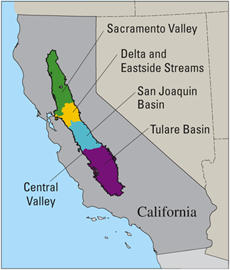
**CASE STUDY: Central Valley Aquifer, California (USA)**

*Prepared by Sydney Turner, University of Virginia*



**General Overview**

The Central Valley is often referred to as the Great Valley of California. The vast groundwater system in the Central Valley is the largest underground reservoir in the State of California (Faunt, Geologic Survey Fact Sheet, 2009). More impressively, the groundwater basin is the “second largest contiguous groundwater basin in the United States” (after the High Plains Aquifer: Great Valley, 2012). The Central Valley watershed covers over 20,000 square miles in California (Faunt, Geologic Survey Fact Sheet, 2009). Mountains border the Central Valley where water is stored in snowpack. Within the borders of the valley (refer to Appendix A), there are 1,512 miles in length of streams or rivers and 19,812 miles in length of constructed agricultural channels (Faunt, Groundwater Availability of the Central Valley Aquifer). The large and complex hydrologic system has aided the Central Valley in becoming one of the most productive agricultural regions in the world. Due to an increase in competition for water resources, the Central Valley hydrologic system has been under scrutiny for water management practices.

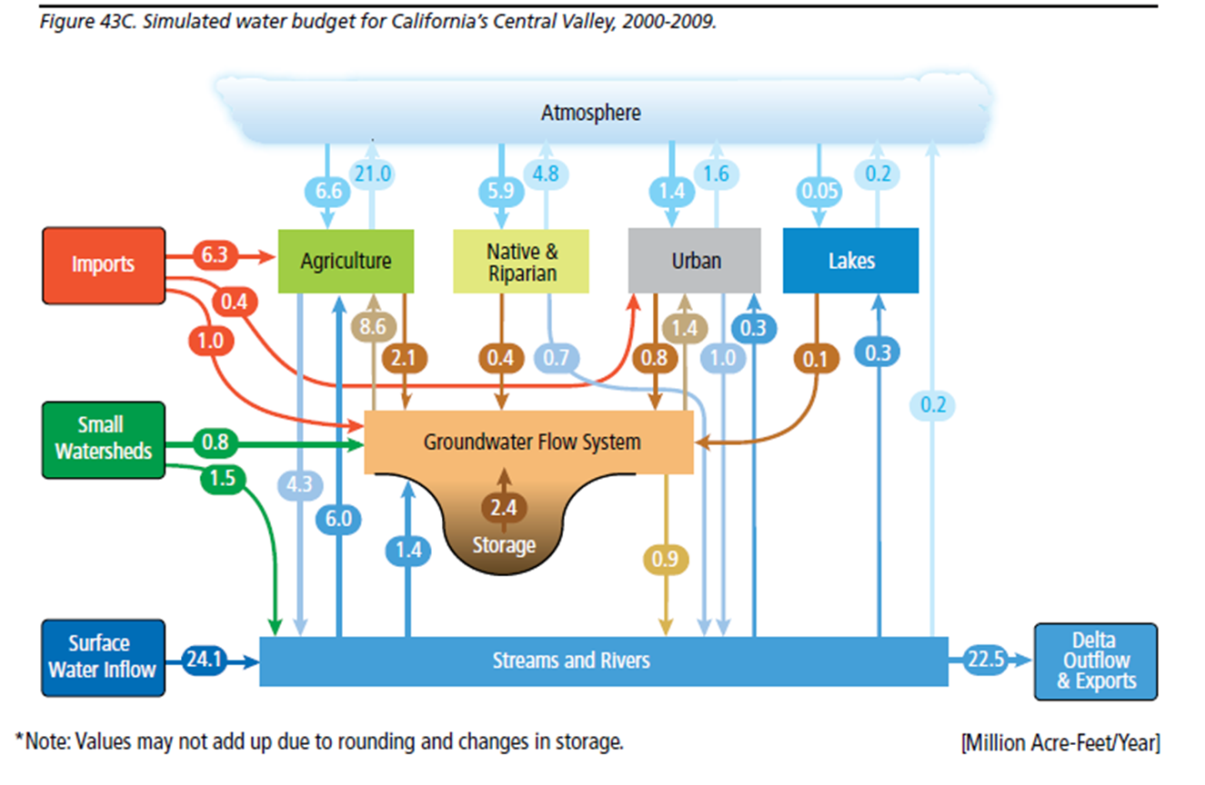
In the interest of solving the water shortages and aquifer depletion in the Central Valley, the water bank account needs to be assessed and balanced. Conjunctive use is defined as “the use of water from multiple sources to meet demand” and usually refers to the holistic management of both surface- and groundwater systems (Faunt, Groundwater Availability of the Central Valley Aquifer). A significant aspect of conjunctive use is finding the most sustainable and efficient way of providing water for the population, the environment, and industry. Predicting water availability is a major concern in the Central Valley. For example, an interesting source of contamination in the Central Valley is remnants of wildfires that have been reoccurring since 2002 (Great Valley, 2002). Fighting these fires consumes a lot of water. Wildfires are unpredictable and can affect the quality and quantity of the water. This makes water budgeting extremely important to account for a diverse set of variables. These variables include droughts, floods, population expansion, pollution, industry growth, and climate change. These variables, combined with a very complex surface water and groundwater interacting hydrologic system, makes the formulation of a water budget and future water availability projections very challenging!

