

UNIVERSITY OF CALIFORNIA
Santa Barbara

Regional Restoration Planning for the Central San Joaquin Valley

A Group Project submitted in partial satisfaction of the requirements for the degree of

Master of Environmental Science and Management

for the

Bren School of Environmental Science and Management

by

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Regional Restoration Planning for the Central San Joaquin Valley

As authors of the Group Project report, we archive this report on the Bren School's website such that the results of our research are available for all to read. Our signatures on the document signify our joint responsibility to fulfill the archiving standards set by the Bren School of Environmental Science and Management.

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The Group Project is required of all students in the Master of Environmental Science and Management (MESM) Program. The project is a year-long activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue.

This Group Project Final Report is authored by MESM students and has been reviewed and approved by:

Dr. Jayajit Chakraborty

Date

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Abstract

In a partnership between the Bren School of Environmental Science and Management and Sequoia Riverlands Trust (SRT), this project proposes a restoration plan for California's Central San Joaquin Valley, spanning Tulare, Kings, Fresno, and Madera counties. The plan bridges the gap between local and statewide goals by consolidating existing conservation plans, addressing gaps in regional knowledge, and engaging local partners and residents to help shape the final plan.

The four-county region has changed drastically over time, with historic ecosystems largely replaced by agriculture and urban development, specifically across the valley floor. This transition has driven groundwater depletion, biodiversity loss, and higher environmental hazard risk. These impacts disproportionately burden already disadvantaged populations, worsening health outcomes. Projected groundwater constraints indicate that large amounts of farmland may require repurposing, which will further these negative impacts. This potential transition, and other existing restoration efforts, can improve habitat connectivity, reduce environmental hazards, meet state-led directives on conservation which encourage nature based solutions, and support community health and economic resilience.

This project synthesizes ecological, hydrological, and sociodemographic data to find that over 2.2 million acres of land can be prioritized for restoration across the region. The final product serves as an applied decision-making tool which includes a series of maps that identify which areas are prioritized for restoration and which ecosystems are impacted, along with a series of restoration strategies and guidance to support alignment between land managers and agencies in the region.

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Sequoia Riverlands Trust, *including but not limited to*: Dr. Logan Robertson Heucker, Executive Director; Adam Livingston, Director of Planning & Policy

Acronyms

ACS	American Community Survey
AW	Applied Water
CBI	Conservation Biology Institute
CDC	Center for Disease Control
CDFW	California Department of Fish and Wildlife
CPAD	California Protected Areas Database
CDPs	Census Designated Places
CSU	California State University
CWHR	California Wildlife Habitat Relationships
DEM	Digital Elevation Model
DWR	Department of Water Resources
EJI	Environmental Justice Index
EPA	U.S. Environmental Protection Agency
FLO	Floodplain
FMMP	Farmland Mapping and Monitoring Program
FOR	Forest
FORE-SCE	Forecasting Scenarios
GBIF	Global Biodiversity Information Facility
GIS	Geographic Information System
GRA	Grassland
GSA	Groundwater Sustainability Agencies
InSAR	Interferometric Synthetic Aperture Radar
JPL	Jet Propulsion Laboratory
LCMAP	Land Change Monitoring, Assessment, Projection
LULC	Land use and land cover
MLRP	Multi-benefit Land Repurposing Program
NBS	Nature-based Solutions
NLCD	National Land Cover Database
PCS	Projected Coordinate System
R2P2	Regional Restoration Planning and Partnership
RIP	Riparian
S2J2	Sierra San Joaquin Jobs Initiative
SGMA	Sustainable Groundwater Management Act
SHR	Shrubland and Chaparral
SPA	Sparsely Vegetated Land
SRT	Sequoia Riverlands trust
SSP	Shared Socioeconomic Pathway
SSURGO	Soil Survey Geographic Database
UCSB	University of California Santa Barbara
USGS	United States Geological Survey
VAL	Valley Foothill Hardwood
WET	Wetland

This project is a partnership between UC Santa Barbara's Bren School of Environmental Science and Management and Sequoia Riverlands Trust (SRT) to create a regional restoration plan for the Central San Joaquin Valley, specifically for Madera, Fresno, Tulare, and Kings Counties.

Project Objectives

- 1) **Synthesize and analyze existing data** to determine potential areas for restoration. Data include:
 - Existing restoration and conservation plans;
 - Projections of areas for farmland retirement and potential multi-benefit land repurposing projects;
 - Sociodemographic data; and
 - Projected climate-related shifts in biological community ranges.
- 2) Support Sequoia Riverlands Trust in **engaging various partners and stakeholders** to identify restoration priorities. Partners and stakeholders include:
 - Regional environmental and social organizations;
 - State and federal agencies; and
 - Community members from the four counties of interest.
- 3) Create a publicly accessible, **interactive plan for regional restoration projects** that prioritizes ecological and socioeconomic needs of the region. This includes:
 - Suggestions for restoration goals and targets;
 - An implementation plan with best practices for community-level restoration; and
 - Resources for funding and long-term sustainability.

The objectives for this restoration plan shifted from a conceptual and exploratory project to an applied, decision-making tool. These objectives seek to expand beyond an ecological focus by integrating ecological, climate, and sociodemographic factors. This evolution emphasizes multi-benefit land repurposing, long-term sustainability, and community-centered restoration, all of which aim to better facilitate implementation and generate long-term impact. This project also recognizes that restoration planning and implementation is not one-size-fits all. The intention of this project is to provide users with a menu of options for restoration or more sustainable practices that are accessible to many different users.

Background & Significance

Background

The San Joaquin Valley and Southern Sierra Nevada are some of the most ecologically unique and biodiverse regions in the country. Millennia of erosion and alluvial deposition has created rich, highly productive soils that support a wide array of species and ecosystems. However, large-scale ecosystem conversion and degradation in the Valley over the past two hundred years has severely impacted local ecosystems, leading to negative effects on local communities. The Valley that was once home to vast wetland, vernal pool, grassland, riparian, and oak woodland habitats has been almost entirely converted to agriculture over the past two hundred years. This area is now one of the most agriculturally productive regions in the United States, improving national food security and supporting the growth of a large agricultural industry and workforce in the region. In addition to land conversion due to agricultural expansion, much of the land has been urbanized for human use and population growth.

To support this agricultural production and community growth, millions of acres of native habitat were converted, wetlands drained, and waterways diverted, resulting in severe environmental costs (Butterfield et al 2021). Not only have local ecosystems been lost, but many physical characteristics of the local environment have been so modified or degraded that they are no longer functional. Examples include the loss of the nutrient rich topsoil due to continual cycles of tilling for agriculture or urban development; heavy modification and regulation of surface water systems for agricultural use and flood control (reducing topsoil regeneration), and the overdraft of groundwater aquifers for irrigation and drinking water, which has led to land subsidence and soil compaction.

Intensive agricultural practices such as fertilizer and pesticide use have also caused soil degradation and severe air and water pollution. Residents of the region are adversely affected by the high levels of agricultural pollution, as well as the limited access to green space, and experience disproportionately poorer health outcomes as a result (Fernandez-Bou et al, 2023). These widely documented adverse human health impacts related to poor water and air quality are known to disproportionately impact the majority non-white population of the region.

Ecosystem restoration can address many of these concerns around ecosystem and human health. Restoration projects can address climate change by increasing carbon sequestration, increasing biodiversity and ecosystem resilience, improving water and air quality by filtering pollutants, supporting groundwater sustainability by promoting recharge and reducing extraction, and can improve community resilience by serving as buffers to natural disasters, namely fire and flooding. Restoring natural spaces also supports human health by providing more access to green space, which can improve mental and physical health in local communities.

This project aims to create a regional restoration plan that provides guidance to landowners, land managers, community members, and other affected parties on where and how to pursue ecosystem restoration projects to best meet the ecological and social needs of the region. By

producing a regional restoration plan with actionable restoration options guided by regional priorities and stakeholder input, the project is providing both the clients and broader community with the information they need to take meaningful action.

Significance

The State of California has attempted to address some of the concerns around groundwater depletion and land subsidence; loss of natural space and biodiversity; worsening water, soil, and air quality; and lack of access to natural space via policy and economic investments. Notable policies and programs that directly affect the long-term agricultural viability and land use include the Sustainable Groundwater Management Act (SGMA), and the Multi-benefit Land Repurposing Program (MLRP). These initiatives aim to regulate groundwater usage across the State, while providing support for strategic land conversion and conservation that can advance a range of state-wide environmental and social priorities (Butterfield et al., 2017; Fernandez-Bou et al., 2023). For example, California is committed to conserving 30% of its land by 2030 and promoting nature-based solutions to climate change through the 30x30 Initiative. Other programs support ecosystem restoration with the goals of increasing carbon sequestration, reducing erosion, and building local resilience to natural disasters.

These state-driven initiatives provide stakeholders in the region with a unique opportunity for coordinated planning for strategic land management, which could include land conversion or repurposing for ecological and economic benefits. Successful planning and implementation can promote ecosystem restoration while achieving multiple benefits such as groundwater recharge, carbon sequestration, expanded community access to open space, increased resilience to natural disasters, and regional economic growth and development (Bryant et al., 2020). It is within this context that Sequoia Riverlands Trust seeks to create an ecosystem restoration plan for the four-county region.

Sequoia Riverlands Trust (SRT) is a regional nonprofit land trust based in Tulare County, California. With a mission to conserve the lands and waters of California's heartland, SRT aims to strategically conserve and restore natural and agricultural lands to promote habitat quality and support a sustainable agricultural industry, while meeting the economic and social needs of the region. SRT was awarded a grant as part of the Sierra San Joaquin Jobs Initiative to plan for ecosystem restoration on a regional (four-county) scale, with the goal that such projects could contribute to statewide conservation targets while also serving as an economic force, creating climate-forward jobs and supporting community resilience for the future.

This project aligns with the Regional Restoration Planning and Partnership (R2P2) component of the Sierra San Joaquin Jobs (S2J2) grant that SRT received. The R2P2 component focuses on:

- 1) Incorporating, integrating and improving past regional conservation and restoration plans.
- 2) Addressing and filling gaps in existing knowledge with consideration of regional goals and needs, including needs around ecosystem restoration, sustainable water management, and community economic resilience.
- 3) Engaging partners such as community groups, resource conservation districts,

government agencies, other non-profit organizations, and community stakeholders, representing their perspectives in the final plan.

The goal of this regional planning effort is to develop a plan that allows environmental organizations, restoration practitioners, state agencies, and other relevant stakeholders to collaborate on a regional level, thus ensuring that future conservation and restoration efforts contribute towards larger, landscape-scale targets. While there are existing statewide restoration plans that establish broad conservation priorities, and detailed plans to address site-specific needs, there is a lack of a middle ground between these two scales that provides practical direction. This plan aims to fill that gap by providing ecosystem-level restoration guidance that aligns site-specific restoration actions with broader landscape-scale conservation goals. Planning processes are also designed to raise awareness and provide support to private landowners, growers, and other community members who are looking to contribute to these biodiversity or habitat restoration goals.

The primary users of the Regional Restoration Plan will be regional land-based restoration organizations, Groundwater Sustainability Agencies (GSAs), local and state governments and agencies, community-based organizations, Tribal representatives, and land use decision-makers across Tulare, Kings, Fresno, and Madera counties. This growing network is focused on implementing high-impact restoration that aligns with existing conservation and restoration plans, as well as CA Executive Order N-82-20, which promotes nature-based solutions to the climate and biodiversity crises. These actors need clear, science-based guidance on where and how restoration can provide multiple benefits—such as recharge, habitat improvement, and flood protection— especially on lands transitioning out of agricultural production.

The broader audience includes state agencies like the Department of Water Resources (DWR), California Fish and Wildlife (CDFW), and the Strategic Growth Council, as well as Tribal governments, community-based organizations, and landowners interested in implementing nature-based solutions on their properties. These users need access to regional-scale planning tools, data, and partnerships to effectively coordinate, fund, and implement restoration projects. A clear restoration strategy will help align local efforts with larger state and federal priorities, increase funding eligibility, and improve ecological outcomes.

SRT has partnered with the Bren School of Environmental Science and Management at the University of California, Santa Barbara (UCSB) to develop this four-county ecosystem restoration plan. With a mission to develop interdisciplinary solutions to environmental problems, train environmental leaders, and work for a sustainable future, the Bren School serves as an ideal partner that brings technical expertise and valuable tools to the project. The development of this restoration plan is a portion of a master's capstone project for the 2026 school year.

Approach and Methods

To support SRT's initiative, the Bren group conducted in-depth geospatial analysis, literature review, and stakeholder engagement to produce a draft restoration plan outline. Geospatial analyses focused on historical, current, and future land use for the region as well as habitat

species distribution and habitat connectivity modelling. Literature review consisted of other restoration plans focused on the region or subsets of the region, papers describing key ecosystem types, habitat and species for the region, and methods papers to identify best methods and practices for conducting some of the analyses in this project. The final restoration plan will consist of a series of maps illustrating a vision for habitat restoration across the four-county region, in addition to a series of guidance documents. The maps, grounded in existing hydrological, ecological, and sociodemographic data, will reflect regional goals with identified priority areas for restoration activities and strategies. Guidance documents will provide resources and strategies for the various restoration goals outlined in the plan. The final restoration plan will be informed by stakeholder and client engagement, as well as the goals and priorities of prior restoration plans in the region. Furthermore, the project will incorporate detailed documentation of research methods, stakeholder engagement, and the spatial analysis process.

The following sections outline the process and reasoning for collecting data, conducting research, making decisions, and creating final deliverables.

Community/Stakeholder Engagement and Developing Deliverables

As part of the restoration planning effort, SRT and two members of the group project team engaged community members and partners with the intention of understanding local and regional needs, concerns, and goals, to ensure that any restoration planning and recommendations would address their concerns and advance broader goals across the four counties. This engagement included a series of virtual and in-person meetings, community outreach, and asynchronous methods of engagement to allow for community feedback on a continuing basis.

For the purposes of this engagement effort, interested parties and participants were separated into two major categories: partners (local environmental and community-based organizations, regional conservation planners and restoration practitioners, and governmental or quasi-governmental agencies) and community members (local residents with less influence over the implementation of large-scale restoration projects but who would still be directly and heavily impacted by any outcomes of this plan). The results of this engagement informed development of the final deliverables for this project, including decisions on the format and structure of the restoration plan and other public communications materials such as the online ArcGIS StoryMap.

Partner/Stakeholder Engagement

Five virtual meetings were held to engage the partners in the restoration planning effort. Each meeting was structured to share information about the project's objectives and goals, provide updates on progress to date, and to solicit feedback, guidance, and direction from the attendees. The main purpose of these meetings was to gain insight into the biggest concerns, needs, and obstacles facing restoration practitioners and those interested in workforce development and community resilience in the region.

From these meetings, and ongoing work with SRT, it became clear that the largest concerns for the future of conservation and ecosystem restoration work in the region are:

- Lack of funding or sustainable funding for restoration projects.
- Lack of consensus between partners and regional stakeholders on regional restoration goals.
- Lack of coordination between partners and regional stakeholders on pursuing potential restoration opportunities, but high interest in engaging in co-managed projects.
- Lack of communication and partnership with local community or landowners (especially farmers), but high interest in expanding these relationships.
- Limited capacity to implement identified restoration projects, but high interest in engaging the local community (especially youth), and developing training programs to create a restoration workforce.

Community Engagement

Six community engagement meetings were held across the region, two in Madera County, two in Fresno County, and two in Tulare/Kings Counties. For each pair of meetings, one was held virtually via Zoom, and the second was held in-person at a centrally located and easily accessible meeting space. This effort engaged over one hundred community members from across the region. Each meeting was free and open to the public, and all attendees were given the option to receive a stipend for participation if desired.

Each meeting was uniformly structured, with a presentation led by a group member that introduced the topic, followed by a short poll, a discussion moderated by SRT staff and group members, and an end-of-meeting survey. Group members and staff hosting the meetings took detailed notes on participant responses, though no identifying information was recorded. All notes were analyzed and coded into common themes, which were used to identify topics of concern using an absolute frequency analysis. A similar process was used to analyze the responses to the polls and post-meeting surveys. The following insights were gained from this engagement process:

Key Insights

Participants were asked a series of ranking questions related to their primary concerns about sustainable land use for the region. Respondents were asked to rate their concerns from “very concerned” to “very hopeful/excited” (*note that totals may not add up to 100% due to rounding*):

- Concerns with regard to land use in the region:
 - Very concerned: 43%
 - Slightly concerned: 29%
 - Somewhat hopeful: 12%
 - Very hopeful/excited: 5%
 - Don’t know: 9%
- Concerns with regard to the future of water use and water sustainability
 - Very concerned: 79%
 - Slightly concerned: 8%
 - Somewhat hopeful: 8%

- o Very hopeful/excited: 1%
- o Don't know: 3%

Participants were also asked to identify their top three issues of concern (*note that totals may not add up to 100% due to rounding*):

- Increasing risk of natural disasters (floods, wildfires, and drought) and their effects on local communities (43% of respondents)
- Poor surface and groundwater quality (39%)
- Lack of safe drinking water and lack of groundwater sustainability (37%)
- Biodiversity and habitat loss (37%)
- Future productivity of agricultural lands and sustainability of the agricultural industry in the region (30%)
- Poor air quality in the region (29%)
- Community resilience (25%)
- Public access to natural spaces (21%)
- Food security (15%)
- Economic resilience (14%)
- Urban development (11%)

The loss of key ecosystem types and ecosystem services, and the future of certain land-use types, are also of high concern. Community members specifically mentioned concerns related to the following ecosystem types:

- Wetlands (19%)
- Grasslands (17%)
- Riparian Zones/Valley Oak woodlands (15%)
- Croplands, specifically as they relate to on-farm restoration (15%)
- Alpine forests or softwood/conifer forests (15%)
- Developed lands and urban lands, specifically as they relate to urban greening, cultivating native plants, and other urban restoration efforts (13%)
- Chaparral/shrublands (6%)

Participant Rights and Safety

Prior to beginning any community or stakeholder engagement, group members applied for and received an exemption from the Institutional Review Board at UCSB. This exemption gave the group flexibility in conducting the stakeholder and community engagement, with the caveat that all activities adhered to specific requirements for protecting participant rights. These caveats included:

- Ensuring that all meetings were announced in advance, and that participants were aware that attendance and participation is voluntary, and that no consequences would be administered for absence or lack of participation
- All outreach and communications materials were accessible and available in multiple languages. This included all fliers, registration forms, sign-in forms, handouts, slideshow presentations, and more. All outreach and communications materials were reviewed and approved by the Institutional Review Board at UCSB.

- Interested participants in community meetings were aware that all registration forms and sign-in forms were optional, and that the meetings were open to the public. Interested participants were also clear that sensitive information would not be collected or stored unless participants voluntarily gave permission to store information for future contact (to join a newsletter, to learn more about the program, or to receive a gift card for participation). Partner meetings were not open to the public, but registration forms were optional, and no sensitive information was collected or stored.
- All information collected for this project is stored in a secure location that is only accessible by those directly involved in the project and will be deleted after the conclusion of this project.

Future Steps

Additional discussion from the partner and community engagement meetings highlighted a few key regional needs, including:

- Ongoing community engagement around land use and conservation planning
- Inclusion of community members who will be directly impacted by the plan and the State policies around conservation and restoration, including but not limited to:
 - Tribal groups and indigenous leaders
 - Farm and field workers
 - Representatives of highly vulnerable communities at risk of being affected by natural disasters, such as those living in wildfire-prone areas or within flood zones
 - Youth and young adults
- Increased investment into workforce development and ecosystem restoration

These needs serve as guidance for SRT as they continue to develop partnerships and regional strategies around conservation, restoration, and economic development.

Developing Project Deliverables

Through community and partner engagement in conjunction with Sequoia Riverlands Trust over the Summer of 2025, it became clear that the final deliverables for this project must include a static restoration plan (preferably in PDF form) as well as interactive, online maps and guidance that are easy to share. This was supported by the results of a final question posed to community members and partners, in which participants were asked to identify their preferred format for the restoration plan that would enhance utility and accessibility. The majority of respondents (42%) preferred an interactive geospatial tool, such as an ArcGIS Dashboard, while 29% preferred a website with interactive maps, and 25% preferred a static PDF format that would simplify sharing and printing the plan.

From outreach and individual engagement with restoration practitioners and environmental organizations across the region, it became clear that though many restoration plans already exist for this region, the major obstacle to project implementation has been the lack of guidance on initial steps, alignment on regional restoration goals, and information on funding and resources for such projects.

In collaboration with SRT, with an understanding of the timeline of this project and the capacity of the group, the team decided that the project would have two major deliverables:

- A PDF containing a series of static maps that outline various major concerns and opportunities identified through the stakeholder and community engagement, followed by a series of documents that provide information on the different ecosystems in the region, goals for each ecosystem based on the current usage of the land, actionable guidance on next steps to implementing restoration projects or engaging in these goals, and potential resources and partners that could support the planning and implementation of restoration projects across the four-county region
- An online and partially interactive ArcGIS StoryMap that can guide users through information about the region and its history, and the objectives and significance of this plan. This StoryMap will also allow users to interact with these maps so they can identify areas of interest, and will guide users to appropriate guidance and resources on pursuing restoration projects in that area of interest

Conducting Research & Reviewing Literature

Our literature review has been conducted in several stages to understand:

1. The ecological and social characteristics of the target region,
2. Relevant regional and state environmental policies, initiatives and objectives, and
3. Previous academic, governmental or organizational restoration planning pertinent to our initial identified objectives.

Literature was selected by collating relevant regional and state planning documents, researching prominent restoration and conservation activities, and consulting with the client.

Once the literature review was completed, we performed a gap analysis to ensure that the entire geographic region and all topics of concern were represented in the research, potentially usable data sources were identified, and a variety of methods for our analyses were evaluated.

After project objectives and specific analyses were agreed upon within the group, and with the client, we performed additional literature review to finalize analyses methods, data resources and scientific accuracy.

Conducting Analysis and Creating Maps

The mapping portion of the plan is the primary avenue for visualizations of Madera, Fresno, Tulare, and Kings counties (hereby known as “the region”). The following sequence of maps was developed by aligning the science and best practices for restoration planning identified through the literature review and the identified partner and community priorities with previous restoration plans for the region and ongoing state initiatives.

Map Sequence for Restoration Plan:

- Historic Conditions
- Current Land Cover
- Current Land Use

- Projected Land Cover Change
- Restoration Priorities for Disadvantaged Communities
- Restoration Priorities (Assuming No Change in Land Cover)
- Restoration Priorities (Given Land Cover Change)
- Final Identification of Restoration Priority Areas in the Region

Together, these maps identify a selection of restoration priority areas and provide guidance on where to best plan for future restoration projects to meet both ecological goals and address human needs.

The primary objective of these maps is to depict a story of changes, threats, and opportunities for the region. In the final product, each map will be shown at three geographic scales (per watershed, per county, and at the four-county scale). For this report, all maps are shown at the four-county scale.

Narrative Methodology and Research Approach

All data were analyzed using R or the ArcGIS Pro software application. All layers are projected to the NAD 1983 California (Teale) Albers projected coordinate system (PCS) to maintain consistency across all layers. This map projection is a California-specific, equal-area projection that is useful for accurate representation of land areas and distances, as required for this project. It is also the standard projection used by the State of California and is the preferred projection for all analyses submitted to the CDFW’s BIOS system, which is the centralized system that hosts all resource and land management datasets (CDFW, 2022).

Some standard data sources, listed below, were used for all maps in this project:

- California State Boundary
- California County Boundaries - The four counties were selected as the boundary layer from the UC Davis Information Center for the Environment’s San Joaquin Valley Counties and exported as the geographic extent.

The following section outlines each of the maps developed in this project, including a description of the map, a justification for including each map in the final product, and the detailed methods and data used to create each map.

Historic Conditions Map

Justification

The purpose of this map is to visualize the historic (pre-colonial) ranges of the nine main ecotypes of the region to provide context on the extent of natural ecosystems before modern development, and, when compared to current land cover maps, how the region has changed. Understanding the types and distribution of native ecosystems helps land managers and restoration practitioners better plan for which restoration interventions are best suited for each area of the region.

Description

The nine main ecosystems shown represented in the Historic Map are: Riparian, Grassland, Wetland, Floodplain, Valley/Foothill Hardwood, Forest (softwood/conifer species), Shrubland

and Chaparral, and Sparsely Vegetated Lands (which includes Alkali Desert Scrub). These ecosystems were chosen by combining two relevant sources: CA Nature-Based Climate Solutions Guidance Documents and the Central Valley Historic Mapping Project developed by the California State University (CSU), Chico Department of Geography and Planning and the Geographic Information Center. This combination aims to accurately represent the landscapes of the four counties of interest, while also achieving the overarching goal of aligning local restoration planning with statewide goals.

Data Used

Dataset Name	Source	Description
Historic Vegetation Base Map (Pre-1900), Central Valley Historic Mapping Project	CSU Chico Department of Geography and Planning and Geographic Information Center	Consists of the most reliable and best available historical vegetation information for the Central Valley in California. A date has not been assigned to the basemap. It consists of a patchwork of sources, scales, and dates, with the earliest source map dated in 1874. The basemap represents the most likely pre-Euro-American vegetation cover.
Modeled Historical Land Use and Land Cover for the Conterminous United States: 1938-1992	USGS Earth Resources Observation and Science (EROS) Center	The Historical 1938 land cover data was produced by USGS EROS researchers using Forecasting Scenarios (FORE-SCE) of land-use modeling. Researchers at USGS used historical data sources and FORE-SCE models to model spatially explicit historical land use and land cover (LULC) change in the conterminous United States from 1938 to 1992. Annual LULC maps were produced with 14 classes.

