values near +1 indicate a more stable climate, where little to no change in the fire regime is expected. FRI and PRS scores for each GCM were combined using a Union operator (i.e., averaged). For a given focal cell, a weighted empirical distribution was developed for FRI and PRS data from the 100 climate analogues for each of the 9 GCMs, separately. The weight of each analogue was determined by the Sigma score, where lower weights were given to analogues that were not a good match to the focal cell's future climate. The current FRI and PRS levels for the cell were evaluated to determine its percentile according to these distributions. For PRS, percentiles close to 100% indicated that the current PRS levels were high compared to its analogues and suggested future PRS will decrease under climate change leading to a score of +1. For FRI, the scoring was agnostic to direction, and low scores were given to cells where the current FRIs were in the tails of the analogue analogion, indicating current FRI was either much higher or much lower than the median analogue condition change in FRI is anticipated). This score was combined with the mean Sigma climate score using the And (minimum) operator to help account for a preponderance of analogues not representative of future climate conditions for a given focal cell.

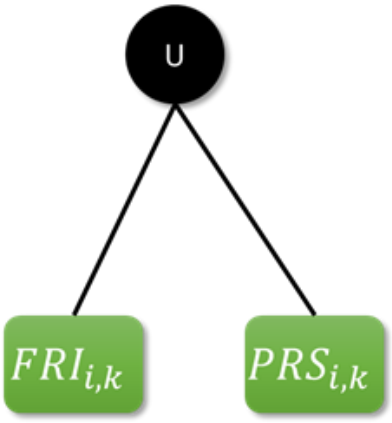

Figure 104. Fuzzy logic model for fire dynamics and fire adapted communities. FRI is the fire return interval and PRS is percent replacement severity, which are derived from LANDFIRE BpS data. Subscripts indicate: i, cell (n = 9,000); k, climate model (n = 9).

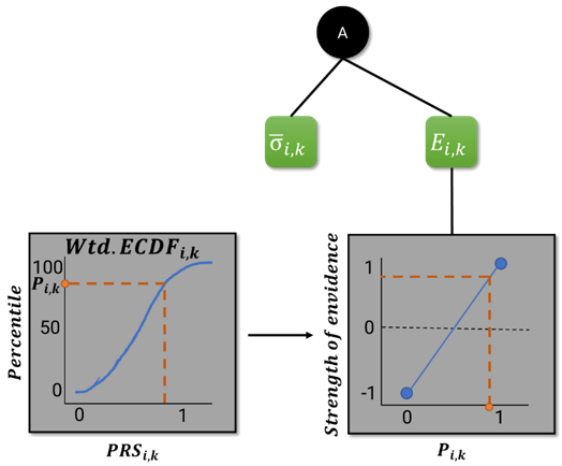

Figure 105. Fuzzy logic model for percent replacement severity.

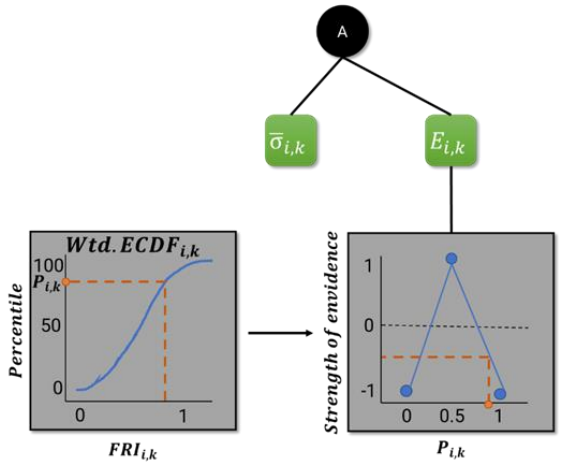

Figure 106. Fuzzy logic model for Fire Return Interval.

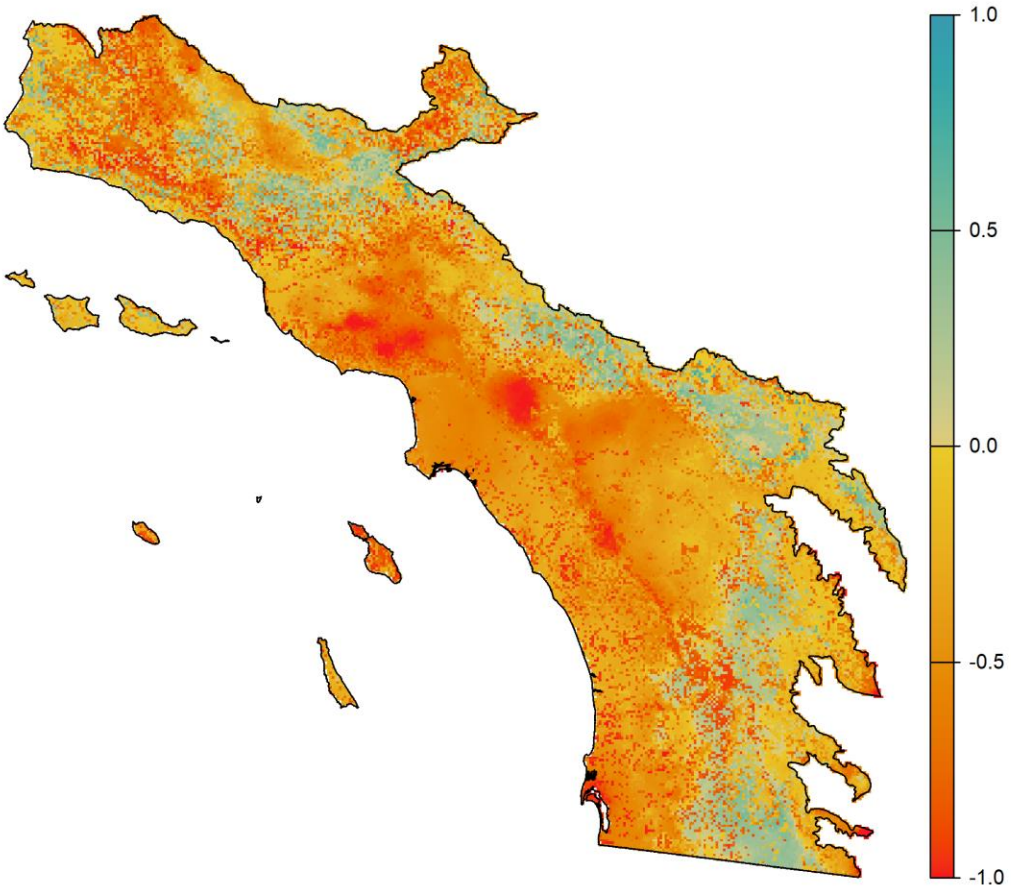

Figure 107. Images of future climate stability scores for fire dynamics and fire adapted communities pillars across the Southern California.

FOREST AND SHRUBLAND RESILIENCE

Forest and shrubland resilience is the ability of forest and shrubland vegetation and structure to remain a forest or shrubland in the face of disturbance (e.g., fire, forest management, climate change, etc.). The Forest and Shrubland Resilience Pillar evaluates forest and shrubland vegetation composition and structure to determine its alignment with desired disturbance dynamics and within tolerances of current and future biophysical conditions when considering changes due to climate change. The last 100 years of forest and shrubland management, combined with changing climates, have resulted in forest and shrubland structure and composition which are not resilient to contemporary disturbances. Forest or shrubland structure and composition are one of the few elements of a wildland that management can modify through treatments to improve conditions.

DESIRED OUTCOME: Vegetation composition and structure align with topography, desired disturbance dynamics, and landscape conditions, and are adapted to climate change.

CURRENT CONDITIONS

PILLAR REPRESENTATION

There are three elements to this pillar; structure, composition, and disturbance, and each has specific metrics. Condition scores are calculated for all three Elements, and they are averaged to represent the pillar. Condition scores range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of achieving the desire outcome for the pillar.

Data Units: Strength of evidence scores (-1, less favorable; +1, more favorable)

File Name: forestShrubResil.tif

Translation method and outcome: Union (average) between the Structure, Composition, and Disturbance Elements.

Translation: Where is forest and shrubland resilience the greatest?

ELEMENT REPRESENTATION: STRUCTURE

Forest or shrubland structure is the spatial distribution of vegetation (live and dead) both vertically and horizontally on the landscape. Prior to European settlement, forests in the Sierra Nevada were characterized by heterogeneous spatial patterns replete with individual large trees, gaps, and tree clumps of various sizes – patterns that were shaped by recurrent fire and other disturbances. After a century-plus of fire exclusion, timber harvesting, agricultural development, urbanization, and other land-use practices, the predominant trend across Californian landscapes is that they have become less

resilient to natural and human-caused disturbances. In many cases some sort of restoration treatment may be necessary to reverse these trends.

The Forest and Shrubland Structure Element is described by four metrics in the RRK: large tree density, canopy layer count, canopy vegetation height, and canopy vegetation cover. One metric was selected to represent resilience for the forest and shrubland structure element: large tree density (indicated by an asterisk). Condition scores range from +1 to -1 representing more favorable to less favorable conditions, respectively. The Element condition score is the same as the large tree density.

Data Units: Condition score, +1 to -1

File Name: structure.tif

Translation: Where is forest and shrubland structure most resilient?

DENSITY – LARGE TREES *

Tier: 2

Data Vintage: 06/2020

Metric Definition and Relevance: Large trees are important to forest manager as they have a greater likelihood of survival from fire, provide sources of seed stock and wildlife habitat, and contribute to other critical processes like carbon storage and nutrient cycling. Large trees are often the focus of management in order to protect existing ones and to foster future ones. In consultation with National Forests, “large trees” have been determined as greater than 30” dbh.

Data Resolution: 30m Raster

Data Units: Continuous, trees per 900 sq m

Data source: California Forest Observatory (Salo Sciences), 2020

File Name: LargeTreeDensity_2020_scored.tif

Type and distribution of data: Zero-inflated, right-skewed distribution representing continuous values. Raw data values range from 0 to 10.

Represent element and pillar: Yes

Translation: Where is large tree density high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of large tree density being higher (positive linear slope). More favorable (translated to +1) set at > 10 trees/ac, and less favorable (translated to -1) set at 0 trees per ac.

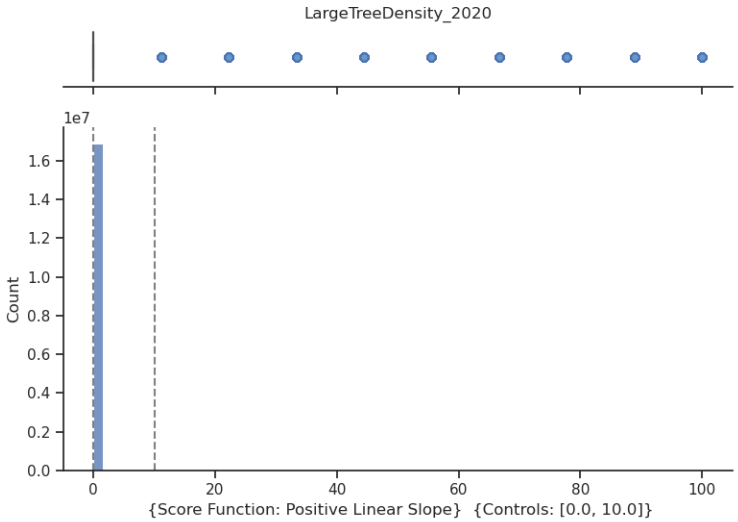

Figure 108. Histogram and scoring criterion of current condition of density of trees greater than 30 inches diameter at breast height across the Southern California.

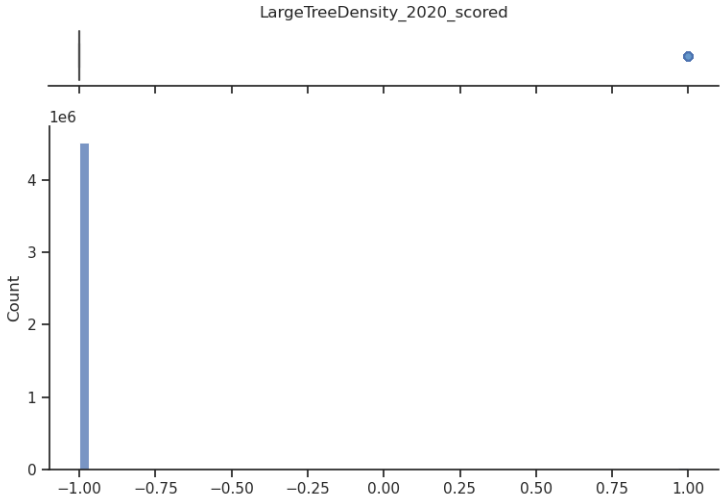

Figure 109. Histogram of translated current condition of density of trees greater than 30 inches diameter at breast height across the Southern California.

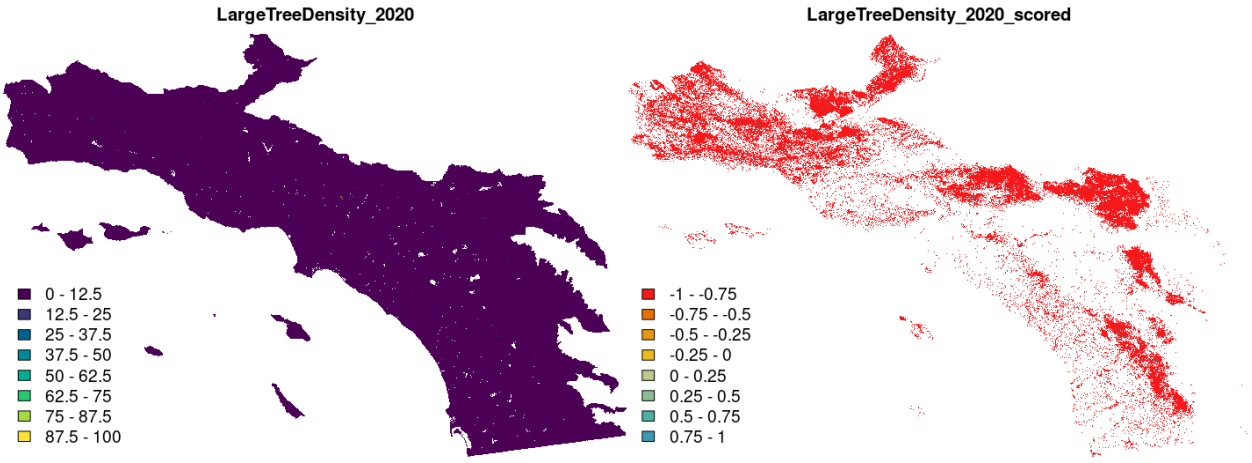

Figure 110. Maps displaying raw metric and translated metric of current condition of the density of trees greater than 30 inches diameter at breast height across the Southern California.

CANOPY LAYER COUNT

Tier: 1

Data Vintage: 06/2020

Metric Definition and Relevance: This layer represents the number of distinct vertical canopy layers of trees. Vertical layer count is a proxy for leaf area index, and maps canopy complexity. Since LANDFIRE doesn't support a NoData value, all NoData pixels in canopy fuel metrics were set to 0 in the Landscape files. (e.g., canopy cover was set to 0 in all NoData locations). Topographic data and surface fuel model remain unaltered.

Data Resolution: 10m Raster

Data Units: Count

Data Source: California Forest Observatory (Salo Sciences), 2020

File Name: CFO_CanopyLayerCount2020Summer_scored.tif

Type and distribution of data: Zero-inflated, right-skewed distribution representing count values. Raw data values range from 0 to 5.

Represent element and pillar: No

Translation: Where are canopy layers high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on

the objective of canopy layers being higher (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) are based on climate and vegetation regions (Table 6).

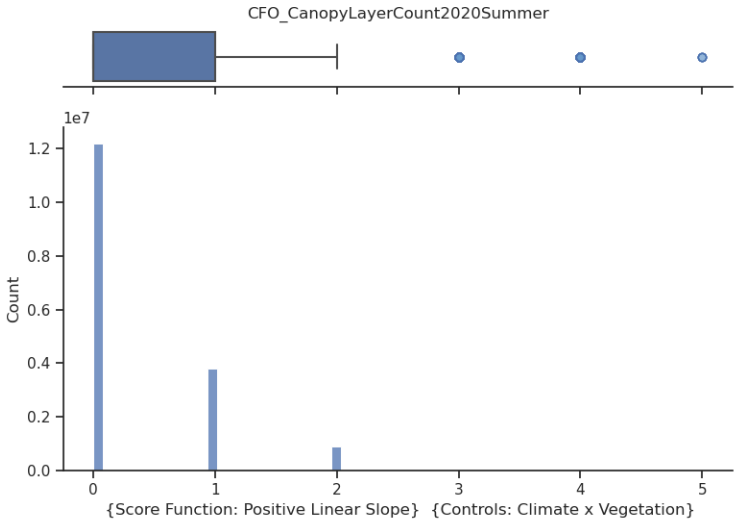

Figure 111. Histogram and scoring of canopy layer count in Southern California

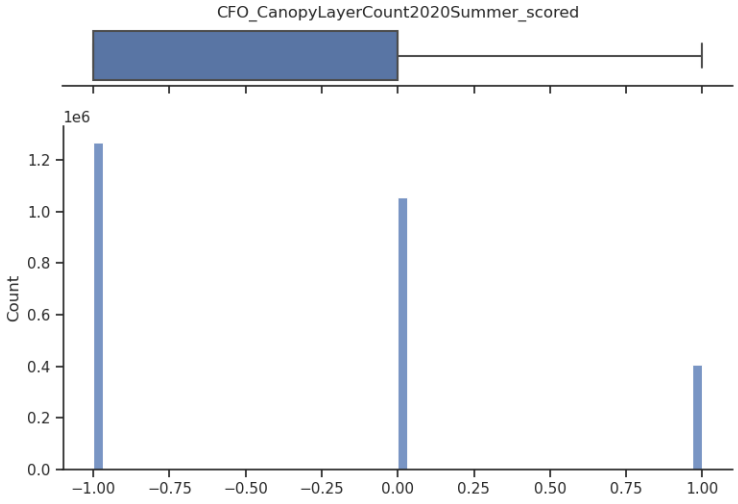

Figure 112. Histogram of translated canopy layer count in Southern California

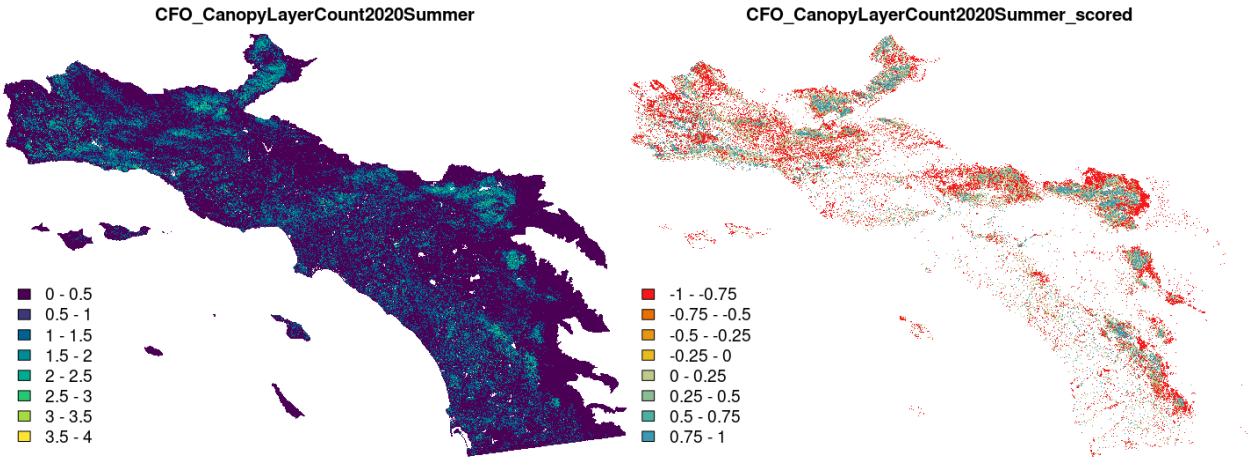

Figure 113. Maps displaying raw metric and translated canopy layer count in Southern California

CANOPY VEG HEIGHT

Tier: 1

Data Vintage: 06/2020

Metric Definition and Relevance: This layer represents distance between the ground and the top of the canopy. Canopy height is a proxy for aboveground biomass and the amount of foliage that may be consumed in a canopy fire. Since LANDFIRE doesn't support a NoData value, all NoData pixels in canopy fuel metrics were set to 0 in the Landscape files. (e.g., canopy cover was set to 0 in all NoData locations). Topographic data and surface fuel model remain unaltered.

Data Resolution: 10m Raster

Data Units: Continuous meters, where each pixel value represents the average height above ground for vegetation within that pixel

Data Source: California Forest Observatory (Salo Sciences), 2020

File Name: CFO_CanopyHeight2020Summer_scored.tif

Type and distribution of data: Zero-inflated, right-skewed distribution representing continuous values. Raw data values range from 0 to 80.

Represent element and pillar: No

Translation: Where is canopy vegetation high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on

the objective of canopy vegetation being higher (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) are based on climate and vegetation regions (Table 6).

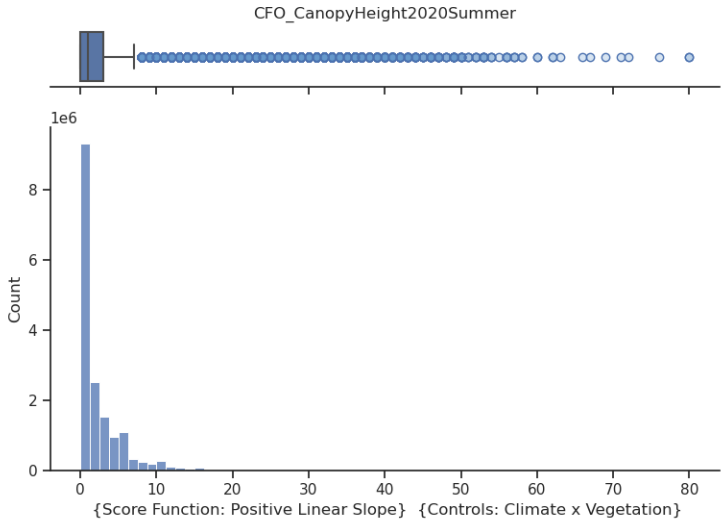

Figure 114. Histogram and scoring of canopy height in Southern California

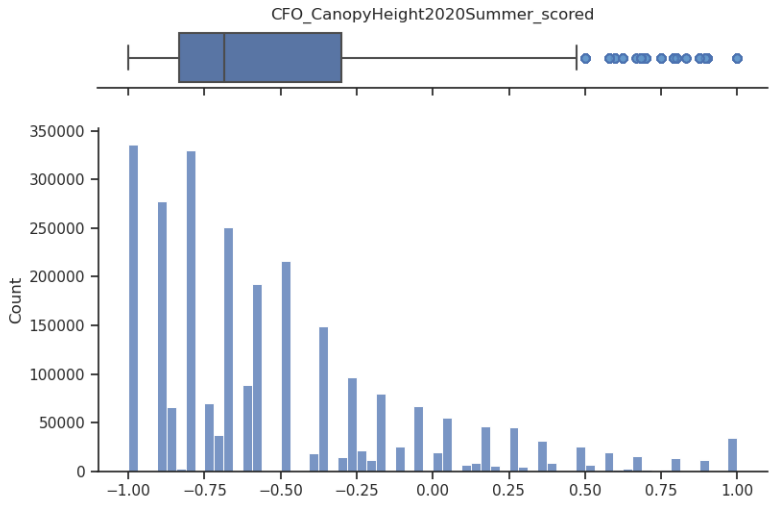

Figure 115. Histogram of translated canopy height in Southern California

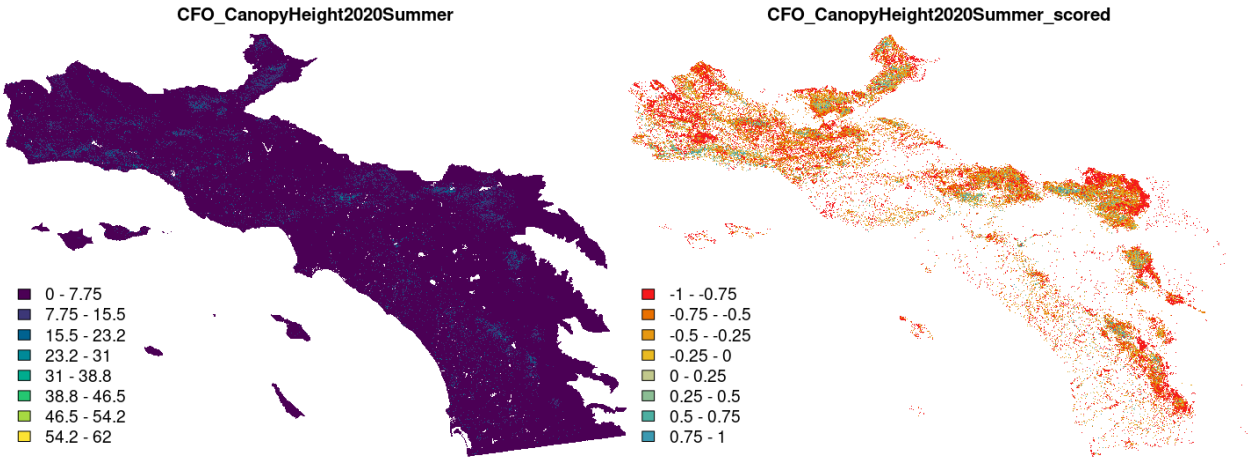

Figure 116. Maps displaying raw metric and translated metric canopy height in Southern California

CANOPY VEGETATION COVER

Tier: 1

Data Vintage: 06/2020

Metric Definition and Relevance: This layer represents horizontal cover fraction occupied by tree canopies. Maps community type & fire regime, as well as available habitat for tree-dwelling species.

Data Resolution: 10m Raster

Data Units: Canopy cover is a 0-100% cover fraction and may be more precisely described as "canopy density." It calculates the proportion of all lidar returns >=5m divided by the total number of returns in that grid cell. This, therefore, does not include all vegetation, but instead describes the density of vegetation in the canopy vertical stratum (veg 5m and taller).

Data Source: California Forest Observatory (Salo Sciences), 2020

File Name: CFO_CanopyCover2020Summer_scored.tif

Type and distribution of data: Zero-inflated, right-skewed distribution representing percentages. Raw data values range from 0 to 100.

Represent element and pillar: No

Translation: Where is canopy vegetation cover high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on

the objective of canopy vegetation cover being higher (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) are based on climate and vegetation regions (Table 6).

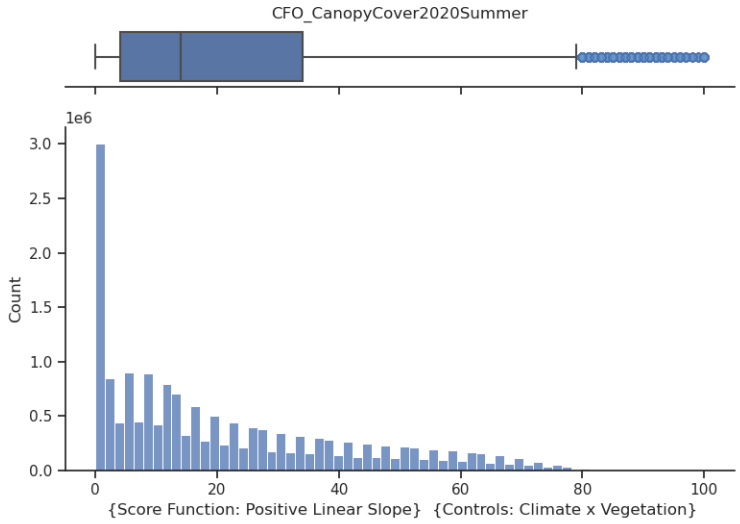

Figure 117. Histogram and scoring of canopy cover in Southern California

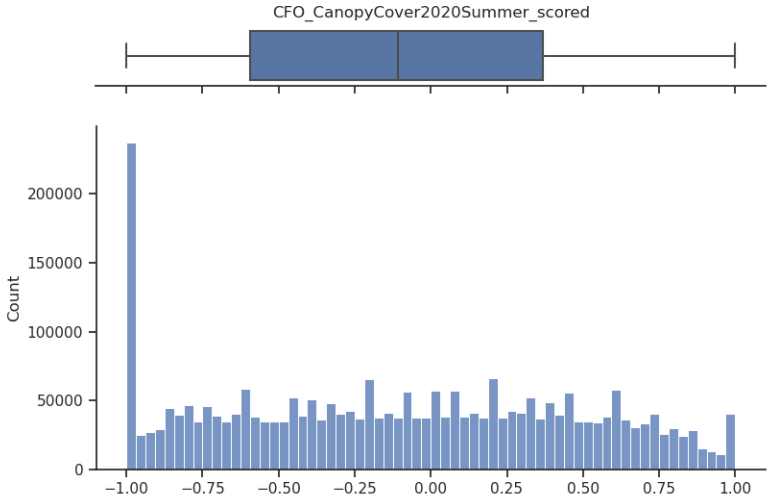

Figure 118. Histogram of translated canopy cover in Southern California

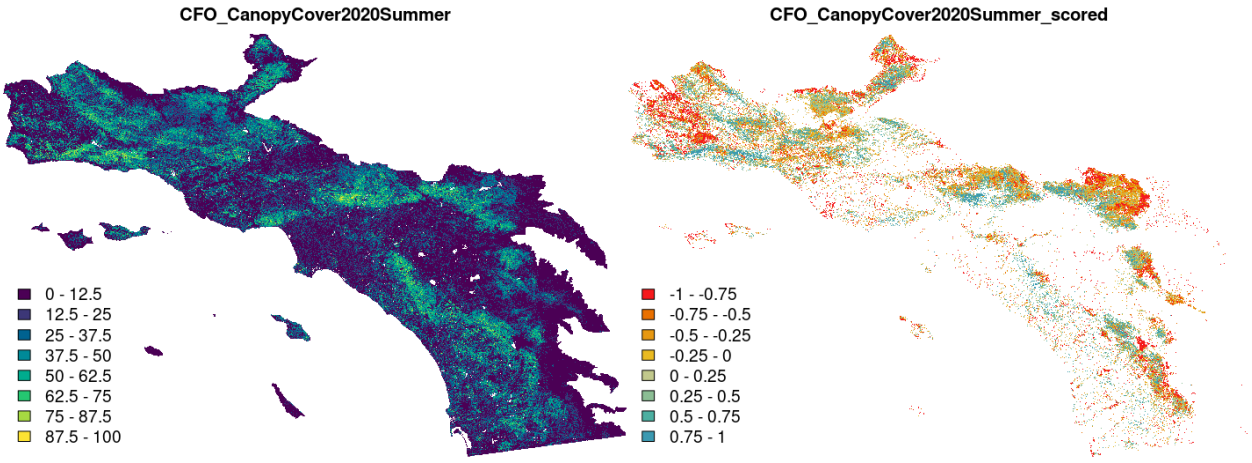

Figure 119. Maps displaying raw metric and translated metric canopy cover in Southern California

ELEMENT REPRESENTATION: COMPOSITION

The composition of a forest is a reference to the biodiversity of the landscape; this includes a diversity of vegetation species, types (e.g., trees, shrubs, forbs, etc.), and distribution. Tree species composition affects many aspects of forest dynamics and function. A diversity of tree and shrub species can confer greater resilience to climate change and beetle outbreaks. The vegetation composition also affects fire dynamics, water reliability, carbon pools and sequestration, and economic diversity pillars. Since European settlement and the adoption of fire suppression and logging, forests of the Sierra Nevada shifted to increased dominance of shade-tolerant and fire-intolerant species like white fir and red fir, incense cedar, Douglas fir, and tanoak. Other species like ponderosa pine, Jeffrey pine, sugar pine, and black oak, which are more shade-intolerant and fire-tolerant, declined in coverage. With increasingly larger and higher-severity fire occurring, forest-cover loss may be significant and shrub cover will increase.

The Composition Element is described in the RRK by six metrics: seral stage (early and late), tree cover, shrub cover, herbaceous cover, absolute change in herbaceous cover, and distribution of obligate resprouting, obligate seeding, and facultative seeding shrub species (and tree and herb). One metric was selected to represent resilience for the forest and shrubland composition element: tree cover (indicated by an asterisk). Condition scores range from +1 to -1 representing more favorable to less favorable conditions, respectively. The Element condition score is the same as the tree cover.

File Name: composition.tif

Translation: Where is forest composition most resilient?

SERAL STAGE

Tier: 2

Data Vintage: 04/2023

Metric Definition and Relevance: The seral stages are categories that represent the developmental progression of forest ecosystems from initial establishment or following a stand replacing event (e.g., high severity fire) to a forest dominated by trees in the upper age classes for a given forest type. Late seral forests are also often characterized by multiple ages of forest trees and dead and dying trees in some form of equilibrium. Seral conditions across landscapes were highly variable prior to major European settlement in the western US. These patterns were highly attuned to dominant disturbance regimes and the multi-scaled variability in environmental conditions across topographic and climatic gradients. These patterns helped to reinforce fire regimes dominated by low- to moderate-severity fire across much of the region and provided for multiple habitat requirements for a wide variety of species.

This metric contains three related data layers. The first is an assignment to each 30 meter pixel of the seral stage it is currently in, either early, mid, or late seral stage. The other two layers represent the proportion of a HUC 12 watershed that is in 1) early seral stage or 2) late seral stage.

EARLY SERAL STAGE

Tier: 2

Data Vintage: 04/2023

Metric Definition and Relevance: The seral stages are categories that represent the developmental progression of forest ecosystems from initial establishment or following a stand replacing event (e.g., high severity fire) to a forest dominated by trees in the upper age classes for a given forest type. Late seral forests are also often characterized by multiple ages of forest trees and dead and dying trees in some form of equilibrium. Seral conditions across landscapes were highly variable prior to major European settlement in the western US. These patterns were highly attuned to dominant disturbance regimes and the multi-scaled variability in environmental conditions across topographic and climatic gradients. These patterns helped to reinforce fire regimes dominated by low- to moderate-severity fire across much of the region and provided for multiple habitat requirements for a wide variety of species.

Data Resolution: 30m Raster, HUC 12 watersheds

Data Units: Categorical 1 - 3 (seral stage), continuous variable 0-1 representing percentage of a HUC (early and late seral stage)

Data Source: FVEG 2023

File Name: SeralStage_EML_202304.tif; early_SeralStage_prop_202304_scored.tif;

Type and distribution of data: Zero-inflated, right-skewed beta-like distribution representing proportions. Raw data values range from 0 to 0.4 for early seral stage.