In the interest of protecting water security and the environment, water governance is key (refer to Appendix U for the concept of water governance, Richter, 2013). Many California laws in the past just focused on surface waters. In 1914, the Water Commission Act allocated water rights for surface water; groundwater was not considered (Faunt, Groundwater Availability of the Central Valley Aquifer). There is not even a requirement for private wells to be metered. This has a tragedy of the commons effect. The groundwater is an under-regulated public resource that can be exhausted by individuals, counties, groups, and industries acting in their own self-interest. The only ‘user’ that doesn’t have the ability to selfishly claim water for itself is the environment.

Responsibility of groundwater management was given to local counties and agencies by the State Legislature. Local governments do have some groundwater programs and ordinances to manage the groundwater within their borders. But local regulations have not done enough to halt depletion of the Central Valley Aquifer; fortunately, collaboration between local agencies and groups, state agencies, federal agencies, the private sector, NGOs, and the civil society have made leaps and bounds in the right direction. Current discussions center around monitoring and assessing the water situation.

**Water Budget & Temporal Variability in Water Availability**

In order to discuss water availability, both surface water and groundwater inflows and outflows and their interaction with each other must be accounted for; they are co-dependent, interacting systems. Groundwater has been the most reliable source of water in the Central Valley considering the “high temporal and spatial variability associated with precipitation, runoff, and surface water availability in the Central Valley” (Faunt, Groundwater Availability of the Central Valley Aquifer). However, groundwater in California is generally thought of as a finite resource because the rate at which water is withdrawn is greater than the rate at which water is recharged by nature, by as much as an 18 percent difference (Great Valley Center, 2012). Heavy land subsidence was the consequence of groundwater pumpage exceeding surface-water deliveries in the San Joaquin Valley in the 1960s, causing record lows for groundwater levels (Faunt, Groundwater Availability of the Central Valley Aquifer). The storage of groundwater relies primarily on recharge from precipitation, leakage from streams and surface-water bodies, and return flow from irrigated agriculture. To help increase the rate of recharge in the aquifer, groundwater recharge programs have targeted permeable deposits to pump water from rivers back into the ground during wet periods. Most rainfall occurs between the months November through April (Faunt, Groundwater Availability of the Central Valley Aquifer). The Central Valley is attempting to capture surface runoff in reservoirs, where it can then be recharged into the aquifers for later utilization in drier seasons or drought years.