Detailed Methodology

The Historic Map draws from the USGS Modeled Historical Land Use and Land Cover for the Coterminous United States 1938 back-casting data, the Pre-1900 Central Valley Historic Mapping Project developed by the CSU, Chico Department of Geography and Planning and the Geographic Information Center. The four counties of interest were selected and used as the geographic boundary for the historic data layers. Extract by Mask was applied to add the datasets to the boundary layer. The pre-1900s vegetation layer overlays the 1938 USGS land cover, which filled areas not represented by the pre-1900s historic dataset. Within the 1938 data, ecotypes were renamed and reclassified to align with those identified in the CA Nature-Based Climate Solutions Guidance Documents and the pre-1900s data.

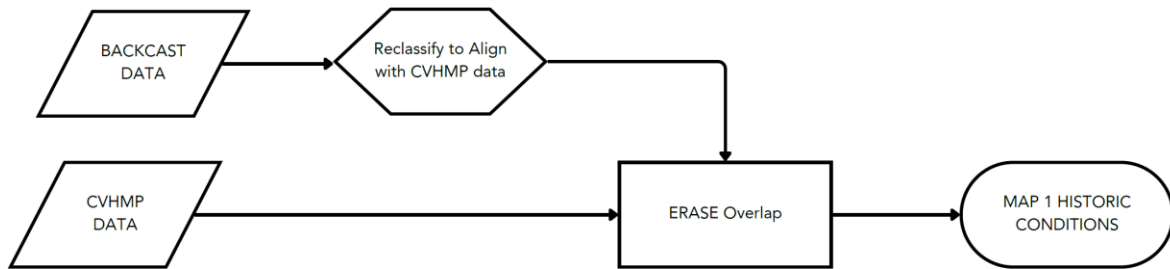


Figure 1. Historic landcover map methodology

Current Land Cover Map

Justification

Understanding the current land cover of the four-county region, and the differences between current day and historic ranges of natural ecosystems, is important for land managers and conservationists as they make ecosystem restoration decisions. To reflect present day conditions, the map characterizes the current distribution of land cover across the region.

Description

This map represents current land cover, including but not limited to intact ecosystems, areas that have been urbanized or developed, and areas that have been converted into irrigated agriculture.

Data Used

Dataset Name	Source	Description
2024 Annual National Land Cover Database (NLCD)	USGS Land Cover Program	The USGS’s Land Cover program has used methodologies from legacy land cover projects, specifically the NLCD and Land Change Monitoring, Assessment, Projection (LCMAP). The goal of the

		data is to provide complete, current, and consistent public domain information on US land use and land cover.
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Detailed Methodology

To visualize the current land cover in the region, the NLCD raster was extracted to match the extent of the study area and reclassified to align with the major ecosystems and land cover types of interest (as determined by the Historic Conditions map and through analysis of major land cover types in the region). For example, developments, cultivated cropland, and pasture lands were retained for visual reference to support comparison with historic conditions. The following table shows the reclassification schema used.

NLCD Value	NLCD Land Cover Classification	Reclassified Ecosystem Type for Restoration Plan
11	Open Water	Open Water
12	Perennial Ice/Snow	No Data
21	Developed, Open Space	Urban/Developed
22	Developed, Low Intensity	Urban/Developed
23	Developed, Medium Intensity	Urban/Developed
24	Developed, High Intensity	Urban/Developed
31	Barren Land	Sparse Vegetation
41	Deciduous Forest	Valley Foothill/Hardwood
42	Evergreen Forest	Forest
43	Mixed Forest	Forest
52	Shrub/Scrub	Shrubland/Chapparal
71	Grassland/Herbaceous	Grassland
81	Pasture/Hay	Pasture/Hay
82	Cultivated Crops	Cultivated Crops
90	Woody Wetlands	Wetlands
95	Emergent Herbaceous Wetlands	Wetlands

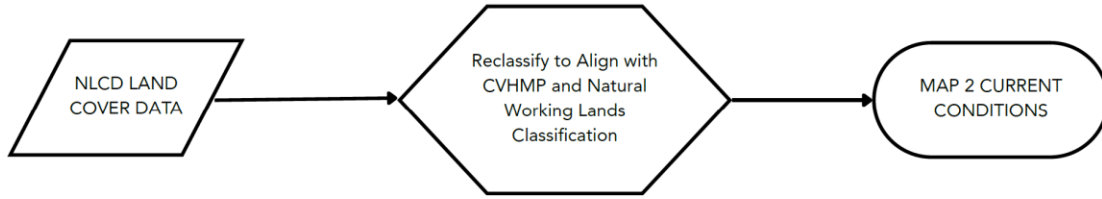


Figure 2. Current landcover map methodology

Current Land Use Map

Justification

To show the major land use types of the region as broad categories to help inform and provide context for general restoration actions. Understanding how the land is being used allows for a general understanding of the current extent and quality of natural habitat and informs recommendations for restoration actions. To better understand the dynamics of the current landscape, this map groups land uses into their major categories.

Description

Using data from the Farmland Mapping and Monitoring Project and the Rural Land Mapping Project, this map divides the region into 7 major land use categories:

- Urban and Built-Up Land
- Farmland (which includes Prime Farmland, Farmland of Statewide Importance, Unique Farmland, Farmland of Local Importance, and Farmland of Local Potential)
- Rural Residential
- Vacant or Disturbed Land
- Non-Agricultural or Natural Vegetation
- Grazing Land
- Other (Confined Animal Agriculture, Semi-Agricultural and Rural Commercial Land)

These land use categories inform the guidance documents, in which different restoration actions are recommended for each land use type. Restoration actions recommended for farmlands are applicable for all types of farmlands shown in this map. However, no restoration actions are recommended for confined animal agricultural lands or for lands categorized as “other.”

Data Used

Dataset Name	Source	Description
Private, State, and Federally protected lands	California Protected Areas Database (CPAD)	CPAD shows all the conserved areas, both publicly and privately protected. This dataset does not include easements

Dataset Name	Source	Description
San Joaquin Valley High Development Threat/Development Threat Level	Conservation Biology Institute (CBI) - Dustin Pearce	This dataset is a selection of the High Development Threat level from the dataset, San Joaquin Valley - Development Threat Level.
Important Farmland Data	California Department of Conservation Farmland Mapping and Monitoring Program (FMMP)	The FMMP data shows where prime or important farmland is located across the state, as determined using chemical and physical properties of the land and the soil

Detailed Methodology

The Farmland Mapping and Monitoring Program (FMMP) dataset was clipped to the study region and reclassified to match the seven land use categories listed in this restoration plan. The reclassification schema is listed above under the map description. To show development pressures and likely future land conversion, the CBI's San Joaquin Valley High Development Threats dataset was added. Finally, the CPAD, the tribal lands data, and current restoration efforts identified through WCB and EcoAtlas were added to contextualize areas listed as "Areas Not Mapped," illustrate existing protected areas and ownership, identify areas of interest, and highlight ongoing restoration efforts that could be expanded upon in the future.

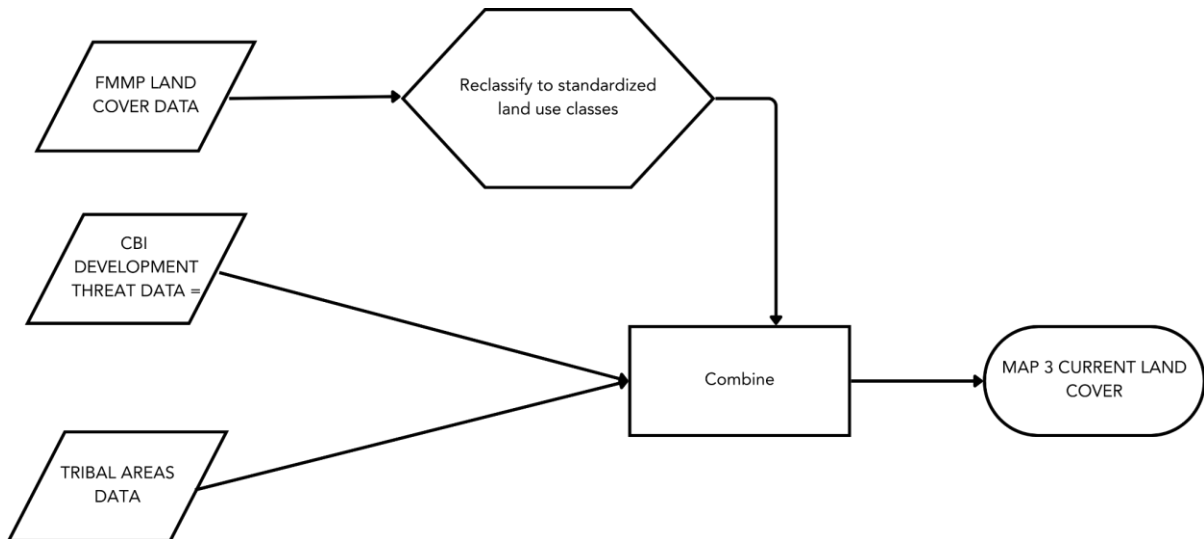


Figure 3. Current land use map methodology

Projected Land Cover Change

Justification

Illustrates areas where land cover could change if repurposing and restoration of agricultural lands does occur in response to SGMA, highlighting opportunities for conservation and land repurposing across the four-county region.

Description

This map identifies areas where land cover could shift away from intensive agriculture, under the assumption that it will no longer be economically feasible to keep some lands in production. Farmlands most likely to be converted (repurposed or restored) were identified through an analysis of water usage by crop type per farm field and the economic trade-offs between staying in production or being fallowed. The rationale for this approach is based on the fact that the major value of a parcel of farmland is derived from the income that a landowner can make from selling the products of the farm, while the major cost is water applied (hereafter referred to as “Applied Water” or “AW”) to the field to grow a certain crop. Therefore, by retiring a field of crops, a landowner will lose the projected income of that crop but will save the amount of water that would have been used to grow that crop for a given year.

Data Used

Dataset Name	Source	Description
2020 Water Year Mapping	LandIQ	The 2020 water year mapping project depicts all “fields” (areas that grow a specific crop type or have a single owner) across California, along with the crop type, acreage, and other relevant spatial information for each field
Crop Revenue Data per Crop Category	Each county’s annual crop report	Each county is required to submit an annual agricultural revenue report to the Agricultural Commissioners Office, with revenue listed per crop type, crop category, and acre
Statewide Agricultural Water Use Data 2016-2020	Department of Water Resources (DWR)	DWR has an estimated average amount of applied water, evaporated water, and consumed water for each crop type in each county, per acre
Important Farmland Data	California Department of Conservation Farmland	The FMMP data shows where prime or important farmland is

Dataset Name	Source	Description
	Mapping and Monitoring Program (FMMP)	located across the state, as determined using chemical and physical properties of the land and the soil
Private, State, and Federally protected lands	California Protected Areas Database (CPAD)	CPAD shows all the conserved areas, both publicly and privately protected. This dataset does not include easements
Water District Service Areas	DWR	Service areas are the general areas managed by individual water districts. These can be used as proxies to understand which areas, fields, and residences have access to surface water
DWR GW Level Percentile Statistics	California Department of Water Resources	Provides percentile statistics for groundwater monitoring wells across California. The data compares recent groundwater elevation measurements to historical levels using data collected by the Department of Water Resources and partner monitoring programs.

Detailed Methodology

A series of analyses were conducted in both ESRI’s ArcGIS Pro and the RStudio software package “PrioritizR” to identify the fields that, if fallowed, would minimize the amount of income lost while still reaching a water saving target, based on total crop income and applied water use per field. Methods for conducting this analysis are adapted from a similar analysis conducted for Kern County, California (Hyon et al., 2025). A 20% water use reduction target is selected for the analysis, as this is considered the “most likely” outcome projected to occur if the Sustainable Groundwater Management Act is implemented and land use shifts occur in response to a changing climate (Escriva-Bou, et al., 2023).

The 2020 edition of each dataset listed above was used for this analysis, as it is the most recent year for which the Statewide Agricultural Water Use data was available. As this analysis focuses on identifying fields for retirement, the LandIQ crop mapping dataset listed above served as the analysis layer to match the spatial resolution required. This dataset was modified through a series of steps to prepare for analysis in R using the PrioritizR package.

Crop types listed in LandIQ and in the individual county revenue reports were standardized and cross-walked to match DWR’s crop categories, as listed in the Statewide Agricultural

Water Use data. All fields in the LandIQ dataset with a spatial area less than one acre, as well as all natural lands, pasture and rangelands, and urban areas were removed from the final spatial data as these are not irrigated fields that could be fallowed. Total revenue per field and total applied water per field were calculated by multiplying values reported by DWR and the individual counties for each crop category per acre by the acreage of each individual field. The Important Farmland shapefile was joined to the LandIQ data, and all fields identified as “Prime Farmland” were designated to be locked out, as they are deemed by the State to be both important and sustainable for the long-term future, and are unlikely to be retired. DWR water district service areas were also joined to the LandIQ shapefile. Water district service areas were used as a proxy for surface water availability - if an area is covered by a water district, that area is considered to have surface water access, and is less likely to be retired as landowners can resort to surface water flows if groundwater is depleted. If an area is not covered by a water district (and therefore assumed to not have readily accessible surface water), that area was prioritized 50% more, given that a lack of surface water could be a factor in deciding to fallow land.

The DWR groundwater level percentile statistics dataset was used to understand groundwater conditions in the area. Groundwater conditions were measured at individual wells over multiple years, and the overall status of “groundwater level” was divided into eight categories by DWR: Low, <10 (Much Below Normal), 10-25 (Below Normal), 25-50 (Normal), 50-75 (Normal), 75-90 (Above Normal), >90 (Much Above Normal), and High. This point data (each point representing an individual well) was converted to a raster that spanned the entire region using the Empirical Bayesian kriging method, which interpolates the point data by accounting for distance between points, average values of points, and uncertainty in the analysis to create a more accurate set of values for the raster. This continuous raster was then reclassified into five main categories to align with those initially identified in the original data (as shown below), converted into a shapefile, and merged with the LandIQ dataset for analysis in PrioritizR. In PrioritizR, the following prioritizations were set based on groundwater accessibility. No categories were assigned 100% prioritization given that that would result in those parcels being chosen every time.

Original Value (DWR)	Reclassified Value	PrioritizR Priority Level
Low	1	75% prioritized
<10	2	50% prioritized
10-25	3	25% prioritized
25-50	4	No prioritization
50-75		
75-90	5	
>90		
High		

With these prioritization levels, the final cost value for each field is calculated in PrioritizR using the following formula:

$$Cost = Base\ Cost \times Surface\ Water\ Access \times Groundwater\ Access$$

- Base cost = acreage of field x revenue per crop category/acre
- Surface Water Access = [1, 1.5], and
- Groundwater Access = [1, 1.25, 1.50, and 1.75]

A series of statistical analyses were conducted in PrioritizR to identify fields that were most likely to be retired to meet a regional 20% reduction in water use, given that the main goal is to reduce the amount of lost revenue in the process. The output of this analysis was imported to ArcGIS and rasterized to a 100m spatial resolution to prevent the identification of individual fields. The CPAD data was then imported, and each protected area was given a five km buffer. All rasterized units identified for retirement within this buffer zone are symbolized to support conservation managers in planning for future land conservation, as conserving these areas if they are retired from active production would support expansion and connectivity of important habitat and open space.

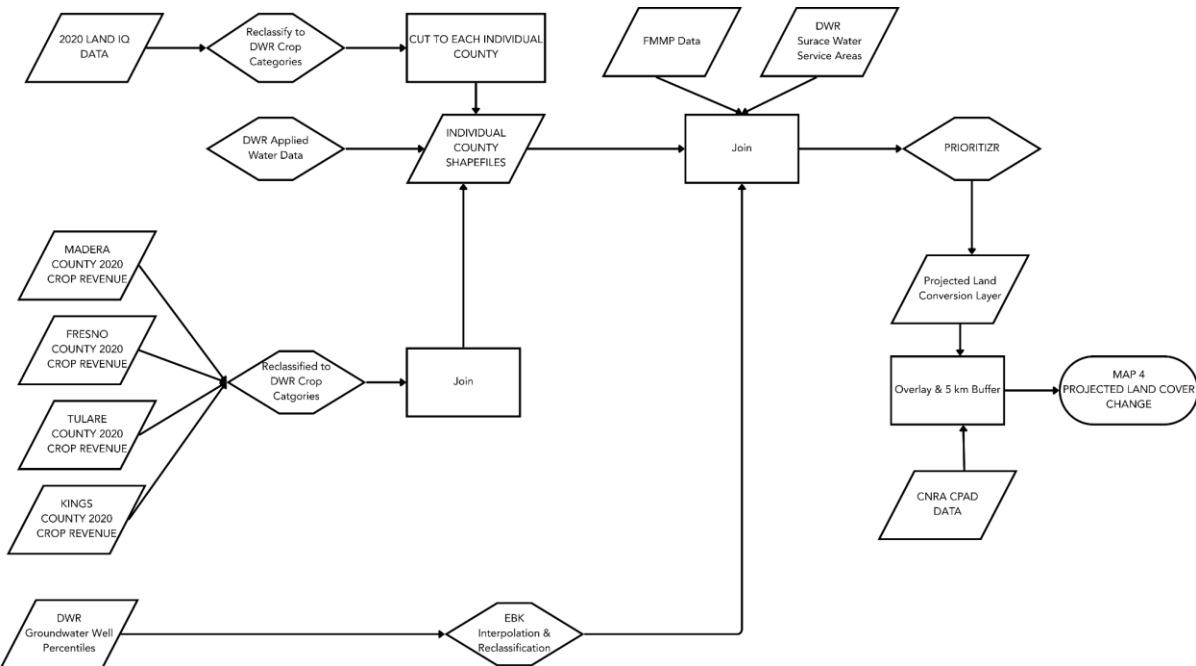


Figure 4. Projected landcover change methodology

Restoration Priorities for Disadvantaged Communities

Justification

To show areas of highest concern based on human health and socioeconomic considerations. The ecosystem services resulting from restoration efforts in these areas would provide the greatest social and economic benefit to local communities and their residents, in addition to benefitting local ecosystems. The areas identified in this map inform the prioritization of restoration efforts in the region with the goal of reaping the highest cumulative social,

economic, and environmental benefits. To center community impacts, the map identifies where restoration could provide the greatest benefits both socially and environmentally.

Description

Identifies areas where ecological restoration could most benefit disadvantaged communities in the region by mitigating impacts from hazards or improving community resilience. Hazards identified for analysis are:

- Air and Water Pollution
- Land Subsidence and Compaction
- Groundwater Overdraft
- Flood and Fire Risk, and,
- Lack of Access to Natural Spaces

These concerns were identified as high priorities in relevant literature as well as community and stakeholder engagement meetings.

Data Used

Dataset Name	Source	Description
2021 California Census Designated Places (CDPs)	U.S. Census Bureau	CDPs are identified at a different spatial resolution than Census tracts or blocks. These boundaries are more accurate for spatially defining communities where people live.
Census Data	American Community Survey (ACS) 2021 5-Year Estimates	ACS data includes information at the CDP level for most indicators listed in the Social Vulnerability module of the Center for Disease Control (CDC) EJ Index.
Drinking Water Quality	CalEnviroScreen	This shapefile includes data on drinking water contaminants and groundwater threats
Air Quality	CalEnviroScreen	PM2.5 and Ozone percentile data was used to identify areas of high air quality concerns.
Flood Risk	FirstStreet Flood Factor	A nation-wide analysis of hydrology, land

Dataset Name	Source	Description
		development, water management systems, and potential impacts of climate change was conducted to create a “flood risk” value for each zip code in the United States.
Floodplain	FEMA Effective Flood Plains	A FEMA dataset that identifies the 100-year flood plain boundaries for the entirety of California
Fire Risk	Contemporary Wildfire Hazard Across California (PyroLogix and US Forest Service)	This dataset shows the potential wildfire risk for the entirety of California, accounting for fuel type and density, management practices, past fire regimes and impacts, hydrology and atmospheric conditions, distance to homes and urban spaces, and future climate scenarios.
Land Subsidence	inSAR Vertical Displacement Data – Collected by European Space Agency and processed by CA DWR	This raster shows total displacement of land in feet since 2015 to the most recent record collected in 2025
DWR GW Level Percentile Statistics	California Department of Water Resources	Provides percentile statistics for groundwater monitoring wells across California. The data compares recent groundwater elevation measurements to historical levels using data collected by the Department of Water Resources and partner monitoring programs.
California AccessShed	CA Natural Resources Agency 30x30	This shapefile shows all areas within California that fall within a half-mile radius

Dataset Name	Source	Description
		of a conserved area or other open space that also provides opportunity for public access

Detailed Methodology

Disadvantaged communities in the study region were defined as the most disadvantaged places in the state of California. Using methods that were used to create the “Social Vulnerability Module” of the CDC 2024 Environmental Justice Index (EJI), a new analysis was conducted to identify the most socially vulnerable (i.e., disadvantaged) communities in California. This analysis was conducted at the Census Designated Place (CDP) level, since these CDPs are both more accurate to the region and spatially consistent with its communities than Census Tracts, which often include large areas of empty land in the more rural areas of the study region, which allows for more accurate planning for future land use and restoration. Census data was aggregated for each “indicator” within the Social Vulnerability Module of the EJI using variables and data from the 2021 American Community Survey 5-year (2017-2021) estimates. The indicators included in this analysis are: minority status (population with any racial status other than the non-Hispanic, white-alone category); poverty (population with income levels below 200% of the federal poverty level); education (population 25 years of age with no high school diploma or equivalent); unemployment (population over 16 years of age who are unemployed); housing cost burden (housing units that have an annual income of less than \$75,000 and pay over 30% of monthly income on housing expenses); lack of health insurance (civilian, non-institutionalized population without health insurance); lack of internet access; elderly (population over 65 years of age); youth (population at or below 17 years of age); disability; English language proficiency (population aged 5 years and older who speak English “less than very well”); group quarters (population living in college residence halls, residential treatment centers, group homes, correctional facilities, and/or worker’s dormitories); and percentage of housing units designated as mobile homes. These indicators were chosen because the populations represented are facing socioeconomic burdens that reduce their capacity to address environmental concerns, improve conditions, or influence land use decisions in their communities (Technical Documentation for the 2024 Environmental Justice Index et al.).

The 2021 ACS five-year estimates were chosen as the most recently created reliable and comprehensive data source for CDPs. All statistics for each indicator were extracted from this dataset and a percentile rank was then calculated for each CDP within each indicator, thus ranking each place against all places in the state of California. If there was no data available for over four of the indicators, then that CDP was removed from the percentile rank calculation to ensure that the missing data did not bias the final analysis (following the CDC EJI calculation methodology). Each of these individual indicator ranks were then added together across each CDP to create a total “summed rank.” These summed ranks were then percentile ranked again to create an overall ranking of all CDPs in California. The top 25% of CDPs (those at or above the 75th percentile of burdens) was selected and designated as

disadvantaged communities. This binary “disadvantaged” characterization was linked to the original shapefile of CDPs in California and clipped to the four-county study region for further analysis of environmental risk or burdens. This new layer is hereby referred to as the “disadvantaged communities layer” in the following paragraphs.

Given the varying spatial resolutions and type of data available for the environmental burdens and risks described above, as well as the different scales at which these hazards need to be managed, each hazard was analyzed individually to identify priority areas where restoration could mitigate or reduce the impacts of that respective burden.

The drinking water pollution data on CalEnviroScreen was available at the census tract level for the state of California, and each tract was assigned a percentile rank of burden compared to all tracts in the state. This data was clipped to the four-county study area, and the tracts at or above the top 80th percentile of burden were extracted to a new layer. This was overlaid with the disadvantaged communities layer to identify all disadvantaged CDPs within the study region that also faced the highest levels of water pollution. A 1,600-meter buffer was created around all identified disadvantaged communities, since such a buffer, if removed from intensive agriculture and restored, can significantly reduce water pollution for that community (Fernandez-Bou et al., 2023).

The air quality data from CalEnviroScreen is also aggregated at the tract level for the state of California. The areas of highest concern (80th percentile) for the two air quality indicators (PM2.5 concentration and ozone levels) were extracted and overlaid to identify regions facing both burdens. The disadvantaged communities within these regions facing the highest levels of air pollution were identified, and a 400-meter buffer was created around these communities as such a buffer, if restored, could encompass enough green space to significantly improve air quality for these communities (Fernandez-Bou et al., 2023).

Flood risk data was compiled at the zip code level for the entire US. Thus, the percentiles assigned to each zip code in the study region were calculated in comparison to the rest of the nation. To better align with other analyses, this dataset was clipped to the extent of California and new percentiles were calculated and assigned to each zip-code across the state. The dataset was then clipped again to the study region, and the zip codes within the top 80th percentile of flood risk across the state within the study region were extracted and merged. The disadvantaged communities within this region of highest flood risk were identified, and the appropriate floodplains around these communities were identified from the FEMA data. Appropriate floodplains were determined to be those that were adjacent to or geographically connected to these disadvantaged communities through a natural waterway. These floodplain areas were then extracted as priority areas for floodplain restoration and flood mitigation in the region.

