SAN JOAQUIN VALLEY

Greenprint

State of the Valley Report

An overview of the characteristics and trends of natural resources in the San Joaquin Valley's rural spaces, with an eye on resource sustainability for the future


















Acknowledgments

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Executive Summary

The San Joaquin Valley of California is one of the world's most productive agricultural regions, is a vital link in California's complex water delivery and transportation systems, and provides important habitat to protect biodiversity. Growth, development patterns, and climate, however, pose ongoing challenges to this unique region.

The San Joaquin Valley Greenprint was created as a voluntary, stakeholder-driven project to help the eight counties of the San Joaquin Valley create long-term environmental and economic sustainability in the face of these challenges. It serves as a resource that can inform land use and resource management decisions in the Valley, emphasizing the importance of crafting regional solutions because economic and environmental challenges and decisions cross jurisdictional boundaries. The SJV Greenprint can be used by Valley planners and decision-makers; local, state, and federal resource managers; and the general public to answer questions like:

» How can we optimize the contributions of agriculture, water and ecological resources to the economy and quality of life in the Valley through regional planning?
» Where are the most strategic locations for groundwater recharge and storage, and what management may be needed to maintain those for such purposes? And, how can we minimize flood damage and utilize excess water from flood years in times of drought?
» How can we identify locations for urban growth while protecting economic and natural resources like prime farmland, oil, minerals, timber, and fisheries?
» Where can we restore biodiversity and connect wildlife habitats, while also achieving other land use benefits like riverside parks for recreation?

The SJV Greenprint has compiled and evaluated a large collection of publicly funded maps and data that portray the Valley's water, agricultural, and ecological resources to create a single repository of information. The maps are publicly available through a single point of access, the SJV Greenprint website (sjvgreenprint.ice.ucdavis.edu), which provides an interactive mapping portal to create maps and explore conflicts and solutions related to the Valley's natural resources and non-urban spaces.

This report uses the collected maps to tell the story of the San Joaquin Valley, a unique, geographically-large, resource-rich, and growing region that faces both challenges and opportunities with impacts ranging from local to national significance. The report provides baseline information on the current conditions and trends of natural resources on the valley floor – Water, Agriculture, Biodiversity, and Energy.

The map and data collection span the full extent of the eight San Joaquin Valley counties – Kern, Tulare, Kings, Fresno, Madera, Merced, Stanislaus, and San Joaquin Counties. Water is the first of resource chapter because it is essential to the other resources the project analyzed. Agriculture, as the dominant driver of the region's economy is next, followed by Biodiversity – the native environmental richness of the Valley – and last but not least, Energy, as a significant economic and environmental factor for the Valley.

Water

Water is the foundation of the San Joaquin Valley's economy and quality of life: farming, ranching, urban users, industry, and natural ecosystems all depend upon water. But like much of California, the San Joaquin Valley faces a supply and demand challenge. Though much of the Valley's water is collected and stored in the Sierra Nevada Mountains, significant portions are also imported through a complex system of state and federal surface water channels and pumped from underground aquifers (also known as groundwater basins).

Characteristics and trends of the Valley's water include:

» Water is a central resource management challenge in the San Joaquin Valley.
» Across the Valley, agriculture is the single largest water user, accounting for 72.5% of all water applied in 2010, followed by environmental uses (21.8%) and urban uses (5.7%).
» Of the total water applied in 2010 that was not reusable, agriculture represented 85.2%, environment 11%, and urban 3.9%.
» Sources of water for the Valley vary from year to year based on precipitation totals and the availability of stored water (both reservoirs and banked groundwater).
» The region's surface water resources are highly regulated and virtually all surface water is already claimed.
» Groundwater is loosely regulated, compared with surface water.
» Based on recent DWR data, groundwater levels in some portions of the Valley are more than 100 feet lower than they were between 1990 and 1998.
» Groundwater pumping is leading to land subsidence across the valley floor. A recent report identified areas with subsidence approaching one foot per year 2008-2010.
» Land subsidence threatens major infrastructure such as canals, roadways, and rail lines and reduces the

Aerial view of the San Joaquin Valley, © Patrick Huber

The San Joaquin Valley is the nation's leading producer of oranges (stock photography) ability of aquifers to recharge.

- Large portions of the Valley have high nitrate levels in the aquifers that provide drinking water, posing potentially significant human health consequences.
- As groundwater levels decline, irrigation wells draw from deeper aquifers that may be more saline, leading to potential soil salinization issues.

Agriculture

The San Joaquin Valley contains some of the richest agricultural lands in the world. Seven out of the ten most productive agricultural counties in the United States are located in the San Joaquin Valley, including the top three (Fresno, Tulare, and Kern Counties, respectively). This remarkable productivity results from the intersection of superior soils, plentiful sun, limited frost danger, favorable winter cooling patterns, and investments in infrastructure that provide water across an otherwise dry landscape.

Some of the trends and pressures facing Valley agriculture include:

- In 2012, the San Joaquin Valley's total agricultural market value was $24.2 billion (2013 inflation-adjusted terms) or 56% of the State's agricultural market value.
- Agricultural revenues across the Valley grew almost 50% (from $16.2 billion to $24.2 billion, 2013 dollars) between 2002 and 2012.
- Valley counties are nationally-leading producers of almonds, pistachios, oranges, tomatoes, grapes, cotton, and milk/dairy production.
- The Valley's shift to permanent crops (orchards and vineyards) has increased the region's agricultural revenues, but reduced flexibility to respond to drought.
- Virtually the entire valley floor can support commercial agriculture.
- 10.5 million acres (60%) of the Valley's land area is in agricultural use.
- Important farmland makes up 5.6 million acres (32%) of the Valley's total land area.
- Grazing lands occupy most of the foothills surrounding the valley floor.
- Most of the Valley's cities are surrounded by high-quality farmland.
- Approximately 740,000 acres of the San Joaquin Valley in 2010 are defined as urban and built-up and rural residential; formerly high-quality agricultural soils, this represents a conversion of about 12% of the Valley's potential important farmland since the establishment of these cities.
- Almost 25% of urban and built-up land use is new since 1984.
- Almost 50% of the region's potential groundwater recharge areas are also prime agricultural land.

Biodiversity

Historic vegetation and landcover maps of the San Joaquin Valley floor in 1850 cover 7,660,484 acres. They show that about 62% of the region was in grasslands, 38% of the region was in wetlands, water, or riparian habitats, and 20% was covered by Alkali scrub. About 69% of the valley floor has been brought into agricultural production, used for urban purposes, or committed to other human use, including energy production. Conservation of the highlands is fairly well established, which permits the continued delivery of water as an ecosystem benefit to the valley floor. The valley floor contains many species that are legally protected and that are in danger of extinction.

- Land conversion since 1850 occupies about 69% of the valley floor, with the largest unconverted lands being annual grasslands used for grazing.
- Overall, for the region, there are 3,043 plant species and 499 vertebrate species; which include 66 state- and federally-listed threatened or endangered species.
- The forested and alpine lands of the Sierra Nevada are the water towers of the region, supplying both surface water and groundwater, an essential ecosystem service for the region.
- Over 38% of all vernal pools in the region have been destroyed, and 8% are classed as degraded.
- Better quality vegetation maps are needed for large parts of the valley floor and foothills, particularly for riparian vegetation to properly ascertain the extent of native vegetation and habitats.

Energy

The San Joaquin Valley is a center for both energy production and transmission in California. More than 250 power generation facilities make their home in the Valley, though the majority of electricity production in the Valley comes from conventional oil/gas. Renewable energy sources such as wind and solar, however, are on the rise and could prove to be a significant economic driver for the region.

Some of the trends defining and shaping energy resources in the Valley include:

- The Valley has more than 63,000 active oil and gas wells, with the majority located in Kern County.
- The San Joaquin Valley accounts for 80% of the State's oil production (6% nationally), valued at approximately $16.4 billion (2012).
- 2012 natural gas production was worth approximately $480 million.
- Almost 90% of the active wells are on vacant or disturbed land, much of which would otherwise be grazing land.
- Hydraulic fracturing in California uses an average of

about 164,000 gallons of water per well.

- Wind power is the second largest energy source generated by the Valley (3,650 MW), followed closely by hydropower (3,600 MW).
- Most of the Valley's wind is generated in the Tehachapi (3,000 MW).
- The San Joaquin Valley has 27 major active solar generation facilities, capable of producing almost 500 MW.
- Fresno County has more solar power plants (12) than any other county, but Kern County can produce almost as much power from its three larger plants.
- Energy groups have mapped many suitable solar and wind power generation sites for future development in the Valley.

Tulare County orange orchard, © John Greening

Next Steps

The completion of this report and the full launch of the SJV Greenprint website signal the close of the first phase of the San Joaquin Valley Greenprint. To date, the Greenprint team has consulted with more than 400 individuals and experts to gather information that has shaped the process and the ultimate presentation of the materials. The data and maps, publicly accessible, provide current and comprehensive information to aid in understanding the status of the Valley's resources, how these interrelate with one another, and how they intersect with local and regional planning.

Friant-Kern Canal, © John Greening

As the Valley faces increasingly tough resource management questions in the face of growth and limited resource challenges, the SJV Greenprint provides a regional tool to find multiple-benefit solutions, reduce conflict, and achieve an economically and environmentally sustainable future for the Valley, as a whole.

Looking ahead, the next phase of the project will focus on applications of the data and maps. The Greenprint's next steps will include the following tasks:

White egret on restored wetlands, © Steve Laymon

- Outreach — to increase awareness of the Greenprint resources, especially to the eight counties, and to present the trends and conditions in the Valley that the mapping and analysis are suggesting, including the challenges and opportunities.
- Pilot projects — to incorporate Greenprint map resources into local land use planning that provide real world utility and value.
- Look for opportunities to align the Greenprint with State and Federal initiatives — to enhance relevance and secure resources for an ongoing Greenprint resource mapping program (e.g. Central Valley Ag Plus, AB 32 Five-year Roadmap).
- Review and document existing policies, programs and implementation tools in use in the Valley.
- Identify conflicts in regulations, policies, or government actions.
- Identify strategies and tools — help the Valley achieve economic growth and resource sustainability.
- Additional mapping and analysis — identify shortfalls or gaps, provide training to access and interpret maps, update and incorporate new maps as information becomes available.
- Publish a guide for resource management to provide a range of specific policies and implementation tools that governments, businesses and communities can self-select to address their economic and resource objectives.

1 Introduction to the SJV Greenprint

The San Joaquin Valley is a region of unique resources and assets. The geographic area includes the tallest peaks of the Sierra Nevada, the Sacramento-San Joaquin River Delta, and some of the United States' richest agricultural land. The region hosts a diversity of natural landscapes and native species, and up and down the Valley—from Kern County in the south to San Joaquin County in the north—it is home to hundreds of diverse cities and communities with rich histories. Significant portions of the San Joaquin Valley are being considered to generate energy to power the State and beyond. The region also connects the dense population centers of northern and southern California for the movement of people, goods, energy, and water. Growth, development patterns, and climate, however, pose ongoing challenges to the region. Water availability, in particular, is an ongoing resource management challenge. In spite of the challenges, Valley decision-makers and stakeholders can work together to develop a path forward that is both economically and environmentally sustainable.

What is the San Joaquin Valley Greenprint?

The San Joaquin Valley Greenprint offers tools for the local consideration of regional conditions, with a focus on the Valley's non-urban spaces. The project's goal is to provide local decision-makers and agencies, the public, resource managers, and state and federal agencies with improved planning information to better balance the economic and environmental needs of the San Joaquin Valley's eight counties. The SJV Greenprint is primarily a collection of maps, assembled as a comprehensive, interactive database that catalogs current conditions and trends of the region's resources. The collection focuses on the themes of water, agriculture, biodiversity, and energy production. These resources support jobs, influence the cost of living, and provide a range of products and services that benefit the entire region.

The SJV Greenprint's map collection provides more than 100 maps that document the Valley's water, agricultural, ecological, and energy features in the region's rural lands. The collection demonstrates how these resources are interrelated across political boundaries and how they are changing under the influence of population growth, changing land use practices, and resource limitations. The maps and data collected for the SJV Greenprint are publicly available through the project's website (sjvgreenprint.ice.ucdavis.edu; Figure 1). Users can download maps or interactively view them via the SJV Mapping Portal, a component of the website.

As both a data resource and a participatory process, the SJV Greenprint project has and will continue to convene decision-makers and stakeholders through forums to share information and foster regional cooperation on strategies that promote resource sustainability while enhancing economic prosperity. Stakeholder and public input have shaped the collection and analysis of data through public meetings, meetings with scientists and data experts, and replies from more than 300 stakeholders via electronic survey. Looking ahead, there will be many more opportunities for stakeholders and the public to explore, comment on, and integrate SJV Greenprint data into local land use projects and regional planning.

The SJV Greenprint is a voluntary, stakeholder-driven project that can help the Valley achieve long-term sustainability of its environment and economy. The project is not intended to override local land use decision-making authority, and the project respects private property rights.

SJV Greenprint website (screenshot)

Why is a regional approach important?

As the population of the San Joaquin Valley (and California) grows and resources are stretched thinner, the Valley must approach its challenges with better and broader information at its disposal. The resources and opportunities that will enable the Valley to maintain and improve its economic and environmental conditions do not respect county boundaries. Resource management decisions made in one county affect neighbors in numerous and complex ways. Agricultural land conversions, groundwater extraction, flood control infrastructure development, natural habitat conversion, and impacts to the shared air basin all have consequences that affect multiple communities and counties.

Local planning and decision-making that also incorporate a valley-wide perspective can produce more economical and sustainable results and help reduce conflicts. Regional data, for example, can be useful as a screening tool for development proposals in ecologically-significant areas that may have impacts to species and natural communities. Good regional data can help local planners and project developers plan around regional impacts, reduce conflicts, and avoid unanticipated costs and delays.

Many local planning groups do not have the staff or resources to accommodate considerations of the regional impact of local decisions The SJV Greenprint assists these local groups by making available a wide range of current public data on regional resources, compiled in a single repository with interactive mapping capability. These data can be incorporated into planning decisions at the county and city levels and can be used as a basis for communication about resources that span multiple jurisdictions, thereby reducing conflicts and improving outcomes.

With population in the San Joaquin Valley expected to almost double by 2060[1], prime farmland and other important resources surrounding Valley cities face conversion pressures. The SJV Greenprint maps provide planners and decision-makers with the ability to layer map views of important farmland, groundwater recharge opportunities, and riparian and wildlife corridors to identify impacts of growth on Valley-wide resources. As an urban and natural resource planning tool with a regional perspective, it transcends jurisdictional boundaries to help cities and counties achieve their goals while ensuring that the region's needs – economically and environmentally – are also considered.

1 California Department of Finance P-1 Population Projections, 2010-2060. http://www.dof.ca.gov/research/demographic/reports/projections/P-1/

Benefits and Applications of the SJV Greenprint

The San Joaquin Valley's resources – water, agriculture, biodiversity, and energy – are finite, with increasing demands being placed upon them. This situation presents unique policy and land use planning challenges to decision-makers, resource managers, and stakeholders working to accommodate the needs of a growing population and the conservation and restoration of finite natural resources. The SJV Greenprint provides an up-to-date, comprehensive, regional map collection that can inform a variety of questions including but not limited to:

- How can we achieve multiple resource management goals – for agriculture, water, and ecological resources – simultaneously to optimize the contributions they make to the economy and quality of life in the Valley?
- Where are the most strategic locations for groundwater recharge and storage, and what management may be needed to maintain them?
- How can we identify locations for urban growth while protecting economic and natural resources like prime farmland, oil, minerals, timber, and fisheries?
- How can we minimize flood damage and utilize excess water from flood years in times of drought?
- Where can we restore biodiversity and connect wildlife habitats, while also achieving other land use benefits like riverside parks for recreation?
- Where are the most strategic sites to build solar and wind energy facilities and other infrastructure that minimize impacts to farming and the environment?
- What strategies can be adopted to increase the Valley's resilience to changes in climate, such as drought?
- How do we craft regional strategies to inform the local implementation of long range conservation and mitigation plans?

Brief history

The San Joaquin Valley Greenprint project grew out of the San Joaquin Valley Blueprint, an effort launched in 2005 by the Valley's Metropolitan Planning Organizations (MPOs), which are also the region's Regional Transportation Planning Agencies (RTPAs), to provide a vision for urban growth in the eight Valley counties. The Blueprint focused on urban challenges, particularly the relationship of land use to transportation, and developed a set of smart growth policies that should minimize development impacts on the non-urban lands of the Valley. The Blueprint uncovered the need for better regional mapping of the Valley's non-urban areas to assist land use and resource management decisions.

The San Joaquin Valley Greenprint was launched in 2011 to complement the Blueprint process and fill in the regional data gaps of the Valley's expansive rural spaces and the resources therein. The SJV Greenprint is a project of the San Joaquin Valley Regional Policy Council and is managed by the Fresno Council of Governments, including a partnership with the University of California, Davis. Decisions are guided by a Steering Committee representing public and private sectors and a diverse range of interests relating to Valley resources. Funding is provided by the California Strategic Growth Council.

About the Maps and Data

The University of California at Davis' Information Center for the Environment (ICE) led the effort to collect, analyze, and map the data for the San Joaquin Valley Greenprint. The ICE team obtained permission assembled data from a wide variety of sources including state and federal agencies; local jurisdictions, policy and regulation programs (e.g. General Plans, Water Management Plans, Habitat Conservation Plans, Agricultural Preservation Programs, etc.); and private and/or NGO collections. Wherever possible, ICE obtained data in the form of maps from the authoritative sources. Most of the data is publicly accessible and is available for download from the SJV Greenprint website (sjvgreenprint.ice.ucdavis.edu), as well as from the original data provider. Some data providers require direct requests for data, for which contact information is available on the SJV Greenprint website. In a few cases, sensitive or proprietary data accessible by the SJV Greenprint for internal use could not be made publicly available.

The SJV Greenprint's study area includes the eight counties of the San Joaquin Valley (San Joaquin, Stanislaus, Merced, Madera, Fresno, Tulare, Kings, and Kern Counties), although many of the maps extend beyond the eight-county region to include the upper watersheds that drain into northern San Joaquin Valley counties (Calaveras, Tuolumne, and Mariposa).

Maps and data included in the San Joaquin Valley Greenprint collection needed to meet the following criteria:

1. Address a topic significant to the San Joaquin Valley and its rural lands;
2. Cover the entire region (in some cases, data was included that did not cover the entire region but enhanced understanding of the region, and/or provided inter-county coverage);
3. Sourced from a reputable, preferably authoritative source;
4. Show comparisons of trends over time, preferably;
5. Publicly accessible and/or available for redistribution or, critical to the analysis of resource issues.

Using the Maps

The SJV Greenprint website (sjvgreenprint.ice.ucdavis.edu) hosts the complete data catalog with more than 100 data/map layers. There are three ways that users can access the data.

1. The SJV Greenprint Mapping Portal provides an interactive tool that allows users to create their own map views of the Valley based on more than 100 map layers. Anyone can assemble maps from the many available layers. However, saving map compositions (to be available for later use) requires that permission be granted by the website administrator. Users can print a map from their web browser or save screenshots of the map without login permissions. Users can also download copies of each dataset to their local computer for use in their own locally installed GIS software. If users are interested in contributing new data to the collection, they must contact the website administrator.[2]
2. The website also organizes maps by primary "theme." These themes are useful tools for grouping the information by major topic: Water, Agriculture, Biodiversity, Energy, Land Use Planning, Transportation, and Land Use/Land Cover. Analysis of trends from the first four of these themes comprise the chapters of this "State of the Valley" report.
3. Maps and data can be accessed through the map collection http://sjvgreenprint.ice.ucdavis.edu), identified by theme, map description, data source, source date, and download date, with links to access the original data sources.

2 For information on SJV Greenprint data and mapping portal log-in privileges, contact Nathaniel Roth (neroth@ucdavis.edu). Final decisions on website access will be made by the SJV Greenprint Project Steering Committee.

2 State of the Valley Overview

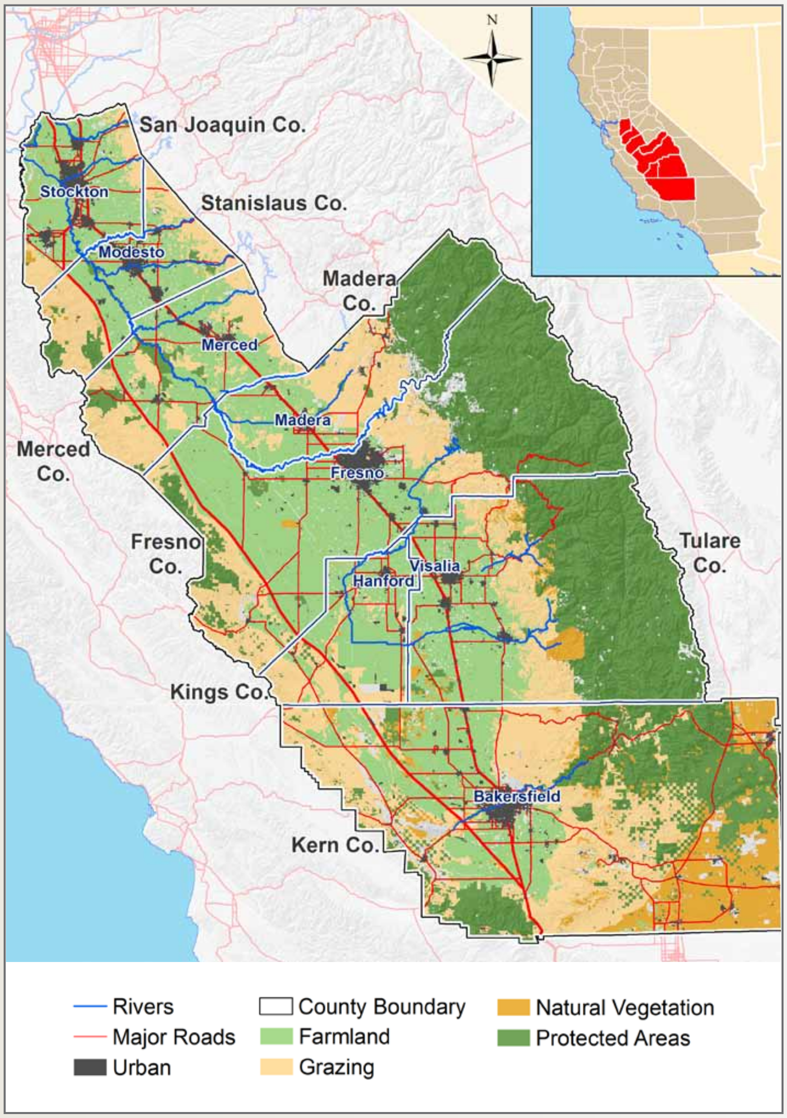
The State of the Valley report tells the story of the San Joaquin Valley, based on interpretation and analysis of the SJV Greenprint's collection of maps and additional research. The report summarizes some of the features, trends, and pressures of four resource categories—Water, Agriculture, Biodiversity, and Energy. The SJV Greenprint's map collection, accessible via the website (http://sjvgreenprint.ice.ucdavis.edu), provides considerably more information and detail than this report can cover. The map images used in this report provide a snapshot of the Valley and demonstrate the kinds of data found in the online database. To view the full range of detail provided by the maps, visit the SJV website (http://sjvgreenprint.ice.ucdavis.edu). Additional information about the maps can also be found in the technical report, available on the SJV Greenprint website.

To set the context for the following chapters, this overview presents a brief profile of the San Joaquin Valley, a region that is unique, resource-rich, and geographically large and diverse, with a growing population. The eight-county San Joaquin Valley occupies 17.6 million acres. To the east, it rises to the tallest mountain peaks of the Sierra Nevada. To the south and west, the region is cradled by the Tehachapi Mountains and California's coastal ranges, with the Sacramento-San Joaquin River Delta to the north.

The region is home to nearly four million people, with population projected to grow to more than seven million by 2050. The region's low cost of living, growing industries, and relative proximity to both the San Francisco Bay Area and Los Angeles region make it an attractive destination. There are currently 62 incorporated cities in the region, and many more unincorporated communities. The City of Fresno is the Valley's largest city, and the state's 5th largest, with a current population of 505,000. To accommodate growth, urban centers will have to grow up and/or out. Much of the past urban growth spread onto natural landscapes, wildlife habitat, and high-quality agricultural soils.

The San Joaquin Valley contains some of the richest agricultural lands in the United States, including seven out of the nation's ten most productive agricultural counties. The region's rich soils, abundant sun, cool winters with limited frost danger, and government investments in water delivery infrastructure all contribute to the region's remarkable agricultural productivity. This productivity is a major economic engine for the Valley. The region also has an active oil industry, mainly at the southern end of the Valley, which includes the Midway-Sunset Oil Field, the third largest oil field in the United States.

The San Joaquin Valley



Source: SJV Greenprint

Water availability is an ongoing resource challenge for the San Joaquin Valley. The majority of the Valley's water use supports its large agricultural economy (about 72% of water use in the Valley). As underscored by the drought of 2013-2014, there is uncertainty about the availability of water for all uses within the Valley. Water supplies come from groundwater reserves, melted snowpack from the Sierra Nevada, and water deliveries via the Central Valley Project (Friant-Kern Canal, Delta-Mendota Canal, and other canals and facilities) and the State Water Project (California Aqueduct). All of these sources are showing signs of changing supply as 1) the water table drops due to groundwater overdraft, 2) a changing climate portends more irregular precipitation patterns and generally warmer temperatures, and 3) statewide demands for water increase.

Despite its water challenges, the region has an interesting current and historical hydrological profile. The San Joaquin River is the second longest river in California and once was among the best salmon-fishing rivers in the country. It was dammed in the 1940's to store water for irrigation and manage flood risk. Near the southwestern corner of the San Joaquin Valley lies the Tulare Lake Basin, into which once flowed several Sierra Nevada rivers, forming the largest freshwater lake west of the Mississippi River. River flows have since been diverted and the dry lakebed converted to farmland, but the region still provides patches of wetland habitat that birds use while migrating along the Pacific Flyway.

San Joaquin Valley: Facts and Figures at a Glance

Size of the 8-county San Joaquin Valley	17.6 million acres
San Joaquin Valley land in ag production	5.6 million acres
San Joaquin Valley ag production + grazing	10.5 million acres
Land under federal and state management	4.4 million acres
Total value of San Joaquin Valley agriculture:	$24.2 billion (2013 dollars)
Percentage of applied water in the Valley used for agriculture, environment, and urban in 2010	72.5%, 21.8%, 5.6%
Top three-ranked ag producing counties in the United States	Fresno, Tulare, and Kern Counties
Number of species in the San Joaquin Valley	3,043 plant species, 499 vertebrae species
Federally or state listed threatened or endangered species	66
How much land is protected open space?	5.1 million acres (including federal lands)
Percentage of valley floor land converted since 1850	69%
Total Urban and Built-up Land in 2010	580,000 acres
Total Rural Residential land in 2010	160,000 acres
Area of non-grazing farmland converted to urban development between 1984 and 2010	At least 141,000 acres

Source: SJV Greenprint data and analysis; details in subsequent chapters

The eight counties of the San Joaquin Valley contain more than five million acres of protected open space, predominantly in the upper elevations of the Sierra Nevada. These lands provide an array of ecosystem benefits (e.g. water storage, flood control, water and air filtration, recreation, timber) and can also increase the region's resilience to changes in climate. By contrast, on the valley floor, about 69% of the natural habitat area has been converted to agriculture, dwellings, and other human uses. Though the Valley has undergone significant conversion of its native lands, there still remain opportunities to conserve and restore its natural habitats for the benefit of the region's economy and environmental sustainability.