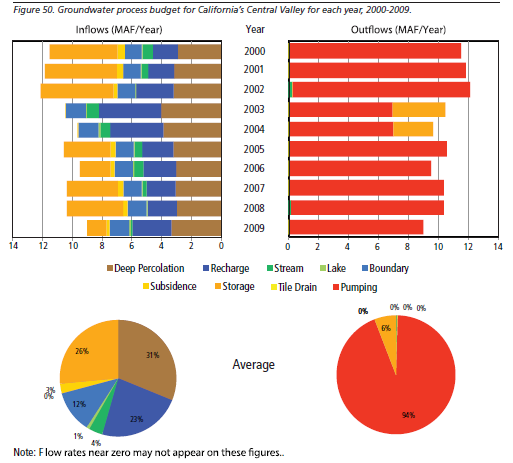


***Figure 1***

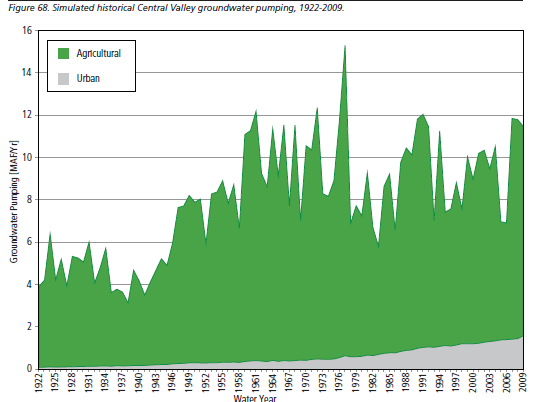
Water delivery systems operating since the 1970s have been very important to transporting water from the Sacramento Valley to the San Joaquin Valley. The northern regions in the Central Valley are wetter, receiving between 13-26 inches of precipitation in an average year; the southern regions are drier, receiving between 5-18 inches of precipitation in an average year (Faunt, Groundwater Availability of the Central Valley Aquifer). The southern San Joaquin Valley is also notorious for groundwater pumping due to a smaller supply of surface water. In order to supply water to the agricultural powerhouse southern region, water delivery systems have been vital.

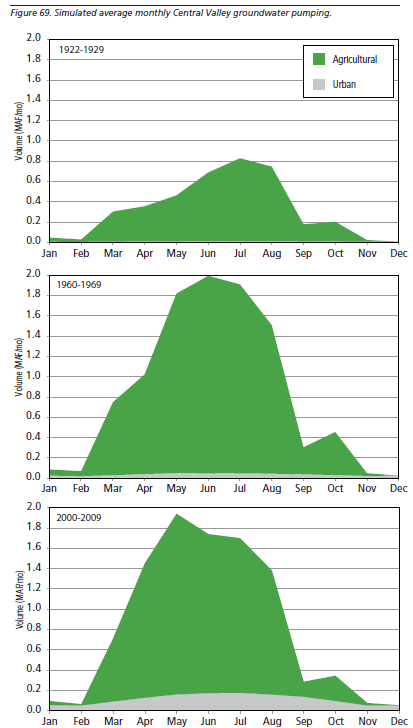
With the help of the water delivery system, water levels and water availability improved immensely in the San Joaquin Valley. Particularly in the Tulare Basin, water scarcity is still prevalent however, resulting in major depletion of the groundwater storage (refer to Appendix P for the simulated cumulative annual changes in the Central Valley aquifer-system storage between 1962-2003 (Faunt, Groundwater Availability of the Central Valley Aquifer) . Groundwater pumping is at its highest between the months of March through August, which aligns with the growing season for most farmers (refer to Appendix Q for simulated monthly average Central Valley groundwater pumping, California Department of Water Resources, 2013).

Figures 1 (above), 2 and 3 (below) illustrate some of the water estimates from the C2VSim (California Central Valley Groundwater-Surface Water Simulation) Model prepared by California’s Department of Water Resources for the Central Valley Aquifer. The model is an integrated numerical model that simulates water movement through the linked land surface, groundwater and surface water flow systems in California’s Central Valley.



