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Water and the Future of the San Joaquin Valley

Technical Appendix E: Supplemental Information on Water Quality and Land Use

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ACRONYMS

CVPIA	Central Valley Project Improvement Act
DWR	California Department of Water Resources
GSA	groundwater sustainability agency
HR	hydrologic region
N	nitrogen
SGMA	Sustainable Groundwater Management Act
SAGBI	Soil Agricultural Groundwater Banking Index
USFWS	United States Fish and Wildlife Service

Introduction

This appendix provides supplemental information and data sources and methods used to describe drought impacts on rural community water supply, suitability of different types of land uses for groundwater recharge, and potential land uses for retired lands, as summarized in the main report *Water and the Future of the San Joaquin Valley*.

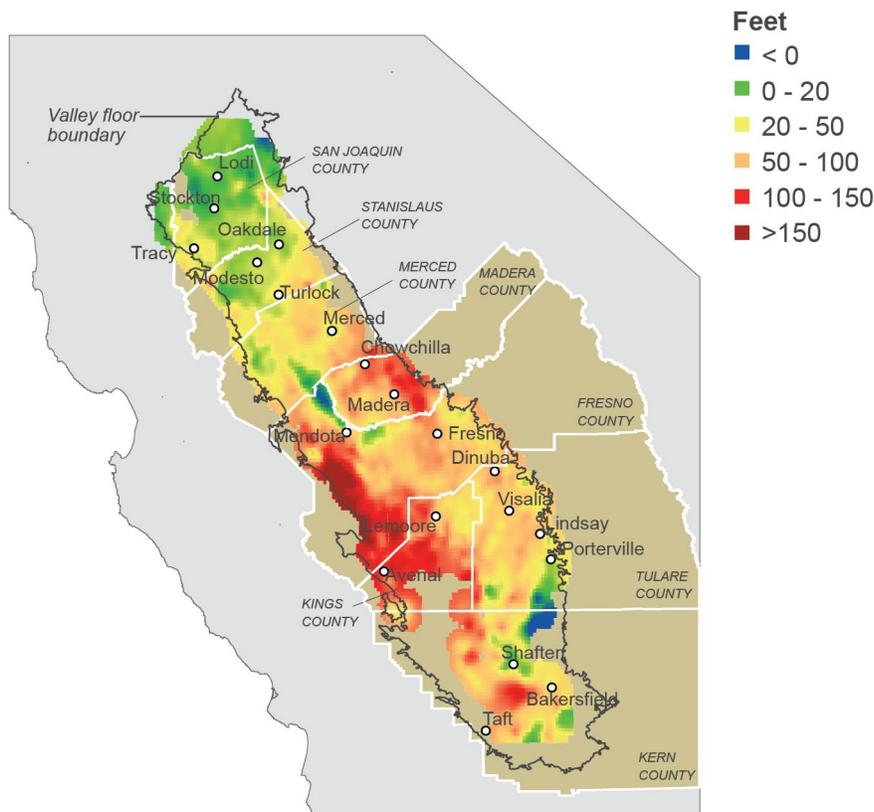
Domestic Well Shortages During the 2012–16 Drought

Many rural communities in California faced water supply shortages during the 2012–16 drought. San Joaquin Valley residents were affected disproportionately as groundwater levels fell precipitously (Figure E1). Droughts result in less natural replenishment of aquifers, and farmers also pumped significantly more groundwater to keep their crops alive (see [Technical Appendix A](#) for valley-wide groundwater depletion estimates). By 2014, many shallow domestic wells in the valley started going dry.

FIGURE E1

Groundwater levels fell precipitously in many parts of the San Joaquin Valley during the 2012–16 drought

Groundwater depth change (2012-16)



SOURCE: Author calculations using DWR Well Completion Reports and Groundwater Level Data Reports.

The state does not formally oversee domestic wells in California. Following the declaration of a drought emergency in January 2014, the state’s interagency drought task force created an online portal to allow reporting of shortages with the goal of providing emergency drinking water supplies. The self-reported information occasionally contained errors and duplicates, and the Department of Water Resources (DWR) improved these estimates in 2018. Table E1 shows households that reported drinking water shortages from January 2014 to May 2018.

TABLE E1

Households reporting water supply shortages from domestic wells or other non-community water systems (2014–18)

County	Households reporting water supply shortages
Fresno	75
Kern	17
Kings	83
Madera	307
Merced	60
San Joaquin	26
Stanislaus	82
Tulare	1,383
San Joaquin Valley total	2,033
California total	2,598
San Joaquin Valley share of California	78%

SOURCES: Department of Water Resources (2018).