Represent element and pillar: No

Translation: Where is proportion of early seral within the historical range?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable and less favorable conditions, respectively. The proposition of more favorable is based on the

objective of the proportion of the HUC12 sub watershed being within the historical range of early seral forest. We used two-tailed smooth (Gaussian) scoring, reflecting the perspective that a landscape could have both too little and too much early seral condition to support forest ecosystem functions. More favorable (translated to +1) set at 0.15 to 0.25 proportion of the sub watershed, and less favorable (translated to -1) represented in two ways (two-tailed test): too little early seral (-1 score) set at 0 proportion of the sub watershed; and too much early seral set at >40% of the sub watershed. Alternative translations could have a broader favorable range and higher or lower values for too much early seral.

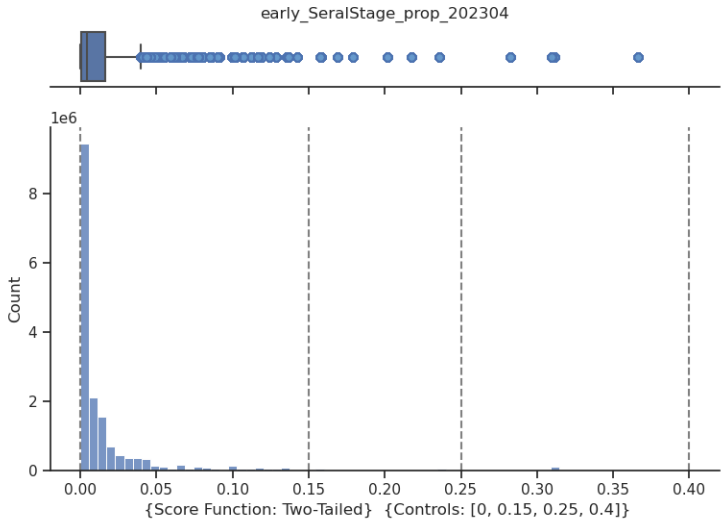

Figure 120. Histogram and scoring of early seral stage in Southern California

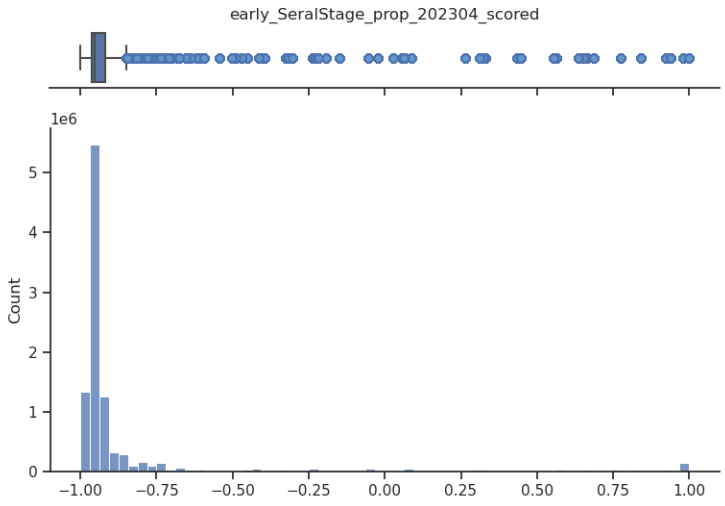

Figure 121. Histogram of translated early seral stage in Southern California

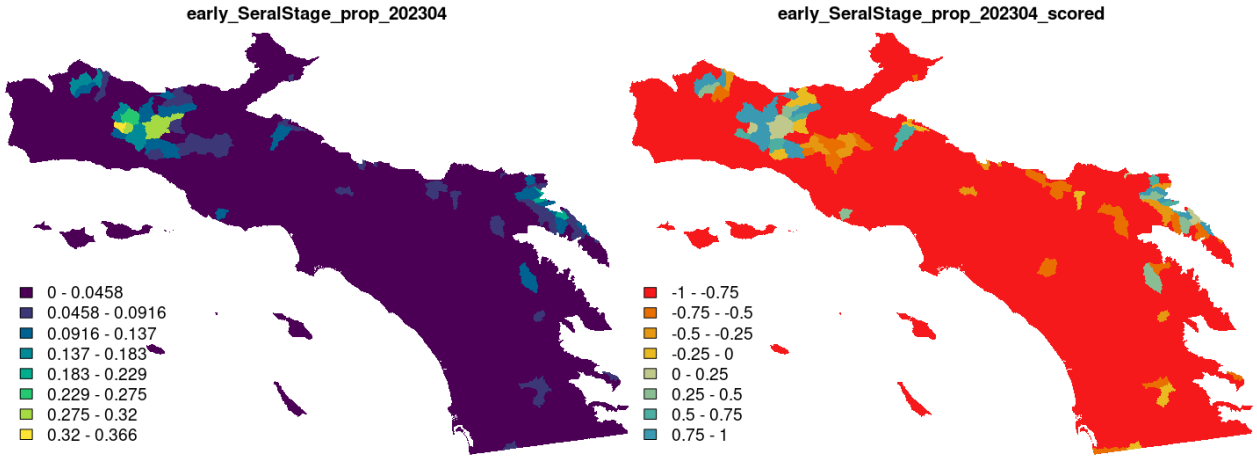

Figure 122. Maps displaying raw metric and translated metric early seral stage in Southern California

LATE SERAL STAGE

Tier: 2

Data Vintage: 04/2023

Metric Definition and Relevance: The seral stages are categories that represent the developmental progression of forest ecosystems from initial establishment or following a stand replacing event (e.g., high severity fire) to a forest dominated by trees in the upper age classes for a given forest type. Late seral forests are also often characterized by multiple ages of forest trees and dead and dying trees in some form of equilibrium. Seral conditions across landscapes were highly variable prior to major European settlement in the western US. These patterns were highly attuned to dominant disturbance regimes and the multi-scaled variability in environmental conditions across topographic and climatic gradients. These patterns helped to reinforce fire regimes dominated by low- to moderate-severity fire across much of the region and provided for multiple habitat requirements for a wide variety of species.

Data Resolution: 30m Raster, HUC 12 watersheds

Data Units: Categorical 1 - 3 (seral stage), continuous variable 0-1 representing percentage of a HUC (early and late seral stage)

Data Source: FVEG 2023

File Name: SeralStage_EML_202304.tif; late_SeralStage_prop_202304_scored.tif

Type and distribution of data: Zero-inflated, right-skewed, beta-like distribution representing proportions. Raw data values range from 0 to 0.53 for late seral stage.

Represent element and pillar: No

Translation: Where is the proportion greatest of late seral within the historical range?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable and less favorable conditions, respectively. The proposition of more favorable is based on the objective of the proportion of the HUC12 subwatershed being within the historical range of late seral forest. We used one-tailed scoring, reflecting the perspective that a landscape could have too little late seral forests but not too much to support forest ecosystem functions. More favorable (translated to +1) set at > 0.53 proportion of the subwatershed (positive linear slope), and less favorable (translated to -1) set at < 0 proportion of the subwatershed. The more favorable threshold is based on the mid-point of the historical range. Alternative translations could be to have two-tailed test for late seral, where high values (e.g., above 0.8) are considered less favorable. Also, the threshold for more favorable could be lowered to the bottom end of the historical range, but that would not reflect the range of conditions that exist across landscapes and if all watersheds were managed toward that value it would potentially weaken the resilience of forest ecosystem functions. The transition between more and less favorable could be broader, going beyond the lower end of the historical range, for example ranging from 0.2 or 0.3 to 0.6 as opposed to have a broader favorable range and higher or lower values for too much early seral.

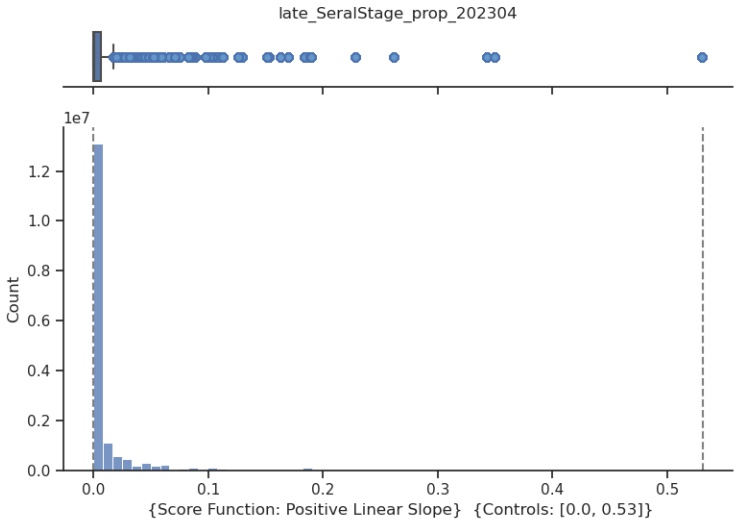

Figure 123. Histogram and scoring of late seral stage in Southern California

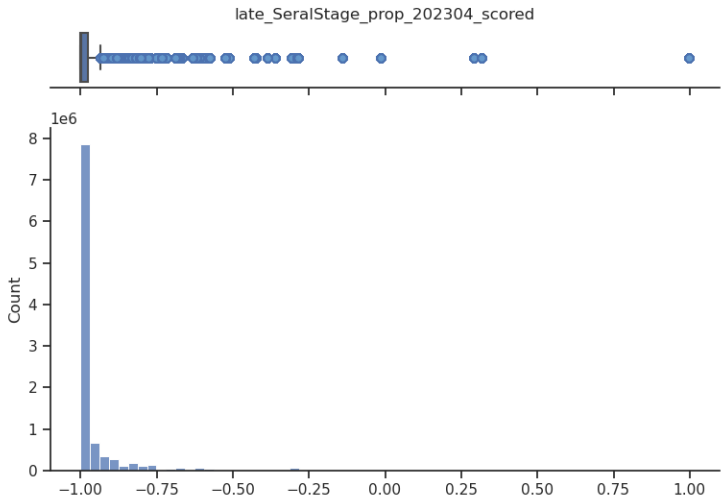

Figure 124. Histogram of translated late seral stage in Southern California

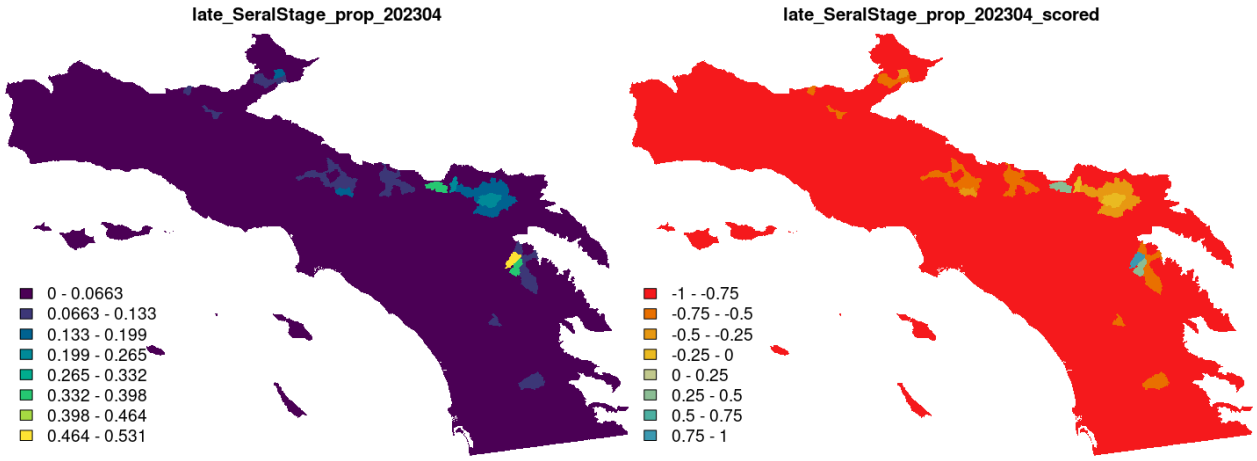

Figure 125. Maps displaying raw metric and translated metric late seral stage in Southern California

TREE COVER *

Tier: 1

Data Vintage: 12/2021

Metric Definition and Relevance: Total tree cover as measured by the fractional non-overlapping absolute tree cover, viewed vertically. Provides a first order measure of vegetation type when combined with parallel observations of shrub and herbaceous cover. Data from the National Land Cover Database (NLCD) are used for training, and NLCD definitions for cover (for example, the distinction between tree vs shrub) are expected to be similar in the CECS data sets.

Data Resolution: 30m Raster

Data Units: Fractional non-overlapping absolute cover

Data Source: CECS; https://california-ecosystem-climate.solutions/

File Name: VegCover_Tree_2021_scored.tif

Type and distribution of data: Right-skewed distribution representing proportion values. Raw data values range from 0 to 0.944.

Represent element and pillar: Yes

Translation: Where is tree cover high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of canopy layers being higher (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) are based on climate and vegetation regions (Table 4).

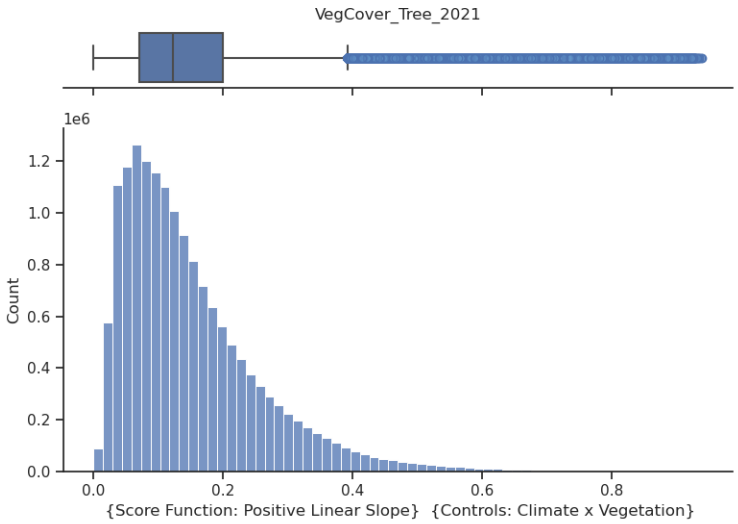

Figure 126. Histogram and scoring of tree cover in Southern California

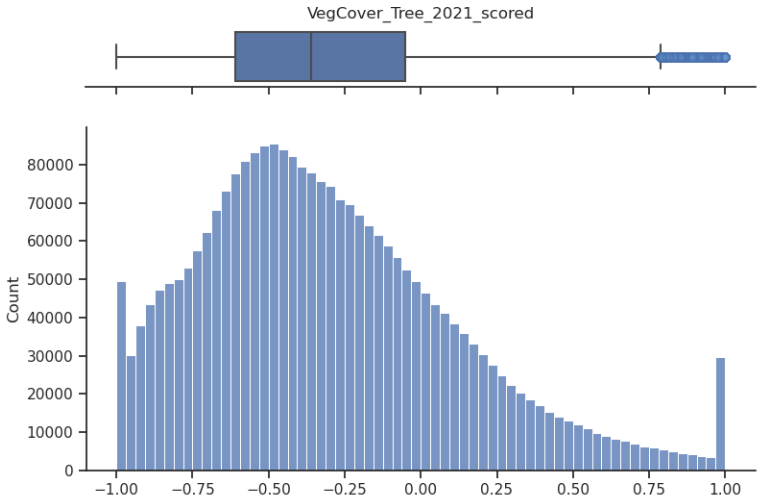

Figure 127. Histogram of translated tree cover in Southern California

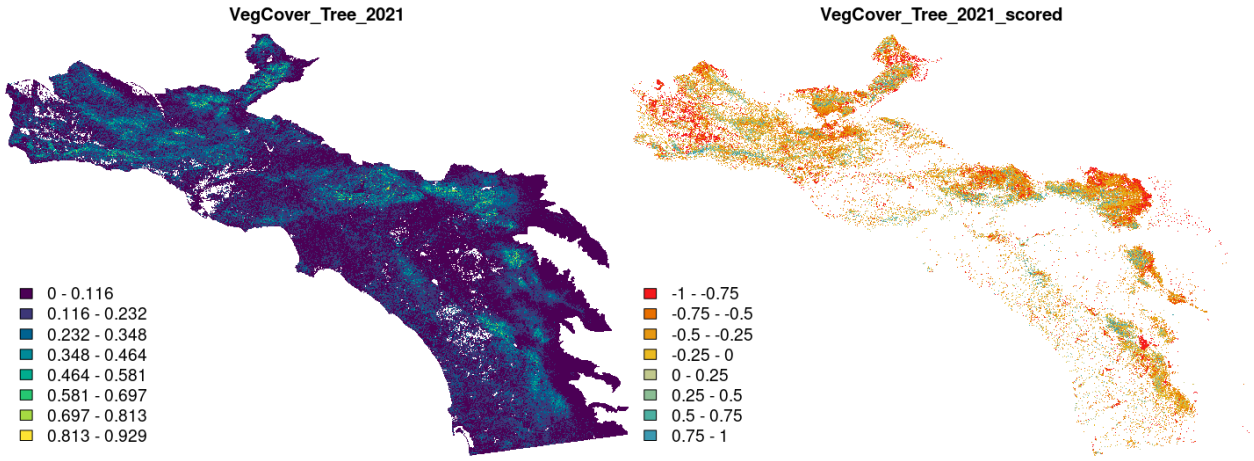

Figure 128. Maps displaying raw metric and translated metric tree cover in Southern California

SHRUB COVER *

Tier: 1

Data Vintage: 12/2021

Metric Definition and Relevance: Total shrub cover as measured by the fractional non-overlapping absolute shrub cover, viewed vertically. Provides a first order measure of vegetation type when combined with parallel observations of tree and herbaceous cover. Data from the National Land Cover Database (NLCD) are used for training, and NLCD definitions for cover (for example, the distinction between tree vs shrub) are expected to be similar in the CECS data sets.

Data Resolution: 30m Raster

Data Units: Fractional non-overlapping absolute cover

Data Source: CECS; https://california-ecosystem-climate.solutions/

File Name: VegCover_Shrub_2021_scored.tif

Type and distribution of data: Asymmetric distribution representing proportion values. Raw data values range from 0 to 0.775.

Represent element and pillar: Yes

Translation: Where is shrub cover high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of shrub cover being high (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) are based on climate and vegetation regions (Table 4).

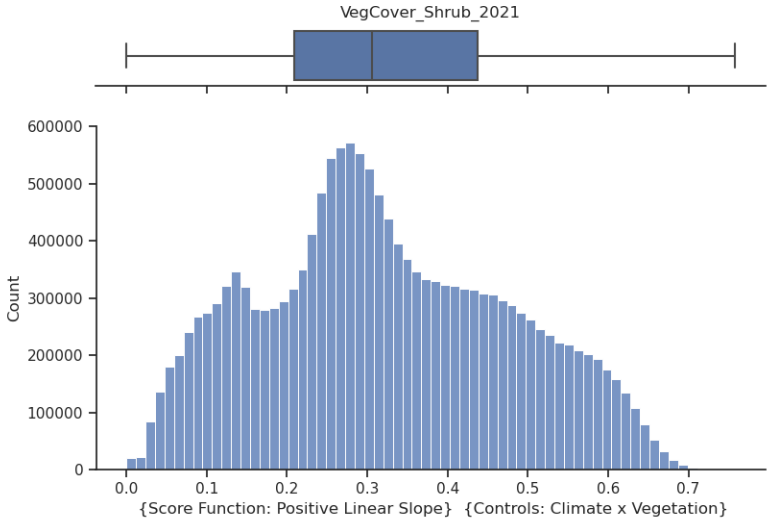

Figure 129. Histogram and scoring of shrub cover in Southern California

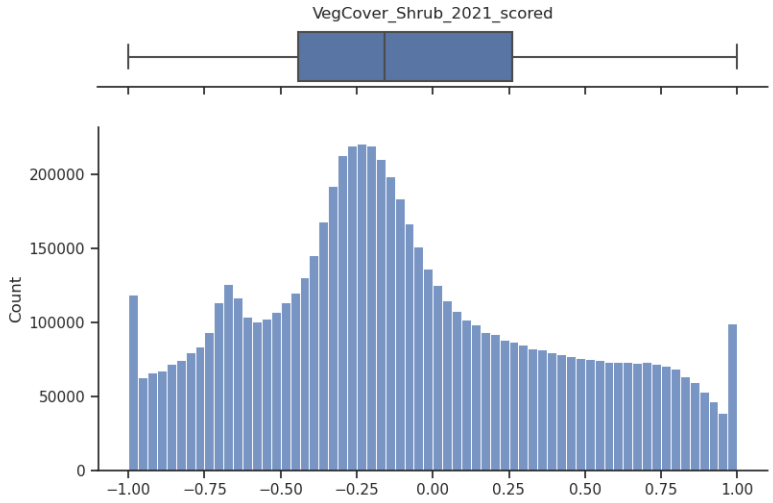

Figure 130. Histogram of translated metric shrub cover in Southern California

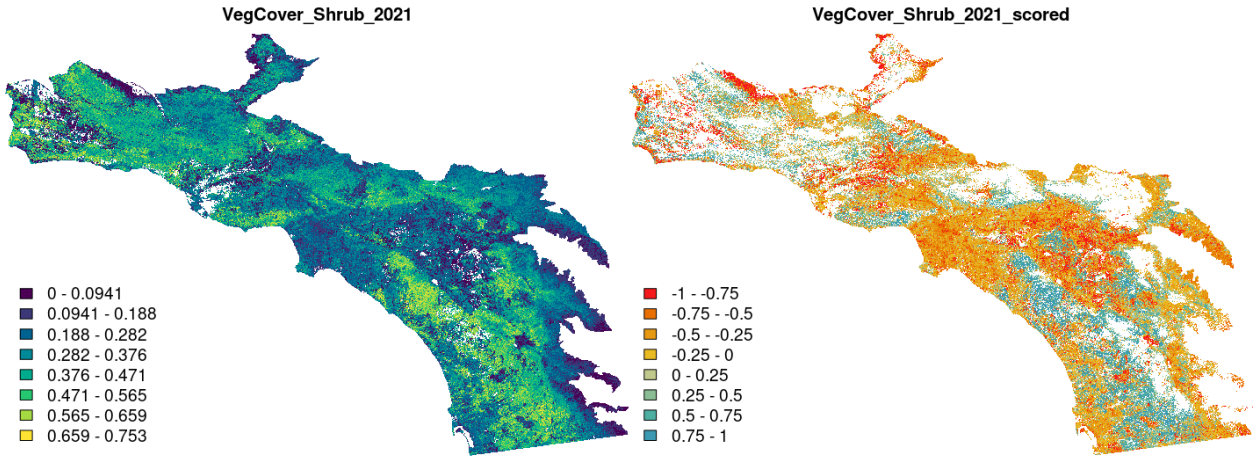

Figure 131. Maps displaying raw metric and translated metric shrub cover in Southern California

HERBACEOUS COVER *

Tier: 1

Data Vintage: 12/2021

Metric Definition and Relevance: Total herbaceous cover as measured by the fractional non-overlapping absolute herbaceous cover, viewed vertically. Provides a first order measure of vegetation type when combined with parallel observations of tree and herbaceous cover. Data from the National Land Cover Database (NLCD) are used for training, and NLCD definitions for cover (for example, the distinction between tree vs shrub) are expected to be similar in the CECS data sets.

Data Resolution: 30m Raster

Data Units: Fractional non-overlapping absolute cover.

Data Source: CECS; https://california-ecosystem-climate.solutions/

File Name: VegCover_Herb_2021_scored.tif

Type and distribution of data: Right-skewed distribution representing proportion values. Raw data values range from 0 to 0.892.

Represent element and pillar: Yes

Translation: Where is herbaceous cover low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of canopy layers being lower (negative linear slope). More favorable (translated to -1) and less favorable (translated to +1) are based on climate and vegetation regions (Table 4).

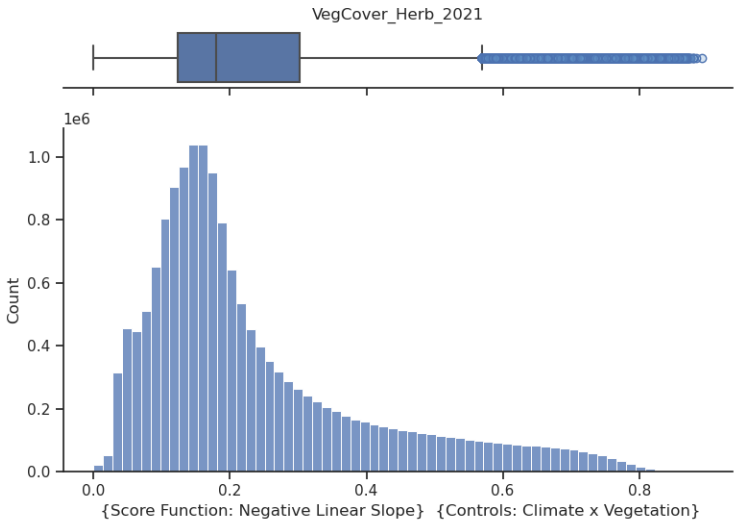

Figure 132. Histogram and scoring of herbaceous cover in Southern California

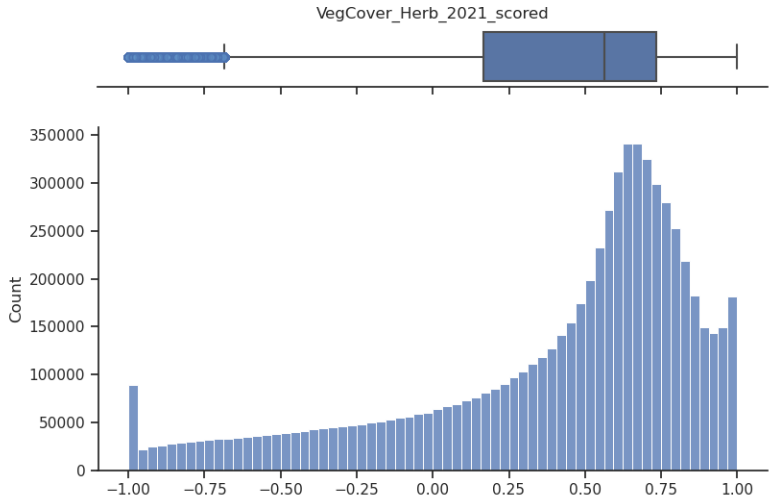

Figure 133. Histogram of translated herbaceous cover in Southern California

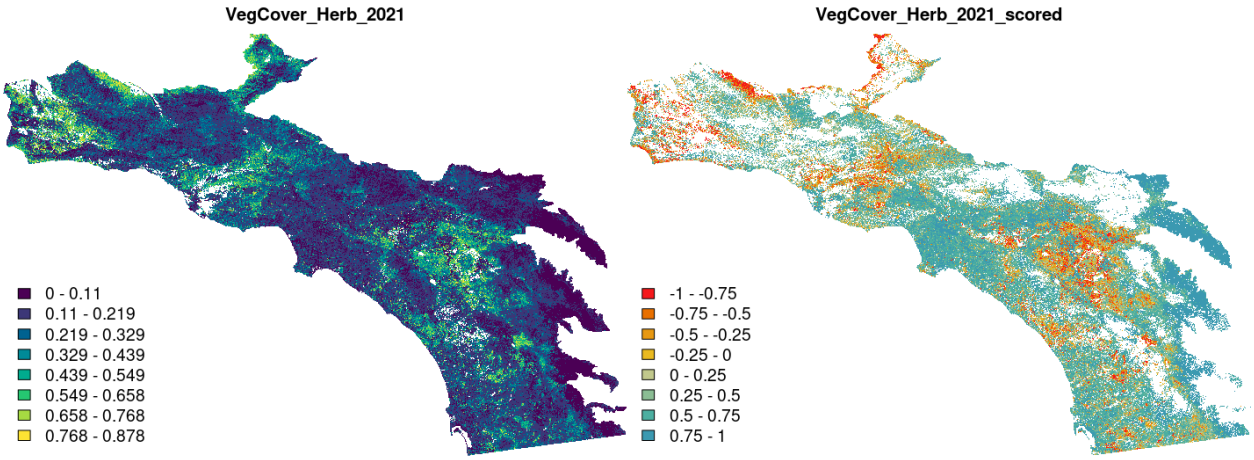

Figure 134. Maps displaying raw metric and translated metric herbaceous cover in Southern California

ABSOLUTE CHANGE IN HERBACEOUS COVER

Tier: 3

Data Vintage: 2020

Metric Definition and Relevance: A raster dataset representing absolute change of herbaceous fractional (%) land cover in the Southern California Region.

Data Resolution: 30m Raster

Data Units: Percent, absolute change

Data Source: San Diego State University CWC Project Team

File Name: AbsChgeInHerbCover1986_90To2016_20_scored.tif

Type and distribution of data: Normal, skewed distribution representing percentages. Raw data values range from -91.8 to 118.6.

Represent element and pillar: No

Translation: Where is herbaceous cover change low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of canopy layers being lower (negative linear slope). More favorable (translated to +1) set at < 35.94, and less favorable (translated to -1) set at -35.385.

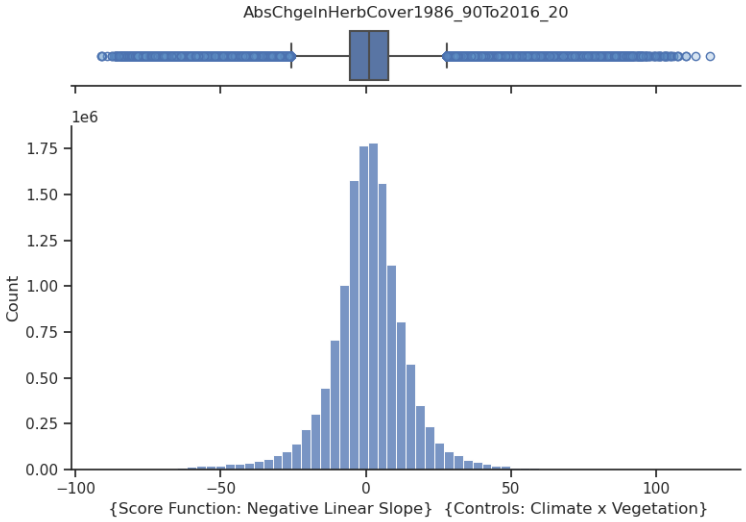

Figure 135. Histogram and scoring of herbaceous cover change in Southern California

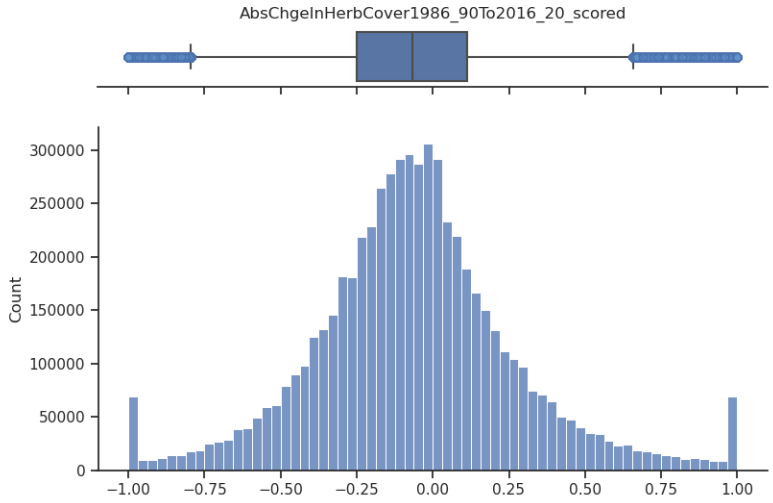

Figure 136. Histogram of translated herbaceous cover change in Southern California

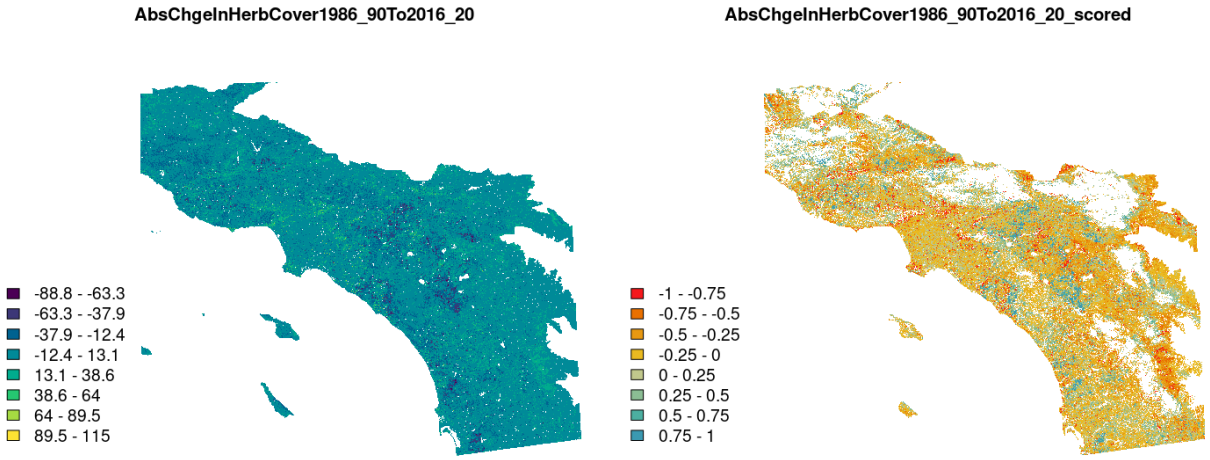

Figure 137. Maps displaying raw metric and translated metric herbaceous cover change in Southern California

DISTRIBUTION OF OBLIGATE RESPROUTING, OBLIGATE SEEDING, AND FACULTATIVE SEEDING SHRUB SPECIES (AND TREE AND HERB)

Tier: 2

Data Vintage: 2011

Metric Definition and Relevance: This dataset consists of 5 raster files of the proportion of above ground live biomass in these vegetation type categories: (1) Shrub obligate resprouting; (2) Shrub obligate seeding; (3) Shrub facultative seeding; (4) Tree; and (5) Herb. The spatial extent of these data cover 6,441,208 ha and is defined by the 42 Level IV Ecoregions (Bailey 2016) that intersect the four

southern US Department of Agriculture (USDA) National Forests in southern California (Angeles, Cleveland, Los Padres, and San Bernardino).

Mediterranean-climate region (MCR) shrublands have evolved a set of regeneration strategies in response to periodic, high-intensity wildfires: obligate seeding (OS), obligate resprouting (OR), and facultative seeding (FS) species. Spatial variation is seen in different regeneration strategies. In California, previous studies have found a higher abundance of OR species in mesic environments and OS species in xeric environments).