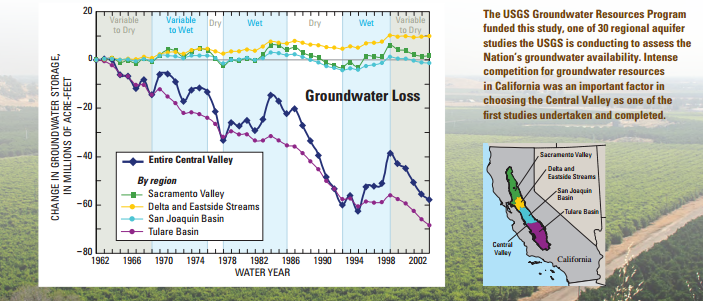
***Figure 2. Simulated Central Valley groundwater pumping***





***Figure 3a and 3b. Simulated average monthly Central Valley groundwater pumping***

Figure 4 below is based on outputs from the USGS Central Valley Hydrologic Model (CVHM). The model is built on knowledge from USGS and other Federal, State, and local studies. The model compares simulated and historically observed groundwater levels, stream flows, and subsidence.



***Figure 4.***

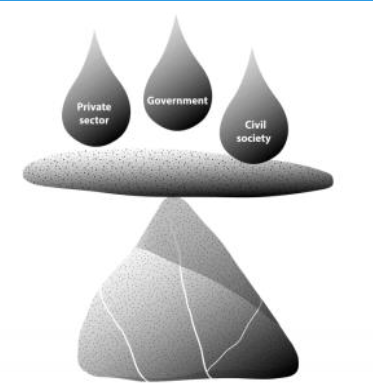
**Water Stakeholders**

**FARMERS:**

*California Farm Bureau Federation*

(Information from <http://www.cfbf.com/CFBF/About_Us/What_We_Do/About_Farm_Bureau/CFBF/AboutUs/AboutUs.aspx?hkey=41ee7d9c-ffe6-4ec2-a760-967b105e94a8>)

“The California Farm Bureau Federation is a non-governmental, non-profit, voluntary membership California corporation whose purpose is to protect and promote agricultural interests throughout the state of California and to find solutions to the problems of the farm, the farm home and the rural community. Farm Bureau is California's largest farm organization, comprised of [53 county Farm Bureaus](http://www.cfbf.com/CFBF/CountyFarmBureaus/CFBF/CountyFarmBureaus/Default.aspx)currently representing nearly 78,000 agricultural, associate and collegiate members in 56 counties. Farm Bureau strives to protect and improve the ability of farmers and ranchers engaged in production agriculture to provide a reliable supply of food and fiber through responsible stewardship of California's resources.”

**GOVERNMENT:**

*California Department of Water Resources*

(Information from [http://www.water.ca.gov/#](http://www.water.ca.gov/))

“In 1956, the Legislature passed a bill creating DWR to plan, design, construct, and oversee the building of the nation's largest state-built water development and conveyance system. Today, DWR protects, conserves, develops, and manages much of California's water supply including the State Water Project which provides water for 25 million residents, farms, and businesses. Working with other agencies and the public, DWR develops strategic goals, and near-term and long-term actions to conserve, manage, develop, and sustain California's watersheds, water resources, and management systems. DWR also works to prevent and respond to floods, droughts, and catastrophic events that would threaten public safety, water resources and management systems, the environment, and property.”

**INFORMED CITIZEN / Civil Society:**

*Central Valley Water Awareness Committee*

(Information from <http://www.centralvalleywater.org/water_awareness/action/water_conservation/>)

“No resource is more vital to life than water – for our families to drink and cook with, for the food and fiber products the Valley produces, and for the beauty we see in trees and yards around us. Water is not an unlimited resource. Here in the Valley, water is usually in short supply. That’s why we have to make every effort to help conserve this precious resource.”

