SPFC Facilities

This subsection presents a high-level summary of the SPFC facilities that are described in more detail in the SPFC Descriptive Document (DWR, 2010b). Figures 2-10 shows an overview of the SPFC facilities.

Except for the backwater effect of flows mingling in the Delta, SPFC facilities on the Sacramento River and tributaries operate independently from SPFC facilities on the San Joaquin River and tributaries. The Sacramento River system carries flood flows that are about 10 times greater in volume than those in the San Joaquin River system.

Both the Sacramento and San Joaquin rivers use bypass systems to carry a large portion of floodwater. Together, the rivers and their tributaries have nearly 1,600 miles of project levees. Non-SPFC reservoirs in each system have flood reservation storage that significantly helps attenuate flows and aids in operation of downstream SPFC facilities.

Sacramento River Basin The flood management system along the Sacramento River and tributaries manages flood flows originating from an area of approximately 27,000 square miles. Major tributaries to the Sacramento River include the Feather, Yuba, Bear, and American rivers, which discharge to the Sacramento River from the east. Three smaller upstream SPFC projects (North Fork Feather River near Chester, Middle Creek, and Adin projects) are on streams tributary to the Sacramento River. Figure 2-11 shows an overview and design flow capacities of SPFC facilities in the Sacramento River Basin.

Figure 2-10. Overview of SPFC Facilities in the Central Valley

Figure 2-11. Design Flood Flow Capacities Within the Sacramento River, Bypasses, and Major Tributaries and Distributaries in the Sacramento River Basin

Upstream from Ord Ferry at about RM 183 on the Sacramento River, most SPFC facilities were constructed primarily to help reduce local flooding and have no association with the continuous flood management system that stretches from Ord Ferry to Collinsville in the Delta.

Flow in the Sacramento River is reduced by spilling floodwater into bypass areas through historic overflow areas and SPFC weirs. The first spill from the Sacramento River occurs just upstream from the start of the levee system at Ord Ferry. Floodwater leaves the river through three non-SPFC flood overflow areas and flows into the Butte Basin, which drains into the Sutter Bypass. Additionally, floodwater spills into bypasses over five SPFC weirs. Because of these spills to the bypass areas, the design flow capacity of the Sacramento River generally decreases in a downstream direction except where tributary inflow increases river flow locally. For example, the design capacity of the Sacramento River upstream from the leveed system is about 260,000 cfs. Downstream from the Tisdale Weir, the design capacity of the river is only 30,000 cfs.

The comprehensive system of SPFC levees, river channels, overflow weirs, drainage pumping plants, and flood bypass channels is the largest flood management system in California. This system includes the following major SPFC facilities:

- About 440 miles of river, canal, and stream channels (including an enlarged channel of the Sacramento River from Cache Slough to Collinsville)
- About 1,000 miles of levees (along the Sacramento River channel, Sutter and Yolo basins, and Feather, Yuba, Bear, and American rivers)
- Four relief bypasses (Sutter, Tisdale, Sacramento, and Yolo bypasses)
- Knights Landing Ridge Cut to connect the Colusa Basin to the Yolo Bypass
- Five major weirs (Sacramento Weir, built in 1916; Fremont Weir, built in 1924; and Moulton, Tisdale, and Colusa weirs, built in 1932 and 1933)
- Two sets of outfall gates
- Five major drainage pumping plants
- Numerous appurtenant structures such as minor weirs and control structures, bridges, and gaging stations

San Joaquin River Basin The flood management system along the San Joaquin River manages flood flows originating from an area of approximately 16,700 square miles in the Sierra Nevada, Central Valley, and Coastal Ranges in Central California. Major tributaries to the San Joaquin River include the Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, and Fresno rivers, which discharge to the San Joaquin River from the east. In addition, during flood release events from Pine Flat Reservoir, some Kings River flows are diverted north through the James Bypass into the San Joaquin River.

Unlike on the Sacramento River, where SPFC levees are continuous from Ord Ferry to the Delta, San Joaquin River SPFC levees are intermittent from near RM 225 to the Delta. The Chowchilla, Eastside, and Mariposa bypasses are the main SPFC facilities for the upstream portion of the San Joaquin River system. For portions of the system, these bypasses are the only SPFC facilities, and the San Joaquin River itself is not part of the SPFC. The bypass system ends upstream from the Merced River.

Figure 2-12 shows an overview and design flow capacities of SPFC facilities in the San Joaquin River Basin. The State operates SPFC facilities in the San Joaquin River Basin based on the 1955 profile rather than on design flows from the O&M manuals. Where the design flow capacities from O&M manuals were different for the left-bank levee and right-bank levee along a particular reach, the lowest capacity is shown on Figure 2-12.

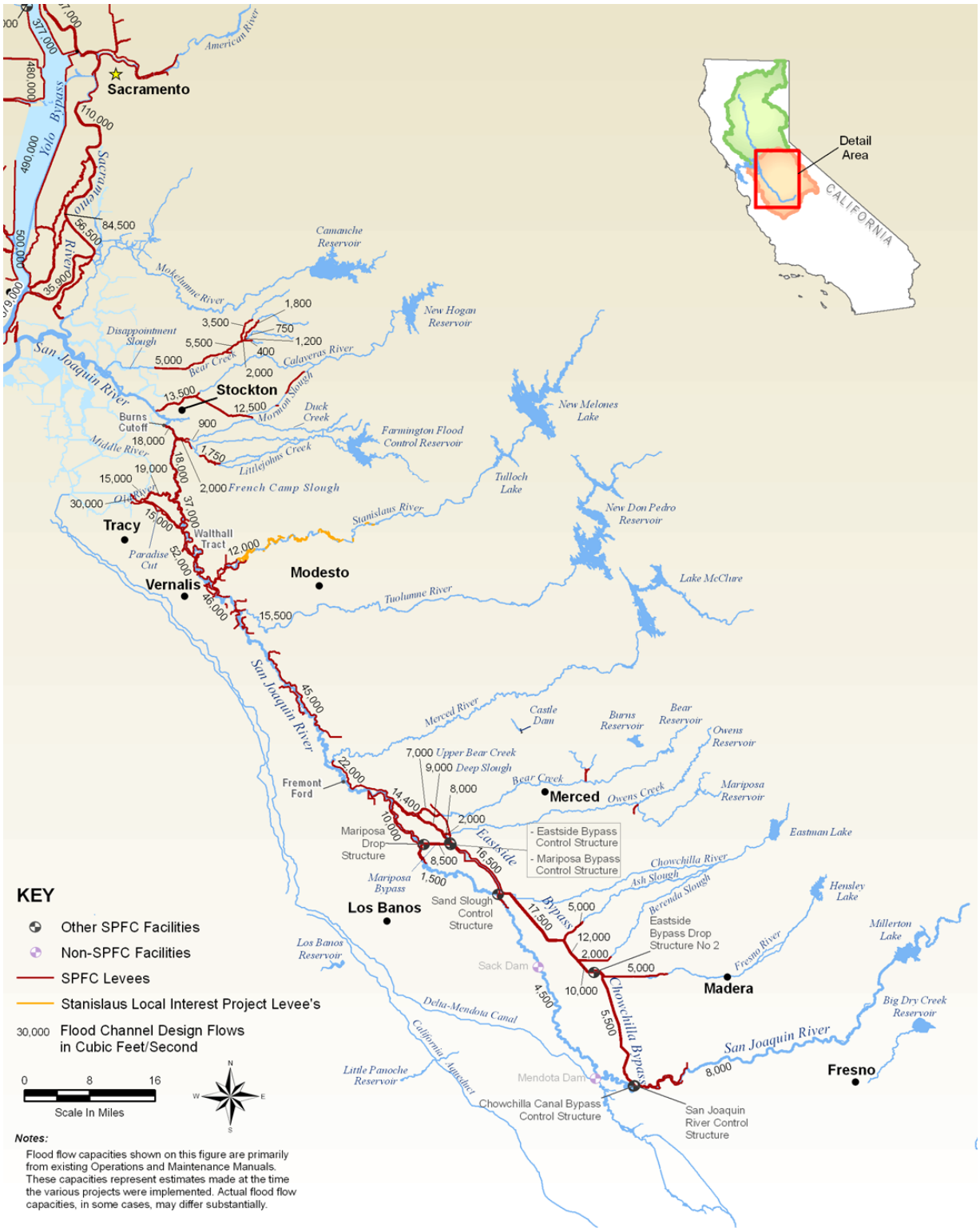


Figure 2-12. Design Flood Flow Capacities Within the San Joaquin River, Bypasses, and Major Tributaries and Distributaries in the San Joaquin River Basin

Major SPFC facilities along the San Joaquin River and tributaries include the following:

- Chowchilla Canal Bypass (and levees), which begins at the San Joaquin River downstream from Gravelly Ford, diverts San Joaquin River flows, and discharges the flows into the Eastside Bypass
- Eastside Bypass (and levees), which begins at the Fresno River, collects drainage from the east, and discharges to the San Joaquin River between Fremont Ford and Bear Creek
- Mariposa Bypass, which begins at the Eastside Bypass and discharges to the San Joaquin River (and levees)
- Approximately 99 miles of levees along the San Joaquin River
- Approximately 135 miles of levees along San Joaquin River tributaries and distributaries
- Six instream control structures (Chowchilla Bypass Control Structure, San Joaquin River Control Structure, Mariposa Bypass Control Structure, Eastside Bypass Control Structure, Sand Slough Control Structure, and San Joaquin River Structure)
- Two major pumping plants

Local Flood Control Projects

Non-project, or local, levees, by definition, are not a part of the State-federal system or the SPFC. However, it is important to recognize that these non-project levees affect the performance of the SPFC as part of the greater Sacramento-San Joaquin Flood Management System. In addition, the levee system in the Delta downstream from Collinsville on the Sacramento River and downstream from the Stockton area on the San Joaquin River is composed entirely of non-project levees.

The majority of Delta levees, more than 730 miles, are non-project levees that are not part of an authorized federal flood control project. These levees have been built and maintained by landowners or RDs to protect agricultural lands. Although not part of the State-federal system, failures of these non-project levees are recognized to affect the performance of the project levees and impact on surrounding lands and properties. A portion of the costs for non-project levee maintenance may be reimbursed under the Delta Levees Maintenance Program established in 1973, CWC Section 12980 et seq., and reimbursement opportunities were also significantly increased by the Delta Flood Protection Act of 1988. While early levees

were built to different heights and cross sections, non-project levees at least are required to meet the State's Flood Hazard Mitigation Plan standards to be eligible for federal financial assistance in case of a flood. Over the last 30 years, the State has provided supplemental financing for levee maintenance and emergency response through DWR's Delta Levee Maintenance Subventions Program.

Transient Flood Storage

Transient flood storage is the temporary detention of water on the floodplains adjacent to rivers to allow for attenuating and delaying flood peaks by holding and slowly releasing floodwaters. This is achieved by the formation of artificial obstructions (e.g., weirs) to direct floodwater away from the river channel and to constrain flooding within a defined area. Bypasses, wetlands, and agricultural easements provide transient storage in the Sacramento and San Joaquin river basins (e.g., Yolo Bypass and San Luis National Wildlife Refuge (NWR) Complex).

Diversions, Fish Screens, and Ladders

A large number of diversion structures on rivers and streams to provide for irrigation and M&I water supplies. Larger and permanent diversions are equipped with fish screens and ladders to allow for fish passage. Most small diversion dams are constructed to seasonally divert water for irrigation and many have installed fish ladders. Some of the major diversions in the Sacramento and San Joaquin river basins include:

- The Red Bluff Diversion Dam – diverts Sacramento River water into the Tehama-Colusa Canal and the Corning Canal; contains fish ladders.
- The Anderson-Cottonwood Irrigation District Diversion Dam diverts water into the Anderson-Cottonwood Irrigation District canal; contains fish ladders.
- The Glenn-Colusa Irrigation District's Hamilton City Pumping Plant. With a diversion capacity of 3,000 cfs, it is the largest diversion on the Sacramento River (USACE, 1999).
- Granlees Diversion Dam – The two fish ladders were retrofitted to allow fish access at a wider range of flows.
- Fremont Weir, located at the northern end of the Yolo Bypass, includes a small fish ladder at the center of the weir that operates during floods that overtop the weir.
- In the southern Delta, the two largest diversions are operated by the SWP and CVP. They have louvers to guide juvenile fish into bypasses

and holding facilities, where salvaged fish are collected and transported back to the Bay Area and Delta.

- The Contra Costa Water District (CCWD) has several diversions in the San Francisco Bay/Sacramento San Joaquin River Delta (Bay-Delta). They sporadically operate a diversion at Mallard Slough in Suisun Bay. New screens are in place at the Los Vaqueros Diversion on Old River. New screens are being constructed at the CCWD Rock Slough Intake.

Transportation

Transportation plays an essential role in the economy and the overall functioning of society. Providing mobility enables individuals to participate in the labor force, visit friends and relatives, participate in cultural activities, and generally contribute to economic activity. The movement of goods and services, and the overall economic activity of a region, is also dependent on a functional transportation network.

The Sacramento and San Joaquin river basins are served by a complex transportation network. Several major highways, rail lines, public transit systems, ports, and airports serve as the primary modes of travel and the transportation of goods and services. The location of many of the major transportation routes are shown on Figure 2-13.

Counties are required to have a circulation or transportation element within their general plan. These general plan elements document the major transportation routes and methods within each county, which are summarized in this section.

Only ports that have a regional significance are described below. Airports are described that are classified as Primary Commercial Service Airports according to the Federal Aviation Administration.

Figure 2-13. Major Transportation Routes in the Sacramento and San Joaquin River Basins

Regional Transportation Routes and Methods There are seven different regional transportation routes and methods discussed and listed below. These routes and modes provide the bulk of the regional movement of goods and services.

Interstate 5
I-5 is the major north-south route linking the entire west coast of the United States. It operates as a local, regional, and Interstate freeway, and is a major trucking route for many of the goods transported throughout the west coast.

Interstate 80
I-80 is a major east-west route that links the west coast of the United States to the east coast. It is a major route used for local access, but it also functions as one of the major east-west routes of the country.

State Route 99
SR 99 is a major north-south route that runs almost the entire length of both the Sacramento and San Joaquin river basins. The highway runs east of I-5 and serves as a trucking route, and access between most Central Valley and San Joaquin River Basin cities and communities.

Union Pacific Railroad
The Union Pacific (UP) Railroad is one of the major freight carriers on the west coast. It has tracks travelling in all directions. Many tracks are shared between UP and other rail carriers, as discussed below.

Burlington Northern Santa Fe
Burlington Northern Santa Fe (BNSF) is the major competitor of UP. BNSF exclusively provides freight service. BNSF and UP share tracks.

Amtrak
Amtrak is the national passenger rail carrier throughout the United States. Amtrak does not own its own tracks, but uses the UP and BNSF rails. Services provided by Amtrak operate in all directions daily, with most stations based in larger communities.