Fire risk data was compiled as a continuous raster data layer for the entire state of California. The raster data is divided into ten “percentiles” as recommended in the process documentation and metadata shared with the dataset. In a similar manner to the previous analyses, areas at or above the 80th percentile (highest 20% of risk) of fire were extracted, and the disadvantaged communities within or near this high fire risk area were identified. As

wildfire mitigation can only be conducted on a very large scale, the entire high-risk area was identified as a priority for restoration.

For land subsidence, InSAR (Interferometric Synthetic Aperture Radar) data TRE ALTAMIRA, collected and compiled by the California Natural Resources Agency and Department of Water Resources, and InSAR data from NASA's Jet Propulsion Laboratory (JPL), collected and compiled by Govorcin et al., were compared to identify the most comprehensive and useful dataset for the region and its needs. The TRE ALTAMIRA dataset was chosen as it is used by the State of California for managing water resources, administering and implementing SGMA, and for monitoring impacts of land subsidence. This data is also a raster that visualizes cumulative displacement over 10 years (2015-2025), rather than an average annual rate of subsidence, as is shown in the NASA JPL data. This data was processed in ArcGIS for this analysis. All raster cells that had positive displacement values, or showed areas of uplift, were removed from the analysis, as the major concern for the region is land subsidence. The new raster was reclassified into five quantiles to best identify areas of highest subsidence across California. The areas of highest displacement (those in the 5th quantile, or in the 80th percentile) were extracted and converted to a polygon for better visualization.

For the sake of accuracy, the State did not interpolate the raster to assign values of displacement to areas without collected data. This was intentional to avoid bias in the data, or to assume land subsidence values without validation. For this reason, the raster was not interpolated to cover the entire region and remove data gaps in this analysis either.

Lands are subsided due to overpumping of groundwater, so that continued withdrawal of groundwater for agricultural uses will only exacerbate the issue and should be limited as much as possible. Land subsidence also heavily impacts infrastructure, and lands that are at risk of continued subsidence or settling due to groundwater extraction and further soil compaction in surrounding areas not be built on. There are options for compacted or heavily subsided lands, including but not limited to restoration. Any restoration efforts for floodplain, wetland, or riparian ecosystems, or efforts to install groundwater recharge basins, can have an additional benefit of reducing groundwater extraction and reducing subsidence in the future. However, given that significantly compacted land cannot be restored to its previous elevations, these areas were not given specific priority for restoration.

The groundwater data used was the raster interpolated from point data shared by the CA DWR and percentiled during the analysis for Map 4 (Projected Land Cover Change). As this raster already showed ten percentiles of groundwater depth across the region, no further analysis or data modification was needed for this analysis. The worst levels of groundwater overdraft (measured groundwater is within the 20th percentile of historic groundwater levels) were selected and overlaid with the disadvantaged communities layer to identify the CDPs in the most severely overdrafted areas of the region. There is no specific ecosystem restoration action that can directly mitigate groundwater overdraft. However, groundwater recharge projects and specific ecosystem restoration efforts, especially in wetland, floodplain, or riparian ecosystems, can replenish aquifers.

The California Nature Access-shed dataset is a map of open access areas in California; it includes a half-mile buffer around these areas to identify regions that have access to natural

space. The disadvantaged communities layer was overlaid and masked with this dataset to identify places that do not meet the requirements for access to green space. A half-mile buffer was created around these communities to identify priority areas where ecological restoration or conservation could also increase access to natural areas in the region.

All priority restoration areas identified for each individual hazard were merged into one restoration priority layer and overlaid by a second layer showing all CDPs in the study region, with disadvantaged communities highlighted.

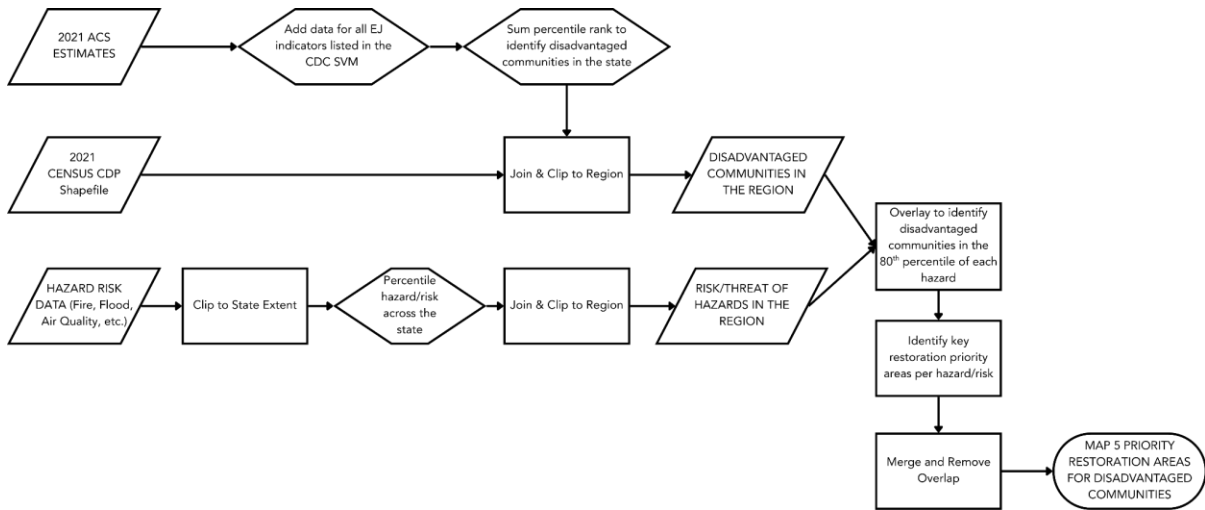


Figure 5. Restoration priorities for disadvantaged communities methodology

Restoration Priorities (Assuming No Change in Land Cover)

Justification

This map shows the opportunities for ecosystem restoration under current land use that are both climate-resilient and sustainable. Building on multiple datasets, this map identifies areas that are most suitable for restoration based on current ecological conditions.

Description

This analysis incorporates:

- Projected species distribution ranges of a series of native species of the region, as identified using the California Wildlife Habitat Relationships (CWHR) System. Species distribution ranges are determined based on current recorded observation data, physical environmental conditions, and future climate projections under SSP 5-8.5
- Land degradation metrics
- Current (2024) land cover data

Restoration priorities are identified as areas where a significant portion of species (at least 50% of species identified per ecosystem type) exist and are classified into different priority levels based on proximity to natural land and amount of degradation. This prioritization supports restoration practitioners in making decisions on where to distribute limited resources to gain maximum benefits for local ecosystems.

All of the above analyses were conducted using the 2024 NLCD dataset to help plan users understand opportunities for ecosystem restoration if no land use changes occur in response to state resource management and conservation goals.

Data Used

Dataset Name	Source	Description
California Wildlife Habitat Relationships (CWHR)	State of California Department of Fish and Wildlife	CWHR links over 700 California wildlife species to 59 habitat types. The database provides information on species life history, geographic range, habitat association(s), and management to support wildlife conservation and planning.
Soil Survey Geographic Database (SSURGO) Percent Soil Data: <ul style="list-style-type: none"> ● pH ● Silt ● Sand ● Clay ● Organic Matter 	U.S. Department of Agriculture, Natural Resources Conservation Service & Conservation Biology via DataBasin	The soil data sets were created by digitizing maps, compiling soil information, and revising results using remote sensing. The final resulting maps consist of georeferenced digital map data and computerized attribute data.
DWR GW Level Percentile Statistics	California Department of Water Resources	Provides percentile statistics for groundwater monitoring wells across California. The data compares recent groundwater elevation measurements to historical levels using data collected by the Department of Water Resources and partner monitoring programs.
North American Global Humidity Index (annual)	CGIAR Consortium for Spatial Information Trabucco, A. & Zomer, R. J.	The Global Humidity Index is a global climate dataset that measures long-term moisture conditions by comparing annual precipitation to potential evapotranspiration, producing an aridity index that is indicative of the balance between water supply and atmospheric demand across landscapes. The values range from

Dataset Name	Source	Description
		dry to humid conditions and can assess climate patterns, ecosystem water availability, and environmental stress.
Shuttle Radar Topography Mission (SRTM) 90 m DEM of California, USA	Conservation Biology Institute	The SRTM Elevation data is a global elevation dataset organized into 1° x 1° raster times that provide terrain elevation at spatial resolutions of 1, 3, or 30 arc-seconds (approximately 30m, 90m, and ~1km).
WorldClim CMIP6 – Future Climate, 10 Minutes Spatial Resoluion	WorldClim – Global Climate Data Fick, S. E. & Hijmans, R. J.	The bioclimatic variables are derived from monthly temperature and precipitation values to create biologically meaningful values. These variables can be used in species distribution modeling to show the impacts of species undergoing environmental changes.
Species Occurrence Data	Global Biodiversity Information Facility (GBIF)	GBIF Species Occurence Data is a global biodiversity dataset that compiles records documenting presence of a species at specific locations and times. It aggregates observations and species records from sources like research insitutions, natural history museums, and citizen science projects. The information provided is a georeference showing species distributions.
Landscape Intactness (1 km), California - 2025	Conservation Biology Institute	California statewide landscape intactness shows a 1km resolution dataset that estimates terrestrial landscape conditions across California by integrating multiple spatial datasets on human impacts to identify areas with higher or lower ecological intactness.
Connectivity with land	Schloss et al., 2021	The data models landscape

Dataset Name	Source	Description
use, topography, and climate		connectivity for climate-driven species movement across California. It integrates spatial data on land use, human modifications, topography, and present and projected climate conditions to estimate movement pathways.

Detailed Methodology

The analysis splits each ecosystem type into several sub-habitats, each of which is defined and characterized by the CDFW in the CWHR System. The applicable sub-habitats and their corresponding ecosystem were as follows:

- Wetland
 - Fresh Emergent Wetland
 - Saline Emergent Wetland
- Shrubland and Chaparral
 - Montane Chaparral
 - Mixed Chaparral
 - Chamise-Redshank
- Grassland
 - Annual Grassland
 - Perennial Grassland
 - Wet Meadow
 - Pasture
- Riparian:
 - Montane Riparian
 - Valley Foothill Riparian
- Forest
 - Subalpine Conifer
 - Red Fir
 - Lodgepole Pine
 - Sierran Mixed Conifer
 - Jeffrey Pine
 - Montane Hardwood-Conifer
- Valley Foothill/Hardwood
 - Montane Hardwood
 - Blue Oak Woodland
 - Valley Oak Woodland
 - Blue Oak-Foothill Pine
- Sparsely Vegetated Land
 - Alkali Desert Scrub

From there, important species associated with each sub-habitat were identified from the descriptions of each habitat type in the CWHR system, and species distribution models were created for each of the species identified for each of the ecosystems above. Some species exist in multiple habitats, so their species distribution model was associated with every ecosystem they were listed in. These species distribution models were created in Wallace.

Wallace is an R shiny app that performs Maxent analyses, a statistical analysis for ecological niche modelling that combines environmental variables with occurrence data to predict suitable habitat.

Several methodologies exist for creating species distribution models (SDMs). Maxent is one of the most adopted methodologies for landscape ecology research, and was particularly useful for our mass analysis of species throughout the four-county region. The machine learning algorithm works with only presence points and handles complex non-linear relationships to extrapolate species presence likelihood in our setting. Using Maxent allowed us to consider landscape-scale range shifts and contractions for many species in a region where native species presence can be low, and where climate change can drive unpredictable interactions with other environmental variables, causing species to forge new ecological niches in the study area.

Environmental variables used in this analysis include: groundwater levels, soil data that classified the pH and soil composition per unit of analysis, aridity, elevation, slope and aspect. The slope and aspect raster datasets were manually created in ArcGIS using the DEM dataset. All predictor variables were then prepared as raster inputs for Wallace. Environmental variables incorporated into this analysis also included climatic variables pulled from WorldClim using the following variables:

- Bio 1: Annual Mean Temperature
- Bio 2: Mean Diurnal Range (Mean of monthly (max temp – min temp))
- Bio 5: Max Temperature of Warmest Month
- Bio 6: Min Temperature of Coldest Month
- Bio 12: Annual Precipitation
- Bio 15: Precipitation Seasonality (Coefficient of Variation)

All species distribution models were then transferred to a future climate scenario, assuming a projected Shared Socioeconomic Pathway (SSP) 5-8.5 climate scenario. These individual species distribution projections then loaded and processed in R. First they were reclassified into a binary metric of either suitable (1) or poor (0) habitat, with any cell with a suitability prediction above 0.50 to be classified as suitable, and any cell below 0.50 as unsuitable. Each unique species distribution model per ecosystem type (a combination of all sub-habitats within each ecosystem type) was then overlaid on each other, and all cells that were “suitable” for at least 50% of the unique species (removing all repeat SDMs for species that may exist in more than one sub-habitat) in that ecosystem type were then classified as “suitable” for the ecosystem type as a whole. These “suitable” classifications show where ecosystem ranges could shift under this future climate projection.

The EPA Potential Wetland Areas dataset was used to further check the projected suitable ranges for wetland and riparian habitats as determined through this stacked SDM process.

- For wetland ecosystems: The projected habitat range raster for wetlands were overlaid onto this EPA dataset, and all cells that fully intersected (matched) the projected wetland areas as identified by the EPA were characterized as valid projected areas, and were extracted to create a new “correct” projected habitat range raster for this ecosystem. This was done because wetlands emerge as a result of physio-hydrological dynamics, and are better predicted by where topography and water flow allow for surface water deposition and retention, rather than by projected species presence alone.
- For riparian ecosystems: The projected habitat range raster for riparian ecosystems were overlaid onto the EPA dataset, and all cells that fell within a 250m buffer of the EPA projected wetland areas were extracted to create a new “correct” projected habitat range raster for riparian ecosystems. This is because, similar to wetland ecosystems, riparian zones are geographically determined to develop around the borders of rivers or streams, and should be identified based on geographic proximity to streams rather than on projected species presence alone.

Next, an overlay analysis was conducted using the land degradation layer to capture where restoration work will require fewer or greater resources. The land degradation raster classified each 30m cell as one of six degradation values, each of which was given a “prioritization” weight, as shown below:

- Cells classified as moderately low or moderately high intactness were weighted 150% (multiplied by 1.5)
- Cells classified as high or low intactness were weighted 100% (multiplied by 1)
- Cells classified as very high or very low were weighted 50% (multiplied by 0.5)

These criteria prioritize areas that will require only a moderate amount of restoration (and thus, less time and labor), over severely degraded landscapes that would require too much time and labor, or highly intact landscapes that may not benefit as much from intervention.

A final prioritization weight was added to lands based on distance from natural spaces. This was done to align with the general consensus in restoration ecology that proximity to natural areas is a key objective when targeting lands for restoration, as restoration activities could expand existing habitat and provide additional space for species movement, seed dispersal, and genetic evolution. This second level of weights were applied using the following criteria:

- Areas currently classified as natural land (all areas classified as “forests,” “grasslands,” “shrubland/chaparral,” “valley/foothill hardwood,” “sparsely vegetated land,” and “pasture/grazing land” in the reclassified NLCD layer from the “Current Land Cover” map) were weighted 200% (multiplied by 2)
- Areas within 100 meters of “natural lands” were weighted 150% (multiplied by 1.5)
- Areas that were neither on nor near natural lands (over 100m distance from natural lands) were weighted 100% (multiplied by 1)

The prioritizations given to land intactness and to proximity to natural land magnified each other, culminating in a series of 7 output values ranging from 0.5 to 3.

Distance to Natural Lands	Degradation Value	Final Prioritization Value
Projected Ecosystem Range Raster shows likelihood of ecosystem existence in the future and ON Natural Land: 2	Very high: 0.5	1
	High: 1.5 priority	$2 \times 1.5 = 3$
	Moderately high: 1	$2 \times 1 = 2$
	Moderately low: 1	$2 \times 1 = 2$
	Low: 1.5	$2 \times 1.5 = 3$
	Very Low: 0.5	1
Projected Ecosystem Range Raster shows likelihood of ecosystem existence in the future and NEAR Natural Land 100 meters - 1.5	Very high: 0.5	0.75
	High: 1.5 priority	$1.5 \times 1.5 = 2.25$
	Moderately high: 1	$1.5 \times 1 = 1.5$
	Moderately low: 1	$1.5 \times 1 = 1.5$
	Low: 1.5	$1.5 \times 1.5 = 2.25$
	Very Low: 0.5	0.75
Projected Ecosystem Range Raster shows likelihood of ecosystem existence in the future and NOT ON or NEAR - 1	Very high: 0.5	0.5
	High: 1.5 priority	$1 \times 1.5 = 1.5$
	Moderately high: 1	$1 \times 1 = 1$
	Moderately low: 1	$1 \times 1 = 1$
	Low: 1.5	$1 \times 1.5 = 1.5$
	Very Low: 0.5	0.5

These restoration priority values were visualized using a gradient, which can help land managers identify ideal areas for restoration. All prioritization rasters for each ecosystem were merged to create a single layer visualizing all areas on a single prioritization gradient.

Finally, we incorporated habitat connectivity corridors in the study region. Several state agencies, universities and non-governmental organizations have created connectivity analyses for California. We therefore selected analyses that were congruent with our approach to restoration prioritization and the unique considerations of our project. Given

that this analysis evaluates suitability for multiple species, incorporates future climate scenarios, and has a planning scale that spans the valley floor, foothill and high Sierra Nevada region, we opted for The Nature Conservancy’s (TNC) Present-Day Connectivity in California, which uses the Omniscape program to identify areas of optimized ecological flow without drawing a direct line between two habitat cores and prioritizes connectedness between all natural areas within a 50km radius. TNC tuned their model to include projected ecological suitability of many plant and animal species, assuming two different climate scenarios, and created linkages between habitats in different topographies to reflect potential migration and adaptation by species from lower to higher elevations. TNC then determined multiple connectivity pathways, classified as either “diffuse,” “intensified,” or “channelized,” for each climate scenario and for a combination of the scenarios. For this analysis, we included all areas determined to be diffuse, intensified, or channelized in the combination climate scenario.

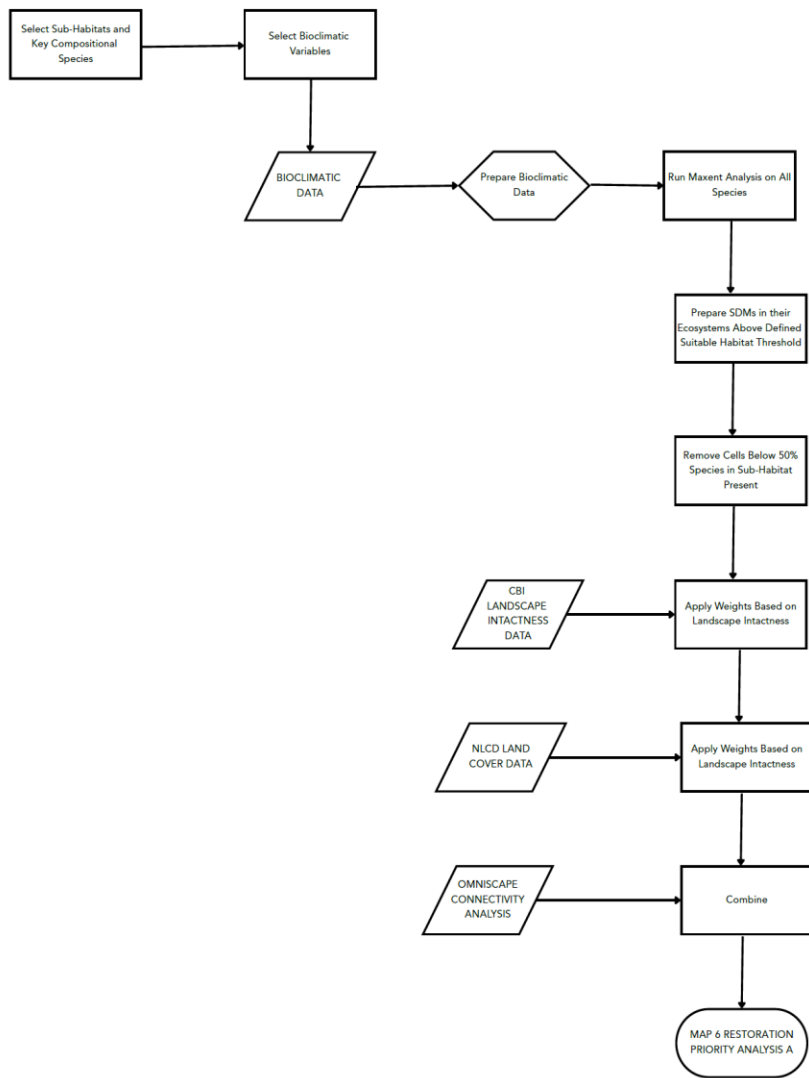


Figure 6. Restoration priorities (assuming no change in land cover) methodology

Restoration Priorities (Given Land Cover Change)

Justification

Illustrates opportunities for ecosystem restoration under projected future land cover. Shows where restoration should be prioritized, given that all areas identified for land cover change (Map 4) are available for ecosystem restoration. This can be helpful for local planners and restoration practitioners as they develop and design projects for land repurposing and restoration on agricultural lands.

Description

Priority areas were identified using a combination of the outputs of the species distribution models in Restoration Priorities (Assuming No Change in Land Cover) analysis (stacking habitat distributions under future climate scenarios, and creating restoration priorities based on projected species presence), with the outputs of the projected land retirement analysis. This process identified areas for potential repurposing or restoration to native ecosystems in its area that are weighted more heavily due to concurrence with where land retirement may occur. This helps users understand opportunities for ecosystem restoration if all lands identified for change are restored completely to natural habitat. Projected outcomes are subject to changes in state and regional policy, funding and capacity of restoration practitioners, and personal decisions of landowners in the region.

Detailed Methodology

Some of the interim outputs of the analyses for the “Projected Land Cover Change” map (Map 4) and the “Restoration Priorities (Assuming No Change in Land Cover)” map (Map 6) were combined to create this map. Namely, the shapefile output from the PrioritzR analysis conducted to identify projected areas for land cover change was extracted and rasterized to a 30m resolution to match the extent and resolution of the ecosystem range projection rasters. The values of the cells were already classified as a binary, where any areas projected for land cover change were classified as “1” and any cells not projected for change were classified as “0.” The individual ecosystem range projections (pre-prioritization weighting) were extracted individually and merged into a single raster layer that was then reclassified to a binary of “presence/absence,” where any cell that was classified as a potential future areas for ecosystem existence was reclassified as “1” and any other cell in the region was classified as “0.” The raster calculator tool was used to create a new output raster, using the following conditions:

- If the binary raster of projected land cover change is 0, then the output is 0
- If the binary raster of projected land cover change is 1, and the binary raster of quality habitat (as determined by the stacked SDMs) is 0, then the output is 1
- If the binary raster of projected land cover change is 1, and the binary raster of quality habitat (as determined by the stacked SDMs) is 1, then the output is 2

Through this process, the output raster had cells ranging from 0 to 2, with 1 and 2 corresponding to moderate to high restoration priority. The rasters were symbolized to match Restoration Priority Analysis A to facilitate comparison.

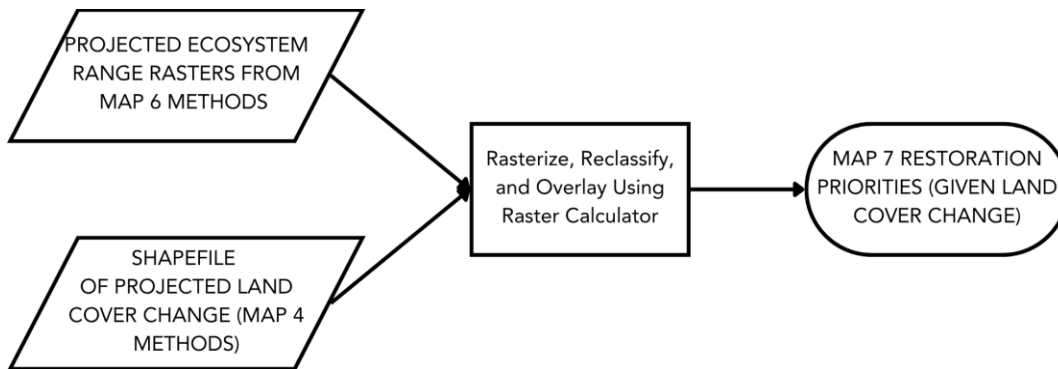


Figure 7. Restoration priorities (given land cover change) methodology

Final Identification of Restoration Priority Areas in the Region

Justification

To identify key target areas where restoration could be implemented to have the greatest ecological, societal, and economic benefit. This provides restoration practitioners and land managers with a final visualization of all areas that should be considered for restoration across the region, regardless of prioritization within categories (e.g. greater or lesser societal benefit or more or less impact on ecosystems).

Description

This final static map demonstrates where areas of highest priority for restoration exist to support and enhance ecological resilience and meet the needs of disadvantaged communities in the region.

Detailed Methodology

This map was developed by overlaying the outcomes of the three restoration priority maps (Maps 5, 6, and 7). The outcomes of the ecological restoration priority analyses illustrating both potential land cover scenarios (land retirement or not) were both narrowed to the highest priority areas (those given a priority value of 2 or greater) and added to this final visualization. This restoration priority value has different definitions for each individual ecosystem or analysis. However, these priority values indicate that the area identified for restoration is either on or near to natural land and has some level of degradation that is not too severe or too pristine to rule out restoration as a viable option for land managers in the region. All areas identified as priority restoration zones for disadvantaged communities in the region were included in this map, with no additional analysis, in an effort to ensure that community concerns were included in the final analysis without any additional bias for specific areas over others. This ensures that no communities were inadvertently ranked against each other nor were specific concerns raised by residents considered more important than any other.