**ENVIRONMENTALIST / CALIFORNIA EPA**

*State Water Boards Groundwater Workplan*

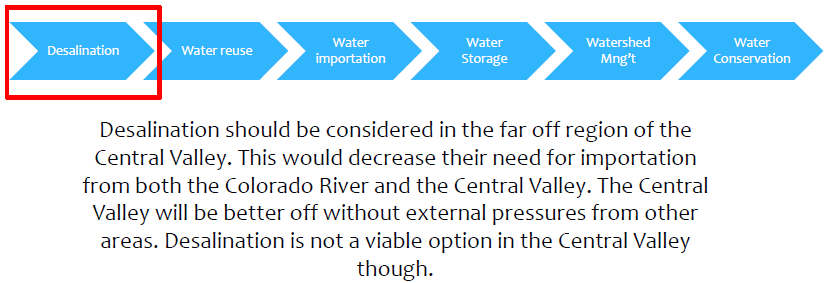
(Information from <http://www.swrcb.ca.gov/water_issues/programs/groundwater/workplan.shtml>)

“Population growth and more intensive land use will place increased demands on the State’s water supply. At the same time, surface water runoff is projected to decline due to the effects of climate change. These and other factors point to an increased reliance on groundwater. However, many of California’s aquifers are already experiencing contamination and/or overdraft. These challenges do not lend themselves to a “one size fits all” solution, given the varying physical and institutional characteristics of California’s groundwater basins. The Water Boards are developing a workplan that aligns its current groundwater protection efforts, the ongoing actions of other entities with groundwater management responsibilities, and potential actions that the Water Boards and others could pursue. A goal of the workplan is to promote collaboration and cooperation among local, regional, and State agencies and other stakeholders to help promote more effective groundwater management that supports beneficial uses over the long-term. Whether implemented at the local, regional, or State level, the Water Boards believe that an effective groundwater management program generally requires five key elements to be in place: thresholds, monitoring/assessment, governance/management, funding, and enforcement.”

**Water Tools**

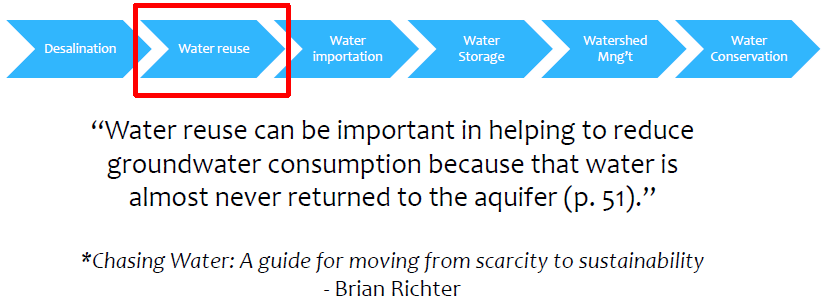
“The achievement of an acceptable tradeoff between groundwater use and the long-term effects of that use” is a recognized definition of groundwater sustainability (Faunt, Groundwater Availability of the Central Valley Aquifer). The Central Valley will only be sustainable when it can put a cap on their water withdrawals based on allowing for environmental flows, supporting a population, and acclimating to climate change.

Discuss the appropriateness or opportunity to use each of the six water tools highlighted in *Chasing Water* to achieve groundwater sustainability. Try to highlight both the positives and the negatives of each tool. Use the tips below to guide you. Make a strategy to move the Central Valley aquifer towards a sustainable future. Take into consideration the most economical and environmentally beneficial leverage points in the watershed.

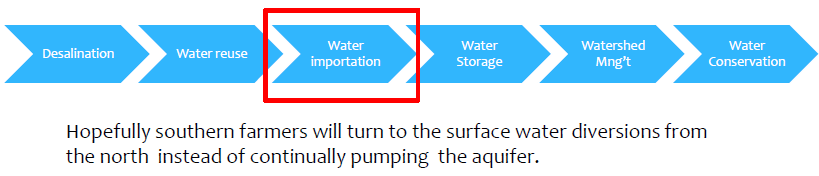


Desalination would help decrease their need for importation from both the Colorado River and the northern region of the Central Valley. The Central Valley would be more than willing to rid themselves of the external pressure of fighting for rations of water. Desalination tends to be extremely expensive. Desalination plants use a large amount of energy leading to possible increases in air pollution. Desalination would make the cost of water increase.