Poor air and water quality concerns plague the region and the health of its residents. A recent study of nitrate contamination of ground wells found that about 20% of wells assessed in the Tulare Basin had nitrate levels above the Maximum Contaminant Level, many of these wells providing water to at-risk populations.

Underscoring many of its challenges, the San Joaquin Valley confronts some socioeconomic problems that have elicited comparison to Appalachia. The percentage of people living at or beneath the poverty rate is as high as 24.8% in Fresno and Tulare Counties, with rates dropping in the northern-most Valley counties (Stanislaus is 19.2% and San Joaquin County is 17.5%). Educational achievement rates are also significantly lower in the San Joaquin Valley than the rest of the state. The percentage of those receiving a Bachelor's degree or higher is less than 15% in five of the eight Valley counties, compared with a state rate of 30.5%.

The San Joaquin Valley is home to the primary road and rail routes for personal and freight movement between the San Francisco Bay and Sacramento areas and Southern California, including the Ports of Los Angeles and Long Beach. In 2007, nearly 500 million tons of goods moved into, out of, within, or through the San Joaquin Valley, transported by trucks, rail, water, or air. The vast majority, 92%, of goods were moved by trucks across the Valley's highway system.[1] The Valley also hosts the initial construction segments of the California High Speed Rail (HSR), which broke ground in 2014. The project brings more than $6 billion in investment to the San Joaquin Valley, but also a host of challenges, both agricultural and environmental. It remains the subject of ongoing legal actions.

The next four chapters provide more detail about the characteristics of the San Joaquin Valley and the pressures it faces, with some questions and considerations regarding the economic and environmental sustainability of the region as a whole. Further detail is provided by the SJV Greenprint website maps and data, available online.

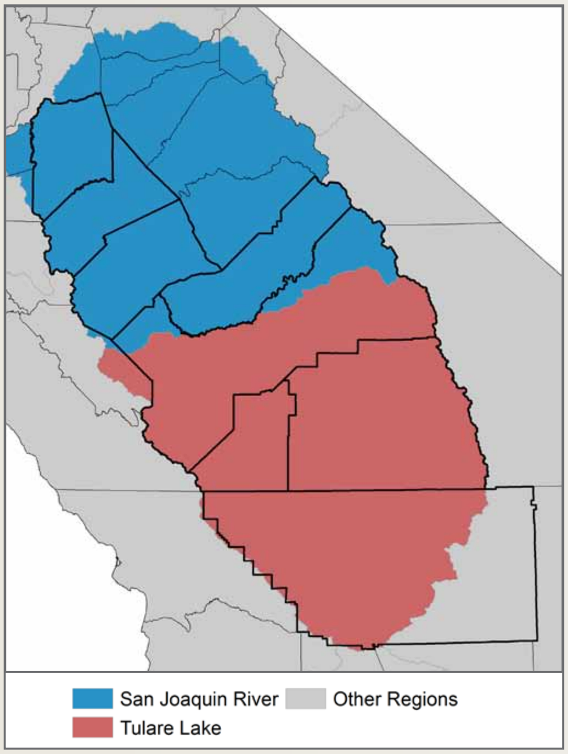
1 *San Joaquin Valley Interregional Goods Movement Plan, San Joaquin Valley Regional Transportation Planning Agencies, http://www.sjvcogs.org/pdfs/2012/2012-06-14%20Task%204.pdf*

3 State of the Valley: WATER

Key Points

- The historic Tulare Lake is now dry and only receives water from its tributaries during flood flows.
- A recent report by UC Davis calculates the likely loss in gross agricultural revenue due to the 2014 drought is $519 million.
- Across the Central Valley (Sacramento and San Joaquin Valleys) the drought may cost 14,500 jobs and create a total economic loss of almost $1.7 billion.
- Agriculture is by far the largest user of water.
- Virtually all of the surface water in the Valley is subject to an existing water right.
- Groundwater provided almost 20% of the water supply for the entire Valley in 2010. During droughts, the proportion is higher.
- Portions of the Valley have seen groundwater elevations drop by more than 200 feet since 1960.
- Portions of the Valley subsided 28 feet between 1926 and 1970.
- A recent USGS report identified some areas subsiding by approximately a foot per year between 2008 and 2010.

Figure 1. The San Joaquin River and Tulare Lake Hydrologic Regions (HRs)



Source: DWR

- These areas of subsidence directly impact major infrastructure such as canals, highways, and railways. Past costs to remediate these impacts have ranged well into the millions of dollars.
- Following subsidence, the ability to recharge groundwater may be compromised.
- Groundwater contamination from surface activities impacts large areas of the Valley with a disproportionate impact on disadvantaged communities.

Overview

Water is one of the central management challenges of the San Joaquin Valley, and is the foundation of the Valley's economy and quality of life. Both surface water and water pumped from underground aquifers are critical to the region's farming, ranching, urban users, industry, and natural ecosystems.

The natural flow of water in the San Joaquin Valley generally starts in the Sierra Nevada where it falls as snow, is stored through the winter and spring until it melts, and then flows westward through the region's major rivers (the Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, San Joaquin, Kings, Kaweah, Tule, and Kern) to the valley floor. These natural flows define the state's Hydrologic Regions, as used by the California Department of Water Resources (DWR).

The San Joaquin Valley is divided into two Hydrologic Regions (HR)—the San Joaquin River HR and Tulare Lake HR (approximately 9.8 and 10.8 million acres respectively)—which include the valley floor and their watersheds. These HRs are further broken down for water analysis into twenty DWR Planning Areas (an average size of 1 million acres each). See Figure 1.

The San Joaquin River HR is comprised of six primary rivers, which converge and flow northward into the Sacramento-San Joaquin River Delta. The Tulare Lake HR, in the southern portion of the Valley, is an enclosed basin that once collected all the surface flows from the Kaweah, Tule, Kern, and Kings Rivers. With no natural surface drainage, historic lakes (Tulare Lake was once the largest freshwater lake west of the Mississippi) received the south Valley's river flows, which eventually evaporated or were absorbed as groundwater. River flows are now diverted to reservoirs and canals, only reaching the dry Tulare Lakebed in periods of major flood.[1] (Read more about the historic Tulare Lake in the Biodiversity chapter).

Some of the region's precipitation also filters into deep groundwater basins – also called aquifers – below the Valley. These groundwater basins contain enormous quantities of water, though pumping has significantly depleted them. The basins replenish slowly, and extreme levels of withdrawal can compromise their ability to hold water in the future.

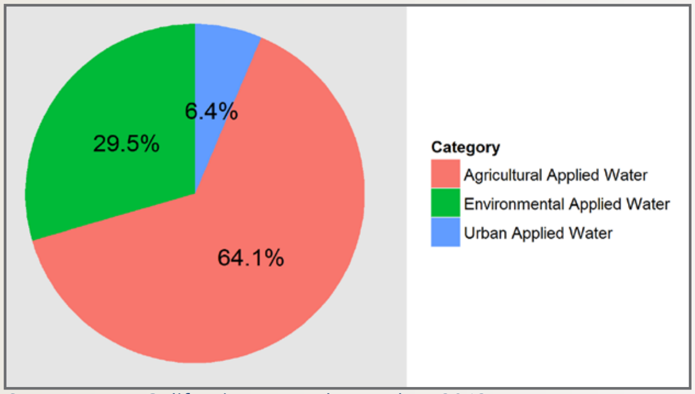
Water Sources and Uses

DWR tracks all of the water that enters and exits defined areas in the state through water balance spreadsheets.[2] These spreadsheets measure the amount of water applied for agricultural, urban, and environmental purposes. Figures 2 and 3 present a breakdown for the Valley's two Hydrologic Regions, based on DWR's water balance spreadsheets.[3] Water for agriculture comprises the majority of usage in the San Joaquin Valley, more so in the Tulare Lake HR. The proportion of water directed to environmental uses in the San Joaquin River HR is almost double that of the Tulare Lake HR; water for urban use is relatively small and consistent between the northern and southern hydrologic regions of the San Joaquin Valley.

Over the 13-year timespan of the State's water balance tracking – 1998-2010 – water uses varied annually, mainly due to fluctuations in available surface water. Whereas agricultural and urban water uses were relatively stable, environmental uses varied greatly from year to year. Typically, a minimum quantity of water for environmental uses is allocated based on the total available water supply. In years of plentiful water, environmental water uses receive a larger share of available water, which ex-plains its variability over time.

Figure 2. San Joaquin River HR

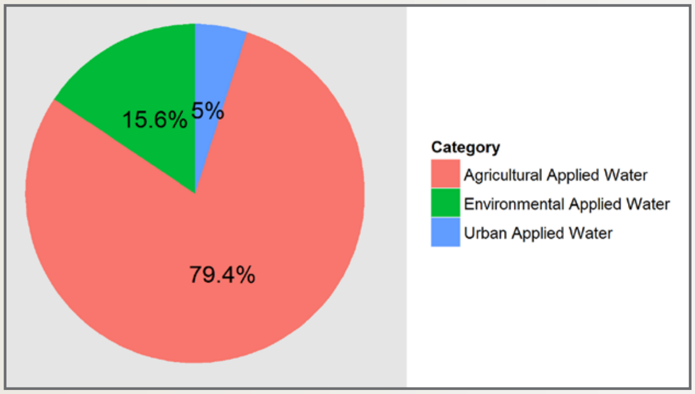
Applied water by major use type in 2010



Source: DWR, California Water Plan Update 2013

Figure 3. Tulare Lake HR

Applied water by major use type in 2010



Source: DWR, California Water Plan Update 2013

1 The Kings River at Island Weir must be above 4,750 cubic feet per second to reach Tulare Lake. Below that all flows are transferred to the San Joaquin River by way of the North Fork-Fresno Slough-James Bypass channel http://www.krcd.org/_pdf/Kings_River_Handbook_2009.pdf (page 26)

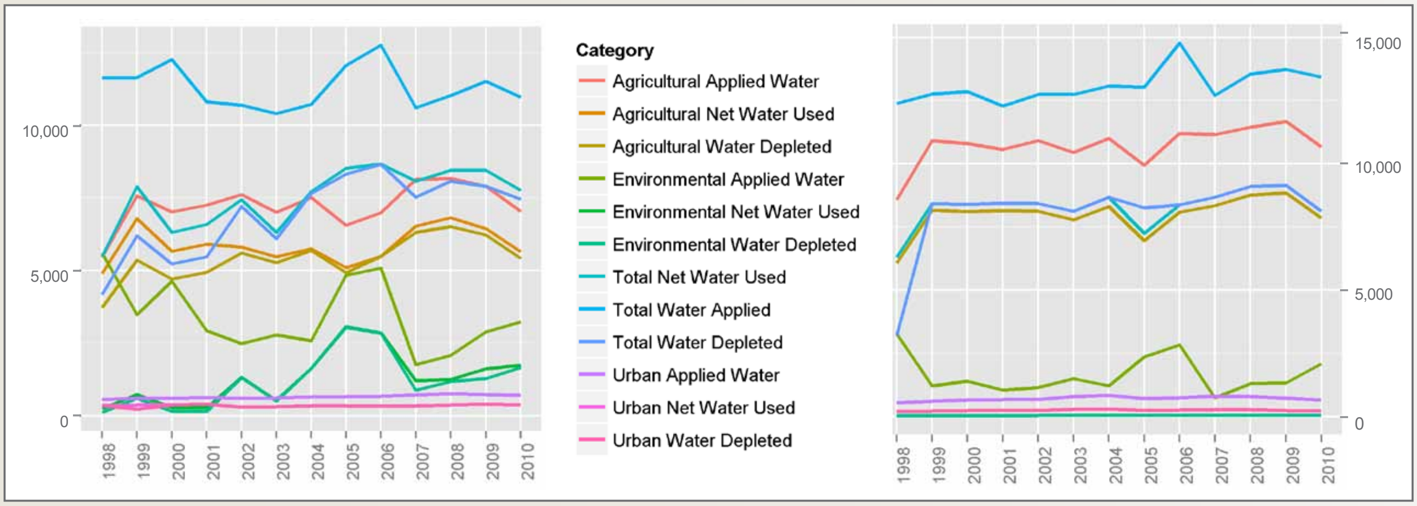
2 DWR water balance spreadsheets monitor the state's water use, as well as water use for the state's ten DWR-defined Hydrologic Regions and 56 Planning Areas. DWR also estimates whether water is available for subsequent reuse or is lost to evaporation or saline sinks. DWR does not distribute the water balance data at a finer geographic scale than the Planning Area due to uncertainty of water use estimates at finer geographic scales.

3 The Greenprint uses the same dataset as the California Water Plan Update 2013 , which covers the years 1998-2010. http://www.waterplan.water.ca.gov/cwpu2013/index.cfm

Figure 4. Water Use, San Joaquin River HR

Figure 5. Water Use, Tulare Lake HR

~ Thousands of acre feet of water applied and depleted by year (1998-2010) ~



Source: DWR, California Water Plan Update 2013

Table 1. 2010 Water Use (Applied and Depleted) for the San Joaquin River and Tulare Lake Hydrologic Regions

Measured in thousands of acre feet of water

Criteria	San Joaquin River	Tulare Lake
Total Urban Applied Water	700	668
Total Urban Water Depletion	376	228
Total Agricultural Applied Water	7,028	10,663
Applied Water-Crop Production	6,519	9,826
Agricultural Depletion	5,416	7,845
Total Environmental Applied Water	3,232	2,094
In-stream Applied Water	644	0
Wild & Scenic Applied Water	2,090	2,017
Wild and Scenic Outflow (Depletion)	1,184	0
Total Managed Wetlands Applied Water	497	78
Managed Wetlands Outflow (Depletion)	246	0
Managed Wetlands Depletion	474	51
Environmental Water Depletion	1,657	51
Total Water Applied	**10,959**	**13,425**
Total Water Depletion	**7,450**	**8,124**

Source: DWR, California Water Plan Update 2013

Table 2. 2010 Water Sources for the San Joaquin River and Tulare Lake Hydrologic Regions

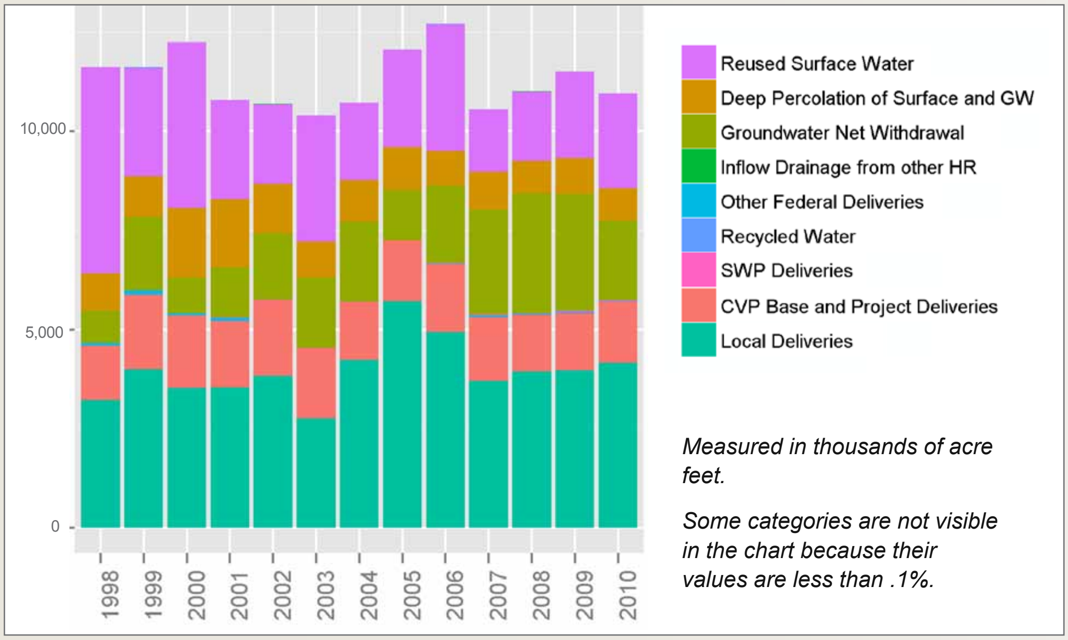
Measured in thousands of acre feet of water

	San Joaquin River	Tulare Lake
Local Deliveries	4,167	2,785
CVP Base and Project Deliveries	1,530	2,021
Other Federal Deliveries	22	0
SWP Deliveries	30	979
Groundwater Net Withdrawal	1,999	2,339
Deep Percolation of Surface and Groundwater	811	3,198
Reuse and Recycling	2,400	2,103
Total	**10,959**	**13,425**

Source: DWR, California Water Plan Update 2013

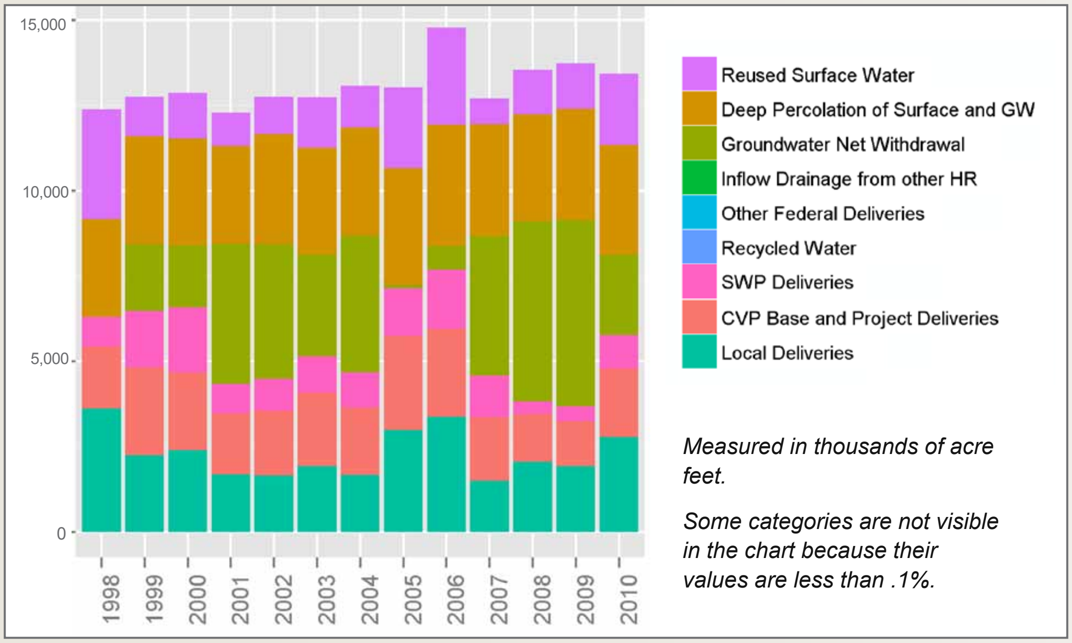
Uses – Figures 4 and 5 chart changes over time in both applied and depleted water (water unable to be reused), from 1998 to 2010, for the San Joaquin River HR and the Tulare Lake HR. The San Joaquin River region shows more variability than the Tulare Lake region. Total depletion for the San Joaquin River HR shows a slight upward trend, though trends are not as apparent in the individual urban, agricultural, and environmental depletions. Table 1 provides details on the total quantities of water applied and depleted for urban, agricultural, and environmental uses

Figure 6. Developed water sources for the San Joaquin River HR



Source: DWR, California Water Plan Update 2013

Figure 7. Developed water sources for the Tulare Lake HR



Source: DWR, California Water Plan Update 2013

in 2010, the most recent year for which DWR provides data.[4]

Sources **–** Figures 6 and 7 chart the sources and respective quantities of water that enter the Valley's two hydrologic regions and their changes over time between 1998 and 2010. Water enters the Valley from its own rivers that descend from the Sierra Nevada into reservoirs and canals, as well as from Northern California imports via the State Water Project and Central Valley Project (read more about these state and federal water delivery systems below, in the Surface Water section, below). Similar to the trends in water use, the San Joaquin River HR exhibits greater variability than the Tulare Lake HR in the quantities of water sourced from various inputs. In both hydrologic regions, precipitation patterns largely determine variations in water source quantities from year to year. Table 2 provides further de-tails on the quantitative distribution of water inputs in the most recent year for which DWR provides data, 2010, for the two regions. Precipitation patterns were slightly above average in 2010.[5]

Overall, the Valley faces challenges meeting its water demands. With varying surface water availability from year to year, the Valley depends heavily on groundwater supplies, particularly in dry years. If precipitation patterns become more irregular, as projected with climate change, the Valley could potentially experience increasingly severe droughts and floods that could further affect the balance of water supply and demand.

4 These terms are inherited from the DWR water balance and water portfolio datasets. Applied water includes all water that is used for a purpose regardless of its later reusability. Depleted water is the total water applied that cannot be reused. This can include evaporation, evapotranspiration, loss to salt sinks, or flow to the ocean.

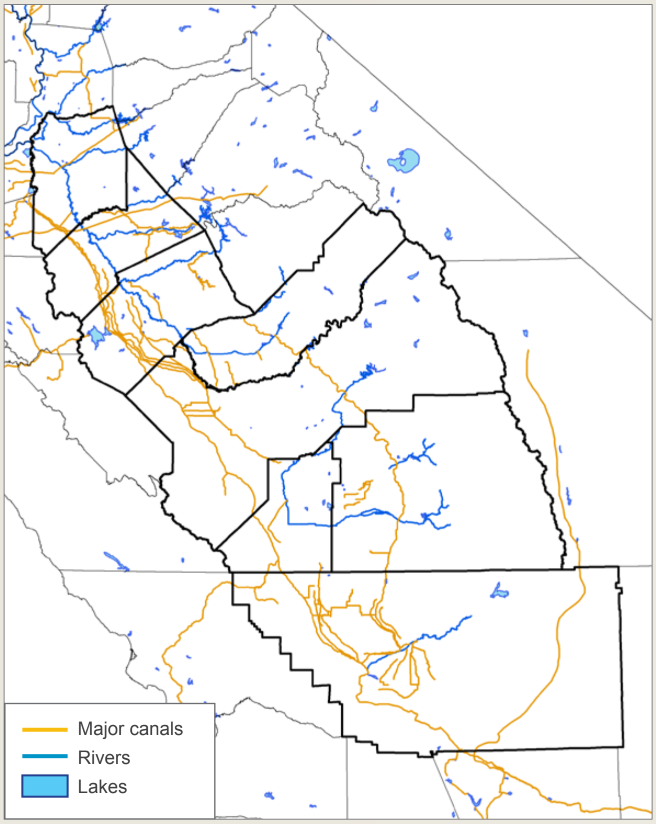
5 According to DWR, the San Joaquin River HR was at 106% of normal, and the Tulare Lakes HR at 116%

Surface Water

Surface water moves to and through the Valley via natural rivers and a complex system of reservoirs and canals distributed throughout the state. Precipitation is the key variable in the overall quantity of surface water available to the San Joaquin Valley, as well as the entire state. The San Joaquin Valley receives less precipitation than the northern part of the state, and it falls predominantly from November to April, mostly as snow in the Sierra Nevada. Spring snowmelt and natural runoff from the Sierra is captured by a series of reservoirs (Millerton, Pine Flat, and Kaweah Lakes, and Lake Success) and distributed throughout the Valley using a combination of natural and artificial waterways. Most of the primary natural waterways are diverted for human consumption (municipal and agricultural uses), and usually run dry or nearly dry for portions of the year.

In addition to rivers and lakes, the Valley's residents and economy benefit from federal and state investments in infrastructure that bring water from northern California south along the valley floor. The State Water Project, managed by DWR, transports water from the Sacramento-San Joaquin River Delta to both the San Joaquin Valley's farmland and to Southern California urban areas through the California Aqueduct, which runs roughly parallel to Interstate 5. The San Joaquin Valley also receives water through portions of the Central Valley Project, operated by the U.S. Bureau of Reclamation, which links the San Joaquin and Kern Rivers along the eastern edge of the Valley via the Friant-Kern Canal, and connects the Delta back to the San Joaquin River via the Delta-Mendota Canal. Figure 8 illustrates the Valley's major rivers, canals, and lakes.

Figure 8. Rivers, lakes, and major canals



Source: DWR, California Resources Agency CalAtlas

Virtually all surface water in the San Joaquin Valley is regulated by a mixture of state and federal laws and court decisions. The California State Water Resources Control Board (SWRCB) regulates all surface water rights and considers the surface waters of the San Joaquin Valley to be fully appropriated by existing water rights. California's water rights law originated from a mixture of English Common Law and Spanish and Mexican Laws; they evolved over time as a result of developments and conflicts, e.g. the Gold Rush.[6] Riparian water rights generally apply to land immediately adjacent to a water source. Droughts or other reductions in water supply are shared equally among riparian rights holders. Water drawn based on riparian rights must be used within the same watershed and may not be diverted for storage. Riparian water rights carry the most seniority of all water rights and are always tied to the land, regardless of property ownership changes.

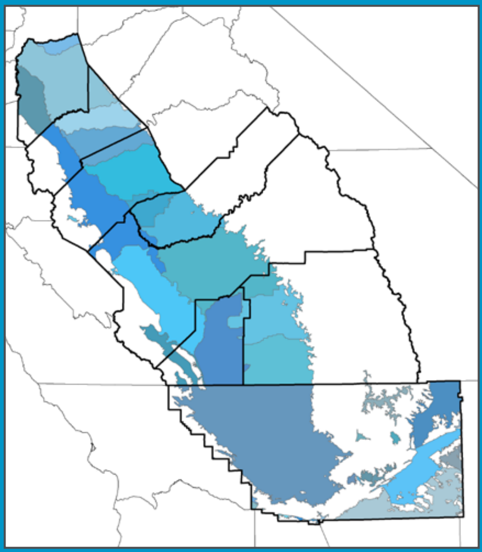
Appropriative rights, developed during the Gold Rush, allow for the transfer and use of water in locations far from the source. The Water Commission Act of 1914 established the modern permitting process for appropriative rights, which created a hierarchy of water rights seniority based on the date of application for the permit. Pre-1914 appropriative rights are both more senior and subject to less scrutiny than post-1914 rights. In times of water shortage, the most junior rights' holders are the first to receive water curtailments.

Prior to large-scale human water use, plant and wildlife communities grew based on natural flows and water cycles. As demonstrated in the Water Sources and Uses section, above, environmental water use makes up a variable percentage of total water use in the San Joaquin Valley. The Endangered Species Acts (both Federal and State), subsequent species listings, court decisions, and negotiated agreements have assigned minimum required flows for many of the rivers in the San Joaquin Valley to maintain bird, fish, and other native species habitats.

Floods are an issue related to both surface water and groundwater supply and management. Above-average precipitation poses problems and opportunities for the San Joaquin Valley. DWR is currently preparing an update to the 2012 Central Valley Flood Protection Plan (CVFPP), to be released in 2017. The updated CVFPP will refine recommendations made in the 2012 plan based on a series

6 *http://www.waterboards.ca.gov/waterrights/board_info/water_rights_process.shtml*

Figure 9: Groundwater basins of the San Joaquin Valley



Source: DWR

Note: Shades of blue represent individual groundwater basins

The eight-county San Joaquin Valley Region overlaps 39 groundwater basins or sub-basins identified by DWR, as shown in Figure 9.[1] A groundwater basin may have multiple aquifers storing water at dif-ferent depths, and can be closely linked with other basins. There are sixteen large basins under the valley floor, twelve small basins perched in valleys of the Sierra Nevada and Tehachapi, seven underlying the Mojave, and four in the coast range along the western edge of the study area. The region contains both alluvial and fractured rock aquifers. Alluvial aquifers store groundwater in the pores between old river deposits. Fractured rock aquifers store water in cracks or other spaces within the otherwise im-permeable rock. Alluvial aquifers generally underlie the valley floor while fractured-rock aquifers exist under the foothill and mountains of the region.