Creating Restoration Implementation Guidance Documents

The guidance document was developed through a sequential process beginning with literature review to identify relevant restoration strategies across multiple scales, from regional plans to statewide guidance documents and scientific literature (see Literature

Review section for detailed methodology). Each of the eight ecosystem types was then researched and defined based on ecological characteristics relevant to the four-county study area. Land use categories were subsequently researched and defined in the context of each ecosystem, recognizing that current management influences restoration feasibility and approach. Finally, restoration actions identified through literature review were matched to specific ecosystem-land use combinations based on documented effectiveness and ecological appropriateness.

Development of the guidance document occurred in parallel with the mapping component of the restoration plan, with iterative cross-referencing to ensure consistency between map classifications and guidance document categories. This parallel workflow ensures that users can seamlessly navigate from identifying their property on the maps to locating relevant restoration guidance. The organizational structure reflects both the ecological framework of the study area and the practical reality that restoration strategies must account for current land management.

Results & Deliverables

The majority of the data analysis conducted for this project is presented via the maps in this section. Additional in-depth literature review, research, and outreach helped inform the creation of the guidance documents. The following map (Figure 8) illustrates the size and location of the region in relation to the state of California.

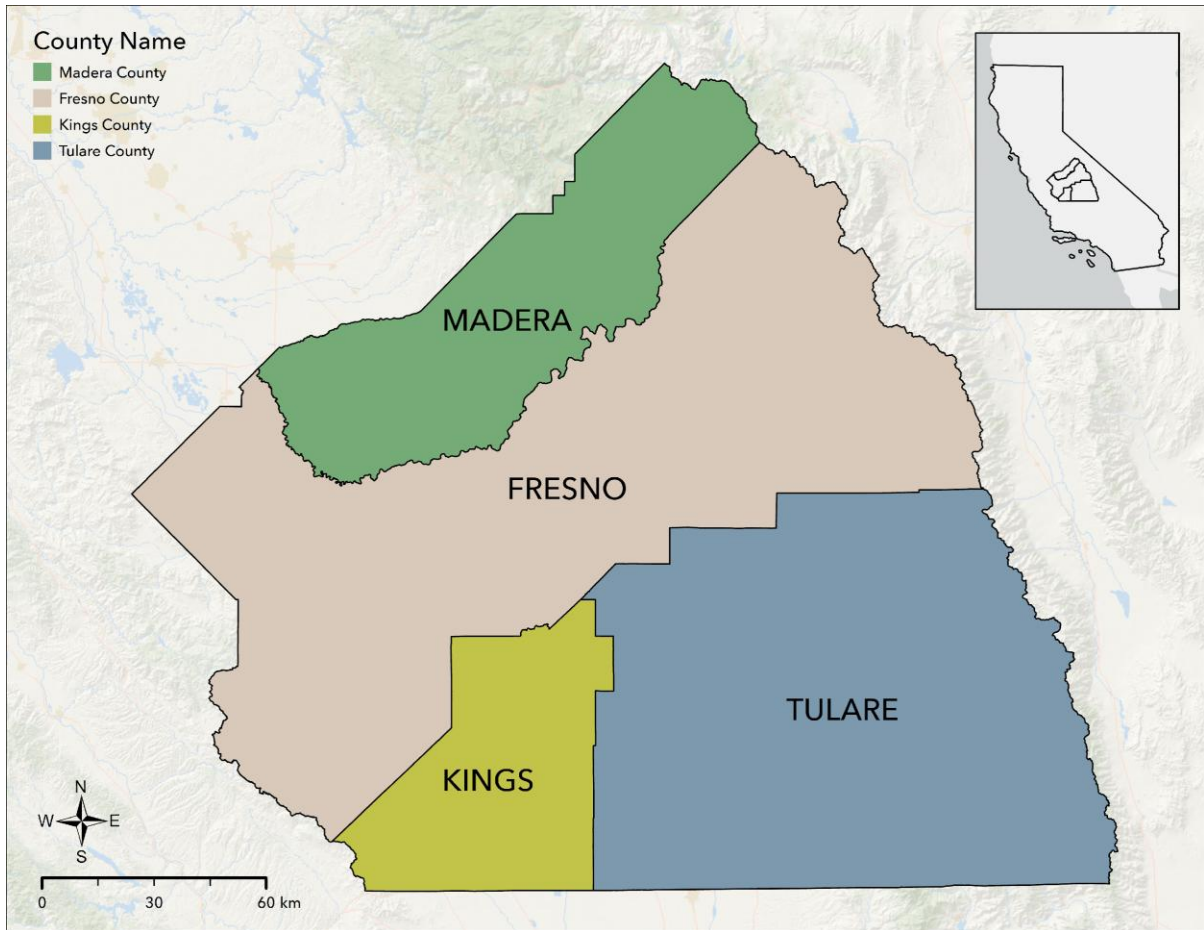


Figure 8. Study region

The major ecosystem types that existed in the central San Joaquin Valley and foothills before settler colonialist alteration include riparian, grassland, wetland, floodplain, valley/foothill hardwood, forest, shrubland and chaparral, and sparsely vegetated ecosystems (Figure 8). Open water is also shown to be readily available in several locations. Grassland and shrubland/chaparral ecosystems dominated much of the Valley and lower elevation areas, indicating that their distributions were historically the most extensive. Forest cover was concentrated in the higher-elevation, mountainous regions. The valley/foothill hardwood areas appear to primarily exist in transition zones between grasslands and forested habitats. Sparsely vegetated areas tended to be scattered, aligning with drier, more extreme environments.

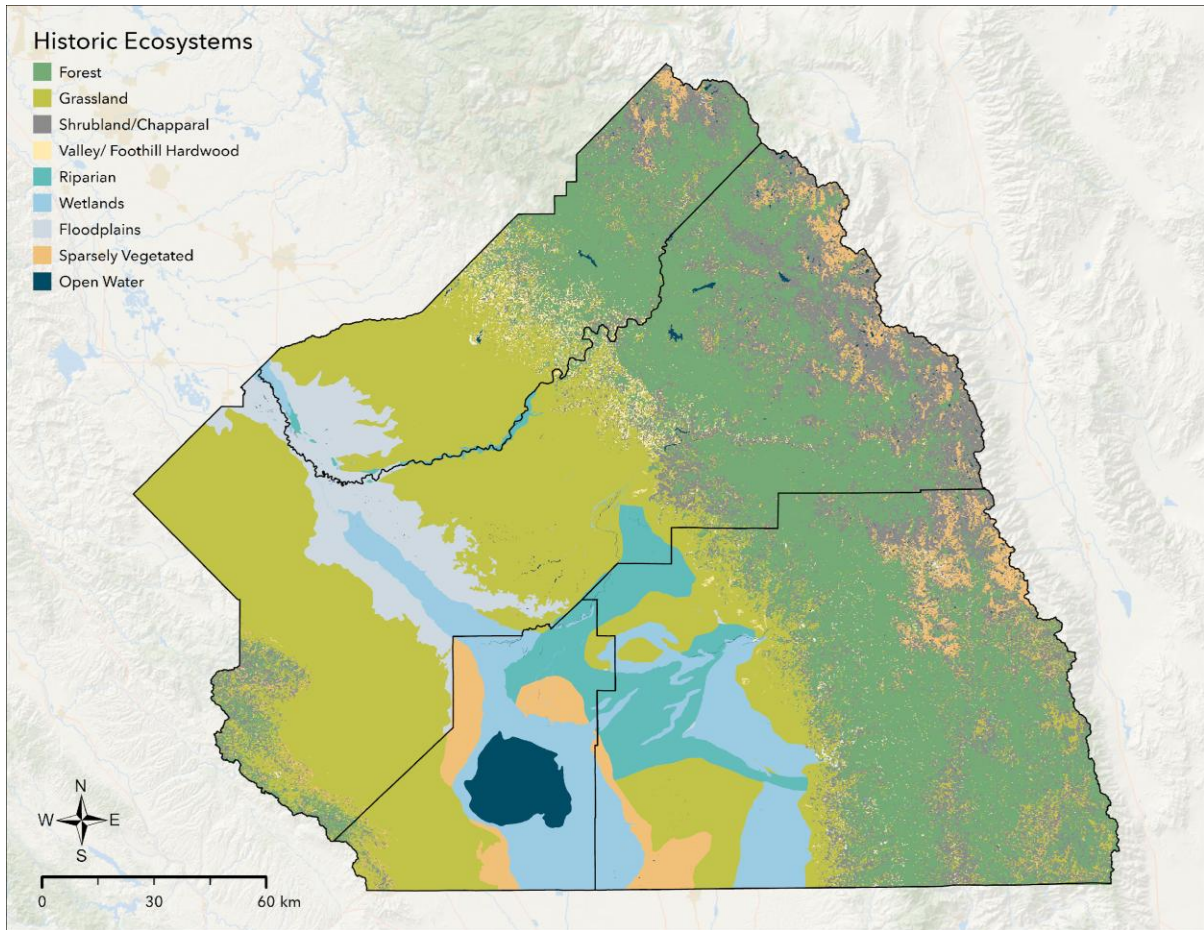


Figure 9. Map 1: Historic conditions. The nine main ecosystems shown (forests, grasslands, shrublands/chaparral, Valley/Foothill hardwood, riparian, wetlands, floodplains, and sparsely vegetated areas) were chosen by combining ecosystems of interest outlined in the CA Nature-Based Climate Solutions Guidance Documents and the Central Valley Historic Mapping Project (CSU Chico).

A comparison of the historic land cover map (Figure 9) and the current land cover map (Figure 10) shows that the valley has been heavily altered, with most of the historic ecosystems now covered by either agriculture, rangeland, urban, or built-up land. Urban and cultivated croplands now dominate the valley floor and lower elevation areas, with most urban areas concentrated in the central or western lowland regions. Grassland, shrubland/chaparral, and valley/foothill hardwood ecosystems remain widespread but are particularly fragmented in developed and agricultural areas. Forests still retain much of the historic distribution in higher-elevation alpine regions, with less conversion than lowland ecosystems, though some cover has been lost. This reduction is likely due to changes in precipitation patterns and fire regimes, as well as increased infestations of invasive pests that contribute to mortality across the ecosystem. Current cover also indicates that wetlands and open water are limited, indicating significant changes and modifications to the natural hydrology and water systems of the region.

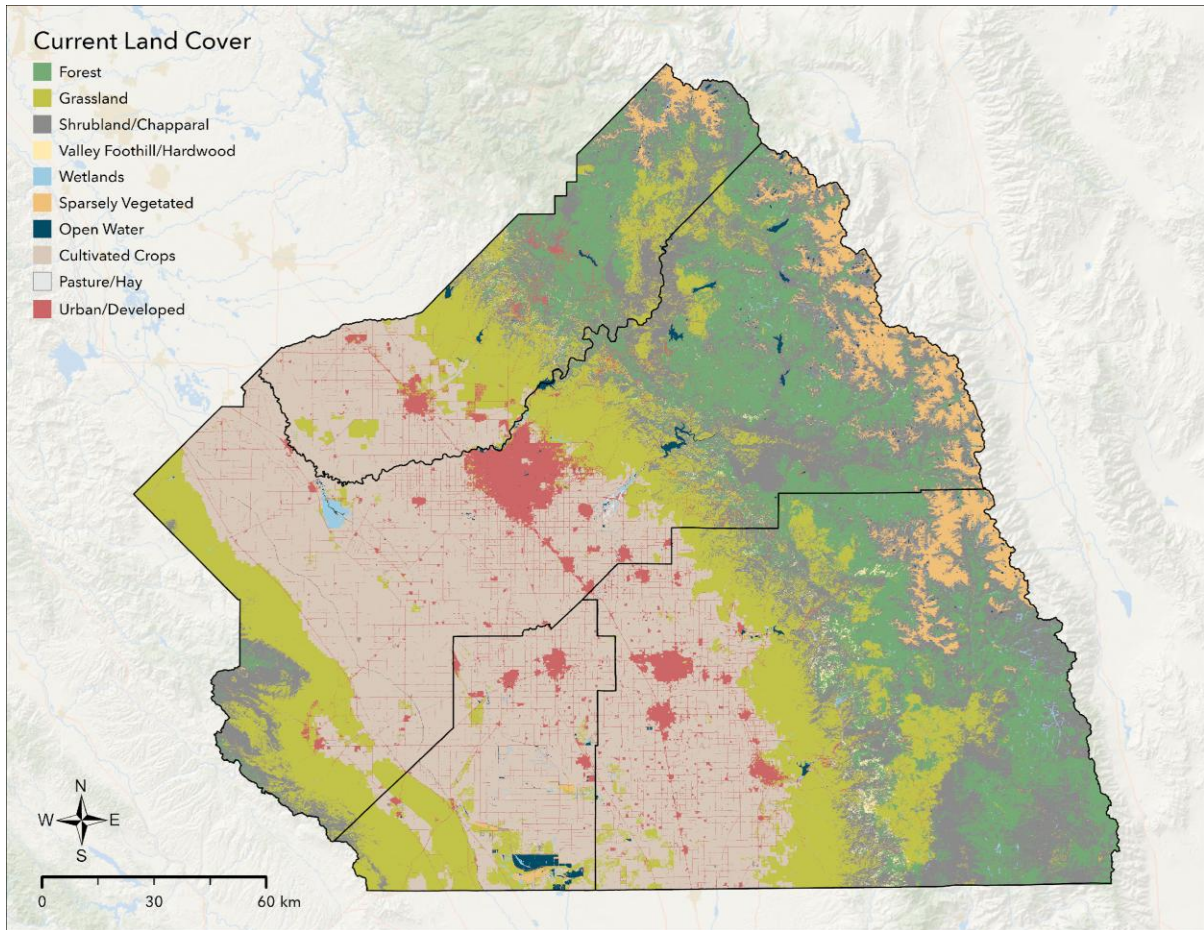


Figure 10. Map 2: Current Land Cover. Current land cover encompasses the actual physical properties of the region, including but not limited to vegetation and vegetation type (including agriculture) and urban or developed areas. Data Used: USGS NLCD 2024.

The amount of change between the historic and current land cover maps, including the total acreage changes for each land cover or land use type, as well as the percentage of change per land cover or land use type, are shown below (Figure 11).

These results are averaged for the entire region, but the spatial distribution of land cover and land uses across the region as displayed in Maps 1 and 2 (Figures 9 and 10) illustrates that the conversion has been most extreme along the valley floor. Very little natural land remains, and most land has been converted into irrigated agriculture. The foothill region, which has also seen mass conversion to agricultural uses, retains higher levels of ecological integrity. This is because most of the agricultural use comes in the form of grazing land, which, when well managed, generally does not result in the same level of eradication of ecological function and landscape integrity as in the largely monoculture farms on the valley floor (Bartolome et al, 2014).

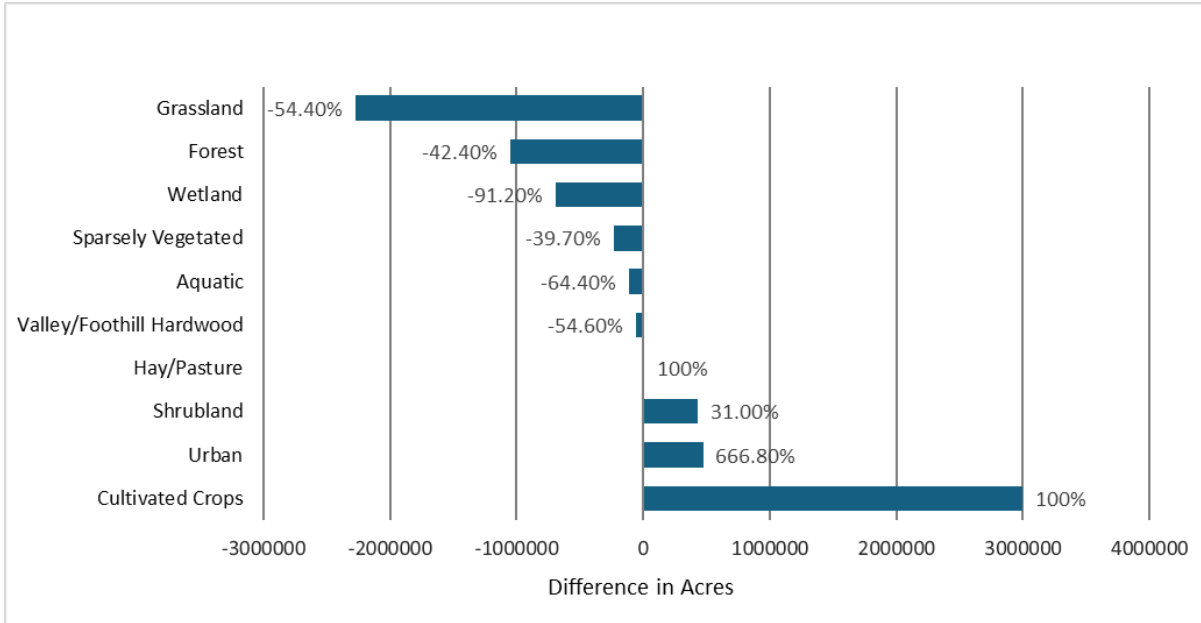


Figure 11. Area change in acres for each land cover class between Historic and Current Conditions in the region. Negative values indicate declines in land cover extent from historic to current conditions, while positive values indicate increases.

The current land cover of the region can be classified into certain management and ownership categories, as shown in the current land use map (Figure 12), which shows the distribution of current human uses of the land. These uses are often determined in large-scale plans created by regional zoning authorities, county supervisors, and state government agencies. This map also shows the amount of land protected permanently under federal and state conservation efforts, as well as projected future development.

Similar to the results of the current land cover analysis (Figure 10), current land use results indicate that agriculture dominates the valley floor across the four counties. Furthermore, the valley floor contains the majority of the urban and built-up areas, which are clustered tightly around the surrounding agricultural lands. Natural vegetation is confined to the foothills and is mostly isolated, aside from large swaths of protected lands located in the Sierra Nevada Mountains and the western edges of Fresno and Kings counties. The total acreage allocated to each land use or management category is also shown below (Table 1).

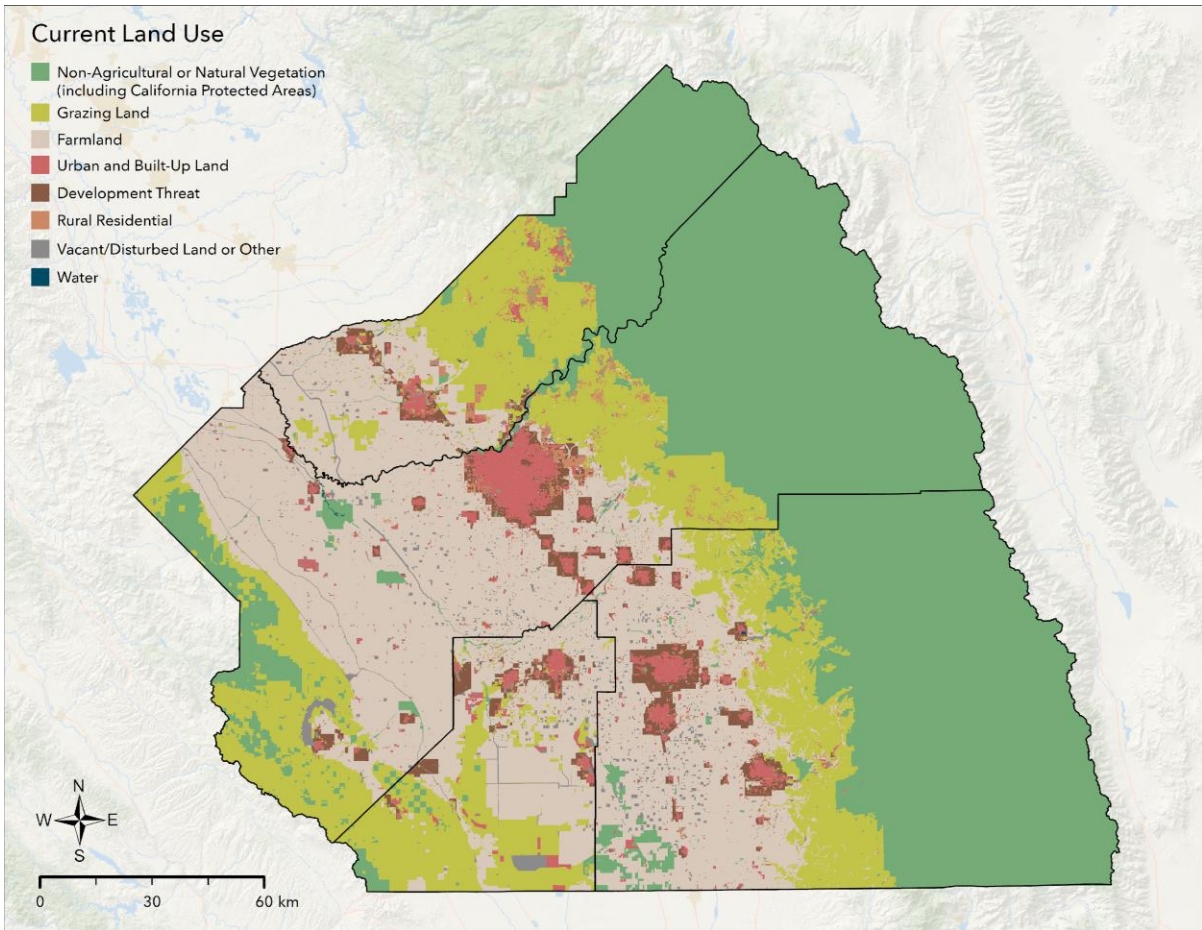


Figure 12. Map 3: Current Land Use. Land use categories describe the extent of different physical characteristics that exist in the region, characterized based on their usage and the social and economic relevance to local communities. The seven major land use categories (natural vegetation, grazing land, farmland, urban land, rural residential lands, and vacant or disturbed lands) highlight where implementation of the different restoration actions listed in this plan is recommended. Development pressures and existing protected areas also identified.

Table 1. Total acreage of all land use types in the four-county study area

Land Use Category	Acres
Protected Area	3,640,181
Farm	2,988,159
Grazing Land	2,000,732
Urban and Built Up	271,222
Nonagricultural/Natural Vegetation	242,290
Rural Residential Land	105,555

Land Use Category	Acres
Vacant or Disturbed	80,609
Other	71,561
Federal Tribe	56,259
Water	15,164

The majority of actively used land in the region is characterized as “agricultural lands” (Table 1). Any impacts or changes to this land use will have great effects across all sectors in the region, including but not limited to the economy and the environment. However, there are likely to be large-scale changes to the region in response to implementation of SGMA. The projected land cover change map (Figure 13) identifies areas where currently farm fields could be converted away from agriculture if groundwater use for irrigation is reduced by 20%.

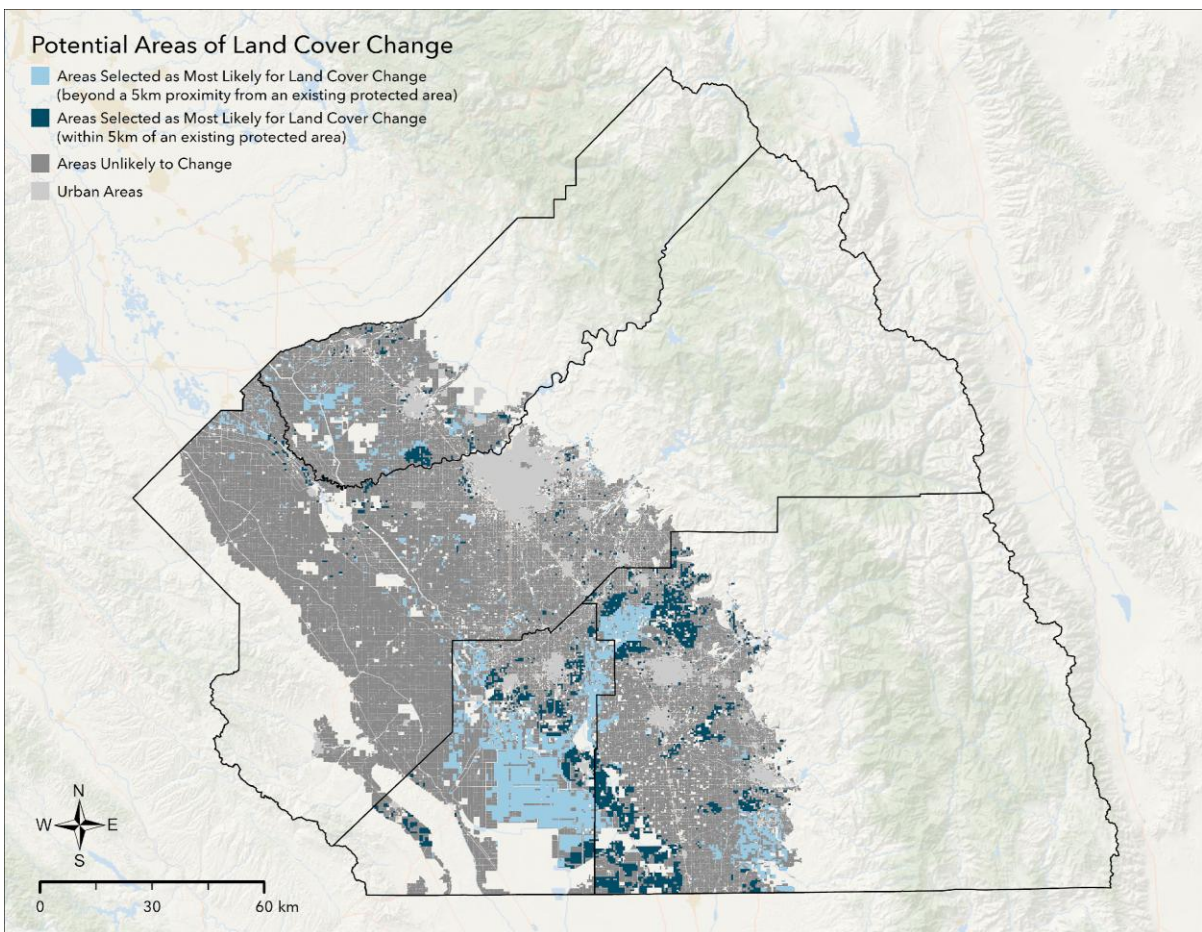


Figure 13. Map 4. Projected land cover change. Illustrates areas where land cover could change if agricultural lands are repurposed and restored to natural ecosystems in response to the Sustainable Groundwater Management Act. Highlighted areas are those that could best support a region-wide reduction of groundwater usage for the lowest economic trade-off, while dark blue areas show where conservation and land repurposing could serve to expand existing habitat.