Greyhound
Greyhound is the largest regional bus service in the United States. Most major cities within the United States have a Greyhound bus station. Greyhound buses run along the major highways including I-5, I-80, and SR 99. Greyhound serves both large and small communities and provides service to many communities not served by rail.

Ports

The Sacramento River Deep Water Ship Channel was constructed in 1963. This 30-foot-deep ship channel runs from Collinsville to the City of West Sacramento where the Port of West Sacramento is located. Nearly 50 vessels carrying 595,246 metric tons of cargo called on the port in 2008 (USACE, 2010). The lock at the upper end of this channel is no longer operated for shipping purposes, but continues to block the migration of all fish from the deep water channel back to the Sacramento River.

The Port of Stockton is located in Stockton on the San Joaquin River. Constructed in 1933, the San Francisco Bay to Stockton Deep Water Ship Channel (Stockton Channel) extends from Suisun Bay near Chipps Island to Stockton. The Stockton Channel is 35 feet deep and can handle 55,000-ton-class vessels with full loads. More than 300 ships and barges used the channel in 2005 (URS, 2007). Both the West Sacramento and Stockton ports are likely to expand in the future, which would result in an increase in ship and barge traffic through the Delta.

Upper Sacramento River Region The Upper Sacramento River Region includes portions of the counties of Shasta, Tehama, Butte, Glenn, Colusa, Sutter, and Yolo. Both I-5 and SR 99 are the major north-south routes along the entire reach of the region. Branching off of both I-5 and SR 99 are several state highways that serve local communities with a majority of the routes being in an east-west direction. Below is a listing of the major routes within the region, as designated by the county general plan and the areas those routes serve.

- SR 162, SR 36, SR 273, SR 299, and SR 151 serve the area west of I-5 in Shasta, Tehama and Glenn counties
- SR 44, SR 36, SR 32, and SR 70 serve the area east of I-5 in Shasta, Tehama and Butte counties
- SR 20 and SR 16 serve the area west of I-5 in Colusa and Yolo counties
- SR 32, SR 45, SR 162, SR 20, and SR 113 serve the area east of I-5 and west of SR 99 in Tehama, Glenn, Colusa, Sutter and Yolo counties

No ports are located within this region; however, there are two airports. The Redding Municipal Airport is just south of Redding, while the Chico Municipal Airport is to the north of Chico. There are several locally based small bus-only public transit systems within the region. These transit systems are listed below along with a description of their service area.

- **Tehama Rural Area Express** – Service connects Red Bluff, Corning, Los Molinos, Gerber, Tehama, and places in between

- **Redding Area Bus Authority** – Serves the greater Redding Metropolitan Area

- **Glenn Ride Bus Service** – Provides service from Chico to Willows with stops at Artois, Orland, and Hamilton City

- **Butte Regional Transit** – Provides local service in Chico, Oroville, and Paradise with other travel to communities throughout Butte County

- **Yolo Bus** – Serves Sacramento, Davis, Woodland, Vacaville, and Winters

Lower Sacramento River Region The Lower Sacramento River Region includes portions of the counties of Yolo, Sutter, Sacramento and Solano. I-5 and SR 99 are the major north-south freeway routes. In addition, Interstate 505 (I-505) connects I-5 and I-80. SR 50 and I-80 are the major east-west routes. Many north-south routes start from and merge into I-80 and SR 50. Below is a listing of the major routes within the region, as designated by the county general plan and the areas those routes serve.

- SR 20, SR 70, SR 65, SR 16, and SR 104 serve the area east of SR 99 in Butte, Yuba and Sacramento counties

- SR 133, SR 45, and SR 160 serve the area west of SR 99 and east of I-5 in Yolo and Solano counties

- SR 16, SR 113, SR 12, and SR 160 serve the area west of I-5 in Yolo and Solano counties

There is one major port located within the Delta, the Port of West Sacramento. The port deals primarily with bulk items that are produced within the Central Valley, such as agricultural products and raw materials used in construction.

The Sacramento International Airport (SMF) is located within the region. The airport is the busiest passenger airport within the entire Central Valley. No ports are located within the Lower Sacramento River Region. There are several public transit agencies located throughout the area, the largest being Regional Transit, which provides both bus and light rail services to the Sacramento Metropolitan Area. These transit systems are listed below along with a description of their service area.

- **Regional Transit** – Provides bus and rail service throughout the entire Sacramento Metropolitan Area

- **Fairfield/Suisun Transit** – Local service within Fairfield and Suisun with regional transit to Vacaville, Dixon, Davis, Sacramento, Benicia, El Cerrito, Pleasant Hill, and Walnut Creek

- **Yolo Bus** – Serves Sacramento, Davis, Woodland, Vacaville, and Winters

- **Vacaville City Coach** – Local service within the city of Vacaville

Delta The Delta Region includes portions of the counties of Yolo, Sacramento, Solano, San Joaquin, and Contra Costa. I-5 and SR 99 are the major north-south routes, while I-80 and SR 50 are the major east-west routes within the region. Several major Interstates and State routes traverse the region serving the local population. Below is a listing of the major routes within the region, as designated by the county general plan and the areas those routes serve.

- SR 12, SR 84, SR 113, SR 160, and SR 220 serve the area north of the Sacramento River in Sacramento and Solano counties

- SR 12, SR 160, SR 4, SR 120 and Interstates 580 and 205 serve the area south of the Sacramento River in San Joaquin and Contra Costa counties

There is one major port located within the Delta, the Port of Stockton. The port deals primarily with bulk items that are produced within the Central Valley, such as agricultural products and raw materials used in construction. Stockton Metropolitan Airport is the only commercial airport located within the region. There are also several locally based bus-only public transit systems within the region. These transit systems are listed below along with a description of their service area.

- **Regional Transit** – Provides bus and rail service throughout the entire Sacramento Metropolitan Area

- **Yolo Bus** – Serves Sacramento, Davis, Woodland, Vacaville, and Winters

- **San Joaquin Regional Transit** – Local transit within the Stockton Metropolitan Area with regional transit reaching to Lodi, Tracy, Manteca, Ripon, Lathrop, Escalon, Modesto, and Sacramento

Lower San Joaquin River Region The Lower San Joaquin River Region includes portions of the counties of San Joaquin, Contra Costa, and Stanislaus. I-5 and SR 99 are the major north-south routes. Below is a listing of the major routes within the region, as designated by the county general plan and the areas those routes serve.

- SR 12, SR 4, SR 26, SR 104, SR 120, and SR 88 serve the area east of SR 99 in Sacramento and San Joaquin counties
- SR 132, SR 4, and SR 165 serve the area west of SR 99 in Contra Costa and Modesto counties
- SR 132, SR 108, and SR 120 serve the area east of SR 99 in Modesto County

No major ports are located within the region. Modesto City-County Airport is the only airport within the region. There are also several locally based bus-only public transit systems within the region. These transit systems are listed below along with a description of their service area.

- San Joaquin Regional Transit – Local transit within the Stockton Metropolitan Area with regional transit reaching to Lodi, Tracy, Manteca, Ripon, Lathrop, Escalon, Modesto, and Sacramento
- Modesto Area Express – Local service within the Modesto Metropolitan Area with regional service to Dublin and Manteca
- Stanislaus Regional Transit – Regional transit among Modesto, Oakdale, Riverbank, Merced, Turlock, and Gustine

Upper San Joaquin River Region The Upper San Joaquin River Region includes portions of the counties of Merced, Madera, and Fresno. I-5 and SR 99 are the major north-south routes and several routes branch off of both I-5 and SR 99 to serve the communities to the east and west. Below is a listing of the major routes within the region, as designated by the county general plan and the areas those routes serve.

- SR 140, SR 180, SR 41, SR 145, and SR 65 serve the area east of SR 99 in Merced, Madera and Fresno counties
- SR 152, SR 165, SR 140, SR 59, SR 33, SR 180, SR 41, and SR 145 serve the area east of I-5 and west of SR 99 in Merced, Madera, and Fresno counties
- SR 152 serves the area west of I-5 in Merced and Fresno counties

Within the region is the Fresno-Yosemite International Airport (FAT). This is the second busiest commercial airport after the SMF airport and an important transit hub for people living in the San Joaquin River Basin. No ports are located within the region; however, there are also several locally based bus-only public transit systems within the region. These transit systems are listed below along with a description of their service area.

- Merced County Transit – Local service in Merced and Los Banos with regional transit among Merced, Los Banos, Hilmar, Turlock, Delhi, Livingston, and Atwater
- Fresno Area Express – Local service throughout the entire Fresno Metropolitan Area with service in Fresno, Pinedale, and Clovis
- Madera Area Express – Local service throughout the city of Madera
- Chowchilla Area Transit Express – Local service throughout the city of Chowchilla
- Madera County Connection – Regional transit among cities including Madera, Chowchilla, Fairmead, La Vina, Ripperdan, Eastin Arcola, Madera Ranchos, Coarsegold, Oakhurst, and North Fork

Water Supply

This section discusses the major water supply projects and facilities that impact integrated flood management in the Sacramento and San Joaquin river basins.

Central Valley Project Development and construction of the CVP was authorized under federal Reclamation law passed in 1902. The CVP is the largest surface water storage and delivery system in California, including 20 reservoirs with a combined storage capacity of approximately 11 MAF; eight powerplants, and two pump-generating plants with a combined generation capacity of approximately 2 million kilowatts; and approximately 500 miles of major canals and aqueducts. The CVP supplies water to more than 250 long-term water contractors in the Central Valley, Santa Clara Valley, and Bay Area. Figure 2-14 shows the locations of CVP and other major water supply facilities in the State.

Figure 2-14. Major Water Supply Facilities in California

The CVP has the potential to deliver about 7 MAF annually to agricultural and M&I customers and for environmental purposes. Of this 7 MAF, about 6.2 MAF is supplied for agricultural uses, 0.5 MAF for urban uses, and 0.3 MAF for wildlife refuges (DWR, 2005c). However, while an annual delivery capability of 7 MAF exists, actual deliveries have historically been much lower. Historically, about 90 percent of CVP water has been delivered to agricultural users. The CVP also provides flood control, navigation, power, recreation, and water quality benefits.

Several regulatory requirements and agreements affect operation of the CVP. The Central Valley Project Improvement Act (CVPIA), signed into law in 1992, redefined the purposes of the CVP to include protection, restoration, and enhancement of fish, wildlife, and associated habitats and protection of the Bay-Delta Estuary as having equal priority with other purposes. Before passage of the CVPIA, operation of the CVP was affected by SWRCB Decisions 1422 and 1485 (D-1422 and D-1485), and the Coordinated Operations Agreement. D-1422 and D-1485 identify minimum flow and water quality conditions at specified locations that are to be maintained, in part, through operation of the CVP. The Coordinated Operations Agreement specifies the responsibilities shared by the CVP and the SWP for meeting the requirements of D-1485. In December 1994, a Bay-Delta Protection Plan was implemented through the SWRCB to help protect the ecosystem of the Bay-Delta Estuary. SWRCB Decision 1641 (D-1641) superseded D-1485 in 1999 and was later amended in 2000. Coordinated operations of the CVP and SWP continue to be based on the Coordinated Operations Agreement.

During development of the CVP, the United States entered into long-term contracts in the Central Valley with many major water rights holders, who belong to three major groups: (1) Sacramento River Settlement Contractors, (2) San Joaquin River Exchange Contractors, and (3) CVP Water Service Contractors.

Members of Sacramento River Settlement Contractors have pre-1914 water rights on the Sacramento River. Because of the significant influence of the CVP on flows in the Sacramento River, these water rights holders entered into contracts with Reclamation. Most of the agreements established the quantity of water rights water (base supply) the Sacramento River Settlement Contractors are allowed to divert from April through October without cost, and also established a supplemental CVP supply allocated by Reclamation for availability and for cost.

San Joaquin River Exchange Contractors are contractors who receive CVP water from the Delta via the Mendota Pool. Under exchange contracts, the parties agreed not to exercise their San Joaquin River water rights in

exchange for a substitute CVP water supply from the Delta. These exchanges allowed for water to be diverted from the San Joaquin River for use by CVP Water Service Contractors in the San Joaquin River Basin and Tulare Lake Basin.

Before construction of the CVP, many irrigators on the west side of the Sacramento River Basin, on the east and west sides of the San Joaquin River Basin, and in the Santa Clara Valley relied primarily on groundwater. With completion of CVP facilities in these areas, irrigators signed agreements with Reclamation for delivery of CVP water as a supplemental supply. Several cities also have similar contracts for M&I supplies; these irrigators and cities are known as CVP Water Service Contractors.

State Water Project The SWP was authorized in 1959 and was designated to readjust geographical imbalances between California's water resources and water needs. The project extends from Plumas County in the north to Riverside County in the south. Major SWP facilities are shown on Figure 2-14. The SWP delivers water to service areas in the Feather River Basin, Bay Area, San Joaquin River Basin, Tulare Basin, and Southern California (USBR, 2005b).

SWP project elements include 23 dams and reservoirs, six power plants, 17 pumping plants, and 533 miles of aqueduct. The principal storage feature of the SWP is Lake Oroville, with a gross pool of 3.5 MAF. Located on the Feather River about 4 miles northeast of Oroville, Oroville Dam releases water that flows through the Feather and Sacramento rivers before reaching the Delta. The SWP shares storage space with the CVP in San Luis Reservoir.

Major SWP conveyance facilities in the Central Valley include the North Bay, South Bay, and California aqueducts. The North Bay Aqueduct diverts water from Barker Slough in the north Delta for agricultural and M&I uses in Napa and Solano counties. The South Bay and California aqueducts carry water from the Delta to the Bay Area and to Southern California, respectively. In the southern portion of the Delta, the Harvey O. Banks Delta Pumping Plant lifts water into the California Aqueduct from the Clifton Court Forebay.

Water in the main stem of the California Aqueduct flows south by gravity into the San Luis Joint-Use Complex, which was designed and constructed by the federal government and is operated and maintained by DWR. Within the complex are O'Neill Forebay, Sisk Dam and San Luis Reservoir, the Gianelli Pumping-Generating Plant, Dos Amigos Pumping Plant, and the San Luis Canal. This section of the California Aqueduct serves both the SWP and the federal CVP.

After leaving the Joint-Use Complex, water travels through the central San Joaquin River Basin and splits near Kettleman City into the Coastal Branch Aqueduct, completed in 1997, to serve San Luis Obispo and Santa Barbara counties. The water in the main stem is pumped up California's hilly terrain by three pumping plants – Buena Vista, Teerink, and Chrisman – until it reaches Edmonston Pumping Plant. Water is then lifted nearly 2,000 feet up and over the Tehachapi Mountains through 10 miles of tunnels.

Contracts between DWR and the 29 SWP water contractors define the terms and conditions governing water delivery. Table A, an exhibit in the water supply contracts, is the maximum supply of scheduled water that a contractor may request. SWP Contract Table A allocations are contracts executed in the early 1960s that established the maximum annual water amount that each long-term contractor may request from the SWP. The total of the 29 contractors' maximum Table A amount for deliveries is about 4.13 MAF per year. Of this amount, about 2.6 MAF is designated for Southern California, nearly 1.2 MAF for the San Joaquin River Basin, and the remaining 373 TAF for the San Francisco Bay, Central Coast, Feather River areas, and north Delta water rights settlement (DWR, 2005c).