The San Joaquin Valley's groundwater reservoir is a complex system of smaller interconnected aquifers at varying depths, with an intricate interleaving of clay, sand, gravel, and silt that functions as a single water-yielding unit.[2] On the west side of the Valley, the Corcoran Clay layer forms a thick layer limiting groundwater access across several basins. It stretches from the historic Kern Lake bed north to approximately Modesto.

1 California Department of Water Resources (DWR) in Bulletin 118-2003 http://www.water.ca.gov/groundwater/bulletin118/update2003.cfm

2 http://pubs.usgs.gov/of/2001/ofr01-35/

of Basin-Wide Feasibility Studies (BWFS), Regional Flood Management Planning, and the development of a 2017 Conservation Strategy by the State.[7] The Central Valley Flood Planning Office (DWR) BWFS for the San Joaquin River Basin will "evaluate physical actions to improve flood system performance, flexibility, and resiliency." Regional Flood Management Plans are underway for the upper, mid, and lower San Joaquin River, assisting local agencies as they develop long-term regional flood management plans. The 2017 Conservation Strategy will focus on the development of a system-wide conservation plan to enhance the recovery and stability of native species populations and biotic community diversity.

Groundwater

Despite its importance, San Joaquin Valley groundwater is loosely regulated, relative to surface water, and extraction via groundwater pumping is largely unmonitored. The State has considered legislation to regulate groundwater withdrawals and implement monitoring, but no action has been taken. Groundwater quality, on the other hand, is monitored by the SWRCB Groundwater Ambient Monitoring & Assessment Program (GAMA).[8]

The DWR California Statewide Groundwater Elevation Monitoring (CASGEM) Program is the authority on groundwater trends in the state — groundwater depth, location, the effects of pumping, and groundwater recharge.[9] Assessments, however, are incomplete as they are based on records collected from a network of monitoring wells rather than direct reports from all wells. This makes it challenging to accurately analyze groundwater trends for the Valley, and exposes a need for improved monitoring of this valuable resource.

Overall, groundwater levels in the Valley have been dropping significantly. Figures 10a and 10b illustrate groundwater elevations (height of the groundwater surface above sea level)[10] in 1960 and 2010, while Figure 11 presents changes in groundwater elevation from 1960 to 2010.[11] Only areas where the 1960 and 2010 datasets overlap are shown. A few small portions of the Valley, identified in bright blue, show increases in groundwater elevation (possibly caused by irrigation or groundwater recharge efforts), but all other areas indicate a drop in groundwater elevation, ranging from a few feet to approximately 215 feet over the 50 years. The greatest decreases in groundwater elevation are presumably the result of groundwater withdrawal and a lack of, or low rate of, groundwater recharge. These large decreases occur primarily

7 http://www.water.ca.gov/cvfmp/

8 The California Department of Health monitored the quality of drinking water systems, including groundwater, until 2013 when the responsibility moved to the SRWCB GAMA.

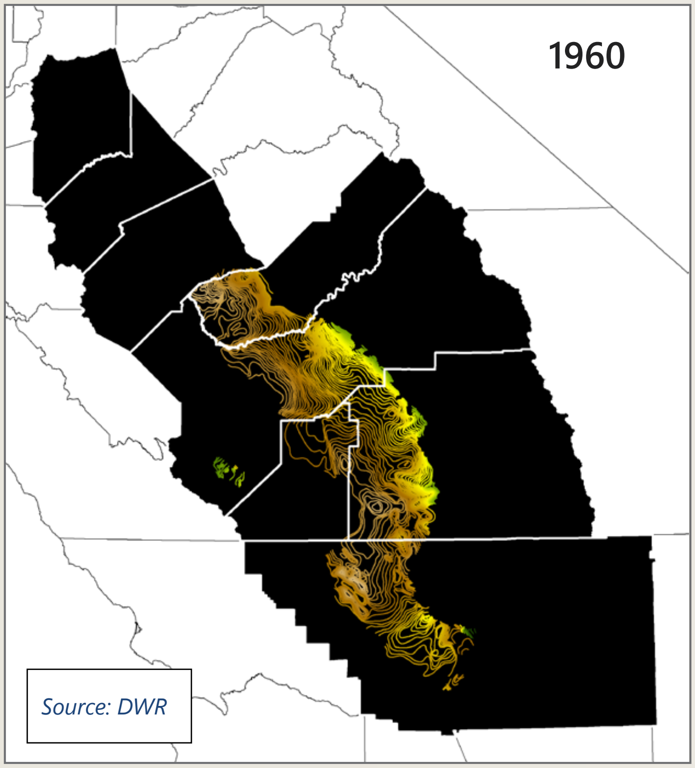
9 CASGEM is a collaboration with local and regional groups. http://www.water.ca.gov/groundwater/casgem/online_system.cfm.

10 Groundwater elevations are used because, like surface water, groundwater flows from higher to lower elevations, and the use of groundwater elevation instead of depth to groundwater allows for easier analysis of groundwater flows. It is important to recognize that in many parts of the Valley, the groundwater surface is below sea level.

11 While the data do not cover the entirety of the Valley floor in every year, DWR has released copies of the groundwater elevation contour intervals that they have assembled for every year from 1960-2010.

Figure 10a and 10b. Comparison of groundwater elevations, 1960 and 2010

Groundwater elevation is measured as the height above (or below) sea level. Whites indicate that groundwater levels are close to sea level. Browns, then yellows, and finally green show successively higher elevations of the water table.



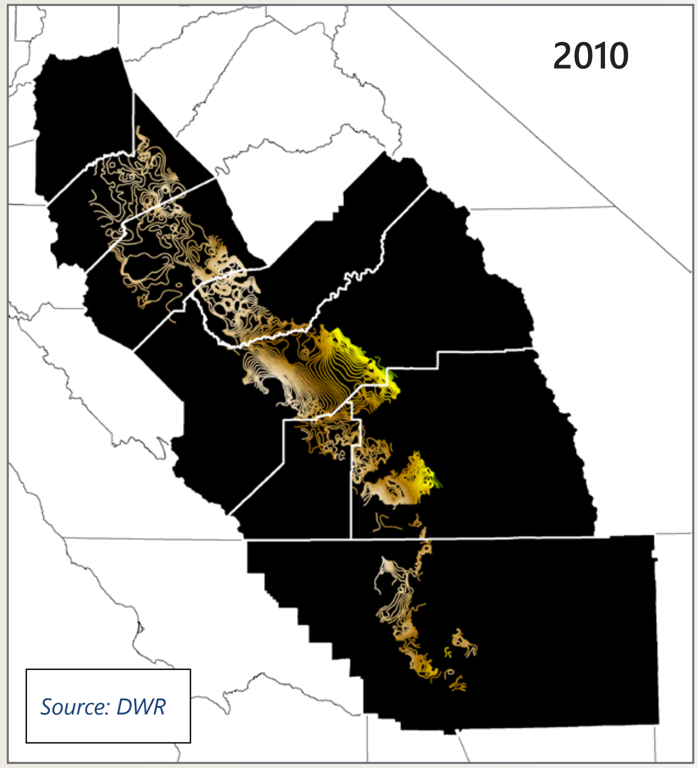
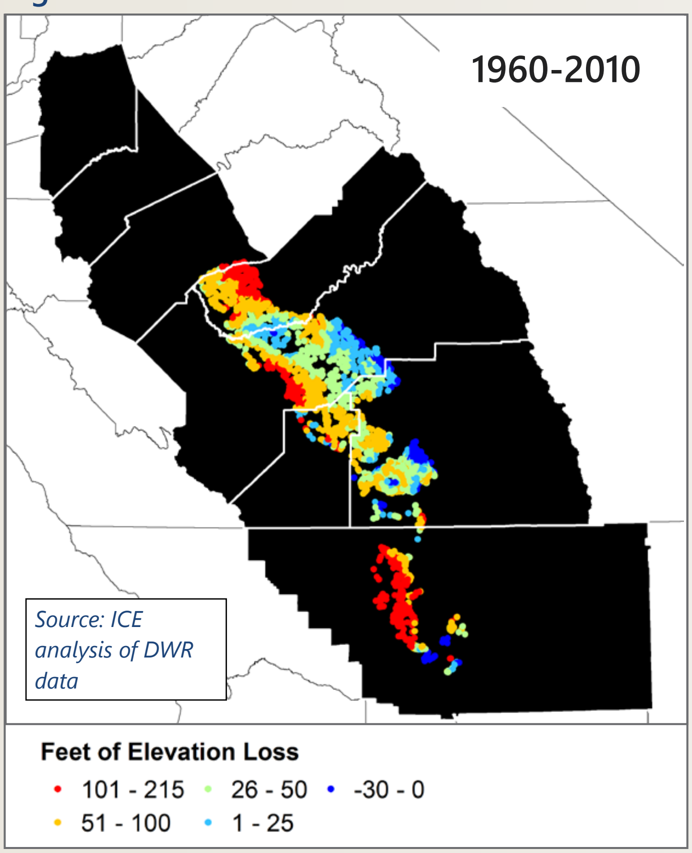
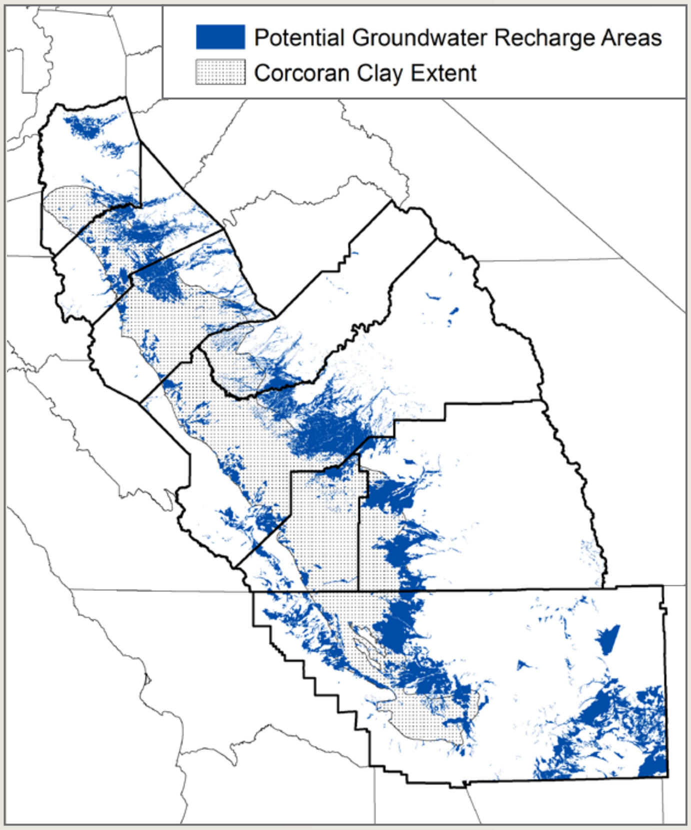


Figure 11. Groundwater elevation loss



Note: Areas only shown where 1960 and 2010 groundwater elevation data overlap. Measured in feet.

Figure 12. Potential groundwater recharge areas and Corcoran Clay extent



Source: Data provided by USGS and NRCS, analysis by the California Water Institute

along the center of the valley floor. The area around the City of Chowchilla shows some of the largest groundwater elevation drops, likely due to urban growth demands and poor recharge soils.

Loss of groundwater and high levels of water demand in the region due to growing population, agriculture, and drought conditions, are motivations for understanding and preserving the functionality of groundwater recharge areas. Ideal recharge areas are characterized by porous soils and bedrock that allow water to filter into the Valley's underground aquifers.

Figure 12 maps potential groundwater recharge areas based on surface soil composition. In the absence of detailed subsurface data, the true potential for recharge can only be estimated. Good recharge locations largely overlap with the alluvial fans where Valley rivers and streams enter the valley floor. Alluvial soils are porous, permitting water to more quickly absorb into the aquifers. In contrast, the dense soils found in the central and western parts of the Valley, like the Corcoran Clay, impede water absorption.

According to DWR's most recent drought report to the Governor,[12] most counties—Tulare and Fresno Counties, in particular—have seen very recent increases in depth to groundwater (in other words, a drop in groundwater elevation), as a result of the drought. Some areas have seen groundwater elevations recently drop more than 100 feet below the lowest elevations recorded, which occurred in the timeframe between 1990 and 1998. Between the spring of 2013 and 2014, depths to groundwater dropped more than 60 feet. Plunging groundwater depths raise a number of concerns. First, the cost of pumping groundwater increases as wells continue to be drilled deeper.[13] Second, continued groundwater losses will most likely lead to continuing problems with land subsidence. Third, as shallower aquifers are depleted, deeper aquifers with lower quality (higher saline content) water must be tapped.

Land subsidence is a long-term challenge for the San Joaquin Valley – and one that is directly related to groundwater levels. Land subsidence occurs when the surface of the ground drops in elevation as a result of large-scale groundwater withdrawals that cause deep clay formations to compress from the overlying weight and concurrent loss of underlying pressure from the water-bearing strata. The western edge of the valley floor lost up to 28 feet of ground to deep subsidence over the period 1926-1970 (Figure 13), according to USGS data.[14] More recent research by the USGS demonstrates that subsidence is a real and ongoing problem, with portions of the Valley experiencing approximately a foot per year of subsidence (Figure 14).[15]

The changing elevation of the Valley's land surface has several implications. The compaction of soils may make it harder for groundwater levels to recharge. Also, potential damage to major canals and associated maintenance costs may impede surface water deliveries to the region. A recent report from the California Water Foundation estimated that the federal government paid $88.2 million (2013 dollars) to repair land subsidence-induced damages, with a conservative estimate of another $90 million (2013 dollars) for the repair of wells damaged by subsidence.[16] Major infrastructure, both in existence and in planning

12 Public Update for Drought Response Groundwater Basins with Potential Water Shortages and Gaps in Groundwater Monitoring. April 30, 2014 (the most recent report before this report went to print), the data this report is based on post-dates the acquisition of data from DWR for groundwater elevations. http://www.water.ca.gov/waterconditions/docs/Drought_Response-Groundwater_Basins_April30_Final_BC.pdf

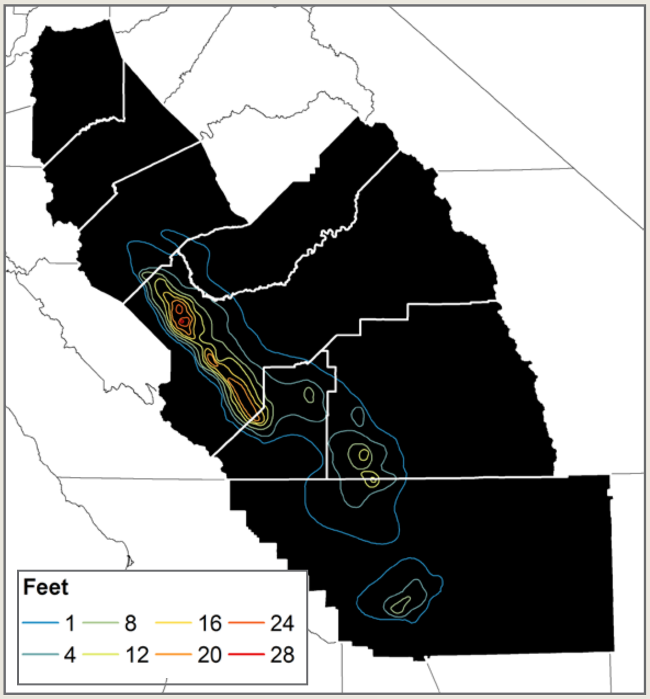
13 The Preliminary 2014 Drought Economic Impact Estimates in Central Valley Agriculture report estimates that the Central Valley-wide increased costs of groundwater pumping will be approximately $450 million. https://watershed.ucdavis.edu/files/biblio/Preliminary_2014_drought_economic_impacts-05192014.pdf

14 http://pubs.er.usgs.gov/publication/pp437I

15 http://pubs.usgs.gov/sir/2013/5142/

16 http://www.californiawaterfoundation.org/uploads/1397858208-SUBSIDENCEFULLREPORT_FINAL.pdf

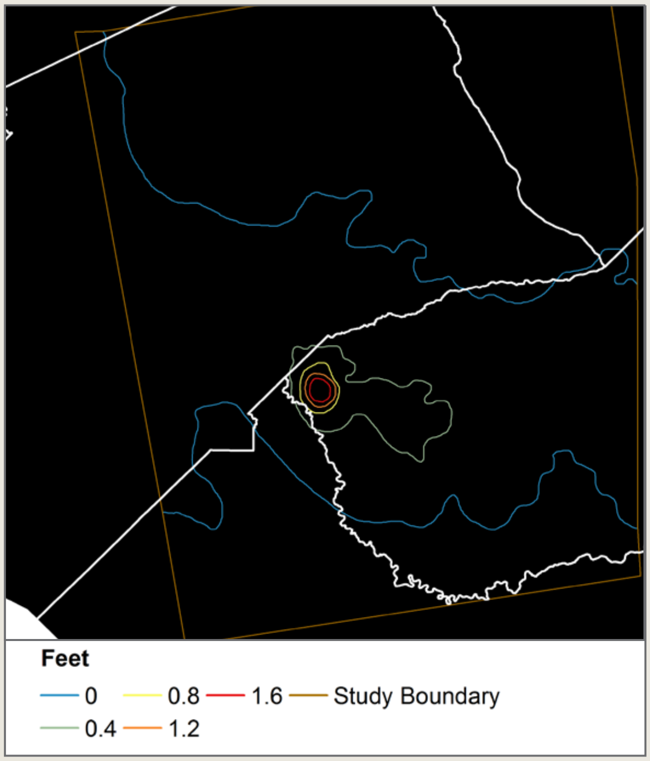
Figure 13. Land subsidence, 1926-1970



Source: Digitized from Figure 2 in USGS report "Land Subsidence in the San Joaquin Valley, California, as of 1980" by R. L. Ireland, J. F. Poland, and F. S. Riley,1984

Figure 14. Close-up of subsidence 2008-2010

Near intersection of Madera, Fresno, and Merced Counties



Source: Digitized from Figure 17A in USGS Report "Land Subsidence along the Delta-Mendota Canal in the Northern Part of the San Joaquin Valley, California, 2003–10" by Michelle Sneed, Justin Brandt, and Mike Solt, 2013

Approximate point of maximum subsidence in the San Joaquin Valley. Land surface subsided about 9m from 1925 to 1977 due to aquifer-system compaction. Signs on the telephone pole indicate the former elevations of the land surface in 1925 and 1955.

Source: USGS
Copyright: Richard Ireland

stages, passes through areas of land subsidence, including the California Aqueduct, the Delta-Mendota Canal, the Cross Valley Canal, Interstate 5, Highway 99, and proposed routes for the California High Speed Rail.

Groundwater contamination levels throughout the San Joaquin Valley are increasing, generating significant concern statewide. A recent study, conducted by UC Davis,[17] examined nitrate levels in the Tulare Lake Basin and found that land use and water management practices and policies have created conditions for nitrate concentrations in groundwater to reach and exceed safe levels. Many rural, low-income populations in the Tulare Lake Basin receive their water from small water systems with disproportionately high levels of nitrates. These communities, also known as disadvantaged communities (DACs), have limited financial resources to address nitrate contamination. The groundwater report suggests possible remediation methods, including treatment at the point of usage and blending of tainted water with clean water to dilute toxins to safe levels. Alternatively, the Valley can take steps to reduce the amount of nitrogen fertilizers applied and/or apply them with care to prevent percolation into the groundwater system. While the problem disproportionately impacts small and poor communities, responsibility is shared by the entire Valley. This situation illustrates how unintended consequences resulting from short-sighted land (and water) use can have long-term, detrimental consequences to the public good.

Conclusions and Considerations

Water supply is critical to the Valley's economy. A May 2014 report by the Watershed Center, University of California Davis estimated that San Joaquin Valley counties lost $519 million in gross agricultural revenue as a result of the state's ongoing drought.[18] According to UC Davis calculations, the entire Central Valley (including the Sacramento Valley) has lost 14,500 jobs due to the drought, for a total economic loss to the Central Valley of almost $1.7 billion.

In short, the San Joaquin Valley faces challenges in meeting its water demands. The region depends heavily on groundwater withdrawal to supplement its surface water resources, particularly in dry years, leading to overall declines in groundwater levels. When groundwater is withdrawn in excess, land subsidence tends to occur. Years like 2005 and 2006, when rainfall was 127% of normal, present the opportunity to recharge the Valley's groundwater supplies. In some parts of the San Joaquin Valley, particularly in Kern County (for example the Kern Water Bank), groundwater banking is an established practice whereby both injection and later extraction of ground water are part of overall water use.

If conditions become more extreme, as projected under climate change, the Valley may experience both more severe flood years, and more intense droughts, such as the one from 2012 to present. As planners and resource managers evaluate upcoming decisions, questions such as these should be kept in mind:

- What areas are important to the region's groundwater recharge?
- Does this action or project depend on water from a source that may not be reliable in the long-term future?
- Is the project sensitive to the challenges posed by land subsidence?
- Could a project be redesigned or relocated to increase its water efficiency?
- Is the area subject to groundwater contamination and does that impact this project?

The San Joaquin Valley Greenprint and its interactive mapping portal provide access to information and tools to help answer these questions and the myriad other interconnected resource decisions in the San Joaquin Valley. As a comprehensive collection of data on natural and developed resources in the Valley's rural lands, the SJV Greenprint gives planners, resource managers, and decision-makers, as well as the public, the ability to layer various resource values on top of one another to evaluate development decisions through a regional lens. With these tools, any resident or stakeholder can investigate the complexity of planning decisions and contribute to the environmental and economic viability of the San Joaquin Valley.

17 http://groundwaternitrate.ucdavis.edu/

18 https://watershed.ucdavis.edu/files/biblio/Preliminary_2014_drought_economic_impacts-05192014.pdf

3 State of the Valley: AGRICULTURE

Key Points

- Seven of the eight San Joaquin Valley counties are among the national top ten in agricultural market value.
- Fresno, Tulare, and Kern Counties are the number one, two, and three counties nationally for total agricultural value.
- 10.5 million acres (60%) of the eight-county Valley's land area is in agricultural use.
- Important farmland (Prime, Statewide, Unique and Local Importance farmland), makes up 5.6 million acres (32%) of the Valley's total land area.
- 4.9 million acres (28%) of the Valley's total land area is grazing.
- There are 580,000 acres identified as urban and built-up and 160,000 acres of rural residential mapped in 2010.
- Of the 580,000 acres of urban and built-up, more than 140,000 acres (24%) was developed between 1984 and 2010.
- In 2012, the Valley produced $24.2 billion dollars in agricultural market value (in $2013 inflation adjusted dollars).
- The Valley accounts for 6% of the nation's agricultural market value and 56% of the State's.
- The Valley's agricultural market value is growing: it grew 17.5% from 2007 to 2012.
- Almost 50% of the Valley Counties' potential groundwater recharge areas are also prime farmland.
- The Valley's shift to permanent crops (orchards and vineyards) has increased the region's agricultural revenues, but reduced flexibility to respond to drought.
- Substantial areas of the central San Joaquin Valley have existing or growing soil salinity challenges that reduce or eliminate crop productivity.

Overview

The San Joaquin Valley is, without a doubt, a national agriculture powerhouse. In terms of total market value (animal and crops), seven of the eight San Joaquin Valley counties are among the national top ten in agricultural market value. Fresno, Tulare, and Kern Counties respectively occupy the top three positions, with Merced, San Joaquin, and Stanislaus Counties ranking fifth, sixth, and seventh. In the category of crop value, six Valley counties are in the top ten nationally, with the remaining two being within the top fifteen – Fresno and Kern Counties are number one and two, respectively. And, for animals and animal products, four Valley counties are in the top ten, and another three are in the top thirty – Tulare and Merced are number one and two, respectively.[1]

This remarkable productivity results from a combination of superior soils, plentiful sun, cool winters with limited frost danger, and incredible investments in infrastructure that deliver water to and across an otherwise dry landscape. While the agricultural characteristics of the Valley are not singular, they are rare, defining only a select few regions globally.

Should the quality of any of the features that characterize the region's agricultural abundance be degraded or diminished, the region's productivity would suffer. Urban growth, rural residential units, and transportation infrastructure consume space and break up (or fragment) the agricultural landscape. This leads to losses in

1 National Agricultural Statistics Service (NASS) 2012 Census of Agricultural. The Census of Agriculture is conducted every five years. http://www.agcensus.usda.gov/

production acreage and efficiency. Droughts impact the water supply and salinization impacts the soils. Groundwater pumping, in excess, causes land subsidence, which damages critical infrastructure such as canals and reduces the ability to replenish aquifers in the future. Improved resource management, benefitting from the use of new and better information, can mitigate the risks from each of these pressures on the region's agricultural economy.

The following pages lay out observations and assessments of the current state of many of the Valley's agricultural features and their recent trends. Further analysis on factors and resources that relate to agriculture are explored in other chapters of this report, most notably in the water section.

Characteristics of San Joaquin Valley Farmland

It should come as little surprise that the majority of the San Joaquin Valley is largely unable to grow crops without irrigation. This is a product of the region's dry climate, but also its soils and hydrology. The eastern portions of the valley floor, particularly the alluvial fans where rivers and streams enter the valley floor, have more capacity to grow without irrigation due to better water movement and soil characteristics. The western portions of the Valley, on the other hand, are more limited because soils are poorer with varying, but higher, degrees of salinity and clay, resulting in water drainage challenges.