NOTES: The table reports corrected data from the state’s [dry water supply reporting portal](#). This updates the data reported in Hanak et al. (2015) and Hanak et al. (2017) on households with dry domestic wells.

Suitability of Soils for Groundwater Recharge

Expanding groundwater recharge could help the valley address up to a quarter of its long-term groundwater overdraft ([Technical Appendix B](#)). The most suitable soils are those that will allow the water to percolate into the ground quickly. Figure E2 shows that this suitability varies considerably across the valley.¹

Recharge conditions are generally less favorable on the valley’s west side due to poor soil permeability, salinity, and the presence of deep clay layers that limit water percolation. Some of the most favorable recharge conditions are clustered in alluvial fans in the northeast, southeast, and the Kern basin.

Recharge Suitability of Different Land Uses

Conditions also vary across different land uses. They are relatively favorable in the two largest land use categories—cropland and open space—which take up 61 percent and 29 percent of all acreage on the valley floor, respectively. Urban areas across the valley also show potential for recharge. Not surprisingly, recharge conditions are poor on the valley’s managed wetlands, where thick clay layers do not allow the water to percolate into the ground.

Considering these regional and land-use variations will be important as groundwater sustainability agencies (GSAs) in the valley begin developing groundwater recharge projects. One particular area for attention is the development of lands in the urban “spheres of influence”—areas that are currently cropland or open space, but that have the potential to be developed as cities grow (Jezdimirovic 2018). As Figure E3 shows, a majority of these lands has at least moderately good suitability for recharge in four of the valley’s five subregions. Planning will be required to protect the most suitable areas—and avoid paving them over.

¹ Other factors that will determine the feasibility of recharge include the availability of surplus water and unused storage capacity in the aquifer. For cropland suitability reported below, the shares of land that are at least moderately good for recharge based on surface soil conditions from UC Davis (shown in figures) are similar to the shares using a measure that also considers suitability of conditions at deeper levels within the aquifer from the mapping company Land IQ.

FIGURE E2

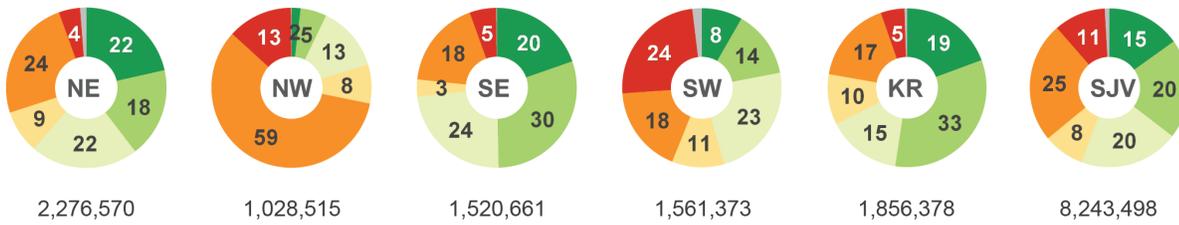
Suitability of soils for recharge by land use in five San Joaquin Valley subregions

Comparisons of recharge suitability

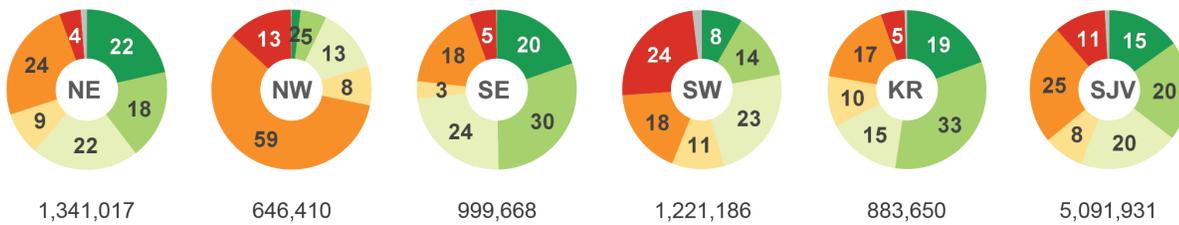
Sagbi rating

■ Excellent ■ Good ■ Moderately Good ■ Moderately Poor ■ Poor ■ Very Poor ■ Not in SAGBI coverage