Local The Sacramento River Basin has relatively abundant water supplies in comparison to the other regions of the State. This river basin provides its own M&I and agricultural water relying on a mix of surface water diversions, on the Sacramento River and its tributaries, and groundwater extraction to meet local water supply needs. Major water supplies in the river basin are provided through surface storage reservoirs. The largest reservoirs are Shasta Lake, with the CVP, on the upper Sacramento River, and Lake Oroville, with the SWP, on the Feather River. These major reservoirs also provide flood storage capacity to operate as part of the flood control system.

The SWP, CVP, Cross-Valley Canal, Delta-Mendota Canal, San Luis Canal, and Kern County Water Agency deliver water to the San Joaquin River Basin. Other major surface water supply projects in the San Joaquin River Basin are located on the Merced and Tuolumne rivers. The New Exchequer Dam impounds Merced Irrigation District's Lake McClure. This lake is the only large water supply reservoir in the Merced River Basin and it has a capacity of 1 MAF. The Hetch Hetchy Reservoir system on the Tuolumne River provides water to the San Francisco Bay area. The Modesto Irrigation District and Turlock Irrigation District jointly divert about 1 MAF per year (MAF/year) of Tuolumne River water for agricultural use from the New Don Pedro Reservoir. East Bay Municipal Utility District (EBMUD) receives water from Camanche and Pardee reservoirs on the Mokelumne River and conveys it through the San Joaquin River Basin via the 80-mile long Mokelumne Aqueducts to serve the East

Bay. In addition, many urban areas in the San Joaquin River Basin rely solely on groundwater for their supply, where groundwater overdraft occurs in much of the valley floor.

In addition to the Delta's function as a critical element of both regional and interregional water supply conveyance systems, it supports in-Delta diversions for agriculture and M&I use. In-Delta agricultural diversions include approximately 1,800 diversions taken directly from the channels and sloughs. Major in-Delta municipal diversions include CCWD diversions and associated Los Vaqueros Project diversions. CCWD diversions include Millard Slough, Rock Slough, Old River intakes, and an under-construction Alternative Intake Project on Victoria Canal. The Los Vaqueros Reservoir is a 100 TAF reservoir used by CCWD to address seasonal water quality degradation associated with Delta water supplies. CCWD stores water in Los Vaqueros Reservoir that is diverted from the Delta when water quality is favorable, for later release and blending when Delta water quality is degraded. In Suisun Bay and Suisun Marsh, far fewer agricultural diversions exist because of brackish waters. However, many State and privately managed wetlands divert water seasonally from Suisun Marsh sloughs.

Power and Energy

The following provides a brief overview for each of the major power production facilities.

Hydropower Facilities

State Water Project

Power generation from SWP facilities are mainly provided from the operation of the Hyatt-Thermalito facilities downstream from Lake Oroville. The combined 900-megawatt Hyatt Pumping-Generating Plant and Thermalito Pumping-Generating Plant (Hyatt-Thermalito) generate about 2.2 billion kilowatt-hours in a median water year, while the 3-megawatt Thermalito Diversion Dam Power Plant adds another 24 million kilowatt-hours a year (DWR, 1996a). Generation at existing SWP aqueduct recovery plants—Gianelli, Alamo, Devil Canyon, and Warne—varies with the amount of water conveyed. These four plants generate about one-sixth of the total energy used by the SWP. (The Gianelli Pumping-Generating Plant is a joint SWP and Reclamation facility.)

The primary purpose of the SWP power generation facilities is to meet energy requirements for the SWP pumping plants. To the greatest extent possible, SWP pumping is scheduled during off-peak periods, and energy generation is scheduled during on-peak periods. Although the SWP uses more energy than it generates from its hydroelectric facilities, DWR has

exchange agreements with other utility companies and has developed other power resources. When available, surplus power is sold by DWR to minimize the net cost of pumping energy.

Central Valley Project
The CVP is a system of 20 dams and reservoirs, as well as canals, and power plants. The CVP power facilities include 11 hydroelectric power plants with 38 generators, and have a total maximum generating capacity of 2,045,000 kilowatts (Reclamation, 2005a). Major factors that influence power plant operations include downstream water releases, electric system needs, and CVP use demand. CVP power generation facilities initially were developed based on the premise that power could be generated to meet project use loads. The Reclamation Act of 1939 provided for surplus power to be sold first to preference customers, including irrigation districts, and RDs, cooperatives, public utility districts, municipalities, and large educational or government facilities. Surplus commercial power may then be sold to non-preference utility companies. The first commercial power generated by the CVP was sold in 1945.

Other Hydroelectric Facilities
In addition to CVP and SWP hydroelectric facilities, other hydroelectric facilities are present in the Sacramento River Basin. Hydroelectric generation facilities are investor-owned utility companies, such as Pacific Gas and Electric Company (PG&E) and Southern California Edison Company (SCE); by municipal agencies, such as the Sacramento Municipal Utility District (SMUD); and by several water and irrigation districts. Some of the larger facilities outside the CVP and SWP systems include PG&E's Pit System and McCloud-Pit System in Shasta County; PG&E's Upper North Fork Feather River System in Plumas County; SMUD's Upper American River Project System in El Dorado County, and Yuba County Water Agency's (YCWA) Yuba River Project in Yuba County.

In the Lower San Joaquin River Region, some of the larger facilities outside the CVP and SWP systems include SCE's Big Creek System and Mammoth Pool Project in Fresno County; and the New Don Pedro Project jointly owned by Turlock Irrigation District and Modesto Irrigation District in Tuolumne County.

Natural Gas Storage and Conveyance The Delta Region contains some of the most productive natural gas fields in the State. The largest of the two dozen fields are under Brannan Island, Twitchell Island, and Bradford Island. Under McDonald Island is a natural gas storage facility for PG&E. The Delta-Suisun area has approximately 240 operating natural gas wells (DPC, 2009).

Natural gas pipelines within the Delta connect gas wells to the storage and processing facilities and serve local gas fields and regional pipelines. These pipelines carry gas across the Delta-Suisun from Bay Area refineries to depots in Sacramento and Stockton for distribution to Northern California and Nevada. PG&E is constructing a major pipeline from Canada to Southern California within existing utility alignments, under a transmission line, and along I-5. The Mojave Pipeline Company has recently proposed a 600-mile-long pipeline to bring gas from the present terminus in Bakersfield to the Sacramento area, Fairfield, and the East Bay.

Natural gas pipelines, storage areas, and compressor stations are also located in the Sacramento River Basin and other parts of Northern California. Although few gas fields and storage areas exist in the San Joaquin River Basin, several major pipelines traverse the entire length of the San Joaquin River Basin.

Electrical Transmission The flat, largely unpopulated Delta terrain is a valuable site for electricity transmission lines. There are more than 500 miles of transmission lines and more than 60 substations that lie within the Delta boundaries (DPC, 2009). Several electrical peaking plants surrounding the Delta-Suisun area depend on these transmission lines. Along with these regional lines, local lines serve the population residing within the legal Delta boundaries. PG&E, SMUD, and Western Area Power Administration oversee most of the transmission lines and provide local electric service within the Delta-Suisun area. The regional lines carry power within California as well as between regions of the western United States.

Wind Farms Wind energy plays an integral role in California's electricity portfolio. On a cumulative basis, a total of 2,517 megawatts of wind capacity has been installed in California, the third among all states in the United States. It is about 3.1 percent of the State's total power generation (AWEA, 2009). There are two major wind farms, Montezuma Hills and Altamont Pass, within or near the Delta Region. Additionally, hundreds of homes and farms are using smaller wind turbines to produce electricity.

Utilities and Public Services

Various county and local agencies within the cities and counties of the Sacramento River and San Joaquin river basins provide solid waste and wastewater removal and management, emergency services, public safety, fire protection, and law enforcement services.

Water Treatment, Sewer and Stormwater Urban areas use treatment facilities to process wastewater, discharge treated wastewater into rivers, and/or evaporate or percolate the treated wastewater in large open ponds.

Smaller communities and individual homes use septic tanks and leach fields for dispersion of wastewater effluents. Many of these leach fields are located within the floodplain.

Communication Towers The Delta area is full of flat and open areas that let radio waves transmit for a long distance. With this advantage, four television and some radio transmission towers have been installed in the Delta. Four television transmission towers are located east of Walnut Grove, Sacramento County, and two radio transmission towers are near Locke. The Air Force and Navy radio towers are located in eastern Solano County.

2.1.3 Biological Conditions – Terrestrial and Aquatic Resources

Biological conditions of the Sacramento and San Joaquin river basins addressed in this section include terrestrial and aquatic habitats and common wildlife and fish species found in these habitats. Special-status species of plants, wildlife, and fish are also described, with a particular focus on those species most likely to be associated with the flood management system. Invasive species with the greatest potential to cause ecological damage and the highest probability of being associated with the flood management system are also listed and described. The section concludes with a discussion of recreational uses of the fish and wildlife resources and a discussion of conservation planning efforts that have been recently completed or are underway to address the decline of native wildlife, fish, and plants in the Bay-Delta and Central Valley. Our discussion draws heavily from the CALFED Multi-Species Conservation Strategy (MSCS) (CALFED, 2000a), and interested readers are referred to that document for additional information.

Historic and Regional Perspective

Historically, much of the Central Valley was an extensive seasonal floodplain that was shallowly inundated during flood events and spring snowmelt. Flowing water and the hydraulic, geomorphic, physical, and biological processes that are associated with flowing water were primarily responsible for the structure and function of the ecological communities that were found throughout this region. Because the frequency and intensity with which these processes interacted was highly variable both temporally and spatially, a diverse mosaic of riparian, wetland, and upland habitats developed across the Central Valley. These habitats included riparian forests and riparian scrub along river channels, and along the natural levees that formed next to the Central Valley's major rivers; vast networks of seasonal and permanent marshes and wetlands that developed along abandoned river channels, oxbow lakes, tidal sloughs, and within flood basins; alkali wetlands, grasslands, and scrub on ancient lake beds, basin rims, and alluvial fans; and vernal pools with associated native grasses and forbs on ancient (i.e., mid- to early-Pleistocene aged) river floodplains, terraces, and basin rims. These habitats supported a diversity of native plants, wildlife, and fish uniquely adapted to California's Mediterranean climate and to the highly dynamic nature of the Sacramento River and San Joaquin River systems as well as the Bay-Delta Estuary.

Human settlement, agricultural development, and development of the Central Valley's flood management and water delivery infrastructure have reduced these habitats to a small percentage of their original extents (CVHJV, 1990a; Hickey et al., 2003; Kelly et al., 2005; TNC, 1987).

Despite extensive habitat loss, almost 500 native fish and wildlife species (DFG, 2007), thousands of species of native plants, and countless species of aquatic and terrestrial invertebrates (as well as many more nonnative species) are still found within the Sacramento and San Joaquin river basins. However, connectivity among remnant patches of native habitat as well as interaction with the fluvial processes (e.g., floodplain inundation, bank scouring, and sediment deposition) that shaped these habitats have been reduced or altered. Habitat reduction and alteration is one of the primary reasons that many species are considered to be rare, threatened, or endangered by the U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Game (DFG), or California Native Plant Society (CNPS) (hereafter collectively referred to as special-status species). More specifically, recent estimates indicate that more than 200 special-status species of plants, fish, wildlife, and invertebrates may be found within the Sacramento and San Joaquin river basins (CALFED, 2000a).

Aside from direct habitat loss and alteration, the native habitats and species found within the Central Valley and Bay-Delta have been adversely affected by a host of nonnative and invasive species. These regions now contain an unknown number of nonnative species, and a new species (many of which are aquatic invertebrates) is estimated to be introduced at least every 14 weeks (Cohen and Carlton, 1998). These species have the potential to dramatically alter the structure of the Bay-Delta's aquatic food web to the detriment of native pelagic fish and aquatic organisms (Sommer et al., 2007). Competition from nonnative sunfish (e.g., green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus dolomieui*), bluegill (*Lepomis macrochirus*), and small mouth bass (*Micropterus dolomieui*) and other game fish from the eastern United States have similarly had a negative effect on anadromous fish and a native sunfish (the Sacramento perch (*Archoglites interruptus*)) that was formerly widely distributed throughout the Sacramento and San Joaquin river basins. Nonnative, invasive plant species that are similarly detrimental to native ecosystems are widespread where they often outcompete native plants for light, space, and nutrients, further degrading habitat quality for native fish and wildlife (CALFED, 2000b).

Summary of Important Terrestrial and Aquatic Habitats in the Study Area

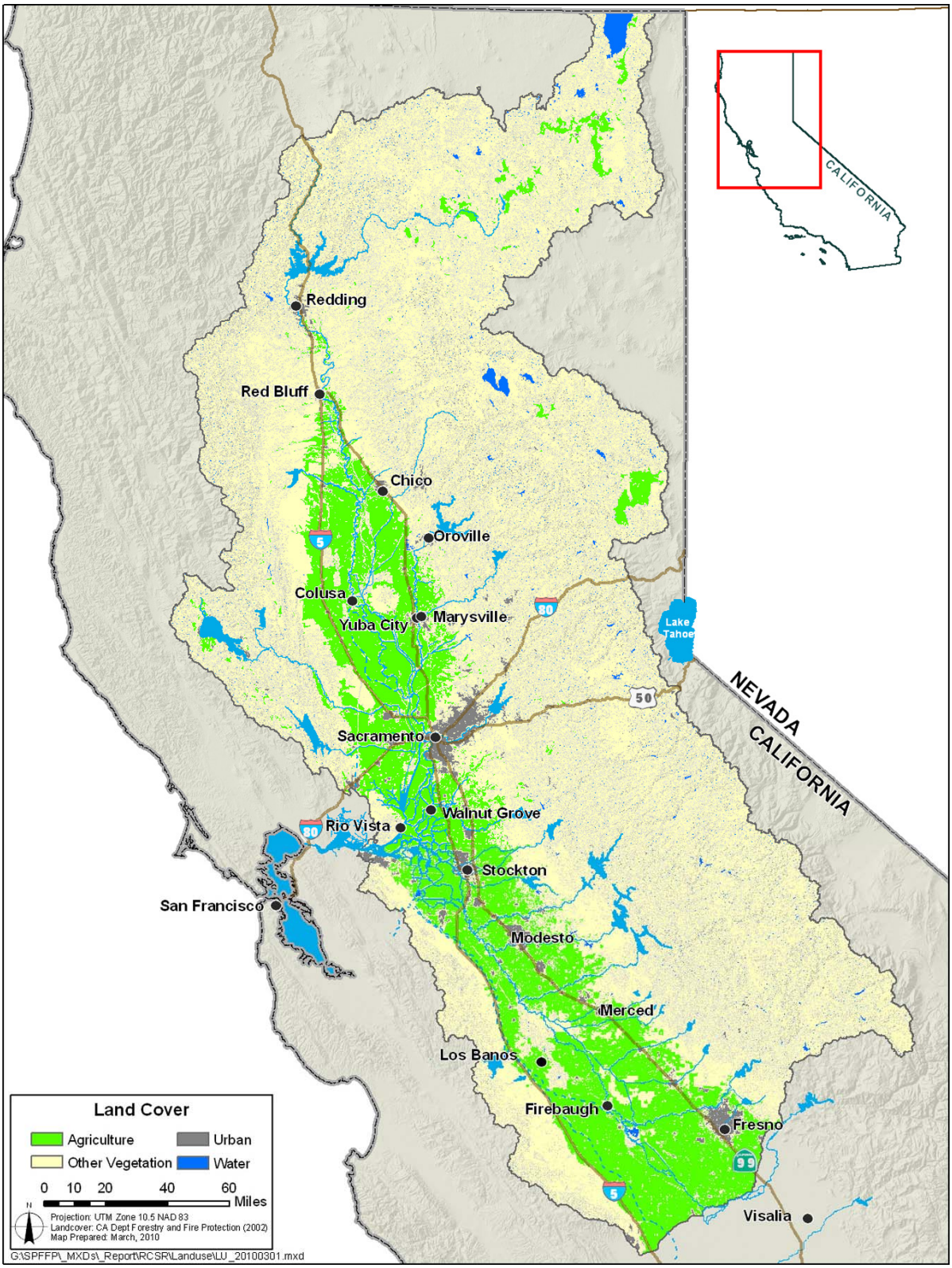
This next section describes the terrestrial and aquatic habitats that occur in the Sacramento and San Joaquin river basins. In addition, wildlife and fish species expected to be found in these habitats are also discussed. Terrestrial plant communities include saline emergent wetlands, fresh emergent wetlands, valley/foothill riparian, vernal pools, and agricultural land. Aquatic habitats include the Sacramento River, Sacramento River

floodplain bypasses, major tributaries to the lower Sacramento River, lower San Joaquin and Stanislaus rivers, and the Delta.