Figures 1 and 2 demonstrate the varying degrees of commercial growing limitations on Valley irrigated and non-irrigated lands. Most of the valley floor has relatively few limitations under irrigated conditions. The soils around the edges of the valley tend to be better than the center of the valley floor, largely because of alluvial deposits in the soil from the surrounding mountains and better drainage. Under non-irrigated conditions, the southern and western portions of the valley floor are more limited than the areas on the eastern side of the Valley because less water is naturally available in the soil. Soil mapping data from the Natural Resources Conservation Service (NRCS), part of the US Department of Agriculture (USDA), portray agricultural suitability of Irrigated and Non-Irrigated Land Capability Classes, which identify the severity of soil limitations for

Figure 1. Irrigated land capability class

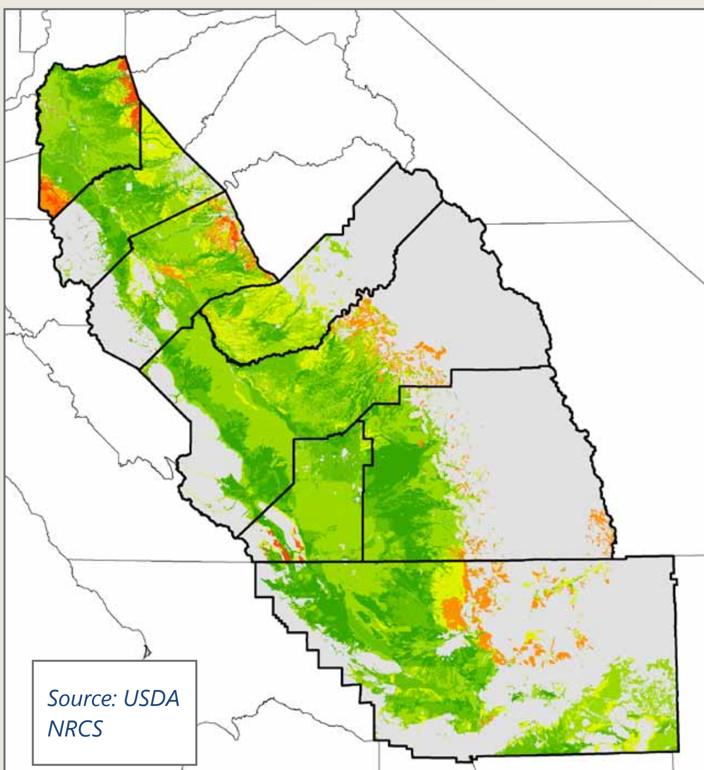
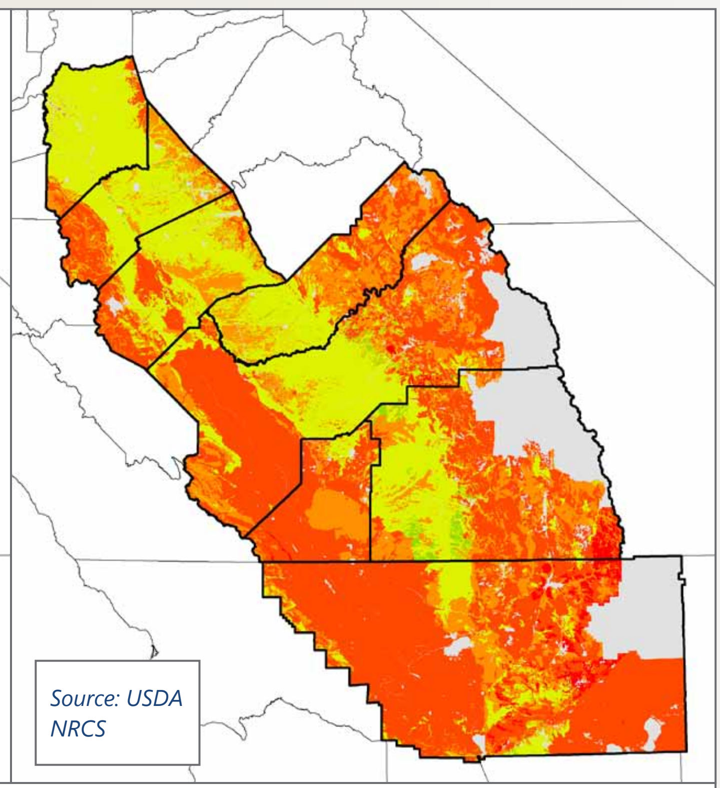


Figure 2. Non-irrigated land capability class



- Unclassified
- Slight Limitations
- Moderate Limitations
- Severe Limitations
- Very Severe Limitations
- Limitations, Limited to Pasture, Range, Forestland, Natural Habitat
- Severe Limitations, Unsuited to Cultivation
- Very Severe Limitations, Unsuited for Cultivation
- Limitations Precluding Use for Commercial Plant Production

Table 1. Farmland Mapping and Monitoring Program, "Important Farmlands"

Prime Farmland	Farmland with the best combination of physical and chemical features, able to sustain long-term agricultural production. This land has the soil quality, growing season, and moisture supply needed to produce sustained high yields. Land must have been used for irrigated agricultural production at some time during the four years prior to the mapping date.
Farmland of Statewide Importance	Similar to prime farmland but with minor shortcomings, such as greater slopes or less ability to store soil moisture. Land must have been used for irrigated agricultural production at some time during the four years prior to the mapping date.
Unique Farmland	Farmland of lesser quality soils used for the production of the state's leading agricultural crops. This land is usually irrigated, but may include non-irrigated orchards or vineyards as found in some climatic zones in California. Land must have been farmed at some time during the four years prior to the mapping date.
Farmland of Local Importance	Land of importance to the local agricultural economy, as determined by each county's board of supervisors and a local advisory committee.

Source: DOC FMMP

Figure 3. Land use and productivity

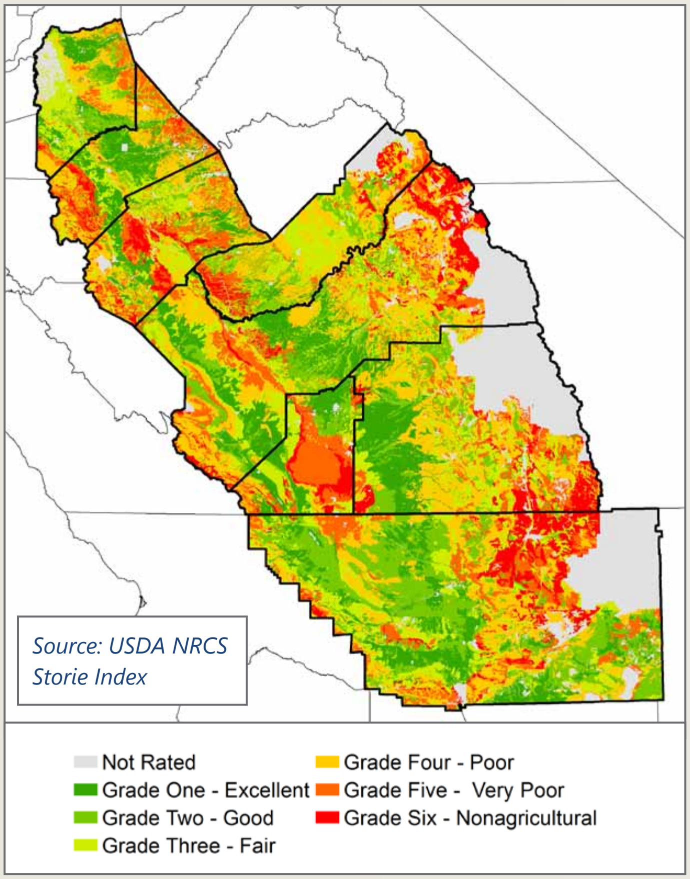
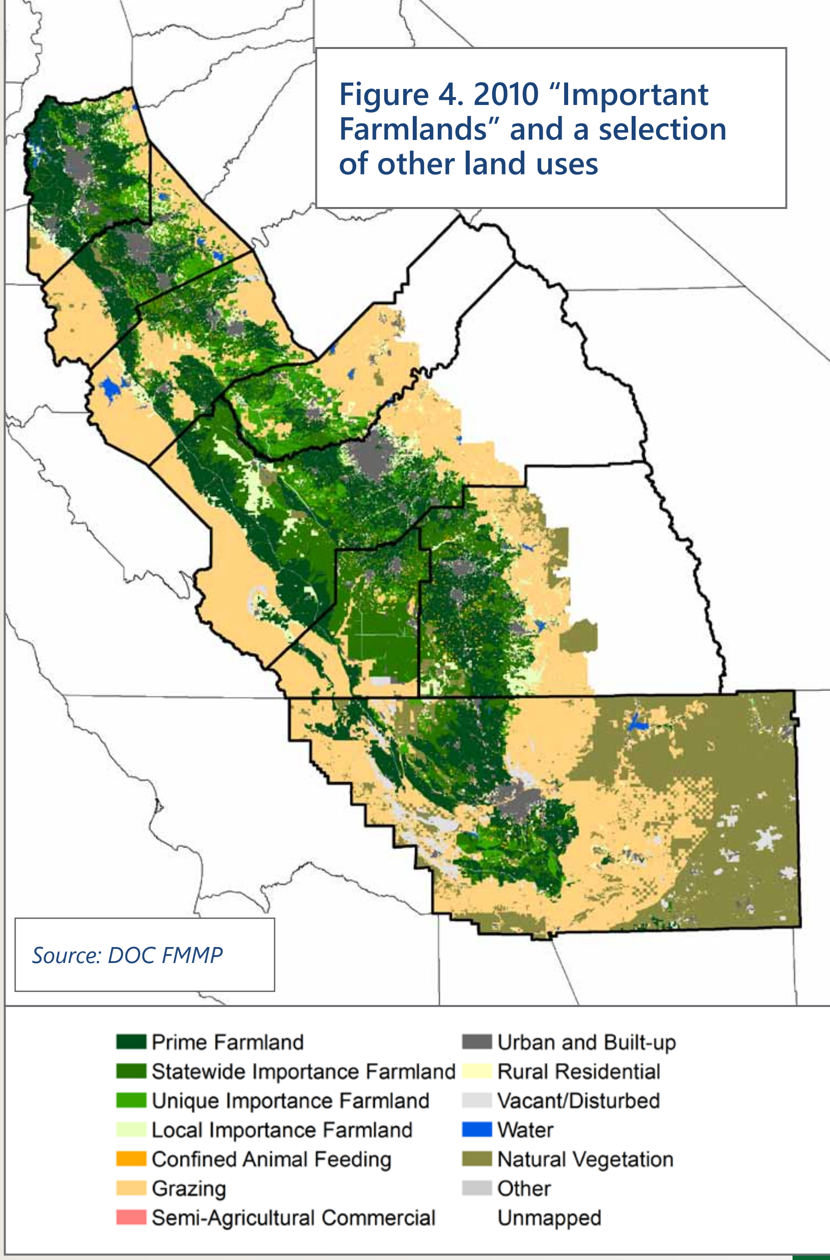


Figure 4. 2010 "Important Farmlands" and a selection of other land uses



commercial agricultural production.[2]

Figure 3 depicts overall soil and production quality in the San Joaquin Valley, demonstrating the magnitude of the Valley's suitability for agriculture. This map uses the Storie Index, a common California soil standard that rates soil quality from 0 to 100 based on multiple factors including soil texture, type, chemistry, and slope. These are frequently simplified into a six-class system.[3] Because inputs to the Storie index overlap with the irrigated and non-irrigated land capability classes, many of the lessons drawn are similar. The outer edges of the valley floor, particularly the alluvial fans for the rivers and streams are home to the

2 Uses the SSURGO dataset, which is the most detailed spatial and categorical representation of the nation's surface soils. The SSURGO dataset is a complex relational database that provides detailed information about the location, classification, chemistry, and physical characteristics of the top two meters of soil.

3 Some lands classified under the Storie Index as non-agricultural are used for productive commercial agriculture in the San Joaquin Valley.

Figure 5. Initial FMMP mapping

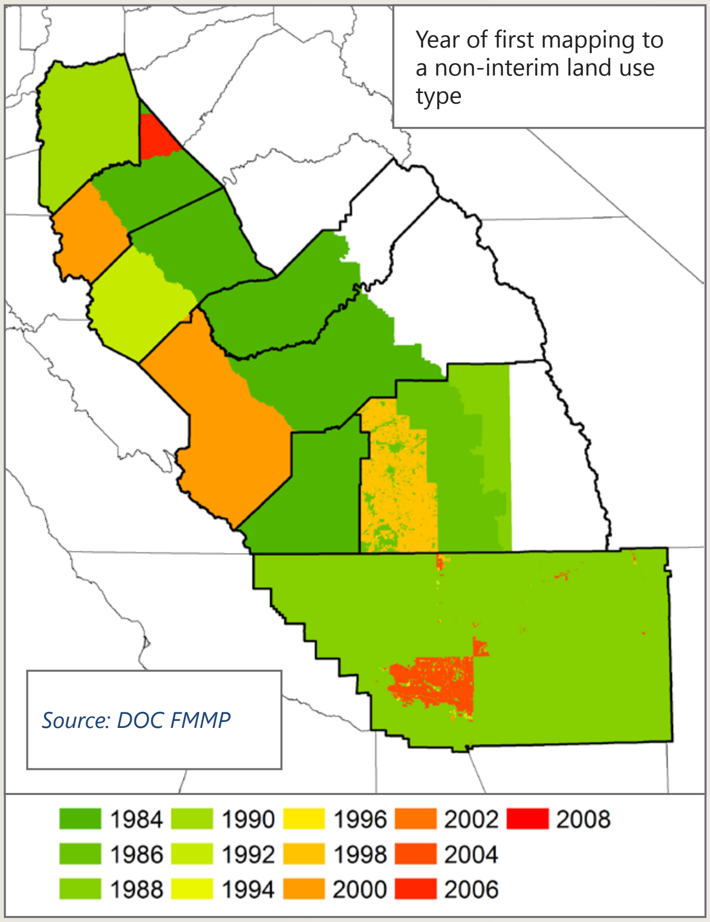
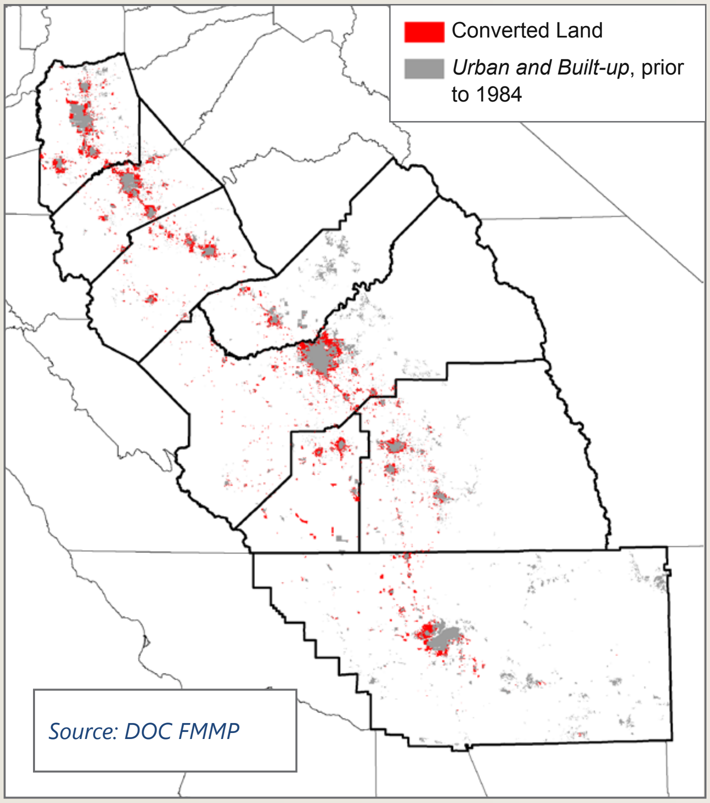


Figure 6. Farmland conversion, 1984-2010



most productive agricultural lands. The central portions of the Valley are poorer productivity zones largely due to drainage and soil salinity challenges.

The eight counties of the San Joaquin Valley make up a total land area of 17.6 million acres, of which approximately 5.6 million acres is farmland meeting the California Department of Conservation's (DOC) definitions of prime, statewide, unique, and local importance farmland in the 2010 Farmland Mapping and Monitoring Program (FMMP) (Figure 4).[4] In other words, close to one-third, 32%, of the Valley's total land area produces crops. An additional 4.9 million acres are identified by the FMMP as grazing land, accounting for 28% of Valley lands, bringing the total percentage of Valley land used for food production to 60%.

Because the FMMP-mapped area expanded over time, identifying temporal trends can be challenging. Figure 5 shows the extent of initial mapping by year. This "first mapping" was developed by comparing each dataset in chronological order and identifying the classification given during the first year in which it was mapped with a non-interim classification.[5] These range from 1984 through 2008, with the majority of the region's agricultural land being mapped by 1992.

Since the mid-1800s, approximately 740,000 acres (1,156 square miles) of the Valley have been converted from either natural space or farmland into buildings and homes according to the FMMP. Of that total, 580,000 acres were converted to urban and built-up (Figure 6), and the additional 160,000 acres to rural residential, according to the 2010 FMMP. Almost all of these developed lands occupy areas that would qualify as important farmland if they had not been developed. These 740,000 acres of developed space represent approximately 12% of the Valley's potential important farmland acreage.

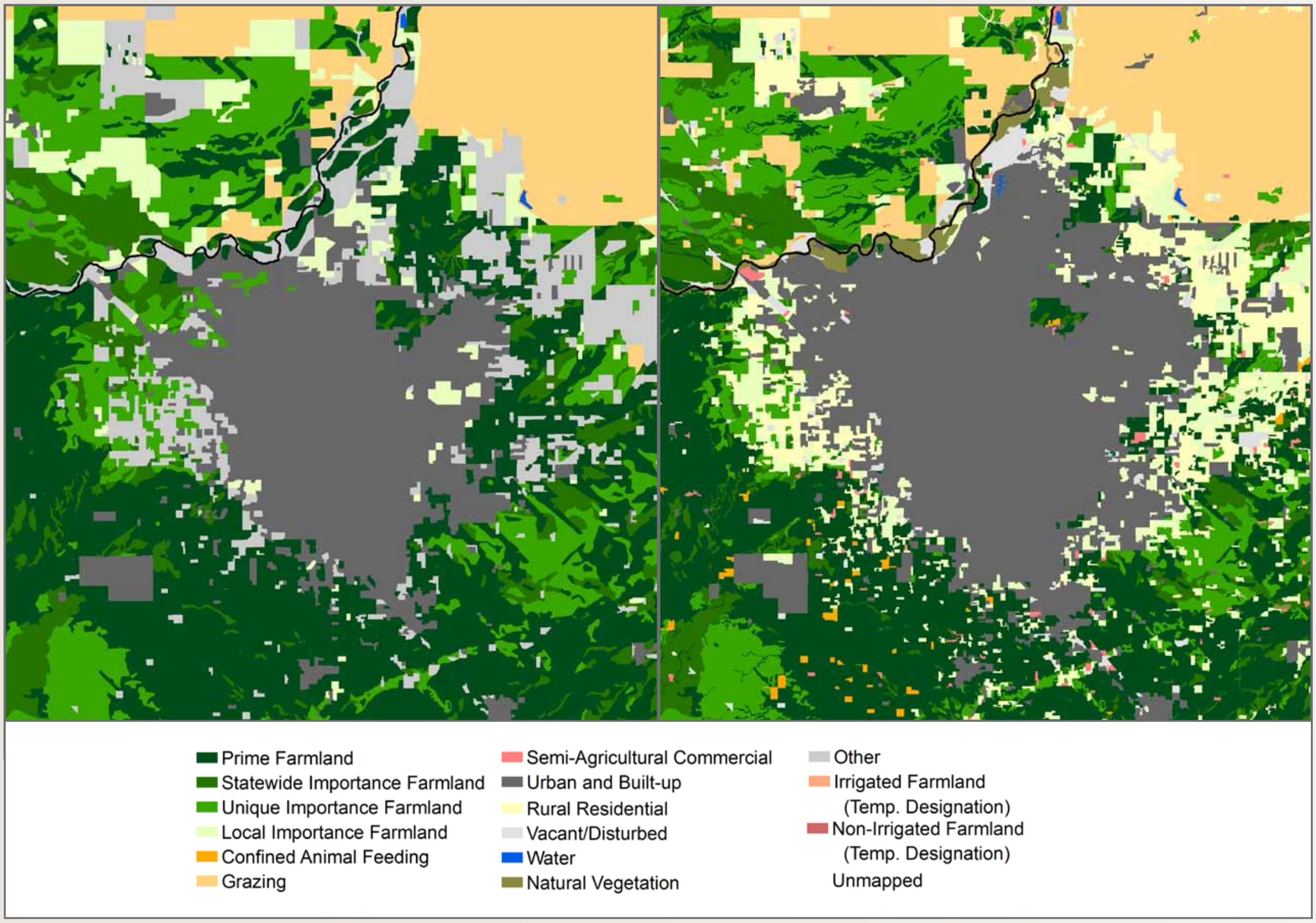
Of the 580,000 acres classified as urban and built-up in 2010, at least 141,000 acres were developed between 1984 and 2010.[6] The majority of that farmland conversion—65.5%, or 92,500 acres—was first mapped as prime farmland, 20.6% (29,200 acres) farmland of

4 As of the publication date of this report, the 2012 FMMP data was being released county by county and was not yet available for the entire Valley. The requirements for classification into each of the FMMP's data types are specific, repeatable, and the basis for one of the State's most useful time-series datasets. The FMMP has been released for every even-numbered year since 1984. Over the dataset's history, the quality of mapping has improved and some additional land use types have been added, which makes for imperfect comparisons over time; it is, however, the best available dataset for tracking land use changes over time. It is important to note that land can move between agricultural types depending on whether it has been actively farmed or irrigated during the preceding four years in addition to improvements to the underlying soils data.

5 Prior to the completion of detailed soils mapping by the NRCS, some areas were given interim classifications.

6 Time frame varies as a result of when FMMP initially started mapping certain regions; see Figure 5.

Figure 7a. Fresno FMMP mapping, 1984 **Figure 7a. Fresno FMMP mapping, 2010**



statewide importance, 7.1% (10,000 acres) unique importance, and 6.8% (9,600 acres) converted from farmland of local importance.

Figure 7a and 7b show land use changes that occurred between 1984 and 2010 near the City of Fresno. Over this time, one can clearly observe the expansion of the urban and built-up categories. As improvements in the FMMP mapping occurred, one can also observe that land identified as "other" in 1984 was split into categories in 2010 like rural residential, vacant/disturbed, confined animal feeding, natural vegetation, and semi-agricultural commercial.

Table 2. Assessment of Crop Data Sources

Dataset	Pros	Cons
CropScape, by the National Agricultural Statistics Service (NASS)	» Time-series (Annual) » Detailed crop classification » National Scale	» Accuracy challenges (confusion between similar plant types i.e. between types of nut orchard and citrus orchard, or crops that have similar multi-spectral characteristics
Department of Water Resources (DWR) Land Cover Survey	» Spatially detailed » Detailed crop classification » Highly accurate	» Infrequent updates » Not available for the entire region over a short time span
Dr. Hollander / California Multisource Landcover map (CAML) [2]	» Time-series (1990, 2010) » Detailed crop classification	» Accuracy unknown for 1990, due to lack of alternative sources for comparison.
County Agricultural Commissioners	» Continual data collection » Field level data » Locally sourced and validated data	» Challenging data structure » New and unproven dataset » Inconsistent data access policies from county to county, which makes it difficult to assess regional trends

Source: SJV Greenprint analysis

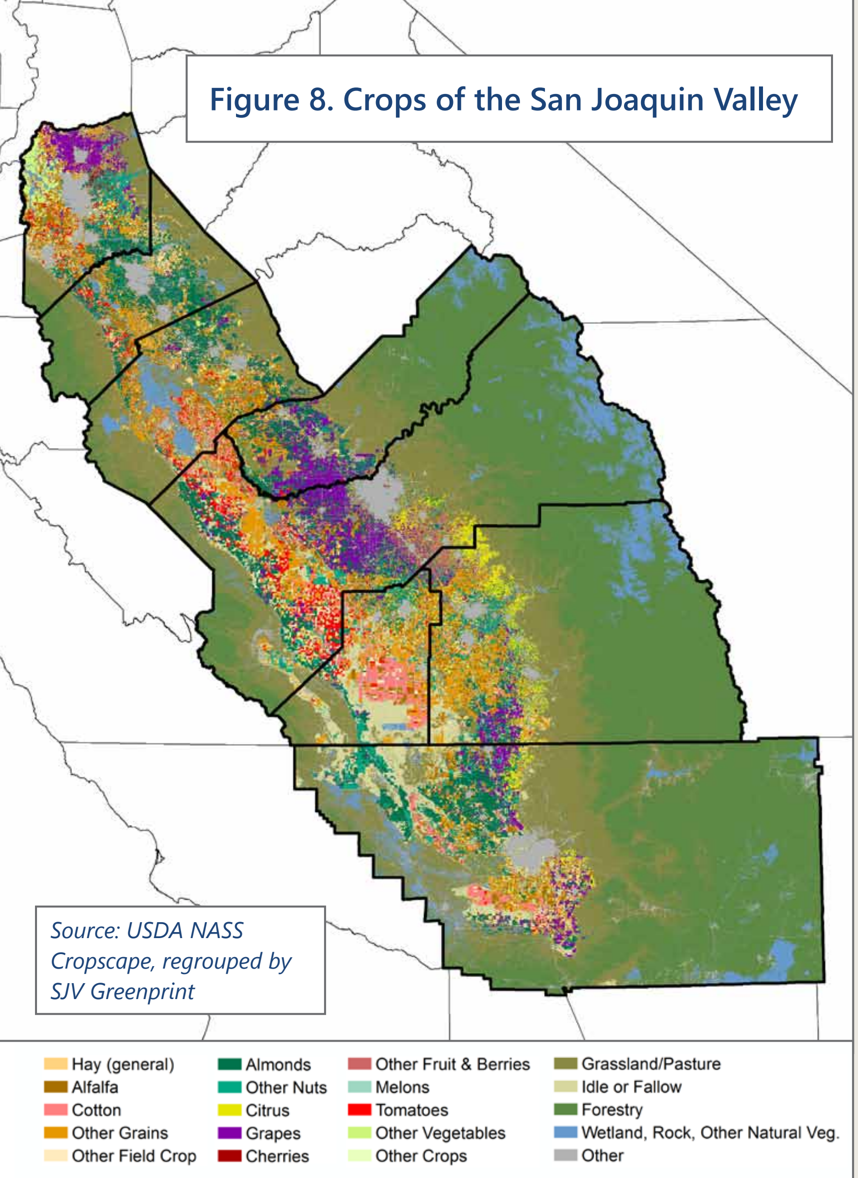


Figure 8. Crops of the San Joaquin Valley

Source: USDA NASS Cropscape, regrouped by SJV Greenprint

Crop Patterns

High-quality farmlands are a finite resource and their conversion to other uses reduces the suitable space for cultivating high-value crops. While conversion trends from farmland to urban spaces are identifiable with FMMP data, it is more difficult to track shifting trends in specific crop location over time. At present, there are no regional crop datasets that can be relied upon for specific crop patterns. See Table 2 for a breakdown of the benefits and drawbacks of the four main sources of crop data.

In spite of the flaws reflected by available crop data, each source contributes a valuable piece to the bigger picture. Figure 8, from NASS, provides a good look at cropping patterns from 2010-13,[7] distinguishing regions of the San Joaquin Valley as dominant producers of certain crops: grapes (in purple) are dominant around Fresno and Lodi, citrus (orange) along the foothills in Tulare County, and cotton (pink) in Kings County.

The SJV Greenprint considers the DWR land cover dataset the most reliable of the crop mapping datasets for the areas and dates it covers because it was heavily field verified. Looking ahead, the Agriculture Commissioner's pesticide permit data might provide significant crop mapping data detail over the next few years.

Many of the highest value crops grow predominantly on important agricultural lands. Soils of prime and statewide importance account for 97% of melon production, almost 95% of tomato, 94% of cotton, 85% of all citrus and cherry production, 81% of alfalfa, 80% of almonds, and 79% of grape production.

The Agricultural Value of the San Joaquin Valley

The economic value of the San Joaquin Valley's agricultural production is tremendous. The total agricultural market value, in 2013 inflation-adjusted terms,[8] for the San Joaquin Valley's agricultural products (crop and animal) in 2012 was $24.2 billion, which equates to 56% of California's total agricultural market value.[9] This value has been increasing over time: $16.2B in 2002 and $20.6B in 2007, (in 2013 dollars), representing rises of 19.6% and 17.4% over the respective five-year time frames. As value has increased, however, the number of individual farms, size of farms, and total acreage of cropland has decreased since 2002 (see Tables 3 and 4).

The increase in value of agricultural production despite decreases in cultivated lands indicates that San Joaquin Valley farmers are producing more value from less land. This trend is caused by a combination of factors, namely the switch to higher value crops and increases in commodity prices for many of the high-value crops. Based on harvested cropland, the 2012 Census of Agriculture indicates that, in 2013 dollars, the market value per acre of harvested crops increased from approximately $2,300 in 2002, to $2,700 in 2007, to $3,100 in 2012. To summarize the importance of the San Joaquin Valley's agricultural economy, Table 3 relates some basic statistics for the Valley's agricultural production to California totals.