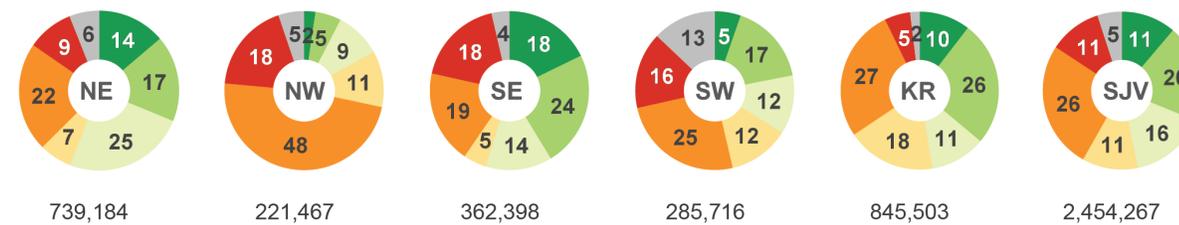
Total SAGBI (modified)



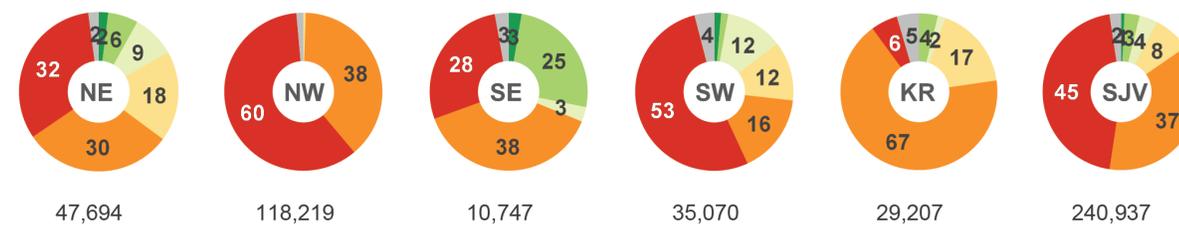
Cropland SAGBI



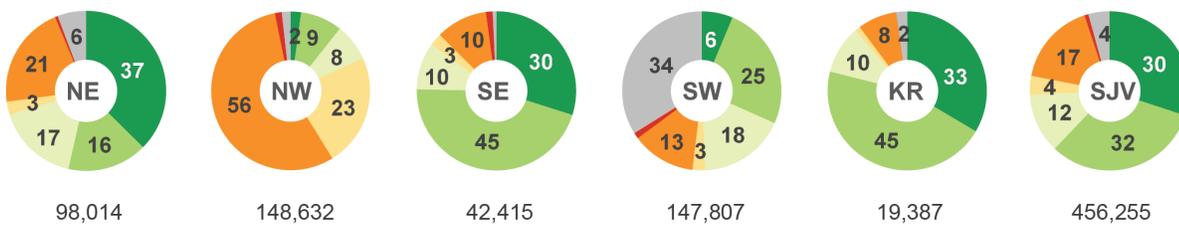
Open space SAGBI



Managed wetlands SAGBI



Urban Footprint SAGBI

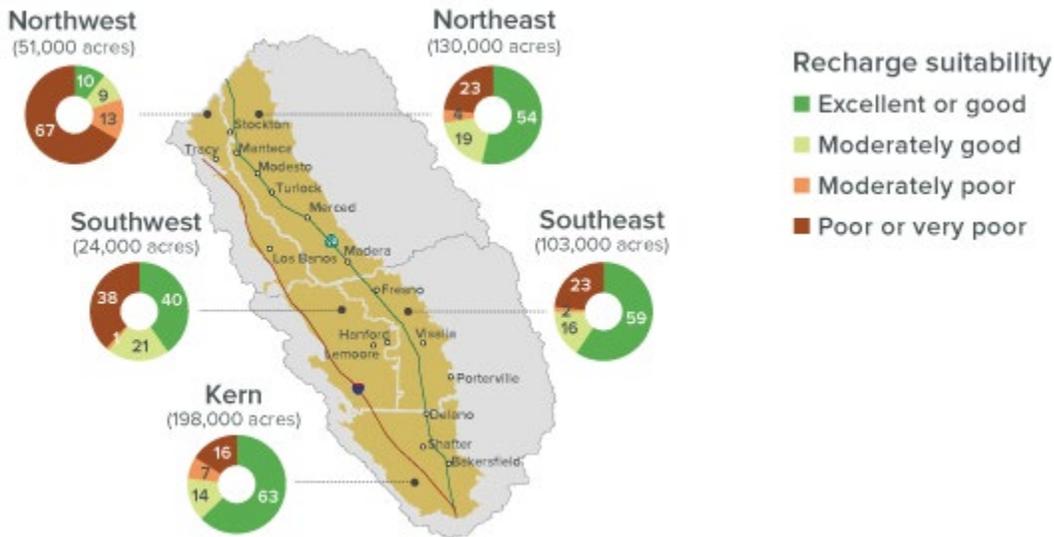


SOURCES: Soil suitability: University of California Davis Soil Resource Lab (2015); land use in 2014: Department of Water Resources (2017).