The following summary descriptions of these terrestrial, agricultural, and aquatic habitats list species generally thought to be associated with these communities or that these communities could potentially support. It should not be inferred that presence of the species listed have been confirmed.

Terrestrial Plant Communities

Terrestrial plant communities include the remnant native and naturalized plant communities within the Bay-Delta and Central Valley. The primary biological characteristics, including dominant plant species, structural characteristics, and wildlife expected to be found in these plant communities are described in the following sections. The general locations of urban areas, agricultural land, and native plant communities are shown on Figure 2-15.



Note: Other Vegetation includes everything that is not Agriculture, Urban, or Water

Figure 2-15. Land Use in the Sacramento and San Joaquin River Basins

Saline Emergent Wetland Saline emergent wetland includes tidal salt marsh and tidal brackish marsh within the Bay-Delta. These are habitats dominated by emergent plant species that tolerate saline or brackish conditions within the intertidal zone or are found on lands that historically were subject to tidal exchange (i.e., diked wetlands). Dominant plant species include cordgrass (*Spartina* spp.), pickleweed (*Salicornia* spp.), jaumea (*Jaumea carnosa*), California seablite (*Suaeda californica*), arrowgrass (*Triglochin* spp.), alkali heath (*Frankenia salina*), saltgrass (*Distichlis spicata*), brass-buttons (*Cotula* spp.), salt rush (*Juncus lesueurii*), tufted hairgrass (*Deschampsia caespitosa*), tule (*Scirpus acutus*), and broadleaf cattail (*Typha latifolia*) (Springer, 1988). Species of birds expected to use saline emergent wetlands include common birds such as herons, egrets, ducks, hawks, Virginia rail (*Rallus limicola*), American coot (*Fulica americana*), shorebirds, swallows, and marsh wren (*Cistothorus palustris*). Characteristic mammals include species of shrews, bats, mice, raccoon (*Procyon lotor*), and river otter (*Lontra canadensis*). Additionally, a number of species from adjacent uplands frequently visit the wetlands to feed. Several species of lizards and snakes frequent the edge of the high marsh. And, common amphibians such as the Pacific tree frog (*Hyla regilla*) and western toad (*Bufo boreas*) may use saline emergent marsh after heavy rains (Springer, 1988).

Many special-status plant species are associated with saline emergent wetlands including Ferris's milk-vetch (*Astragalus tener* var. *ferrisiae*), soft bird's beak (*Cordylanthus mollis* ssp. *mollis*), palmate-bracted bird's beak (*C. palmatus*), San Francisco gumplant (*Grindelia hirsutula* var. *maritime*), Suisun Marsh thistle (*Cirsium hydrophilum* var. *hydrophilum*), heartscale (*Atriplex cordulata*), San Joaquin spearscale (*A. joaquiniana*), brittlescale (*A. depressa*), Delta button celery (*Eryngium racemosum*), and hispid bird's beak (*C. mollis* ssp. *hispidus*). Special-status species of wildlife that are heavily dependent on saline emergent wetlands include clapper rail (*Rallus longirostris obsoletus*), California least tern (*Sterna antillarum browni*), and salt marsh harvest mouse (*Reithrodontomys raviventris*).

Freshwater Emergent Wetland Fresh emergent wetland habitats include a variety of seasonal and permanent wetlands such as tidal and nontidal emergent wetlands that primarily support herbaceous plant species intolerant of saline or brackish conditions; portions of the intertidal zones of the Bay-Delta as well as permanent wetlands outside the tidal and intertidal zones, such as river bottoms immediately adjacent to low-flow channels, backwaters, and sloughs, and natural and managed seasonal wetlands. Managed seasonal wetlands include federal refuges, private hunting clubs, and private environmental lands. Plant species found in fresh

emergent wetlands are mainly herbaceous perennials and annuals that are adapted to surviving in submerged or saturated soil.

Nonnative and native species characteristic of perennial fresh emergent wetlands include broadleaf cattail, tule, common reed (*Phragmites australis*), common rush (*Juncus effusus*), Baltic rush (*J. balticus*), and knotweed (*Polygonum* spp.). Goodding's willow (*Salix gooddingii*), sandbar willow (*S. exigua*), and Himalayan blackberry (*Rubus armeniacus*) are woody plants that tolerate flooding and are frequently found around the margins of perennial fresh emergent wetlands. There are at least 200 species of birds that have been identified in the emergent wetlands of the Yolo Basin and the Delta.

Plant species found in seasonally inundated fresh emergent wetlands range from species tolerant of prolonged inundation (some of which are discussed above) to species adapted for growth in both wet and dry conditions. Seasonal fresh emergent wetlands may contain considerable cover of upland species as well. In addition to the species listed above, species commonly present in seasonal fresh emergent wetlands include tall flatsedge (*Cyperus eragrostis*), dallisgrass (*Paspalum dilatatum*), Bermudagrass (*Cynodon dactylon*), Italian ryegrass (*Lolium multiflorum*), Mediterranean barley (*Hordeum marinum* ssp. *gussoneanum*), slender sedge (*Carex praegracilis*), Santa Barbara sedge (*Carex barbarae*), poverty rush (*Juncus tenuis*), and curly dock (*Rumex crispus*).

Species of birds found in fresh emergent wetlands include song sparrow (*Melospiza melodia*), common yellowthroat (*Geothlypis trichas*), marsh wren, western (*Aechmophorus occidentalis*) and Clarks grebes (*Aechmophorus clarkii*), and red-winged blackbird (*Agelaius phoeniceus*). Mammal species that use this habitat include California vole (*Microtus californicus*) and common muskrat (*Ondatra zibethicus*). Pacific chorus frog and western terrestrial garter snake (*Thamnophis elegans*) are generally found in this habitat type as well. These areas are critical wintering grounds for migratory birds along the Pacific Flyway, supporting nearly 70 percent of the migratory ground for migratory birds along the Pacific Flyway (CVHJV, 1990b). Many of these species are described below under "Rice."

Special-status plant species associated with fresh emergent wetlands include Suisun Marsh aster (*Symphyotrichum lentum*), rose mallow (*Hisbiscus lasiocarpus*), bristly sedge (*Carex comosa*), Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*), Mason's lilaeopsis (*Lilaeopsis masonii*), Sanford's arrowhead (*Sagittaria sanfordii*), slough thistle (*Cirsium crassicaule*), and marsh skullcap (*Scutellaria galericulata*). Special-status wildlife species that are closely dependent on fresh emergent wetlands

include California black rail (*Laterallus jamaicensis coturniculus*), giant garter snake (*Thamnophis gigas couchi*), and western pond turtle (*Actinemys marmorata*).

Valley/Foothill Riparian Riparian habitats typically include a structurally diverse mixture of trees, shrubs, vines, and herbaceous undergrowth. Tree canopies may be continuous or discontinuous, or absent altogether (as in riparian scrubs). Remnant riparian habitat exists between levees set back from the Sacramento River, primarily upstream from Colusa, on or at the toe of levees. Valley/Foothill riparian habitat includes all successional stages of woody vegetation generally dominated by willow (*Salix gooddingii, S. lasiolepis, S. exigua, S. lasiandra*), Fremont cottonwood (*Populus fremontii*), valley oak (*Quercus lobata*), and California sycamore (*Platanus racemosa*). Common understory species include nonnative Himalayan blackberry, and several native species including California blackberry (*Rubus ursinus*), western poison oak (*Toxicodendron diversilobum*), Dutchman's pipevine (*Aristolochia californica*), California button-willow (*Cephalanthus occidentalis*), blue elderberry (*Sambucus mexicana*), California rose (*Rosa californica*), and coyote brush (*Baccharis pilularis*) are found in the higher floodplain. California wild grape (*Vitis californica*) is a conspicuous vine found growing within the canopy of this forest. Common herbaceous species include Santa Barbara sedge (*Carex barbarae*), hoary nettle (*Urtica dioica*), and creeping wild rye (*Leymus triticoides*).

Large, mature riparian forest stands support the most dense and diverse breeding bird communities in California (Gaines, 1974). As described previously, the extent and width of riparian habitat varies throughout the system. Tall riparian trees provide high-quality nesting habitat for raptors such as red-tailed hawk (*Buteo jamaicensis*), red-shouldered hawk (*Buteo lineatus*), osprey (*Pandion haliaetus*), bald eagles, and white-tailed kite (*Elanus leucurus*). Herons, egrets, and cormorants also nest communally in riparian trees. They also provide nesting habitat for cavity-nesting species, such as downy woodpecker (*Picoides pubescens*), wood duck (*Aix sponsa*), northern flicker (*Colaptes auratus*), ash-throated flycatcher (*Myiarchus cinerascens*), oak titmouse (*Baeolophus inornatus*), tree swallow (*Tachycineta bicolor*), and white-breasted nuthatch (*Sitta carolinensis*). In addition, riparian forests and associated wetlands produce populations of insects that feed on foliage and stems during the growing season. These insects, in turn, are prey for migratory and resident birds, including Pacific-slope flycatcher (*Empidonax difficilis*), western wood-pewee (*Contopus sordidulus*), olive-sided flycatcher (*Contopus cooperi*), warbling vireo (*Vireo gilvus*), orange-crowned warbler (*Vermivora celata*), yellow warbler (*Dendroica petechia*), Bullock's oriole (*Icterus bullockii*), black phoebe (*Sayornis nigricans*), yellow-billed magpie (*Pica nuttalli*), bushtit

(*Psaltriparus minimus*), Bewick's wren (*Thryomanes bewickii*), lazuli bunting (*Passerina amoena*), blue grosbeak (*Guiraca caerulea*), American goldfinch (*Carduelis tristisa*) and spotted towhee (*Pipilo maculates*). Mammalian species common to riparian forests include, but are not limited to, ringtail cat (*Bassariscus astutus*), gray squirrel (*Sciurus griseus*), Virginia opossum (*Didelphis virginiana*), raccoon, desert cottontail (*Sylvilagus audubonii*), and striped skunk (*Mephitis mephitis*). Special-status species found in riparian areas include Delta button celery, , Western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), bank swallow (*Riparia riparia*), Swainson's hawk (*Buteo swainsoni*), riparian brush rabbit (*Sylvilagus bachmani riparius*), San Joaquin woodrat (*Neotoma fuscipes riparia*), and valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*).

Riparian habitats are found throughout the planning area; however, these remnant habitats represent only a small fraction of the originally extant habitat that was formerly widely distributed along river systems within the Central Valley.

Annual Grassland Annual grassland habitat is composed of an assemblage of native and nonnative annual grasses and, occasionally, native perennial grasses and native and nonnative forbs. Commonly encountered nonnative species include Italian rye grass, slender wild oat, soft chess (*Bromus hordeaceus*), ripgut brome (*Bromus diandrus*), foxtail fescue (*Vulpia myuros*), medusa-head (*Taeniatherum caput-medusae*) and Mediterranean barley. Although not common, native perennial grasses are occasionally found in this community. Characteristic species include blue wild rye (*Elymus glaucus*), purple needle grass (*Nassella pulchra*), and, in mesic or alkaline areas, creeping wild rye. Nonnative forbs such as redstem filaree (*Erodium cicutarium*), long-beaked filaree (*E. botrys*), rose clover (*Trifolium hirtum*), bur clover (*Medicago polymorpha*), dissected geranium (*Geranium dissectum*), and dovefoot geranium (*G. molle*), lesser hawkbit (*Leontodon taraxacoides*), and many other herbaceous weeds inhabit grassland communities. Common native forbs include California goldfields (*Lasthenia californica*), little-headed clover (*Trifolium microcephalum*), variegated clover (*Trifolium variegatum*), popcorn flower (*Plagiobothrys fulvus*), fiddleneck (*Amsinckia menziesii*), red maids (*Calandrinia ciliata*), and frying pans poppy (*Eschscholzia lobbii*). Various native bulbs (*Triteleia* spp., *Brodiaea* spp., *Dichelostemma* spp.) are also found in annual grasslands.

Annual grasslands were historically distributed more widely in the Central Valley and may have contained a significant number of perennial grasses, particularly in more mesic locations. Most of these grasslands have been

converted for other uses, including agricultural, urban, and industrial uses, and remaining grasslands are now dominated by nonnative species.

Vernal pools are common within annual grasslands where a restrictive soil layer is present (e.g., hardpan or claypan). Vernal pools are characterized by low-growing annual grasses and forbs adapted to live both on land and in water. Vernal pools are typically distinguished by a unique host of native and endemic plant species adapted to the extreme conditions created by the cycles of inundation and drying. Some dominant plant species include downingia (*Downingia* spp.), goldfields (*Lasthenia* spp.), popcornflower (*Plagiobothrys* spp.), coyote thistle (*Eryngium* spp.), woolly marbles (*Psilocarphus* spp.), and pale spike-rush (*Eleocharis macrostachya*). Many special-status plants, invertebrates, and wildlife are native to or associated with vernal pools and surrounding annual grasslands, including western spadefoot (*Spea hammondii*), California tiger salamander (*Ambystoma califoriense*), several species of fairy shrimp (*Branchinecta* spp.) and tadpole shrimp (*Lepidurus packardi*), several species of grasses in the *Orcuttieae* tribe, and various narrowly restricted endemic species that belong to characteristic vernal pool genera (e.g., *Limnanthes floccosa* ssp. *californica* or *Lasthenia conjugens*).