If this projection of land cover change does occur, nearly 520,000 acres of land will be impacted and potentially become available for ecosystem restoration (Table 2).

Table 2. Acres Converted, Water Saved, and Revenue Lost

Acres	Water Saved (acre-ft)	Cost (Million \$)	Cost Savings (Million \$)	Cost/Acre-ft (\$)
519,890	1,592,263.80	1,437.83	1,587.77	903.01

Across the study region, there are 3,322,173 total acres of farm fields over 1 acre in size. A 20% reduction in water use will likely affect approximately 15.6% of these fields. Though these impact numbers seem high, it is important to place these results within the context of the region, and to analyze each crop category individually to understand the impacts of these changes on each agricultural sector. The following graph (Figure 14) shows how these impacts will likely be dispersed amongst the different crop categories, and which crop categories may be most significantly affected by juxtaposing the acres projected for conversion against the total number of acres in production, per crop category.

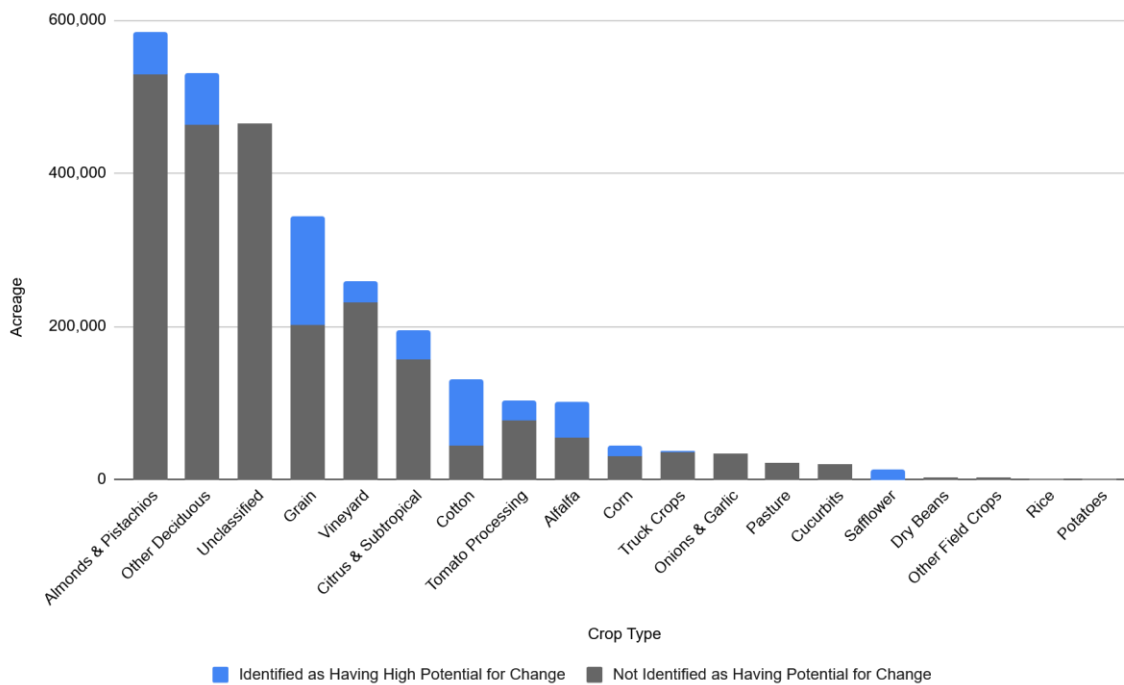


Figure 14. Acres projected for repurposing or restoration vs. total acreage in production per crop category.

Projected conversion will most impact water-intensive crop types that do not generate as much revenue per acre as some of the highest-value cash crops such as almonds & pistachios. For example, cotton is a water-intensive crop that does not generate as much revenue as other crop categories in the region, and so is most likely to be impacted more heavily than other crop categories. On the other hand, grain has a high percentage of total acreage projected to be impacted. As grain is not a highly water-intensive crop, this large impact is likely due to its low revenue-generating capacity. This means more acreage of this crop

category can be converted to other uses and there will be little impact on total revenue generated by all crop categories across the region. In contrast to these lower-value crops, safflower is projected to be heavily impacted by water use restrictions across the region. This is a high-revenue generating crop category, so was expected to be impacted less by these restrictions. However, this crop is mostly grown in Kings County and is likely highly impacted by the geographic location in which it is grown. As this area of the region has high levels of groundwater overdraft and land subsidence, and low surface water access, it is much more likely to be impacted by groundwater restrictions.

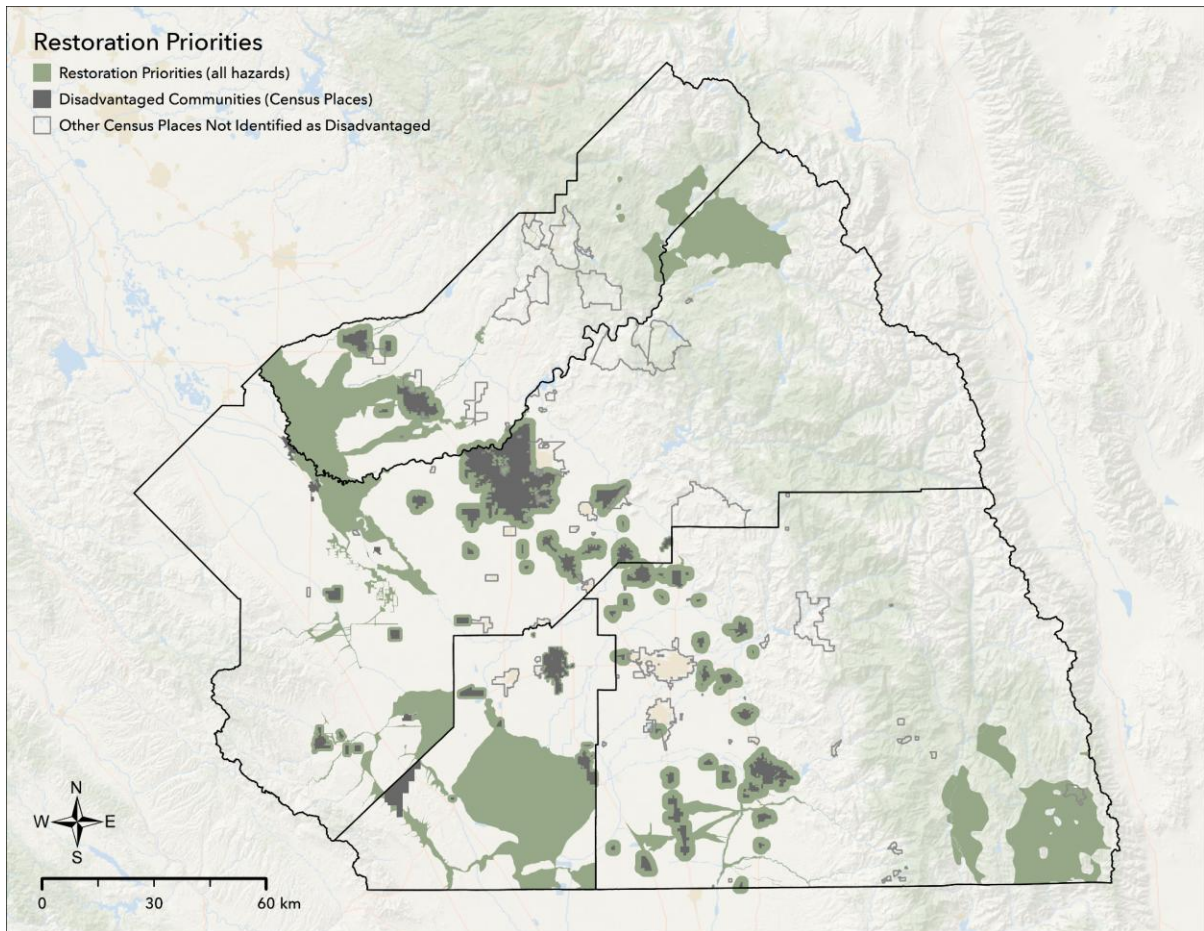


Figure 15. Map 5: Restoration priority areas around disadvantaged communities

From the disadvantaged communities analysis using ACS data, a total of 391 socially disadvantaged CDPs (top 25% in the state) were identified across California, with 64 of them located within the study region (Figure 15). These 64 CDPs are dispersed across all four counties, and each face a different level of risk for each hazard. Together, these disadvantaged CDPs host a cumulative population of 1,069,099 people, which is approximately 68.2% of the region's total population of 1,567,338. The number of disadvantaged communities and populations that face the highest burden (at or above the 80th percentile) of each hazard, as well as the acreages prioritized for restoration to mitigate these hazards for these communities, are shown in Table 3.

Table 3. Population and CDPs Affected by Each Environmental Hazard and Areas Projected for Restoration

Hazard/Risk	Number of Disadvantaged CDPs (out of 64)	Total Population Affected	Percent of total disadvantaged population of region	Acres Prioritized for Restoration
Air Quality	43	871,260	81.5%	89,265.27
Water Quality	46	900,737	84.3%	346,422.80
Flood Risk	27	769,684	72.0%	637,538.80
Fire Risk	0	--	--	342,456.30
Land Subsidence	32	304,203	28.4%	N/A
Groundwater Depletion	26	758,374	70.9%	N/A
Lack of Access to Green Space	28	89,894	8.4%	77,067.54

The residents of the region that are affected by one hazard may or may not be impacted by a different hazard. Due to this, the overall percentages of the total population affected by a hazard do not total 100%.

The environmental hazards of poor water quality and poor air quality affect the largest proportion of disadvantaged peoples, affecting over 80% of the total disadvantaged population of the region each (Table 3). This indicated a strong need for restoration actions that improve environmental health. These risks are easier to mitigate for and reduce than other risks, as repurposing of farmland and development of green space buffers around affected communities can serve to significantly reduce the impacts of poor air and poor water quality.

A substantial proportion of the disadvantaged population of the region also face increased flood risks. As seen in Map 1 (Figure 9), much of the valley floor was covered in floodplains, wetlands, or riparian areas, as well as open water in the Tulare Lake basin. This area is now protected from inundation and seasonal floods thanks to the multiple dams on the rivers; however, there is still risk of floodwaters overflowing embankments on extremely wet years (e.g. 2023).

In contrast, land subsidence and groundwater depletion affect fewer communities but still represent regional concerns. Although limited access to green spaces affects a small percentage of the population, it remains important for improving quality of life. Wildfire, though a big contributor to poor air and water quality and loss of natural ecosystems in the region, is more likely to occur in the higher elevation areas of the region, further away from most CDPs in the region. Regardless of the fact that the areas of higher risk to wildfire do not directly intersect with any of the disadvantaged CDPs identified, the environmental and

health risks associated with wildfire in this region are significant enough to warrant forest and shrubland restoration in these areas.

Overall, these results highlight that restoration targeting water, air, and flood hazards can yield the greatest social and environmental co-benefits for disadvantaged populations. Spatial distribution across the region is also important to consider when analyzing the impacts of environmental hazards on disadvantaged communities, as well as the spatial distribution of potential restoration areas prioritized to mitigate these negative impacts on these communities.

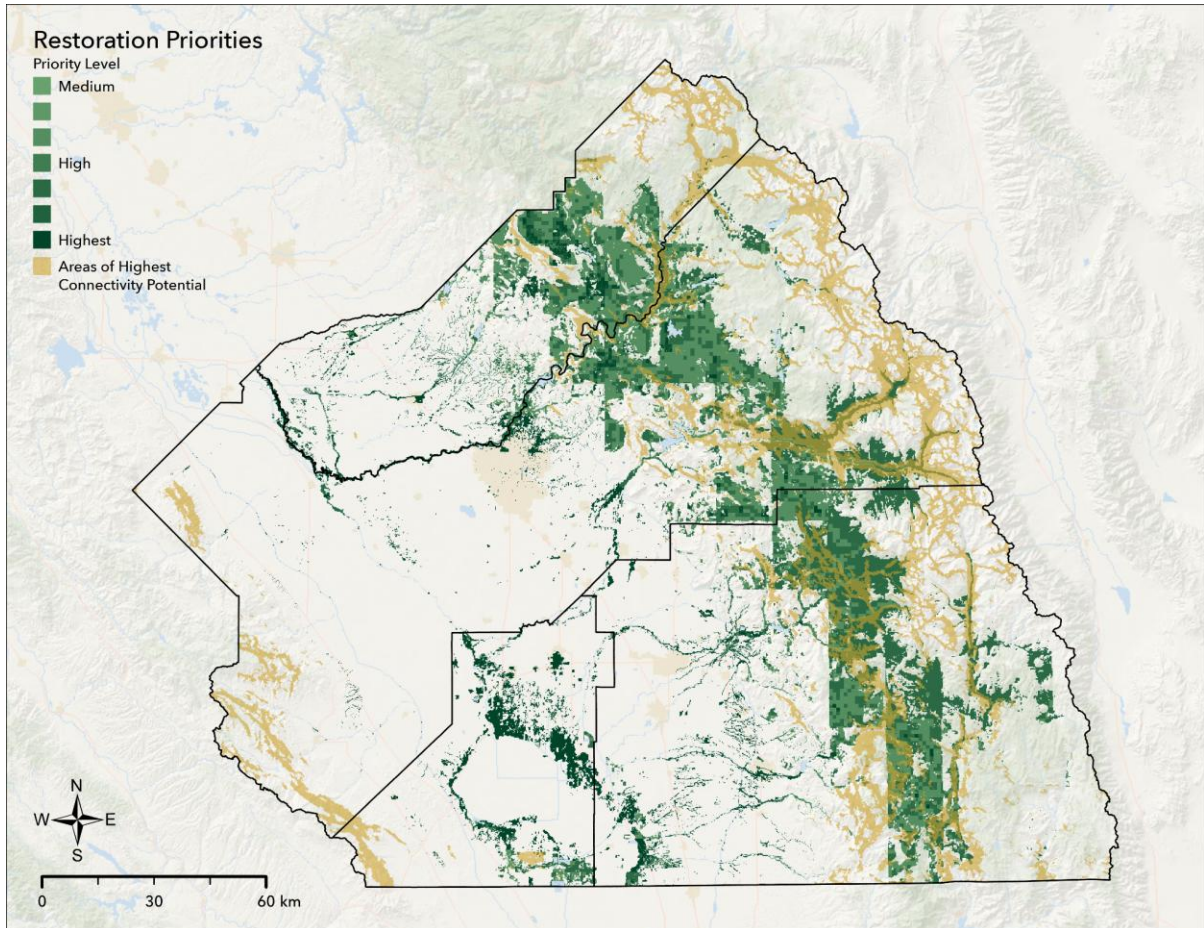


Figure 16. Map 6: Restoration Priorities (Assuming No Change in Land Cover). This map identifies priority areas for restoration based on ecological niche, incorporating potential shifts caused by a changing climate. Restoration priorities are determined using current land degradation and proximity to natural spaces (as determined by the 2025 land cover dataset). Connectivity potential was added to reflect possible species movement across the landscape.

Some of the projected ranges for each ecosystem may overlap, which could cause some acres to be counted multiple times for different ecosystems. This is because ecosystems do not have defined boundaries, and instead transition into each other through a range of smaller sub-habitat types. These transition zones are suitable areas for multiple different ecosystems, and will likely host multiple ecosystem types over the years as shifts occur due to climate change. The total acreage values (Table 4) are identified through the overall

combination/overlap of all species distribution models identified for each ecosystem type, while prioritization is identified through a system of weights based on distance to natural space and degradation. As all natural ecosystems in the current NLCD 2024 land cover data is classified together as “natural space,” the prioritization value for each cell will not be affected by ecosystem type, even in those areas of overlap between ecosystem ranges.

Table 4: Total acreage of “good” habitat for each ecosystem type

Ecosystem Type	Total Acreage Identified for Restoration
Wetlands	270,074
Valley/Foothill Hardwood	497,601
Sparse Vegetation	544
Shrubland	1,100,896
Riparian	145,442
Grassland	58,346
Forest	181,428

Table 5. Summary statistics of all AUCc values for all species distribution models generated in Maxent and used to create restoration priority layers

Average	Median	Min	Max	Range
0.85114343	0.879	0.317	0.995	0.678

These results identified zones within the four-county study region that can be considered to be higher priority areas for restoration if land cover conditions remain the same. The ecosystem most prevalent in the prioritization is shrubland/chaparral, followed by valley/foothill hardwood ecosystem. The ecosystem least prioritized for restoration is sparsely vegetated, which aligns with the low amounts of sparsely vegetated ecosystems that historically covered the region, followed by grassland.

These results are expected, as species grasslands, wetlands and valley riparian areas are the ecosystems that have been most converted to other land use types, so there are less observations of the species of interest for each habitat type. This lack of occurrence data limits the Maxent algorithm’s ability to extrapolate suitable habitat, resulting in smaller extents.

These ecosystems also have different abilities to respond to climate change. The results align with the theory of climate velocity, which states that as species adapt to a changing climate, their climatic niche must shift across the landscape at a speed that boosts their survivability or they become extinct (Thorne et al, 2020). Rugged, complex landscapes allow for shorter migration distances to compatible climatic niches, as they often facilitate microclimate establishment and quicker access to different elevations. In contrast, flatter landscapes often experience similar climatic conditions at larger distances, requiring species to migrate further to find their climatic niche. Chaparral/shrubland and valley/foothill hardwood systems are

strongly associated with more complex landscapes, while grasslands and sparsely vegetated areas are often found in flatter areas. This affords the different ecosystems vastly unequal areas to colonize and partially explains the gaps in total area of suitable habitat.

Not all of this land is or will be available for restoration work in the future. However, a large portion of land has been identified as areas where land cover could need to change in the near future, if a 20% of water use reduction is implemented across the region (Figure 13). If this does occur, it is important to know which of these potential areas of conversion could also serve as suitable habitat for the majority of identified species of the region (as identified in Figure 16). This overlap of the two analyses is shown below (Figure 17).

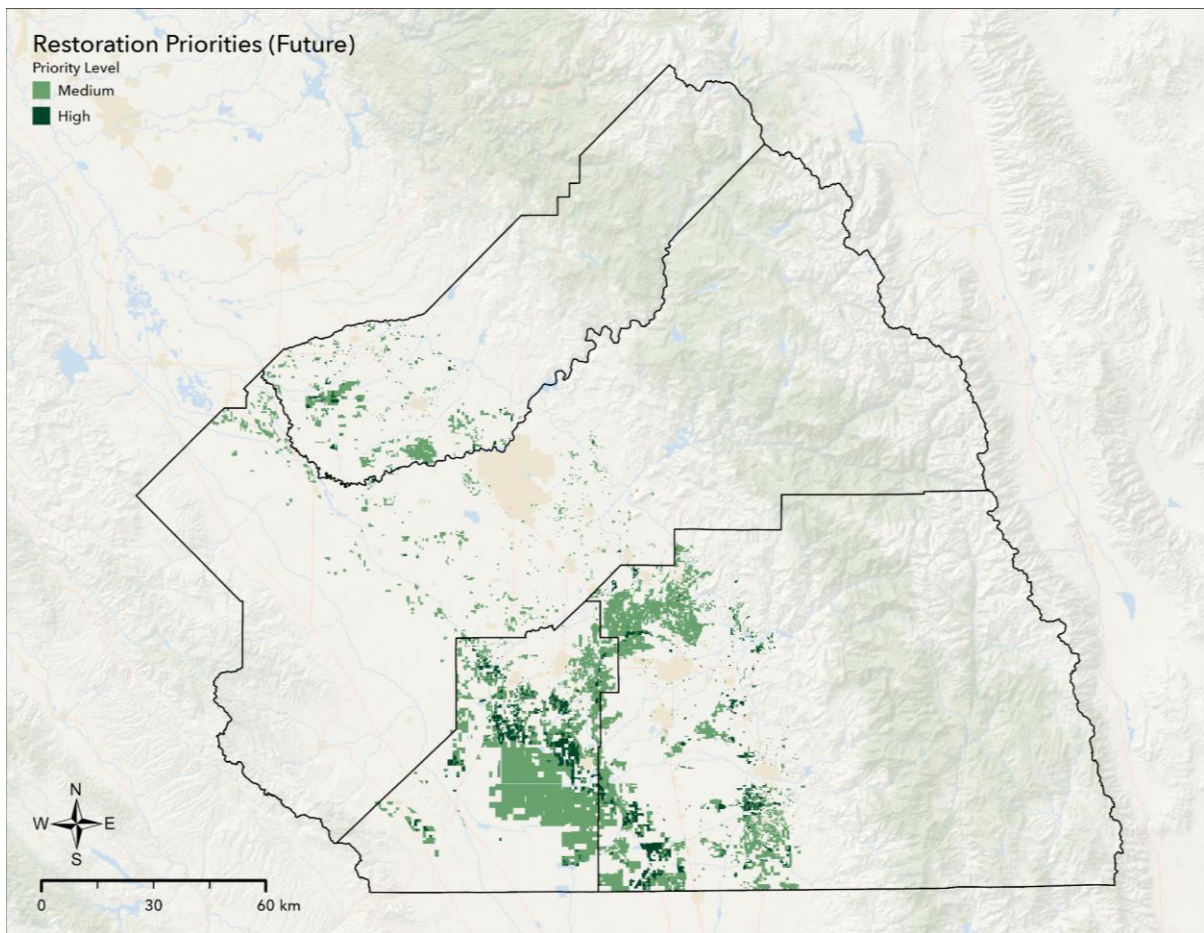


Figure 17. Map 7: Restoration Priorities (Given Land Cover Change). This map identifies priority areas for restoration focus, with the assumption that land cover will change in response to SGMA as projected in Map 4 (Projected Land Cover Change) and will be available for restoration. All areas highlighted are of high priority for restoration, but are further prioritized based on habitat suitability for species of interest in the region.

Approximately 12,663 acres of projected ecosystem range prioritized for restoration overlap the farmlands projected to face potential land cover change if water restrictions are implemented across the region. Most of this area identified is suitable habitat for wetland, riparian, and grassland ecosystems, though there are also other ecosystem types represented in this analysis.

As discussed previously, much of the area prioritized for restoration in the various analyses overlap each other. Understanding the outputs of each analysis is important, as each illustrates priority restoration areas for different goals and management strategies. However, it is also important to understand where all of these priority areas lie in relation to each other, and where restoration could occur in the region to meet any of the various goals.