Analyzing the spatial rasters depicting OS-, OR- or FS- dominated pixels, researchers found dramatically different spatial patterns between the three shrub regeneration strategies. FS species covered the greatest spatial distribution, accounting for 3,372,125 ha (71%) of shrub dominated pixels in the study area: the FS group covered a range of productivity gradients and vegetation types, although it was notably absent from high elevation areas. In contrast, OS-dominated pixels covered the smallest spatial area (21,899 ha, 5% of shrub dominated pixels) occurring throughout the study area from coastal Big Sur and the Santa Ynez Mountains on the Los Padres National Forest to interior locations including the eastern fringes of the San Jacinto mountains (desert shrub vegetation) in the south. Finally, pixels dominated by OR species covered a similarly small area, 25,075 ha (5% of shrub dominated pixels in the study area), showing aggregations in the San Bernardino and San Gorgonio Mountains on the San Bernardino National Forest; San Gabriel Mountains on the Angeles National Forest, and throughout higher elevations on the Los Padres National Forest. OR-dominated pixels were notably absent in lower elevation areas with low water availability, as indicated in the relationship with climatic water deficit and solar radiation. The proportion of each post-fire shrub regeneration type is critical for a number of reasons, including assessing the ability of shrublands to recover from multiple, short-interval fires or helping to prioritize areas for post-fire restoration.

Data Resolution: 30m Raster

Data Units: Percentage of life history/post-fire regeneration type per pixel (0 – 100)

Data Source: Underwood, E.C., Q.M. Sorenson, C.C. Schrader-Patton, N.A. Molinari and H.D. Safford. 2023. Resprouting, seeding, and facultative seeding shrub species in California's Mediterranean-type climate region. *Frontiers in Ecology and Evolution* 11:1158265. doi: 10.3389/fevo.2023.1158265

Underwood, E.C.; Q.M. Sorenson, C.C. Schrader-Patton (2023). Obligate resprouting, obligate seeding, and facultative seeding shrub species in California's Mediterranean-type climate region [Dataset]. Dryad. https://doi.org/10.25338/B8FS9V

File Name: SoCal_ObResprouters_pp_v1.tif; SoCal_ObSeeders_pp_v1.tif; SoCal_FacSeeders_pp_v1.tif; SoCal_Tree_pp_v1.tif; SoCal_Herb_pp_v1.tif

Translation: None

ELEMENT REPRESENTATION: DISTURBANCE

California forests evolved with a suite of frequent disturbances: wildfires (both from lightning and burning by indigenous people), bark beetle-caused mortality, drought-caused mortality, avalanches, landslides, and windthrow, all of which created forest heterogeneity across the landscape. This heterogeneity included variations in surface and ladder fuels, which moderated fire behavior and spread. The variations in stand density and forest opening also served as critical habitats for wildlife. Forested areas are now more homogeneous due to lack of disturbance. The lack of disturbance is evident in the forest structure.

The Disturbance Element is described in the RRK by eleven metrics: change in average annual climatic water deficit, cumulative tree cover loss, cumulative shrub cover loss, risk of tree dieoff during drought, goldspotted oak borer, multi-stressor refugia, shrublands with low natural regeneration potential post-fire in Southern California, shrub resiliency within 15 years per year interval since 1975, potential climate refugia (baseline historical conditions), potential climate refugia (under modeled climate change (MIROC model), and potential climate refugia (under modeled climate change (MIROC model and CNRM-CM5 model)). Two metrics describe and represent the disturbance element: risk of tree dieoff during drought and goldspotted oak borer (indicated by asterisks). The condition scores for each of the metrics are averaged to derive a condition score for the disturbance element.

File Name: disturbance.tif

Translation: Where is forest and shrubland disturbance processes resilient?

CHANGE IN AVERAGE ANNUAL CLIMATIC WATER DEFICIT – NEAR FUTURE – DRIER

Tier: 3

Data Vintage: 2022

Metric Definition and Relevance This raster dataset represents a projection of the difference in the mean annual climatic water deficit between the baseline period (1950-1980), and a near future period (2030-2059) under the MIROC (Drier) scenario of climate change.

Data Resolution: 30m Raster

Data Units: Continuous, mm

Data Source: San Diego State University CWC Project Team

File Name: ChangeInAverageAnnualCWD-NearFutureDrier_scored.tif

Type and distribution of data: Normal skewed distribution representing continuous values. Raw data values range from -203.371 to 237.372.

Represent element and pillar: No

Translation: Where is change in average annual climatic water deficit high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the

objective of higher change in average annual climatic water deficit (positive linear slope). More favorable (translated to +1) set at 154.239, less favorable (translated to -1) set at > -86.844.

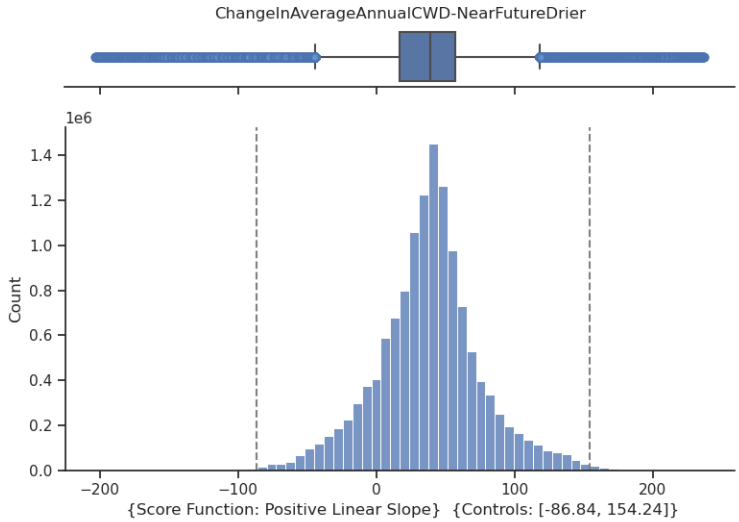

Figure 138. Histogram and scoring of change in average annual climate water deficit, near future drier, in Southern California

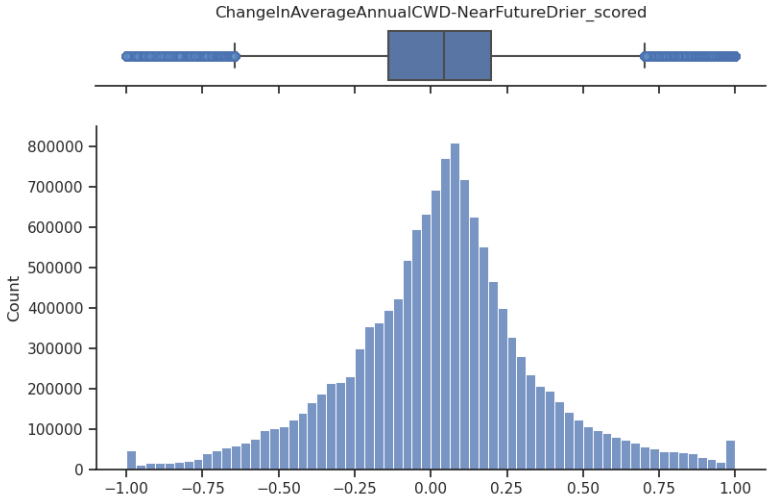

Figure 139. Histogram of translated change in average annual climate water deficit, near future drier, in Southern California

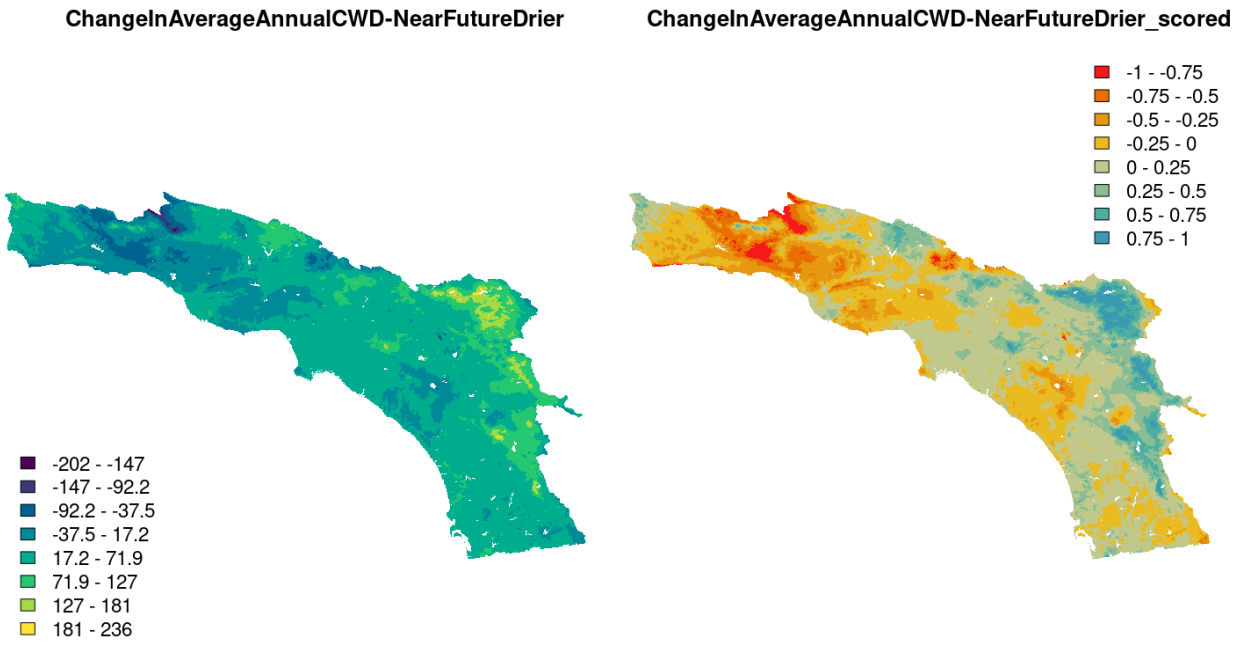

Figure 140. Maps displaying raw metric and translated metric change in average annual climate deficit, near future drier, in Southern California

CUMULATIVE TREE COVER LOSS

Tier: 1

Data Vintage: 12/2020

Metric Definition and Relevance: The cumulative loss of tree cover over a 30-year period (1992-2021). Tree cover loss reflects fires, harvest/management and dieoff. Only disturbances that are sufficient to trigger the Continuous Change Detection and Classification algorithm are included; low-level, diffuse dieoff is likely missed.

Data Resolution: 30m Raster

Data Units: Proportion, cumulative fractional non-overlapping absolute tree cover loss, where tree cover is a continuous variable from 0 to 1. Cumulative loss can exceed 1 in cases with multiple disturbances.

Data Source: CECS; https://california-ecosystem-climate.solutions/

File Name: DistHist_Severe_Tree_19922020_scored.tif

Type and distribution of data: Zero-inflated, right skewed distribution representing proportion. Raw data values range from 0 to 1.709.

Represent element and pillar: No

Translation: Where is cumulative tree cover loss low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of cumulative tree cover loss being lower (negative linear slope). More favorable (translated to +1) and less favorable (translated to -1) are based on climate and vegetation regions (Table 5).

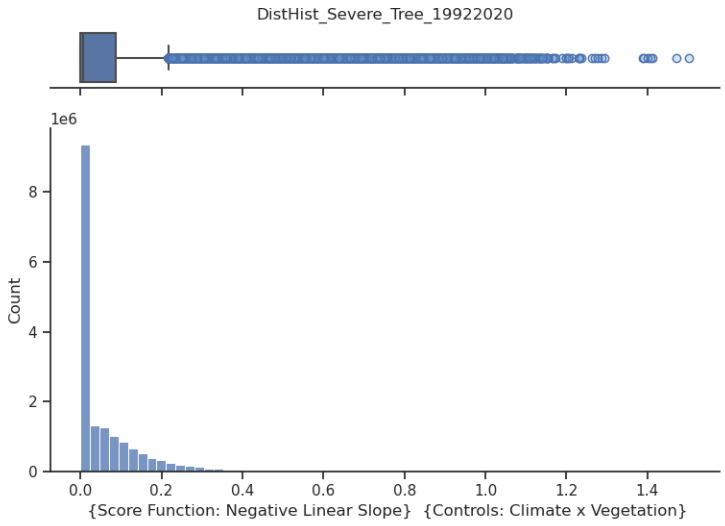

Figure 141. Histogram and scoring of cumulative tree cover loss in Southern California

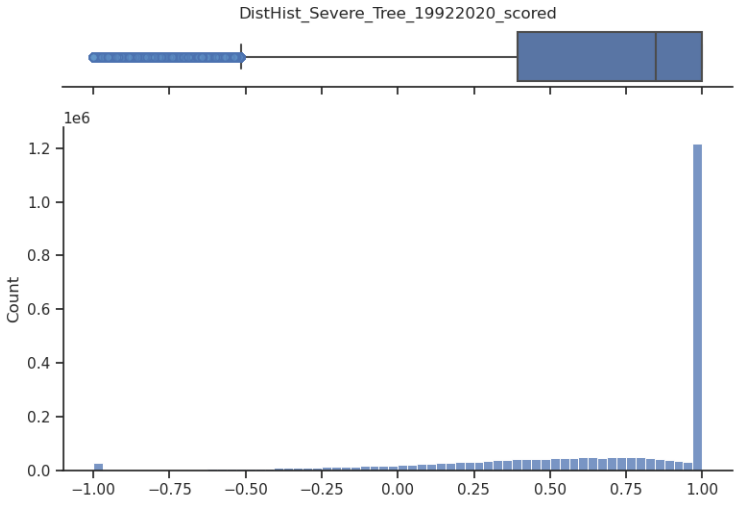

Figure 142. Histogram of translated cumulative tree cover loss in Southern California

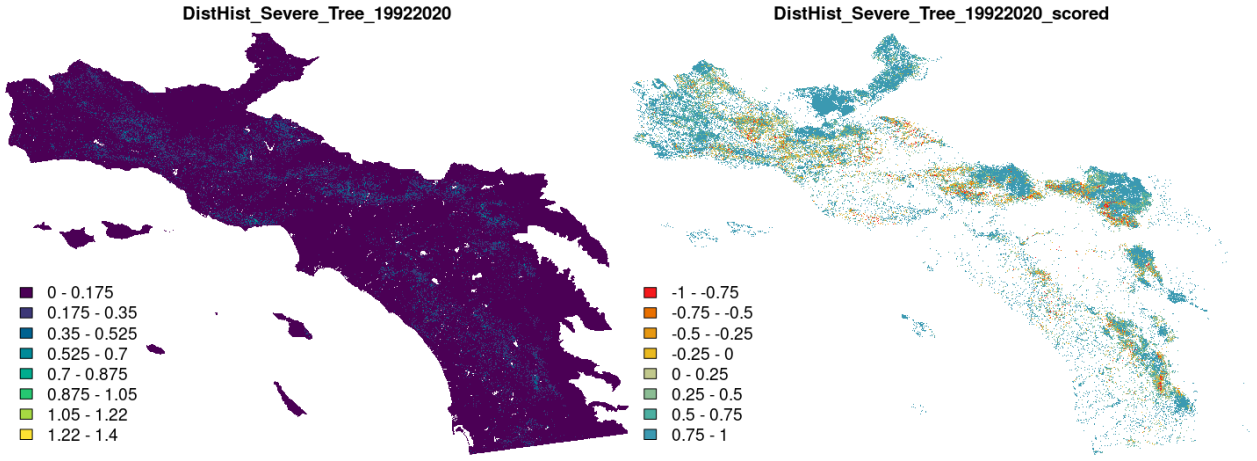

Figure 143. Maps displaying raw metric and translated metric cumulative tree cover loss in Southern California

CUMULATIVE SHRUB COVER LOST

Tier: 1

Data Vintage: 12/2020

Metric Definition and Relevance: The cumulative loss of shrub cover over a 30-year period (1992-2021). Shrub cover loss reflects fires, harvest/management and dieoff. Only disturbances that are sufficient to trigger the Continuous Change Detection and Classification algorithm are included; low-level, diffuse dieoff is likely missed.

Data Resolution: 30m Raster

Data Units: Proportion, cumulative fractional non-overlapping absolute shrub cover loss, where shrub cover is a continuous variable from 0 to 1. Cumulative loss can exceed 1 in cases with multiple disturbances.

Data Source: CECS; https://california-ecosystem-climate.solutions/

File Name: DistHist_Severe_Shrub_19922020_scored.tif

Type and distribution of data: Zero-inflated, right skewed distribution representing proportion. Raw data values range from 0 to 1.755.

Represent element and pillar: No

Translation: Where is cumulative shrub cover loss low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of cumulative shrub cover loss being lower (negative linear slope). More favorable

(translated to +1) and less favorable (translated to -1) are based on climate and vegetation regions (Table 5).

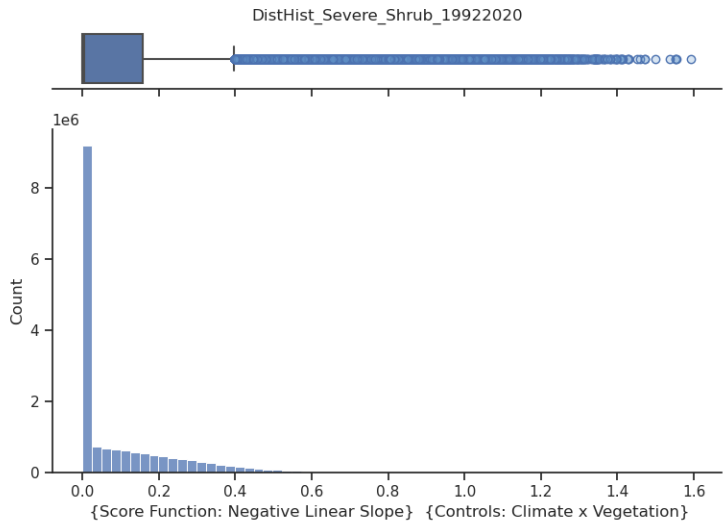

Figure 144. Histogram and scoring of cumulative shrub cover lost in Southern California

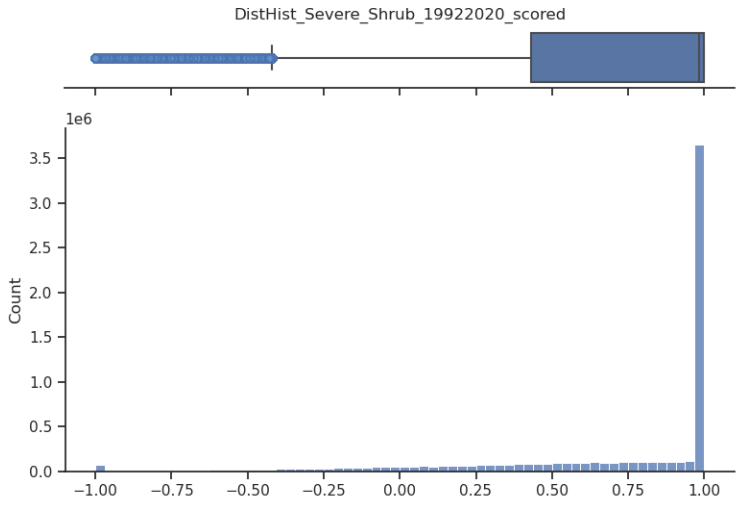

Figure 145. Histogram of translated cumulative shrub cover lost in Southern California

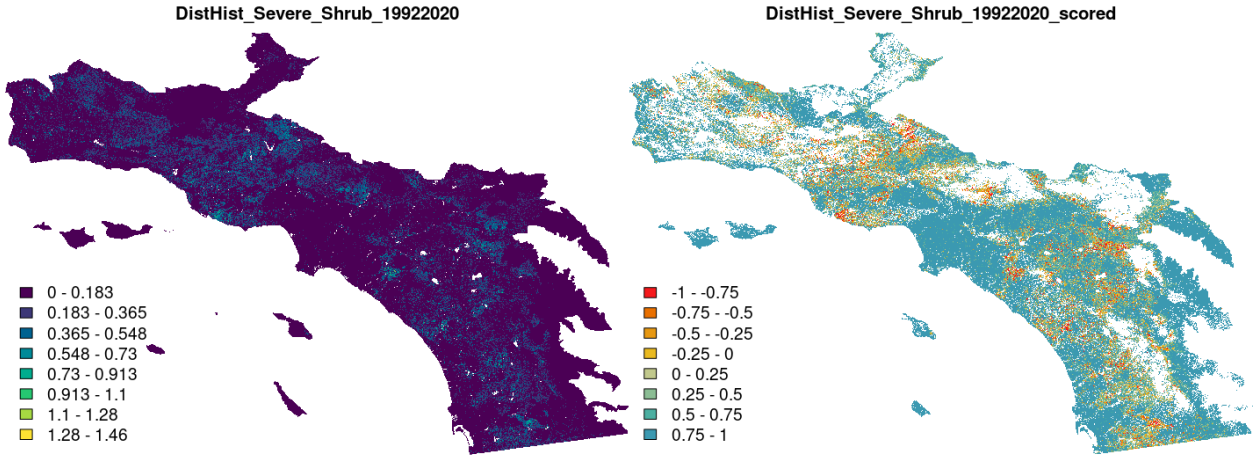

Figure 146. Maps displaying raw metric and translated metric cumulative shrub cover lost in Southern California

RISK OF TREE DIEOFF DURING DROUGHT *

Tier: 1

Data Vintage: 12/2021

Metric Definition and Relevance: A quantitative continuous variable that reflects the risk of tree dieoff during a significant drought period (SPI48 drought = -2).

Data Resolution: 30m Raster

Data Units: Index, low to high vulnerability

Data Source: CECS; https://california-ecosystem-climate.solutions/

File Name: Vulner_TreeDieoff_SPI_2_2021_scored.tif

Type and distribution of data: Right skewed distribution representing index values. Raw data values range from 0 to 20000.

Represent element and pillar: Yes

Translation: Where is risk of tree dieoff during drought low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of tree dieoff during drought being lower (negative linear slope). More favorable

(translated to +1) and less favorable (translated to -1) are based on climate and vegetation regions (Table 5).

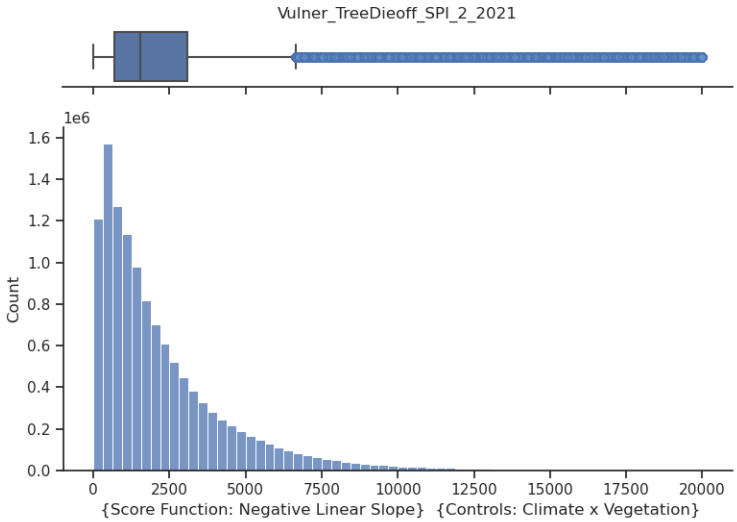

Figure 147. Histogram and scoring of risk of tree dieoff during drought in Southern California

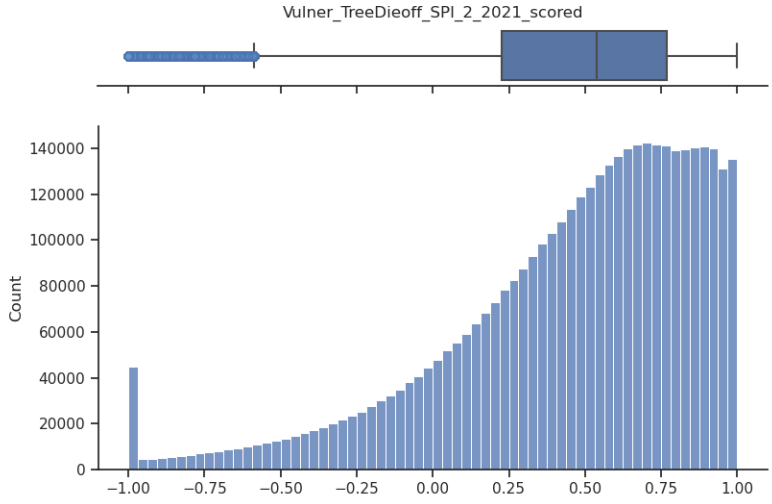

Figure 148. Histogram of translated risk of tree dieoff during drought in Southern California

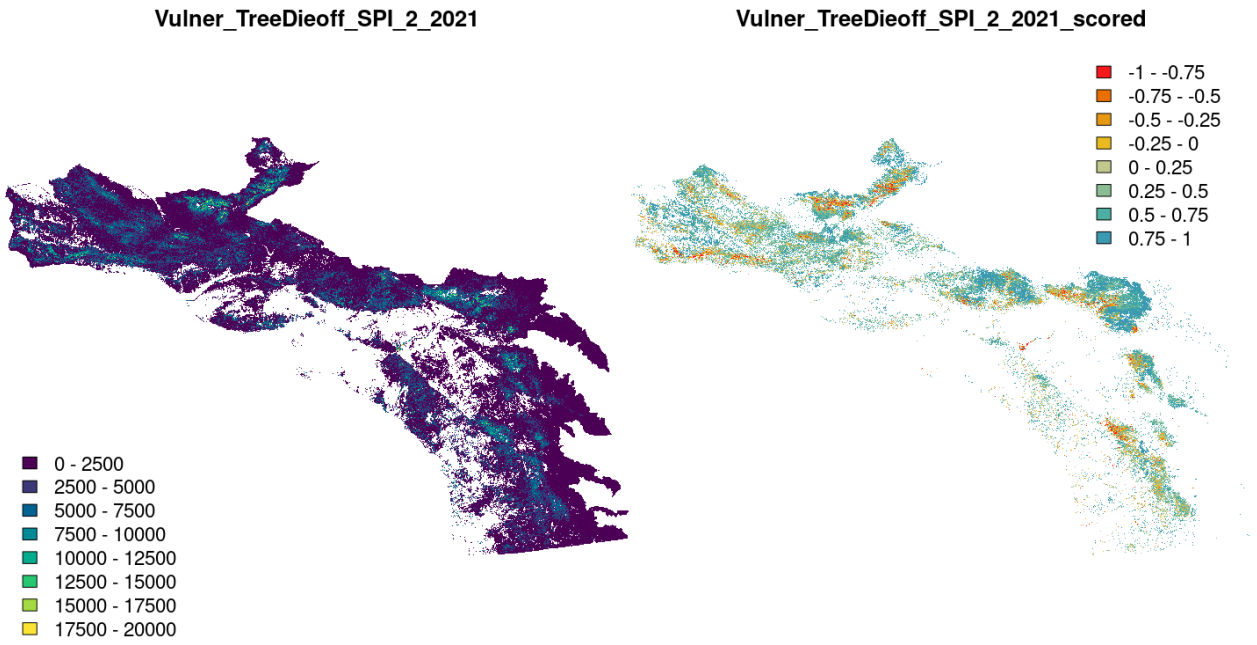

Figure 149. Maps displaying raw metric and translated metric risk of tree dieoff during drought in Southern California

GOLDSPOTTED OAK BORER *

Tier: 2

Data Vintage: 2010 to 2021

Metric Definition and Relevance: Tree mortality and other forest damage is detected by annual aerial surveys over forested lands by state and federal agency staff. The primary purpose of the aerial survey is to create sketch maps of areas containing current year conifer and hardwood mortality, defoliation, and other damage. Number of trees and acres with damage are calculated for areas surveyed and reported annually using the methodology described below. Aerial surveys have been recognized for over fifty years as an efficient and economical method of detecting and monitoring forest change events over large forested areas. As with all remotely sensed data, some amount of ground-truthing is required before the data can be considered reliable. The goldspotted oak borer was identified based on field surveys starting in 2006, and coded as goldspotted oak borer during aerial detection surveys beginning in 2010.

Data Resolution: 30m Raster

Data Units: Count, trees per acre

Data Source: R5 Aerial Detection Monitoring

File Name: goldspotOakBorer_mortality_scored.tif

Type and distribution of data: Asymmetric distribution representing count values. The raw data range from 26 to 345630.

Represent element and pillar: Yes

Translation: Where is goldspotted oak borer mortality low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of goldspotted oak borer mortality low (negative linear slope). More favorable (translated to +1) set at 345630, less favorable (translated to -1) set at > 26. Alternative approaches could be to set -1 at the top value, but that would result in a more favorable interpretation of goldspotted oak borer mortality.

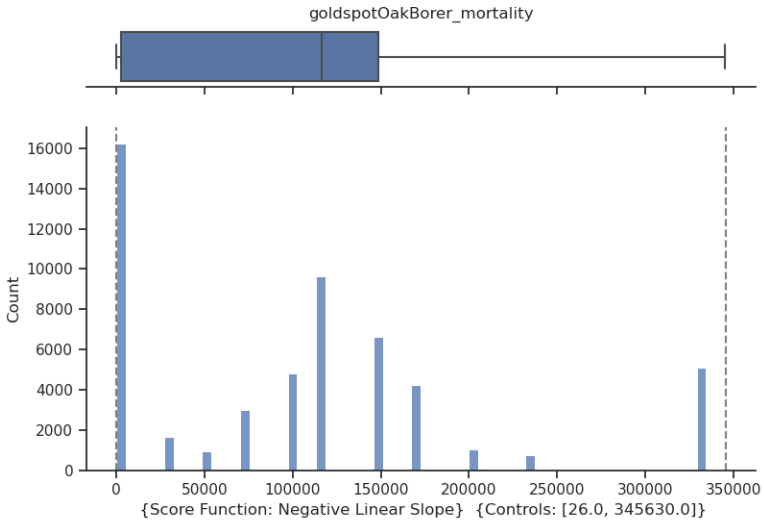

Figure 150. Histogram and scoring of goldspotted oak borer in Southern California

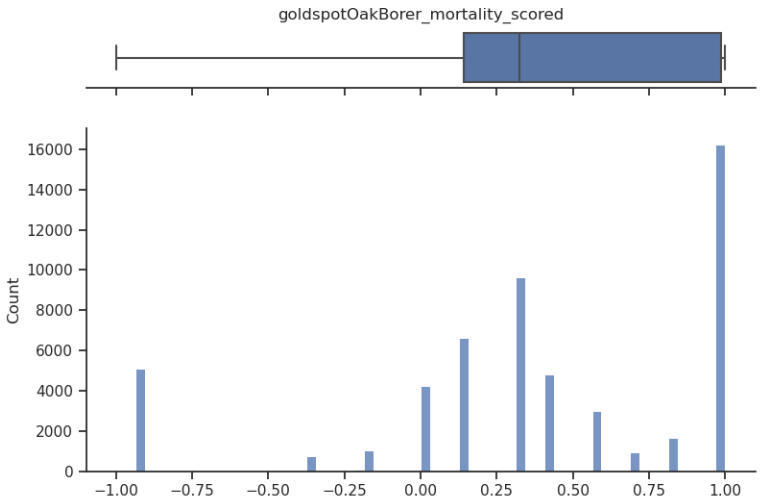

Figure 151. Histogram of translated goldspotted oak borer in Southern California

Figure 152. Maps displaying raw metric and translated metric goldspotted oak borer in Southern California

MULTI-STRESSOR REFUGIA

Tier: 3

Data Vintage: 2021

Metric Definition and Relevance: This raster dataset represents sites that may provide protection for natural communities from multiple threats including climate, fire, altered river channels, and density of recreational activities.

Data Resolution: 270m Raster

Data Units: Index, low to high resilience capacity

Data Source: San Diego State University CWC Project Team

File Name: refugia_capacity_4domains_sum_scored.tif

Type and distribution of data: Normal, left-skewed distribution representing count values. Raw data values range from 2.012 to 3.675.

Represent element and pillar: No

Translation: Where is multi-stressor refugia high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of higher change in multi-stressor refugia (positive linear slope). More favorable (translated to

+1) set at 3.675, less favorable (translated to -1) set at > 2.329. Alternative approaches could be to set -1 at the top value, but that would result in a more favorable interpretation of damage potential.