Typical bird species associated with annual grasslands include northern harrier (*Circus cyaneus*), ring-necked pheasant (*Phasianus colchicus*), mourning dove (*Zenada macroura*), horned lark (*Eremophila alpestris*), western meadowlark, red-tailed hawk, red-shouldered hawk, American kestrel (*Falco sparverius*), western kingbird (*Tyrannus verticalis*), western bluebird (*Sialia mexicana*), loggerhead shrike (*Lanius ludovidianus*), and savannah sparrow (*Passerculuc sandwichensis*). Mammal species that use annual grasslands include deer mouse (*Peromyscus maniculatus*), California vole, California ground squirrel (*Spermophilus beecheyi*), Botta's pocket gopher (*Thomomys bottae*), black-tailed jackrabbit (*Lepus californicus*), American badger (*Taxidea taxus*), and coyote (*Canis latrans*). Common reptile species associated with annual grasslands include western fence lizard (*Sceloporus occidentalis*), western racer (*Coluber mormon*), and gopher snake (*Pituophis melanoleucus*). California toad (*Bufo boreas*) is a common amphibian in grassland communities. Special-status species that depend upon annual grassland for at least a portion of their ecological requirements include those species associated with vernal pools discussed above plus western pond turtle, giant garter snake, Swainson's hawk, and western burrowing owl (*Athene cunicularia*).

Annual grasslands are also present along riverine sand dunes found in the western Delta in the vicinity of Antioch. These dunes support many of the nonnative grasses listed above in addition to native species such as California broom (*Lotus scoparius*) and naked buckwheat (*Eriogonum*

nudum). Special-status plants at the Antioch dunes include evening primrose (*Oenothera deltoides* ssp. *howellii*) and Contra Costa wallflower (*Erysimum capitatum ssp. angustatum*). Lange's metalmark butterfly (*Apodemia mormo langei*) is also found within grasslands on dune habitats.

Alkali Desert Scrub Alkali desert scrub is restricted to the southern and southwestern San Joaquin River Basin and. It is s low-growing, shrub-dominated community frequently characterized by members of the goosefoot family (*Chenopodiaceae*) that are tolerant of high alkalinity, especially iodine bush (*Allenrolfea occidentalis*) and seablites (*Suaeda* spp.). Alkali desert scrub also frequently includes various saltbrush species such as cattle saltbush (*Atriplex polycarpa*) and spinescale saltbush (*A. spinifera*). With the exception of high rainfall years when annual grass growth can be dense, herbaceous plant cover is typically also sparse and characterized by annual grasses such as Mediterranean barley and red brome (*Bromus madritensis* ssp. *rubens*). This habitat type is typically on sandy to loamy soils on rolling, dissected alluvial fans with low relief.

Wildlife species typically associated with upland scrub habitat include common and federally or state-listed species such as kangaroo rats (*Dipodomys* spp.), Nelson's antelope squirrel (*Ammospermophilus nelson*), kit fox (*Vulpes macrotis*), coyote, side-blotched lizard (*Uta stansburiana*), and blunt-nosed leopard lizard (*Gambelia sila*).

This community was formerly extensive but has been greatly reduced by agricultural conversions, flood control activities, and groundwater pumping.

Agricultural Communities Agricultural communities are composed of the entire range of agricultural crops grown in the Bay-Delta and Central Valley (refer to Section 2.1.4 for information). For the purposes of this section, agricultural crops have been grouped according to major crop types, largely defined by agronomic practices and structural characteristics that influence habitat and species suitability. Because agricultural land has replaced native habitat, many crops and agricultural practices now provide important habitat for some species of wildlife; these species are described below, where appropriate. Unless otherwise noted, the relationship between agricultural habitats and wildlife use was determined from the California Wildlife Habitat Relationships system (DFG, 2005).

Rice

Rice cultivation occurs within the northern Sacramento River Basin, where this crop is widely cultivated, and in portions of Merced County. Rice is grown as a monoculture, using tillage or herbicides to eliminate unwanted vegetation. Other vegetation is generally confined to the berms, ditches,

and canals between and around fields, and is dominated by wetland plants, both native and nonnative. Typical plants found in uncleared ditches, canals, and field edges include bulrush (tule), cattail, nutsedge (*Cyperus* spp.), rushes (*Juncus* spp.), Johnson grass (*Sorghum halepense*), Harding grass (*Phalaris aquatica*), western vervain (*Verbena lasiostachys*), and Bermuda grass. Giant reed (*Arundo donax*), an invasive nonnative species, is found along some rice fields.

In terms of wildlife habitat quality, rice fields, because they provide shallowly flooded wetland habitat with pockets of emergent vegetation, provide a reasonable surrogate for the wetland habitats that historically characterized large parts of the Sacramento and San Joaquin river basins. They attract a wide variety of waterfowl, wading birds, shorebirds, and gulls (Fleskes et al., 2005). During fall migration (which begins in late June), flooded rice fields provide prime habitat for a wide variety of shorebird species (Shuford et al., 1998). Hundreds or thousands of individuals of more than a dozen species forage for invertebrates during brief stopovers on their way south. In winter, flooded rice fields support large numbers of overwintering killdeer (*Charadrius vociferous*), greater yellowlegs (*Tringa melanoleuca*), long-billed curlew (*Numenius americanus*), and similar shorebirds. During these winter months, especially after the waterfowl-hunting season, large flocks of waterfowl such as Canada geese (*Branta canadensis*), snow geese (*Chen caerulescens*), northern pintails (*Anas acuta*), cinnamon teal (*Anas cyanoptera*), and gadwall (*A. strepera*) forage in flooded rice fields. These shorebird and waterfowl concentrations attract raptors, especially northern harrier, American peregrine falcon (*Falco peregrinus anatum*), and bald eagle (*Haliaeetus leucocephalus*). When not flooded, rodent populations in the fields may also attract raptors including white-tailed kite, red-tailed hawk, American kestrel, Swainson's hawk, and short-eared owl (*Asio flammeus*). Flooded rice fields and irrigation canals also provide important habitat for the giant garter snake, a species that, similar to waterfowl and shorebirds, has had its preferred wetland habitat greatly reduced and now relies upon rice fields as surrogate habitat.

Irrigated Row and Field Crops

Row crops are found throughout the Central Valley and the Bay-Delta and are especially common in the southern Sacramento River Basin and San Joaquin River Basin. Row crops are generally monotypic plantings of low to moderate height. Most row crops are annual species, although a few (e.g., strawberries) are perennials. Most crops are grown using tillage or herbicides to eliminate unwanted vegetation although a variety of ruderal, herbaceous species such as tall wild oats (*Avena fatua*) or yellow star thistle (*Centaurea solstitialis*) may be found along the edges of row crops along with other nonnative invasives including yellow nutsedge (*Cyperus*

esculentus), lambs quarter (*Chenopodium polyspermum*), and Johnson grass.

Row crops provide relatively poor wildlife habitat due to the intensity of management and lack of structural diversity. Some species that may be found in this habitat type include common species such as black-tailed jackrabbit, desert cottontail, Botta's pocket gopher, California ground squirrel as well as northern harrier, red-tailed hawk, American kestrel, mourning dove, ring-neck pheasant, western kingbird, American crow (*Corvus brachyrhynchos*), western meadowlark, Brewer's blackbird (*Euphagus cyanocephalus*), and red-winged blackbird. Special-status species such as Swainson's hawk, burrowing owl, tricolored blackbird (*Agelaius tricolor*), and greater sandhill crane (*Grus canadensis*) may also use row crops.

Dryland and Irrigated Grain Crops

Grain crops (e.g., safflower, wheat, barley, corn, milo, sorghum, and sudan grass) are found throughout the Sacramento and San Joaquin river basins. These are generally large, robust, annual crops grown in monotypic plantings that occasionally exceed 6 feet in height, especially corn. Most (except wheat and barley) are warm-season crops irrigated by furrows or flood irrigated and harvested once per season. Cool-season crops such as wheat and barley are generally not irrigated and sustained only by rainfall.

Grain crops provide forage for a variety of songbirds, game birds, small rodents, and waterfowl, and are planted specifically to benefit wildlife in some State wildlife areas (DFG, 2008a) and on private land in the form of restricted agriculture easements. Specific species that use grain crops include many of the species described above under row crops. Additionally, game species like ring-neck pheasant also make extensive use of these habitats. Coyotes and raptors may use these habitats for foraging following harvest.

Pasture and Irrigated Hayfields

Pasture and irrigated hayfields are found throughout the Sacramento and San Joaquin river basins. They include crops such as alfalfa (*Medicago sativa*) and various species of perennial and annual grasses and forbs that are cultivated for livestock feed (e.g., hay or silage). They are particularly common in the Delta. Alfalfa is a perennial plant that generally lives for 5 years or more, and is harvested several times in the growing season. Herbicides are generally used to control weeds and eliminate unwanted vegetation; any vegetation remaining on field margins includes a variety of nonnative grasses and forbs. Pasture, hay, and silage crops are generally perennial grasses (e.g., *Lolium perenne* or *Festuca aru-ndinacea*) mixed with various species in the pea (*Fabaceae*) family. Similar to alfalfa, they

may be mowed or grazed several times during the growing season. Both crops are usually flood irrigated or subirrigated. Aside from the species listed above, a variety of weedy ruderal, herbaceous species may be found in these habitats such as curly dock, Johnson grass, toad rush (*Juncus bufonis*), black mustard (*Brassica* nigra), red maids, and similar species.

Pasture and irrigated hayfields provide valuable raptor foraging habitat, particularly following mowing or grazing when the rodents may be especially available for these species. Swainson's hawks are known to be especially attracted to alfalfa fields for foraging. Tricolored blackbirds also use pasture for foraging. Shorebirds and gulls may also make extensive use of these habitats, particularly when flood irrigation creates areas of shallow inundation and moist, bare soil that provide foraging opportunities for these species. Irrigated pastures also provide suitable winter habitat for greater sandhill crane and may provide nesting and foraging habitat for burrowing owl.

Flood irrigated pastures with saturated soils and standing water of varying depths are conducive to the production of invertebrates that are the main food source for migrating waterfowl and other birds that periodically forage in these fields. Greater sandhill crane forage and roost in these habitats, and many ducks, geese, and shorebirds also commonly use these habitats throughout the Sacramento and San Joaquin river basins. During the dry season, many ground-nesting birds, such as ring-neck pheasant and Western meadowlark, nest in pastures.

Vineyards, Deciduous Orchards, and Evergreen Orchards
Orchards and vineyards are also found throughout the Sacramento and San Joaquin river basins. Orchards and vineyards are generally monotypic, tree- or vine-dominated habitats that are planted in uniformly straight rows and intensively pruned to encourage fruit production and facilitate fruit harvest. Common crops include grapes, walnuts, almonds, pistachios, various stone fruits, and various citrus fruits. Understories are managed to discourage weeds through a variety of methods (e.g., herbicides, discing, flaming). There is an increased use of permanent cover crops in upland vineyards as sustainable agricultural practices are being implemented. Drip irrigation is typically employed; although some orchards may be flood-irrigated or irrigated via aerial sprinklers.

These habitats typically have low to very low habitat values for most wildlife due to the intensity of management activities, lack of structural diversity, and lack of understory cover. Birds that may use these habitats include California quail (*Callipepla californica*), mourning dove, yellow-billed magpie, and American crow. Additionally, raptors may also occasionally use mature orchards for nesting. Some species that use

orchards and vineyards, such as ground squirrel, American crow, Brewer's blackbird, and European starling (*Sturnus vulgaris*), often are considered agricultural pests, and efforts to control these species are commonly implemented.

Fisheries and Aquatic Resources

The Sacramento and San Joaquin rivers, their primary tributaries, and the Delta provide vital fish habitat necessary for adult and juvenile foraging, spawning, egg incubation and larval development, juvenile nursery areas, and migratory corridors. This section includes: (1) a general description of the different aquatic habitats, (2) a discussion on the relationship of ecological processes to aquatic habitats and community composition, and (3) a description of those fish commonly found in aquatic communities.

Aquatic Habitats

Sacramento River

The reach of the Sacramento River between Shasta Dam and Red Bluff exhibits cool water temperatures because of regulated releases from Shasta and Keswick dams, and a stable channel with little meander. Riffle and deep pool habitats are abundant in comparison with reaches downstream from Red Bluff. Immediately below Keswick Dam, the river is deeply incised in bedrock with very limited riparian vegetation and no functioning riparian ecosystems. Near Redding, the river flows into the valley and the floodplain broadens. Historically, this area appears to have had wide expanses of riparian forests, but much of the river's riparian zone is currently subject to urban encroachment. Despite net losses of gravel since construction of Shasta Dam, substrates in much of this reach contain gravel suitable for salmonid spawning, some of which is introduced through a gravel augmentation program. This reach provides much of the remaining spawning and rearing habitat of several listed anadromous salmonids. For this reason, it is one of the most sensitive and important stream reaches in the Central Valley. Three water-control structures, Keswick Dam, Anderson-Cottonwood Irrigation District, and Red Bluff Diversion Dam, are located along the Sacramento River in this reach.

The Sacramento River from Red Bluff to Colusa generally functions as a large alluvial river with active meander migration through the valley floor. The river is classified as a meandering river, where relatively stable, straight sections alternate with more sinuous, dynamic sections (Sacramento River Conservation Area Forum, 2003). The active channel is fairly wide in some stretches and the river splits into multiple forks at many different locations, creating gravel islands, often with riparian vegetation. Historic bends in the river are visible throughout this reach and appear as scars of the historic channel locations with the riparian corridor and oxbow

lakes still present in many locations. The channel remains active and has the potential to migrate in times of high water. Point bars, islands, high and low terraces, in-stream woody cover, early successional riparian plant growth, and other evidence of river meander and erosion are common in this reach. The channel has varying widths, and aquatic habitats consist of shallow riffles, deep runs, deep pools at meander bends, glides, and shallow vegetated floodplain areas that become inundated during high flows.

The general character of the Sacramento River changes downstream from Colusa from a dynamic and active meandering channel to a confined, narrow channel restricted from migration. While setback levees exist along portions of the river upstream from Colusa, the levees become much narrower along the river edge as the river continues south to the Delta. Surrounding agricultural lands encroach directly adjacent to the levees, which have cut the river off from the majority of its riparian corridor, especially on the eastern side of the river. The majority of the levees in this reach are lined with riprap, allowing the river no erodible substrate. The channel width is fairly uniform and river bends are static as a result of confinement by levees. Therefore, aquatic habitats are fairly homogenous because depth profiles and substrate composition are fairly uniform throughout the reach. Multiple water diversion structures in this reach move floodwaters into floodplain bypass areas during high-flow events.