For more information, check out: <http://time.com/7357/california-drought-debate-over-desalination/>.

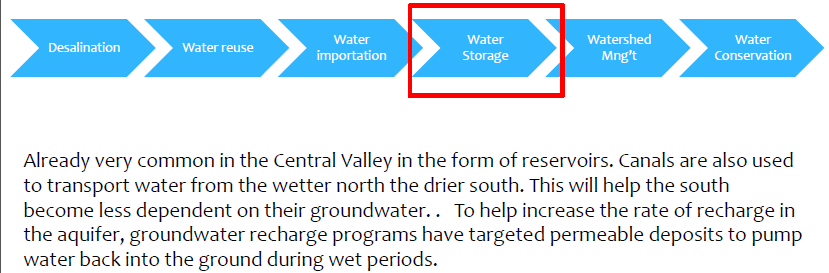


“Water reuse can be important in helping to reduce groundwater consumption because that water is almost never returned to the aquifer (Richter, Chasing Water, p. 51).” Using recycled water reduces the reliance on imported surface water and groundwater. Reclaimed water will be extremely useful as non-potable water used for irrigation or industry. Reclaimed water can also be used to recharge the aquifer. Greywater does not need to meet strict criteria for potable water during the water treatment process; therefore, greywater takes less energy to produce.

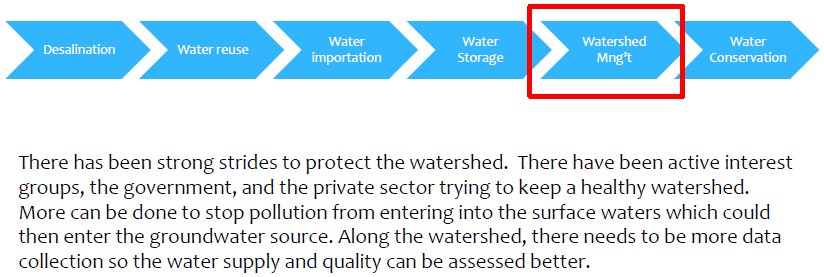


Canals are also used to transport water from the wetter north to the drier south. This will help the south become less dependent on groundwater. The State Water Project, the nation's largest state-built water and power development and conveyance system, provides water supplies for 25 million Californians and 750,000 acres of irrigated farmland.

For more information on the State Water Project, check out <http://www.water.ca.gov/swp/>.



Water storage is already very common in the Central Valley in the form of reservoirs. Reservoirs tend to be victims of evaporation, especially in the warmer southern regions of California. Reservoir releases also do not mimic the natural flow patterns of pre-developed rivers. An aquifer is another form of water storage; however, in the Central Valley the water is being pumped out too quickly, depleting the aquifer supply. To help increase the rate of recharge in the aquifer, groundwater recharge programs have targeted permeable deposits to pump water back into the ground during wet periods.



There has been pressure to protect the watershed from active interest groups, the government, and the private sector. The Department of Pesticide Regulation takes a leading role of assessing the water quality with the Division of Drinking Water and Environmental Management of the California Department of Public Health (Great Valley, 2012). They are targeting possible contaminating activities (PCA) such as septic systems, farms using fertilizers and pesticides, animals waste, landfills, and dry cleaners. The Total Maximum Load (TMDL) is being tested in many waterways so better regulations can be put forth on the amounts of contaminants being released into the Central Valley water system. More can be done to stop pollution or the salinization of surface water which could contaminate the groundwater source.

Throughout the watershed, there needs to be more data collection so the water supply and quality can be better assessed. Metering all groundwater withdrawals will be a necessity to manage the watershed. Water rights will need to be allocated responsibly in order to stop or decrease further depletion of the aquifers. The Central Valley could benefit from a water market setup.

25 state and federal agencies collaborated to create an initiative to improve water supplies in the Delta. The program is called CALFED Bay-Delta Program. Not only is it invested in protecting the water quality, water supply, and ecosystem restoration, but it also has a levee integrity program. This program inspects levees for potential failure to decrease the risk of seawater intrusion (CALFED Bay-Delta Program, 2007).