The San Joaquin Valley generated more than eight times

7 Note that this analysis of "cropping patterns" isn't a precise analysis of every crop within a given location. This means that if you view the larger patterns of cropping on the basis of a multi-acre area, the crops will be broadly correct, though are likely to reveal errors distinguishing among similar crops (hay and alfalfa, for example).

8 All dollar values are converted to 2013 equivalent dollars using a CPI based correction factor from: http://www.bls.gov/data/inflation_calculator.htm

9 2012 Census of Agriculture

Table 3. Agricultural Production and Market Values, 2012, 2007, 2002

Percentages indicate what percent of California's Agriculture is provided by the San Joaquin Valley Counties.

	2012			2007			2002		
	California	SJV %	SJV	California	SJV %	SJV	California	SJV %	SJV
Number of Farms	77,857	32.5%	25,324	81,033	32.9%	26,620	79,631	35.6%	28,357
Land in Farms (acres animals and crops)	25,569,001	35.8%	9,151,381	25,364,695	38.3%	9,726,737	27,589,027	36.2%	9,990,355
Total Cropland (acres)	9,591,783	51.3%	4,917,401	9,464,647	51.4%	4,868,275	10,994,161	49.5%	5,436,657
Harvested Cropland (acres)	8,007,461	54.1%	4,331,306	7,633,173	55.1%	4,207,894	8,466,321	54.7%	4,633,578
Irrigated Land (acres)	7,861,964	53.8%	4,230,147	8,016,159	54.5%	4,367,420	8,709,353	54.3%	4,727,419
Market Val. of Ag. Products ($1,000)	43,232,730	56.0%	24,205,803	38,073,106	54.1%	20,599,510	33,338,307	48.6%	16,218,280
Crops, inc. Nusery and Greenhouse ($1,000)	30,798,071	43.4%	13,374,966	25,733,731	44.3%	11,395,972	24,809,225	42.3%	10,494,452
Livestock, poultry, and animal products ($1,000)	12,434,659	74.8%	9,305,483	12,339,374	74.6%	9,203,536	8,529,082	67.1%	5,723,832

Source: NASS, Ag. Census 2012, 2007, 2002. All dollar values converted to 2013 dollars.

Table 4. Growth/change between the 2002 & 2007, and 2007 & 2012

	2007 to 2012				2002 to 2007			
	% CA Growth	CA Change	% SJV Growth	SJV Change	% CA Growth	CA Change	% SJV Growth	SJV Change
Number of Farms	-3.9%	-3,176	-4.9%	-1,296	1.8%	1,402	-6.1%	-1,737
Land in Farms (acres animal and crops)	0.8%	204,306	-5.9%	-575,356	-8.1%	-2,224,332	-2.6%	-263,618
Total Cropland (acres)	1.3%	127,136	1.0%	49,126	-13.9%	-1,529,514	-10.5%	-568,382
Harvested Cropland (acres)	4.9%	374,288	2.9%	123,412	-9.8%	-833,148	-9.2%	-425,684
Irrigated Land (acres)	-1.9%	-154,195	-3.1%	-137,273	-8.0%	-693,194	-7.6%	-359,999
Market Value of Ag Products ($1,000)	13.6%	5,159,625	17.5%	3,606,293	14.2%	4,734,799	27.0%	4,381,230
Crops, inc. nursery and greenhouse ($1,000)	19.7%	5,064,340	17.4%	1,978,994	3.7%	924,506	8.6%	901,520
Livestock, poultry, and animal products ($1,000)	0.8%	95,285	1.1%	101,947	44.7%	3,810,293	60.8%	3,479,704

Source: NASS, Ag. Census 2012, 2007, 2002. All dollar values converted to 2013 dollars.

as much market value from crops per harvested acre than the national average in 2012. Nationally, the market value for agricultural products in 2012 was $400.2 billion, meaning that the San Joaquin Valley's eight counties accounted for 6% of the nation's total agricultural value (and California represented 11%). The San Joaquin Valley's 6% of total national agricultural value is generated from just 1.0% of the nation's total acreage in farms, which is why it was so much more productive than the national average.

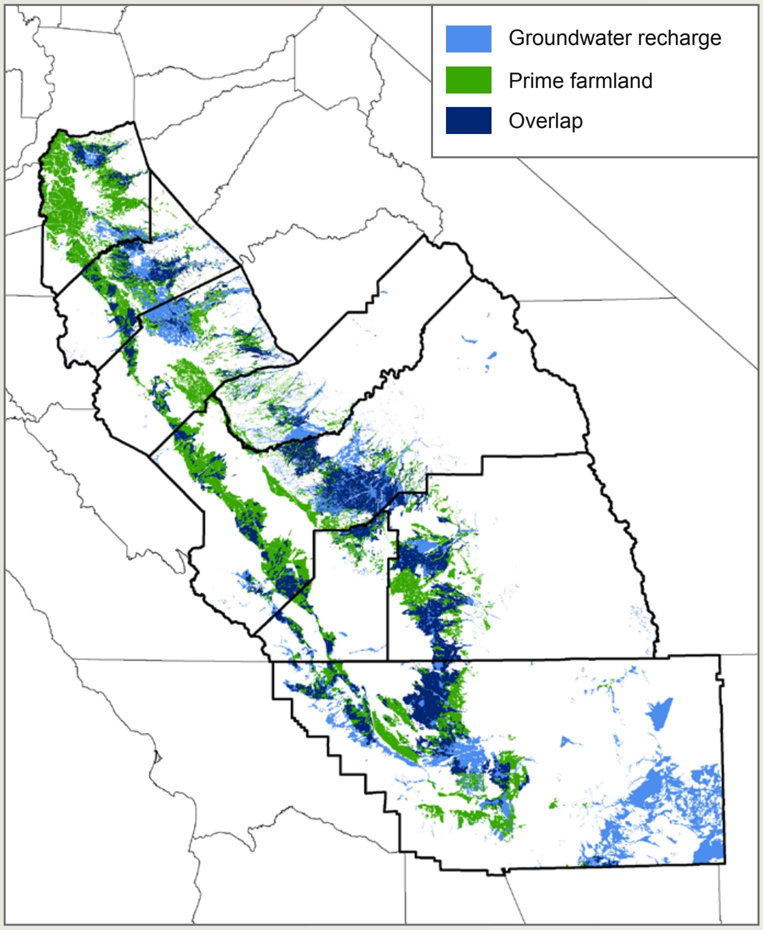
Crop value and land use trends in the San Joaquin Valley share some similar patterns with the rest of California, but also show some distinguishing trends (Table 4). The number of farms in the San Joaquin Valley has been shrinking, like the rest of California, but at a faster pace. Those farms, however, appear to be getting bigger. While both the Valley and California suffered significant losses to overall farmland acreage between 2002 and 2007, that trend stabilized over the next five years. As has been demonstrated by other datasets, the value of San Joaquin Valley crop commodities

Table 5. Growth, selected commodities between 2002 & 2012

Commodity	Growth in Acres Harvested	Growth in Production	Units	Growth in Value
Alfalfa	-439,444	-544,463	tons	$158,379,000
Almonds	296,105	377,660	tons	$2,669,270,000
Beans	-6,020	-7,662	tons	$20,408,000
Cattle	NA	559,099	head	$988,453,000
Cherries	11,274	48,900	tons	$163,162,000
Citrus	9,467	808,198	tons	$445,726,000
Cotton	-312,828	-767,516	bales	-$505,587,000
Grapes	38,989	-122,024	tons	$2,488,429,000
Melons	-14,638	-376,249	tons	$5,754,000
Milk	NA	99,733,839	ctw	$2,287,504,000
Poultry	NA	-72,091,976	head	$125,734,000

Source: County Agricultural Commissioners.
Note: Dollar values were converted to $2013 prior to comparisons. 1 ctw = 100 lbs of product. Merced County figures calculated for 2003 instead of 2002.

Figure 9. Potential groundwater recharge areas overlapping prime agricultural land



Source: DOC FMMP and California Water Institute, CSU Fresno

has been increasing, and at a significantly higher rate than the rest of California.

Total market values (converted to 2013 dollars) for all but one of the commodities in the San Joaquin Valley increased from 2002 to 2012 despite reductions in acreage and production (Table 5). This indicates the importance of crop and commodity prices.[10] According to the Agricultural Census, many crops doubled in per unit value between 2002 and 2012 with leaders being almonds (132% increase), alfalfa (114%), nectarines (103%), and grapes (95%).[11]

Table 3 also demonstrates the substantial reduction in land being harvested for both alfalfa and cotton, with cotton being the only commodity on this list showing a negative growth in market value over the decade. Between 2002 and 2012, alfalfa cultivation decreased by more than 400,000 acres and alfalfa harvested decreased by more than a half million tons, but the near doubling of market value per ton of alfalfa allowed the alfalfa crop to increase in total value. The livestock industry in the Valley has seen some shifts too – the poultry industry has shrunk, and cattle herds and milk production are growing.

Across the Valley, land has been converted from annual crops (cotton, alfalfa, beans, and melons, for example) to permanent crops such as almonds, grapes, citrus, and other fruit and nut trees, which tend to generate higher revenues. The shift toward higher-profit, permanent crops, however, comes at the expense of flexibility for farmers, and the region at large, especially in times of drought. Orchards and vineyards represent a substantial financial investment on the farmer's part and cannot be fallowed when the region's limited water resources are made scarcer by climate patterns and other competing demands for water.

10 County-level Agricultural Commissioner's reports. 2002 and 2012 were selected for convenience and the ability to compare results to the NASS Agricultural Censuses. Ag. Commissioner's Reports are released annually and in many counties historic archives extend back decades. County Ag. Commissioner's reports and the Census of Agriculture are created using different methods. In general the trends identified appear to be similar, though the exact values do not match.

11 http://nass.usda.gov/Statistics_by_State/California/Historical_Data/index.asp

Other Challenges Facing Valley Ag Resources

Conversion of agricultural land to urban use isn't the only challenge facing the Valley's agricultural heritage. Other pressures include conversion to energy production, transportation infrastructure, water availability, and soil salinity.

The region's energy production industries convert rural lands – usually productive agricultural and ranching lands – into solar energy facilities (see Chapter Five for more information on the Valley's energy production facilities). There are 27 solar facilities currently operating in the eight-county San Joaquin Valley. Oil and natural gas production also intersect with agricultural lands, particularly ranching activities in the southern Valley, fragmenting the agricultural landscape by removing small areas from active production.

The agricultural industry in the Valley represents about 85% of the net water use in the region.[12] With the move to permanent crops and variation in annual precipitation, the availability of water is a primary limiting factor on the agricultural industry. Forecasts of future water availability indicate increases in annual variability as a result of likely shifts in precipitation patterns that may make water deliveries throughout the dry summer more difficult.

In many cases, potential groundwater recharge areas overlap with prime agricultural land. Across the eight San Joaquin Valley counties, just under 50% of the potential groundwater recharge area is also defined as prime agricultural land (Figure 9). Another 15% is defined by the FMMP as natural vegetation. Because groundwater recharge areas are determined by soil types, regardless of whether it is already developed, almost 9.5% of the groundwater recharge areas may be compromised by existing development. Farmland of statewide importance and grazing lands represent between 8% and 8.5% of recharge area potential.

Soil salinity is an ongoing challenge in portions of the western San Joaquin Valley. This condition occurs as a result of naturally-occurring saline soil components and irrigation and drainage practices. In some cases, groundwater from deeper aquifers also contains salts. Irrigating soils with salt-containing groundwater exacerbates the salinization of soil, particularly on soils with poor drainage, which leads to reduced crop production. Additional irrigation is an option to flush salts down in the soil, but requires

12 *DWR water balance data prepared for the 2013 Water Plan Update. http://www.waterplan.water.ca.gov/cwpu2013/index.cfm.*

Figure 10. Soil Salinity

Represented as electrical conductivity measured in decisiemens per meter (dS/m)

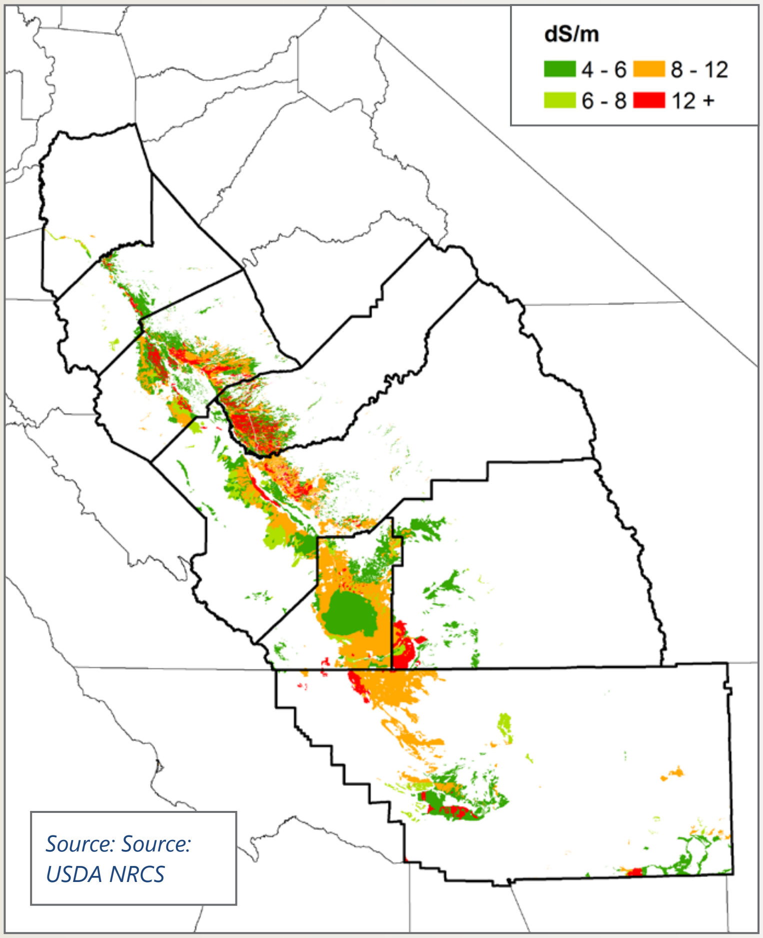


Table 6: Salt tolerance by crop type

Sensitive (0-4 dS/m)	Moderately Tolerant (4-6 dS/m)	Tolerant (6-8 dS/m)	Highly Tolerant (8-12 dS/m)
Almond	Corn	Fig	Barley
Bean	Grain Sorghum	Oats	Cotton
Clover	Lettuce	Pomegranate	Olive
Onion	Soybean	Sunflower	Rye
Potato	Tomato	Wheat	Wheatgrass

Source: Adapted from Brady, N.C., 2002, The Nature and Properties of Soils, New Jersey, USA, Prentice Hall as presented in Management of Irrigation-Induced Salt-Affected Soils, a brochure publication of the FAO (ftp://ftp.fao.org/agl/agll/docs/salinity_brochure_eng.pdf).

additional application of an already limited resource, and may lead to longer-term salinization following the short-term benefit.

Figure 10 shows the soils with higher soil salinity (as measured by electrical conductivity), based on the parent soil material (the underlying geologic soil composition). Soil salinity levels are generally higher in the western portion of the Valley than in the eastern side, where Sierra Nevada rivers deposit rich alluvial soils. Salinity levels are highest in southwest Tulare County, western Madera County, and central Merced County. Certain crops are more and less sensitive to saline soils as shown in Table 6. Soil salinity can be managed to some extent through irrigation and drainage practices but due to the complex interactions between irrigation, soil chemistry, drainage, and groundwater, identifying a maximum threshold for commercial agriculture is beyond the scope of this report.

Table 7: Salt tolerance and yield reductions

Crop	Max. Soil Salinity Without Yield Loss	% Decrease in Yield per dS/m above Threshold	% Decrease in Yield		
			4 dS/m	6 dS/m	8 dS/m
Bean	1	19	57	95	100
Carrot	1	14	42	70	98
Strawberry	1	33	99	100	100
Onion	1.2	16	45	77	100
Almond +	1.5	19	48	86	100
Plum +	1.5	18	45	81	100
Apricot +	1.6	24	58	100	100
Orange	1.7	16	37	69	100
Peach	1.7	21	48	90	100
Grapefruit +	1.8	16	35	67	99
Lettuce	1.3	13	35	61	87
Grape +	1.5	9.6	24	43	62
Pepper	1.5	14	35	63	91
Sweet Potato	1.5	11	28	50	72
Corn	1.7	12	28	52	76
Cabbage	1.8	9.7	21	41	60
Celery	1.8	6.2	14	26	38
Alfalfa	2	7.3	15	29	44
Spinach	2	7.6	15	30	46
Cucumber	2.5	13	20	46	72
Tomato	2.5	9.9	15	35	54
Broccoli	2.8	9.2	11	29	48
Sudan Grass	2.8	4.3	5	14	22
Red Beet ++	4	9	0	18	36
Zucchini	4.7	9.4	0	12	31
Soybean	5	20	0	20	60
Ryegrass	5.6	7.6	0	3	18
Wheat, Durum	5.7	5.4	0	2	12
Wheat ++	6	7.1	0	0	14
Sorghum	6.8	16	0	0	19
Date Palm	4	3.6	0	7	14
Sugar beet	7	5.9	0	0	6
Cotton	7.7	5.2	0	0	2
Barley ++	8	5	0	0	0

Source: Maas, E.V, 1984, Salt Tolerance of Plants, in Handbook of Plant Science in Agriculture.
Note: Yield losses are calculated for 4, 6, and 8 dS/m assuming that yield loss is linear. + Tolerance is based on growth rather than yield, ++Less tolerant during emergence and seedling.

Conclusions and Considerations

The San Joaquin Valley's agricultural economy continues to grow in value, largely because of shifts toward cultivating higher value crops. Losses to farmable land and uncertainty in water availability, however, challenge the Valley's overall productivity. As a result, the conversion of productive agricultural land into other uses should be carefully weighed against the costs to the Valley's agricultural economy across the region.

A recent report by the Watershed Center, University of California Davis estimated significant costs of the ongoing drought to Valley agriculture. The report estimated a gross agricultural revenue loss to the San Joaquin Valley counties of $519 million.[13] According to UC Davis calculations, the entire Central Valley (including the Sacramento Valley) has lost 14,500 jobs, for a total economic loss to the Central Valley of almost $1.7 billion.

The Valley's soils remain a key feature of the region's agricultural economy. While water is portable, the soils and their properties are not. Land, once converted out of agriculture, rarely returns to it.

In some cases, agricultural land is retired. Through a variety of government-funded programs, farms have retired more than 77,000 acres of marginalized land from agricultural production. Lands are retired due to soil salinization, water drainage problems (particularly on lands sitting atop the impermeable Corcoran clay), and unreliable irrigation availability. While the necessity of retiring lands is unfortunate, there can be ancillary benefits including restoration of native habitat, prioritization of irrigation waters for important farmland, and potential locations for solar farms.

- What areas are important to the region's agricultural economy because of soils?
- Is this area a groundwater recharge area that can serve as both cropland and groundwater recharge?
- Does the project overlap with an area producing a high value crop? How widespread is that crop?
- Does the action being considered make an appropriate trade in providing regional benefits for the conversion of agricultural land?

The San Joaquin Valley Greenprint and its interactive mapping portal provide access to information and tools to help answer these questions and the myriad other interconnected resource decisions in the San Joaquin Valley. As a comprehensive collection of data on natural and developed resources in the Valley's rural lands, the SJV Greenprint gives planners, resource managers, and decision-makers, as well as the public, the ability to layer various resource values on top of one another to evaluate development decisions through a regional lens. All of the data and maps presented in this report can be explored in much greater detail online.

13 *https://watershed.ucdavis.edu/files/biblio/Preliminary_2014_drought_economic_impacts-05192014.pdf*


Vineyard © John Greening


Pistachios, Stock photo

4 State of the Valley: BIODIVERSITY

Dry Creek © John Greening

Key points:

- Land conversion since settlement occupies about 69% of the valley floor, with the largest unconverted lands being annual grasslands used for grazing.
- Overall, there are 3,043 plant species and 499 vertebrate species in the region, including 66 federally or state listed threatened or endangered species.
- The forested and alpine lands of the Sierra Nevada are the water towers of the region, supplying both runoff and groundwater, an essential ecosystem service for the region.
- More than 38% of all vernal pools in the region have been destroyed, and 8% are classed as degraded.
- Better quality vegetation maps are needed for large parts of the valley floor and foothills, particularly for riparian vegetation, to properly ascertain the extent of native vegetation and habitats.
- The valley floor covers about 43% of land area in the compiled maps. The foothills occupy 25%, federal lands 26.5%, and the desert region of eastern Kern County occupies 5% of the region.

Overview

Plants, wildlife, and other organisms are integral ecosystem components, acting together with non-living factors such as water and climate. Regions with higher numbers of species (also called higher levels of biodiversity) support greater natural plant productivity, and are more resilient to natural habitat disruptions like wildfire, as well as man-made disruptions to landscape, and potentially, climate change.[1] This biodiversity also supports the health and sustainability of "ecosystem services" upon which humans and other species depend, including purification of air and water, flood and drought protection, decomposition of wastes, soil renewal, pollination of crops, pest control, and more.[2]

The preservation of ecosystem services, such as water stored in the snowpack of the Sierra Nevada Mountains, has long been recognized as an important value in the San Joaquin Valley. In fact, residents and farmers around Visalia were supportive of the creation of Sequoia National Park in 1890 because preservation of the high country would help ensure the availability of water on the valley floor. Because of those historic actions to conserve the alpine and forest habitats of the Sierra Nevada, the high country is a reliable water resource for the valley floor, contains some of the most intact blocks of natural lands remaining in the region, and is home to many native species. Today, those resources are more valuable than ever as humans increasingly recognize that our own survival depends upon the health of natural ecosystems. The importance of species and habitats has further been recognized by a series of national and state laws that aim to balance the needs of species with those of the human population.

This chapter reviews the condition and trends of the biological and natural resources in the region, with a

1 Cardinale et al. 2012. Biodiversity loss and its impact on humanity. Nature 486: 59=67.

2 Isbell et al. 2011. High plant diversity is needed to maintain ecosystem services. Nature 477: 199-202.

focus on the valley floor. Overall, landscape conversion to human use has impacted the Valley dramatically, but there remain opportunities for land use decisions that prioritize the importance of biodiversity and associated ecosystem benefits.

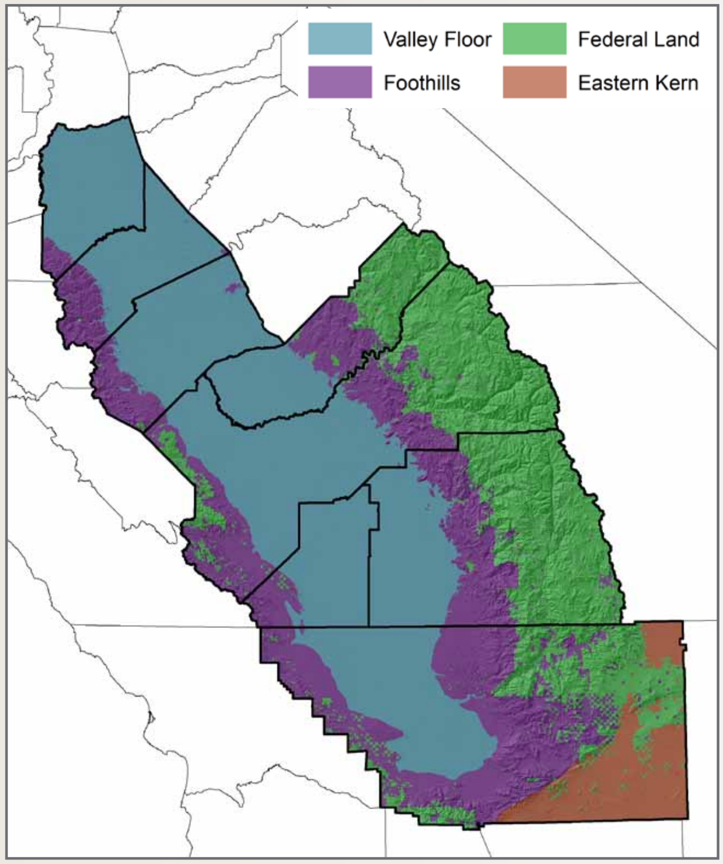
Land Conversion

The eight-county region of the San Joaquin Valley covers about 27,480 square miles (17.5 million acres). In analyzing biodiversity data for the Valley, the SJV Greenprint looked at four distinct ecosystem types: the "valley floor," "foothills," "federal lands," and "eastern Kern." The majority of the SJV Greenprint's information is focused on the valley floor. For purposes of analysis, the valley floor includes all lands below 525 feet (160 meters), which covers 11,698 square miles (7,486,972 acres, or 43% of the region). The foothills cover the private lands above this point up to the federal lands in the Sierra Nevada, covering 6,940 square miles, or about 25% of the region. Federal lands in the eight-county region occupy 7,287 square miles, or about 26.5% of the region, primarily in the Sierra Nevada, (Sequoia and Kings Canyon National Parks, Sequoia National Forest, and Sequoia National Monument), and also some national wildlife refuges and other federal conservation sites along the Valley's western border. Finally, the project includes some data assembled that covers the desert lands in southeastern Kern County, which occupy 1,555 square miles, or about 5% of the region (Figure 1).

The region, particularly the valley floor, has undergone dramatic change since European settlement and agriculture began. Several large freshwater lakes, the most well-known being Tulare Lake, were found on the valley floor. Records of the size of this lake show it fluctuated between 560 square miles and 690 square miles, depending on yearly precipitation,[3] and was once the biggest fresh water lake west of the Mississippi. Tulare Lake and others, including Buena Vista Lake and Kern Lake, were stream-fed lake and

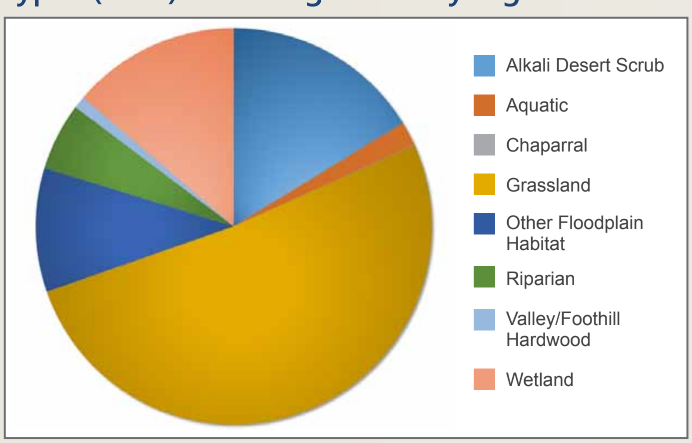
3 Negrini, RM, PE Wigand, S DRaucker, K Gobalet, JK Gardner, MQ Sutton, RMYohe II. 2006. The Rambla highstand shoreline and the Holocene lake-level history of Tulare Lake, California, USA. Quaternary Science Reviews 25:1599-1618.