NOTES: SAGBI is the "Soil agricultural groundwater banking index." The figure shows the suitability of soils for recharge if all soils with restrictive layers that would inhibit recharge were modified by deep tillage, a practice common for some crops.

FIGURE E3

Soil recharge suitability in undeveloped areas surrounding San Joaquin Valley cities



SOURCE: Jezdimirovic (2018).

NOTE: The figure uses the modified SAGBI index for soil suitability, 2014 land use (Department of Water Resources 2017 and spheres of influence from the San Joaquin Valley Greenprint).

Recharge Suitability of Cropland

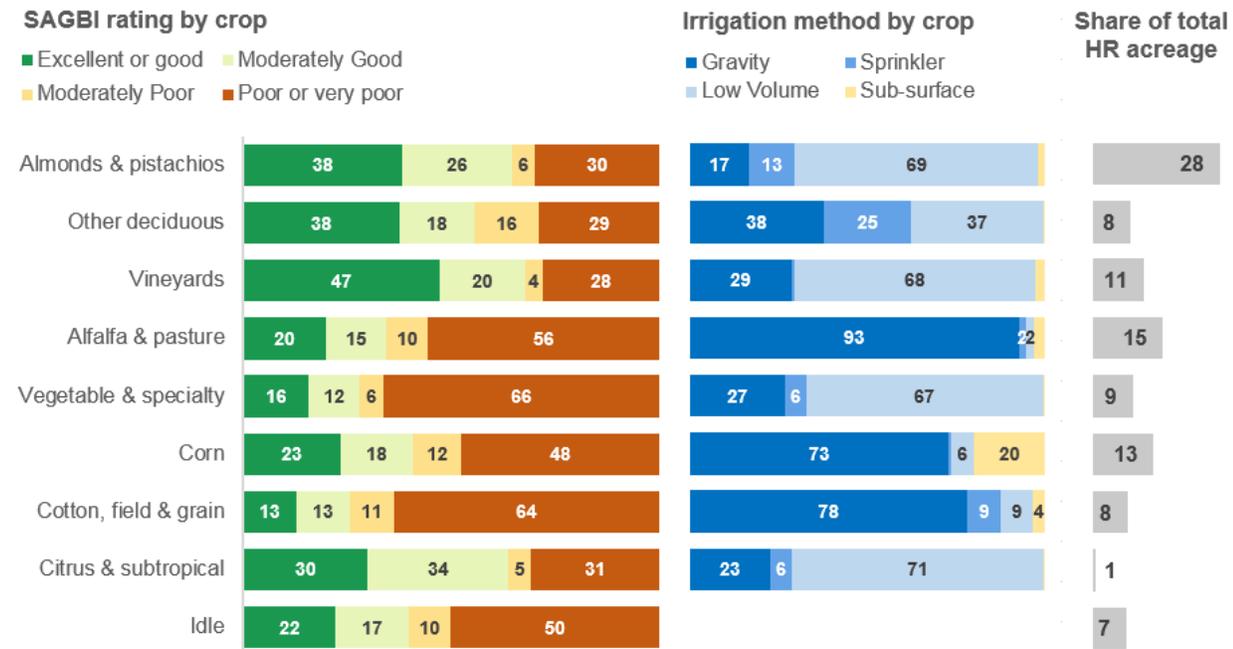
Recharging on cropland—particularly with winter and early spring flooding of fields—may be one of the most promising ways to cost-effectively expand recharge in the valley (Hanak et al. 2018). Even on suitable soils, however there are factors that can pose obstacles to expanding this practice. One is the suitability of the crop itself. For instance, some crops (e.g., corn silage) are heavily fertilized with nitrogen; flooding these fields could significantly increase nitrate contamination of the aquifer. And some crops (e.g., non-deciduous trees such as citrus) cannot tolerate flooding. As described in the main report (Figure 3.7 and related text), about a quarter of the cropland with soils suitable for recharge was planted to crops that are suitable for recharge, with low or no nitrogen fertilization in 2014 (alfalfa and vines). About a half of the suitable lands were planted to crops that are suitable for recharge, as long as the N is carefully managed (e.g., almonds, other deciduous trees, and some field crops). Roughly 16 percent is planted to crops that are not suitable, including citrus (which does not tolerate flooding), and corn (which receives large quantities of manure fertilization).