Sacramento River Floodplain Bypasses

There are three major floodplain bypasses—Butte Basin, Sutter Bypass, and Yolo Bypass—with a total of 10 overflow structures along the mainstem Sacramento River (six weirs, three flood relief structures, and an emergency overflow roadway) that provide access to broad, inundated floodplain habitat during wet years. Unlike other Sacramento River and Delta habitats, floodplains and floodplain bypasses are seasonally dewatered (as high flows recede) during late spring through autumn. This prevents introduced fish species from establishing year-round dominance except in perennial water sources (Sommer et al., 2003). Moreover, many of the native fish are adapted to spawn and rear in winter and early spring (Moyle, 2002a) during the winter flood pulse. Introduced fish typically spawn during late spring through summer when the majority of the floodplain is not available to them.

Major Tributaries to the Lower Sacramento River

Aquatic habitats found in the lower Feather River vary as the river flows from releases at Oroville Dam facilities down to the confluence with the Sacramento River at Verona. At the upper extent, the approximate 8-mile low-flow (about 600 cfs) section contains mainly riffles and runs, which provide spawning habitat for the majority of Feather River Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus mykiss*).

Also present in the low-flow section is a series of remnant gravel pit pools/ponds that connect to the main channel. This stretch is fairly confined by levees as it flows through the city of Oroville. From the downstream end of the low-flow section, the Feather River is fairly active and meanders its way south to Marysville. However, this stretch is bordered by active farmland, which confines the river into an incised channel in certain stretches. In some locations, adjacent farmlands are in the process of being restored to floodplain habitat with the relocation of levees to become setback levees.

Flows in the lower American River (downstream from Nimbus Dam) are generally cold and clear, providing habitat for anadromous and resident fish species. The river is fairly low gradient and is composed of riffle, run, glide, and pool habitats. Dams along the watershed have reduced gravel inputs to the system, but the lower American River contains large gravel bars and forks in many locations, leaving gravel/cobble islands within the channel. The majority of the lower American River is surrounded by the American River Parkway, preserving the surrounding riparian zone. The river channel does not migrate to a large degree because of the geologic composition that has allowed the river to incise deep into sediments, leaving tall cliffs and bluffs adjacent to the river. Downstream from William Pond Recreation Area (approximately river mile 14) the natural levees and bluffs are replaced by constructed levees that provide flood protection to the community of Carmichael, the City of Sacramento, and City of Rancho Cordova. Riparian habitat is still found in this part of the river; however, it tends to be confined to narrower bands between the river channel and levees. Riparian habitat is also present on several in-channel islands that are common between William Pond Recreation Area and the Capital City Freeway crossing.

Lower San Joaquin River

The lower San Joaquin River downstream from the Merced River is characterized by a relatively wide (approximately 300 feet) channel with little canopy or overhead vegetation and minimal bank cover. Aquatic habitat in the San Joaquin River is characterized primarily by slow-moving glides and pools, is depositional in nature, and has limited water clarity and habitat diversity. Many of the fish species using the lower San Joaquin River use this lower segment of the river to some degree, even if only as a migratory pathway to and from upstream spawning and rearing areas. The furthest downstream section of the river also is used by certain fish species (e.g., delta smelt (*Hypomesus transpacificus*)) that make little to no use of areas in the upper segment of the river (see Delta discussion below).

Major Tributaries to the Lower San Joaquin River
Aquatic habitats in the lower Stanislaus, Tuolumne, and Merced rivers vary longitudinally and provide fish spawning, rearing, and/or migratory habitat for a diverse assemblage of common Central Valley native and nonnative fish species. Aquatic habitats include riffles, runs, pools, and glides. Floodplain and associated riparian habitat also varies with the development of levees and encroachment of agriculture and urban uses. Flows in all three river systems are highly altered by dams and diversions that are managed for flood control and water supply purposes. The upstream extent of migration for anadromous salmonids in the Stanislaus, Tuolumne, and Merced rivers is formed by the Goodwin, LaGrange, and Crocker-Huffman dams, respectively.

Delta
The Delta is a vast, interconnected network of streams, rivers, marshes, sloughs, tidal channels, shoals, and similar freshwater and brackish habitats that support a diverse assemblage of aquatic species (Sommer et al., 2007), many of which have been introduced from other areas (Cohen and Carlton, 1998). The Delta and Suisun Bay, on the western edge of the Delta, are located at the confluence of the Sacramento and San Joaquin rivers and represent the most important, complex, and controversial geographic area for both anadromous and resident fisheries and distribution of California water resources for numerous beneficial uses. The Delta's channels are used to transport water from upstream reservoirs to the southern Delta, where federal and State facilities (Jones Pumping Plant and Harvey O. Banks Delta Pumping Plant, respectively) pump water into CVP and SWP canals, respectively.

The availability of suitable habitat within these aquatic communities is highly dynamic both temporally and spatially in response to shifts in specific ecological processes, most importantly changes in freshwater inflows and salinity. In addition to these factors, environmental conditions such as water temperature, predation, food production and availability, competition with introduced exotic fish and invertebrate species, and pollutant concentrations all contribute to interactive, cumulative conditions that have substantial effects on Delta fish populations.

The Delta serves as a migration path for all Central Valley anadromous species returning to their natal rivers to spawn. Adult Chinook salmon move through the Delta during most months of the year. Salmon and steelhead juveniles depend on the Delta as transient rearing habitat during migration through the system to the ocean and could remain for several months, feeding in marshes, tidal flats, and sloughs. In addition, Delta outflow influences abundance and distribution of fish and invertebrates in the Bay through changes to salinity, currents, nutrient levels, and pollutant

concentrations. Delta smelt is a key species driving many of the ongoing water management decisions in the Delta.

Aquatic Habitat Relationship to Ecological Processes Numerous physical, chemical, and biological processes interact within the Sacramento and San Joaquin rivers, major tributaries, and Bay-Delta to shape the aquatic communities found therein. In large part, these processes are driven by river flows, which, historically, have been highly variable in timing, magnitude, and duration within and among years. Currently, the water management system for the Central Valley controls the timing of peak flows through the Sacramento River and San Joaquin River watersheds. Surface water storage reduces peak flows during the wet season, providing flood management. Controlled releases during the dry season have provided additional water for agricultural, municipal, and industrial use.

Dams and reservoirs have also changed sediment transport and deposition in the Central Valley. Large amounts of fine sediment have deposited behind the largest dams (e.g., in Shasta Lake and Lake Oroville). Dam outflows tend to carry little sediment into the downstream river segment, but displace and remove sediment from the downstream segment's channel, and thus cause net erosion of the channel bed and banks (Kondolf, 1997), resulting in degradation of these aquatic habitat components. The blockage by dams of sediment movement downstream also contributes to the armoring of channel banks where all but the coarsest grain particles (e.g., large gravel, cobble, and boulders) are transported downstream (e.g., in the Tuolumne River downstream from New Don Pedro Dam and the Stanislaus River downstream from New Melones Dam) (Kondolf, 1997; Mount, 1995).

All structures constructed in the channel or on the active floodplain (including dams, berms and levees, and bank protection) alter flows and sediment erosion and deposition, and thus have consequences for channel form. The most substantial effects result from bank protection, berms and levees, and dams. Bank protection (e.g., stone revetment, riprap) is installed for the purpose of reducing lateral movement of the channel. Berms and levees restrict floodwaters to a small portion of the floodplain, and create deeper and faster peak flows capable of eroding and transporting more sediment that may expand the channel cross-sectional area. Dams affect channel form by reducing the frequency and magnitude of larger flow events, and by blocking sediment from entering downstream channel segments; thus, reducing the overall channel size or causing excessive incision (Kondolf, 1997). Dams also play an important role in altering the temperature in the major rivers within the Central Valley. The reservoirs behind dams have an insulating effect on stored water, creating a pool of

artificially cold water that is available for release to the downstream riverine habitats.

In the tidally influenced Delta, a transitional zone between freshwater and marine environments, the cause-and-effect relationship between freshwater outflow and aquatic community composition and diversity is complex and often dictated by a chain or web of events rather than by specific, direct effects (Burau et al., 1998). However, the balance between freshwater outflows and saltwater inflows has been described as being critically important for the ecology of the Delta (e.g., Sommer et al., 2007; Kimmerer et al., 2008) and, by extension, to many of the native fish species.

As mentioned above, historically the Delta was characterized by a shifting mosaic of salinity patterns in response to maximum freshwater outflows during the winter and spring months and saltwater intrusion into the Delta during the summer and fall months. These patterns would shift annually in response to increases or decreases in runoff associated with rainfall and snowfall amounts. With the construction of California's water storage and delivery projects (i.e., the CVP and SWP), as well as modifications to the Delta for water deliveries, flood protection, and shipping, the magnitude of these inter-annual shifts in salinity patterns have been reduced (Kimmerer et al., 2008).

The mixing zone between saltwater and freshwater is commonly referred to as the entrapment zone, a region of the Bay-Delta characterized by higher levels of particulates (most of which are transported into the Bay-Delta from the Sacramento and San Joaquin rivers), higher abundances of several types of organisms (such as phytoplankton and zooplankton), and maximum turbidity. It is commonly associated with the position of the two parts-per-thousand salinity isopleth (X2), but actually occurs over a broader range of salinities (Kimmerer, 1992). Although X2 and the entrapment zone may not be as closely related as previously believed (Burau et al., 1998), X2 continues to be used as an indicator of the entrapment zone location. In recent years, this zone in the Bay-Delta has ranged between approximately Honker Bay and Sherman Island (river kilometer 70 to 85) (USFWS, 2008).

As a consequence of higher levels of particulates, X2 is likely biologically significant for some aquatic species (Jassby et al., 1995). Mixing and circulation in this zone concentrates plankton and other organic material, thus increasing food biomass and production. Larval fish such as striped bass (*Morone saxatilis*), delta smelt, and longfin smelt (*Spirinchus thaleichthys*) may benefit from enhanced food resources present in the entrapment zone. Additionally, it is possible that the beneficial physical

and biological processes concentrated within X2 may be enhanced or muted, depending upon the cross-sectional area associated with X2 and the suitability of the physical habitats associated with X2 for specific species (Unger, 1994). The relationship between physical habitat elements and aquatic communities is described in more detail within the following section.

Relationship to Physical Habitat Elements As previously described, much of the land in the Sacramento and San Joaquin river basins was historically characterized by an extensive, interconnected network of marshes and other wetlands, riparian forests, and seasonal floodplains. In addition to providing important habitat for terrestrial species, these communities provided essential habitat for many of the fish species found in the region. Although these areas have been reduced to a fraction of their original extents, they continue to fulfill a variety of aquatic habitat functions. Seasonal floodplains and shaded riverine aquatic (SRA) habitat are especially important for native fish in the Sacramento and San Joaquin rivers and their major tributaries.

Seasonal floodplains act as an interface zone between terrestrial and aquatic habitats. The shallow water, lower velocity flows, presence of standing vegetation and organic matter, and comparative absence of nonnative, predatory fish provide spawning and rearing habitat for a variety of native fish, including many special-status species adapted to the dynamic nature of seasonal floodplain inundation (Sommer et al.; 2001, 2003). Although many of these species may also use marshes and other areas of submerged aquatic vegetation for spawning or rearing, research suggests that permanent marshes, because they lack the dynamic qualities of seasonal floodplains, provide lower quality habitat for native fish at the expense of improved habitat for nonnative fish such as largemouth bass (*Micropterus salmoides*) and other nonnative predatory species (Nobriga et al., 2005; Brown, 2003). The relative lack of seasonal floodplains within the lower Sacramento River system (with the notable exceptions of the Yolo Bypass and lower Cosumnes River) and complete absence in the San Joaquin River system is likely one reason for the observed decline of Chinook salmon, Sacramento splittail (*Pogonichthys macrolepidotus*), and similar special-status species that are adapted to exploit the dynamic nature of seasonal floodplain habitats (NMFS, 2009; Moyle et al., 2007).

SRA habitat is composed of riparian vegetation and in-stream tree and shrub debris that provides important fish habitat. SRA habitat is defined as the near-shore aquatic habitat occurring at the interface between a river and adjacent woody riparian habitat. The principal attributes of this aquatic habitat type are an adjacent bank composed of natural, eroding substrates supporting riparian vegetation that either overhangs or protrudes into the

water, and water that contains variable amounts of woody debris, such as leaves, logs, branches, and roots and has variable depths, velocities, and currents. Riparian habitat provides structure (through SRA habitat) and food for fish species. Shade helps maintain water temperatures, while low overhanging branches can provide sources of food by attracting terrestrial insects and providing habitat and organic material for aquatic invertebrates. As riparian areas mature and banks erode, the vegetation sloughs off into the rivers, creating structurally complex habitat consisting of in-stream woody material that provides refugia from predators, creates higher water velocities, and provides habitat for aquatic invertebrates. For these reasons, many fish species are attracted to SRA habitat, particularly native salmonids. Similar to the decline in seasonal floodplain habitat, the loss of SRA habitat is likely one reason for the observed decline in salmonid populations throughout the region.

Geomorphic processes such as channel migration, chute-cutoff, and avulsion (tearing away) are crucial to the formation of oxbow lakes, sloughs, and side channels and other off-channel habitats on actively meandering rivers, these are collectively referred to as off-channel water bodies (Kondolf and Stillwater Sciences, 2007). Off-channel water bodies (OCWB) evolve over time as a function of sediment deposition and scour, vegetation colonization and succession, and the buildup of organic detritus from aquatic vegetation. A variety of riverine species depend on OCWBs for habitat. For example, in the Sacramento River corridor, OCWBs provide critical habitat for western pond turtle, Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychochelilus grandis*), California roach (*Hesperoleucus symmetricus*), and Chinook salmon. They also harbor several nonnative species, such as largemouth bass, and bullfrogs (*Raca catesbeiana*), which prey upon native fish, and red-eared sliders (*Trachemys scripta*) that compete with native western pond turtles for food and space.

Fish Species Associated with the Aquatic Communities The physical processes and habitat elements described above support a large and diverse assemblage of native and nonnative fish (Table 2-3). These species include recreationally and commercially important species such as salmonids and many sunfish species as well as species listed as threatened or endangered (see Table 2-4). The striped bass is a recreationally important fish but is nonnative and is a major predator. Aside from these freshwater and euryhaline (tolerating a wide range of salinity) species (i.e., species tolerant of a wide salinity range) found within the Bay-Delta and Central Valley river systems, more than 200 species of fish, mostly marine species, exist in adjacent portions of the San Francisco Estuary (Miller and Lea, 1972), and some of these species may occasionally use portions of the western Delta

during periods of reduced freshwater flows from the Sacramento and San Joaquin rivers.