Figure 1. Four main land types



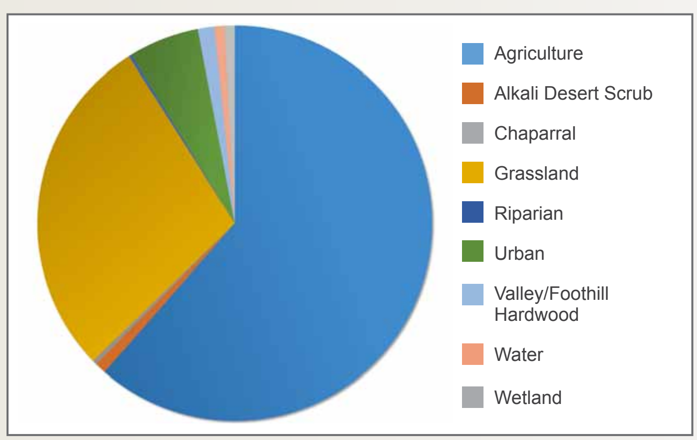
Source: USGS digital elevation model, processed

Figure 2. Proportion of historic landcover types (1850) in the eight-county region



Source: The Central Valley Historic Mapping Project, Chico State, 2003

Figure 3. Proportion of current landcover types (2002)



Source: Fire and Resource Assessment Program (FRAP) wetland ecosystems that received Sierra Nevada snowmelt. Pollen samples taken from the ancient lakebeds suggest that the vegetation around the lakes prior to 7,000 years ago was more similar to the desert and steppe vegetation now found in the Great Basin, and which is still found on parts of the valley floor today. Research also shows evidence of more giant Sequoias (*Sequoiadendron*) in the Sierra Nevada between 24,000 and 8,500 years ago than are now found.[4]

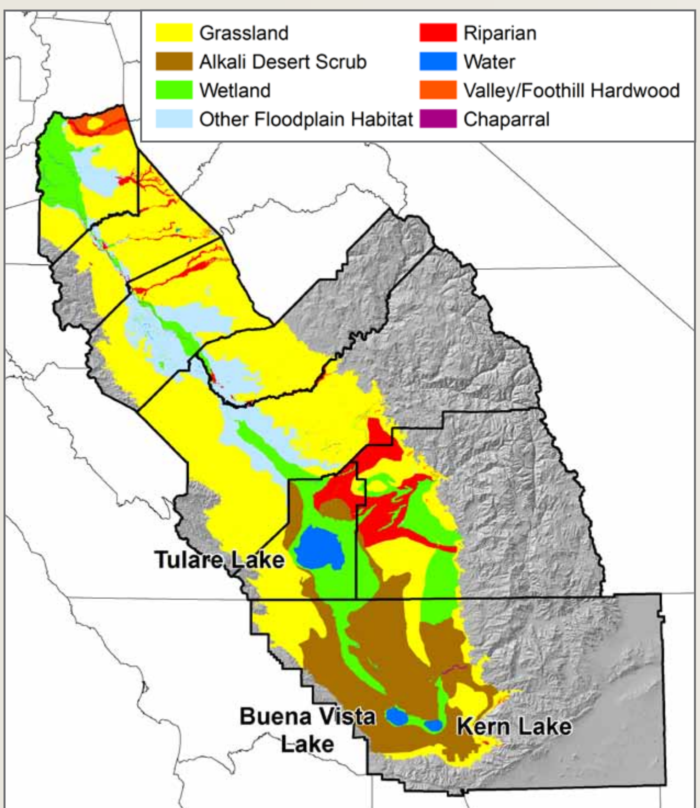
4 Davis, O.K., 1999. Pollen analysis of Tulare Lake, California: great basin-like vegetation in central California during the full-glacial and early Holocene. Review of Paleobotany and Palynology 107, 249–257.

Table 1. Landcover Categories and Extents, Current and Historic

Landcover Category	Current Landcover Type Extents (Acres)	Historic Landcover Type Extents (Acres)	Change (Acres)	Change (Square Miles)
Agriculture	5,763,182		5,763,182	9,005
Urban	541,418		541,418	846
Alkali Desert Scrub	86,761	1,527,521	-1,440,760	-2,251
Chaparral	32,317	3,469	28,847	45
Grassland	2,650,489	4,814,106	-2,163,617	-3,381
Riparian and Floodplain Habitats	21,566	1,463,877	-1,442,311	-2,254
Valley/Foothill Hardwood	126,691	93,116	33,575	52
Water	78,117	186,051	-107,934	-169
Wetland	76,830	1,289,384	-1,212,554	-1,895

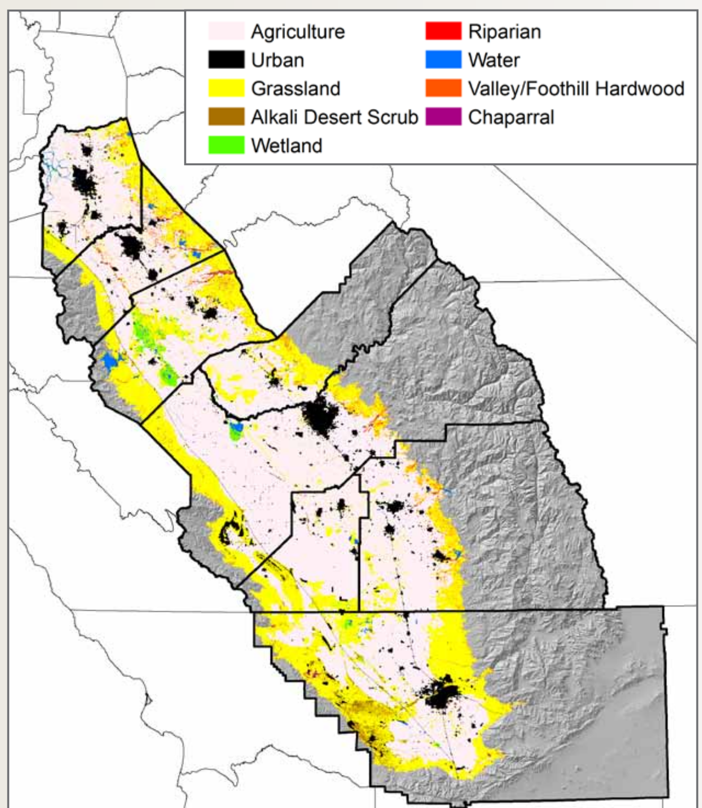
Source: Central Valley Historic Mapping Project, Chico State, 2003; Fire and Resource Assessment Program (FRAP), 2002

Figure 4. Historic landcover patterns (1850)



Source: A multi-map reconstruction from the Central Valley Historic Mapping Project, Chico State, 2003

Figure 5. 2002 Landcover patterns, 2002



Source: Fire and Resource Assessment Program (FRAP), 2002

Table 2: Extent, in acres, of wildlife habitats for natural vegetation types in the eight counties

WHR Description	Fresno	Kern	Kings	Madera	Merced	San Joaquin	Stanislaus	Tulare	Total in Acres	Total Square Miles
Urban	140,437	185,632	33,826	27,298	37,140	82,193	66,911	56,139	629,576	984
Agriculture	1,385,829	1,076,477	615,136	364,571	579,440	607,094	399,973	793,785	5,822,305	9,097
Alpine-Dwarf Shrub	9,726	-	-	2,190	-	-	-	1,162	13,078	20
Annual Grassland	528,106	1,339,155	209,110	263,190	497,282	169,782	320,242	339,216	3,666,082	5,728
Alkali Desert Scrub	1,902	278,638	5,348	183	1,371	-	-	5	287,447	449
Aspen	-	-	-	111	-	-	-	-	111	0
Barren	319,531	60,547	163	80,573	2	652	301	185,577	647,347	1,011
Bitterbrush	-	2,978	-	-	-	-	-	-	2,978	5
Blue Oak-Foothill Pine	127,022	53,234	1,587	64,343	16,492	12,205	58,545	88,695	422,124	660
Blue Oak Woodland	186,454	247,071	7,234	72,382	44,398	9,162	31,780	262,381	860,862	1,345
Coastal Oak Woodland	216	4,596	5	-	3,589	1,860	1,288	-	11,555	18
Chamise-Redshank Chaparral	20,678	6,882	570	52	247	-	36,822	11,308	76,558	120
Coastal Scrub	17,781	12,652	7,121	-	1,268	10	2,681	-	41,512	65
Desert Riparian	-	2,195	-	-	-	-	-	-	2,195	3
Desert Scrub	30	1,116,251	-	-	-	-	-	-	1,116,281	1,744
Desert Succulent Shrub	-	6,677	-	-	-	-	-	-	6,677	10
Desert Wash	-	3,668	-	-	-	-	-	-	3,668	6
Freshwater Emergent Wetland	9,519	7,499	2,873	1,044	45,019	5,497	2,563	2,742	76,756	120
Jeffrey Pine	35,890	77,401	-	1,938	-	-	-	75,341	190,569	298
Joshua Tree	-	4,981	-	-	-	-	-	-	4,981	8
Juniper	760	11,073	-	588	-	-	-	4,480	16,901	26
Lacustrine	319	277	267	371	126	178	15	49	1,601	3
Lodgepole Pine	36,406	5	-	29,807	-	-	-	124,470	190,689	298
Mixed Chaparral	54,074	107,766	994	7,359	641	42	19,021	26,467	216,364	338
Montane Chaparral	44,031	20,384	-	17,929	-	-	-	77,024	159,368	249
Montane Hardwood-Conifer	15,679	6,163	-	32,825	-	73	143	3,736	58,620	92
Montane Hardwood	103,656	61,724	-	85,521	1,552	1,974	5,511	153,983	413,921	647
Montane Riparian	993	2,323	-	998	-	-	-	3,630	7,944	12
Perennial Grassland	-	1,913	-	-	-	-	-	-	1,913	3
Pinyon-Juniper	1,670	169,434	-	-	-	-	-	162,396	333,500	521
Ponderosa Pine	72,557	13,902	-	38,521	-	-	-	54,214	179,193	280
Red Fir	215,871	612	-	88,875	-	-	-	194,846	500,204	782
Riverine	1,013	539	-	3	-	9,770	106	-	11,431	18
Subalpine Conifer	214,361	77	-	37,620	-	-	-	107,526	359,585	562
Sagebrush	262	80,691	-	18	-	-	-	23,642	104,613	163
Sierran Mixed Conifer	219,157	46,437	-	115,729	-	-	-	268,406	649,728	1,015
Unknown Conifer	314	6,323	5	2,012	898	269	820	11,434	22,076	34
Unknown Shrub	29,683	154,994	3,230	26,546	6,509	2,610	6,728	38,917	269,218	421
Valley Oak Woodland	22	33,151	-	-	335	-	514	148	34,171	53
Valley Foothill Riparian	1,197	576	1,213	536	4,536	5,332	7,412	951	21,754	34
Water	40,899	16,645	2,120	9,788	24,567	3,880	8,794	10,653	117,346	183
White Fir	17	860	-	229	-	-	-	7	1,114	2
Wet Meadow	10,285	1,913	-	4,349	47	-	-	16,004	32,597	51

Source: Derived from FRAP data. Note: Includes the extent of urban and agriculture, as measured by FRAP. Provides a rough measure of the degree of settlement that has taken place on the Valley floor.

A multi-map reconstruction of historic vegetation and landcover in California's Central Valley[5] provides a glimpse of what much of the San Joaquin Valley floor looked like in 1850. About 62% of the region's 7,660,484 acres was grasslands, 38% was wetlands, water, or riparian habitats; and 20% was covered by alkali scrub (Figure 2). By comparing the historically-mapped area with the 2002 Fire and Resource Assessment Program (FRAP) map (Figure 3), we can assess the degree of conversion on the valley floor over the past 164 years (Table 1).

Since 1850, large portions of the valley floor have been converted to agricultural production, urban use, and other purposes, including energy production. The extent of open water and grasslands has declined by 58% and 44.9%, respectively. Riparian and other floodplain habitats declined by 98.5%; wetlands declined by 94% and alkali desert scrub declined by 94.3%. Whereas these five land types once represented 98.9% of the landcover, they now only represent 31%, indicating that about 69% of the valley floor has been converted. Of the areas that have been converted, more than 99% were converted to agriculture, urban, or rural residential categories, and 0.67% to increased valley hardwoods and chaparral. These numbers are approximations based on a reconstructed historic map, but nonetheless point to the high level of conversion that has occurred on the valley floor.

Conversion of the valley floor's natural lands and lakes was active in the late 1800's. By 1899, Tulare Lake was reduced to patches of wetlands and dry except during flood cycles, due to diversions of incoming waters for agriculture. This led to the widespread decline of Tule reeds (*Schoenoplectus acutus*), and the loss of a productive lake-based fishery. Additionally, the United States Government created a series of dams along the major rivers of the southern Sierra Nevada (including the Merced, San Joaquin, Kings, Kaweah, Tule and Kern rivers) during the early 1900's, in response to repeated requests from valley residents. These dams store water for late season use in the valley and have helped reduce the risk of flooding on cleared agricultural lands. However, their creation also contributed to the decline of lakes and wetlands on the valley floor. Some people suggest retaining more lake and wetlands on the valley floor could be a more efficient and ecologically-sensitive way to store water for use in times of drought.[6]

5 The central valley historic mapping project was conducted by Chico State, and published in 2003. The report that accompanies the GIS map used in this chapter can be found at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/docs/cmnt081712/sldmwa/csuchicodptofgeographyandplanningcentralvalley.pdf

6 http://www.indybay.org/newsitems/2009/07/11/18607139.php

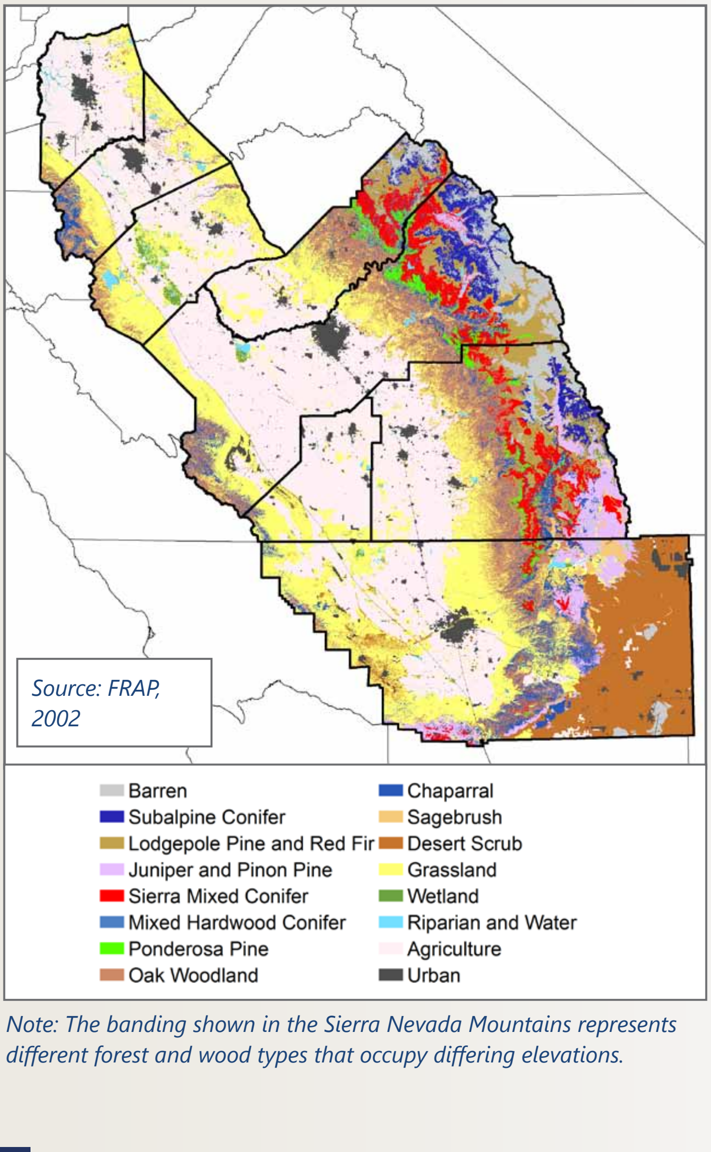
Current Landcover

The SJV Greenprint looked at two maps that portray current land patterns for the whole eight-county region – the Fire Resource and Protection Program (FRAP) map, 2002,[7] and the California Augmented Multi-source Landcover map (CAML),[8] a more recent compilation of multiple sources – to identify general patterns of native vegetation types across the whole region. FRAP identifies 41 California Wildlife Habitat Relationship (WHR) types. Annual grasslands and blue oak habitats are among the most extensive and occupy 5,728 and 2,005 square miles, respectively (Table 2). The elevations occupied by many vegetation types in the Sierra Nevada

7 California Department of Forestry and Fire Protection, Sacramento, CA. 2002.

8 Hollander, A. D. 2010. California Augmented Multisource Landcover Map (CAML 2010) [computer file]. Information Center for the Environment, University of California, Davis, California.

Figure 6. FRAP map, 2002, including foothills and forests

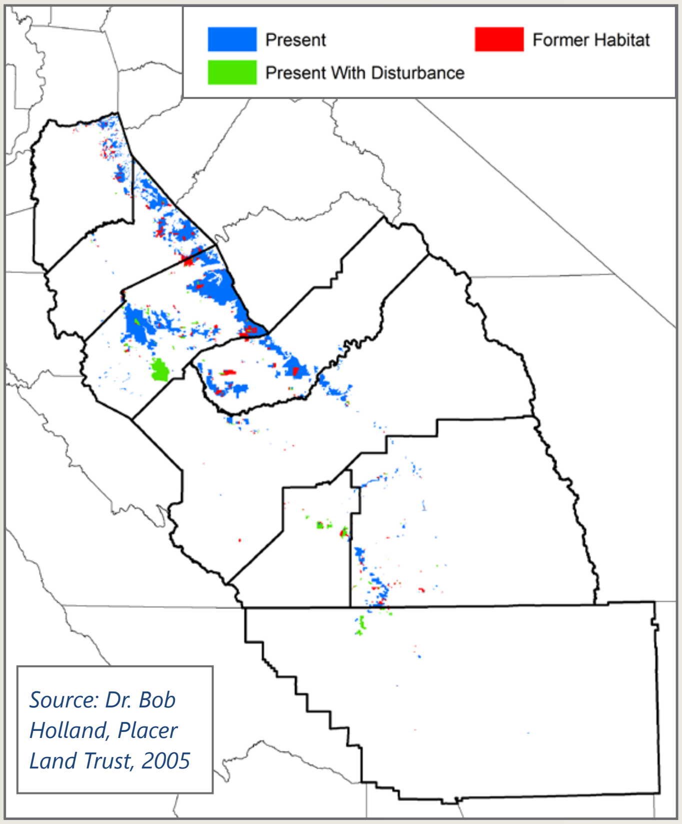


Note: The banding shown in the Sierra Nevada Mountains represents different forest and wood types that occupy differing elevations.

are visible in the FRAP map (Figure 6). The FRAP map also identifies 10,084 square miles of agriculture and urban land use in the region, though specific agricultural details are not provided.

The CAML map, which shows similar natural landcover patterns to FRAP, also identifies 11 types of agriculture, which are not differentiated in FRAP. Agricultural types interact with natural resources in different ways. First, they provide varying levels of utility as habitat to animals in the region. For example, alfalfa and irrigated grain crops are some of the better feeding habitats for Swainson's Hawks and migratory waterfowl. By contrast, orchards and vineyards have lower levels of utility for the majority of species that use altered landscapes. Second, different types of crops require differing levels of irrigation: alfalfa and almonds, for example, are among the higher consumers of this limited resource. [Further information about crop patterns is provided in Chapter 3: Agriculture.]

Figure 7. Vernal Pools



Source: Dr. Bob Holland, Placer Land Trust, 2005

Vernal Pools

Vernal pools are among the most important special habitat types in California. They have high-biodiversity value because of the many species that aggregate around these seasonal pocket wetlands. Based on vernal pool mapping by Dr. Bob Hollander in 2005,[9] the Greenprint aggregated three types of pools: Present, Present with Disturbance, and Former Habitat. The map in Figure 7 identifies 1,297 vernal pools and pool complexes in the eight-county San Joaquin Valley, with 603 listed as present, 101 present with disturbance, and 503 listed as former habitat. Merced, San Joaquin, and Stanislaus Counties have the highest number of vernal pools in relatively good condition (Table 3).

Native Plants and Animals

The San Joaquin Valley is home to a broad diversity of plant and animal species. There are 3,043 plant species, including 1,189 subspecies and varieties, according to the Calflora database of plant observations.[10] Some of these plant species are "endemic," meaning, they are found only in California. The number of California endemic plant species for each county in the region ranges from 100-250.[11]

For animals, there are 499 vertebrate species in the San Joaquin Valley, out of a total of 694 California vertebrates. By taxonomic group, these include 286 bird species, 128 mammal species, 28 amphibian species, and 57 reptile species. The SJV Greenprint determined these numbers

9 Coverage of vernal pool habitat in California's Central Valley for baseline period (1976-1995), 1997, and 2005. Source: Dr. Bob Holland, Placer Land Trust.

10 Calflora, http://www.calflora.org/

11 Thorne, J. H., J.H. Viers, J. Price, D. M. Stoms. 2009. Spatial patterns of endemic plants in California. Natural Areas Journal 29:137-148.

Table 3. Vernal pools in SJV counties

	Fresno	Kern	Kings	Madera	Merced	San Joaquin	Stanislaus	Tulare	Total
Present	41	12	8	63	179	170	153	67	693
Present With Disturbance	8	7	11	9	38	7	7	14	101
Former Habitat	26	12	19	40	130	112	100	64	503

Source: Dr. Bob Holland, Place Land Trust, 2005

Table 4. Number of species and observations in SJV counties

	Observations	Number of Species and Terrestrial Communities	Number of Listed Species	Number of Plant species	Number of Listed Plant Species	Number of Animal Species	Number of Listed Animal Species
Tulare	535	116	24	61	10	50	14
Stanislaus	179	55	16	18	6	35	10
San Joaquin	553	52	14	11	3	39	11
Merced	604	72	18	26	5	41	13
Madera	295	56	17	22	6	32	11
Kings	108	29	11	6	1	22	10
Kern	1067	137	30	62	11	69	19
Fresno	588	132	35	60	12	67	23

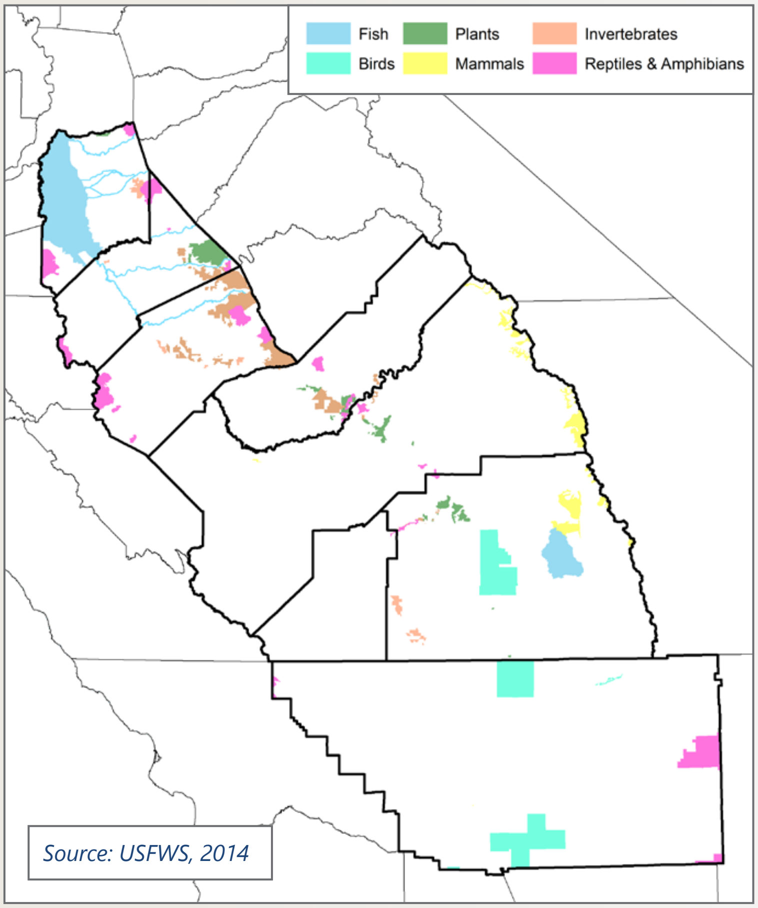
Source: CNNDB, 2014

based on an overlay of range maps from the California Wildlife Habitat Relationships Model (CWHR)[12] for the eight-county region.

Under federal law, the U.S. Fish and Wildlife Service lists current threatened, endangered, and species proposed for listing on their website.[13] For the eight-county region, they find ten fish (species and subspecies); four amphibians (+1 proposed and +2 candidate species); three reptiles; six birds (+ 1 candidate species); eight mammals (+1 candidate species); 24 plants (+1 candidate species); and seven invertebrate species.

Records of observed locations of rare plants and animals are maintained by the California Department of Fish and Wildlife in the California Natural Diversity Database (CNDDB). This geo-referenced list includes more than 3,929 observation records in the region since 1980. These records represent 237 rare plant and animal species and 13 critical habitats; and an additional 29 plant and 37 animal species that are listed as threatened, endangered, or as candidates to be listed under either the Federal or State Endangered Species Acts in the eight-county region. Table 4 lists the recorded observations of rare and special-status plant and vertebrate species in each county.

Figure 8: USFWS critical habitats



Source: USFWS, 2014

Under California law, and using the CNDDB records to find listed species, there are 17 plant species plus seven 'rare'; 3 amphibians and 2 candidate species; seven birds; four reptiles; eight mammals; and one fish species in the region. These species are a subset of the 29 plant and 37 animal species listed above.