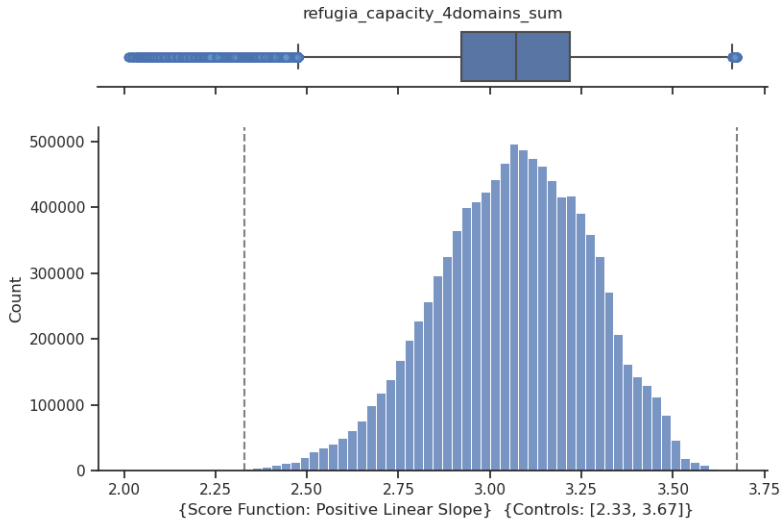

Figure 153. Histogram and scoring of multi stressor refugia in Southern California

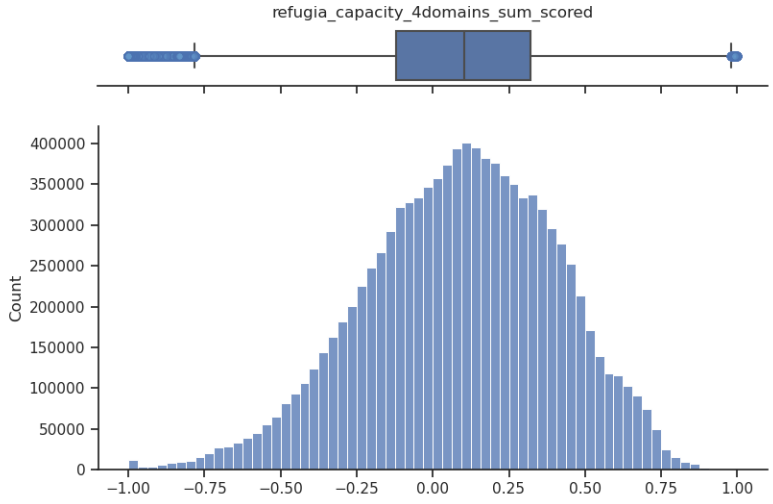

Figure 154. Histogram of translated multi stressor refugia in Southern California

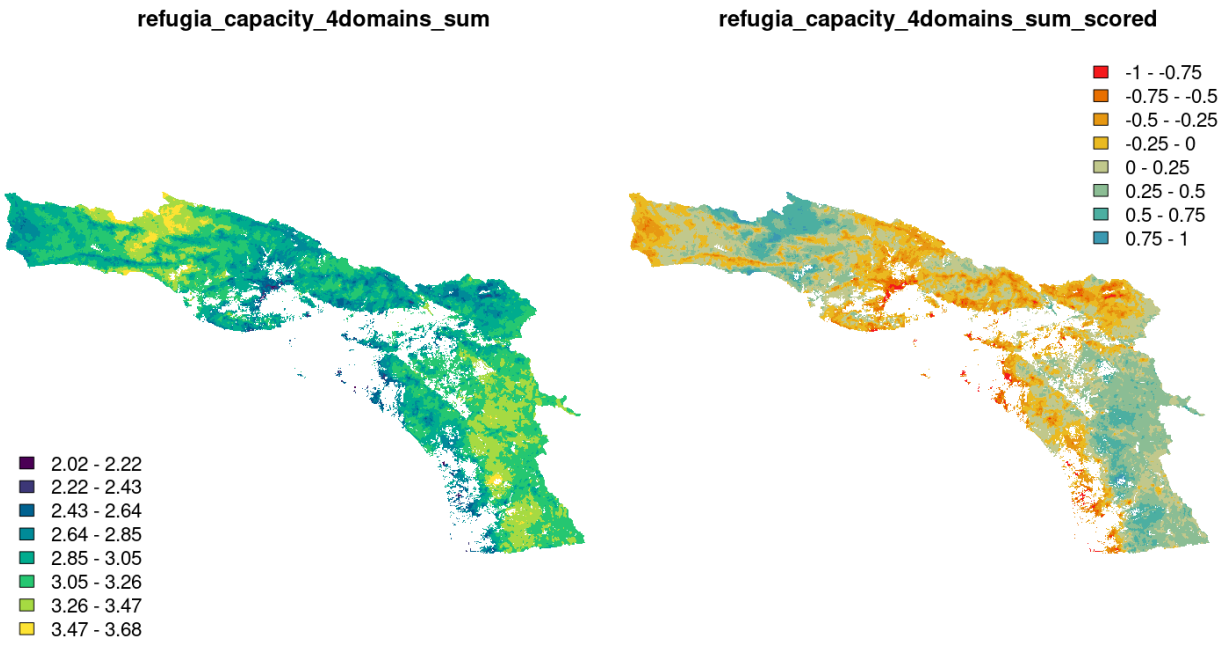

Figure 155. Maps displaying raw metric and translated metric multi stressor refugia in Southern California

SHRUBLANDS WITH LOW NATURAL REGENERATION POTENTIAL POST-FIRE IN SOUTHERN CALIFORNIA

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Identifying locations where shrubland vegetation will not recover naturally post-fire is a challenge given the vast areas that are regularly burned in southern California. When shrublands are within the historic fire return interval, e.g., 55 years for low-elevation shrubland, biomass accumulates and shrub cover recovers after 10–14 years. However, in many parts of southern California, the fire return interval has decreased, often in conjunction with an increase in non-native plant species, drought, and nitrogen deposition. Under these conditions, post-fire biomass recovery can be impeded and, in some cases, may result in type conversion from native shrubland to non-native grassland. Researchers developed a repeatable method to identify areas of low regeneration potential in southern California using fire history data and applying two thresholds guided by the published literature. Low regeneration pixels either had a 'number of fires in the last 40 years' of three or more fires, or the 'time since last fire' was <10 years. Researchers identified pixels that met these criteria as having low natural regeneration potential post-fire and, as a consequence, these areas could represent candidate areas for post-fire restoration in shrublands.

The spatial extent of these data cover 6,441,208 ha and is defined by the 42 Level IV Ecoregions (Bailey 2016) that intersect the four southern US Department of Agriculture (USDA) National Forests in southern California (Angeles, Cleveland, Los Padres, and San Bernardino).

Data Resolution: 30m Raster

Data Units: Binary. 1 = shrub pixel has low regeneration potential post-fire, 0 = shrub pixel has potential to regenerate post-fire (based on decision rules).

Data Source: Underwood, E.C. and A. D. Hollander. 2023. Areas of low natural regeneration potential post-fire in shrublands of southern California (selected years between 2008 and 2020) [Dataset]. Dryad. https://doi.org/10.25338/B8CH2T

See Underwood and Hollander 2023 for rasters for the other 8 years

File Name: prepregen2020.tif

Translation: None

SHRUB RESILIENCY, NUMBER OF DISTURBANCE EVENTS PER 15 YEAR INTERVAL SINCE 1975

Tier: 2

Data Vintage: 2019

Metric Definition and Relevance: Count of short return interval fires (within 15 years) across southern CA (1950-2019) that can be used to identify sites that have experienced frequent fire (e.g. more than one fire within a 15 year period) that could lead to vegetation-type conversion.

Data Resolution: 270m Raster

Data Units: A count metric indicating the number of times each site (at the pixel level) met a threshold of a 15-year fire-return interval from 1950 to 2019.

Data Source: San Diego State University CWC Project Team

File Name: fireswithin15years_1950-2019_2ormorefires_scored.tif

Type and distribution of data: Zero-inflated, right skewed distribution representing count values. Raw data values range from 0 to 9.

Represent element and pillar: No

Translation: Where are the number of disturbance events low?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of number of disturbance events per 15 year interval being lower (negative linear slope). More

favorable (translated to +1) and less favorable (translated to -1) are based on climate and vegetation regions (Table 5).

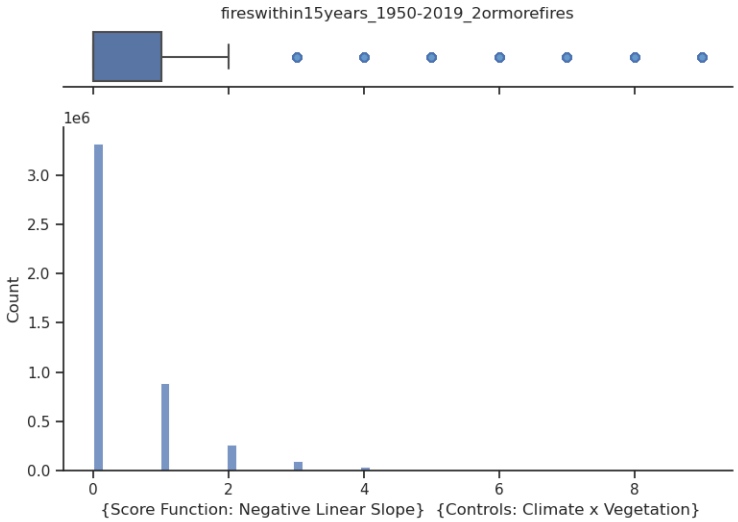

Figure 156. Histogram and scoring of shrub resiliency, number of disturbance events per 15 year interval since 1975, in Southern California

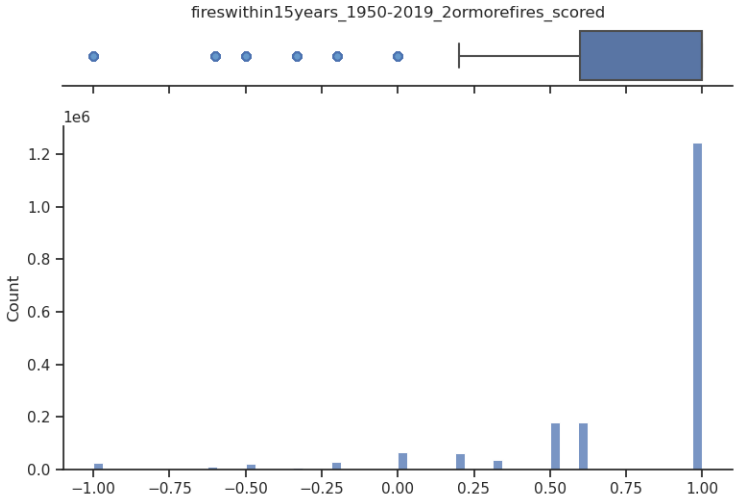

Figure 157. Histogram of translated shrub resiliency, number of disturbance events per 15 year interval since 1975, in Southern California

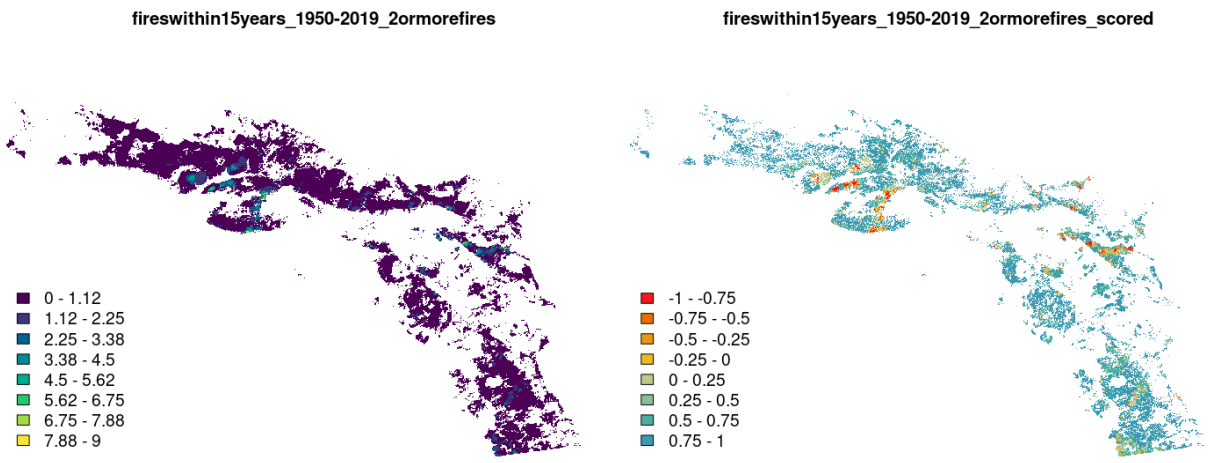

Figure 158. Maps displaying raw metric and translated metric shrub resiliency, number of disturbance events per 15 year interval since 1975, in Southern California

POTENTIAL CLIMATE REFUGIA – BASELINE (HISTORICAL) CONDITIONS

Tier: 3

Data Vintage: 1981 - 2010

Metric Definition and Relevance: This raster dataset represents habitat types (natural vegetation communities) and their distribution across the array of climate conditions that each separate habitat type is found in under the baseline climate conditions. A 2015 map of the state's natural vegetation compiled from multiple sources was classified to the National Vegetation Classification Standard's mid-level classification, called "Macrogroup". Thirty one natural vegetation macrogroups are identified in the map, covering 99.87% of the state's natural terrestrial vegetation, and occupying 353,271 km2.

This serves as the foundation from which habitat types will be exposed to predicted changes in climate. Data are arrayed across 0 to 1 in terms of their exposure to current climate conditions. This data layer provides a baseline of vegetation adapted to "historic" conditions; i.e. climate conditions from the recent past; 1981-2010.

Data Resolution: 270m Raster

Data Units: 0- 1. Low values indicate higher resilience to threats. High values indicate significant exposure to climate change. -1 represents 'non analog' areas, i.e. locations that are outside the historic climate envelope of a given vegetation type.

Data Source: Information Center for the Environment, UC Davis

File Name: hst8110_scored.tif

Type and distribution of data: Asymmetric distribution representing index values. Raw data types range from 0.05 to 1.

Represent element and pillar: No

Translation: Where is protection from disturbances lowest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of low significant exposure to climate change (negative linear slope). More favorable (translated to +1) set at 0.05 probability, less favorable (translated to -1) set at the highest observed value of 1.00 probability.

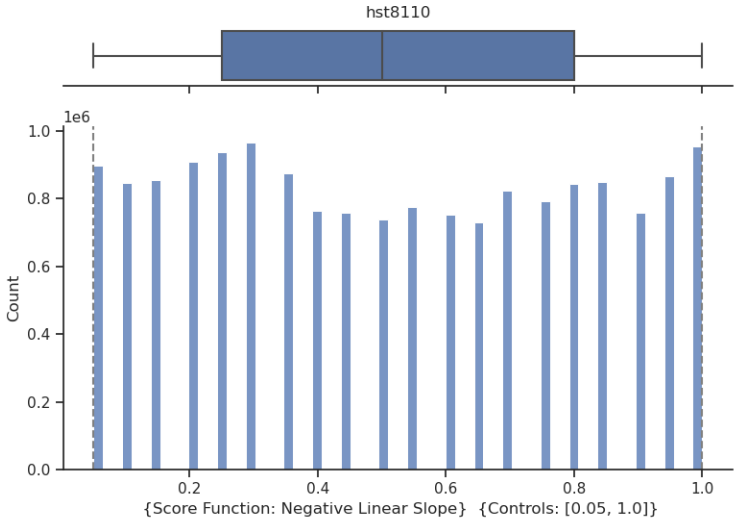

Figure 159. Histogram and scoring of potential climate refugia (baseline historical conditions) in Southern California

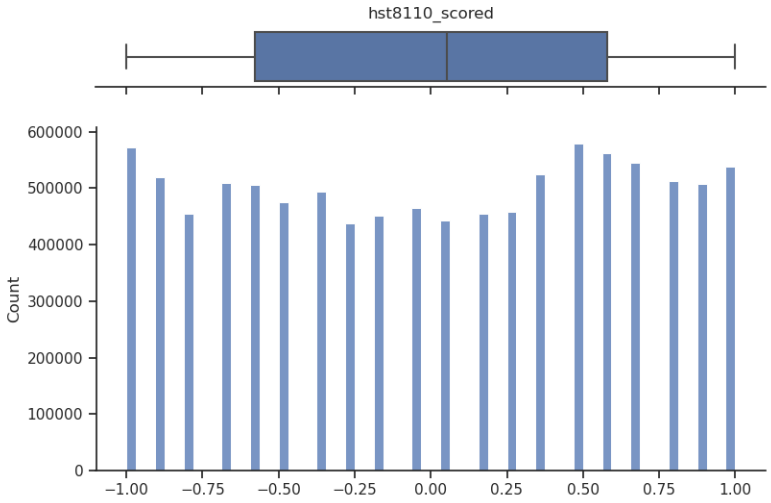

Figure 160. Histogram of translated potential climate refugia (baseline historical conditions) in Southern California

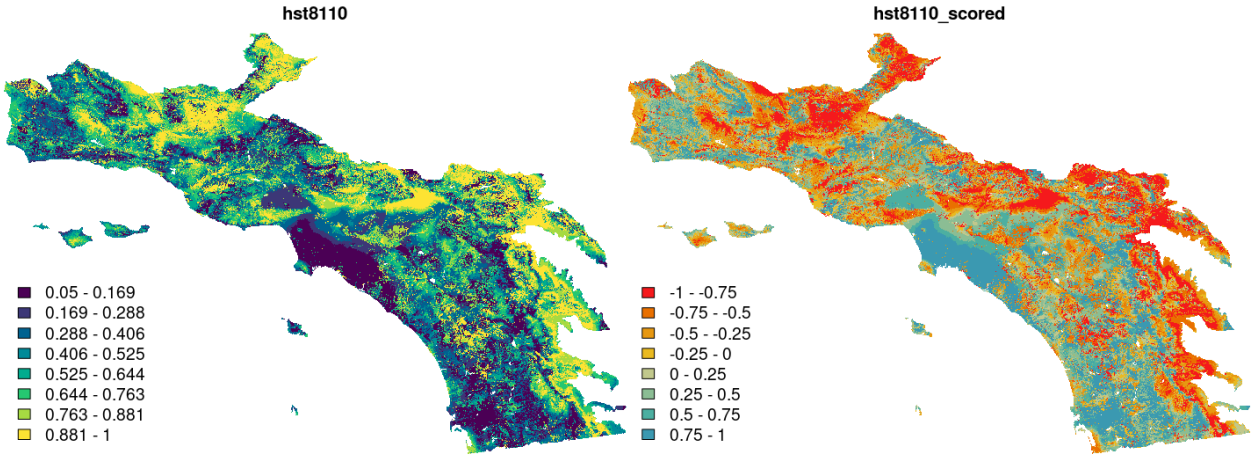

Figure 161. Maps displaying raw metric and translated metric potential climate refugia (baseline historical conditions) in Southern California

POTENTIAL CLIMATE REFUGIA – UNDER MODELED CLIMATE CHANGE (MIROC MODEL – HOTTER AND DRIER)

Tier: 3

Data Vintage: 2016

Metric Definition and Relevance: This raster dataset represents habitat types (CWHR habitat classes) and their predicted exposure to climate stress across the array of predicted climate conditions (separate layers for early (2010 - 2039), mid (2040-2069), and late century (2070-2099)) for all habitat types in comparison to the baseline climate conditions. This serves as the foundation from which habitat types will be exposed to predicted changes in climate. Data are arrayed across 0 to 1 in terms of their exposure to current climate conditions. These three data layers can be used to help land managers allocate limited resources for climate-adaptive field work by providing a view of climate risk that varies across the lands they manage.

The Climate Change Model used in this analysis is the MIROC Earth System Model. This ESM, named "MIROC-ESM", is based on a global climate model MIROC (Model for Interdisciplinary Research on Climate) which has been cooperatively developed by researchers in Japan and others. This model suggests a hotter and drier future. The emission scenario used is the RCP 8.5, which represents a range of warming statewide from 1.99 to 4.56°C and between a 24.8% decrease in precipitation and a 22.9% increase, respectively.

Data Resolution: 270m Raster

Data Units: 0- 1. Low values indicate higher resilience to threats. High values indicate significant exposure to climate change. -1 represents 'non analog' areas, i.e. locations that are outside the historic climate envelope of a given vegetation type.

Data Source: Information Center for the Environment, UC Davis

File Name: miroc_85_1039_scored.tif; miroc_85_4069_scored.tif; miroc_85_7099_scored.tif

Type and distribution of data: Asymmetric distribution representing index values. Raw data values range from 0.050 to 1.

Represent element and pillar: No

Translation: Where is protection from disturbances lowest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of low significant exposure to climate change (negative linear slope). More favorable (translated to +1) set at 0.05 probability, less favorable (translated to -1) set at the highest observed value of 1.00 probability.

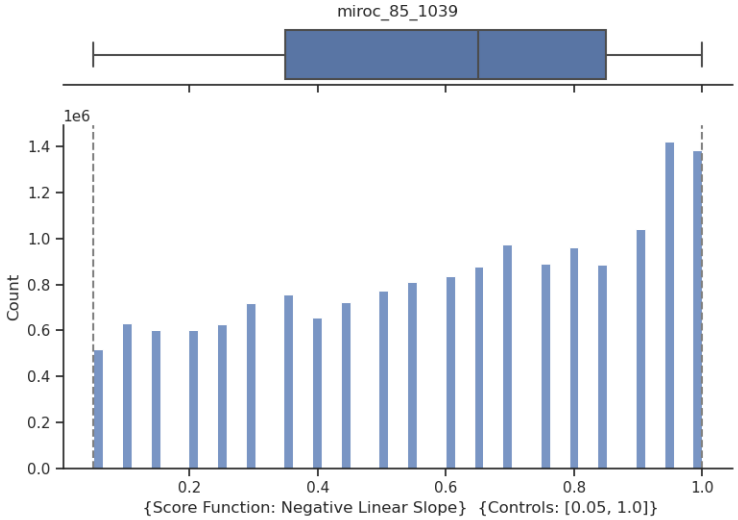

Figure 162. Histogram and scoring criterion of potential climate refugia, under modeled climate change, MIROC model 2010-2039, in Southern California

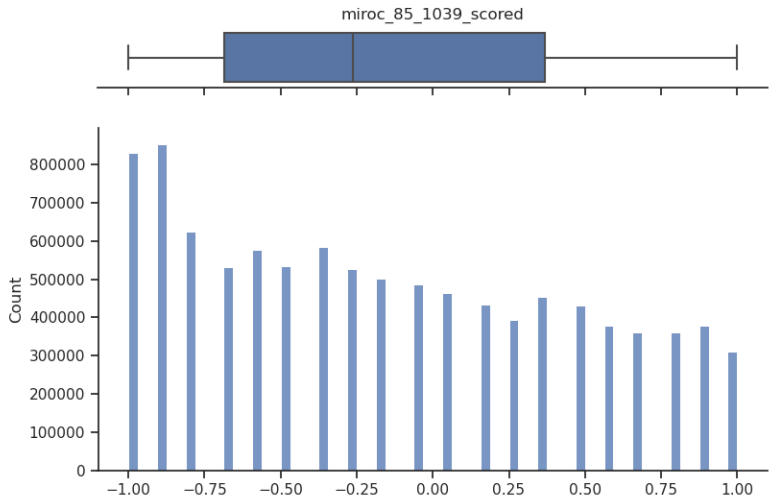

Figure 163. Histogram of translated potential climate refugia, under modeled climate change, MIROC model 2010-2039, in Southern California.

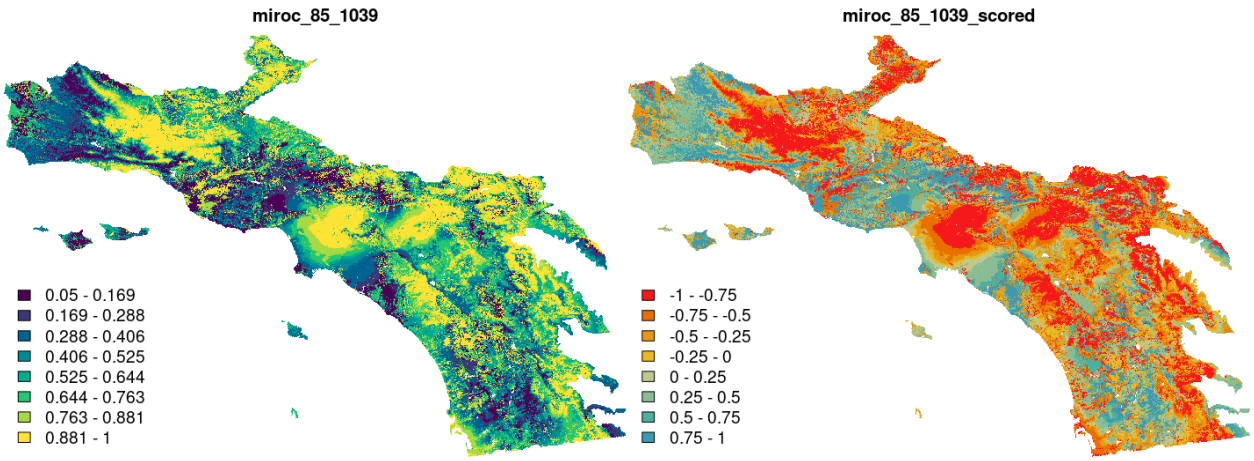

Figure 164. Maps displaying raw metric and translated metric potential climate refugia, under modeled climate change, MIROC model 2010-2039, in Southern California.

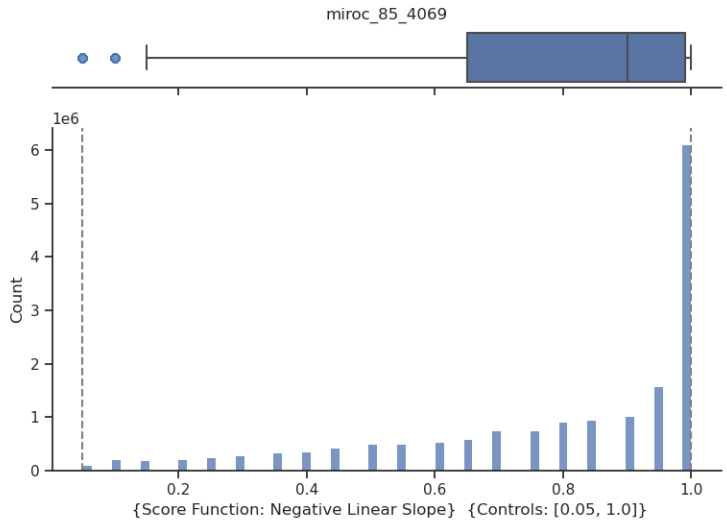

Figure 165. Histogram and scoring criterion of potential climate refugia, under modeled climate change, MIROC model 2040-2069, in Southern California.

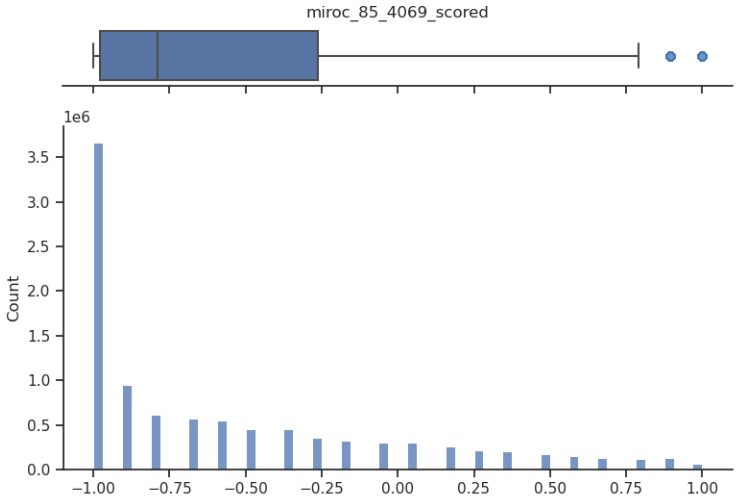

Figure 166. Histogram of translated potential climate refugia, under modeled climate change, MIROC model 2040-2069, in Southern California

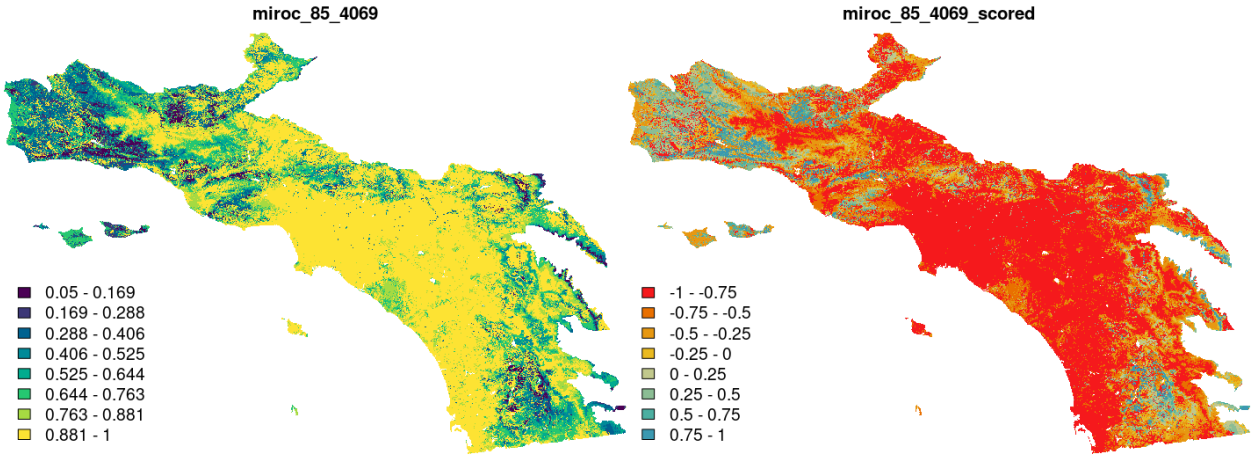

Figure 167. Maps displaying raw metric and translated metric potential climate refugia, under modeled climate change, MIROC model 2040-2069, in Southern California

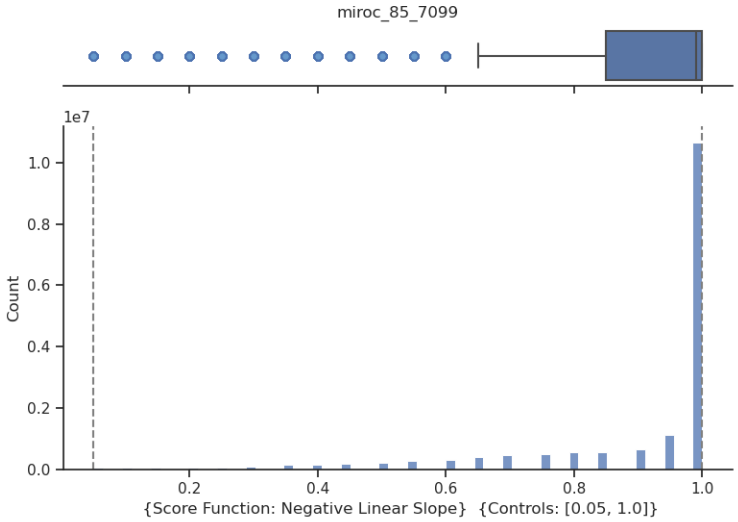

Figure 168. Histogram and scoring criterion of potential climate refugia, under modeled climate change, MIROC model 2070-2099, in Southern California

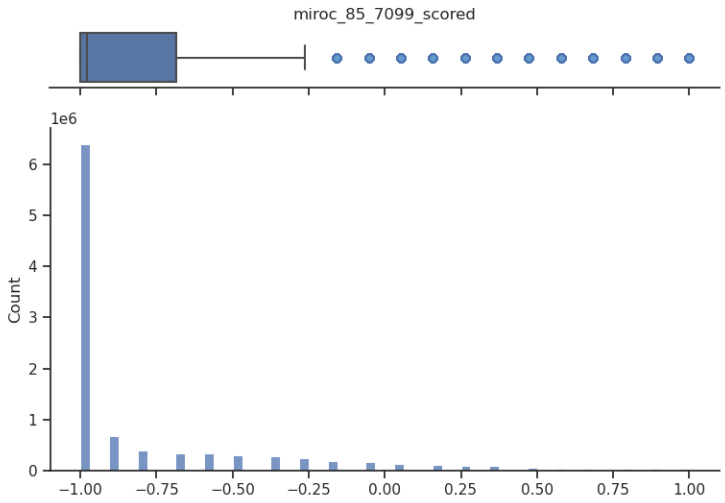

Figure 169. Histogram of translated potential climate refugia, under modeled climate change, MIROC model 2070-2099, in Southern California

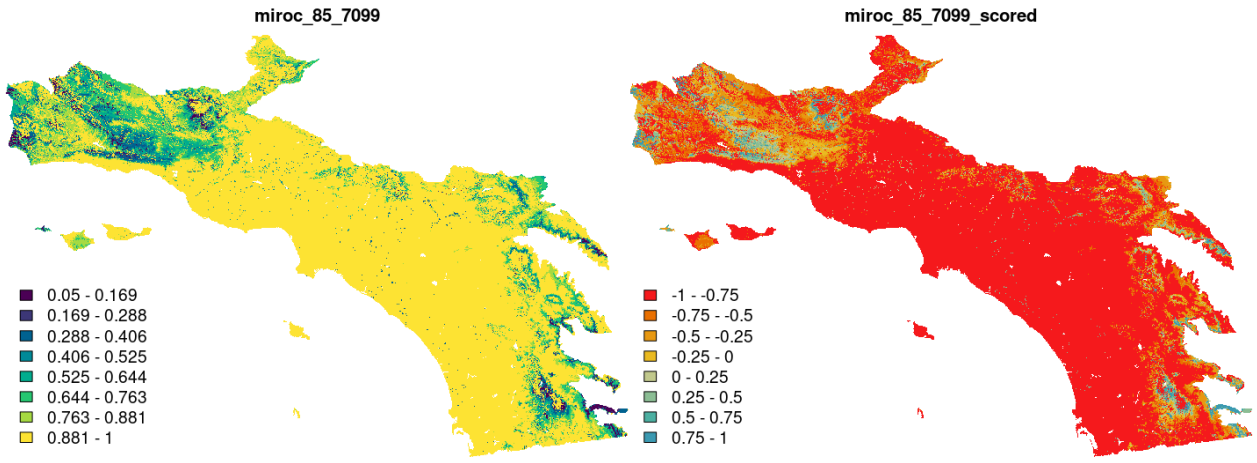

Figure 170. Maps displaying raw metric and translated metric potential climate refugia, under modeled climate change, MIROC model 2070-2099, in Southern California

POTENTIAL CLIMATE REFUGIA – UNDER MODELED CLIMATE CHANGE (MIROC MODEL – HOTTER AND DRIER) AND CNRM-CM5 (WETTER AND WARMER))

Tier: 3

Data Vintage: 2016

Metric Definition and Relevance: This raster dataset represents habitat types (Macro Veg Type, largely equivalent to CWHR habitat classes) and their predicted exposure to climate stress across the array of predicted climate conditions (separate layers for early (2010 - 2039), mid (2040-2069), and late century (2070-2099)) for all habitat types in comparison to the baseline climate conditions. This serves as the

foundation from which habitat types will be exposed to predicted changes in climate. Data are arrayed across 0 to 1 in terms of their exposure to current climate conditions. These three data layers can be used to help land managers allocate limited resources for climate-adaptive field work by providing a view of climate risk that varies across the lands they manage.

This analysis uses both the Miroc Earth System Model and the CNRM-CM5. CNRM-CM5 is an Earth system model designed to run climate simulations. It consists of several existing models designed independently and coupled through the OASIS software. Both were used under the RCP 8.5 emission scenario given that this is more likely under current emission levels.

This data layer is provided as a summary of likely exposure results. Exposure Scores:

- 1 = Refugia: CNRM-CM5 only (CNRM exposure values < 80%)
- 2 = Refugia: MIROC-ESM only (MIROC exposure values < 80%)
- 3 = Refugia Consensus (both models agree exposure values < 80%)
- **8 = High Exposure (both models agree exposure values >95%)**
- **9 = Very High Exposure (both models agree exposure values >99%)**

Data Resolution: 270m Raster

Data Units: 0, 1, 2, 3, 8, 9 Low values indicate higher resilience to threats. High values indicate significant exposure to climate change. -1 represents 'non analog' areas, i.e. locations that are outside the historic climate envelope of a given vegetation type.

Data Source: Information Center for the Environment, UC Davis

File Name: combine85_all7_scored.tif

Type and distribution of data: Asymmetric distribution representing index values. Raw data values range from 1 to 6994.

Represent element and pillar: No

Translation: Where is protection from disturbances lowest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of low significant exposure to climate change (negative linear slope). More favorable (translated to +1) set at 0 probability, less favorable (translated to -1) set at > 6994.