Native anadromous species found in the Sacramento and San Joaquin river basins include: four runs of Chinook salmon, steelhead trout, green and white sturgeon (*Acipenser medirostris* and *A. transmontanus*), and Pacific lamprey (*Lampetra tridentata*). Native resident species include delta smelt, Sacramento pikeminnow, Sacramento splittail, Sacramento sucker, Sacramento perch (*Archoplites interruptus*), hardhead (*Mylopharodon conocephalus*) and other native minnows, and rainbow trout (*Oncorhynchus mykiss*). Introduced anadromous species include striped bass and American shad (*Alosa sapidissima*). Introduced resident species include: largemouth bass, smallmouth bass, white and black crappie (*Pomoxis annularis* and *P. nigromaculatus*), channel catfish (*Ictalurus punctatus*), white catfish (Ameiurus catus), brown bullhead (*Ictalurus nebulosus*), bluegill, green sunfish, golden shiner (*Notemigonus crysaleucas*), and brown trout (*Salmo trutta*). The striped bass is a recreationally important fish but is a predator of threatened salmonid and smelt species.

Table 2-3. Fish Associated with Sacramento and San Joaquin River Basins Aquatic Communities

Common Name	Scientific Name	Delta	Sacramento River	San Joaquin River
Native Species				
Hitch	*Lavinia exilicauda*	X	X	X
Blackfish	*Orthodon macrolepidotus*	X	X	X
California roach	*Lavinia symmetricus sp.*	X	X	X
Hardhead	*Mylopharodon conocephalus*	X	X	X
Sacramento splittail	*Pogonichthys macrolepidotus*	X	X	X
Pikeminnow	*Ptychocheilus grandis*	X	X	X
Sacramento sucker	*Catostomus occidentalis*	X	X	X
Delta smelt	*Hypomesus transpacificus*	X	X	
Longfin smelt	*Spirinchus thaleichthys*	X	X	
Steelhead/rainbow trout	*Oncorhynchus mykiss*	x	X	X
Chinook salmon	*Oncorhynchus tshawytscha*	X	X	X[1]
Threespine stickleback	*Gasterosteus aculeatus*	X	X	X
Prickly sculpin	*Cottus asper*	X	X	X
Tule perch	*Hysterocarpus traski*	X	X	X
White sturgeon	*Acipenser transmontanus*	X	X	X
Green sturgeon	*Acipenser medirostris*	X	X	X

Table 2-3. Fish Associated with Sacramento and San Joaquin River Basins Aquatic Communities (Contd.)

Common Name	Scientific Name	Delta	Sacramento River	San Joaquin River
Introduced Species				
American shad	*Alosa sapidissima*	X	X	X
Threadfin shad	*Dorosoma petenense*	X	X	X
Goldfish	*Carassius auratus*	X	X	X
Red shiner	*Cyprinella lutrensis*	X	X	X
Carp	*Cyprinus carpio*	X	X	X
Golden shiner	*Notemigonus chrysoleucas*	X	X	X
Roseface shiner	*Notropis rubellus*	X	X	X
Fathead minnow	*Pimephales promelas*	X	X	X
White catfish	*Ameiurus catus*	X	X	X
Black bullhead	*Ameiurus melas*	X	X	X
Channel catfish	*Ictalurus punctatus*	X	X	X
Wakasagi	*Hypomesus nipponensis*	X	X	X
Western mosquitofish	*Gambusia affinis*	X	X	X
Inland silverside	*Menidia beryllina*	X	X	X
Striped bass	*Morone saxatilis*	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X
Redear sunfish	*Lepomis microlophus*	X	X	X
Smallmouth bass	*Micropterus dolomieu*	X	X	X
Largemouth bass	*Micropterus salmoides*	X	X	X
White crappie	*Pomoxis annularis*	X	X	X
Black crappie	*Pomoxis nigromaculatus*	X	X	X
Bigscale logperch	*Percina macrolepida*	X		
Yellowfin goby	*Acanthogobius flavimanus*	X		
Shimofuri goby	*Tridentiger bifasciatus*	X		
Chameleon goby	*Tridentiger trigonocephalus*	X		

Source: Moyle, 2002b; California Department of Fish and Game, unpublished data

Notes:
[1] Only the fall/late-fall run of Chinook salmon are found in the San Joaquin River; winter-run and spring-run fish are confined to the Sacramento River watershed.

Special-Status Species

The CALFED MSCS list of special-status species provides a good sample of species of concern in the Sacramento and San Joaquin river basins. It includes 244 species of plants, fish, and other animals, approximately 200 of which were determined to be potentially affected by CALFED project activities (CALFED, 2000a). Because the MSCS area is larger than the Sacramento and San Joaquin river basins, the list of special-status species considered in the Central Valley Flood Protection Plan (CVFPP) has been reduced to only include those species likely to make significant use of the Bay-Delta (including surrounding agricultural areas), the Sacramento River

and San Joaquin River (and their tributaries on the valley floor), and wetland and riparian habitats connected to or adjacent to these areas. For the purposes of the CVFPP, the MSCS list of special-status species has been further reduced to only include species that are listed as either threatened or endangered under the federal or California Endangered Species Act (ESA) or, in the case of plants, species on List 1B of the CNPS's Inventory of Rare and Endangered Plants (CNPS, 2009).

DFG Species of Special Concern and Fully Protected Species (FP), as well as CNPS List 2 species, are not included on this list. Although DFG Species of Special Concern, FP, and CNPS List 2 species are considered to be worthy of special conservation consideration within California, the species listed in Table 2-4 are, mostly, California endemic species or species that rely on habitats nearly exclusively for breeding, foraging, or other critical ecological requirements. Additionally, these species have experienced significant habitat reductions and, therefore, have been afforded higher levels of regulatory protection. All 244 species considered by CALFED to be worthy of conservation consideration, as well as full species accounts for the species listed below, may be found in the CALFED MSCS (CALFED, 2000a). Critical habitat for these species, where it has been officially designated by the USFWS, is shown on Figure 2-16.

Table 2-4. Primary Threatened and Endangered Species and Rare Plants Within the Sacramento and San Joaquin River Basins

Species	Status	Habitat
Invertebrates		
Lange's metalmark butterfly (*Apodemia mormo langei*)	FE	Riverine sand dunes at Antioch Dunes NWR
Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)	FT	Elderberry shrubs within riparian areas
Reptiles/Amphibians		
Giant garter snake (*Thamnophis gigas*)	FT, ST	Freshwater marsh, ponds, and other slow-moving waters; requires uplands above the floodplain for winter hibernation.
Birds		
Greater sandhill crane (*Grus canadensis tabida*)	ST	Agricultural fields for foraging; shallowly flooded wetlands for roosting (does not nest in the Sacramento and San Joaquin river basins)
Swainson's hawk (*Buteo swainsoni*)	FT, ST	Large trees for nesting; low, open herbaceous grassland and agricultural land for foraging, especially alfalfa

Table 2-4. Primary Threatened and Endangered Species and Rare Plants Within the Sacramento and San Joaquin River Basins (Contd.)

Species	Status	Habitat
Bald eagle (*Haliaeetus leucocephalus*)	SE	Does not nest in the Central Valley but frequently hunts along Central Valley lakes and rivers in the winter
California clapper rail (*Rallus longirostris obsoletus*)	FE, SE	Salt and brackish marshes in the Bay Area, including Suisun Marsh and environs
California least tern (*Sterna antillarum browni*)	FE, SE	Mostly known from Southern California; only observation from Montezuma Slough area
Black rail (*Laterallus jamaicensis cotumiculus*)	ST	Marshes and bay margins with shallow water and dense vegetation from the Delta westward
Western yellow-billed cuckoo (*Coccyzus americanus occidentalis*)	SE	Nests and forages in dense riparian vegetation, usually associated with early successional vegetation such as cottonwood and willow
Bank swallow (*Riparia riparia*)	ST	Colonial nester on vertical, exposed sandy banks; forages over surrounding water and open habitats
Fish		
North American green sturgeon (*Acipenser medirostris*)	FT	Marine to estuarine habitats of the western Delta and San Francisco Bay; spawns in upper reaches of Sacramento and Feather rivers
Chinook salmon – Spring Run (*Oncorhynchus tshawytscha*)	FT, ST	Spawns in tributaries to upper Sacramento River
Chinook salmon – Winter Run (*Oncorhynchus tshawytscha*)	FE, SE	Spawns in upper Sacramento River
Central Valley steelhead (*Oncorhynchus mykiss*)	FT	Spawns throughout the Sacramento and San Joaquin river systems but more common in Sacramento Valley
Delta smelt (*Hypomesus transpacificus*)	FT, ST[1]	Estuarine habitats; spawns in lower reaches of the Sacramento and San Joaquin river on shallow floodplains and within shallow marsh channels

Table 2-4. Primary Threatened and Endangered Species and Rare Plants Within the Sacramento and San Joaquin River Basins (Contd.)

Species	Status	Habitat
Fish (Contd.)		
Longfin smelt (*Spirinchus thaleichthys*)	ST[2]	Marine to estuarine habitats; spawns in deeper channels of the Sacramento River below Rio Vista and, potentially, the lower San Joaquin River
Mammals		
Riparian brush rabbit (*Sylvilagus bachmani riparius*)	FE, SE	Dense riparian scrub and woodland with well-developed understory along the Stanislaus River (Caswell State Park) and scattered locales along lower San Joaquin River
Riparian wood rat (*Neotoma fuscipes riparia*)	FE	Riparian woodland with well-developed understory along the Stanislaus River (Caswell State Park)
Salt marsh harvest mouse (*Reithrodontomys raviventris*)	FE, SE	Edges of saline emergent wetland, including Suisun Marsh, within the Bay Area; require uplands above floodplains
Plants		
Delta button-celery (*Eryngium racemosum*)	SE, 1B	Heavy alkaline clay soils within floodplains of the San Joaquin River
Contra Costa wallflower (*Erysimum capitatum* ssp. angustatum)	FE, 1B	Riverine sand dunes at Antioch Dunes NWR
Antioch Dunes evening-primrose (*Oenothera deltoides* ssp. *howellii*)	FE, 1B	Riverine sand dunes at Antioch Dunes NWR
Suisun thistle (*Cirsium hydrophilum* var. hydrophilum)	FE, 1B	Suisun Marsh along smaller channels
Suisun Marsh aster (*Symphyotrichum lentum*)	1B	Riverbanks, marshes, and channels in riparian scrub, tule, and similar vegetation
Delta tule pea (*Lathyrus jepsonii* var. jepsonii)	1B	Edges of marshes and riparian scrub, primarily within the Delta; occasionally on riverbanks and rip-rap
Soft bird's beak (*Cordylanthus mollis* ssp. *mollis*)	FE, 1B	Salt to brackish marsh, primarily around Suisun Marsh

Table 2-4. Primary Threatened and Endangered Species and Rare Plants Within the Sacramento and San Joaquin River Basins (Contd.)

Species	Status	Habitat
Slough thistle (*Cirsium crassicaule*)	1B	Sloughs, riverbanks, and marshes along the San Joaquin River
Sanford's arrowhead (*Sagittaria sanfordii*)	1B	Marshes, sloughs, canals, and similar areas with slow-moving or still water primarily outside the Delta within Sacramento and San Joaquin valley
Mason's lilaeopsis (*Lilaeopsis masonii*)	SR, 1B	Exposed un-vegetated mud flats within the tidal zone of the Delta, lower Sacramento River, and lower San Joaquin River

Source: DFG, 2009a

Notes:
[1] The delta smelt is a State of California candidate for having its listing status upgraded to endangered under the California Endangered Species Act.
[2] The longfin smelt is not officially considered a state listed species; however, a petition to list the species as threatened under the California Endangered Species Act has been received and reviewed by the California Fish and Game Commission. The listing has been found to be warranted but has not been officially approved as of August 2009.

Key:
1B = Rare, threatened, or endangered within California and elsewhere (California Native Plant Society)
FE = Federally endangered
FT = Federally threatened
SE = State of California endangered
SR = State of California Rare Species
ST = State of California threatened

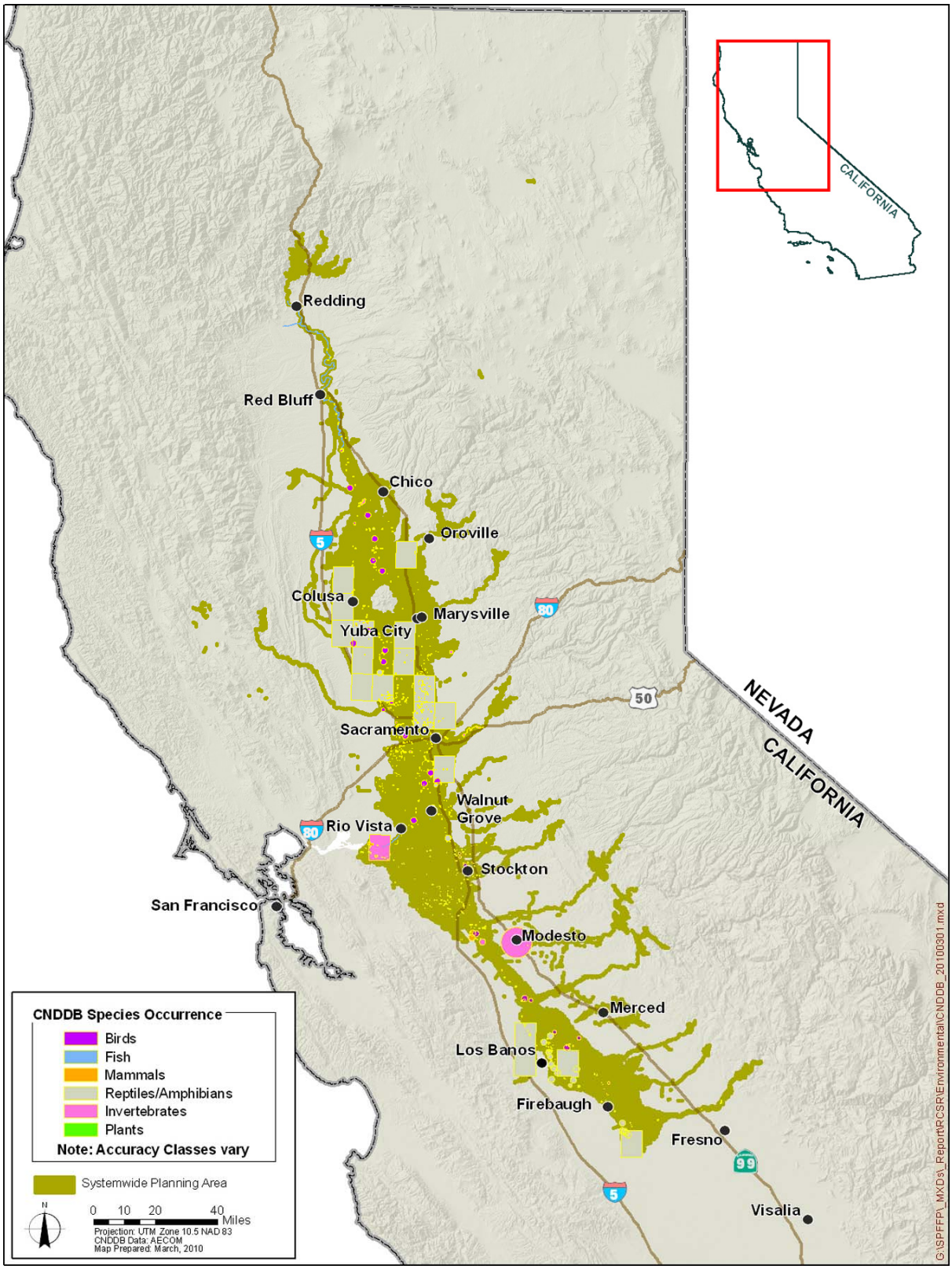


Figure 2-16. CNDDB Occurrences

Invasive Species

In this report, an invasive species is considered to be any "species that is nonnative to the ecosystem under consideration, and whose introduction causes, or is likely to cause, economic or environmental harm, or harm to human health" (National Invasive Species Council, 2001). Because this section is primarily concerned with ecological effects, the species discussed in this section are those species particularly likely to cause ecological harm; although, they may have adverse effects on human health or cause economic harm as well.