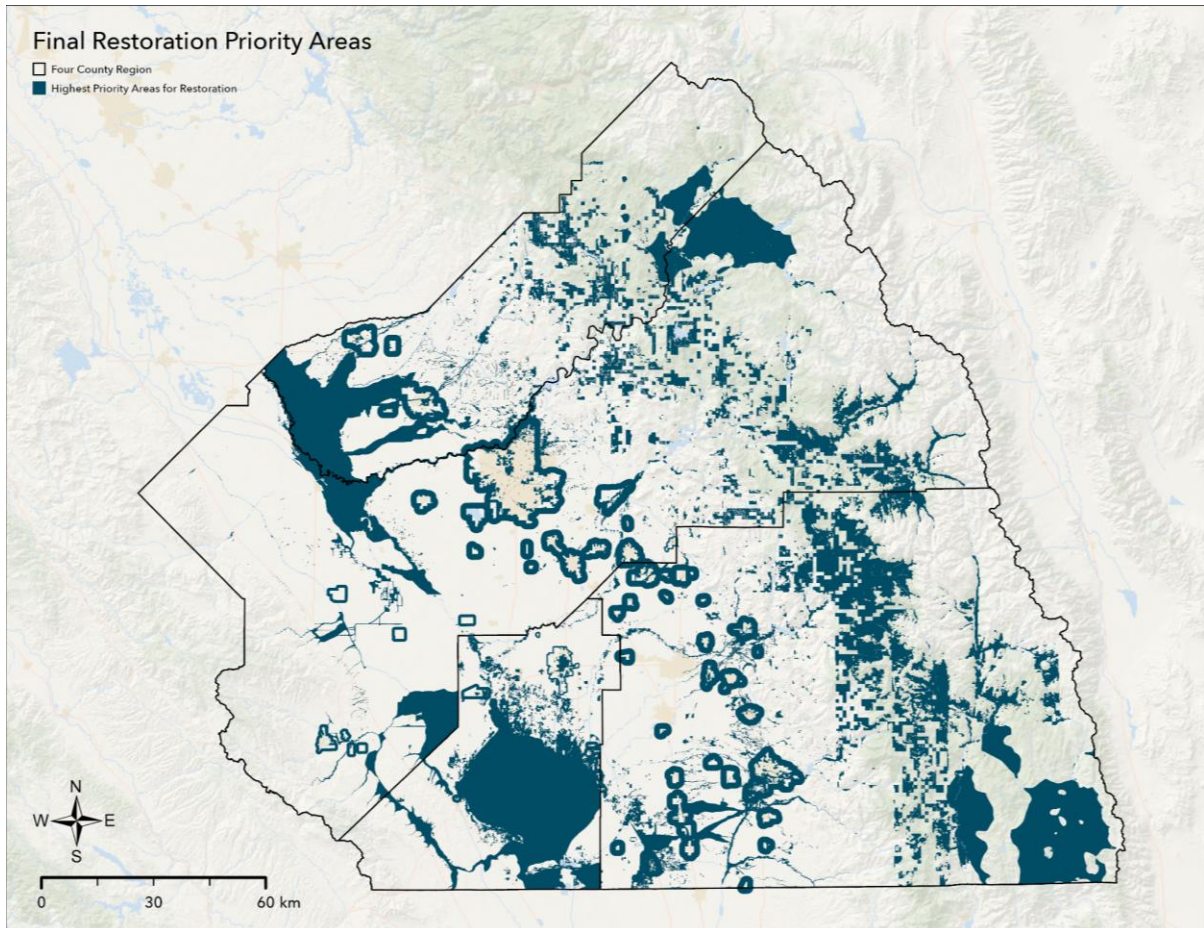


Figure 18. Map 8: Final Identification of Priority Restoration Areas in the Region. This map identifies the highest priority areas from Maps 5 (Restoration Priorities for Disadvantaged Communities), Map 6 (Restoration Priorities Given Current Land Cover), and Map 7 (Restoration Priorities Given Land Cover Change). These include those areas prioritized as at least “higher” or of “highest” priority in Maps 6 and 7, and all areas identified in Map 5.

This combination of restoration priority areas from all prior analyses identifies a total of 2,259,889 unique acres prioritized for restoration across the region.

Guidance Documents

The restoration guidance portion of the project connects the maps included in the restoration plan with potential options for restoration efforts based on specific property conditions. Suitable restoration actions are identified based on historic ecosystems, and characterized by current land uses. These actions aim to generate ecosystem services that benefit land managers and environmental health. Actions are included in ecosystem overview portions of the restoration plan, with more detailed information available in the action glossary.

A total of 84 unique restoration actions were compiled, occurring 273 times across the 8 ecosystems of interest. Actions were separated into categories, six of which occur in each ecosystem, including Site Preparation & Soil Management; Invasives & Weed Control; Native Planting, Protection & Maintenance; Erosion Control; Wildlife; and Vegetation & Fire Management. An additional category of Hydrology was included in three ecosystems, including Floodplains, Valley Foothill Hardwood, and Wetland.

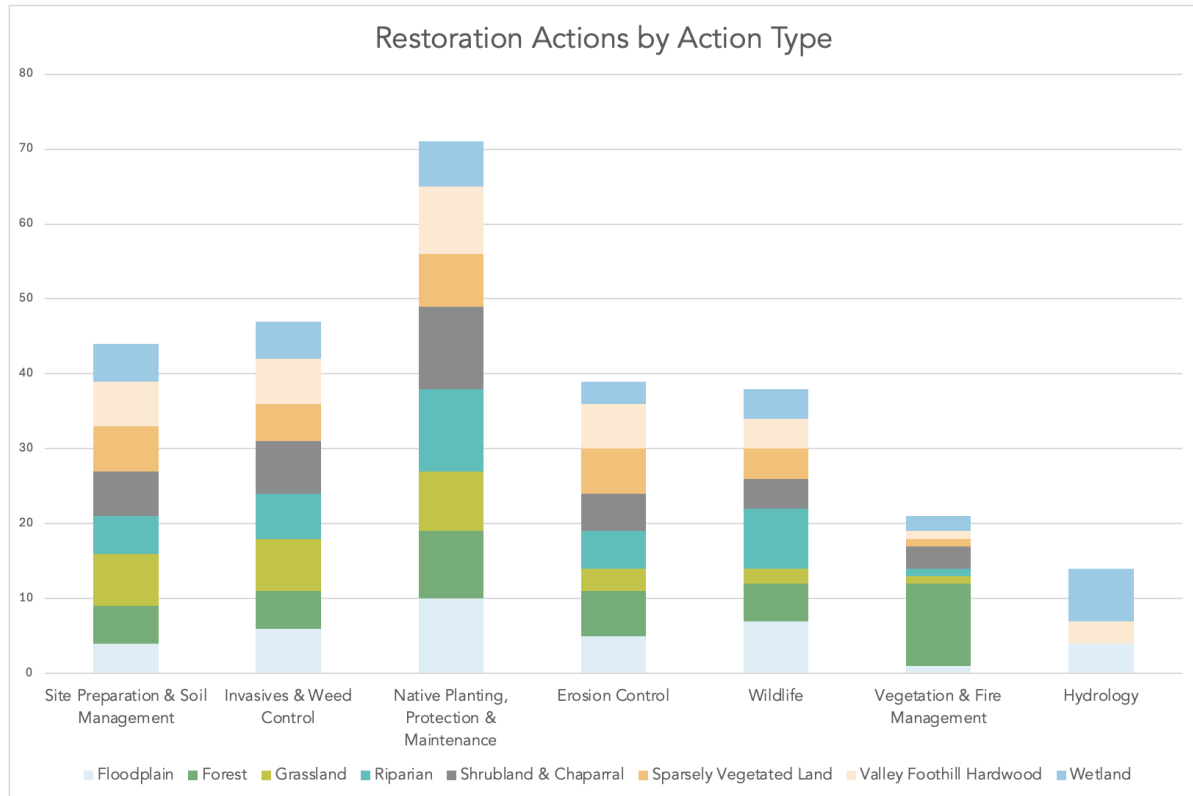


Figure 19. Restoration actions by action type: Native Planting, Protection & Maintenance is the category with the most unique actions (20) and the highest number of action occurrences between all ecosystems (70), followed by Invasives & Weed Control (8 unique, 47 occurrences) and Site Preparation & Soil Management (17 unique, 44 occurrences).

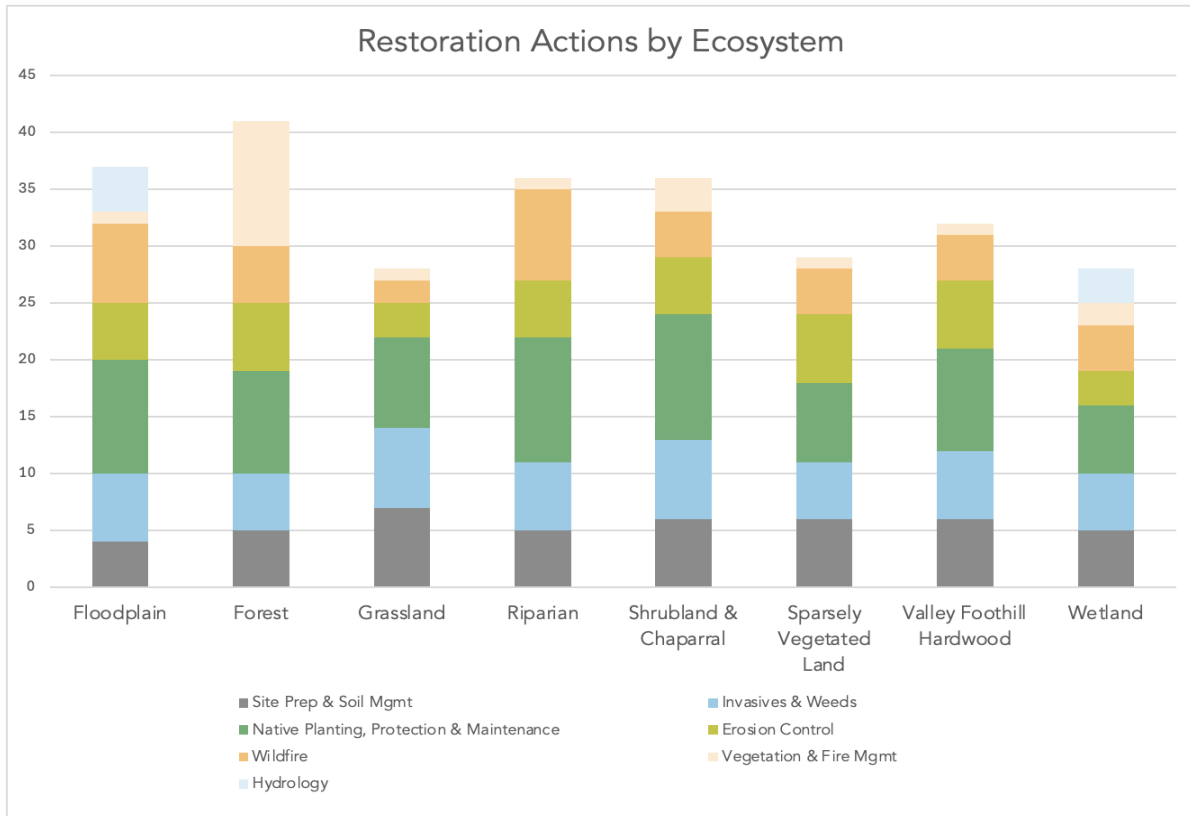


Figure 20. Restoration actions by ecosystem: The ecosystem with the most action is Forest, with 41 actions, followed by Floodplain (37) and Valley Foothill Hardwood (35). On average, each ecosystem has about 34 actions.

Table 6. Complete list of restoration actions: Actions are listed in the glossary in alphabetical order and include ecosystem-specific information and resources to support implementation

Restoration Action	Category	FLO	FOR	GRA	RIP	SHR	SPA	VAL	WET
Adjusting tillage cycles	Site Prep & Soil			X					
Air curtain burner	Vegetation & Fire		X						
Animal exclusion devices	Planting & Protection	X	X	X	X	X	X	X	X
Bank grading	Erosion Control			X					
Bare root seedlings	Planting & Protection	X			X	X			
Biochar	Site Prep & Soil		X	X		X		X	
Biocrust protection	Site Prep & Soil						X		
Bioengineering	Erosion Control	X	X	X		X	X	X	X
Boulder complexes	Wildlife	X			X				
Breaching or removing infrastructure	Site Prep & Soil								X
Brush layering	Erosion Control		X			X	X	X	

Restoration Action	Category	FLO	FOR	GRA	RIP	SHR	SPA	VAL	WET
Brush management	Vegetation & Fire								X
Brush piles	Wildlife	X	X		X	X	X	X	
Coarse woody debris	Wildlife	X	X		X				X
Coir logs & fiber rolls	Erosion Control	X	X		X	X	X	X	X
Compost	Site Prep & Soil		X	X	X	X	X	X	X
Coppicing	Vegetation & Fire					X			
Deep tillage and irrigation	Site Prep & Soil				X				
Discing	Site Prep & Soil			X		X		X	
Dormant cuttings	Planting & Protection				X				
Drainage tile adjustments	Hydrology								X
Filling pits or ponds	Hydrology								X
Fire-resistant landscaping	Vegetation & Fire		X						
Flexible wood placement	Erosion Control				X				
Geomorphic complexity	Site Prep & Soil	X							
Group selection	Vegetation & Fire		X						
Herbicide application	Invasives & Weeds	X	X	X	X	X	X	X	X
Hydromulch	Erosion Control	X	X	X		X	X	X	
Implement functional flow regime	Hydrology	X							
Install inset floodplain terrace	Hydrology	X							
Install screens to pumps and ditches	Wildlife				X				
Install water control structures	Hydrology								X
Integrated pest management (IPM)	Invasives & Weeds	X	X	X	X	X	X	X	X
Log erosion barriers	Erosion Control	X	X				X	X	
Manage compaction, tillage or soil	Site Prep & Soil								X
Managed grazing	Invasives & Weeds	X	X	X	X	X	X	X	X

Restoration Action	Category	FLO	FOR	GRA	RIP	SHR	SPA	VAL	WET
Manual removal	Invasives & Weeds	X	X	X	X	X		X	X
Mastication of vegetation	Vegetation & Fire		X			X			
Mechanical removal	Invasives & Weeds	X	X	X	X	X	X	X	
Mowing	Invasives & Weeds	X		X	X	X	X	X	X
Mulching	Site Prep & Soil	X	X	X	X	X		X	
Mycorrhizal inoculation	Planting & Protection	X	X	X	X	X	X	X	
Native cover seeding	Erosion Control	X	X		X	X	X	X	X
Native hay/straw spreading	Planting & Protection			X					
Nesting and perch structures	Wildlife	X	X	X	X	X	X	X	X
Nursery stock planting	Planting & Protection	X	X	X	X	X	X		X
Oak seedling planting	Planting & Protection							X	
Oak seedling production	Planting & Protection							X	
Pile burning	Vegetation & Fire		X						
Pollinator habitat enhancement	Wildlife	X	X	X	X	X	X	X	X
Prescribed burn	Vegetation & Fire	X	X	X	X	X	X	X	X
Propagated cuttings	Planting & Protection							X	
Reduce or exclude grazing	Planting & Protection				X	X			
Reduce runoff	Erosion Control				X				
Regeneration, natural	Planting & Protection		X		X				X
Regrade topography	Site Prep & Soil				X		X		X
Remove hardened surfaces	Site Prep & Soil						X		
Remove sediment or fill	Site Prep & Soil								X
Replacement planting	Planting & Protection	X	X	X	X	X	X	X	X
Reshape contours	Hydrology	X							
Riparian planting	Planting & Protection	X							
Salvaging and transplanting	Planting & Protection			X					
Seed tree	Vegetation & Fire		X						
Seeding techniques	Planting & Protection	X	X	X	X	X	X	X	X

Restoration Action	Category	FLO	FOR	GRA	RIP	SHR	SPA	VAL	WET
Setback or remove levees	Hydrology	X							
Shelterwood	Vegetation & Fire		X						
Single tree selection	Vegetation & Fire		X						
Smokewater application	Planting & Protection					X			
Snag retention	Wildlife	X	X		X	X	X	X	X
Soil mounding	Site Prep & Soil	X							
Soil scarification or ripping	Site Prep & Soil		X	X	X	X	X	X	
Solarization	Invasives & Weeds					X			
Spawning riffles	Wildlife	X			X				
Strip/patch seeding	Planting & Protection			X					
Supplemental irrigation	Planting & Protection	X	X			X	X		
Swathing	Invasives & Weeds			X					
Thinning: manual	Vegetation & Fire		X						
Thinning: mechanical	Vegetation & Fire		X						
Topsoil salvage and replacement	Site Prep & Soil	X	X	X		X	X	X	
Tree shelters	Planting & Protection	X	X		X	X		X	X
Vegetated rip rap	Erosion Control				X				
Weed mat	Planting & Protection	X	X		X	X	X	X	

ArcGIS StoryMap

An ArcGIS StoryMap outlining findings of the GIS analyses conducted for the restoration plan was developed for the client. As there was no additional analysis conducted, results associated with this StoryMap are not included in this report.

Discussion and Conclusions

Discussion

The results of the initial stage of our analysis (as shown in Map 1 Historic Conditions, Map 2 Current Land Cover, and Map 3 Current Land Use) reveal the spatial extent and distribution of land cover alteration that has occurred since the 19th century. As shown in Figure 1, the conversion to agricultural and urban land uses has led to substantial decreases in aquatic, sparsely vegetated lands, valley/foothill hardwood, grassland, forest, and wetland ecosystems. A major force driving these changes has been the intensive irrigated agriculture that dominates the region, especially along the valley floor.

To reach some level of sustainability for future success, land use will need to change from intensive agriculture to more sustainable forms of agriculture, as well as other land uses. There are many contradicting studies, projections, and fields of thought on how this could occur. However, there is consensus that this will eventually occur, either proactively with cooperation and policy implementation, or out of necessity due to a loss of groundwater. One major policy that will drive some of this change is the Sustainable Groundwater Management Act (SGMA).

The San Joaquin Valley is predicted to face an approximate 20% reduction in groundwater use due to a combination of restrictions under SMGA, climate change, and other environmental regulations (PPIC, 2025). Understanding how, and especially where, farms across the region will be impacted by this water use reduction will be beneficial to landowners and restoration practitioners as they make decisions about the potential future of this farmland. The projected land cover change map (Map 4) identifies most of the Tulare Lake basin - especially the lake bottom which lies primarily in Kings County - as the most likely area to be affected by groundwater regulations, with other identified areas scattered around the southeast and northern portions of the region.

It is important to note that although this analysis identifies huge potential for change in the region, the areas identified for potential conversion are a small proportion of the total land in active production across the four counties. Many individual landowners will be impacted, but those impacts are distributed across the different crop categories and across the four counties in such a way that no single crop type or economic niche should be completely impacted. Actual land use decisions are also influenced by many factors, including market conditions, policy incentives, and individual landowner decisions. Therefore, the projected land retirement and opportunity areas should be interpreted as scenarios instead of explicit forecasts. There is also no guarantee that land projected for change will be restored. Multiple avenues of repurposing exist, from clean energy projects to transitioning to less water-intensive crops to ecosystem restoration. We do not intend to prescribe an outcome for these areas, but, for this restoration plan, we assume that local landowners and land managers will pursue the restoration actions listed in this plan to promote ecosystem health and connectivity in the region. This analysis and restoration plan accounts for this uncertainty by providing a range of restoration and repurposing options for lands in a variety of states.

Repurposing or converting lands that are currently in irrigated agriculture to some form of natural ecosystem can have a positive impact on human health and community resilience. From the results of the community engagement conducted at the beginning of this project, it became evident that residents of the region were highly concerned about a variety of threats directly related to agricultural activity in the region - particularly, the loss of groundwater access for residents, increased land subsidence in the region, and increasingly poor air and water quality across the region. The communities identified in this analysis as being disadvantaged based on a variety of indicators that characterize vulnerabilities that could impact how communities are able to respond to environmental hazards, improve environmental conditions, advocate for community interests and needs, and make decisions for their own communities. These communities are often much more vulnerable to environmental and economic burdens but are also much more likely to exist in the intersection of all these burdens.

Ecosystem restoration can mitigate these concerns by reducing pesticide use, reducing dust and particulate matter in the air, and by reducing stress on water resources. Creating a 400m green buffer around communities facing high levels of air pollution can improve air quality in communities by reducing exposure to pesticides in the air as well as emissions from farm equipment (Fernandez-Bou et al., 2023). Fernandez-Bou et al. found that 1600-m buffers around communities across the San Joaquin Valley can result in water use reductions of 2.18 km³/year and reductions in nitrate leaching into aquifers of 105,500 t/year. Though quantitatively less for this smaller region, the impacts of such buffers around these communities can be quite meaningful. Creating a 1600m green buffer around communities facing high levels of drinking water pollution from chemical runoff and infiltration into drinking water wells can improve water quality and water availability. Restoration can also provide buffers against wildfires and floods across the region. Proactively conducting activities that focus on removing fuels, especially ladder fuels that can lead to crown fires and managing invasive species that are highly flammable, can both increase native biodiversity and reduce risk of wildfire. Additionally, creating buffers of restored natural areas near and around communities can ensure protection against fast-moving fires, as native vegetation often slows the spread of fire through a variety of adaptations. Areas identified for restoration in floodplains can also be useful in protecting communities from unexpected and highly damaging floods, as these areas can then be used as overflow areas or stormwater catchment zones where excess water can be diverted and allowed to infiltrate rather than impact a disadvantaged community. This has the added benefit of recharging groundwater aquifers. Though land subsidence cannot be reversed, groundwater recharge is a method of ensuring that groundwater stores are sustainable for longer, which will support the communities and farmers across the region. Areas to prioritize for these concerns can be seen in Map 5 (Restoration Priorities for Disadvantaged Communities).

Restoration projects can easily provide many benefits to the region, but these benefits will be even more impactful if [something about longevity and long-term benefits that can be gained by siting restoration projects in areas where they are likely to succeed in the present and the future under a worst-case climate scenario, and where they can provide habitat and connectivity - aka why we did Map 6].

Implications

For managers who are pursuing ecological restoration, the results displayed in Maps 1-3 will have a strong bearing on the restoration actions they pursue. Land-use characteristics greatly influence the type, intensity, and duration of restoration activity to achieve standard restoration objectives. Urban areas, for example, face different challenges and may have different objectives than grazing lands. How restoration on these different land use types can contribute to wider ecological recovery, too, will greatly vary. Grazing lands, for example, can buffer natural lands from some edge effects, while urban areas can become important islands of pollinator habitat. Some land uses may also have resulted in such abrasive soil degradation, topography change or colonization from invasive species that meaningful restoration work must start with a period of soil regeneration or large-scale earth moving, while others may have the base environmental conditions to begin planting key vegetation. The highly geographically diverging land uses illustrated in maps 1-3 will therefore undoubtedly mean that future strategic restoration planning on the valley floor, in the foothills, and in the high sierras will need to account for this.

The analyses in this project can be used by restoration practitioners to identify where to prioritize restoration that can be either local to a single area, or synchronized across the four-county region. The analysis is an initial filter of areas that have enough species native to the region projected to be within their environmental niche, even under the global climate change scenario with the highest mean global warming. Connectivity, proximity to existing natural lands, and state of land degradedness are all factored into the analysis, while zones in the region are not ruled out solely because land cover classifications are either urban/built-up or agricultural. Additionally, areas that could enhance human health and community resilience, or protect against natural disasters are also identified. Though restoration can and should occur in all prioritized lands in the region (Figure 18), leveraging the ecosystem benefits that can be gained from restoration work to support disadvantaged communities in the region is especially important, and should be of highest priority.

As far greater areas of lands are prioritized in the foothills and high Sierras under current land use, giving the valley floor far fewer opportunities to restore ecological communities with the same ease, it is noteworthy that the study design does not entirely exclude non-natural land covers such as agricultural land. The design therefore allows planners and practitioners to make decisions with information geared toward enhancing the ease of restoration success for areas that are high or highest priority, while still having useful information to consider actions such as urban greening or regenerative agriculture.

Considerations: Restoration goals, and potential actions that could be implemented to achieve these goals, are outlined in the restoration guidance section of the restoration plan. These actions and the accompanying descriptions and resources are meant to provide managers, restoration practitioners, and landowners with a suite of potential options to implement on the diverse ecosystems and land types in the region, and support region-wide ecosystem benefits. However, restoration is rarely straightforward in this region, given the complexity and variability of the land use and ecosystems. Differences in landowners,

ecosystem type, soil conditions, water availability, and community context influence the feasibility of restoration in a given location. Specific considerations may include:

- **Landownership:** Over 3.3 million acres in the four counties is privately owned farmland. Given that this plan provides a menu of voluntary restoration options, restoration actions that are implemented will reflect economic realities and landowner willingness as much as ecological priority. Therefore, demonstrations and pilot projects that show the tangible benefits of restoration will be essential for large-scale restoration across the region. Consideration of sustainable and diverse revenue streams to support restoration will also be critical.
- **Uncertainties around land transition policies:** Implementation of SGMA across the state is expected to contribute to farmland retirement across the region as groundwater allocations are reduced. Farmland retirement presents an opportunity for strategic and multi-benefit land repurposing. The land fallowing analysis conducted in this report identifies areas where retired farmland could contribute to the expansion of protected areas if restored. However, not all farmland that is retired will necessarily be restored to historic ecological conditions. GSAs, and local and regional planners should work with landowners and local communities to identify the best use for retired fields.
- **Ecosystem heterogeneity:** The diverse range of habitats and ecosystems in the region require distinct restoration strategies that consider the local conditions and unique ecosystems present. Given the intense agriculture present in the Valley, there may be fewer opportunities in the valley floor to restore ecological communities with the same ease as in the foothills and Sierra. Restoration will often be driven by outcomes related more to ecosystem services, and the “success” of a restoration project will be measured and may vary accordingly. Restoration practitioners should prioritize site-specific assessments that consider the ecological history and current conditions of each area.
- **Degraded Soil and Ecological Baselines:** Decades of intensive agricultural activity in the San Joaquin Valley have significantly altered the Valley’s physical and biological condition. Severe groundwater extraction has led to soil compaction, loss of groundwater storage, land subsidence, and salinization of groundwater resources. Restoration of severely degraded areas may require additional investment of time and resources.
- **Cost and Labor Needs:** Restoration of some ecosystems can be incredibly costly or labor intensive, especially when the historic ecosystem has been completely lost or heavily degraded. Even for those areas where recommended restoration actions are less intense, there are still considerations of labor costs and labor supply to conduct these actions. Restoration is an ongoing process that requires years of maintenance even after some natural ecological functions and conditions have been restored. Restoration at this scale will take decades, and huge amounts of investment. Restoration practitioners and land managers in the region should work closely with biologists and experts in the field to determine what actions are needed and what

goals are feasible to meet some of the objectives of restoration as outlined in this plan.