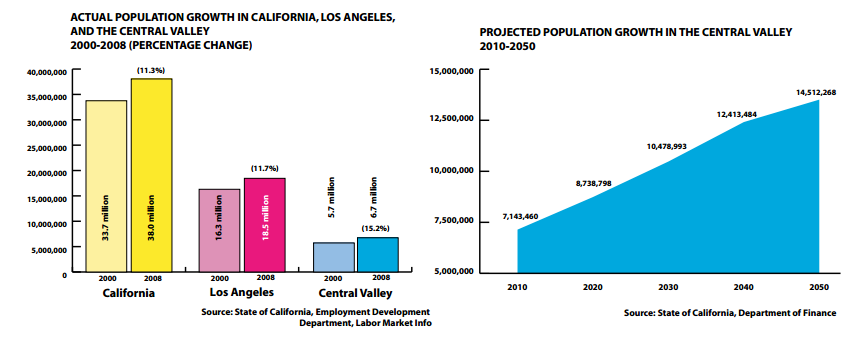


Inefficient use of water resources is a large issue, especially with an emphasis on the agricultural industry. As water prices rise in the coming years, water saving will also rise. This is why investing in water conservation is important now. Water conservation tends to be the cheapest option. Due to increased pressure and funding, farmers have become quite innovative in the region implementing best practices on their farm. Changing irrigation techniques and using fewer pesticides make a large impact on conserving water. Reducing water consumption will decrease pumping out of the aquifer and increase environmental flows in the surface water.

**Appendix A: Supplemental Information**

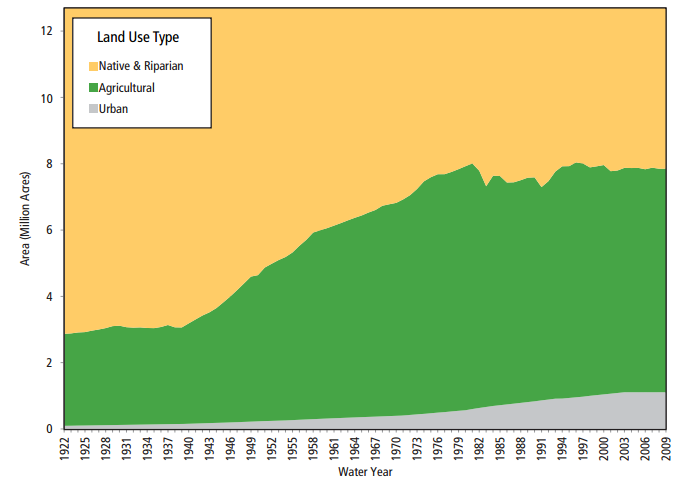
**Population Growth in the Central Valley**

**(Figure from Great Valley, 2009)**



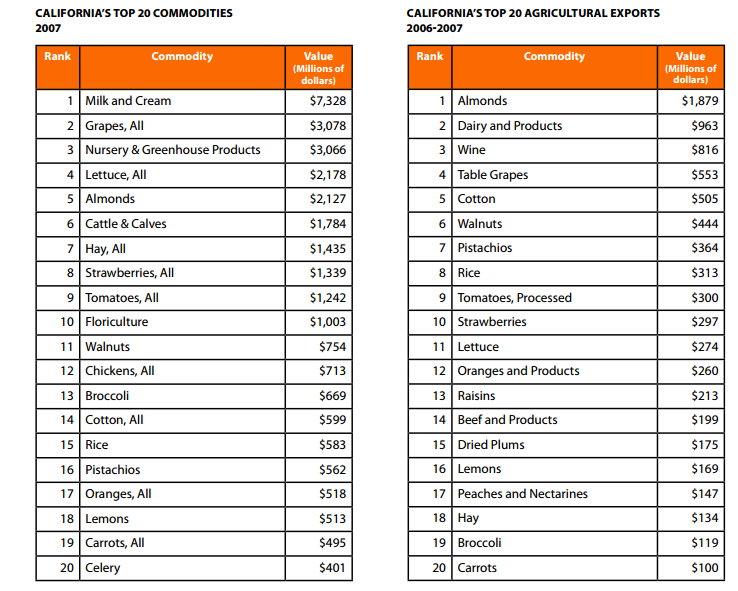
**Historical Land Use Changes in the Central Valley, 2000-2009**