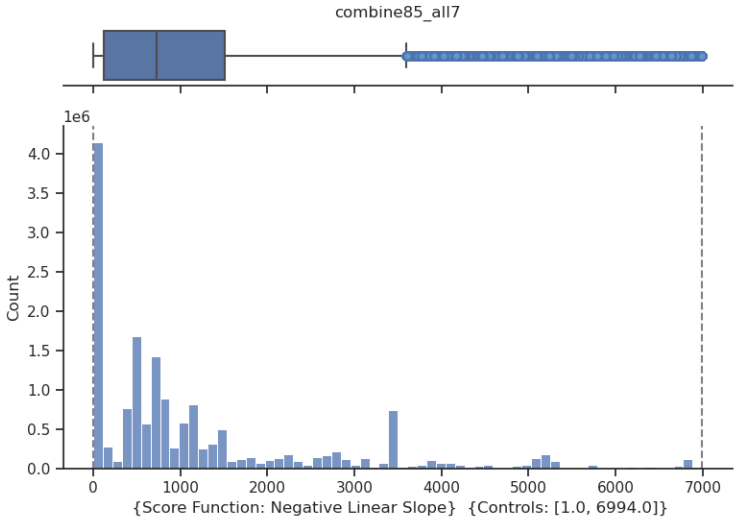

Figure 171. Histogram and scoring criterion of potential climate refugia, under combined modeled climate change, MIROC model and CNRM-CM5, in Southern California

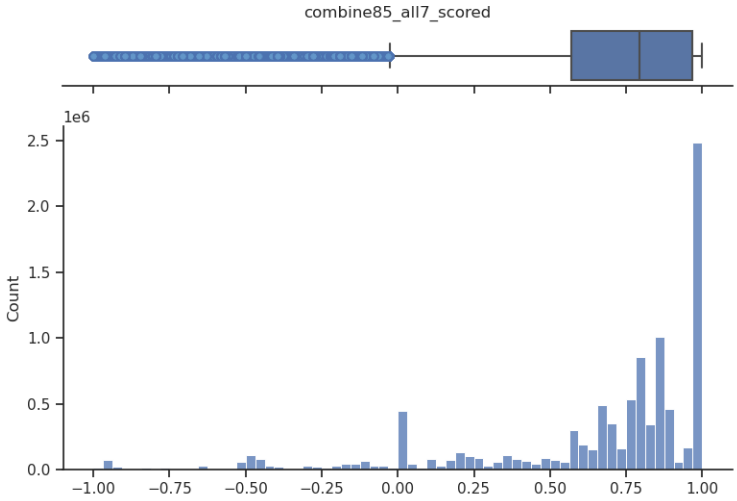

Figure 172. Histogram of translated potential climate refugia, under combined modeled climate change, MIROC model and CNRM-CM5, in Southern California

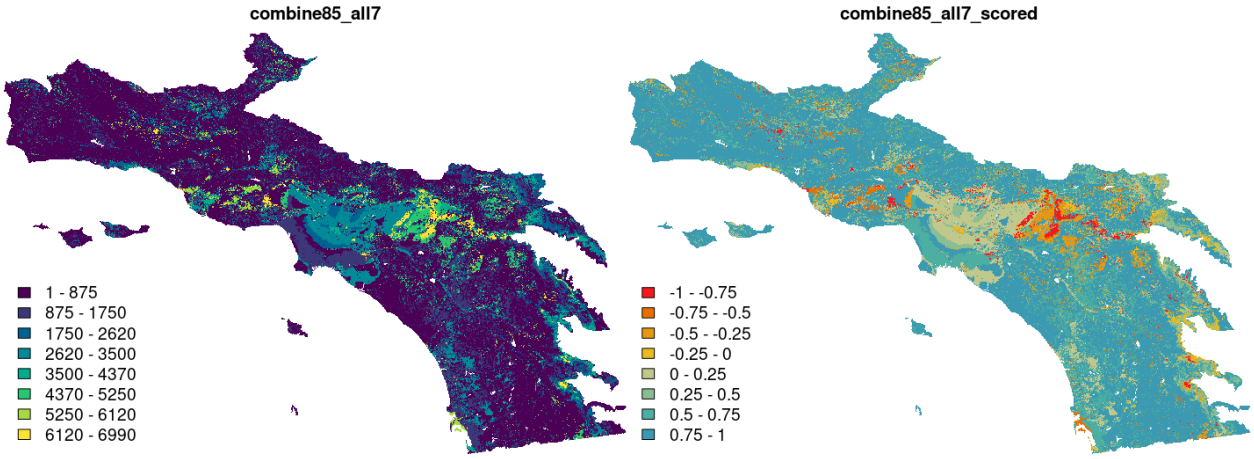

Figure 173. Maps displaying raw metric and translated metric potential climate refugia, under combined modeled climate change, MIROC model and CNRM-CM5, in Southern California.

FUTURE CONDITION

Metric definition and relevance: This model evaluates the likelihood and severity of dominant vegetation type conversion under climate change. The LANDFIRE Biophysical Setting (BpS) data were used represent natural potential vegetation for a given cell based on its biophysical setting and subjected to a "natural" disturbance regime (LANDFIRE 2020). This was chosen over existing vegetation to remove the influence of recent disturbances on focal and climate analog cells and to represent potential change in dominant vegetation type due to changes in climate. These methods were similar to those used by Parks et al. (2018) who looked at climate analogues across the western US and characterized potential future vegetation under projected climate change constraints.

Data Resolution: 1-km, resampled to 30-m to match current conditions data

Data Units: Translated strength of evidence score. Values near -1 indicate large changes in the fire regime are likely, while values near +1 indicate little to no change is expected.

Data Source: LANDFIRE Biophysical Setting (BpS) (LANDFIRE 2020).

File Name: forestShrubResil030_future.tif

Future climate stability interpretation: Each of the six main BpS vegetation groups were ranked to represent an approximate functional distance among types (Table 2). Absolute difference between current vegetation group and each of the 100 climate analog types was calculated for each focal cell in the Sierras. For example, a larger difference would be recorded for a conifer to grassland transition compared to a conifer to hardwood transition. An analogue SOE score of +1 where the vegetation type stayed the same, and a -1 where the absolute difference from the focal vegetation group rank was >4. The value of 4 roughly corresponded to shifts from tree-dominated to non-forest types. The Sigma score, which also varies from +1 to -1 reflecting the representativeness of each climate analogue (+1 indicates strong climate match, -1 indicates weak climate match), is combined with the analogue score

(lowest score; the And operator) to derive the stability score. This emphasized the role of non-analogue conditions by scoring these analogues lower regardless of their ecological score.

Table 2. Ordinal rankings for the six main BpS vegetation groups assessed in the climate analogevaluation. All other groups were not assessed.

Ordinal	BPS Group
1	Conifer
2	Hardwood-Conifer
3	Hardwood
6	Shrubland
8	Grassland
10	Sparse
NA	Barren-Rock/Sand/Clay
NA	Open Water
NA	Perennial Ice/Snow
NA	Fill-Not Mapped
NA	Riparian

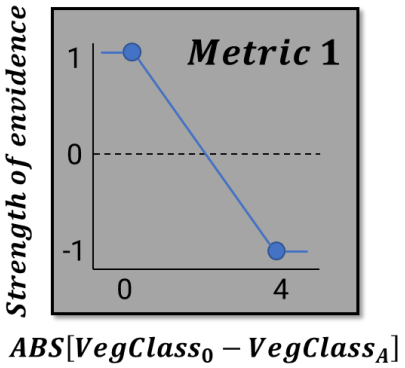

Figure 174. Fuzzy logic for evaluating potential vegetation type changes using the rankings found in **Table 2**

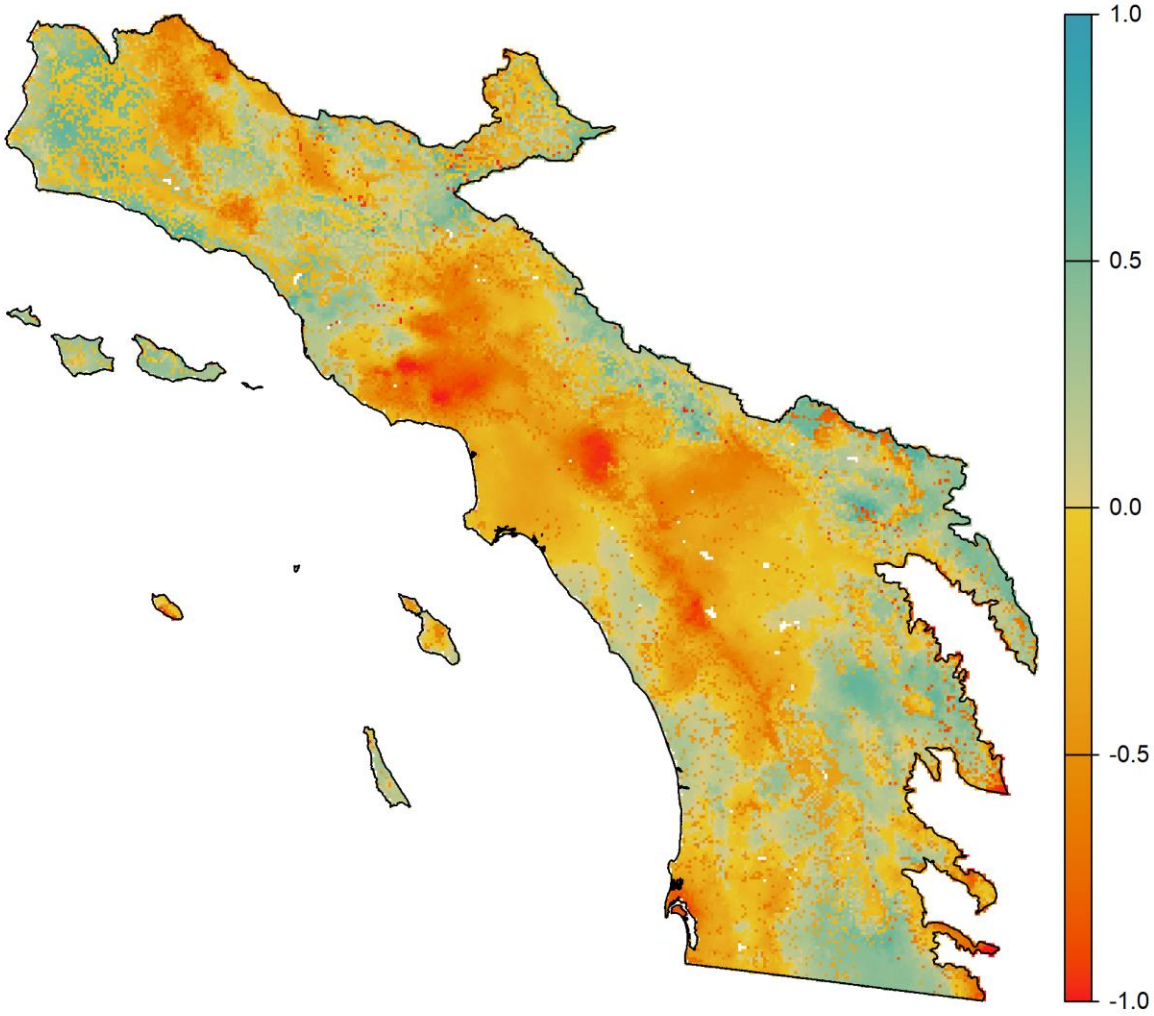

Figure 175. Images of climate constraint assessment for the Forest Resilience pillar. Dark blue colors (positive strength of evidence scores) indicate minimal differences among focal cells and their respective 100 climate analog locations; dark red colors indicate a high degree of change.

SOCIAL AND CULTURAL WELL-BEING

The landscape provides a place for people to connect with nature, recreate, to maintain and improve their overall health, and an opportunity to contribute to environmental stewardship. While the elements of this pillar include public health and engagement, recreation quality, and equitable opportunities producing quantifiable, measurable, and actionable metrics remains challenging. These metrics are still under development and insights into these potential metrics are appreciated.

Desired Outcome: The landscape provides a place for people to connect with nature, to recreate, to maintain and improve their overall health, and to contribute to environmental stewardship, and is a critical component of their identity.

CURRENT CONDITIONS

PILLAR REPRESENTATION

The social and cultural well-being pillar has four elements (public health, engagement, recreation quality, and equitable opportunity), but the Southern California RRK only describes one of the four elements: equitable opportunity, which is where environmental justice resides.

Data Units: Condition score, +1 to -1

File Name: socialCultural.tif

Translation: Where is social and cultural well-being greatest?

Translation method and outcome: Values range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of greater well-being.

ELEMENT REPRESENTATION: EQUITABLE OPPORTUNITY

Equitable Opportunity is the fair treatment and meaningful involvement of all people regardless of race, color, national origin or income regarding the development, implementation and enforcement of environmental laws, regulations policies and land management.

The equitable opportunity element is described by twelve metrics: four that are generated by California (poverty percentile, housing burden percentile, unemployment percentile, and tribal land designations), and one generated by San Diego State University (trail density), and seven generated by the United States Census Bureau (American Indian or Alaska Native race alone and multirace population concentration, Hispanic/Latino population concentration, Black/African American population concentration, Hispanic and/or Black, Indigenous or Person of Color (HSPBIPOC), Asian population concentration, multi-race not American Indian population concentration, low income population concentration). Resilience at the element level is represented by the average condition of five metrics

(indicated by asterisks): poverty percentile, housing burden percentile, unemployment percentile, tribal land designations, and trail density). The condition scores for each of these metrics are averaged to derive a condition score for the equitable opportunity element.

File Name: envJustice.tif

Translation: Where is equitable opportunity greatest?

Translation method and outcome: Values range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of more equitable opportunity.

POVERTY PERCENTILE *

Tier: 1

Data Vintage: 10/2021

Metric Definition and Relevance: Percent of population living below two times the federal poverty level. The U.S. Census Bureau determines the federal poverty level each year. The poverty level is based on the size of the household and the age of family members. If a person or family's total income before taxes is less than the poverty level, the person or family are considered in poverty. Many studies have found that people living in poverty are more likely than others to become ill from pollution.

Data Resolution: 30m Raster

Data Units: Percent, 0 to 100, population below 2 * poverty level

Data source: California Environmental Protection Agency, CalEnviroScreen 4.0

File name: Poverty_Pctl_scored.tif

Represent element and pillar: Yes

Type and distribution of data: Asymmetric distribution representing percent values. Raw data range from 0.05 to 100.

Translation: Where is poverty percentile the lowest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively, with investments begin directed at less favorable areas to improve conditions, in this case to infuse resources into communities that are most in need. The proposition of more favorable is based on the objective of understanding where community investments are less critical (negative linear slope). More favorable (translated to +1) set at 0.05% low-income populations, and less favorable (translated to -1) set at 100% low income.

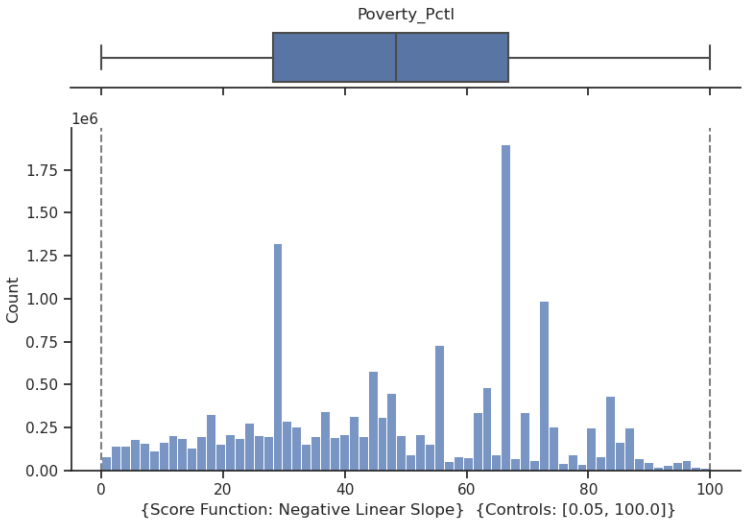

Figure 176. Histogram and scoring criterion of current condition for poverty percentile across the Southern California

Figure 177. Histogram of translated current condition for low-income population across the Southern California

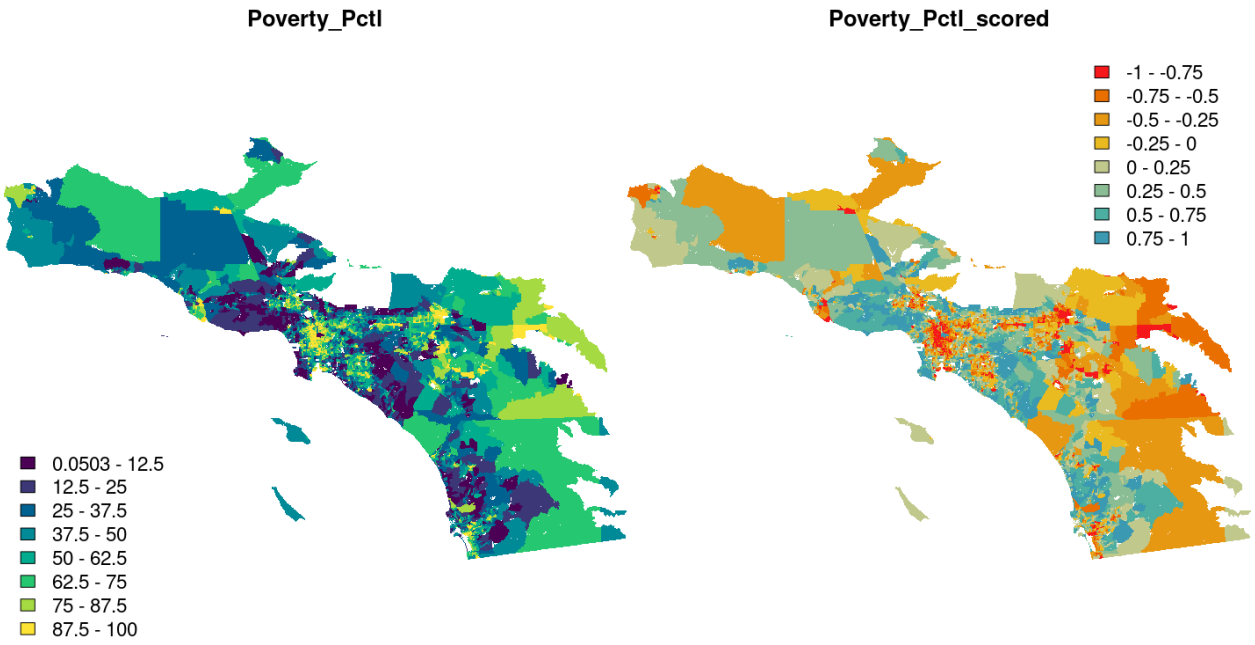

Figure 178. Maps displaying raw metric and translated metric of current condition poverty percentile across the Southern California

HOUSING BURDEN PERCENTILE *

Tier: 1

Data Vintage: 10/2021

Metric Definition and Relevance: Housing-Burdened Low-Income Households. Percent of households in a census tract that are both low income (making less than 80% of the HUD Area Median Family Income) and severely burdened by housing costs (paying greater than 50% of their income to housing costs). (5-year estimates, 2013-2017).

The cost and availability of housing is an important determinant of well-being. Households with lower incomes may spend a larger proportion of their income on housing. The inability of households to afford necessary non-housing goods after paying for shelter is known as housing-induced poverty. California has very high housing costs relative to much of the country, making it difficult for many to afford adequate housing. Within California, the cost of living varies significantly and is largely dependent on housing cost, availability, and demand.

Areas where low-income households may be stressed by high housing costs can be identified through the Housing and Urban Development (HUD) Comprehensive Housing Affordability Strategy (CHAS) data. We measure households earning less than 80% of HUD Area Median Family Income by county and paying greater than 50% of their income to housing costs. The indicator takes into account the regional cost of living for both homeowners and renters, and factors in the cost of utilities. CHAS data are calculated from US Census Bureau's American Community Survey (ACS).

Data Resolution: 30m Raster

Data Units: Percent, 0 to 100

Data source: California Environmental Protection Agency, CalEnviroScreen 4.0

File name: HousingBurdenPctl_scored.tif

Represent element and pillar: Yes

Type and distribution of data: Asymmetric distribution representing percent values. Raw data range from 0.038 to 100.

Translation: Where is housing burden percentile the lowest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively, with investments begin directed at less favorable areas to improve conditions, in this case to infuse resources into communities that are most in need. The proposition of more favorable is based on the objective of understanding where community investments are less critical (negative linear slope). More favorable (translated to +1) set at 0.038% low income household populations, and less favorable (translated to -1) set at 100% low income household populations.

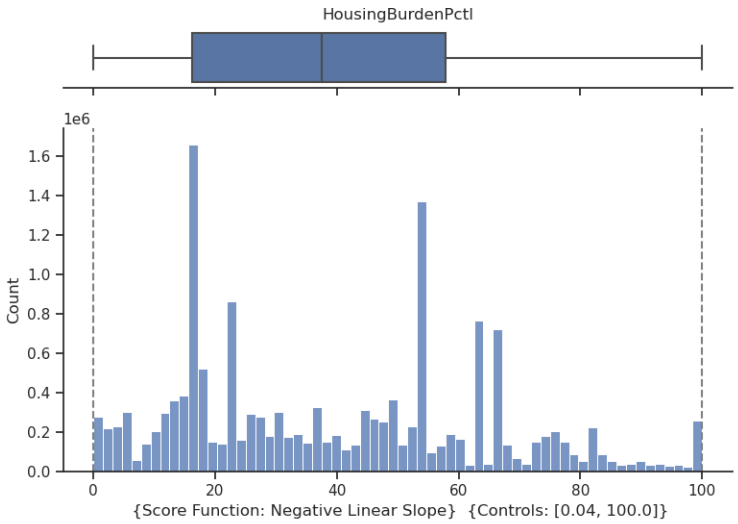

Figure 179. Histogram and scoring criterion of current condition for housing burden percentile across the Southern California

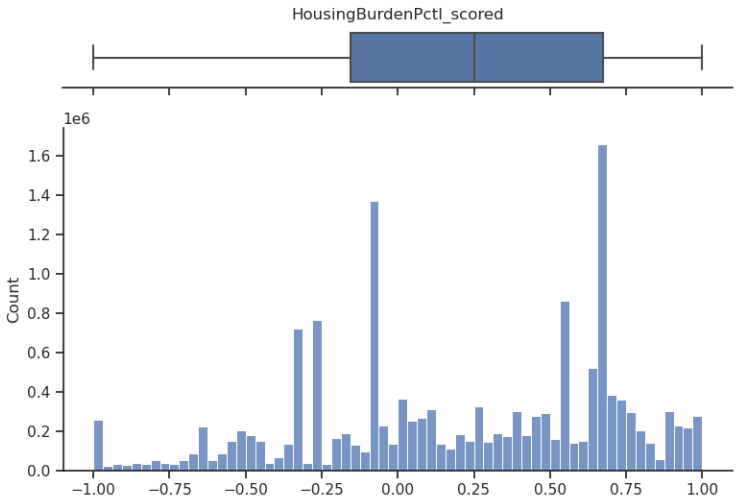

Figure 180. Histogram of translated current condition for housing burden percentile across the Southern California

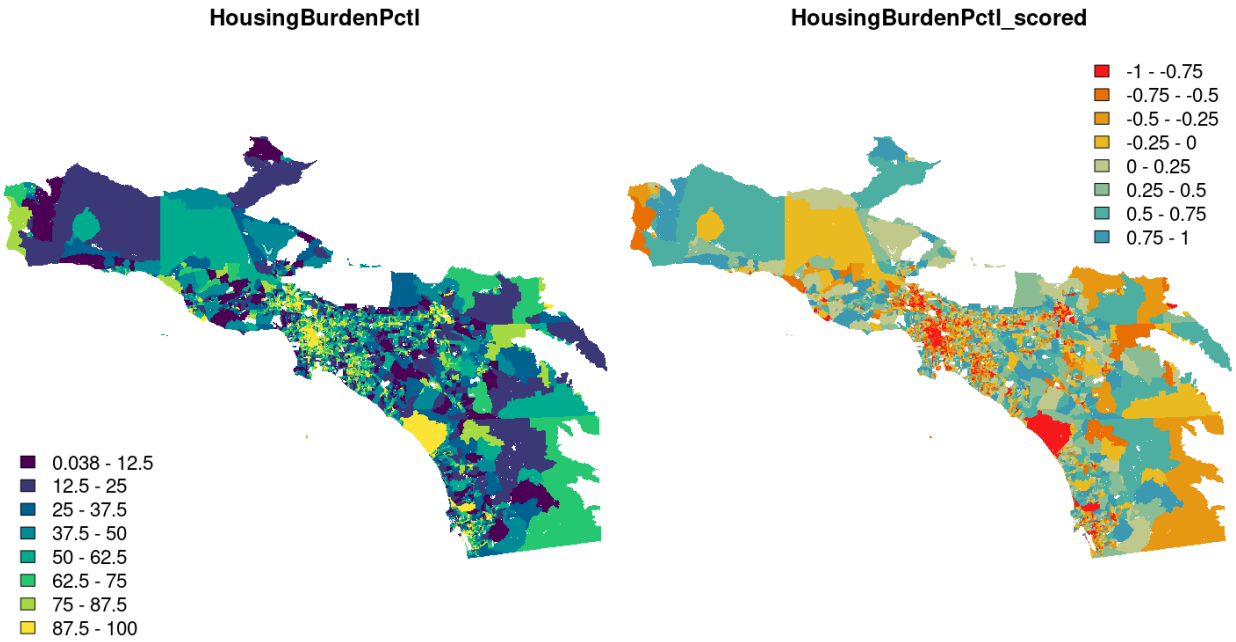

Figure 181. Maps displaying raw metric and translated metric of current condition for housing burden percentile across the Southern California

UNEMPLOYMENT PERCENTILE *

Tier: 1

Data Vintage: 10/2021

Metric Definition and Relevance: Percentage of the population over the age of 16 that is unemployed and eligible for the labor force. Excludes retirees, students, homemakers, institutionalized persons except prisoners, those not looking for work, and military personnel on active duty (5-year estimate, 2015-2019).

Because low socioeconomic status often goes hand-in-hand with high unemployment, the rate of unemployment is a factor commonly used in describing disadvantaged communities. On an individual level, unemployment is a source of stress, which is implicated in poor health reported by residents of such communities. Lack of employment and resulting low income often constrain people to live in neighborhoods with higher levels of pollution and environmental degradation.

Data Resolution: 30m Raster

Data Units: Percent, 0 to 100, unemployed population

Data Source: California Environmental Protection Agency, CalEnviroScreen 4.0

File Name: Unemployment_Pctl_scored.tif

Represent element and pillar: Yes

Type and distribution of data: Asymmetric distribution representing percent values. Raw data range from 0 to 100.

Translation: Where is unemployment percentile the lowest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively, with investments begin directed at less favorable areas to improve conditions, in this case to infuse resources into communities that are most in need. The proposition of more favorable is based on the objective of understanding where community investments are less critical (negative linear slope). More favorable (translated to +1) set at 0% unemployment population, and less favorable (translated to -1) set at 100% unemployment population.

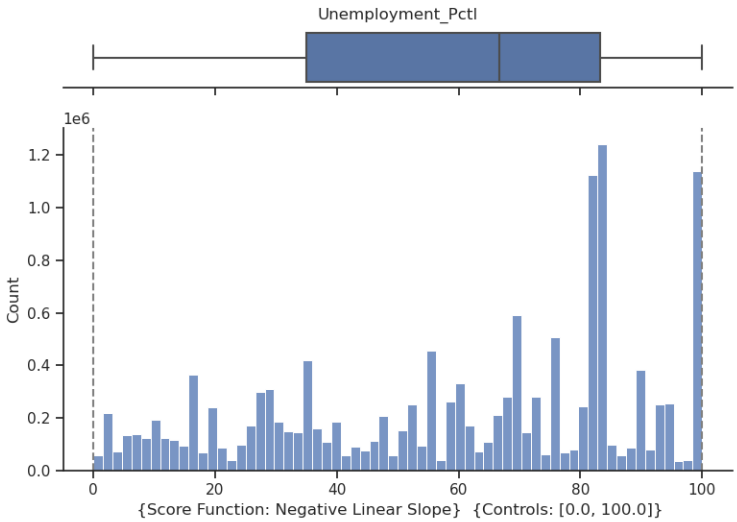

Figure 182. Histogram and scoring criterion of current condition of unemployment percentile across the Southern California

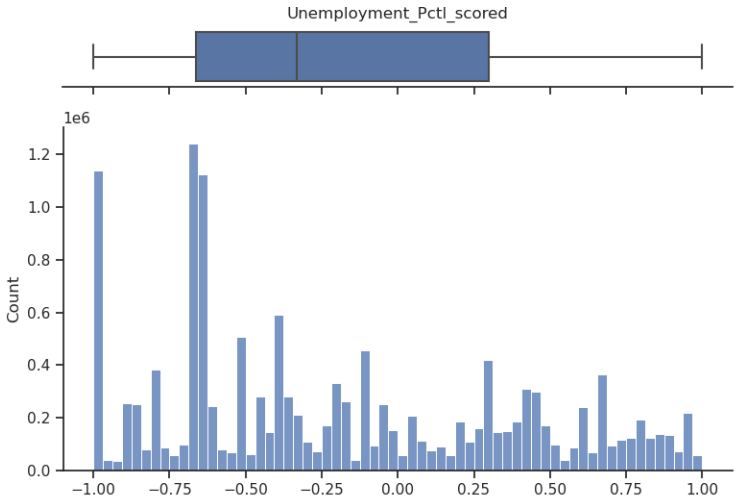

Figure 183. Histogram of translated current condition of unemployment percentile across the Southern California

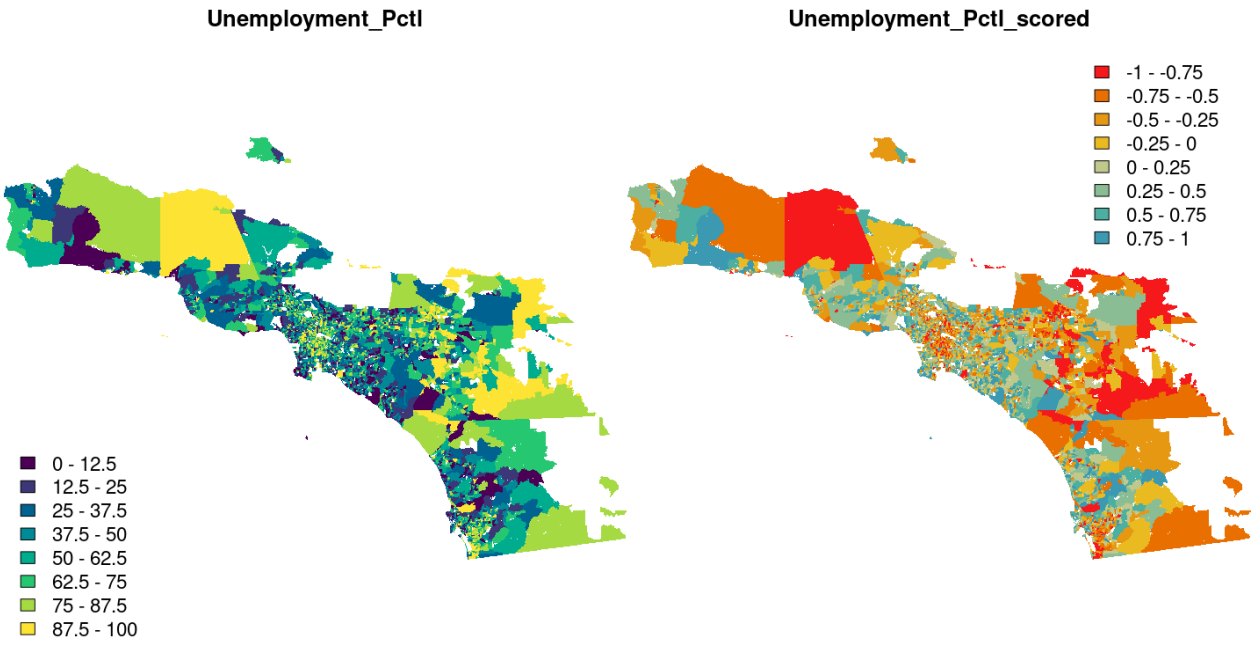

Figure 184. Maps displaying raw metric and translated metric of current condition of unemployment percentile across the Southern California

TRIBAL LAND DESIGNATIONS *

Tier: 1

Data Vintage: 2022

Metric Definition and Relevance: Lands under the control of federally recognized Tribes. These boundaries have been clipped to the boundary of California so that only the portions of each Tribal area that fall within California are included. For purposes of this designation, a Tribe may establish that a particular area of land is under its control even if not represented as such on CalEPA's DAC map and therefore should be considered a DAC by requesting a consultation with the CalEPA Deputy Secretary for Environmental Justice, Tribal Affairs and Border Relations at TribalAffairs@calepa.ca.gov

Data Resolution: 30m Raster

Data Units: Binary, 0 (Presence), 1 (Absence)

Data source: California Environmental Protection Agency, CalEnviroScreen 4.0

File name: SB535tribalboundaries2022_scored.tif

Represent element and pillar: Yes

Type and distribution of data: Binary distribution representing presences/absences. Raw data range from 1 to 1.

Translation: Where are tribal land designations?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of understanding where community investments are more critical (positive linear slope). More favorable (translated to +1) set at 1, and less favorable (translated to -1) set at > 0.