12 *https://www.dfg.ca.gov/biogeodata/cwhr/*

13 *http://www.fws.gov/sacramento/es_species/Lists/es_species_lists-form.cfm*

Table 5. The species that are included in the critical habitats (Figure 8)

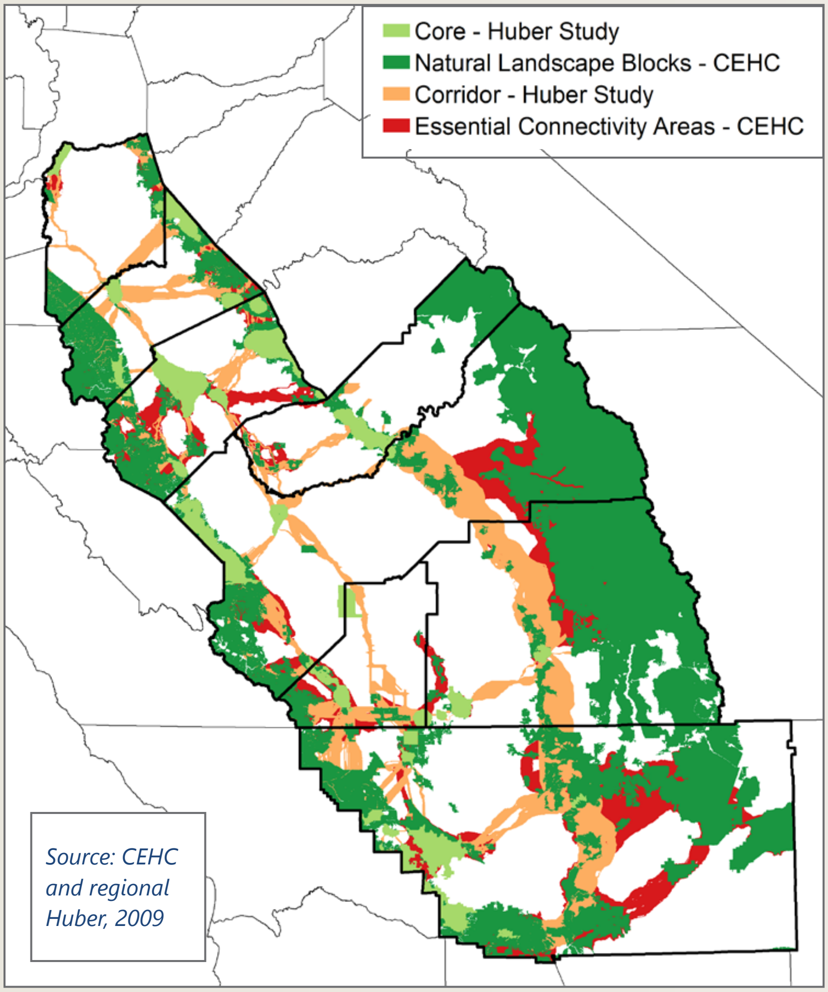
Category	Common Name	Scientific Name	State Status	Federal Status	Acres	Valley Floor
Birds	California Condor	Gymnogyps californianus	Endangered	Endangered	353,501	y
	Southwest Willow Flycatcher	Empidonax traillii extimus	Endangered	Endangered	4,558	n
Fish	Delta Smelt	Hypomesus transpacificus	Endangered	Threatened	317,424	y
	Little Kern Golden Trout	Oncorhynchus mykiss whitei	None	Threatened	82,334	n
	Steelhead - California Central Valley	Oncorhynchus mykiss	None	Threatened	502*	y
Reptiles and Amphib-ians	Alameda Whipsnake	Masticophis lateralis euryxanthus	Threatened	Threatened	2,024	n
	California Red-Legged Frog	Rana draytonii	None	Threatened	75,073	y
	California Tiger Salamander - Central Population	Ambystoma californiense	Threatened	Threatened	98,394	y
	Desert Tortoise	Gopherus agassizii	Threatened	Threatened	80,514	n
	Mountain Yellow-Legged Frog - Northern California DPS	Rana muscosa	Endangered	Proposed Endangered	220,485	n
	Sierra Nevada Yellow-Legged Frog	Rana sierrae	Threatened	Proposed Endangered	264,958	n
	Yosemite Toad	Anaxyrus canorus	None	Proposed Threatened	410,931	n
Inverte-braes	Conservency Fairy Shrimp	Branchinecta conservatio	None	Endangered	89,496	y
	Longhorn Fairy Shrimp	Branchinecta longiantenna	None	Endangered	3,165	y
	Vernal Pool Fairy Shrimp	Branchinecta lynchi	None	Threatened	206,286	y
	Vernal Pool Tadpole Shrimp	Lepidurus packardi	None	Endangered	83,698	y
Mammals	Buena Vista Lake Shrew	Sorex ornatus relictus	None	Endangered	84	y
	Fresno Kangaroo Rat	Dipodomys nitratoides exilis	Endangered	Endangered	888	y
	Sierra Nevada Bighorn Sheep	Ovis canadensis sierrae	Endangered	Endangered	129,375	n
Plants	Colusa Grass	Neostapfia colusana	Endangered	Threatened	144,379	y
	Fleshy Owls Clover	Castilleja campestris ssp. succulenta	Endangered	Threatened	163,579	y
	Greenes Tuctoria	Tuctoria greenei	Rare	Endangered	120,798	y
	Hairy Orcutt Grass	Orcuttia pilosa	Endangered	Endangered	77,363	y
	Hoover's Spurge	Chamaesyce hooveri	None	Threatened	111,806	y
	Keck's Checkermallow	Sidalcea keckii	None	Endangered	1,081	y
	Large Flowered Fiddleneck	Amsinckia grandiflora	Endangered	Endangered	160	n
	San Joaquin Orcutt Grass	Orcuttia inaequalis	Endangered	Threatened	126,780	y

Source: California Department of Fish and Wildlife, 2014, http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/TEAnimals.pdf, http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/TEPlants.pdf
** Fish species habitat measured in stream miles, not acres.*

When plants and animals are listed as “threatened” or “endangered” under the Federal Endangered Species Act, the U.S. Fish and Wildlife Service is responsible for the development of plans to “recover” the species and subsequently delist them after recovery. Critical habitat is often included as part of the recovery plan and is defined by the Endangered Species Act[14] as habitat that contains features essential for conservation of threatened and endangered species. Critical habitats, according to the USFWS, for various species in the eight county region are shown in Figure 8. In aggregate, these areas represent locations that are suitable for 28 of the listed species, which are displayed in Table 5. Note that several well-known listed species such as the San Joaquin Kit Fox do not show up on the table, because while they have recovery plans, those plans do not include critical habitat maps.

14 *Endangered Species Act, Section 7; http://www.fws.gov/ENDANGERED/laws-policies/index.html*

Figure 9. Regional Wildlife Connectivity



Regional Connectivity Models

Two assessments of regional wildlife connectivity needs have been made for the San Joaquin Valley: the California Essential Habitat Connectivity (CEHC) assessment conducted by Caltrans,[15] and a regional analysis conducted by Huber, et al.[16] These analyses are based off of recognized benefits of preserving or restoring connections between large blocks of natural habitat along the lines most likely to be traversed by animals. Figure 9, a combination of both models, shows the zones most likely to be used. Planners and others can use these maps to assess whether wildlife connectivity is a concern in project areas, and to evaluate what options might be available to maintain or restore it.

15 Spencer, W.D., P. Beier, K. Penrod, K. Winters, C. Paulman, H. Rustigian-Romsos, J. Strittholt, M. Parisi, and A. Pettler. 2010. California Essential Habitat Connectivity Project: A Strategy for Conserving a Connected California. Prepared for California Department of Transportation, California Department of Fish and Game, and Federal Highways Administration. http://www.dot.ca.gov/hq/env/bio/project_materials.htm

16 Huber, P. R., S. Greco, J. H. Thorne. 2010. Spatial scale and its effects on conservation network design: trade-offs and omissions in regional versus local scale planning. Landscape Ecology. 25: 683-695. http://www.springerlink.com/content/c3564585tt2uj64l/

Detailed Sub-Regional Maps

The detail in maps of vegetation patterns across the Valley is inconsistent, but detailed sub-regional maps, where available, provide a great deal of information useful for planning purposes. The California Department of Fish and Wildlife provides a detailed map of vegetation in the Sacramento-San Joaquin River Delta region (Figures 10a and 10b) in the northern part of the Valley. The regional map identifies about 53,280 acres of wetland habitats, 59,740 acres of riparian vegetation, and 36,483 acres of riverine habitat. The map's detailed inventory can provide useful targets for conservation, especially in light of wide-scale reductions of wetland, riparian, and riverine habitats identified by USFWS as critical habitat. There is a need for similarly detailed vegetation maps of the entire valley floor and foothill lands to identify remnant patches of native vegetation (like willows along minor depressions) and document the extent of riparian zones, especially in the foothills.

Conclusions and Considerations

In sum, the biodiversity of the SJV Greenprint region remains relatively intact at higher elevations, but has been greatly impacted on the valley floor. Conservation efforts such as the management of reserves and easements, re-establishment of riparian zones and wildlife corridors, reintroduction of wildlife such as tule elk and California condor, have led to a greater awareness of the needs of native species. However, due to the extensive conversion of natural habitats, particularly on the valley floor, there is a need to conserve what remains to support biodiversity and ecosystem processes.

As planners and resource managers make land use and conservation prioritization decisions, the regional perspective provided by the SJV Greenprint can help inform questions such as:

» What groundwater recharge zones can also provide high value wildlife habitat?

Figure 10a. Delta/North Valley vegetation

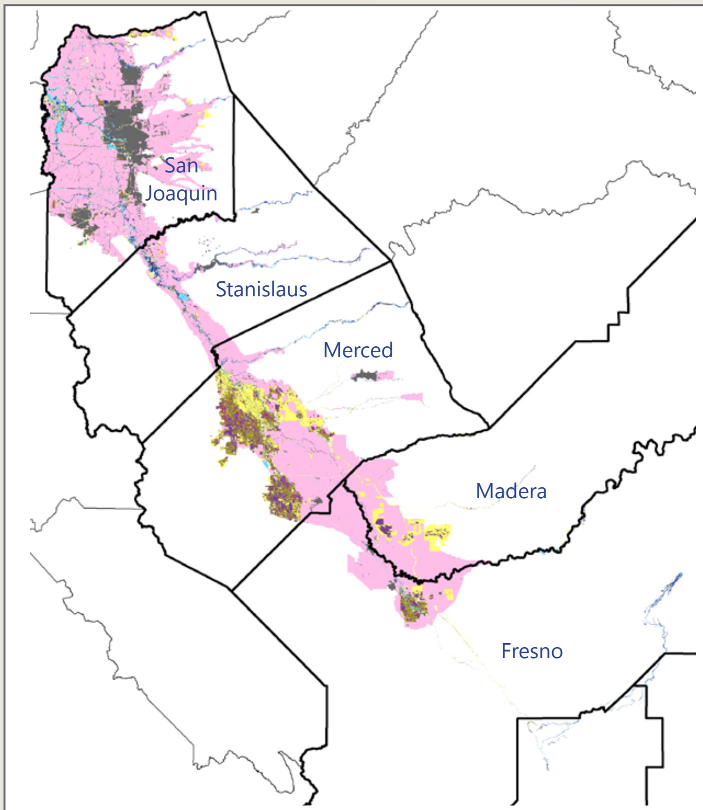
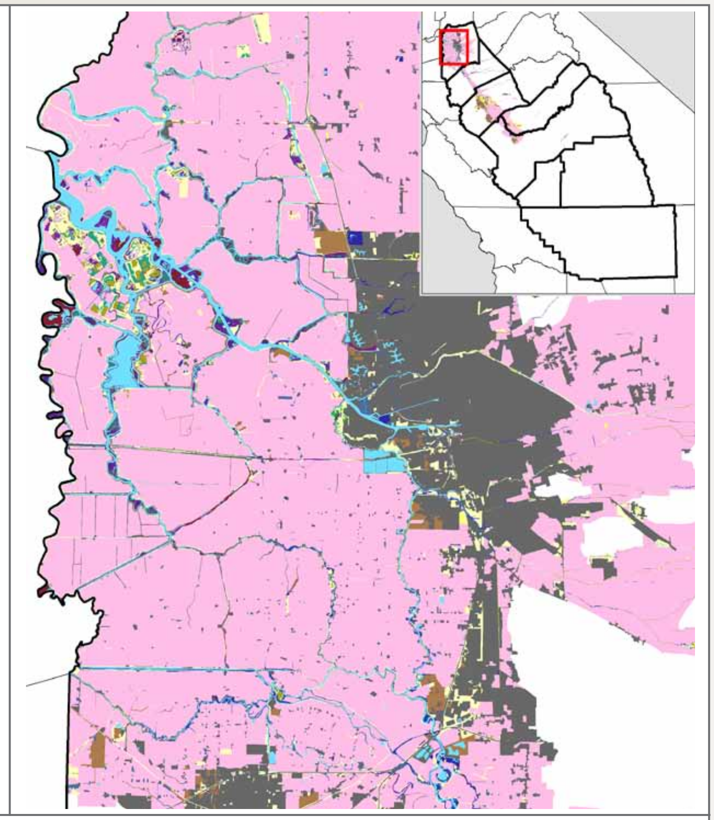


Figure 10b. Detailed vegetation, Merced County



Source: California Department of Fish and Wildlife, 2011

- Where can riparian restoration efforts be combined with wildlife corridors and other needs?
- Where can we restore biodiversity and connect wildlife habitats, while also achieving other land use benefits like riverside parks for recreation?
- Can we identify areas for urban and energy development that also minimize impacts to wildlife and ecosystem processes?
- Where are high-priority habitats for rare species that proposed development projects can avoid or prepare to mitigate for?
- Where can agricultural practices also provide wildlife habitat benefits?
- What agricultural lands have relatively low value that might be retired and used for habitat restoration?
- Where can flood management modifications positively contribute to habitat availability?

The San Joaquin Valley Greenprint and its interactive mapping portal provide access to information and tools to help answer these questions and the myriad other interconnected resource decisions in the San Joaquin Valley. As a comprehensive collection of data on natural and developed resources in the Valley's rural lands, the SJV Greenprint gives planners, resource managers, and decision-makers, as well as the public, the ability to layer various resource values on top of one another to evaluate development decisions through a regional lens. With these tools, any resident or stakeholder can investigate the complexity of planning decisions and contribute to the environmental and economic viability of the San Joaquin Valley.

4 State of the Valley: ENERGY

Stock photo

Key Points

- As of January 2014, the San Joaquin Valley has about 63 thousand active oil or gas wells.
- Almost 90% of the active wells are on vacant or disturbed land (Based on the 2010 FMMP), a majority of which would probably be grazing land.
- In 2012, the Valley produced 155 million barrels of oil and 144 billion cubic feet of natural gas.
- The 2012 oil production had a value of $16.4 billion and natural gas $480 million.
- The Valley's oil production is 80% of the State's and 6% of the nation's oil production.
- Hydraulic fracturing a well in California requires a daily average of 164,000 gallons of water per well.
- In 2012, 68 million barrels of formation water (generally saline water that comes from the same geologic formation as the oil) were produced in the San Joaquin Valley.
- The San Joaquin Valley has 27 major active solar generation facilities capable of producing 496.4 MW of electricity.
- The largest number of active major solar generation facilities are in Fresno County.
- Wind energy is the second largest source of electricity in the Valley behind oil and gas burning power plants.
- Wind energy can produce 3656.9 MW. 3000 MW of that total is from the Tehachapi region of Kern County.

Overview

The San Joaquin Valley is a center for both energy production and transmission in California. The Valley's largest contribution to the State's power system comes from more than 80 conventional oil/gas power plants that create more than 7,500 megawatts (MW).[1] The southern end of the San Joaquin Valley is a major petroleum-producing region, accounting for approximately 6% of the nation's oil production, though every county in the Valley produces some oil or natural gas. Wind farms span the northern and southern ends of the Valley, generating more than 3,657 MW of power, the Valley's second largest source of electricity. Hydropower provides 3,600 MW. The eight San Joaquin Valley counties have 27 solar electricity-generating plants that produce more than 496 MW of power, with more plants in planning stages. Biomass electrical generation is the last major contributor at just under 440 MW.

Many of the State's major electrical transmission lines pass through the San Joaquin Valley as they connect Northern and Southern California. The California Energy Commission and its collaborators, both public and private, identified regions around the state with the right climate conditions to generate renewable energy resources and the ability to transmit that energy to the State's power grid. Many of these lie within the Valley's eight counties.

1 Power Plant information for all operational power plants with capacity greater than 0.1 MW, provided by Jacque Gilbreath, California Energy Commission, on 6/9/2014. Generation capacities are the maximum output in MW.

Fossil Fuels

The San Joaquin Valley has a long and productive history of fossil fuel production.[2] The fossil fuel industry in the Valley produces both oil and natural gas. Oil is by far the more valuable, but natural gas is a substantial regional product. Within the Valley, the production of both oil and natural gas requires drilling wells and installing infrastructure (pipes and roads) to collect and transport the product for processing or distribution. Much of the natural gas coming from the Valley is collected as a byproduct of extracting oil, and is known as "associated gas," although there are also natural gas only wells in the Valley.

Kern County is well-known as a petroleum producer, though oil or gas wells are present in all counties in the Valley. As of January 2014, the California Department of Conservation's (DOC) Division of Oil, Gas, and Geothermal Resources (DOGGR) reports 63,238 active wells, 8,082 idle, and 11,222 wells classified as being new and in the process of being drilled across 166 oil fields. Of these wells, the vast majority occur in Kern County.

Of the approximately 63,000 active wells, 56,600 are on land classified by the DOC's Farmland Mapping and Monitoring Program as vacant or disturbed. The grazing category of land holds about 3,500 wells, and prime farmland 1,700. Most of the vacant or disturbed land with oil wells is hilly and would likely be grazing land if not for the petroleum operations.

Based on DOGGR's most recent available report on oil and gas production,[3] seven of the top ten oil fields in the state

2 *ftp://ftp.consrv.ca.gov/pub/oil/history/History_of_Calif.pdf*

3 *ftp://ftp.consrv.ca.gov/pub/oil/annual_reports/2012/PR03_PreAnnual_2012.pdf*

Figure 1a. Well location and status with Oil Field boundaries and DOGGR Districts.

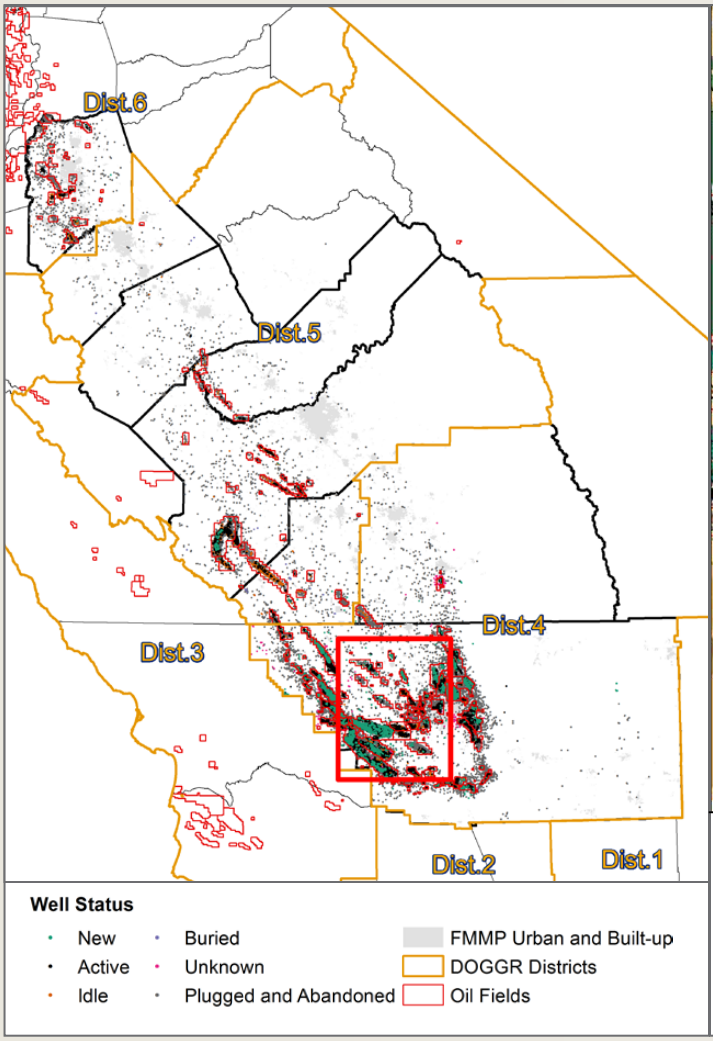
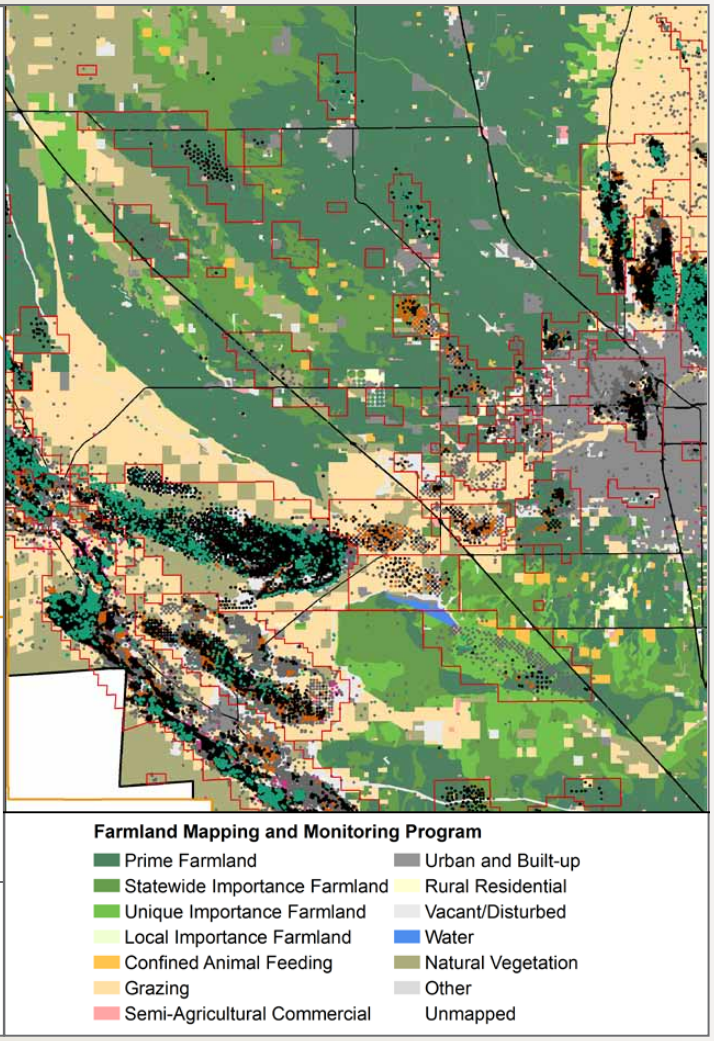


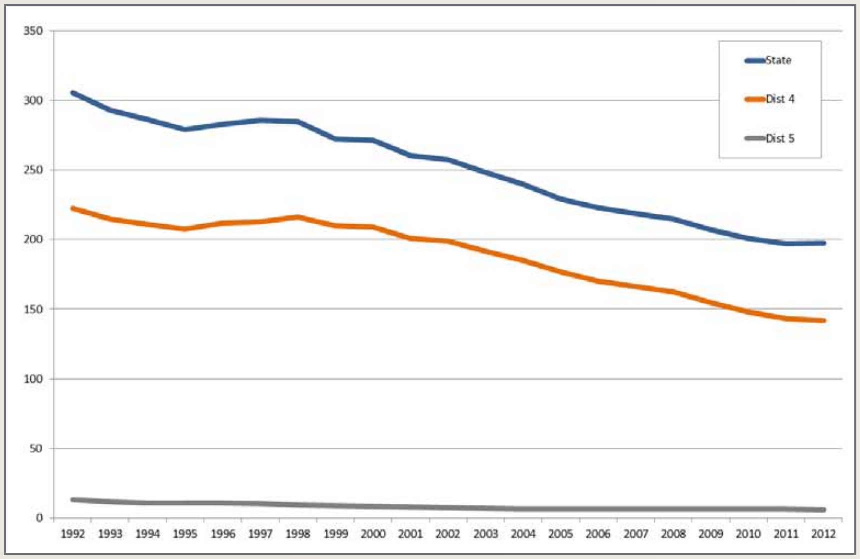
Figure 1b: An inset of a portion of Kern County is presented for detail.



Source: DOGGR

Figure 2. Districts 4 and 5 oil production

Total California production for comparison. Units are in millions of barrels



Source: DOGGR annual reports

are within the San Joaquin Valley. The Valley produced approximately 155 million barrels of oil and 144 billion cubic feet of natural gas in 2012. This represents almost 80% of the state's oil production (6% of national production) and 65% of the state's gas production (less than 1% of national production), valued at $16.4 billion and $480 million, respectively, based on December 31, 2012 prices per barrel of oil.[4]

The San Joaquin Valley spans three DOGGR districts, with District 4—covering the counties of Kern, Tulare, and Inyo—being the dominant producer in the state. District 5, further north, produces much less oil (ranging between 3 and 5 percent of District 4's production) and covers the counties of Kings, Fresno, Madera, Merced, most of Stanislaus, Mariposa, Tuolumne, and Mono. District 6 includes almost all of Northern California, including San Joaquin County. Within San Joaquin County there are a few small volume natural gas producing wells, but almost no oil.

Oil production has been decreasing in the Valley (Figure 2). Because District 4 comprises such a large portion of the state's production, the state's trends largely follow those of the district. Both District 4 and the State have seen steady decreases in production since 2002. Between 2004 and 2012, Valley oil production decreased approximately 12% and California totals decreased at a rate of about 8%. The U.S. Energy Information Administration revised a prior report indicating that Monterey Shale oil reserves contained 13.7 billion barrels of recoverable oil to 600 million barrels in early 2014.[5]

A significant byproduct of oil and gas extraction is large quantities of water (68 million barrels in 2012 for Districts 4 and 5, according to the 2012 production report). The water is generally saline with high concentrations of heavy metals, including low-grade radio nuclides, which must be disposed of through evaporation ponds or injection wells, or treated and tested prior to occasional reuse as irrigation water.[6] Evaporation ponds allow the water to evaporate, leaving behind the salts and metals that are usually relocated to disposal sites. Injection wells dispose of the water by pumping it at very high pressure deep underground from whence it came. It is important to note that the water produced comes from the same geologic formations that contain the oil and does not come from the normal surface or near surface water sources. This water is toxic for most other uses without treatment and has been implicated as a health risk for humans and wildlife.[7]

Hydraulic Fracturing – In the past five years, hydraulic fracturing (also known as fracking or well stimulation) has re-invigorated the oil industry in the United States, and there is great interest in its development in California. The widespread use of well stimulation, however, is a concern for many reasons including water quality, surface contamination, and related transportation and land conversion. The California Department of Conservation (DOC) developed interim regulations for well stimulation (effective January 1, 2014), and will author permanent regulations to be effective for 2015 and beyond.[8] The DOC will prepare a comprehensive Environmental Impact Report for well stimulation across the State.

The well stimulation technique of hydraulic fracturing pressurizes wells with water to fracture surrounding rock to extract more oil and gas. Though it requires significant use of water, California reserves appear to be using substantially less water than in many other parts of the United States. The Western States' Petroleum Association and the well logs filed with the DOC indicate that, on average, hydraulic fracturing requires approximately 164,000 gallons of water

4 $105.65 per barrel of Midway-Sunset 13 degree API gravity crude oil on 12/31/2012 (ftp://ftp.consrv.ca.gov/pub/oil/annual_reports/2012/PR03_PreAnnual_2012.pdf) and $3.35 per thousand cubic feet of natural gas in December of 2012 (http://www.eia.gov/dnav/ng/hist/n9190us3m.htm)

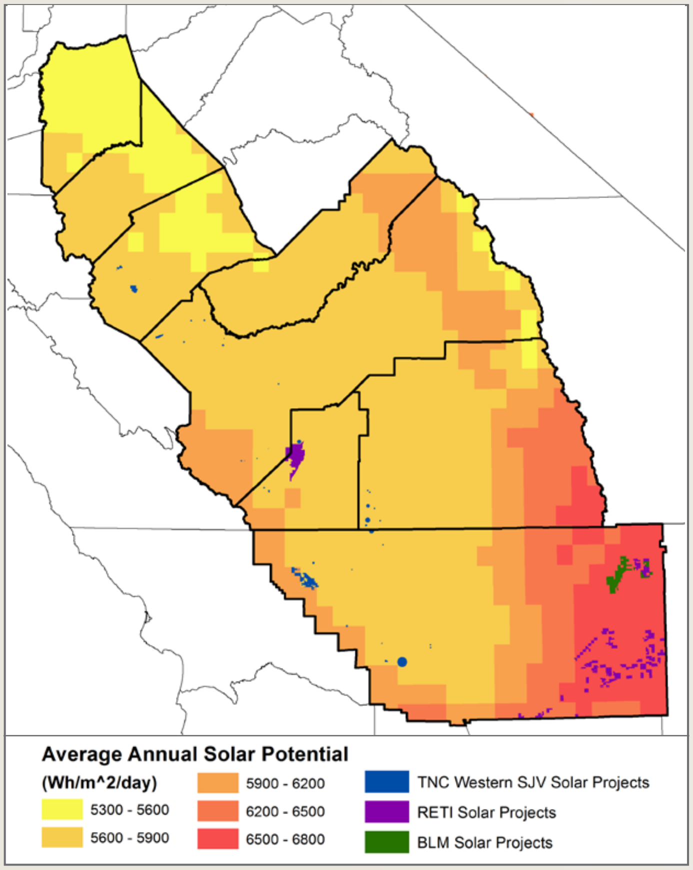
5 http://www.reuters.com/article/2014/05/21/eia-monterey-shale-idUSL1N0O713N20140521, A detailed report is expected sometime in June 2014.