Caveats and Limitations

In the process of choosing and cleaning data for the analyses conducted in this project, some assumptions needed to be made that could have affected the outcome of these analyses. These assumptions and the resulting limitations are listed below:

Disparate Data Timeframes: Data that were used as inputs for multiple analyses were standardized and shared. This ensures consistency between the maps, which allows them to be compared against each other. Such datasets include but are not limited to the NLCD dataset, the DWR groundwater percentages data, and the FMMP data. Additionally, all datasets used for each individual map are aligned temporally with each other (all datasets are from the same year). However, this does not mean that each map is temporally aligned with all the other maps. For example, Map 4 (Projected Land Cover Changes) used datasets from 2020, while Map 5 (Restoration Priorities for Disadvantaged Communities) used CDP boundaries and census data from 2021. Additionally, environmental risk data are all projections created by analyzing a variety of data, including current and past physical and environmental conditions, from a variety of sources and timeframes. This difference in data timeframes is due to limitations in data availability. This creates complications when comparing the various maps against each other.

Disparate Spatial Resolutions: Differences between vector and raster datasets, as well as multiple resampling processes, may obscure variations in resolution. As a result, the outputs should be interpreted as regional planning guidance rather than precise predictions for site-level restoration.

Prime Farmland Designations: Prime farmlands are an official designation of the State of California, based on soil characteristics, degradation factors, and water reliability. As this is a soil designation, these boundaries do not align with field boundaries or parcel boundaries. Some of the fields (as determined by LandIQ) in the region have multiple different farmland designations, as they have multiple soil types. Fields were standardized to a single farmland designation using a “majority” intersect join in ArcGIS. Thus, the fields that had much of their area covered by the “prime” farmland shapefile were classified as “prime,” while those that had less than 50% of their area covered by the prime farmland shapefile were classified as “not prime.” Prime farmlands are assumed to be of least likelihood to be converted or affected by water regulations and were “locked out” of the analysis on where potential land cover could shift due to groundwater regulations. However, this may not always hold true. A more detailed analysis should be conducted without completely “locking out” prime farmlands to better understand how lands could be followed across the region.

Crop type crosswalk: Some counties reported on multiple different crops in a single group, which did not always align with the DWR categories. However, the crop types included in the group were listed. Thus, the crop category that the group would be cross-walked to the crop category that most of the crop types within that group fell into. However, this does bring an element of uncertainty into the analysis, as there were a few crop types cross walked to a

specific crop category that belonged in a different category. The table in Appendix C shows the final crosswalk criteria that were used to reclassify all the fields in this dataset, with values that create uncertainty highlighted in yellow.

Applied Water Amounts: Applied water is a useful metric to understand the water use and potential water savings across the region. In this analysis, we assume that all applied water is extracted from groundwater, and all water savings will help the region meet groundwater savings targets. However, this may not hold true for all fields, as many landowners have surface water rights. A more detailed analysis should be conducted to prioritize areas that are “white areas” or “groundwater dependent areas” as applied water savings in these areas would reduce groundwater overdraft (Niles et al., 2024).

Determine total income per crop type: For crops not reported by the County but listed in the LandIQ data, other sources were used to identify the average income per acre for those crops, such as the average income per acre as reported by the other counties in the study region. These additional data sources are listed in Appendix B.

Standardized Land Use and Land Cover Change: This analysis assumes that land cover change will be mostly determined through an economic analysis of revenue earned per crop type and water used per crop type. Though there are other variables included in the analysis, we still presume that the only outcome to an economic imbalance is complete restoration or repurposing. Other options do exist for landowners, including transitioning to a less water-intensive crop type or purchasing water from the market.

Species Distribution Models: Areas we prioritize for restoration based on ecological considerations were grounded in Species Distribution Models. This approach was chosen for several reasons governed by the logistic and practical considerations of the project and has several benefits. There are also several drawbacks, which are noted below:

- There are several types of SDM. The major categories of model are correlative and mechanistic. Even within correlative models, different algorithms such as Maxent or Random Forest can produce notably different results. Even more, not only are SDM outputs dependent upon choice of algorithm, but also factors related to data input such as spatial resolution, regularization settings, and choice of environmental variables. Choice of environmental variables is particularly pertinent to our study. As we ran the model on over 100 species, we were capacity limited to conduct in-depth literature reviews on each species. This meant that the environmental variables we selected were not tailored to the individual biologically deterministic conditions of each species, but more general variables.
- The SDMs were developed using species occurrence records and environmental predictors under a single future climate change scenario (SSP5-8.5), representing a high-emissions trajectory. This scenario does help illustrate potential climate pressure on ecosystems, but the actual future conditions may differ depending on global outcomes
- Sampling bias is a common problem for species distribution models. Occurrence records are disproportionately concentrated near roads, population centers, and heavily surveyed areas. While Maxent has corrective mechanisms for this, some of

the model output is still inevitably biased by this. SDMs also don't incorporate all relevant ecological factors that determine species survival at a given location. Population dynamics, dispersal limitations, competition and mutualisms may make suitable habitat inaccessible or functionally unsuitable. Slow-dispersing tree species, for example, may be projected to become climatically suitable under future projections at a given location but be completely unreachable given realistic dispersal rates. Our methodology of stacking Species Distributional Models is impacted by this. Communities are determined by biological interactions as well as environmental compatibility. Relying on species richness works well as an initial indication of a high enough probability that functioning communities can form but would need further investigation into individual species biological characteristics to increase model accuracy.

Restoration Priorities on Federal Lands: Given that some of the most intact habitats in our study area are located in the foothills and in the Sierra Nevada Mountains, our habitat restoration prioritization analyses, which are based on a number of variables including future climate conditions, much of the forest land identified for restoration is located on National Forest or National Park land. This result underscores the need for diverse, multi-agency partnerships to support the many types of landowners in the four-county region.

Tribal Engagement: Tribal engagement was a stated goal of this project and remains an important and unmet need. Despite its identification as a priority, the timeline and scope of the project did not allow for the meaningful consultation that this work requires. Authentic government-to-government consultation with Indigenous nations cannot be rushed or conducted superficially. It requires dedicated time, resources, and relationship-building that were not available within this project's constraints. Additionally, tribes should not be consulted at the end stage of a project development and implementation process, and should be engaged from the beginning of the process of development of grant proposals (RFPs), statewide and regional plans (including the Sierra San Joaquin Jobs Initiative's Regional Investment Plan for this region), and project design and objectives for individual restoration projects. We are hopeful that partners across the state and region will create meaningful and supportive relationships with indigenous leaders across the region to ensure that their leadership is supported and their needs are met.

Beyond tribal engagement, the project's timeline and capacity constraints limited the depth of community engagement more broadly. The community meetings provided helpful feedback to inform restoration priorities, and that contribution cannot be understated. However, the notes and data from these meetings were assessed quantitatively through interview coding, making it difficult to fully understand the nuance, context, and lived experience of those contributing. In an ideal process, there would have been more opportunity to engage directly and unhurriedly with residents to genuinely understand the day-to-day realities, challenges, and barriers that people in this region face. Those conversations could have made recommended actions more grounded and realistic, and produced a higher quality deliverable that is more likely to be useful to and used by the region.

Recommendations for Restoration & Future Research

From the literature review, community engagement, and analysis processes of this project, the group has developed the following recommendations for land managers, restoration practitioners, planners, and future researchers in the region:

Center local communities in restoration work: Restoration work has the highest impact when coordinated across property lines, requiring the involvement of all individuals, organizations, and communities across the landscape. While restoration priorities have traditionally centered on ecological outcomes, people are inseparable from the environment, and any meaningful ecosystem restoration effort must account for both people and the planet. This is especially true given the history of environmental efforts overlooking vulnerable communities and perpetuating the harms they face. Restoration work must be intentional about minimizing these negative impacts and, where possible, undoing existing ones. This project, as noted in the caveats section, was constrained by limitations in time, capacity, and budget that inhibited community engagement. Restoration work must hold itself to a high standard and actively examine who benefits from ecological interventions and who bears the costs. The most impactful restoration work treats ecological health and community wellbeing as inseparable goals, and doing this well takes time. Restoration work should invest in genuine partnership with affected communities, taking the time to understand existing conditions, learn about historical and ongoing harm, and hear directly from the people who know these landscapes best.

Engage in local and regional planning: Given the complexity of the ecosystems present and the need to consider local conditions on the ground in terms of ecosystem type and health as well as community needs and desires, future analyses would benefit from “zooming in” to specific areas of interest. There are many restoration plans that exist for individual ecosystem types or specific areas within the Central San Joaquin Valley, and this effort builds on those existing plans and brings them together at the four-county scale, but actual implementation of proposed restoration strategies in this plan likely requires a scaled down and localized approach. However, building on existing protecting areas, and creating habitat corridors and linkages benefit from landscape-scale planning and approaches. Additionally, to receive ecosystem services such as improved air and water quality and natural hazard risk reduction, landscape-scale projects and interventions, planned as multi-sector, multi-partner approaches, are needed.

Provide financial incentives and technical assistance to private landowners: This region has always been and continues to be incredibly diverse. From the range of historic ecosystems to the spread of different crop categories in production, to the large variety of land use types and land owner types - there is no one restoration action or outcome that can meet the needs of the entire region. It is important to take this heterogeneity into account when planning for the entire region. With such a diverse set of scenarios, it is incredibly important to leverage the power of private land restoration. However, most residents in the region are not familiar with restoration work or with the various options that exist to support such work on their properties. It is important to develop policies and provide support, both technical and financial, to meet the needs of those who will be most affected by the future transitions that

will occur in the region. Additionally, it is important to consider the economic and social implications of land conversion or ecosystem restoration, and to have ample resources available to support local communities as this occurs. It is vital that any resources, training, and technical support that are provided are tailored to the community and can meet the community needs as best as possible.

Public-private partnerships for restoration on federal land: Expanding public-private partnerships is an important opportunity for streamlining ecosystem restoration across federally managed lands in the region. Federal agencies, such as the U.S. Forest Service and Bureau of Land Management, oversee large areas of land within and surrounding the Central San Joaquin Valley. However, these agencies face funding, staffing, and capacity constraints that limit the progress of restoration projects. Community-based organizations can bridge these gaps by leveraging additional resources and technical expertise through collaborative management agreements. These partnerships would allow restoration efforts on federal lands to align with the regional priorities identified in this plan, and create additional opportunities for workforce development, community engagement, and revived ecological benefits. Collectively, partnerships would fulfill joint restoration goals across public and surrounding lands.

Planning in the four-county region should incorporate system connectedness: The natural and human systems that govern environmental functions and its impacts on people are influenced by factors that exist at several scales. Future planning efforts would benefit from finer-scale ecological assessments, however regional scale thinking should always remain prevalent. Some native species that occur in specific locations in the region can shift to another, restoration activity in one region can have downstream ecological knock-on effects, and planning decisions that improve human wellbeing in one location can cause harm in another. To ensure the long-term success of restoration efforts in the region, regional coordination needs to occur so that environmental and governmental processes are not treated as closed systems. Maintaining updated and temporally compatible datasets, and continued partner engagement to refine these results as priorities and environmental conditions change are important next steps to enacting this recommendation.

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Appendix

Crosswalk Tables for Crop Types to Crop Categories

Some counties reported “groups” of crops, which means multiple different crops or crop types were reported on as one crop type. For example, Madera County reported crop revenues on “Wheat” which included wheat grain, wheat silage, winter forage, and miscellaneous wheat. These groups, and the crop types included within them, did not always align with the DWR crop categories. Thus, the crop category that the group would be crosswalked to is the crop category that the majority of the crop types within that group fell into. This adds an element of uncertainty into the analysis, as there were a few crop types crosswalked to a specific crop category that may have belonged in a different crop category. This table shows the final crosswalk criteria that were used to reclassify all the fields in this dataset, with values that create uncertainty highlighted in yellow.

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
				Grain	Grain and Hay Crops
Wheat (grain, silage, winter forage, miscellaneous)	Hay (Wheat)	Wheat - Grain	Wheat Hay	Wheat	Wheat
	Wheat (grain)		Wheat Grain	Wheat Winter	
	Wheat (silage)		Wheat Silage	Wheat Spring	
Oat (hay)	Other Hay (Barley, oats, sudan grass and winter forage)	Barley - Grain	Barley Silage	Barley	Barley
			Oat Hay	Oats	Oats
			Oat Silage		
		Corn - Grain & Silage		Misc. Grain & Hay	Misc. Grain & Hay
		Other Hay (includes oat hay and wheat hay)			Mixed Grain & Hay

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
		Silage - Small grain (includes barley, oat, sorghum, triticale, and wheat)	Sorghum Silage		
			Triticale Grain		
			Triticale Silage		
			Seed Crops (includes alfalfa, barley, broccoli, cotton, lettuce, mustard, onion, triticale, and wheat)		
				Rice	Rice
				Rice	Rice
				Rice Wild	Wild Rice
				Rice Flooded	
				Rice Upland	
Cotton (lint)	Cotton total (including upland lint,	Cotton - Lint & Seed	Cotton Lint & Seed (all types)	Cotton	Field Crops

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
	seed, pima lint, seed)				
					Cotton
		Cotton Seed			
				Sugar Beets	
				Sugar Beet	Sugar Beets
				Sugar Beet Late	
				Sugar Beet Early	
				Corn	Field Crops
Corn (silage)	Corn, Silage		Corn Silage		Corn
					Field Corn
	Corn, Sweet				Sweet Corn
				Dry Beans	Field Crops
		Beans - Dry			Dry Beans
				Safflower	Field Crops
					Safflower
				Other Field Crops	Field Crops
				Flax	Flax

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
				Hops	Hops
				Grain Sorghum	Grain Sorghum
		Sudangrass (reported as hay)		Sudan	Sudan
				Castor Beans	Castor Beans

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
		Miscellaneous - Vegetable (includes assorted peppers, succulent beans, cabbage, cactus, daikon, cauliflower, cilantro, collards, eggplant, gourds, herbs, kale, lettuce, cantaloupe and other assorted melons, mustard, onions, peas, potatoes, pumpkins, spinach, squash, tomatillos, tomatoes, turnips, watermelon, and zucchini)	Other Field Crops (includes alfalfa silage, alfalfa stubble, barley (grain), barley (hay), beans (dry), corn (grain), corn (human consumption), forage, hay (other), industrial hemp, pasture (irrigated), ryegrass, safflower, sorghum milo, sudan hay, sudan silage and wheat straw)	Misc. Field	Misc. Field Crops
				Sunflower	Sunflowers
				Sorghum/Sudan Hybrid	Hybrid Sorghum/Sudan
				Millet	Millet

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
				Sugarcane	Sugarcane
		Miscellaneous Seed Crops (includes oat, onion, and lettuce)	Other Vegetable Crops (includes asparagus, bell peppers, cantaloupe, carrots, sweet corn, garlic, melons, onions, parsley, pumpkins, radicchio, tomatoes, transplants, and watermelons)		
				Alfalfa	Pasture
Alfalfa (hay)	Hay (Alfalfa)	Alfalfa Hay & Silage	Alfalfa Hay	Alfalfa	Alfalfa and Alfalfa Mixtures
				Alfalfa Mixtures	
				Alfalfa Cut	
				Alfalfa Annual	

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
				Pasture	Pasture
Pasture (irrigated)		Pasture & Rangeland Irrigated	Pasture Range	Pasture	
				Clover	Clover
				Pasture Mixed	Mixed Pasture
		Pasture & Rangeland Native		Pasture Native	Native Pasture
				Misc. Grasses	
				Turf Farm	Turf Farms
				Pasture Bermuda	Bermuda Grass
				Pasture Rye	Rye Grass
				Klein Grass	Klein Grass
				Pasture Fescue	
Rangeland		Pasture & Rangeland Other			Induced High Water Table Native Pasture
				Tomato Processing	Truck, Nursery and Berry Crops

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
Tomatoes (processed)	Tomatoes Proceesed		Tomatoes Processed	Tomato processing	Tomato processing
				Tomato Processing Drip	
				Tomato Processing SFC	
				Tomato Fresh	Truck, Nursery and Berry Crops
Tomatoes (fresh)	Tomatoes (standard and cherry)			Tomato Fresh	Tomato Market
				Tomato Fresh Drip	
				Tomato Fresh SFC	
				Cucurbits	Truck, Nursery and Berry Crops
	Honeydew			Melons	Melons
	Mixed Melons				
	Squash			Squash	Squash
		Cucumbers		Cucumbers	Cucumbers

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
				Cucumbers Fresh Market	
				Cucumbers Machine- Harvest	
	Watermelon			Watermelon	
	Cantaloupe				
				Onions & Garlic	Truck, Nursery and Berry Crops
	Onions (fresh/process ed)			Onions	Onions
				Onions Dry	
				Onions Green	
	Garlic			Garlic	Garlic
				Potatoes	Truck, Nursery and Berry Crops
				Potatoes	Potatoes
				Sweet Potatoes	Sweet Potatoes
				Truck Crops	Truck, Nursery and Berry Crops

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
				Artichokes	Artichokes

Miscellaneous vegetables (cabbage, garlic, herbs, melons, onions, all peppers, potatoes, all squash and miscellaneous truck crops)	Other vegetables (arugula, artichoke, basil, beans (shell and snap), beets, broccoli, cabbage, carrot, casava (root and leaf), cauliflower, celery, chive, cilantro, culantro, corn [processed] cucumber, curry leaf tree, dandelion green, dill, fennel, gourds, jicama, kale, kohlrabi, leeks, marjoram, mint, mustar, nettle, okra, green onion, oregano, parsley, parsnip, peanut, peas, pennywort, chili pepper, potato, pumpkin, purslane, radicchio, radish, rapini,			Truck Crops	Mixed Truck Crops (Four or More)
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rosemary, rutabaga, sage, savor, shallot, spinach, sunchoke, swiss chard, tarragon, tyhme, tinda, tindora, tomatillo, tumeric, turnip, watercress)					
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County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
	Asparagus			Asparagus	Asparagus
				Green Beans	Green Beans
				Carrots	Carrots
				Celery	Celery
	Head Lettuce			Lettuce	Lettuce (all types)
	Lettuce Leaf				
				Peas	Peas
				Spinach	Spinach
				Bush Berries	Bush Berries
	Blueberries	Blueberries			Blueberries
				Strawberries	Strawberries
				Peppers	Peppers
		Broccoli - Processed		Broccoli	Broccoli
				Cabbage	Cabbage
				Cauliflower	Cauliflower
					Brussels Sprouts
					Flowers, Nursery and Christmas Tree Farms

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
					Greenhouse
	Oriental Vegetables				Asian leafy vegetables
	Eggplant				
	Pepper Bell				
		Sweet Corn			
				Almonds & Pistachios	Deciduous Fruits and Nuts
Almonds	Almonds	Almonds - Meats & Hulls	Almonds meat, hulls, shells	Almonds	Almonds
Pistachios	Pistachios	Pistachio Nuts	Pistachios	Pistachios	Pistachios
				Other Deciduous	Deciduous Fruits and Nuts
				Apples	Apples
	Apricots	Apricots	Apricots	Apricots	Apricots
Walnuts	Walnuts	Walnuts	Walnuts	Walnuts	Walnuts
Cherries	Cherries	Cherries	Cherries	Cherries	Cherries
Peaches	Peaches	Peaches - Cling & Freestone	Peaches (all)	Peaches	Peaches
	Nectarines	Nectarines	Nectarines	Nectarines	

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
	Pears	Pears and Asian Pears		Pears	Pears
Plums, dried	Plums	Plums & Pluots	Plums	Plums	Plums
	Plums, dried				
		Prunes - Dried Plums		Prunes	Prunes
Figs				Figs	Figs
				Kiwis	
					Young Perennials

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
Miscellaneous fruits and nuts	Other fruit and nuts	Miscellaneous Fruit/Nut (includes avocados, apples, bushberries, citron, chestnuts, figs, guava, juice grapes, jujubes, kumquat, limes, processed blueberries, processed grapefruit, processed lemons, processed tangerines, and strawberries)	Other Fruit and Nut (includes apples, asian pears, berries, blackberries, blueberries, cherry plums, figs, firewood, kiwifruit, olives, oranges, pecans, persimmons, pluots, pomegranates, prunes, quince, strawberries, tangerines)		Mixed. Deciduous
	Pomegranates	Pomegranates			Pomegranates
	Persimmons	Persimmons			
	Pluots				
		Pecans			
		Quince			
				Citrus & Subtropical	Citrus & Subtropical

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
		Grapefruit (includes pomelos and hybrids)		Grapefruit	Grapefruit
	Lemons	Lemons		Lemons	Lemons
Oranges	Oranges (navel [fresh, processed], valencia [fresh, processed])	Oranges - Navels		Oranges	Oranges
		Oranges - Valencia			
	Mandarin/Tangerine	Tangerines (includes mandarins, tangelos, tangor and seedless varieties)			
				Dates	Dates
				Avocados	Avocados
Olives, fresh and oil		Olives		Olives	Olives
	Other Citrus				Misc. Subtropical Fruits
				Jojoba	Jojoba
					Eucalyptus

County Categories				DWR Crop Categories	
Madera	Fresno	Tulare	Kings	DWR Crop Types	Land IQ Crop Types
					Mixed Subtropical Fruits
		Kiwifruit			Kiwis
				Vineyard	Vineyards
Grapes (raisin varieties, table varieties, wine varieties)	Grapes (raisin varieties, table varieties, wine varieties)	Table Grapes (all)	Grapes Table	Table Grapes	Table Grapes
		Raisins (all)	Grapes Raisins	Raisin Grapes	Raisin Grapes
		Wine Grapes (all)	Grapes Wine	Wine Grapes	Wine Grapes
				Unclassified	Idle
		Miscellaneous (includes bean screenings, safflower, oat grain, garbanzo, corn for humans, sorghum grain, and industrial hemp)			Idle
					Fallowed
					Unclassified Fallow
					Lands Being Prepped for Crop Production

Revenue and Applied Water Tables per Crop Category per County

Madera County				
DWR Category	Acres (LandIQ)	Value per Acre (County Data)	Total Seasonal AW (acre-ft)	Seasonal AW per acre (acre-ft)
Other Deciduous	70233.78	7059.433962	56191.97	0.8000703991
Vineyard	57413.07	3975.395683	220684.53	3.843802685
Unclassified	23470.87	N/A	N/A	N/A
Citrus & Subtropical	7560.08	6138.77551	25847.42	3.418935067
Grain	28180.69	158.810979	17541.92	0.6224801468
Almonds & Pistachios	159846.03	4764.472141	799128.6	4.999364569
Corn	356.02	1382.742857	44469.32	124.9056059
Pasture	1851.42	N/A	N/A	N/A
Alfalfa	8144.72	1601.235955	39100.43	4.80071181
Tomato Processing	1697.32	3980	7669.73	4.518731521
Truck Crops	432.74	5818.75	1610.39	3.72133757
Cotton	392.91	1868.181818	1412.38	3.594665445
Onions & Garlic	245.21	12946.15198	281.06	1.146201852
Cucurbits	32.73	8848.827586	115.53	3.529850314
Dry Beans	N/A	N/A	396.52	N/A
*Onions/Garlic value was determined by using the value per hectare for onions/garlic in Fresno County				
*Cucurbits value was determined by using the value per hectare for cucurbits in Fresno County				
*Dry Beans is removed from the data for this county because there is no LandIQ satellite data showing acres in production				

Fresno County				
DWR Category	Acres (LandIQ)	Value per Acre (County Data)	Total Seasonal AW (acre-ft)	Seasonal AW per acre (acre-ft)
Other Deciduous	202925.59	11652.73003	222040.48	1.09419656
Vineyard	147940.49	5748.171089	640416.72	4.328880757
Unclassified	212609.76	N/A	N/A	N/A
Citrus & Subtropical	52740.29	10991.56832	178661.42	3.387569938
Grain	77505.11	511.4606742	50539.99	0.6520859396
Almonds & Pistachios	288863.15	4925.324381	1612061.61	5.580710529
Corn	9229.81	2043.003214	91180.64	9.878929748
Pasture	13097.93	N/A	N/A	N/A
Alfalfa	30929.27	1433.291771	156597.26	5.063076625
Tomato Processing	69295.34	3937.5	157915.03	2.278869385
Truck Crops	26532.00	8506.768376	50761.76	1.913228036
Cotton	34443.90	2384.627405	128980.78	3.744662103
Onions & Garlic	26724.50	12946.15198	36747.67	1.375055713
Cucurbits	18589.55	8848.827586	50134.12	2.696898082
Other Field Crops	2224.68	6115.368088	7116.65	3.19895539
Dry Beans	861.34	1990.615836	1708.5	1.983538274
Potatoes	217.89	24176.56172	N/A	3.782766058
Safflower	145.83	520	368.95	2.529998951
Rice	1708.26	4427.306354	7601.8	4.450028246
*Other field crops in Fresno County is only Sudangrass. Though the Fresno County crop valuation puts Sudangrass into "grains," LandIQ breaks it out as "other field crops." Tulare County also only counts Sudangrass as "other field crops." Thus, we used Tulare County's valuation of sudangrass for this value in Fresno County				
*Dry Beans value was determined by using the value per hectare for dry beans in Tulare County				
*Potato valuation is a combination of the per hectare valuation of both regular and sweet potatoes at the statewide level, according to CDFA's Ag Statistics Review for 2020				
*Safflower value is found from the statewide data on saffron crops (found in the IPM report)				
*Rice valuation is a combination of the per hectare valuation of rice at the statewide level, according to CDFA's Ag Statistics Review for 2020				