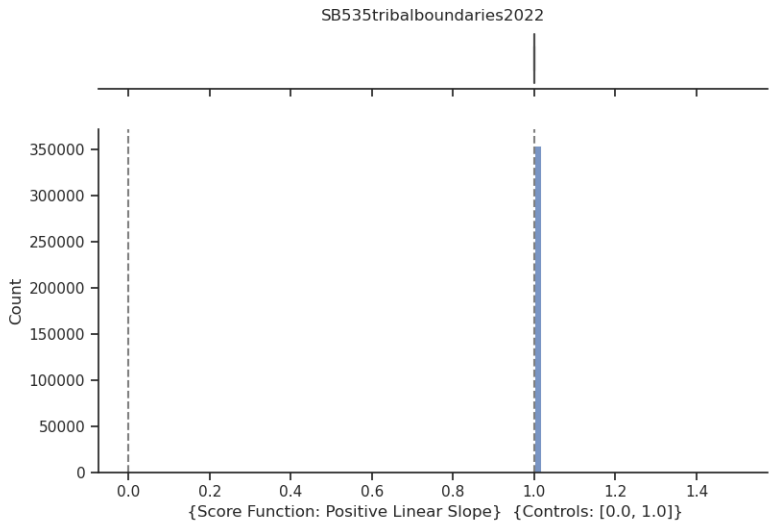

Figure 185. Histogram and scoring criterion of current condition of tribal boundaries across the Southern California

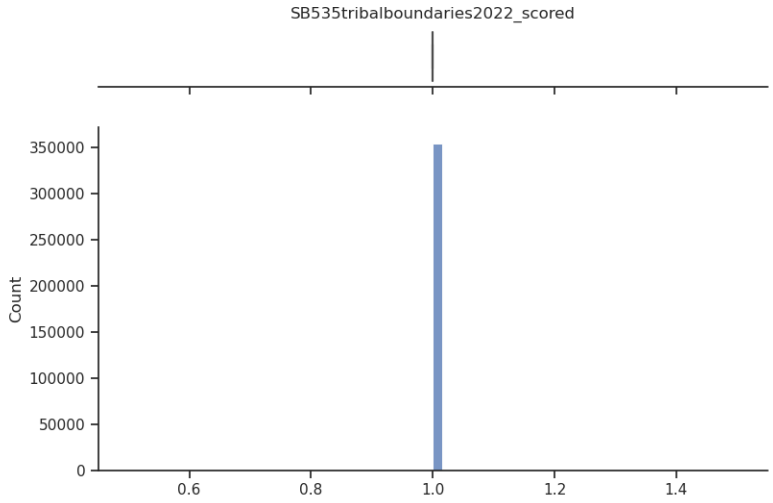

Figure 186. Histogram of translated current condition of tribal boundaries across the Southern California

Figure 187. Maps displaying the raw metric and translated metric of tribal boundaries across Southern California

TRAIL DENSITY *

Tier: 2

Data Vintage: 2023

Metric Definition and Relevance: A raster dataset representing density of trails in the Southern California Region.

Data Resolution: 30m Raster

Data Units: Continuous, km/km2 of trails

Data source: San Diego State University CWC Project Team

File name: Trail_Density_scored.tif

Represent element and pillar: Yes

Type and distribution of data: Zero-inflated, right-skewed distribution representing continuous values. Raw data ranges from 0 to 16.525.

Translation: Where is trail density the highest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of higher trail density (positive linear slope). More favorable (translated to +1) set at 4.846, and less favorable (translated to -1) set at > 0.

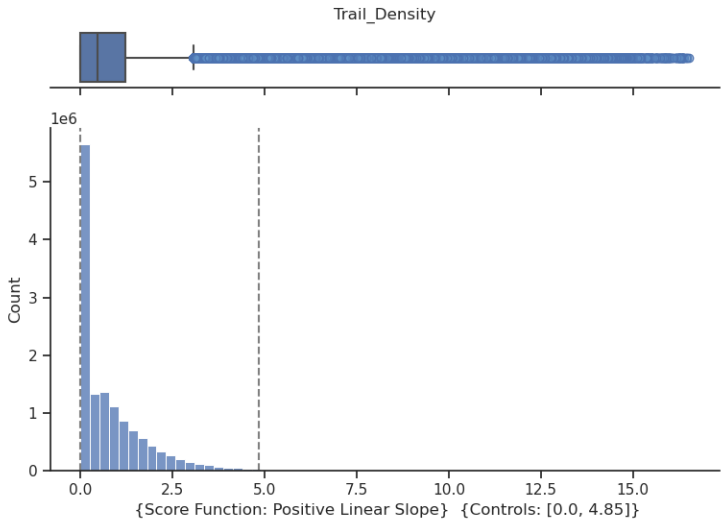

Figure 99. Histogram and scoring criterion of current condition of unemployment percentile across the Southern California

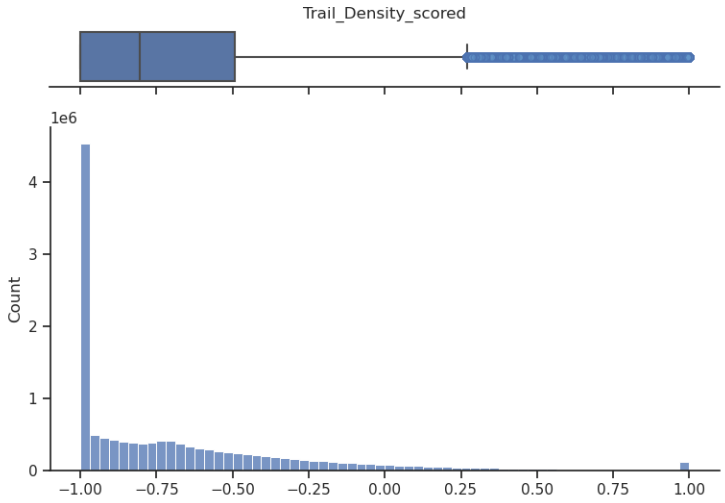

Figure 100. Histogram and scoring criterion of current condition of unemployment percentile across the Southern California

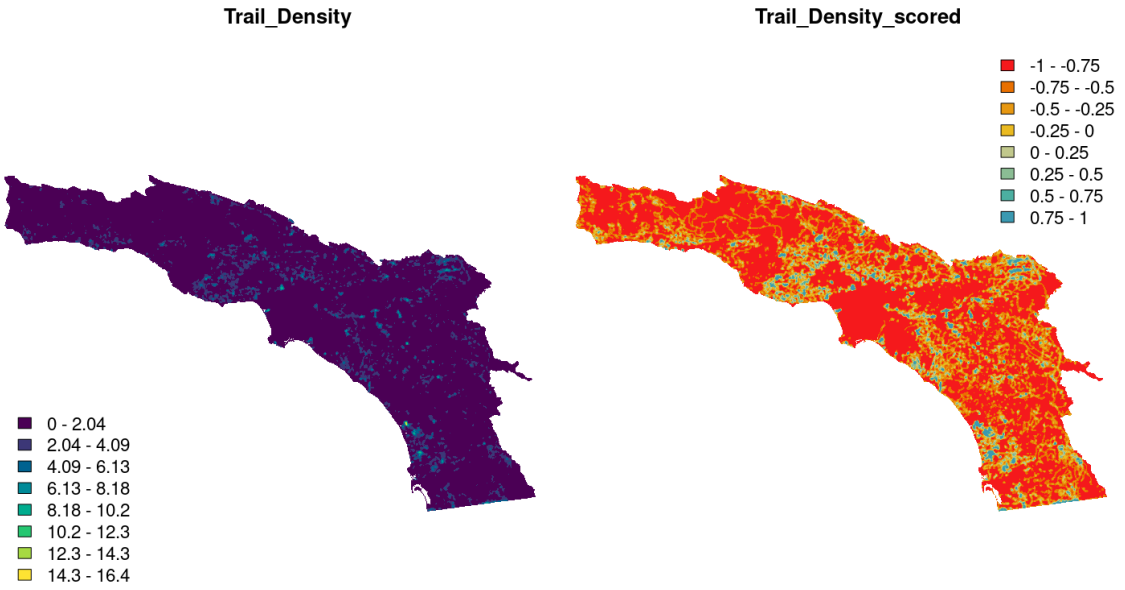

Figure 101. Maps displaying raw metric and translated metric of trail density across Southern California

AMERICAN INDIAN OR ALASKA NATIVE RACE ALONE AND MULTIRACE POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Southern California region's American Indian population. The variable AIAN_ALN_AND_MULTIRACE_AIANALN includes BOTH individuals who select American Indian or Alaska Native as their sole racial identity (they *only* identify as American Indian), AND individuals who select American Indian / Alaska Native as one of two or more racial identities (they *partly* identify as American Indian) in response to the Census questionnaire. IMPORTANT: this self reported ancestry and Tribal membership are distinct identities and one does not automatically imply the other. These data should not be interpreted as a distribution of "Tribal people." Numerous Rancherias in the Southern California region account for the wide distribution of very to extremely high concentrations of American Indians.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as American Indian / Alaska Native alone to the proportion of all people that live within the 13,312 block groups in the Southern California RRK region that identify as American Indian / Alaska native alone. Example: if 5.2% of people in a block group identify as AIANALN, the block group has twice the proportion of AIANALN individuals compared to the Southern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then AIANALN individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total

- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total

- Class Code 3: *Proportionate.* The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion

- Class Code 4: *Somewhat high.* The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total

- Class Code 5: *High.* The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total

- Class Code 6: *Very high.* The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Southern California region population in total

- Class Code 7: *Extremely high.* The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Southern California region population in total (the upper limit is determined by natural breaks,if exceptional outliers are present, but is typically over 6 times (600%)

- Class Code 8: *Exceptionally high.* The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region

- Class Code 99: *Unclassifiable.* The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Data source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: AmerIndianAndMultiRace_2020.tif

Translation: None

HISPANIC/LATINO POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Southern California region's Hispanic/Latino population. The variable HISPANIC records all individuals who select Hispanic or Latino in response to the Census questionnaire, regardless of their response to the racial identity question.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as American Indian / Alaska Native alone to the proportion of all people that live within the 1,207 block groups in the Southern California RRK region that identify as American Indian / Alaska native alone. Example: if 5.2% of people in a block group identify as HISPANIC, the block group has twice the proportion of HISPANIC individuals compared to the Southern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then HISPANIC individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total

- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total

- Class Code 3: *Proportionate.* The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion

- Class Code 4: *Somewhat high.* The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total

- Class Code 5: *High.* The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total

- Class Code 6: *Very high.* The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Southern California region population in total

- Class Code 7: *Extremely high.* The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Southern California region population in total (the upper limit is determined by natural breaks,if exceptional outliers are present, but is typically over 6 times (600%)

- Class Code 8: *Exceptionally high.* The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region

- Class Code 99: *Unclassifiable.* The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Data source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: Hispanic_2020.tif

Translation: None

BLACK/AFRICAN AMERICAN POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Southern California region's Black/African American population. The variable BLACKALN records all individuals who select black or African American as their SOLE racial identity in response to the Census questionnaire, regardless of their response to the Hispanic ethnicity question. Both Hispanic and non-Hispanic in the Census questionnaire are potentially associated with black race alone.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as Black/African American alone to the proportion of all people that live within the 1,207 block groups in the Southern California RRK region that identify as Black/African American alone. Example: if 5.2% of people in a block group identify as BLACKALN, the block group has twice the proportion of BLACKALN individuals compared to the Southern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then BLACKALN individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total

- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total

- Class Code 3: *Proportionate.* The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion

- Class Code 4: *Somewhat high.* The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total

- Class Code 5: *High.* The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total

- Class Code 6: *Very high.* The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Southern California region population in total

- Class Code 7: *Extremely high.* The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Southern California region population in total (the upper limit is determined by natural breaks,if exceptional outliers are present, but is typically over 6 times (600%)

- Class Code 8: *Exceptionally high.* The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region

- Class Code 99: *Unclassifiable.* The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Data source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: Black _2020.tif

Translation: None

HISPANIC AND/OR BLACK, INDIGENOUS OR PERSON OF COLOR (HSPBIPOC)

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: : Relative concentration of the Southern California region's Black/African American population. The variable HSPBIPOC is equivalent to all individuals who select a combination of racial and ethnic identity in response to the Census questionnaire EXCEPT those who select "not Hispanic" for the ethnic identity question, and "white race alone" for the racial identity question. This is the most encompassing possible definition of racial and ethnic identities that may be associated with historic underservice by agencies, or be more likely to express environmental justice concerns (as compared to predominantly non-Hispanic white communities). Until 2021, federal agency guidance for considering environmental justice impacts of proposed actions focused on how the actions

affected "racial or ethnic minorities." "Racial minority" is an increasingly meaningless concept in the USA, and particularly so in California, where only about 3/8 of the state's population identifies as non-Hispanic and white race alone - a clear majority of Californians identify as Hispanic and/or not white. Because many federal and state map screening tools continue to rely on "minority population" as an indicator for flagging potentially vulnerable / disadvantaged/ underserved populations, our analysis includes the variable HSPBIPOC which is effectively "all minority" population according to the now outdated federal environmental justice direction. A more meaningful analysis for the potential impact of forest management actions on specific populations considers racial or ethnic populations individually: e.g., all people identifying as Hispanic regardless of race; all people identifying as American Indian, regardless of Hispanic ethnicity; etc.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as HSPBIPOC alone to the proportion of all people that live within the 1,207 block groups in the Southern California RRK region that identify as HSPBIPOC alone. Example: if 5.2% of people in a block group identify as HSPBIPOC, the block group has twice the proportion of HSPBIPOC individuals compared to the Southern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then HSPBIPOC individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total

- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total

- Class Code 3: *Proportionate.* The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion

- Class Code 4: *Somewhat high.* The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total

- Class Code 5: *High.* The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total

- Class Code 6: *Very high.* The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Southern California region population in total

- Class Code 7: *Extremely high.* The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Southern California region population in total (the upper limit is determined by natural breaks,if exceptional outliers are present, but is typically over 6 times (600%)

- Class Code 8: *Exceptionally high.* The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region

- Class Code 99: *Unclassifiable.* The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Data source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: HSPBIPOC _2020.tif

Translation: None

ASIAN POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the Southern California region's Asian American population. The variable ASIANALN records all individuals who select Asian as their SOLE racial identity in response to the Census questionnaire, regardless of their response to the Hispanic ethnicity question. Both Hispanic and non-Hispanic in the Census questionnaire are potentially associated with the Asian race alone.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identify as ASIANALN alone to the proportion of all people that live within the

1,207 block groups in the Southern California RRK region that identify as ASIANALN alone. Example: if 5.2% of people in a block group identify as HSPBIPOC, the block group has twice the proportion of ASIANALN individuals compared to the Southern California RRK region (2.6%), and more than three times the proportion compared to the entire state of California (1.6%). If the local proportion is twice the regional proportion, then ASIANALN individuals are highly concentrated locally.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total

- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total

- Class Code 3: *Proportionate.* The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion

- Class Code 4: *Somewhat high.* The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total

- Class Code 5: *High.* The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total

- Class Code 6: *Very high.* The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Southern California region population in total

- Class Code 7: *Extremely high.* The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Southern California region population in total (the upper limit is determined by natural breaks,if exceptional outliers are present, but is typically over 6 times (600%)

- Class Code 8: *Exceptionally high.* The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region

- Class Code 99: *Unclassifiable.* The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Data source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: Asian _2020.tif

Translation: None

MULTI-RACE EXCEPT PART-AMERICAN INDIAN POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: The Relative concentration of the Southern California region's population that identifies as "Multiracial", EXCEPT those with part-American Indian identity, in response to the Census questionnaire. "Relative concentration" is a measure that compares the proportion of population within each Census block group data unit that identifies as Multiiracial to the proportion of all people that live within the 13,312 census block groups in the Southern California RRK region. People with part-American Indian identity are not included here but are included in the American Indian or Alaska Native Race Alone and Multirace Population, described above.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total

- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total

- Class Code 3: *Proportionate.* The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion

- Class Code 4: *Somewhat high.* The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total

- Class Code 5: *High.* The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total

- Class Code 6: *Very high.* The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Southern California region population in total

- Class Code 7: *Extremely high.* The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Southern California region population in total (the upper limit is determined by natural breaks,if exceptional outliers are present, but is typically over 6 times (600%)

- Class Code 8: *Exceptionally high.* The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region

- Class Code 99: *Unclassifiable.* The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Data source: U.S. Department of Commerce, Census Bureau, 2020 Decennial Census Redistricting File (PL 94-171).

Racial identity data are reported in Table P1 of the PL 94-171 release. Population counts were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units above).

File Name: MultiRaceNotAmerInd_2020.tif

Translation: None

LOW INCOME POPULATION CONCENTRATION

Tier: 2

Data Vintage: 2020

Metric Definition and Relevance: Relative concentration of the estimated number of people in the Southern California region that live in a household defined as "low income." There are multiple ways to define low income. These data apply the most common standard: low income population consists of all members of households that collectively have income less than twice the federal poverty threshold that applies to their household type. Household type refers to the household's resident composition: the number of independent adults plus dependents that can be of any age, from children to elderly. For example, a household with four people – one working adult parent and three dependent children – has a different poverty threshold than a household comprised of four unrelated independent adults.

Due to high estimate uncertainty for many block group estimates of the number of people living in low income households, some records cannot be reliably assigned a class and class code comparable to those assigned to race/ethnicity data from the decennial Census.

"Relative concentration" is a measure that compares the proportion of population within each Census block group data unit to the proportion of all people that live within the 1,207 block groups in the Southern California RRK region. See the "Data Units" description below for how these relative concentrations are broken into categories in this "low income" metric.

Data Resolution: 30m Raster

Data Units: Categorical

- Class Code 0: *Zero or nearly zero*. The variable is absent (observed value = 0) or is very low; the local proportion of the subject population variable is 10% or less than the same proportion in the Southern California region population in total

- Class Code 1: *Low*. The subject population concentration is low; the local proportion of the subject population variable is between roughly 10% and 50% of the corresponding proportion in the Southern California region population in total

- Class Code 2: *Somewhat low*. The subject population concentration is somewhat low; the local proportion of the subject population variable is between roughly 50% and 85% of the corresponding proportion in the Southern California region population in total

- Class Code 3: *Proportionate.* The subject population concentration is roughly proportionate to the corresponding proportion in the Southern California region population in total - from about 85% to 115% of the regional proportion

- Class Code 4: *Somewhat high.* The subject population concentration is somewhat high; the local proportion of the subject population variable is between roughly 115% and 150% of the corresponding proportion in the Southern California region population in total

- Class Code 5: *High.* The subject population concentration is high; the local proportion of the subject population variable is between roughly 150% and 200% of the corresponding proportion in the Southern California region population in total

- Class Code 6: *Very high.* The subject population concentration is very high; the local proportion of the subject population variable roughly 2 to 3 times that of the corresponding proportion in the Southern California region population in total

- Class Code 7: *Extremely high.* The subject population concentration is very extremely high; the local proportion of the subject population variable is at least 3 times that of the corresponding proportion in the Southern California region population in total (the upper limit is determined by natural breaks,if exceptional outliers are present, but is typically over 6 times (600%)

- Class Code 8: *Exceptionally high.* The subject population concentration is so high that it is an exceptional outlier; the local proportion of the subject population variable is typically greater than 6 or 7 times that of the corresponding proportion in the region

- Class Code 99: *Unclassifiable.* The 90% confidence interval for the estimate is wide enough to cause the values to span four or more classes. In these cases, it is impossible to say with any reasonable certainty whether the concentration is "low" or "high."

Data source: U.S. Department of Commerce, Census Bureau, 2020 American Community Survey 5-Year Survey Estimates.

Data estimating household income as a percent of the applicable federal poverty threshold are reported in Table C17002 of the 2016-2020 ACS 5-year data. Estimates of population living in low income households were obtained via the Data.Census.Gov web portal and joined to the Census Bureau's TIGER/line feature classes for block groups (see reporting units below). Table C17002 provides estimates and error margins for total population living in households with income, and population by ratio of income to applicable poverty: 50% of poverty, 50-99%, etc. Additional calculations are performed to generate an estimate for all people in households with income less than 200% of applicable poverty.

FMI: https://www.census.gov/newsroom/press-releases/2022/acs-5-year-estimates.html

File Name: LowIncome_2020.tif

Translation: None

FUTURE CONDITION

Metric definition and relevance: Future climate constraints on social and cultural well-being was evaluated using projected changes in mean maximum summer temperature. High maximum temperatures are linked to increased energy costs, reductions in public health, and increases in human mortality. Temperatures above 35 C (at 100% humidity) represent the upper limit of human safety, above which the human body can no longer cool itself by evaporating sweat. We use this as a target as a conservative estimate of temperature conditions that may have negative impacts on the well-being of residents where they are sustained year over year.

Data resolution: 1-km, resampled to 30-m to match current conditions data

Data Units: Translated strength of evidence score, +1 to -1

Data source: climateNA, Wang et al. (2016)

File Name: socialCultural030_future.tif

Translation: Where is future climate stability greatest for social and cultural well-being?

Future climate stability: Values near -1 indicate large changes in the fire regime are likely, while values near +1 indicate little to no change is expected. We represent the future climate constraints using two metrics, the first is a direct evaluation of the mean maximum summer temperature for each climate analog where temperatures near 20C (room temperature) receive a score of +1 and temperatures close to 35C (extreme heat) receive a score of -1. This evaluation was also done for the current climate period. The second metric compares the current scores with the future score for each analogue. Analogue analog at are much worse than current scores would indicate a location is expected to experience much warmer conditions than residents are currently used to and therefore receive a score of -1.

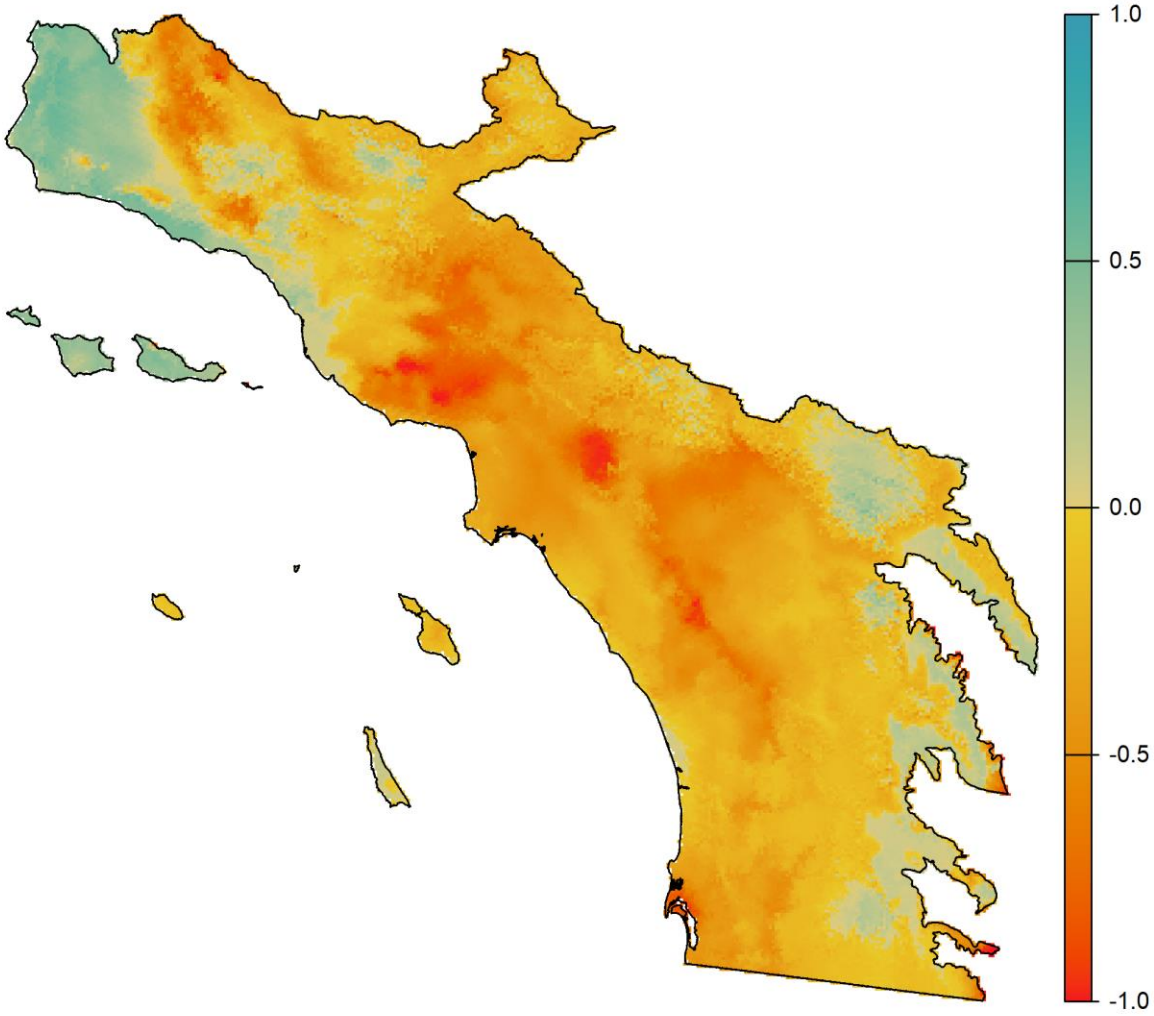

Figure 188. Images of future climate stability scores for the social and cultural well-being pillar across the Southern California.

WETLAND INTEGRITY

Wetlands provide critical habitat, store carbon, enhance water quality, control erosion, filter and retain nutrient pollution, and provide spaces for recreation. They are local and regional centers of biodiversity, and support species found nowhere else across western landscapes. Functional wetland ecosystems will serve increasingly important roles in buffering impacts from extreme climate events, and upland disturbances such as flooding and erosion. Meadow and riparian ecosystems provide ecosystem services and are key linkages between upland and aquatic systems in forested landscapes.

Desired Outcome: Wetland ecosystems are biologically intact, provide multiple ecosystem services, and meadow and riparian ecosystems provide key linkages between upland and aquatic systems in forested landscapes.

CURRENT CONDITIONS

PILLAR REPRESENTATION

The elements of the wetland integrity pillar are the hydrologic function, composition, and structure. The Southern California RRK has metrics for one element, wetland composition. The condition score for the wetland integrity pillar is represented by the average of the condition scores for this element.

Data Units: Condition score, +1 to -1

File Name: wetlandInteg.tif

Translation: Where is wetland integrity high?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of greater wetland integrity.

ELEMENT REPRESENTATION: WETLAND COMPOSITION

Wetland composition pertains to the array of different wetland types, their relative abundance, the uniqueness of their co-occurrence and composition, and their integrity in a given location and area within and across landscapes. Wetland ecosystems include all lentic (e.g. lakes, ponds, bogs, fens) and lotic (e.g., rivers, streams, springs, seeps) aquatic ecosystems, as well as associated vegetated wetlands such as wet meadows and riparian vegetation.

The composition element is described by three metrics in the RRK: aquatic species richness, wetland type composition, and riparian areas. The condition of wetland composition element is represented by a single metric, aquatic species richness (represented by an asterisk).

Data Units: Condition score, +1 to -1

File Name: hydroComposition.tif

Represent pillar: Yes

Translation: Where is wetland composition more resilient?

AQUATIC SPECIES RICHNESS *

Tier: 1

Data Vintage: 02/2018

Metric Definition and Relevance: Aquatic native species richness is a measure of species biodiversity, and is one measurement used to describe the distribution of overall species biodiversity in California for the California Department of Fish and Wildlife (CDFW) Areas of Conservation Emphasis Project (ACE). Native species richness represents a count of the total number of native aquatic species potentially present in each 2.5 sq mile hexagon (systematic grid of hexagons established for the State of California by the Natural Resources Agency) based on species range and distribution information. The data can be used to view patterns of species diversity, and to identify areas of highest native aquatic species richness across the state. The species counts consist of four taxonomic groups – fish, aquatic invertebrates, aquatic amphibians, and aquatic reptiles.

Data Resolution: 30m Raster

Data Units: Counts attributed to each cell based on the associated hexagon

Data source: Aquatic Native Species Richness Summary, Areas of Conservation Emphasis (ACE), version 3.0, California Department of Fish and Wildlife (CDFW); ACE data base

File name: aquatic_species_richness_CA_2018_scored.tif

Represent element and pillar: Yes

Type and distribution of data: Right-skewed distribution representing counts. Raw data values range from 0 to 94 species.

Translation: Where is aquatic species richness highest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of higher aquatic species richness (positive linear slope). More favorable (translated to +1) and less favorable (translated to -1) vary based on climate regions (Table 7). Alternative approaches could be to establish meaningful subregions within the Southern California to constrain the context for interpreting potential species richness for any given site.

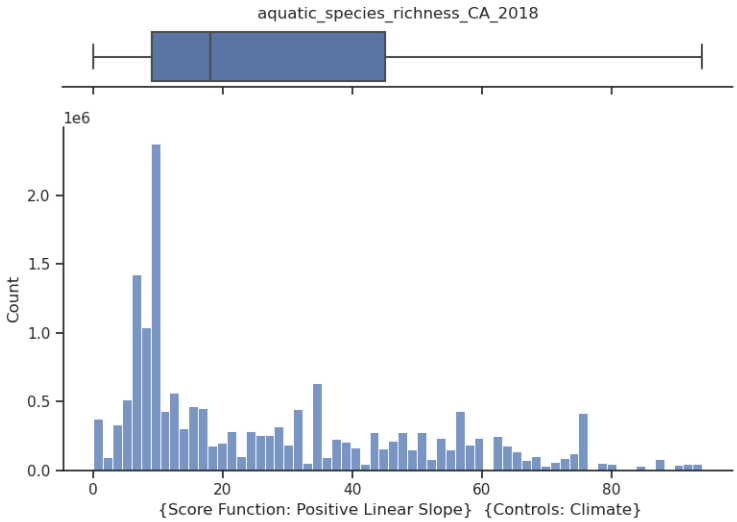

Figure 189. Histogram and scoring criterion of current condition for aquatic species richness across the Southern California

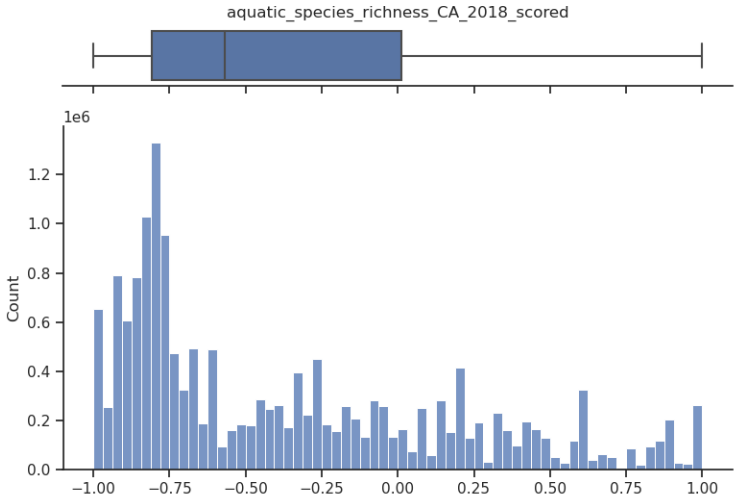

Figure 190. Histogram of translated current condition for aquatic species richness across the Southern California

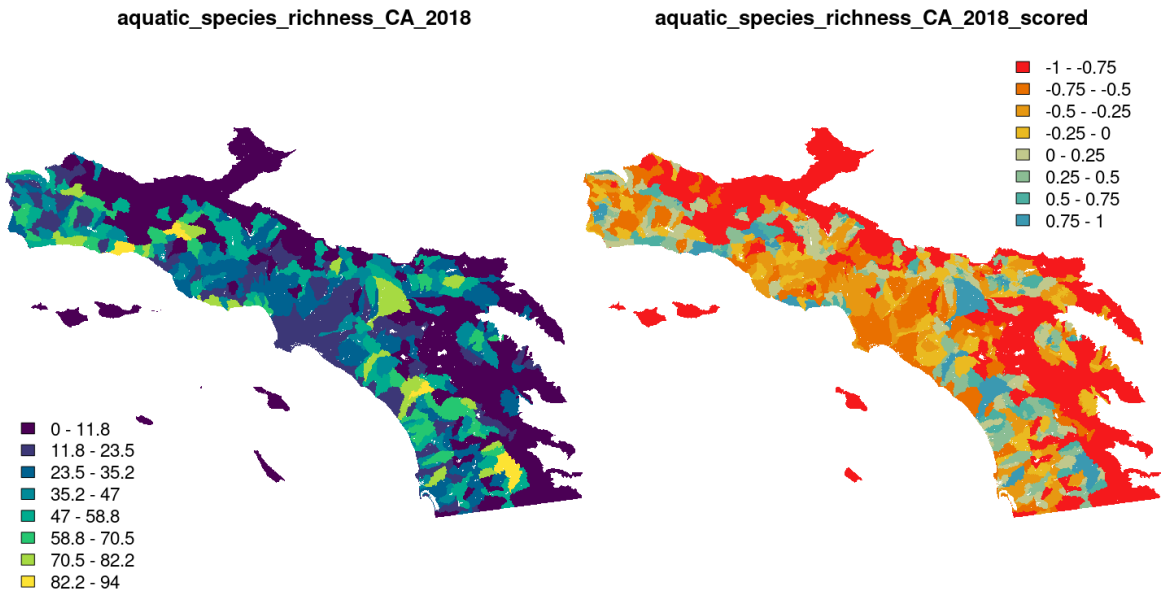

Figure 191. Maps displaying raw metric and translated metric of current condition for aquatic species richness across Southern California

WETLAND TYPE COMPOSITION

Tier: 1

Data Vintage: 06/2018

Metric Definition and Relevance:

- *Wetlands* - This data set represents the extent, approximate location, and type of wetlands and deepwater habitats in the ACCEL boundary for the Southern California. These data delineate the areal extent of wetlands and surface waters as defined by Cowardin et al. (1979).
- *Riparian* - This data set represents the extent, approximate location, and type of riparian habitats in the ACCEL boundary extent. These data delineate the areal extent of riparian habitats as defined by A System for Mapping Riparian Areas in the United States (USFWS, 2009)

Data Resolution: Vector, polygon

Data Units: Binary, 0 (Presence), 1 (Absence)

Data Source: The National Wetlands Inventory, US Fish & Wildlife Service (USFWS)

File Name: NWI_WetlandsType_2018_30m_scored.tif

Represent element and pillar: No

Type and distribution of data: Binary distribution representing presences/absences. Raw values range from 1 to 1.

Translation: Where is wetland type composition the highest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of high wetland type composition (positive linear slope). More favorable (translated to +1) set at 1, and less favorable (translated to -1) set at > 0.