Irrigation systems also pose challenges. Flood- or gravity-based systems are most suitable for recharge because they make it possible to get extra water onto the land quickly. Indeed, the return flow from these systems was historically one of the most important sources of recharge in the valley. For a variety of reasons, these systems have been progressively replaced with sprinkler, and especially drip systems that apply less water to fields. These lower-water systems produce many important benefits—from better crop quality to reduced chemical runoff. But they can make it difficult or impossible to get a lot of water onto fields quickly—a primary advantage of the flood irrigation systems they are replacing. Although comprehensive, geospatial information is not available on irrigation systems, the Department of Water Resources occasionally conducts surveys to determine broad irrigation system trends. Figure E4 uses data from the most recent survey (2010), along with information on soil suitability and cropping patterns in 2014. This data suggest that irrigation systems may be a constraint for recharge on many suitable croplands. Besides alfalfa—a clean N crop that is mostly flood irrigated—the crop with

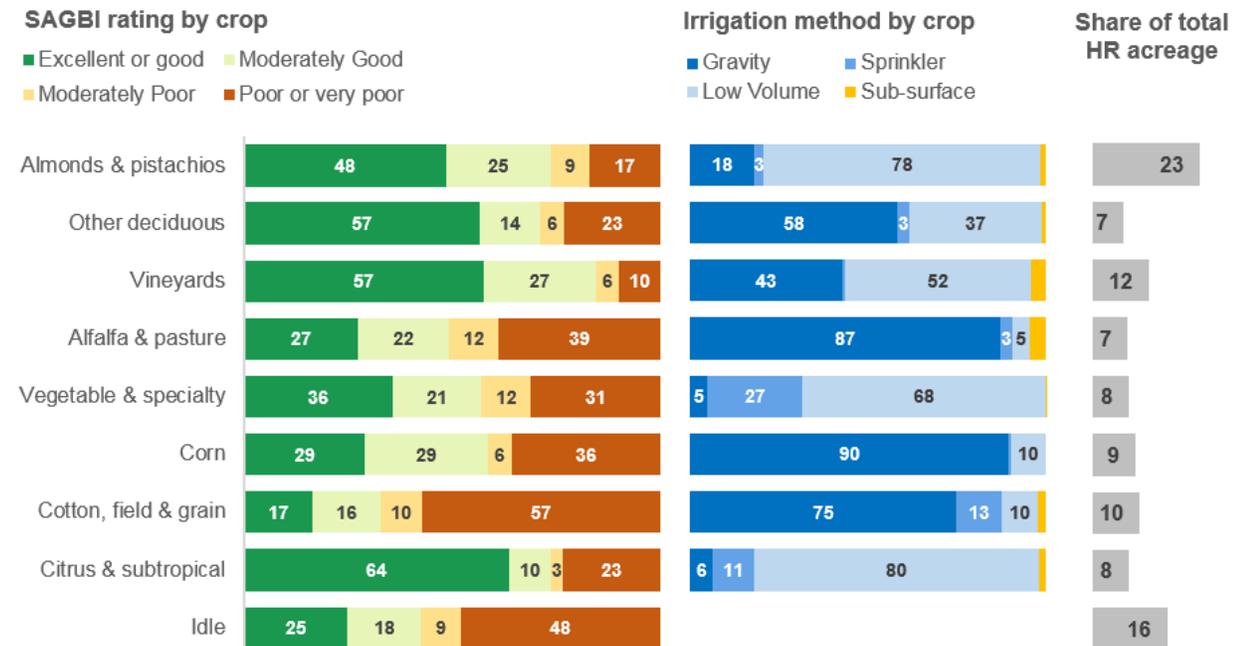
the most extensive use of flood irrigation is corn, which is generally not suitable given fertilization practices. Dual systems—low-water systems that also accommodate flooding—will be needed in suitable areas.

FIGURE E4
Soil suitability for recharge and irrigation systems by crop

A) San Joaquin River Hydrologic Region



B) Tulare Lake Hydrologic Region



SOURCE: SAGBI rating: University of California Davis Soil Resource Lab (2015), land use: Department of Water Resources (2017), irrigation systems by crop: Department of Water Resources (2010).