*Applied water per acre value for potatoes is from state total of applied water for potatoes over the state total irrigated crop acreage for potatoes from the DWR data

Tulare County				
DWR Category	Acres (LandIQ)	Value per Acre (County Data)	Total Seasonal AW (acre-ft)	Seasonal AW per acre (acre-ft)
Other Deciduous	156810.31	6883.009737	297863.65	1.899515746
Vineyard	43485.96	11051.45462	185131.48	4.257269754
Unclassified	82711.17	N/A	N/A	N/A
Citrus & Subtropical	135585.45	12635.60643	452834.22	3.339843707
Grain	142760.12	1022.909317	74534.99	0.522099516
Almonds & Pistachios	83314.49	4764.192584	508384.08	6.101988807
Corn	20069.50	1592.668528	244076.29	12.16155038
Pasture	5411.41	N/A	N/A	N/A
Alfalfa	34027.59	2397.967914	164158.91	4.824288395
Tomato Processing	759.27	4060.015348	2417.38	3.183832889
Truck Crops	5546.29	23424.90842	18563.89	3.347082682
Cotton	6732.04	2253.859779	24708.37	3.670262653
Onions & Garlic	14.64	12946.15198	14.05	0.9599554686
Cucurbits	25.57	8848.827586	255.66	9.997684488
Other Field Crops	30.91	2474.801662	120.2	3.888210565
Dry Beans	1139.60	1990.615836	3845.83	3.374729669
Potatoes	44.10	9783.907407	N/A	3.782766058
Safflower	N/A	N/A	396.47	N/A
*Corn value was determined by using the average value per hectare for corn in Kings, Fresno, and Madera				
*Pasture and unclassified are removed from the analysis (as water use for these land cover types is hard to quantify)				
*Tomato processing value was determined by averaging the value per acre for tomato processing from Kings, Fresno, and Madera counties				
*Onions/Garlic value was determined by using the value per acre for onions/garlic in Fresno County				
*Cucurbits value was determined by using the value per acre for cucurbits in Fresno County				
*Potato valuation is a combination of the per hectare valuation of both regular and sweet potatoes at the statewide level, according to CDFA's Ag Statistics Review for 2020				

*Applied water per acre value for potatoes is from state total of applied water for potatoes over the state total irrigated crop acreage for potatoes from the DWR data

*Safflower is removed from the data for this county because there is no LandIQ satellite data showing acres in production

Kings County				
DWR Category	Acres (LandIQ)	Value per Acre (County Data)	Total Seasonal AW (acre-ft)	Seasonal AW per acre (acre-ft)
Other Deciduous	83374.16128	7726.383851	119902.58	1.438126371
Vineyard	6035.201637	6653.997379	24376.57	4.039064718
Unclassified	113849.344	N/A	N/A	N/A
Citrus & Subtropical	1710.273482	9921.983422	4379.95	2.560964691
Grain	83067.40481	649.8164468	55673.69	0.6702230571
Almonds & Pistachios	38882.91744	5470.634323	307824.01	7.916690162
Corn	14207.42954	1352.259515	136353.67	9.597349723
Pasture	1717.92943	N/A	N/A	N/A
Alfalfa	24381.62859	1538.467454	125939.16	5.165330098
Tomato Processing	26109.35423	4262.546044	58005.21	2.221625609
Truck Crops	3277.802795	12583.4756	6729.47	2.053042975
Cotton	86614.59879	2192.58694	323145.66	3.730845198
Onions & Garlic	5734.682746	12946.15198	9113.8	1.589242231
Cucurbits	984.9261587	8848.827586	2459.5	2.497141515
Other Field Crops	99.71738426	1951.987178	563.42	5.650168265
Dry Beans	527.1098899	1990.615836	1132.15	2.147844352
Safflower	12379.65608	520	28844.75	2.330012224
*Citrus value was determined by averaging the value per acre for citrus/subtropical crops in Tulare, Fresno and Madera Counties				
*Pasture and unclassified are removed from the analysis (as water use for these land cover types is hard to quantify)				
*Truck crop value was determined by averaging the value per acre for truck crops in Tulare, Fresno and Madera Counties				
*Onions/Garlic value was determined by using the value per acre for onions/garlic in Fresno County				

Kings County				
DWR Category	Acres (LandIQ)	Value per Acre (County Data)	Total Seasonal AW (acre-ft)	Seasonal AW per acre (acre-ft)
*Cucurbits value was determined by using the value per acre for cucurbits in Fresno County				
*Dry Beans value was determined by using the value per acre for dry beans in Tulare County				
*Safflower value is found from the statewide data on saffron crops (found in the IPM report)				

Total Acres Projected for Land Cover Change, per Crop Type

Crop Category	Total Acres in Production	Total Acres Projected for Change	Percentage of Total Acres in Production for that Crop Category
Alfalfa	101,002	46,631	46.2%
Almonds & Pistachios	585,030	56,121	9.6%
Citrus & Subtropical	194,510	38,259	19.7%
Corn	44,980	14,371	31.9%
Cotton	130,759	85,996	65.8%
Cucurbits	19,869	0	0%
Dry Beans	2,528	659	26.1%
Grain	344,286	143,293	41.6%
Onions & Garlic	33,576	0	0%
Other Deciduous	530,759	67,466	12.7%
Other Field Crops	2,355	54	2.3%
Pasture	21,316	0	0%
Potatoes	262	0	0%
Rice	1,708	1,496	87.6%
Safflower	12,525	12,482	99.7%
Tomato Processing	102,639	24,830	24.2%

Crop Category	Total Acres in Production	Total Acres Projected for Change	Percentage of Total Acres in Production for that Crop Category
Truck Crops	36,760	476	1.3%
Unclassified	465,483	0	0%
Vineyard	259,344	27,755	10.7%

Species List and Model Outputs

Ecosystem Name	Ecosystem Subtype	Common Name	Scientific Name	AUC Value (auc.val.avg)	AIC Value (delta.AICc)
Valley Foothill Hardwood	Montane Hardwood (MHW)	Jeffrey Pine	Pinus jeffreyi	0.906	0
		Sugar Pine	Pinus lambertiana	0.921	0
		Incense-cedar	Calocedrus decurrens	0.922	0
		California White Fie	Abies concolor	0.936	0
		White Alder	Alnus rhombifolia	0.905	0
		California Black Oak	Quercus kelloggii	0.918	0
		California Laurel	Umbellularia californica	0.935	0
		Acorn Woodpecker	Melanerpes formicivorus	0.911	0
		Mule Deer	Odocoileus hemionus	0.914	0
		California Ground Squirrel	Otospermophilus beecheyi	0.77	0
		Rubber Boa	Charina bottae	0.866	0
		Black Bear	Ursus americanus	0.915	0
Valley Foothill Hardwood	Blue Oak Woodland (BOW)	Blue Oak	Quercus douglasii	0.898	0
		Mariposa Manzanita	Arctostaphylos viscida	0.915	0
		Western Gray Fox	Urocyon cinereoargenteus	0.793	0

Ecosystem Name	Ecosystem Subtype	Common Name	Scientific Name	AUC Value (auc.val.avg)	AIC Value (delta.AICc)
		Western Gray Squirrels	Sciurus griseus	0.876	0
		Mule Deer	Odocoileus hemionus	0.914	0
		Red-Shouldered Hawk	Buteo lineatus	0.796	NA
		Acorn Woodpecker	Melanerpes formicivorus	0.911	0
Valley Foothill Hardwood	Valley Oak Woodland (VOW)	Valley Oak	Quercus lobata	0.863	0
		California Sycamore	Platanus racemosa	0.927	0
		Hinds Black Walnut	Juglans hindsii	0.755	0
		Interior Live Oak	Quercus wislizeni	0.889	0
		Blue Oak	Quercus douglasii	0.898	0
		Blue Elderberry	Sambucus cerulea	0.8	0
		Red-Shouldered Hawk	Buteo lineatus	0.796	NA
		Western Gray Fox	Urocyon cinereoargenteus	0.793	0
		Western Gray Squirrels	Sciurus griseus	0.876	0
		Mule Deer	Odocoileus hemionus	0.914	0
		Oak Titmous	Baeolophus inornatus	0.919	0
Valley Foothill Hardwood	Blue Oak-Foothill Pine (BOP)	Blue Oak	Quercus douglasii	0.898	0
		Foothill Pine	Pinus sabiniana	0.848	0
		Mariposa Manzanita	Arctostaphylos viscida	0.915	0
		Silver Lupine	Lupinus albifrons	0.802	0
		Blue Elderberry	Sambucus cerulea	0.8	0
		California Yerbasanta	Eriodictyon californicum	0.901	0

Ecosystem Name	Ecosystem Subtype	Common Name	Scientific Name	AUC Value (auc.val.avg)	AIC Value (delta.AICc)
		Rock Gooseberry	Ribes quercetorum	0.844	0
		California Redbud	Cercis occidentalis	0.919	0
		Acorn Woodpecker	Melanerpes formicivorus	0.911	0
		Red-Shouldered Hawk	Buteo lineatus	0.796	NA
		Giant Kangaroo Rat	Dipodomys ingens	0.969	NA
Shrublands and Chaparral	Montane Chaparral (MCP)	Whitethorn Ceanothus	Ceanothus cordulatus	0.91	0
		Snowbrush ceanothus	Ceanothus velutinus	0.721	NA
		Greenleaf Manzanita	Arctostaphylos patula	0.914	0
		Pinemat Manzanita	Arctostaphylos nevadensis	0.886	0
		Bitter Cherry	Prunus emarginata	0.892	0
		Huckleberry Oak	Quercus vacciniifolia	0.935	0
		Mountain Mahogany	Cercocarpus ledifolius	0.859	0
		Brush Rabbit	Sylvilagus bachmani	0.745	0
Shrublands and Chaparral	Mixed Chaparral (MCH)	Foothill Pine	Pinus sabiniana	0.848	0
		Interior Live Oak	Quercus wislizeni	0.889	0
		California Yerbasanta	Eriodictyon californicum	0.901	0
		California Buckthorn	Frangula californica	0.842	0
		Incense-cedar	Calocedrus decurrens	0.922	0
Shrublands and Chaparral	Chamise-Redshank Chaparral (CRC)	Buck Brush	Ceanothus cuneatus	0.894	0
		Mariposa Manzanita	Arctostaphylos viscida	0.915	0
		California Buckthorn	Frangula californica	0.842	0
	Alkali Desert Scrub (ASC)	Allscale	Atriplex polycarpa	0.922	0

Ecosystem Name	Ecosystem Subtype	Common Name	Scientific Name	AUC Value (auc.val.avg)	AIC Value (delta.AICc)
Sparsely Vegetated Land		Big Saltbrush	<i>Atriplex lentiformis</i>	0.836	0
		Western Mohave Saltbrush	<i>Atriplex spinifera</i>	0.936	0
		Leaf-Cover Saltweed	<i>Atriplex phyllostegia</i>	0.921	0
Sparsely Vegetated Land	Barren (BAR)	Valley Oak	<i>Quercus lobata</i>	0.863	0
		Lodgepole Pine	<i>Pinus contorta</i>	0.87	0
		California Juniper	<i>Juniperus californica</i>	0.831	0
		Quaking Aspen	<i>Populus tremuloides</i>	0.903	0
		Swainson's Hawk	<i>Buteo swainsoni</i>	0.807	0
		American Avocet	<i>Recurvirostra americana</i>	0.891	0
		Common poorwill	<i>Phalaenoptilus nuttallii</i>	0.708	0
		Horned Lizard	<i>Phrynosoma blainvilli</i>	0.793	0
		American Pika	<i>Ochotona princeps</i>	0.908	0
		Yellow-Bellied Marmot	<i>Marmota flaviventris</i>	0.926	0
Grassland	Annual Grassland (AGS)	Chinook Brome	<i>Bromus laevipes</i>	0.736	NA
		Turkey Mullein	<i>Croton setigerus</i>	0.744	NA
		California Poppy	<i>Eschscholzia californica</i>	0.731	0
		Purple Needlegrass	<i>Nassella pulchra</i>	0.892	0
		Western Fence Lizard	<i>Sceloporus occidentalis</i>	0.758	0
		Common Garter Snake	<i>Thamnophis sirtalis</i>	0.659	NA
		Western Rattlesnake	<i>Crotalus oreganus</i>	0.784	0
		Black-Tailed Jackrabbit	<i>Lepus californicus</i>	0.901	0

Ecosystem Name	Ecosystem Subtype	Common Name	Scientific Name	AUC Value (auc.val.avg)	AIC Value (delta.AICc)
		California Ground Squirrel	Otospermophilus beecheyi	0.77	0
		Western Harvest Mouse	Reithrodontomys megalotis	0.852	0
		California Vole	Microtus californicus	0.785	0
		American Badger	Taxidea taxus	0.802	0
		Coyote	Canis latrans	0.657	0
		San Joaquin Kit Fox	Vulpes macrotis	0.893	0
		Burrowing Owl	Athene cunicularia	0.715	0
		Western Meadowlark	Sturnella neglecta	0.813	0
		Turkey Vulture	Cathartes aura	0.862	0
		Northern Harrier	Circus hudsonius	0.719	0
		American Kestrel	Falco sparverius	0.784	0
		Prairie Falcon	Falco mexicanus	0.756	0
Grassland	Perennial Grassland (PGS)	California Oatgrass	Danthonia californica	0.888	0
		California Goldfields	Lasthenia californica	0.654	0
		Spike Redtop	Agrostis exarata	0.81	0
		Crown brodiaea	Brodiaea coronaria	0.759	0
		Common Garter Snake	Thamnophis sirtalis	0.659	NA
		Northern Harrier	Circus hudsonius	0.719	0
		Burrowing Owl	Athene cunicularia	0.715	0
		Western Kingbird	Tyrannus verticalis	0.839	0
		Say's Phoebe	Sayornis saya	0.845	0
		Western Meadowlark	Sturnella neglecta	0.813	0

Ecosystem Name	Ecosystem Subtype	Common Name	Scientific Name	AUC Value (auc.val.avg)	AIC Value (delta.AICc)
		Savannah Sparrow	Passerculus sandwichensis	0.721	0
		Western Harvest Mouse	Reithrodontomys megalotis	0.852	0
		Long-Tailed Vole	Microtus longicaudus	0.907	0
		Turkey Vulture	Cathartes aura	0.862	0
		Red-Tailed Hawk	Buteo jamaicensis	0.827	0
		American Kestrel	Falco sparverius	0.784	0
		Western Bluebird	Sialia mexicana	0.841	0
		Striped Skunk	Mephitis mephitis	0.845	0
		Coyote	Canis latrans	0.657	0
		Black-Tailed Jackrabbit	Lepus californicus	0.901	0
		Brush Rabbit	Sylvilagus bachmani	0.745	0
Grassland	Wet Meadow (WTM)	California Oatgrass	Danthonia californica	0.888	0
		Iris Leaved Rush	Juncus xiphioides	0.582	0
		Thingrass	Agrostis pallens	0.947	0
		Abrupt Beak Sedge	Carex abrupta	0.893	0
		Nebraska Sedge	Carex nebrascensis	0.879	0
		Pullup Muhly	Muhlenbergia filiformis	0.894	0
		Jeffrey Shootingstar	Dodecatheon jeffreyi	0.907	0
		Panicled Bulrush	Scirpus microcarpus	0.891	0
		Hairy Pepperwort	Marsilea vestita	0.767	0
		Western Cowbane	Oxypolis occidentalis	0.934	0

Ecosystem Name	Ecosystem Subtype	Common Name	Scientific Name	AUC Value (auc.val.avg)	AIC Value (delta.AICc)
		American Bistort	<i>Bistorta bistortoides</i>	0.94	0
		Cows Clover	<i>Trifolium wormskioldii</i>	0.865	0
		Small White Violet	<i>Viola macloskeyi</i>	0.921	0
		Mule Deer	<i>Odocoileus hemionus</i>	0.914	0
		Yellow-Headed Blackbird	<i>Xanthocephalus xanthocephalus</i>	0.93	NA
		Red-Winged Blackbird	<i>Agelaius phoeniceus</i>	0.56	NA
		Brown Trout	<i>Salmo trutta</i>	0.805	NA
		Rainbow Trout	<i>Oncorhynchus mykiss</i>	0.921	0
Grassland	Pasture (PAS)	Sanhill Crane	<i>Antigone canadensis</i>	0.98	NA
Forest	Subalpine Conifer (SCN)	Mountain Hemlock	<i>Tsuga mertensiana</i>	0.944	0
		Whitebark Pine	<i>Pinus albicaulis</i>	0.945	0
		Foxtail Pine	<i>Pinus balfouriana</i>	0.944	0
		Limber Pine	<i>Pinus flexilis</i>	0.838	0
		Pileated Woodpecker	<i>Dryocopus pileatus</i>	0.949	NA
		Clark's Nutcrackers	<i>Nucifraga columbiana</i>	0.799	0
Forest	Red Fir (RFR)	Red Fir	<i>Abies magnifica</i>	0.904	0
		Mountain Hemlock	<i>Tsuga mertensiana</i>	0.944	0
		Western White Pine	<i>Pinus monticola</i>	0.888	0
		Whitebark Pine	<i>Pinus albicaulis</i>	0.945	0
		Foxtail Pine	<i>Pinus balfouriana</i>	0.944	0
		Limber Pine	<i>Pinus flexilis</i>	0.838	0
Forest	Lodgepole Pine (LPN)	Lodgepole Pine	<i>Pinus contorta</i>	0.87	0

Ecosystem Name	Ecosystem Subtype	Common Name	Scientific Name	AUC Value (auc.val.avg)	AIC Value (delta.AICc)
		Quaking Aspen	Populus tremuloides	0.903	0
		Mountain Hemlock	Tsuga mertensiana	0.944	0
		Brewer's Mountain Heather	Phyllodoce breweri	0.921	0
		Bald Eagle	Haliaeetus leucocephalus	0.754	NA
Forest	Sierran Mixed Conifer (SMC)	White Fir	Abies concolor	0.936	0
		Sugar Pine	Pinus lambertiana	0.921	0
		Incense-cedar	Calocedrus decurrens	0.922	0
		California Black Oak	Quercus kelloggii	0.918	0
		Deerbrush	Ceanothus integerrimus	0.915	0
		Mariposa Manzanita	Arctostaphylos viscida	0.915	0
		Mountain Whitethorn	Ceanothus cordulatus	0.91	0
		Spotted Owl	Strix occidentalis	0.896	0
		Fisher	Pekania pennanti	0.96	0
		Black Bear	Ursus americanus	0.915	0
		Bald Eagle	Haliaeetus leucocephalus	0.754	NA
		Mule Deer	Odocoileus hemionus	0.914	0
		Mountain Lion	Puma concolor	0.864	0
		Steller's Jay	Cyanocitta stelleri	0.884	0
		Mountain Kingsnake	Lampropeltis zonata	0.784	0
Rubber Boa	Charina bottae	0.866	0		
Forest	White Fir (WFR)	Black Bear	Ursus americanus	0.915	0
		White Fir	Abies concolor	0.936	0

Ecosystem Name	Ecosystem Subtype	Common Name	Scientific Name	AUC Value (auc.val.avg)	AIC Value (delta.AICc)
		Sugar Pine	Pinus lambertiana	0.921	0
		Snowplant	Sarcodes sanguinea	0.9	0
		Mule Deer	Odocoileus hemionus	0.914	0
		Western Gray Fox	Urocyon cinereoargenteus	0.793	0
Forest	Jeffrey Pine (JPN)	Mule Deer	Odocoileus hemionus	0.914	0
		California Ground Squirrel	Otospermophilus beecheyi	0.77	0
		Brown Creeper	Certhia americana	0.869	0
		Northern Flying Squirrel	Glaucomys sabrinus	0.878	NA
		Acorn Woodpecker	Melanerpes formicivorus	0.911	0
		Rubber Boa	Charina bottae	0.866	0
		Coulter Pine	Pinus coulteri	0.606	NA
		Sugar Pine	Pinus lambertiana	0.921	0
		Lodgepole Pine	Pinus contorta	0.87	0
		Limber Pine	Pinus flexilis	0.838	0
		White Fir	Abies concolor	0.936	0
		Incense-Cedar	Calocedrus decurrens	0.922	0
		Black Cottonwood	Populus trichocarpa	0.865	NA
		Quaking Aspen	Populus tremuloides	0.903	0
		California Black Oak	Quercus kelloggii	0.918	0
		Western Juniper	Juniperus occidentalis	0.862	0
		Mariposa Manzanita	Arctostaphylos viscida	0.915	0
		Mountain Misery	Chamaebatia foliolosa	0.926	0

Ecosystem Name	Ecosystem Subtype	Common Name	Scientific Name	AUC Value (auc.val.avg)	AIC Value (delta.AICc)
Forest	Pinyon-Juniper (PJN)	Single-Leaf Pinyon	Pinus monophylla	0.933	0
		Canyon Live Oak	Quercus chrysolepis	0.892	0
		Jeffrey Pine	Pinus jeffreyi	0.906	0
		Big Sagebrush	Artemisia tridentata	0.788	0
		Narrowleaf Golden Bush	Ericameria linearifolia	0.782	0
		Parry Nolina	Nolina parryi	0.973	0
		Curleaf Mountain Mahogany	Cercocarpus ledifolius	0.859	0
		Antelope Bitterbrush	Purshia tridentata	0.953	0
		Parry Rabbitbrush	Ericameria parryi	0.887	0
		Pinyon Mouse	Peromyscus truei	0.69	0
		Pinyon Jay	Gymnorhinus cyanocephalus	0.995	NA
		Plain Titmouse	Baeolophus inornatus	0.919	0
		Bushtit	Psaltriparus minimus	0.784	0
Forest	Montane Hardwood-Conifer (MHC)	California Black Oak	Quercus kelloggii	0.918	0
		Black Cottonwood	Populus trichocarpa	0.865	NA
		Jeffrey Pine	Pinus jeffreyi	0.906	0
		Sugar Pine	Pinus lambertiana	0.921	0
		Incense-cedar	Calocedrus decurrens	0.922	0
		Black Bear	Ursus americanus	0.915	0
		Mule Deer	Odocoileus hemionus	0.914	0
		Dusky Footed Woodrat	Neotoma fuscipes	0.813	NA
		Acorn Woodpecker	Melanerpes formicivorus	0.911	0

Ecosystem Name	Ecosystem Subtype	Common Name	Scientific Name	AUC Value (auc.val.avg)	AIC Value (delta.AICc)
		Steller's Jay	Cyanocitta stelleri	0.884	0
		Mountain Kingsnake	Lampropeltis zonata	0.784	0
		Rubber Boa	Charina bottae	0.866	0
Riparian	Montane Riparian (MRI)	Quaking Aspen	Populus tremuloides	0.903	0
		Black Cottonwood	Populus trichocarpa	0.865	NA
		Western Azalea	Rhododendron occidentale	0.952	0
		Goodding's Willow	Salix gooddingii	0.78	0
		Rubber Boa	Charina bottae	0.866	0
		North American Beaver	Castor canadensis	0.853	NA
		Chinook Salmon	Oncorhynchus tshawytscha	0.973	NA
		Steelhead Trout	Oncorhynchus mykiss	0.921	0
		Red Legged Frog	Rana draytonii	0.317	NA
		Western Pond Turtle	Actinemys marmorata	0.848	0
Riparian	Valley Foothill Riparian (VRI)	Arizona Aspen	Populus fremontii	0.776	0
		Black Cottonwood	Populus trichocarpa	0.865	NA
		California Sycamore	Platanus racemosa	0.927	0
		Valley Oak	Quercus lobata	0.863	0
		White Alder	Alnus rhombifolia	0.905	0
		Oregon Ash	Fraxinus latifolia	0.853	0
		California Wild Rose	Rosa californica	0.763	0
		California Blackberry	Rubus ursinus	0.851	0
		Buttonbrush	Cephalanthus occidentalis	0.864	0

Ecosystem Name	Ecosystem Subtype	Common Name	Scientific Name	AUC Value (auc.val.avg)	AIC Value (delta.AICc)
		Valley Elderberry Longhorn Beetle	Desmocerus californicus	0.865	NA
		Brush Rabbit	Sylvilagus bachmani	0.745	0
		Swainson's Hawk	Buteo swainsoni	0.807	0
		Red-Shouldered Hawk	Buteo lineatus	0.796	NA
		Dusky Footed Woodrat	Neotoma fuscipes	0.813	NA
		Red-Legged Frog	Rana draytonii	0.317	NA
		Giant Garter Snake	Thamnophis gigas	0.895	NA
		Western Pond Turtle	Actinemys marmorata	0.848	0
Wetland	Fresh Emergent Wetland (FEW)	Baltic Rush	Juncus balticus	0.552	0
		Inland Saltgrass	Distichlis spicata	0.763	0
		Giant Garter Snake	Thamnophis gigas	0.895	NA
		Bald Eagle	Haliaeetus leucocephalus	0.754	NA
Wetland	Saline Emergent Wetland (SEW)	Alkali Heath	Frankenia salina	0.694	0
		Gumweed	Grindelia camporum	0.61	0
		Great Blue Heron	Ardea herodias	0.885	NA
		Great Egret	Ardea alba	0.845	NA
		Northern Harrier	Circus hudsonius	0.719	0
		Virginia Rail	Rallus limicola	0.89	NA
		Western Toad	Anaxyrus boreas	0.743	0