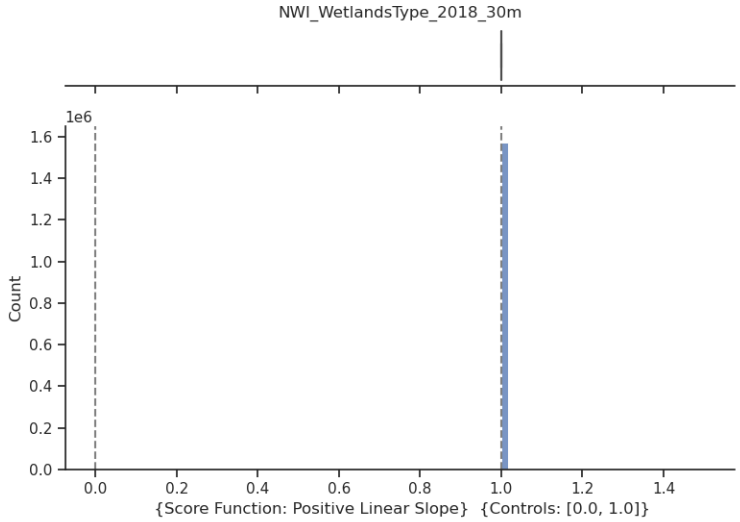

Figure 192. Histogram and scoring criterion of wetlands type composition in Southern California

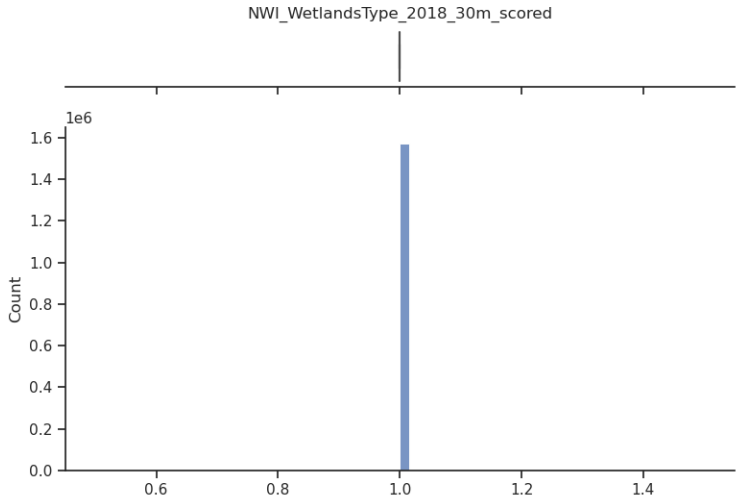

Figure 193. Histogram of translated current composition of wetlands type composition in Southern California

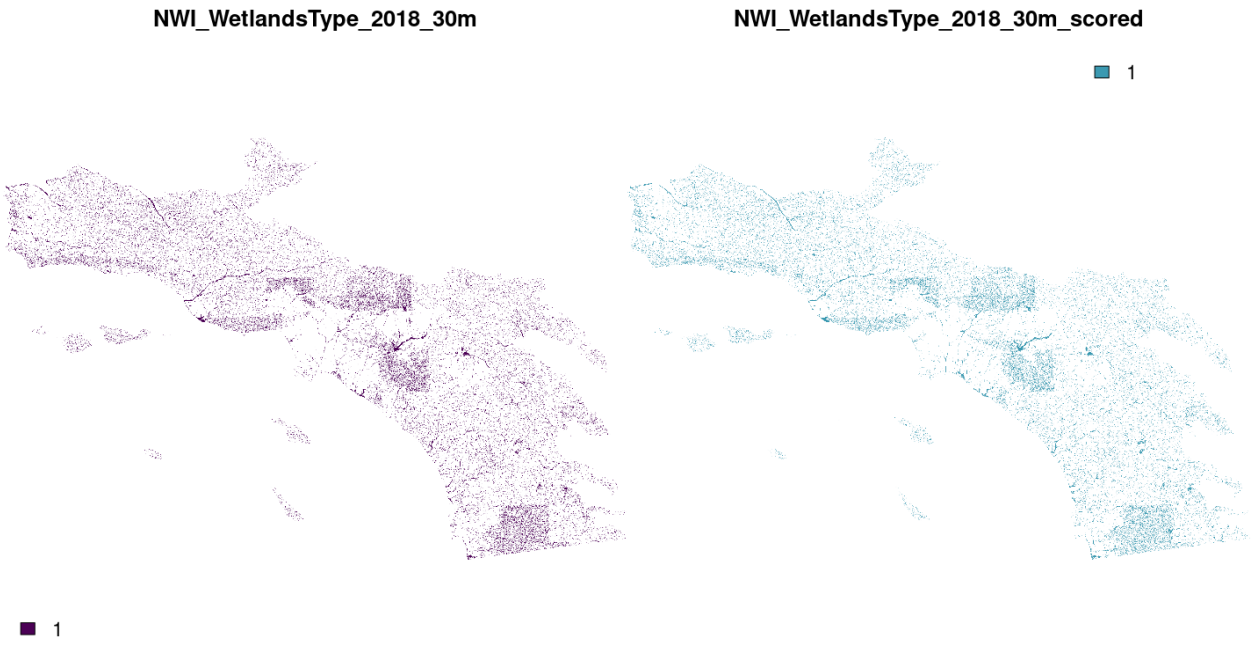

Figure 194. Maps displaying raw metric and translated metric of current condition for wetlands type composition across Southern California

RIPARIAN AREAS

Tier: 1

Data Vintage: 04/2019

Metric Definition and Relevance: These data depict 10-meter raster riparian areas for 50-year flood heights for California in 2019.

Data Resolution: 10m Raster

Data Units: Binary, 0 (Presence), 1 (Absence)

Data source: USDA Forest Service

File name: RiparianAreas10m_2019_scored.tif

Represent element and pillar: No

Type and distribution of data: Binary distribution representing presences/absences. Raw values range from 1 to 1.

Translation: Where is are riparian areas located?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the

objective of high riparian areas (positive linear slope). More favorable (translated to +1) set at 1, and less favorable (translated to -1) set at > 0.

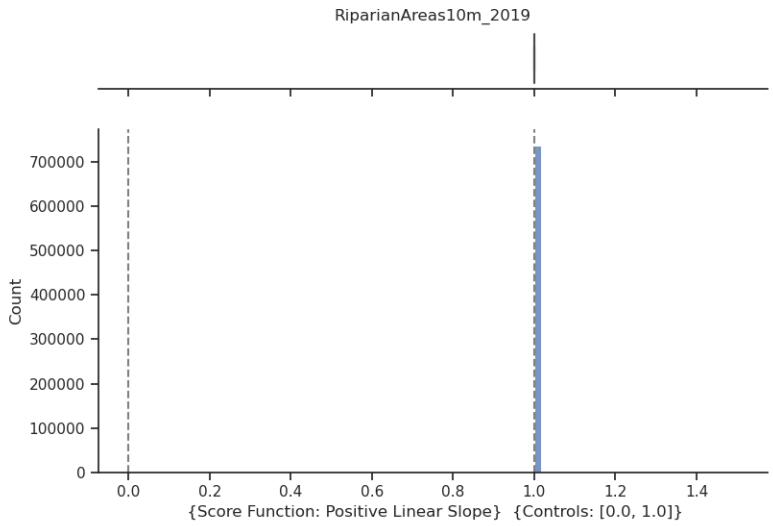

Figure 195. Histogram and scoring criterion of riparian areas in Southern California

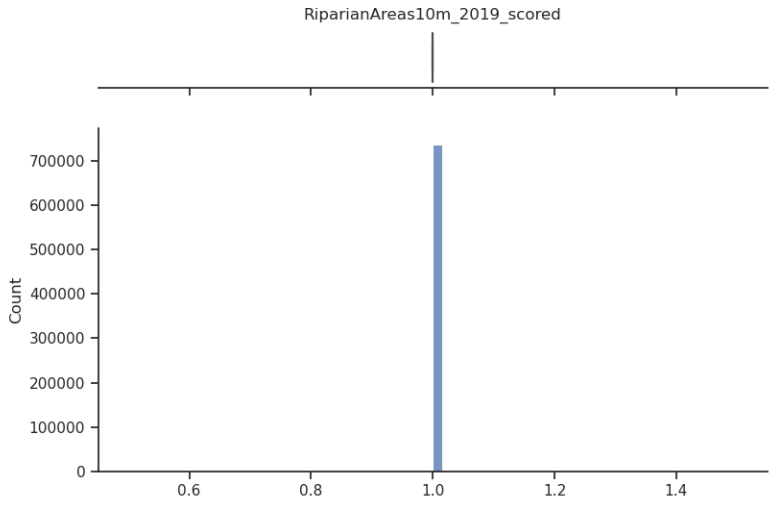

Figure 196. Histogram of translated current composition of riparian areas in Southern California

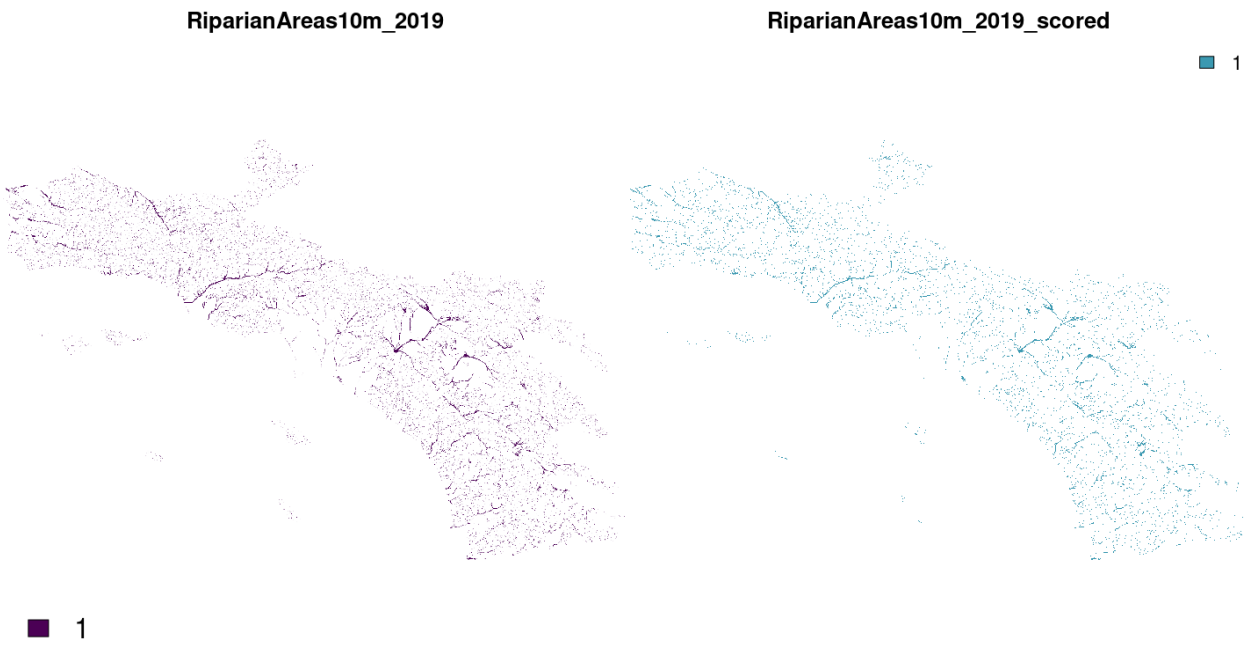

Figure 197. Maps displaying raw metric and translated metric for riparian areas across Southern California

FUTURE CONDITION

Metric definition and relevance: Future climate constraints on water security were evaluated using the climate moisture index (CMI). CMI is a drought metric similar to PDSI and SPE and is calculated as the difference between Potential Evapotranspiration and Precipitation. The CMI model is calibrated such the zero isocline represents shifts from forest to non-forest vegetation (Levesque and Hamann 2022). Large positive values indicate low moisture stress, while large negative values indicate high water stress. PET in calculated using the modified Penman-Montieth method, making it useful across environments.

Data resolution: 1-km, resampled to 30-m to match current conditions data

Data Units: Translated strength of evidence score, +1 to -1.

Data source: climateNA (Wang et al. 2016)

File Name: wetlandInteg030_future.tif

Translation: Where is future climate stability greatest for wetland integrity?

Future climate stability interpretation: Values near -1 indicate large changes in the fire regime are likely, while values near +1 indicate little to no change is expected. The fuzzy logic model consisted of two metrics. The first evaluated the difference between the CMI for a given focal cell and each of its climate analogues. Large negative differences indicate higher climatic moisture stress for the analogue and suggest a future less favorable for forested vegetation. The second metric leveraged the CMI's ability to differentiate climate hospitable to forested vegetation at values >0. Where CMI values were above 0 for the current climate, but below 0 for the future analogue, then this metric would reduce the

values from Metric 1. When evaluated, scores from Metric 2 ranged from -0.5 to -1.0, where differences between current and analogue around 0 received a -0.5, and where differences were -100 or greater received a -1. Both metrics were averaged together to represent the final Water Security score. See Figure 107 in the 'Water Security' pillar, future conditions section.

WATER SECURITY

Forests serve as natural water collection, storage, filtration, and delivery systems as water flows from forests into rivers providing critical aquatic and wetland habitat, while also supplying water for drinking and agriculture. From a more mechanistic perspective, the energy and water balance of forest ecosystems are fundamentally linked. Water is essential to photosynthesis and the latent energy exchange of transpiration is a major driver of water loss. In short, the fate of forests directly influences the quantity and quality of California's freshwater supply.

Desired Outcome: Watersheds provide a reliable supply of clean water despite wide swings in annual precipitation, droughts, flooding, and wildfire.

CURRENT CONDITIONS

PILLAR REPRESENTATION

The water security pillar has two elements – water quantity and water quality. The water security pillar condition score is derived by averaging the condition scores of the quantity and quality elements.

File Name: waterSecurity.tif

ELEMENT REPRESENTATION: WATER QUANTITY

Understanding the interaction between water supply and ecosystem demand informs both the extent of moisture stress and the amount of water available for storage.

The quantity element is described by five metrics: actual evapotranspiration to precipitation fraction during drought, precipitation minus actual evapotranspiration during normal conditions, drought sensitivity, change in average climatic water deficit, and groundwater basin boundaries. Two metrics are used to represent the element: actual evapotranspiration to precipitation fraction during drought and precipitation minus actual evapotranspiration during normal conditions (indicated by asterisks). The condition of water quantity element is represented by the average of the condition scores for the two metrics.

Data Unit: Condition score, +1 to -1

File Name: quantity.tif

Represent pillar: Yes

Translation: Where is water quantity greater?

Translation method and outcome: Condition scores range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of greater water quantity.

ACTUAL EVAPOTRANSPIRATION TO PRECIPITATION FRACTION DURING DROUGHT *

Tier: 1

Data Vintage: 09/2021

Metric Definition and Relevance: Plants respond to conditions in their immediate vicinity. Thus, to understand the vegetative moisture stress during drought, it is important to measure the local moisture balance. The actual evapotranspiration fraction (AETF) provides such a measure. Specifically, it indicates whether a location is expected to experience local drying during a drought, or whether the location receives sufficient precipitation that it will remain moist even during an extended drought. An extended drought is defined by a 48-month period where the Standardized Precipitation Index (SPI, NCAR 2022) is two standard deviations below the long-term mean (SPI-48 = negative 2). Such a drought is expected approximately once every 50 years in the Sierra Nevada. The southern Sierra 2012-2015 drought was a SPI-48 drought = negative 2.0, which resulted in severe vegetation die-off and a marked reduction in water deliveries.

The AETF ranges from 0 to > 1; a low value indicates a wetter location during drought and a high value indicates a drier location. Locations <1 would be expected to generate runoff, even during a significant drought (SPI-48 drought = negative 2.0), and would be expected to continue generating runoff. Locations > 1 would be expected to desiccate the soil during drought, with negligible runoff, and increasing vegetation drought stress. AET/P does not account for lateral water inflow, either as runoff or irrigation.

Data Resolution: 30m Raster

Data Units: Continuous, dimensionless fraction (AET in mm/P in mm).

Data source: CECS; https://california-ecosystem-climate.solutions/

File name: WaterFlux_AETFrac_SPI-2_2021_scored.tif

Type and distribution of data: Right-skewed distribution representing continuous values. Raw values range from 0 to 20.

Represent element and pillar: Yes

Translation: Where is water availability (1-AET/P) during drought the lowest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of lower water availability during drought (negative linear slope). More favorable (translated to +1) set at 2.862 and less favorable (translated to -1) set at > 0.

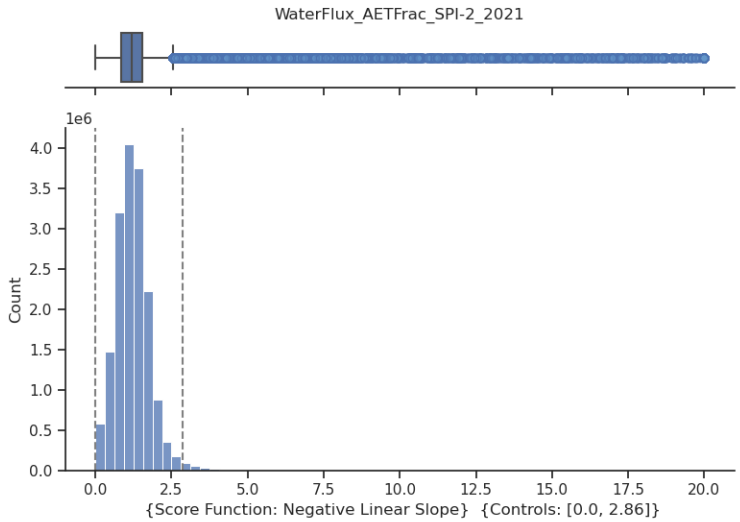

Figure 198. Histogram and scoring criterion of current condition of actual evapotranspiration/precipitation fraction across the Southern California

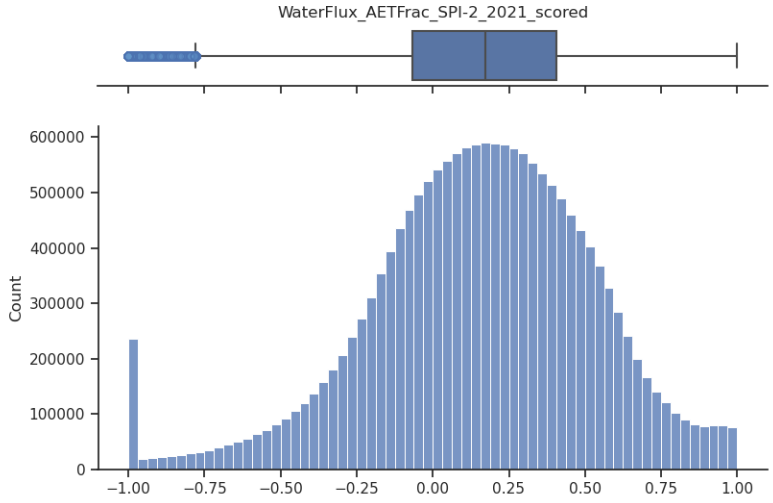

Figure 199. Histogram of translated current condition of actual evapotranspiration/precipitation fraction across the Southern California

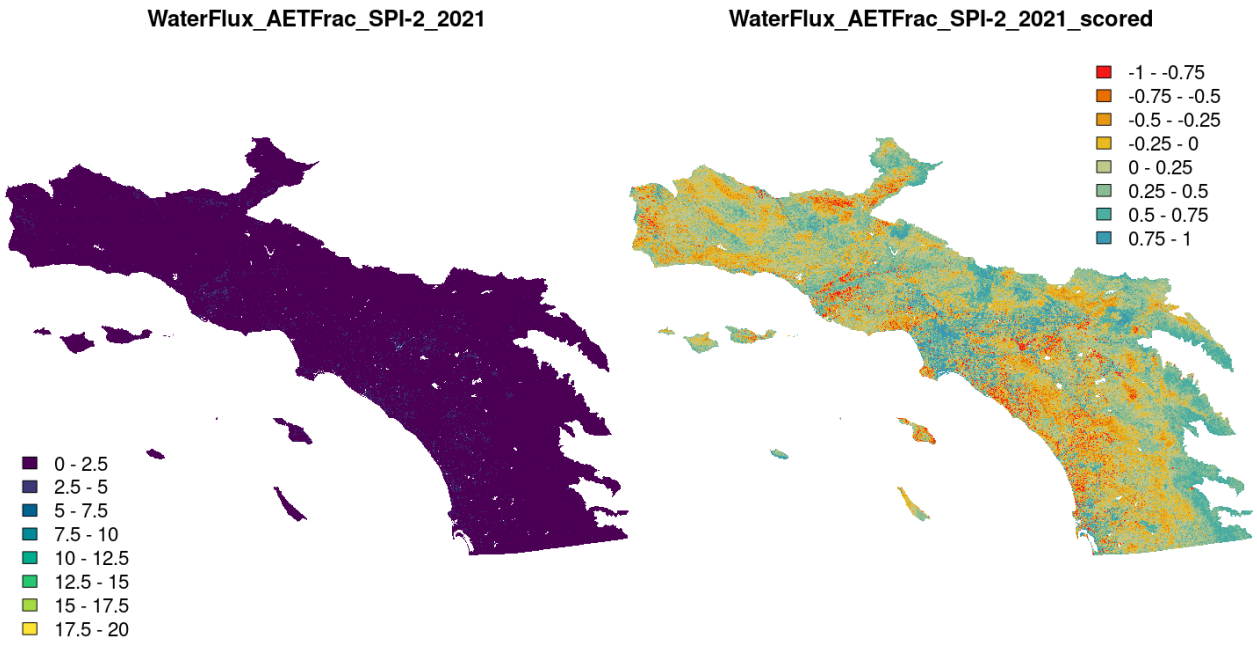

Figure 200. Maps displaying raw metric and translated metric of current condition of actual evapotranspiration/precipitation fraction across the Southern California.

PRECIPITATION MINUS ACTUAL EVAPOTRANSPIRATION DURING NORMAL CONDITIONS *

Tier: 1

Data Vintage: 09/2021

Metric Definition and Relevance: Runoff is a measure of the water available for storage. It is determined by both the water supply and the demand of the existing vegetation. Annual mean runoff measures the "average" vegetative demand and thus provides a comparative index on the potential available runoff. Specifically, Annual Mean Runoff is the expected surplus water that would discharge to surface or ground water flows during a series of years with average precipitation. Larger values indicate more runoff under mean conditions.

Data Resolution: 30m Raster

Data Units: Continuous, mm/y

Data source: CECS; https://california-ecosystem-climate.solutions/

File name: WaterFlux_Runoff_SPI0_2021_scored.tif

Type and distribution of data: Normal, left-skewed distribution representing continuous values. Raw values range from -2000 to 1013 mm/year.

Represent element and pillar: Yes

Translation: Where is water yield the highest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of water yield (positive linear slope). More favorable (translated to +1) set at > 561.927 mm/year, and less favorable (translated to -1) set at -252.387 mm/year.

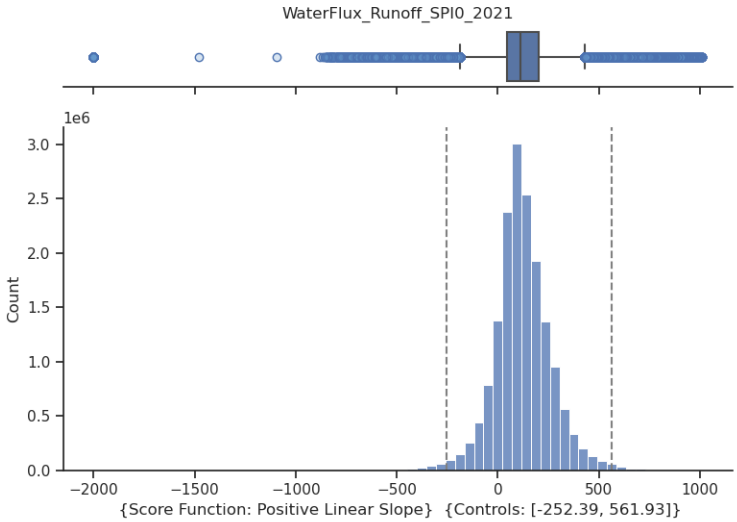

Figure 201. Histogram and scoring criterion of current condition of average annual mean runoff across the Southern California

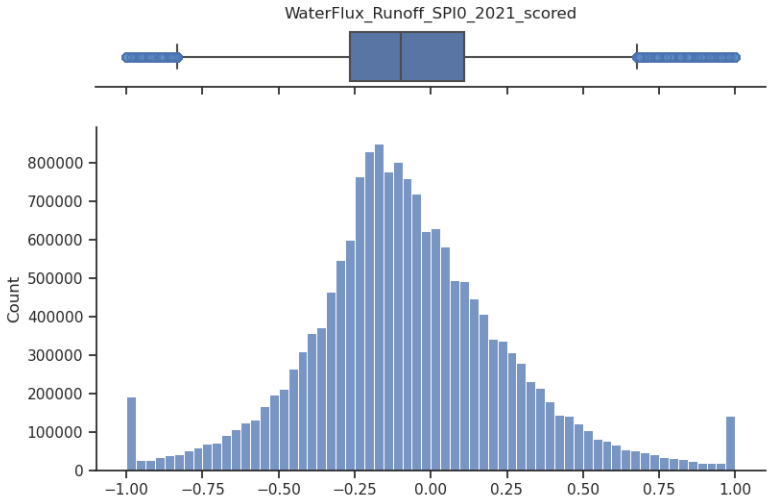

Figure 202. Histogram of translated current condition of average annual mean runoff across the Southern California

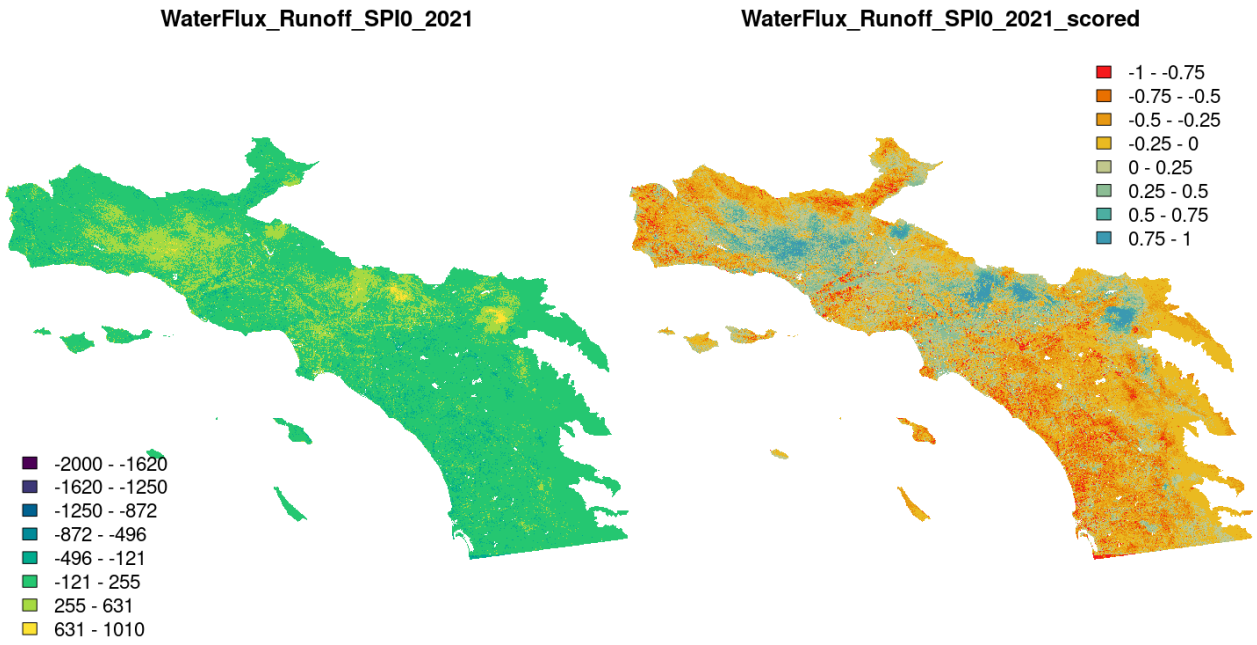

Figure 203. Maps displaying raw metric and translated metric of current condition of average annual mean runoff across the Southern California

DROUGHT SENSITIVITY

Tier: 3

Data Vintage: 2018

Metric Definition and Relevance: This layer represents an estimation of the probability that drought will substantially impact post-fire shrub recovery, potentially leading to vegetation type conversion to invasive grasses and forbs. This type conversion may increase the risk of fire ignition and fire spread.

Data Resolution: 30m Raster

Data Units: Relative index, low to high

Data Source: San Diego State University CWC Project Team

File Name: Drought_Sensitivity_scored.tif

Type and distribution of data: Right-skewed distribution representing probability values. Raw values range from 0 to 1.

Represent element and pillar: No

Translation: Where is drought sensitivity the lowest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the

objective of lower drought sensitivity (negative linear slope). More favorable (translated to +1) set at 0, and less favorable (translated to -1) set at > 1.

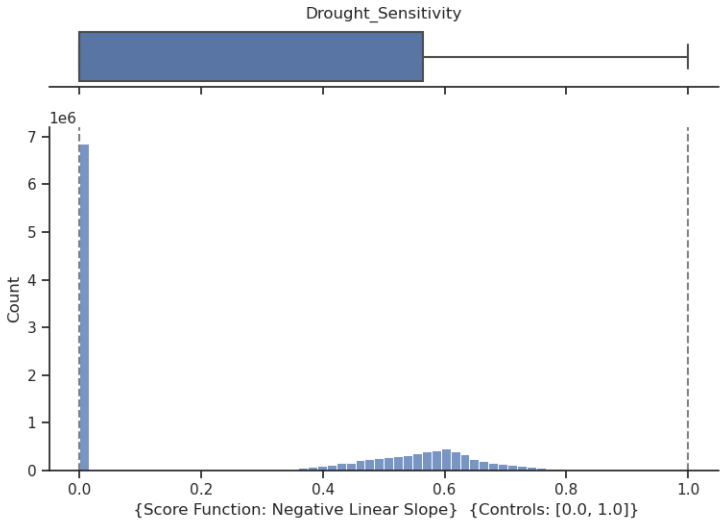

Figure 204. Histogram and scoring of drought sensitivity in Southern California

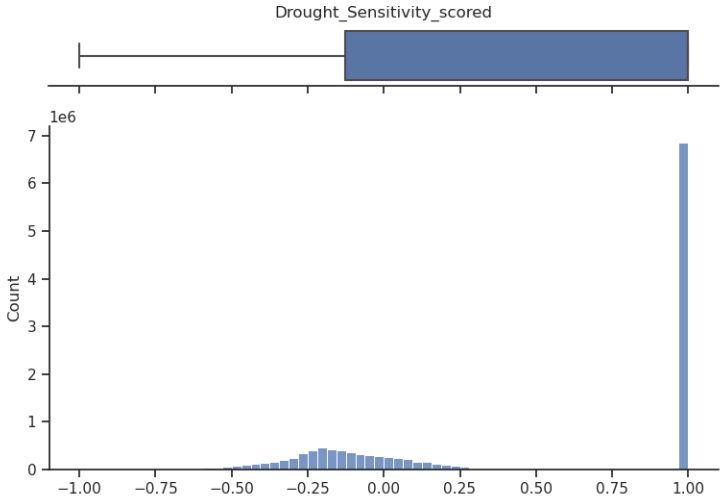

Figure 205. Histogram of translated drought sensitivity in Southern California

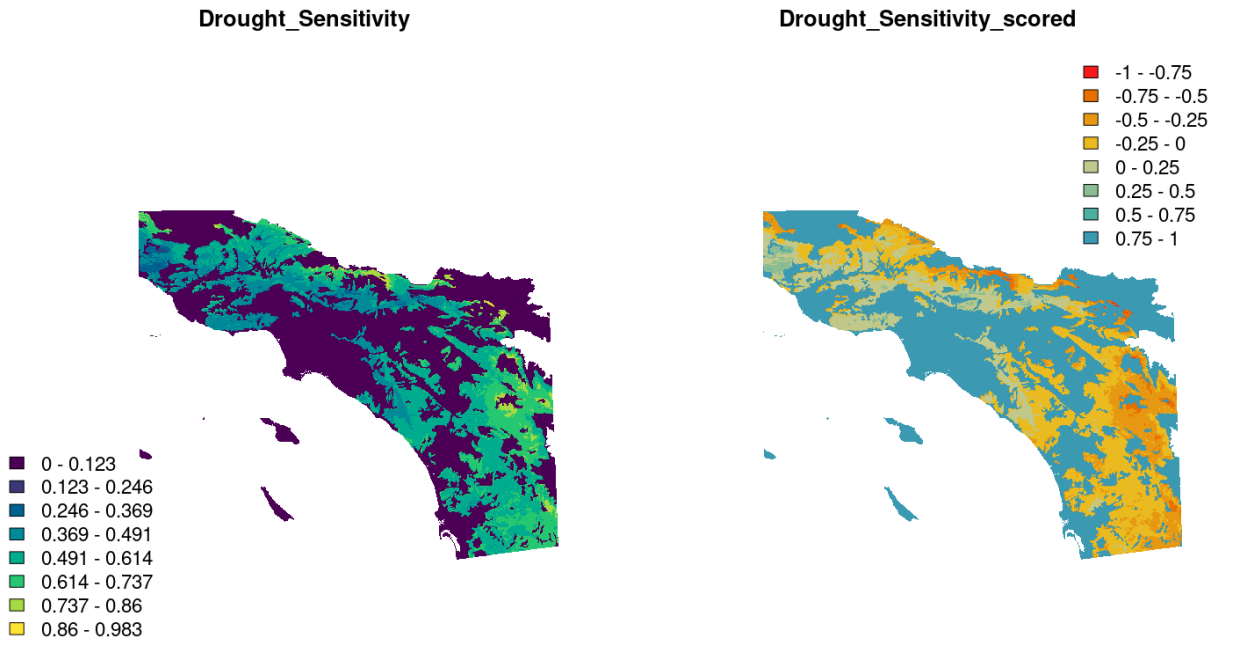

Figure 206. Maps displaying raw metric and translated metric drought sensitivity in Southern California

CHANGE IN AVERAGE CLIMATIC WATER DEFICIT *

Tier: 3

Data Vintage: 2022

Metric Definition and Relevance: Change in Average Annual Climatic Water Deficit - Near Future - Drier. This raster dataset represents a projection of the difference in the mean annual climatic water deficit between the baseline period (1950-1980), and a near future period (2030-2059) under the MIROC (Drier) scenario of climate change.

Data Resolution: 30m Raster

Data Units: mm

Data Source: San Diego State University; Connecting Wildlands and Communities Project Team

File Name: ChangeInAverageAnnualCWD-NearFutureDrier_scored.tif

Type and distribution of data: Normal distribution representing data. Raw data values range from -203.371 to 237.372.

Represent element and pillar: Yes

Translation: Where is change in average climatic water deficit highest?

Translation method and outcome: Raw data values translated to range +1 to -1 representing more favorable or less favorable conditions, respectively. The proposition of more favorable is based on the

objective of higher change in average climatic water deficit (positive linear slope). More favorable (translated to +1) set at 200, less favorable (translated to -1) set at -100.