Potential Uses for Retired Cropland

Our analysis suggests that efforts to bring groundwater basins into balance under the Sustainable Groundwater Management Act (SGMA) may cause 500,000 to 750,000 acres of irrigated cropland to be taken out of production by 2040 in the San Joaquin Valley. Net water savings will need to come from converting cropland to uses that do not require ongoing dedicated water supplies. One important question is how retired lands might be used. To put this question into context, we summarized the potential for land-use conversion over the next 20 years given planning processes in place (Table E2).

We considered four major land cover types: floodplains/riparian forest, wetlands, uplands/desert, and solar facilities. For each of these, we considered information on 1) the acreage that is currently identified in existing planning efforts, 2) the acreage that has been created over the last few decades.

TABLE E2

Planning objectives and restoration efforts for four major land cover types

Land cover type	What is captured in current planning documents?	What has been accomplished in recent decades?	What might we expect given planning and recent accomplishments
Riparian/ floodplain	<ul style="list-style-type: none"> Central Valley Joint Venture habitat objectives call for adding ~175,000 acres in San Joaquin and Tulare basins over the long-term, and set a short-term (10-year) goal of ~17,000 acres (Dybala et al. 2017). Central Valley Flood Protection Plan Conservation Strategy identified a goal of adding 8,000 acres of riparian vegetation along San Joaquin River. “Tulare Basin Riparian and Wildlife Corridor Conservation Report” identified a long-term need to protect and restore 20,000 acres of riparian vegetation. San Joaquin River National Wildlife Refuge Expansion Plan authorizes the expansion of the Refuge by ~10,000 acres through acquisition of fee-title or conservation easements. 	<ul style="list-style-type: none"> Since 1998 restoration efforts on the Sacramento River have restored ~6,000 acres Since 2001 restoration efforts on the San Joaquin River have restored ~5,000 acres (Rentner 2018) 	<ul style="list-style-type: none"> 20,000 acres of riparian forest would be in-line with current planning efforts, but ambitious given pace of previous floodplain restoration efforts in the San Joaquin Valley.
Wetlands	<ul style="list-style-type: none"> Central Valley Joint Venture has a long-term goal of creating ~70,000 acres of additional wetlands in the San Joaquin and Tulare regions (Strum et al. 2017). Tulare Basin Wildlife Partners has recognized a need to protect and restore ~100,000 acres of wetlands in the Tulare Basin. 	<ul style="list-style-type: none"> Roughly 130,000 acres have been conserved within the San Joaquin Valley in 14 CVPIA refuges, largely in the San Joaquin River hydrologic region. The Kern Water Bank has established 7,000 acres of intermittent wetlands as part of its groundwater recharge activities 	<ul style="list-style-type: none"> Although SGMA is unlikely to generate additional surface water for wetlands, expansion of dedicated recharge areas that can also serve as intermittent wetlands is likely—perhaps 20,000 acres.
Upland/ desert	<ul style="list-style-type: none"> The Recovery Plan for Upland San Joaquin Species identified the need for 80,000 acres to be restored and intensively managed to support the recovery of San Joaquin desert wildlife (Kelsey et al. 2018). 	<ul style="list-style-type: none"> Since 1998 the CVPIA Land Retirement Program has restored upland wildlife habitat on 6400 acres of retired farmland. 	<ul style="list-style-type: none"> 80,000 acres of desert upland would be in line with current planning efforts, but very ambitious given pace of previous restoration efforts
Solar	<ul style="list-style-type: none"> Harvesting Clean Energy: How California Can Deploy Large-Scale Renewable Energy Projects on Appropriate Farmland (Elkind 2011) estimates ~100,000 acres of land statewide for solar to meet state’s 2020 goals of 33% renewable electricity. Surface Area Required to Power California with Zero Carbon Emissions and 100 Percent Renewable Energy (2018) estimates ~290,000 acres of land statewide for solar panels to supply a much expanded electricity consumption with 100% renewable energy. The Least Conflict Report (2016) identifies ~470,000 acres of least-conflict land in SJ Valley where solar facilities could be sited. 		<ul style="list-style-type: none"> Up to 50,000 acres of additional solar development might occur on formerly irrigated lands in the valley. While California’s demand for renewable energy is growing, a significant share will likely be met by solar rooftops in urban areas. Some development is also likely to occur on current rangelands.

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