6 http://www.gao.gov/assets/590/587522.pdf

7 Ramirez, Pedro. "Bird Mortality in Oil Field Wastewater Disposal Facilities." Environmental Management 46, no. 5 (November 2010): 820–26. doi:10.1007/s00267-010-9557-4. http://www.usbr.gov/research/AWT/reportpdfs/report157.pdf

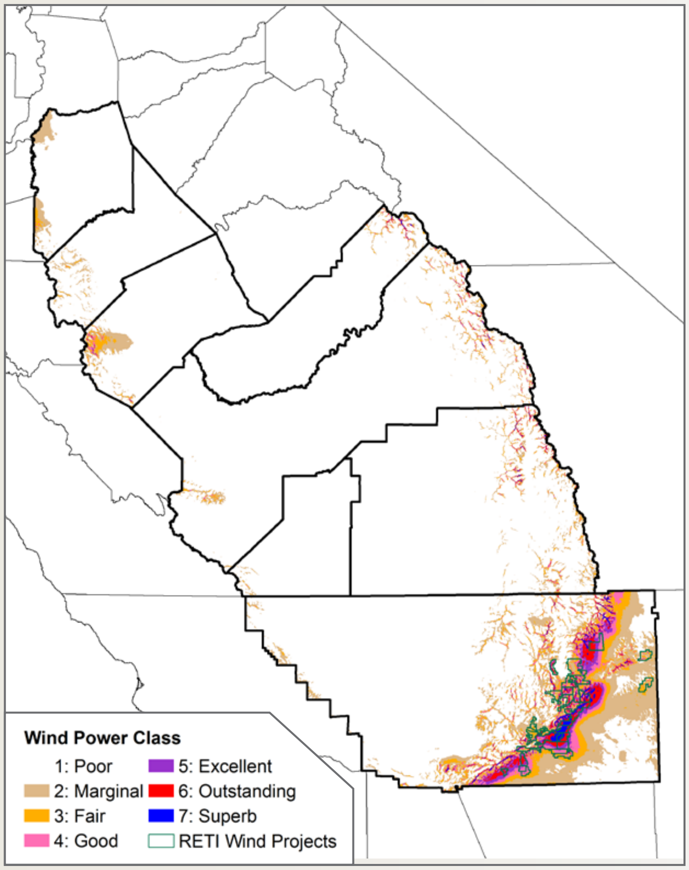
8 http://www.conservation.ca.gov/dog/Pages/Index.aspx

Figure 3. Solar energy potential



Source: Computed by NREL, with TNC, RETI and BLM projects mapped

Figure 4. Wind energy potential and identified wind energy projects



Source: Wind energy calculated by NREL in Wind Power Classes; wind project sites identified by RETI

(a golf course uses around 300,000 gallons per day).[9] By comparison, hydraulic fracturing of Pennsylvania deposits consumes 4.5 million gallons per well.

Renewable Energy

Solar – The San Joaquin Valley has become a "hot spot" for solar energy generation. With plentiful sun and high solar energy potential, many portions of the Valley—particularly along the western, southern, and southeastern (Mojave Desert) areas—have been scouted for potential solar farms.

Across the eight-county region, there are 27 solar energy generation facilities producing at least 100 KW. The largest number are in Fresno County (12) followed by Kings and Tulare (5 each), Kern (3), and both San Joaquin and Stanislaus have one. The total solar electricity production capacity for the San Joaquin Valley counties is 496.4 MW.[10] It is worth noting that while Fresno has the largest number of solar plants, Kern County's plants are larger and produce almost as much energy from three plants as Fresno County does from twelve.

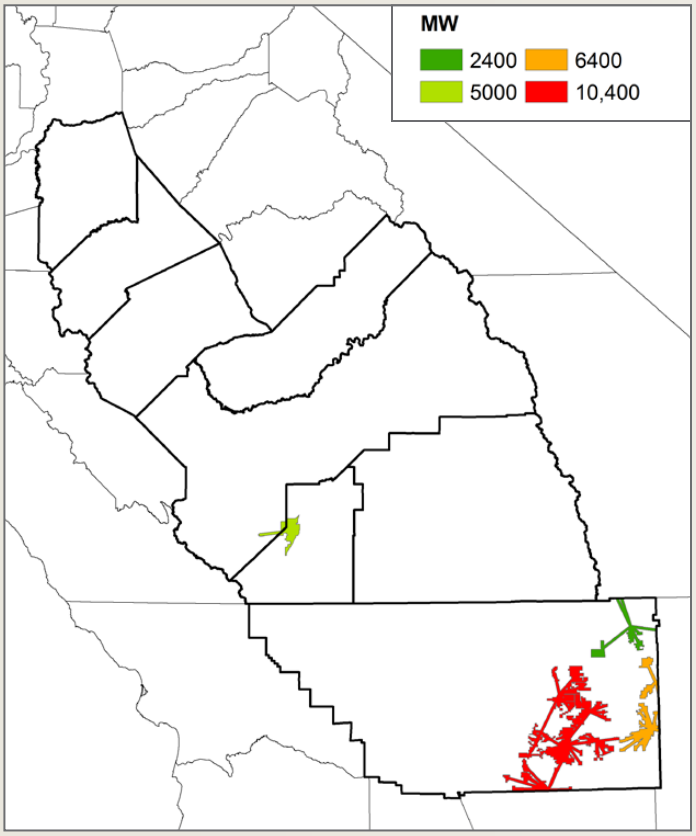
Some groups, from farmers to environmentalists, are concerned about the Valley's initiatives to generate solar energy because these projects compete for space with agricultural, environmental, and fossil fuel interests. Recognizing these potential conflicts, The Nature Conservancy (TNC) recently conducted a study in the Western San Joaquin Valley to identify areas with the least conflict between native species, habitats, and solar project sites.[11] Although there is limited information on specific locations for projected solar projects, TNC assembled a good representation for their study area, which can be combined with data from the Bureau of Land Management and the Renewable Energy Transmission Initiative (RETI), a collaborative including state agencies and publicly-owned

9 *http://www.sfgate.com/science/article/Fracking-in-California-takes-less-water-3850860.php*

10 *Power Plant information for all operational power plants with capacity greater than 0.1 MW provided by Jacque Gilbreath, California Energy Commission, on 6/9/2014. Generation capacities are the maximum output in MW.*

11 *http://scienceforconservation.org/downloads/WSJV_Solar_Assessment*

Figure 5. REIT CREZs, with total energy generation capacity for wind, solar, biomass and geothermal



Source: (computed by NREL) with TNC, RETI and BLM proejcts

and privately-owned utilities. These potential sites are shown in Figure 3, which also shows annual solar energy potential from the National Renewable Energy Laboratory (NREL) for photovoltaic production.[12] Some of these projects have been identified by informed speculation and others have been approved for construction. Some of the data drawn for this analysis are several years old.

Wind – The Tehachapi mountain region has long been a focal point for wind energy generation. Figure 4 demonstrates its high potential for generating wind energy, and the several projects that are already underway there. The region's wind energy production, however, has been hampered by a history of conflict between wind power and native species, particularly raptors and migrating birds.

The eight-county region has a generation capacity of 3,657 MW from the wind. More than 3,000 MW of that is generated in Kern County. San Joaquin County generates 600 MW and Merced 17 MW. Wind energy is the second largest energy source in the Valley behind oil and natural gas, and slightly ahead of hydropower.

12 http://www.nrel.gov/gis/data_solar.html

The Renewable Energy Transmission Initiative (RETI),[13] a working group of the California Energy Commission, has prepared a list of locations with potential for viable, commercial solar and wind projects. The Competitive Renewable Energy Zones (CREZ)[14] identified in RETI underwent substantial analysis to identify the potential capacity for generation in each CREZ. Four CREZ overlap the San Joaquin Valley. One on the Fresno-Kings County border is a high solar energy potential site, while the remaining three are all in Kern County and have a mixture of wind and solar, with small amounts of geothermal and biomass-based electricity generation.

Conclusion & Considerations

Energy production in the San Joaquin Valley is a significant factor in the overall growth and progress of the San Joaquin Valley. Its development poses many challenges, and with careful consideration, opportunities as well. In the regional context of the Valley's planning and resource management decisions, the following are some questions to consider:

- What areas in the eight San Joaquin Valley counties are the most suited to solar energy production, and what other resource trade-offs are made by selecting a location?
- What areas are most suited to wind energy generation? And what other effects may that development have?
- Where are there existing fossil fuel operations? If operations expand, what conflicts may arise with other resources?

The San Joaquin Valley Greenprint and its interactive mapping portal provide access to information and tools to help answer these energy-related questions and the myriad other interconnected resource decisions in the San Joaquin Valley. As a comprehensive collection of data on natural and developed resources in the Valley's rural lands, the SJV Greenprint gives planners, resource managers, and decision-makers, as well as the public, the ability to layer various resource values on top of one another to evaluate development decisions through a regional lens. With these tools, any resident or stakeholder can investigate the complexity of planning decisions and contribute to the environmental and economic viability of the San Joaquin Valley.

13 http://www.energy.ca.gov/reti/

14 The CREZs are geographic areas with high potential for commercially viable renewable energy that are positioned to link to existing electrical transmission corridors.

6 Next Steps and Conclusion

Pixley Wildlife National Refuge© Niki Woodard

Next Steps

With the completion of the San Joaquin Valley Greenprint's primary map assembly efforts, the publication of this report, and the launch of the complete website and Mapping Portal, the SJV Greenprint has a foundation on which to proceed with future efforts. The Greenprint's next steps include the following tasks:

- Outreach — to increase awareness of the Greenprint resources, especially to the eight counties, and to present the trends and conditions in the Valley that the mapping and analysis are suggesting, including the challenges and opportunities.
- Pilot projects — to incorporate Greenprint map resources into local land use planning that provide real world utility and value.
- Look for opportunities to align the Greenprint with State and Federal initiatives — to enhance relevance and secure resources for an ongoing Greenprint resource mapping program (e.g. Central Valley Ag Plus, AB 32 Five-year Roadmap).
- Review and document existing policies, programs and implementation tools in use in the Valley.
- Identify conflicts in regulations, policies, or government actions.
- Identify strategies and tools — help the Valley achieve economic growth and resource sustainability.
- Additional mapping and analysis — identify shortfalls or gaps, provide training to access and interpret maps, update and incorporate new maps as information becomes available.
- Publish a guide for resource management to provide a range of specific policies and implementation tools that governments, businesses and communities can self-select to address their economic and resource objectives.

The San Joaquin Valley is not the only California region developing a greenprint, and different regions around the state are using them in a variety of ways. The following are short profiles of some of the major efforts in other regions.

Habitat and Biodiversity Focused Greenprints

Greenprints often share similarities with the state and federal Natural Communities Conservation Plans (NCCP) and Habitat Conservation Plans (HCP), which are usually developed to mitigate a set of environmental impacts from a given list of projects. Greenprints, however, tend to address a broader array of uses and compile maps not only for species mitigation, but for assessment of a variety of landscape attributes including agricultural lands, riparian and wildlife corridors, hydrology, ecosystem services, and other regional resources. They tend to be advisory rather than regulatory in nature, with an emphasis on avoidance rather than mitigation.

The Bay Area Conservation Lands Network is perhaps the most complete regional effort to date. Through a 5-year exercise involving dozens of local governments, agencies, and stakeholders, they created a detailed landcover map identifying a portfolio of high-priority conservation areas. The maps associated with this exercise are provided online for public use. Since the maps provide a regional view for the nine Bay Area counties, they can be used by many government bodies and citizen groups in their planning efforts to create an expanded regional conservation network. The Bay Area plan focuses specifically on the maintenance of biodiversity and ecosystem services, and participants are currently working on an assessment of the possible impacts from climate change on all open space lands in the region.

Several counties and smaller regions in California are developing county-level Greenprints, typically focused on conservation objectives. Two examples are the Santa Cruz County Conservation Blueprint effort and the Santa Clara Valley Greenprint effort .

Regional Advanced Mitigation

In the southern-most part of California, the San Diego Association of Governments (SANDAG) is at the forefront of implementing regional conservation objectives by linking land mitigation requirements for transportation infrastructure projects to the acquisition of key conservation lands identified in their version of a greenprint. Their forward-thinking mitigation planning is called, the TransNet Environmental Mitigation Program, and is similar to state efforts known as Regional Advance Mitigation Planning (RAMP). RAMP integrates regional maps of important landscape features with assessments of ongoing development.

RAMP offers a way for Regional Transportation Planning Agencies (RTPAs) and other infrastructure agencies to implement regional sustainability designs. Mitigation investments, such as the purchase of lands to offset impacts of construction on listed species, are preferentially selected from a portfolio of areas that have been identified as high-priority for conservation or other reasons. As long as the areas purchased also meet the requirements for preservation of impacted species or agriculture, then selection of those lands provides a double benefit to the public: it meets the legal requirements of mitigation and contributes to open space objectives defined by stakeholders.

While developed in California (with parallel processes going on in other states), the RAMP approach has garnered interest at all levels of government, with federal adoption of the framework within the Department of Interior; state initiatives in California's Departments of Transportation and Water Resources; and a number of county-level initiatives. Funding the process remains a challenge, though San Diego County has calculated that savings to the taxpayer warrant the investment. In 2004 the San Diego County voters approved a county sales tax to begin acquiring lands.

The Orange County Transportation Authority (OCTA) also uses this approach and the county has purchased several parcels identified through a Greenprint stakeholder process. Like San Diego, OCTA is utilizing funds collected from a transportation infrastructure sales tax (measure M), and calculates that this proactive approach provides long-term benefits and savings to the taxpayer.

Rural-Urban Connection Strategy (RUCS)

The Rural-Urban Connections Strategy (RUCS) is a program managed by the Sacramento Council of Governments (SACOG). In this region, planners developed maps and a regional assessment that focus on the economics of maintaining a healthy balance between the region's agricultural economy and the expanding urban areas. RUCS uses data modeling tools to create and test alternative scenarios for agricultural production and evaluates how those changes affect a variety of agricultural inputs and outputs such as water, labor, truck trips, costs, revenues, agricultural tourism, and supporting industries. The RUCS program has earned considerable support by facilitating relationship-building between urban and agricultural stakeholders. While the initial objectives of RUCS revolved around the agricultural economy, it is now expanding to include more environmental and ecosystem service assessments.

Conclusion

The land use challenges facing the eight counties of San Joaquin Valley are significant, with few easy solutions. Water will continue to be a limiting resource, with tensions among urban, agricultural, and environmental uses. Agricultural and natural lands will continue to face conversion pressures as Valley planners and stakeholders weigh the costs and benefits of various land use choices. Economic growth and elevating the region's quality of life will also continue to be leading topics of discussion.

Despite its challenges, the region has many opportunities for coordinated economic growth and resource management. The SJV Greenprint exists as a resource to help Valley decision-makers and stakeholders address regional problems and find solutions.

Now that the first phase of the SJV Greenprint is complete, with the assembled maps and data layers available for use online, the SJV Greenprint Committee puts this tool into the hands of Valley decision-makers and stakeholders to begin utilizing the data to inform and support their planning and decision-making processes. The platform provided by the current map and data collection serves as a starting point for many paths forward.

Regardless of the future shape it takes, the purpose of the SJV Greenprint remains to provide a valuable tool that can inform projects, plans, partnerships, and policies that accommodate regional growth while safeguarding the natural resources required to support growth and enhance quality of life throughout the Valley.

Appendix 1: Abbreviations

BLM	Bureau of Land Management (USDI)
CAML	California Augmented Multi-source Landcover Map
DOC	California Department of Conservation
CADFW	California Department of Fish and Wildlife
DWR	California Department of Water Resources
CNDDB	California Natural Diversity Database
SWRCB	California State Water Resources Control Board
CASGEM	California Statewide Groundwater Elevation Monitoring (DWR)
CVFPP	Central Valley Flood Protection Plan
CVP	Central Valley Project
CREZ	Competitive Renewable Energy Zones
COG	Council of Governments
DAC	Disadvantaged Community
DOGGR	Division of Oil, Gas, and Geothermal Resources (DOC)
ESA	Endangered Species Acts
EIR	Environmental Impact Report
FMMP	Farmland Mapping and Monitoring Program (DOC)
FRAP	Fire and Resource Assessment Program
GAMA	Groundwater Ambient Monitoring & Assessment Program
HSR	High Speed Rail
HR	Hydrologic Regions
ICE	Information Center for the Environment (University of California at Davis)
NASS	National Agricultural Statistics Service
NPS	National Park Service
NRCS	Natural Resources Conservation Service (USDA)
NREL	National Renewable Energy Laboratory
RETI	Renewable Energy Transmission Initiative
SJV	San Joaquin Valley
SSURGO	Soil Survey Geographic Database, National Cooperative Soil Survey (NRCS)
SWP	State Water Project
TNC	The Nature Conservancy
BOR	United States Bureau of Reclamation (USDI)
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USFWS	United States Fish and Wildlife Service (USDI)
USGS	United States Geological Survey (USDI)
WHR	Wildlife Habitat Relationship (California)

Appendix 2: Data Layers

The following table lists the maps and data assembled by the SJV Greenprint team. These maps are all in GIS form, and are described in more detail in the technical report found on the website. The maps are also available for viewing and download through the mapping portal on the website (http://sjvgreenprint.ice.ucdavis.edu). The Information Center for the Environment is not the original source of most datasets. The Greenprint team recommends that users check the original sources for updates, and contact original data providers if questions arise about how to use the materials.

Theme	Map Name	Data Source	Source Date
Administrative Boundaries	Air Quality Basins	CA Air Resources Board	2004
Administrative Boundaries	Air Quality Districts	CA Air Resources Board	2004
Administrative Boundaries	BLM Federal and State Surface Estate	U.S. Bureau of Land Management	2012
Administrative Boundaries	BLM Grazing Allotments	U.S. Bureau of Land Management	2011
Administrative Boundaries	BLM Historic Grazing Allotments	U.S. Bureau of Land Management	2011
Administrative Boundaries	BLM Land Use Planning Areas	U.S. Bureau of Land Management	2012
Administrative Boundaries	California Protected Areas Database (CPAD)	GreenInfo Network/California Strategic Growth Council	2013
Administrative Boundaries	City Limits	San Joaquin Valley Counties	2012
Administrative Boundaries	County Boundaries	CalAtlas	2005
Administrative Boundaries	Disadvantaged Communities	CA Dept of Water Resources	2010
Administrative Boundaries	Incorporated City Limits	CalFire	2013
Administrative Boundaries	National Conservation Easement Database	U.S. Endowment for Forestry and Communities	2012
Administrative Boundaries	National Landscape Conservation System (NLCS) Wilderness Areas	U.S. Bureau of Land Management	2011
Administrative Boundaries	Private Water Districts	CalAtlas	2003
Administrative Boundaries	Public Water Agencies	CA Dept of Water Resources	2009
Administrative Boundaries	SJV Counties	CalAtlas	2009
Administrative Boundaries	Spheres of Influence	San Joaquin Valley Counties	2012
Administrative Boundaries	State Water Districts	CalAtlas	2003
Administrative Boundaries	Taylor Grazing Act Grazing Districts	U.S. Bureau of Land Management	2011
Agriculture	Crops	National Agricultural Statistics Service, CropScape	Varies
Agriculture	Farmland Mapping and Monitoring Program	CA Dept of Conservation	Varies
Agriculture	Retired Farmland	California State University, Stanislaus - Endangered Species Recovery Program	2007
Agriculture	Williamson Act	Various	Varies
Biodiversity	Animal Distributions - San Joaquin Kit Fox Suitability	California State University, Stanislaus - Endangered Species Recovery Program	2012
Biodiversity	Audubon Society Important Bird Areas	Audubon California	2008
Biodiversity	BLM Area of Critical Environmental Concern	U.S. Bureau of Land Management	2010
Biodiversity	California Essential Habitat Connectivity	CalTrans, CA Fish & Game, Federal Highway Admin	2010
Biodiversity	California Natural Diversity Database (CNDDB)	CA Dept of Fish and Wildlife	2012
Biodiversity	Critical Habitats	U.S. Fish and Wildlife Service	Varies
Biodiversity	DFG Areas of Conservation Emphasis (ACEII)	CA Dept of Fish and Wildlife	2010
Biodiversity	Dr. Huber's Dissertation Connectivity	Dr. Patrick Huber	2011
Biodiversity	Herptile Distribution- Tiger Salamander Suitability	California State University, Stanislaus - Endangered Species Recovery Program	2012

Biodiversity	Southern Sierra Partnership Regional Conservation Design	Data Basin	2012
Biodiversity	TNC Ecoregion Priorities	The Nature Conservancy	2005
Energy	BLM Solar and Wind Projects	CA Energy Commission	2008
Energy	BLM Utility Corridors	CA Energy Commission	2008
Energy	Dept. of Oil, Gas, and Geothermal Resources Districts	CA Dept of Conservation	2014
Energy	Geothermal Leases	U.S Bureau of Land Management	2010
Energy	Geothermal Wells	CA Dept of Conservation	2013
Energy	Known Geothermal Resource Areas	CA Energy Commission	2008
Energy	Oil Fields/Administrative Areas	CA Dept of Conservation	2013
Energy	Oil Well Locations	CA Dept of Conservation	2014
Energy	Preliminary and Verified Renewable Energy Right-Of-Way	U.S. Bureau of Land Management	2008
Energy	Proposed DOE 368 Energy Corridors	CA Energy Commission	2008
Energy	Proposed Energy Corridor on Federal Land	USDA Forest Service	2008
Energy	Renewable Energy Transmission Initiative (RETI) Phase 2B	CA Energy Commission	2010
Energy	Solar Resource Potential	National renewable Energy Laboratory	2002
Land Cover	2001 National Land Cover Database (NLCD 2001)	U.S. Geological Survey	2001
Land Cover	2006 National Land Cover Database (NLCD 2006)	U.S. Geological Survey	2006
Land Cover	California Augmented Multisource Landcover map (CAML)	Allan Hollander/ UC Davis - ICE	2010
Land Cover	CalVeg	USDA Forest Service	Varies
Land Cover	Dept of Water Resources (DWR) Land Cover	CA Dept of Water Resources	Varies
Land Cover	DFG Delta Veg Map	CA Dept of Fish and Wildlife	2007
Land Cover	FRAP Best available multi-source	CalFire	2002
Land Cover	FRAP Hardwood Rangeland Vegetation	CalFire	1990
Land Cover	FRAP Riparian Vegetation in Hardwood Rangelands	CalFire	1994
Land Cover	Hardwood Rangeland Vegetation	CA Dept of Forestry and Fire Protection	1990
Land Cover	Historic Vegetation (CSU Chico)	U.S. Fish and Wildlife Service and the U.S. Bureau of Reclamation	2001
Land Cover	National Wetlands Inventory	U.S. Fish and Wildlife Service	2010
Land Cover	Potential natural Plant Communities (Kuchler 1976)	U.S. Bureau of Reclamation	1976
Land Cover	Riparian Vegetation	CA Dept of Water Resources	2011
Land Cover	Vernal Pool Complexes	Dr. Bob Holland, Placer Land Trust	2009
Land Use Planning	Disadvantaged Communities in SJR and Tule Basins	Geospatial Information Center	2010
Land Use Planning	Fire Threat	CA Dept of Forestry and Fire Protection	2004
Land Use Planning	Flood risk	Federal Emergency Management Agency	2014
Land Use Planning	General Plans	CA Natural Resources Agency	2004
Land Use Planning	General Plans	SJV local governments with assembly by ICE	2013
Land Use Planning	General Plans (generalized)	UC Davis - ULTRANS	2010
Land Use Planning	General Plans (Individual)	San Joaquin Valley Cities and Counties	Varies
Land Use Planning	Geothermal Leasing Areas	U.S. Bureau of Land Management	2010
Land Use Planning	HCP and NCCP Plans	CA Dept of Fish and Wildlife	Varies
Land Use Planning	Parcel data	San Joaquin Valley Cities and Counties	Varies
Land Use Planning	SJV Blueprint	San Joaquin Valley Blueprint	2009

Land Use Planning	Zoning (as available)	San Joaquin Valley Cities and Counties	Varies
Soils	Contours of Corcoran Clay Depth in feet	U.S. Geological Survey	2009
Soils	Contours of Corcoran Clay Thickness	U.S. Geological Survey	2009
Soils	Extent of Corcoran Clay	U.S. Geological Survey	2009
Soils	Land Classification of Soils for Irrigation Suitability	U.S. Bureau of Reclamation	2001
Soils	Land Subsidence 1926-1970	U.S. Geological Survey	1984
Soils	Land Subsidence in the Central SJV	U.S. Geological Survey	2013
Soils	Salt Affected Soils of California	Natural Resources Conservation Service	2011
Soils	Soils (SSURGO)	USDA/UC Davis	Varies
Transportation	LocalRoads	Census Bureau (TIGER)	2008
Transportation	Major Roads	Census Bureau (TIGER)	2008
Transportation	Rail lines	Census Bureau (TIGER)	2008
Water Resources	Agriculture Applied Water Variability	CA Dept of Water Resources	2013
Water Resources	Average Water Use by sector	CA Dept of Water Resources	2013
Water Resources	Central Valley Rivers	National Hydrography Dataset	2009
Water Resources	Depth to Shallow Groundwater	U.S. Bureau of Reclamation	1987
Water Resources	Goundwater Elevation Contours	CA Dept of Water Resources	2013
Water Resources	Groundwater Basins	CA Dept of Conservation	2012
Water Resources	Groundwater Contamination-Boron/Selenium/Molybdenum/Electrical Conductivity	U.S. Bureau of Reclamation	1990
Water Resources	Groundwater Rechargeable Soils	California Water Institute	2009
Water Resources	Hydrologic Unit Maps	U.S. Geological Survey	2012
Water Resources	Lakes and Reservoirs	CalAtlas	2009
Water Resources	Major Canals	CA Dept of Water Resources	2009
Water Resources	National Hydrography Dataset (NHD) - High Resolution	U.S. Geological Survey	2012
Water Resources	National Hydrography Dataset (NHD) - Medium Resolution	U.S. Geological Survey	2012
Water Resources	Rivers of California	National Hydrography Dataset	2012
Water Resources	Spring Ground Surface to Water Surface: SJR and Tule Lake Basins	California Water Institute	2009
Water Resources	Spring Groundwater Surface Elevation	California Water Institute	2009
Water Resources	Total Groundwater Withdrawl	CA Dept of Water Resources	2013
Water Resources	Water Supply	CA Dept of Water Resources	2013
Water Resources	Watersheds (CalWater)	CA Dept of Forestry and Fire Protection	1999






SAN JOAQUIN VALLEY

Greenprint

The *State of the Valley* report is a final deliverable for the first phase of the San Joaquin Valley Greenprint. The project is funded by a grant from the California Strategic Growth Council and managed by the San Joaquin Valley Greenprint Steering Committee, with support provided by a team of consultants.

The full report and data catalog can be accessed online at:

sjvgreenprint.ice.ucdavis.edu

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