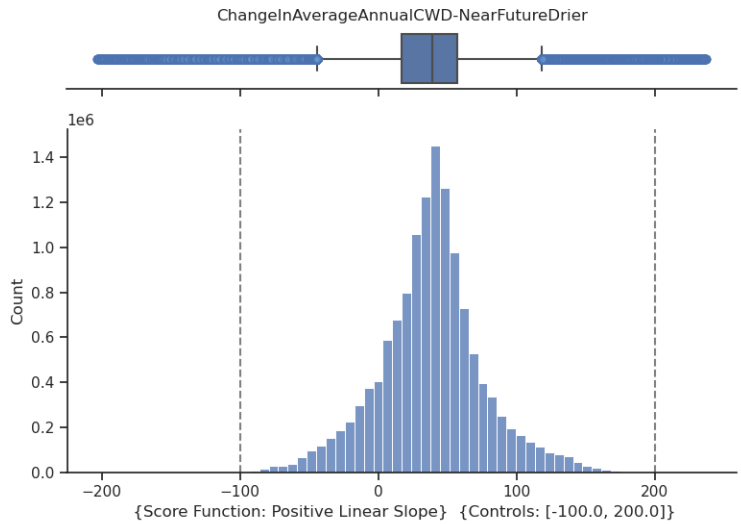

Figure 207. Histogram and scoring of change in average climate water deficit in Southern California.

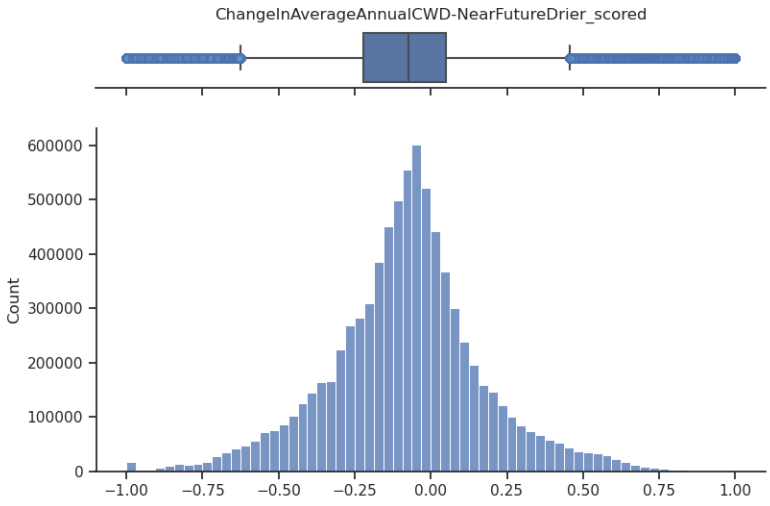

Figure 208. Histogram of translated change in average climatic water deficit in Southern California.

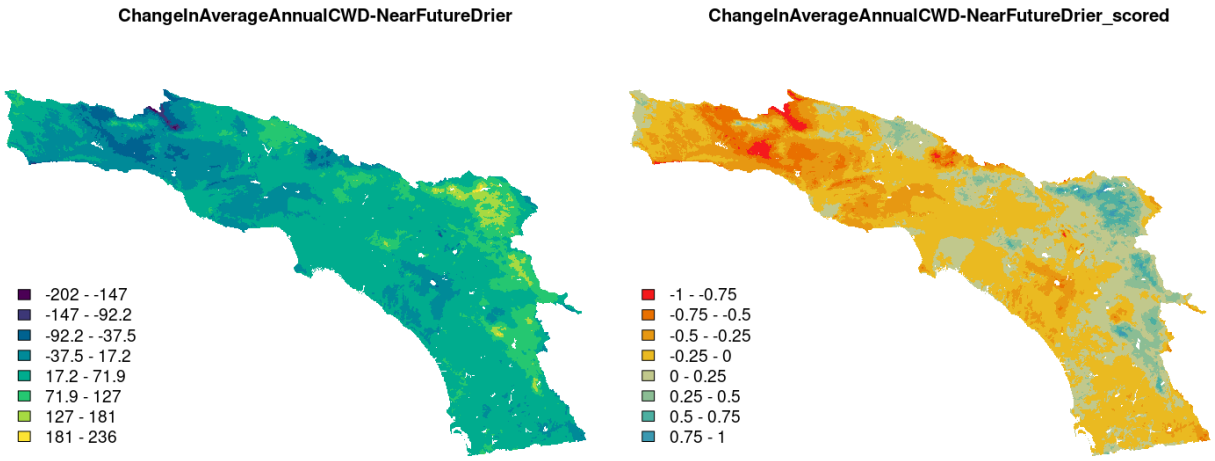

Figure 209. Maps displaying raw metric and translated metric change in average climatic water deficit in Southern California.

GROUNDWATER BASIN BOUNDARIES

Tier: 3

Data Vintage: 02/2022

Metric Definition and Relevance: This dataset shows the boundaries of groundwater basins and subbasins as defined by the California Department of Water Resources as last modified by the Basin Boundary Emergency Regulation adopted on October 21, 2015 and subsequent modifications requested through the Basin Boundary Modification Request Process.

Data Resolution: 30m raster

Data Units: Binary

Data Source: California Department of Water Resources

https://gis.water.ca.gov/arcgis/rest/services/Geoscientific/i08_B118_CA_GroundwaterBasins/FeatureServer

File Name: i08_B118_CA_GroundwaterBasins_scored.tif

Type and distribution of data: Binomial distribution representing continuous values. Raw values range from 1 to 1.

Represent element and pillar: No

Translation: Where are groundwater basin boundaries the highest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of high presence of groundwater basins (positive linear slope). More favorable (translated to +1) set at 1, and less favorable (translated to -1) set at < 0.

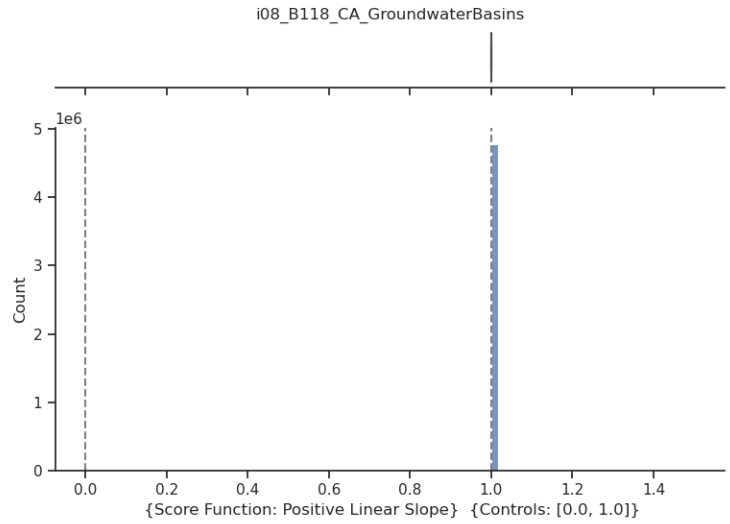

Figure 210. Histogram and scoring of groundwater basin boundaries in Southern California.

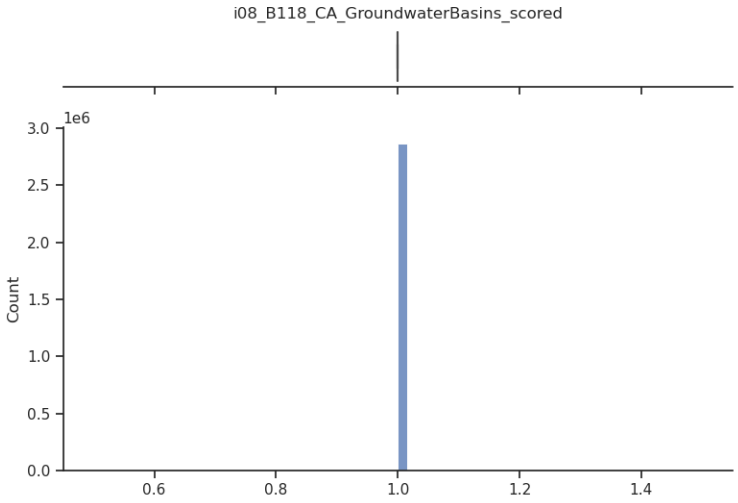

Figure 211. Histogram of translated groundwater basin boundaries in Southern California.

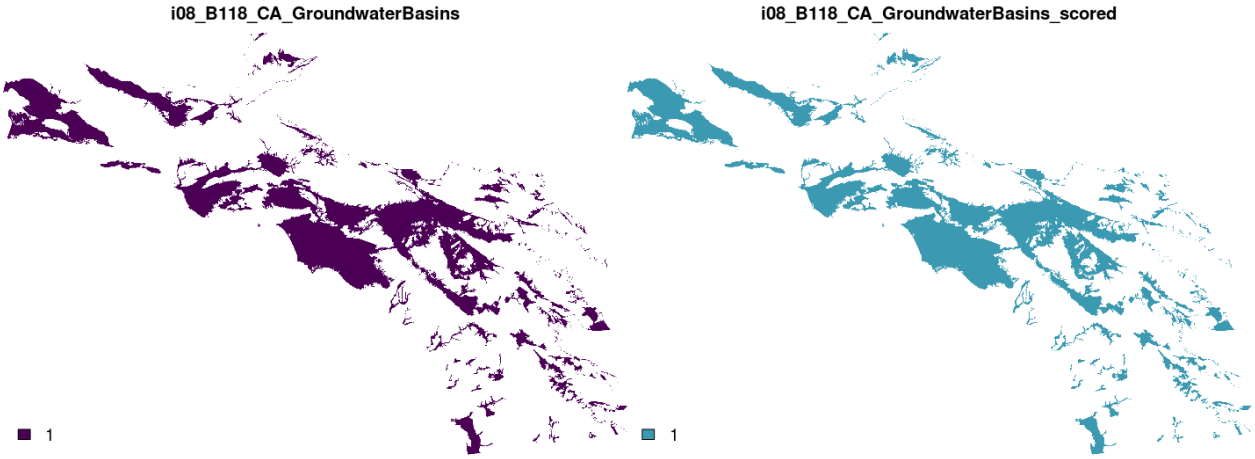

Figure 212. Maps displaying raw metric and translated metric groundwater basin boundaries in Southern California.

ELEMENT REPRESENTATION: WATER QUALITY

Understanding the interaction between water supply and ecosystem demand informs both the extent of moisture stress and the amount of water available for storage.

The quality element is described and represented by one metric: percent impervious surface (indicated by asterisk).

Data Unit: Condition score, +1 to -1

File Name: quality.tif

Represent pillar: Yes

Translation: Where is water quality greater?

Translation method and outcome: Condition scores range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of greater water quantity.

PERCENT IMPERVIOUS SURFACE *

Tier: 1

Data Vintage: 2019

Metric Definition and Relevance: This National Land Cover Database (NLCD) product represents urban impervious surfaces as a percentage of developed surface over every 30-meter pixel of California, extracted from a nationwide layer. The definition of impervious means water does not seep into the ground, it runs off into storm sewers and then into local creeks. Examples of impervious surfaces include highways, streets and pavement, driveways, and house roofs. The relevance of impervious surfaces is the higher the proportion of impervious surfaces the more likely flooding can occur.

Data Resolution: 30m Raster

Data Units: Percent, fractional imperviousness

Data Source: National Land Cover Database (NLCD)

File Name: nlcd_2019_imperviousPercent_CA_scored.tif

Represent element and pillar: Yes

Type and distribution of data: Zero-inflated, right-skewed distribution representing percent values. Raw values range from 0 to 100.

Translation: Where is fractional impervious surface the lowest?

Translation method and outcome: Raw data values translated to range from +1 to -1 representing more favorable to less favorable conditions, respectively. The proposition of more favorable is based on the objective of low fractional impervious surface (negative linear slope). More favorable (translated to +1) set at 100, and less favorable (translated to -1) set at > 0.

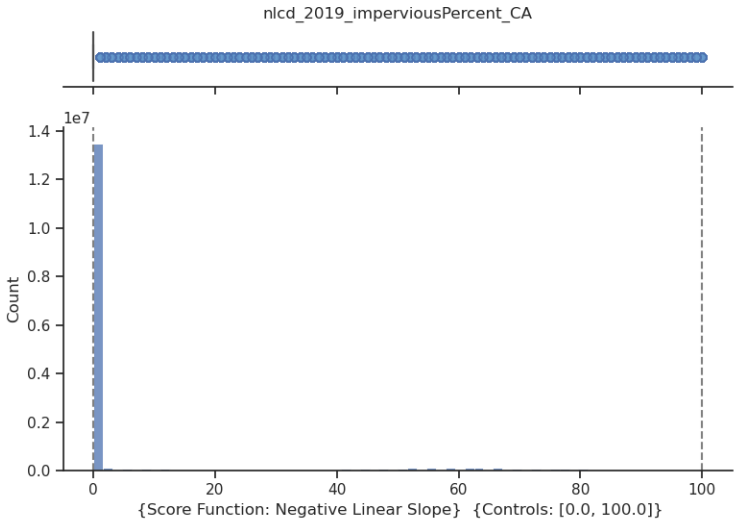

Figure 76. Histogram and scoring of current condition of average annual mean runoff across Southern California

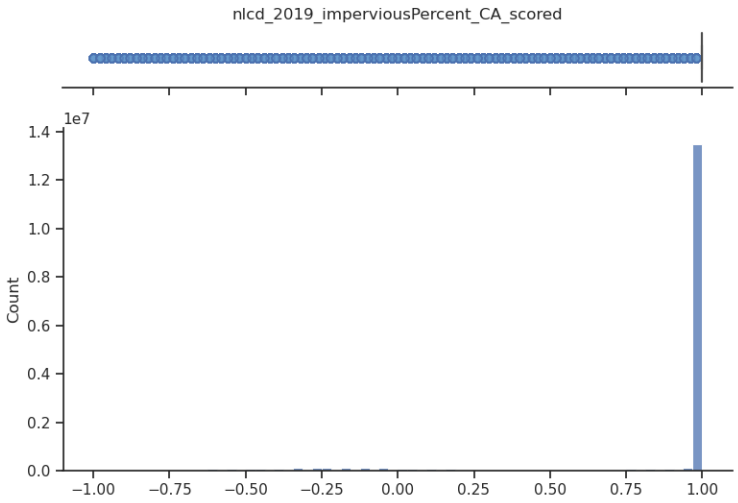

Figure 213. Histogram of translated metric current condition of average annual mean runoff across Southern California

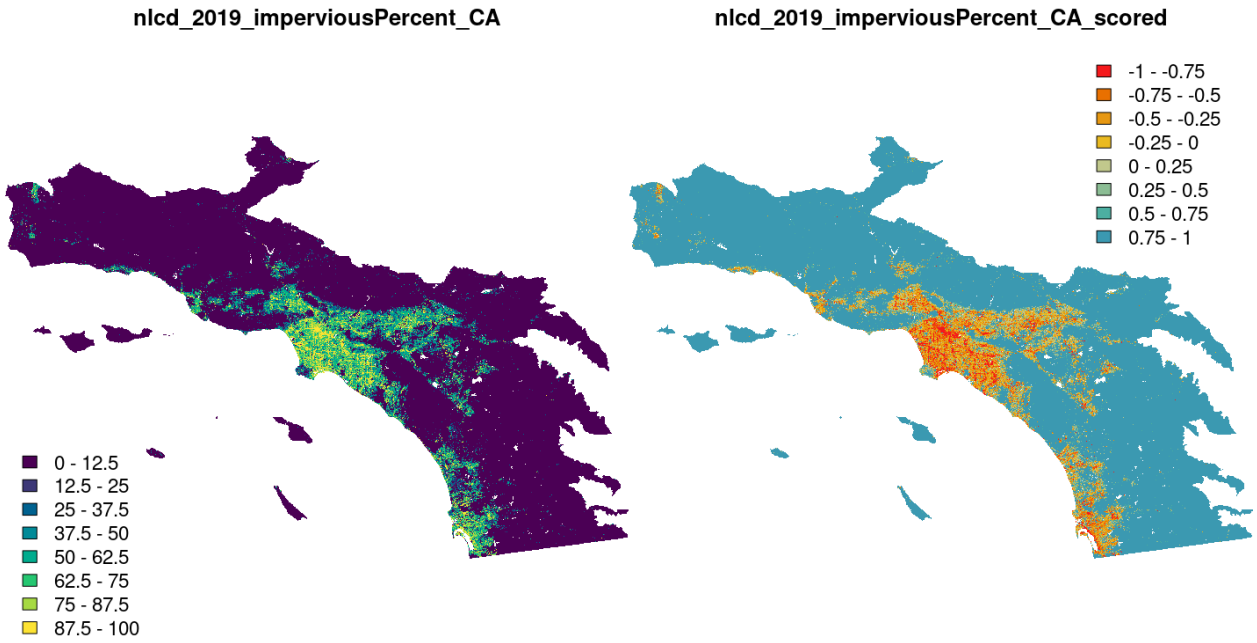

Figure 214. Maps displaying raw metric and translated metric of current condition of average annual mean runoff across the Southern California

FUTURE CONDITION

Metric definition and relevance: Future climate constraints on water security were evaluated using the climate moisture index (CMI). CMI is a drought metric similar to PDSI and SPE and is calculated as the difference between Potential Evapotranspiration and Precipitation. The CMI model is calibrated such the zero isocline represents shifts from forest to non-forest vegetation (Levesque and Hamann 2022). Large positive values indicate low moisture stress, while large negative values indicate high water stress. PET in calculated using the modified Penman-Montieth method, making it useful across environments.

Data resolution: 1-km, resampled to 30-m to match current conditions data

Data Units: Translated strength of evidence score, +1 to -1.

Data source: climateNA (Wang et al. 2016)

File Name: waterSecurity030_future.tif

Translation: Where is future climate most stable for water security?

Future climate stability interpretation: Values near -1 indicate large changes in the fire regime are likely, while values near +1 indicate little to no change is expected. The fuzzy logic model consisted of two metrics. The first evaluated the difference between the CMI for a given focal cell and each of its climate analogues. Large negative differences indicate higher climatic moisture stress for the analogue and suggest a future less favorable for forested vegetation. The second metric leveraged the CMI's ability to differentiate climate hospitable to forested vegetation at values >0. Where CMI values were above 0 for the current climate, but below 0 for the future analogue, then this metric would reduce the values from Metric 1. When evaluated, scores from Metric 2 ranged from -0.5 to -1.0, where differences between current and analogue around 0 received a -0.5, and where differences were -100 or greater received a -1. Both metrics were averaged together to represent the final Water Security score. This score was then combined with the Sigma score using the And operator, which defined the representativeness of each climate analogue. This emphasized the role of non-analogue conditioning these analogues lower regardless of their ecological score.

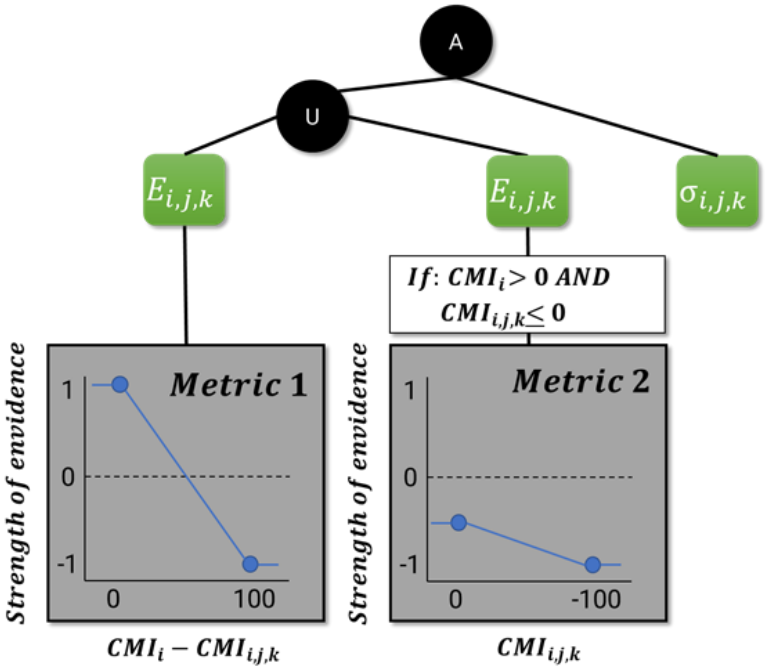

Figure 215. Logic model for water security and wetland integrity. Subscripts are i, cell (n = 90,000); j, analogues (n = 100); k, GCM (n = 9).

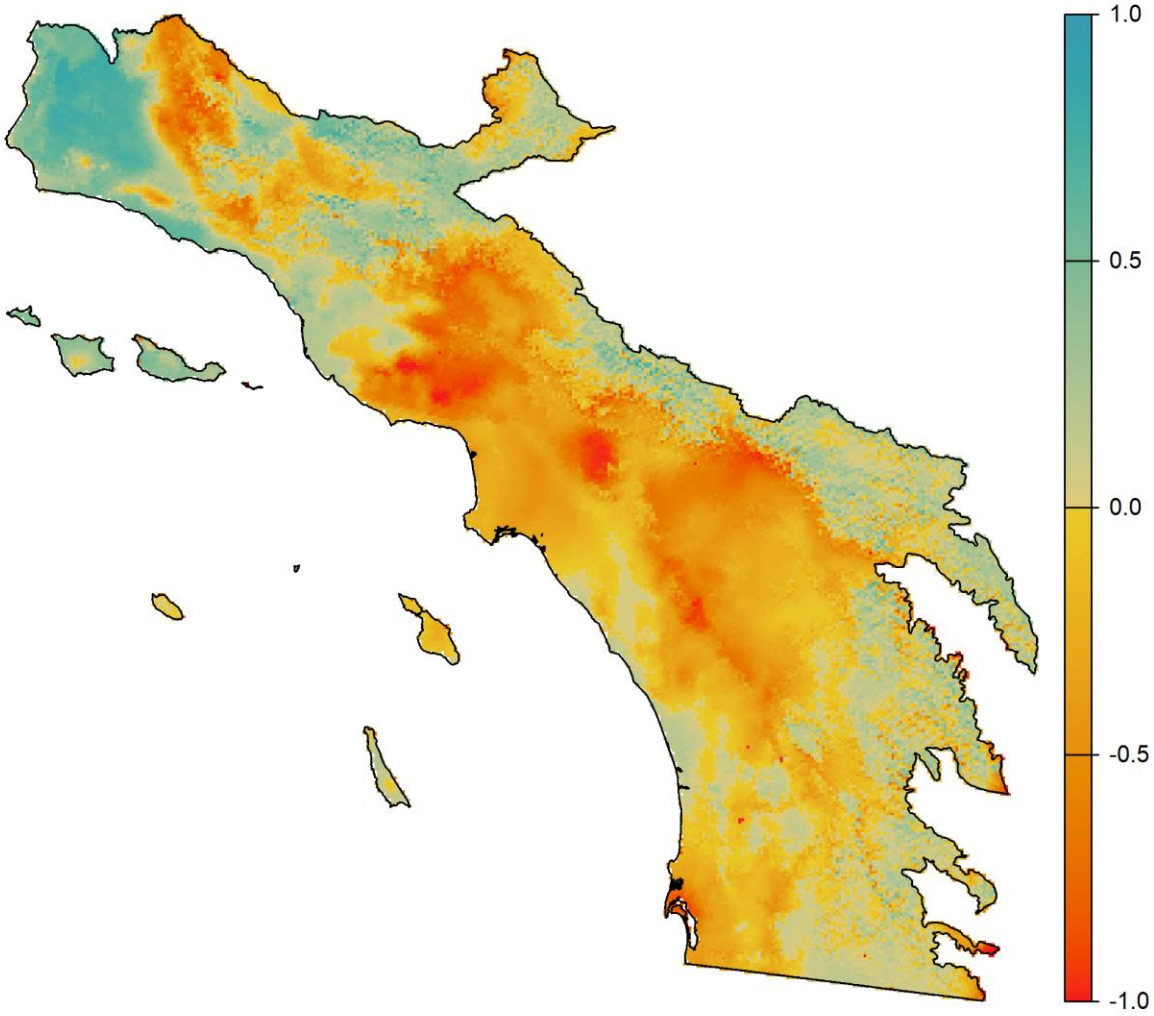

Figure 216. Images of future climate stability score for the water security pillar across the Southern California.

OPERATIONAL DATA LAYERS

Fire

FIRE SEVERITY CLASS (FIRES FROM 2012-2021)

Definition and Relevance: This dataset includes the footprint of all fires in California since 2012, designated in three classes of severity; low, moderate, and high.

Data Vintage: 2012-2021

Data Resolution: 30m Raster

Data Units: Categorical (fire severity class 1 (low severity), 2 (moderate severity), or 3 (high severity))

Data Source: Landsat 8, NASA, Fire History (2022), CAL FIRE Postfire mortality data, Miller et al. 2009; assembled at UC Davis (Joe Stewart)

File Name: fire_severity_class_max_2012to2021.tif

HOUSING UNIT DENSITY

Data Vintage: 01/2020

Definition and Relevance: HUDen is a raster of housing-unit density measured in housing units per square kilometer. The HUDen raster was generated using population and housing-unit count and data from the U.S. Census Bureau, building footprint data from Microsoft, and land cover data from LANDFIRE.

Data Resolution: 30m Raster

Data Units: Housing units per square kilometer

Creation Method: Generate the HUDen raster from the building points. We first converted the building points to a 30-m raster where the raster value is the sum of the housing-units-per-centroid attribute of all building centroids within each raster grid cell. We then generated a smoothed density raster using a three-step process: 1) calculate a 200-m radius moving-window sum of the 30-m housing-unit count raster; 2) calculate a 200-m radius moving-window sum of habitable land cover (in sq km), where habitable land cover is all land covers except open water and permanent-snow/ice; and 3) divide the smoothed housing-unit count raster by the smoothed habitable land cover raster to generate housing unit density in housing units/sq km. To produce the final integer version of the HUDen raster, we set values less than 0.1 HU/sq km to zero, values between 0.1 and 1.5 to a value of 1 HU/sq km, and rounded all other values to the nearest integer.

Data Source: Pyrologix, LLC

File Name: HUden_2020.tif

WILDLAND URBAN INTERFACE

Data Vintage: 2022

Definition and Relevance: The wildland urban interface (WUI) is the area where urban development is in close proximity to wildland vegetation. WUI data for the conterminous U.S. based on 125 million building locations where buildings intermingle with wildland vegetation according to the Federal Register definitions of the WUI. According to the definitions used for our building-based maps and for the census-based maps, WUI is where building density exceeds 6.17 units/km2 and where land cover is either (1) at least 50% wildland vegetation (intermix) or (2) under 50% wildland vegetation but within 2.4 km (1.5 miles) of a patch of wildland vegetation at least 5 km2 in area that contains at least 75% vegetation (interface). The distance selected for the interface definition is based on research from the California Fire Alliance suggesting that this is the average distance firebrands can travel from an active wildfire front (Stewart et al., 2007).

Data Resolution: 30m Raster

Data Units: Categorical

Creation Method: Building point locations were obtained from a Microsoft product released in 2018, updated to 2019-2020 for most of California, which classified building footprints based on high-resolution satellite imagery. Maps were also based on wildland vegetation mapped by the 2016 National Land Cover Dataset (Yang et al., 2018). The mapping algorithm utilized definitions of the WUI from the U.S. Federal Register (USDA & USDI, 2001) and Radeloff et al. (2005). Both classes required a minimum building density of 6.17 buildings per km2. This map of intermix and interface WUI was generated using a circular neighborhood size based on radius distance of 100m to determine building density and vegetation cover on a pixel-by-pixel basis (Bar Massada et al., 2013). Source: USGS ScienceBase Data Catalog; https://www.sciencebase.gov/catalog/item/617bfb43d34ea58c3c70038f

Values in the raster are defined as:

- 0: Not WUI
- 1: Intermix WUI
- 2: Interface WUI

Data Source: WUI, Carlson et al, 2022

File Name: MSB_WUI_CA_100m.tif

Climate Class (5-Class)

Tier: 2

Data Vintage: 1981-2010

Metric Definition and Relevance: Climate is a main driver of ecological pattern and process interactions. These interactions may change across climate gradients making inferences among environments challenging. By identifying areas of similar climate, we can reduce the variability in ecological responses

and evaluate metrics within a constrained set of environmental conditions such that these evaluations are scaled to the dominant processes influencing them. Climate classes represent discrete geographic areas of similar climate conditions that can be used to restrict metric evaluations to within a cell's climate class membership such that these evaluations capture the variability associated with a certain climatic regime (Table 3).

Data Resolution: 30m Raster

Data Units: categorical, class membership

Data Source: Basin Characterization Model (BCM; Flint and Flint) was developed at a 270m spatial resolution and used for the climate data for the variables AET, deficit, Tmin, Tmax climate normal (1981-2010). Each variable was rescaled using a linear transformation to a range of 0-100 to enhance processing speeds using integer formatting. A k-means algorithm was used with various numbers of clusters (5, 8, 10, 15). The k-means was conducted in whitebox geospatial analysis software (https://github.com/jblindsay/whitebox-tools)

File Name: kmeans_5cl_diag_rscl_smooth.tif

Represent Element and Pillar: No

Type and Distribution of Data: Integer

Translation: None

Table 3. Five climate classes were identified to represent discrete geographic areas of similar climate conditions that can be used to restrict metric evaluations.

CLIMATE CLASS	ELEVATION (M)	ACTUAL ET (MM)	DEFICIT (MM)	MIN TEMP (C)	MAX TEMP (C)	BROAD VEGETATION DESCRIPTION
1: ALPINE/ SUBALPINE	2983 (533)	221 (75)	339 (142)	-4 (2)	9 (3)	Subalpine conifer, red fir, juniper, white bark pine
2: MESIC MONTANE	1968 (525)	319 (114)	492 (105)	0 (2)	14 (2)	Mixed-conifer forest, lodgepole, aspen
3: DRY MONTANE	1620 (554)	218 (85)	665 (110)	1 (2)	16 (2)	Dry-forest, sagebrush, chaparral

CLIMATE CLASS	ELEVATION (M)	ACTUAL ET (MM)	DEFICIT (MM)	MIN TEMP (C)	MAX TEMP (C)	BROAD VEGETATION DESCRIPTION
4: LOW MONTANE	1059 (612)	474 (98)	670 (171)	6 (3)	20 (3)	Douglas-fir, oak-yellow pine woodland
5: FOOTHILLS	623 (847)	351 (179)	980 (208)	9 (2)	23 (2)	Conifer-oak woodland and shrubland

APPENDIX

Table A1. Less Favorable Limit and More Favorable Limit for Metrics with varied Climate and Vegetation Regions, Vegetation Cover

CLIMATE x VEGETATION REGION	11	12	21	22	31	32	41	42	51	52
VegCover_Herb_2021 (p1st)	0.027	0.050	0.034	0.038	0.036	0.054	0.040	0.041	0.029	0.028
VegCover_Herb_2021 (p99th)	0.442	0.664	0.707	0.725	0.765	0.767	0.707	0.741	0.730	0.760
VegCover_Shrub_2021 (p1st)	0.092	0.077	0.057	0.050	0.036	0.034	0.043	0.038	0.032	0.031
VegCover_Shrub_2021 (p99th)	0.576	0.636	0.638	0.638	0.648	0.652	0.662	0.649	0.452	0.357
VegCover_Tree_2021 (p1st)	0.060	0.025	0.031	0.019	0.040	0.025	0.024	0.017	0.007	0.010
VegCover_Tree_2021 (p99th)	0.731	0.376	0.598	0.321	0.616	0.379	0.487	0.308	0.320	0.187

Table A2. Less Favorable Limit and More Favorable Limit for Metrics with varied Climate and Vegetation Regions, Disturbance

CLIMATE x VEGETATION REGION	11	12	21	22	31	32	41	42	51	52
DistHist_Severe_Shrub_19922020 (p1st)	0	0	0	0	0	0	0	0	0	0
DistHist_Severe_Shrub_19922020 (p99th)	0.44	0.5	0.53	0.51	0.59	0.66	0.6	0.6	0.52	0.36
DistHist_Severe_Tree_19922020 (p1st)	0	0	0	0	0	0	0	0	0	0
DistHist_Severe_Tree_19922020 (p99th)	0.46	0.28	0.44	0.28	0.52	0.39	0.52	0.33	0.33	0.21
Vulner_TreeDieoff_SPI_2_2020 (p1st)	283.97	111.59	203.7	123.38	329.49	155.42	198.61	83.37	51.37	79

Vulner_TreeDieoff_SPI_2_2020 (p99th)	14485.94	6524.32	13279.58	5684.89	12326.17	6529.63	14835.56	7024.67	15644.25	1939.69

Table A3. Less Favorable Limit and More Favorable Limit for Metrics with varied Climate and Vegetation Regions, Canopy Cover, Height, and Layer Count

CLIMATE x VEGETATION REGION	11	12	21	22	31	32	41	42	51	52
CFO_CanopyCover2020Summer (p1st)	1	1	1	1	1	1	1	1	1	1
CFO_CanopyCover2020Summer (p99th)	75	62	76	60	80	69	79	68	58	35
CFO_CanopyHeight2020Summer (p1st)	0	0	0	0	0	0	0	0	0	0
CFO_CanopyHeight2020Summer (p99th)	19	10	16	7	19	10	20	11	12	5
CFO_CanopyLayerCount2020Summer (p1st)	0	0	0	0	0	0	0	0	0	0
CFO_CanopyLayerCount2020Summer (p99th)	2	2	2	1	2	2	2	2	2	1

Table A4. Less Favorable Limit and More Favorable Limit for Metrics with varied Climate and Vegetation Regions, Species Richness

CLIMATE REGION	1	2	3	4	5
cavity_nesters_excavators_species_richness (p1st)	1	1	1	1	1
cavity_nesters_excavators_species_richness (p99th)	13	11	13	11	3
herbivores_species_richness (p1st)	2	5	3	2	3
herbivores_species_richness (p99th)	28	28	28	28	27
insectivores_species_richness (p1st)	4	10	11	11	12
insectivores_species_richness (p99th)	31	30	44	33	31
predators_species_richness (p1st)	4	8	11	10	11
predators_species_richness (p99th)	25	24	28	27	22
seed_spore_dispersers_species_richness (p1st)	1	2	2	3	5
seed_spore_dispersers_species_richness (p99th)	12	13	13	13	13
soil_aerators_species_richness (p1st)	1	1	1	1	2
soil_aerators_species_richness (p99th)	10	10	10	10	9
t_e_species_richness (p1st)	1	1	1	1	1
t_e_species_richness (p99th)	9	9	10	10	8
wildlife_species_richness (p1st)	8	21	21	21	23
wildlife_species_richness (p99th)	57	57	68	57	56
aquatic_species_richness_CA_2018 (p1st)	5	2	0	1	1
aquatic_species_richness_CA_2018 (p99th)	92	70	94	80	76

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