**(Figure from** **California Department of Water Resources, 2013)**



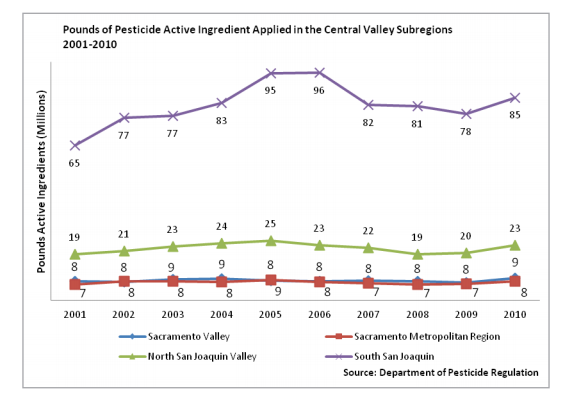
**California Agriculture Commodities**

**(Table from Great Valley, 2009)**



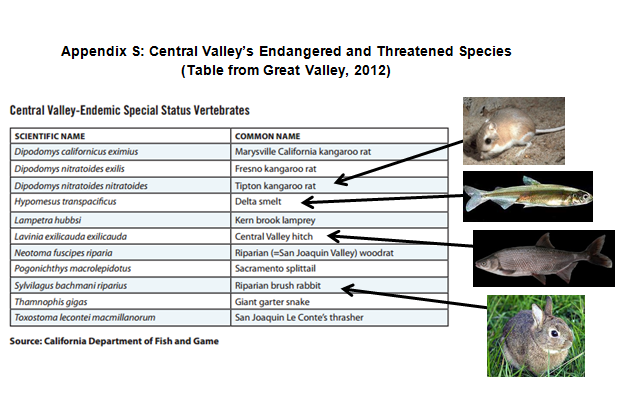
**Pounds of Pesticides, 2001-2010**

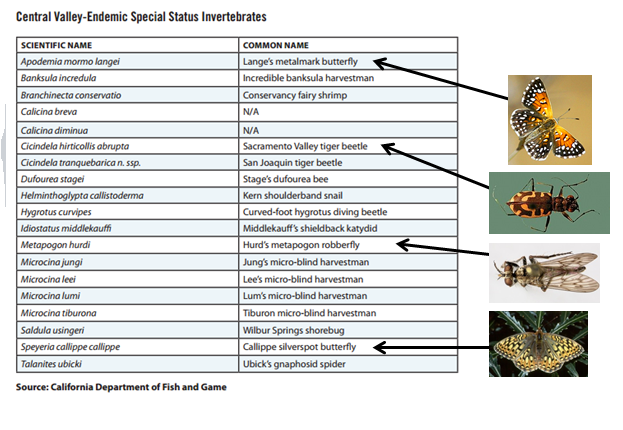
**(Figure from Great Valley, 2012)**



**Central Valley’s Endangered and Threatened Species**

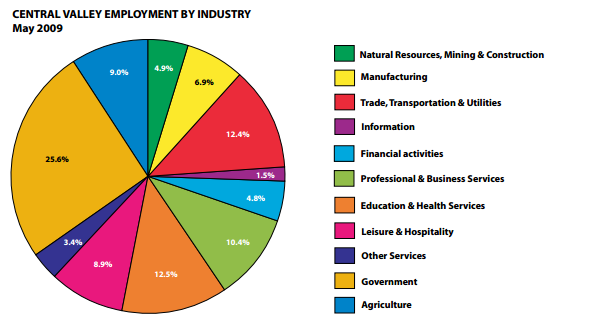
**(Table from Great Valley, 2012)**





**Industry Employment in the Central Valley**

**(Figure from Great Valley, 2009)**



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