For some taxa (e.g., plants), detailed lists of invasive species, their distribution across California, and their potential for adverse effects has been tabulated and described (Cal-IPC, 2006). Additionally, California maintains a ranking system and control program for invasive plants statewide, primarily focused on species with the greatest potential to adversely affect economic activities (although many of these species also have the potential to adversely affect native ecosystems) (DFA, 2009a). Although official lists of invasive species have not been published for other taxa, previous technical reports (e.g., CALFED, 2000b) list and describe other species (e.g., invasive aquatic species) that pose a threat to native ecosystems and species.

While a precise accounting of invasive species found is lacking, it is likely that, based on past estimates from the Bay-Delta alone (Cohen and Carlton, 1998), the total number of invasive plants and aquatic organisms within this region is at least 300 taxa and likely many more than this number, with new invasions occurring on a regular basis (Cohen and Carlton, 1998). The following section summarizes information on key life history characteristics and ecological effects just for those species that have the potential to adversely affect aquatic, riparian, and adjacent wetland ecosystems. Rather than attempting to focus on the entire gamut of species potentially meeting this definition, this section focuses only on taxa that have been previously identified as particularly problematic (Cal-IPC, 2006; CALFED, 2000b) or that have been identified as problematic species in other background documents (e.g., DFG, 2008b). Invasive species that have not previously been identified as causing adverse ecological effects and other species not currently known from the Bay-Delta or Central Valley, but with a high probability of future introduction are discussed in Section 2.2, Likely Future Conditions.

Aquatic Species

Asian Clams

Two species of introduced clams, the Asian clam (*Corbicula fluminea*) and Asian overbite clam (*Corbula amurensis*), have dramatically affected the

ecology of the Bay-Delta and lower Sacramento and San Joaquin rivers. Corbicula was first reported in 1945 and is most abundant in freshwater portions of the Bay-Delta and adjacent river systems; their abundance can exceed 20,000 clams per square foot at certain times of the year (Lucas et al., 2002). Corbula is a more recent introduction from 1986 and is the most abundant bivalve in brackish portions of the Bay-Delta where it can reach densities exceeding 5,000 clams per square foot (Hymanson et al., 1994; Peterson, 1996). Distrubutional patters of both species shift seasonally in response to influx of fresh water during the winter rainy season and salt water intrusion from the San Francisco Bay during the dry summer season, particularly in the western Bay-Delta. However, due to differing salinity tolerances of the two species (i.e., one found in brackish and salt water and the other in fresh water) they effectively dominate the benthic community of the entire lower Sacramento and San Joaquin rivers, Delta, and eastern San Francisco Estuary.

Both species have been implicated as likely one of the primary, if not the primary, causes of phytoplankton decline in the Bay-Delta and adjacent areas (Kimmerer et al., 2008) through their tremendous ability to filter water and, thereby, capture and remove phytoplankton from the food chain. By removing phytoplankton, these species reduce food availability for various species of zooplankton that are the primary food source for many species of pelagic and young-of-the-year fish. Apart from their roles as consumers of phytoplankton, overbite clams play a key role in the cycling and bioaccumulation of contaminants in the food web, particularly selenium, which they may accumulate in sufficient amounts to negatively affect the reproductive success of waterfowl and other predators (Stewart et al., 2004).

Introduced Zooplankton

Zooplankton constitute a diverse group of taxa such as diatoms, copepods, cladocerans, rotifers, and similar taxa. They consume phytoplankton and are frequently consumed by fish, especially young of the year, and various pelagic fish such as longfin smelt and striped bass. Zooplankton can be either pelagic or benthic and are distributed throughout aquatic ecosystems within the Sacramento and San Joaquin river basins. Numerous species of zooplankton have been inadvertently introduced into the Sacramento and San Joaquin river basins through a variety of mechanisms, most frequently in ship ballast water (Cohen and Carlton, 1998; Kimmerer et al., 2008). Once introduced in the Bay-Delta, they frequently outcompete native zooplankton or otherwise alter food webs to the detriment of native species. Examples of introduced zooplankton include *Limnoithona tetraspina*, which is now the dominant copepod in many parts of the estuary (Baxter et al., 2005) and has altered food webs by being a benthic rather than pelagic organism. Similarly, competition from the nonnative myscid shrimp

(*Acanthomysis bowani*) is likely to have adversely affected the abundance of the native myscid shrimp (*Neomysis mercedis*) (Baxter et al., 2005), which was once one of the dominant zooplankton species in the Delta and a major food source for native fish (Orsi and Knutson, 1979). The dramatic increase in nonnative zooplankton within the Delta has been implicated as one of the primary ecosystem stressors within the Bay-Delta (CALFED, 2000b).

New Zealand Mud Snail

The New Zealand mud snail (*Potamopyrgus antipodarum*) has been known to exist in the United States since 1987. In California, New Zealand mud snails were first identified in 2000 within the Owens River. Subsequent infestations have been documented in other watersheds on the eastern slope of the Sierra Nevada as well as numerous drainages in or hydrologically connected to the Sacramento and San Joaquin river basins (Putah Creek, lower Calaveras River, lower Mokelumne River, and lower American River, Alameda Creek, West Antioch Creek, and Napa River) (Montana State University, 2009).

New Zealand mud snails exhibit a wide range of temperature and salinity tolerances. Habitat preferences vary, but tend to extend across a wide variety of aquatic habitats, including streams, lakes and ponds, and brackish waters. New Zealand mud snails can feed on a wide variety of plant and animal matter. Most reproduction in the New Zealand mud snail is asexual, with colonization by the snail requiring only one female. New Zealand mud snail abundances have been recorded at densities of more than 50,000 snails per square foot (Hall et al., 2003).

Because this species produces asexually and is easily spread, tolerates a wide variety of environmental conditions, and grows to extremely high densities, it has the potential to severely affect aquatic ecosystems and native fisheries. Some of these effects include: altering primary productivity by consuming large quantities of periphyton (Hall et al., 2003), outcompeting native gastropods and other native aquatic grazers and detritivorous invertebrates that form the foundation of aquatic food webs (Kerans et al., 2005), altering the food base of vertebrates and invertebrates at higher trophic levels, especially fish (Hall et al., 2003; Ryan, 1982; McCarter, 1986), and altering nutrient cycles (Hall et al., 2003; Chavaud et al., 2003).

Quagga and Zebra Mussel

Quagga mussel (*Dreissena bugensis*) and zebra mussel (*D. polymorpha*) are small, freshwater mollusks that are native to Russia and Ukraine (Mills et al., 1996). It is believed that these species were inadvertently transported to America through the discharge of ship ballast water in the Great Lakes

and subsequently spread to California and other regions of the country on recreational boat hulls. In California, Quagga mussel is distributed throughout the Colorado River system and associated water delivery infrastructure in Southern California. The zebra mussel is only known from San Justo Reservoir in San Benito County. Neither species has been documented in the SPA (DFG, undated). Similar to saltwater mussels, juveniles and adults of both species attach to hard surfaces such as piers, docks, fish screens, water intakes, and other structures. Quagga mussels also have the ability to attach on soft substrates (Mills et al. 1996). These species have tremendous reproductive output and few predators outside their native habitats and are thus able to colonize structures at very high densities, reported at upwards of 750,000 per square meter in the Great Lakes (Cohen et al., 2007).

Both species have similar environmental requirements. Salinity, calcium concentrations, temperature, dissolved oxygen concentrations, and pH have been implicated as potential environmental factors that limit the distribution of these species (Mills et al., 1996; Cohen, 2008). A review of major waterways across California indicated that most of the SPA would be vulnerable to mussel invasions (Cohen, 2008). Notably, the entire mainstem Sacramento River and upper portions of the San Joaquin River were found to be unsuitable mussel habitat. Parts of the Bay-Delta region were also found to be unsuitable due to low calcium or high salinity; although, the pattern of habitat suitability in the Delta is complicated by the mixing of water from different sources (i.e., low-calcium water from the Sacramento River, high-calcium water from the lower San Joaquin and Delta, and high-salinity water from the western Delta and San Francisco Bay). Thus, the pattern of habitat suitability is highly variable both temporally and spatially within the Delta as these different sources of water become more or less important at different times of the year and in different parts of the Delta (Cohen, 2008).

Quagga and zebra mussel have the potential to cause significant ecological and economic damage. Increased facility maintenance and operations costs (at power plants, municipal water utilities, harbors, and similar facilities) associated with quagga and zebra mussel infestations in the eastern United States have been estimated at minimally $100 million annually (see Cohen et al., 2007 and studies referenced therein). Similar to Asian clams, quagga and zebra mussels can also dramatically affect phytoplankton abundance and aquatic food webs. Studies from the Great Lakes region (reviewed in Cohen et al., 2007) have shown large decreases in phytoplankton abundance (60 percent to > 90 percent) in areas infested with zebra mussel and accompanying declines in zooplankton and recreationally and commercially important fisheries. Given California's dependence on water diversion, transport, and delivery systems centered on the Delta and the

declining condition of the Bay-Delta ecosystem, the economic and ecological effects of mussel invasions in the Delta could easily exceed those experienced by the Great Lakes.

Introduced Sportfish
Several species of sportfish have been introduced from the eastern United States. These warm-water game fish, many of which are in the Centrarchid family, include largemouth bass, smallmouth bass, bluegill, green eared sunfish, and black and white crappie. Catfish and carp impact native fish, destroying benthic feeding and spawning habitat. Although these species support a recreationally and economically important fishery, they are also major predators on native fish such as delta smelt and juvenile Chinook salmon (Nobriga and Feyrer, 2007). Predation from these nonnative sportfish, as well as striped bass, is one, among many causes for the observed declines of these species (Kimmerer et al., 2008).

Aquatic Plants Several invasive aquatic plants pose a threat to aquatic habitats. These plants often form thick mats that cause many negative effects, including crowding out native plants and reducing light availability in the water column, which decreases habitat for fish and other wildlife; degrading water quality via nutrient loading, oxygen depletion, and increased temperature; reducing recreational and commercial activities (e.g., boating, swimming, fishing); increasing the presence of submerged aquatic vegetation, which increases habitat availability for nonnative, predatory fish; and, slowing water flow in canals, thereby increasing sedimentation rates, increasing habitat for mosquitoes, and impairing irrigation, drainage, hydroelectric utilities, and urban water supplies (Kimmerer et al., 2008; Cal-IPC, 2006; Bossard et al., 2000; Batcher, 2000; Washington Water Quality Program, 2002). The main means of dispersal is through vegetative fragmentation and transport by water flow and watercraft. Aquatic plants with a California Invasive Plan Council (Cal-IPC) rating of High that are known or expected to pose significant ecological threats to native habitats and species include: egeria (*Egeria densa*), hydrilla (*Hydrilla verticillata*), water hyacinth (*Eichhornia crassipes*), parrotfeather (*Myriophyllum aquaticum*), Eurasian watermilfoil (*M. spicatum*), water primrose (*Ludwigia peploides*), Carolina azolla (*Azolla caroliniana*), and purple loosestrife (*Lythrum salicaria*). Decreased water flows due to exports may have added to hyacinth and hydrilla problems in the eastern Delta.

Terrestrial Plants A host of invasive terrestrial plants are found within the Sacramento and San Joaquin river basins. Many of these (e.g., medusa-head yellow starthistle, numerous other species of annual grasses and thistles) are associated with grasslands and disturbed habitats. Although they are found within the Sacramento and San Joaquin river basins, they

are not likely to negatively affect associated riparian and wetland ecosystems. Additionally, species such as Chinese tallow-tree and two species of knotweed that do have the potential to adversely affect riparian and wetland habitats are not widely distributed through the region; therefore, their potential for significant ecological effects is currently limited. Similar to aquatic invasive species, the species described below are those widely distributed, invasive, terrestrial species that have a Cal-IPC rating of High and that are known or suspected to cause significant ecological problems by outcompeting and displacing native plants and altering habitat structure and availability for native wildlife. These species include: giant reed, tamarisk (*Tamarix aphylla*, *T. parviflora*, *T. ramosissima*), perennial pepperweed, red Sesbania (*Sesbania punicea*), Himalayan blackberry, and fennel (*Foeniculum vulgare*) (Cal-IPC, 2006).

Regional Conservation Efforts

Regional conservation planning has increased to balance the needs of the numerous species of special-status wildlife with urban development and other land-development activities. Regional conservation plans include habitat conservation plans (HCP), which are prepared under the federal ESA, and natural community conservation plans (NCCP), which are prepared under the California Natural Communities Conservation Planning Act. An HCP must accompany an application for an incidental take permit under Section 10 of the federal ESA. The purpose of the habitat conservation planning process associated with the permit is to ensure that the effects of the authorized incidental take are adequately minimized and mitigated (USFWS, 2005). At the State level, a similar document, a NCCP can also be prepared. The primary objective of the NCCP program is to conserve natural communities at the ecosystem scale while accommodating compatible land use (DFG, 2009b). The preparation of an NCCP results in the issuance of an incidental take permit from the DFG for State-listed species covered in the plan. Large HCP and/or NCCP efforts that have been completed or are underway are listed below, and the regions covered by these documents are depicted on Figure 2-17.

- Natomas Basin HCP (Adopted April 2003)
- Bay-Delta Conservation Plan (in preparation)
- CALFED Bay-Delta Program (Approved June 2000)
- Yolo County HCP/NCCP (in preparation)
- South Sacramento HCP (in preparation)
- Yuba-Sutter HCP (in preparation)

- San Joaquin County HCP (adopted 2001)
- East Contra Costa HCP/NCCP (Adopted July/August 2007)
- Butte Regional HCP/NCCP (Administrative Draft in preparation)
- Placer County HCP/NCCP (in preparation)
- Central Valley Joint Venture Implementation Plan (2006)
- Solano County HCP (in preparation)
- PG&E Operations and Maintenance – San Joaquin Valley HCP

Numerous other local conservation efforts and entities (resource conservation districts, Sacramento River Conservation Area Forum, Merced County conservation efforts, and other private and public conservancies) contribute to habitat and species protection and conservation activities.

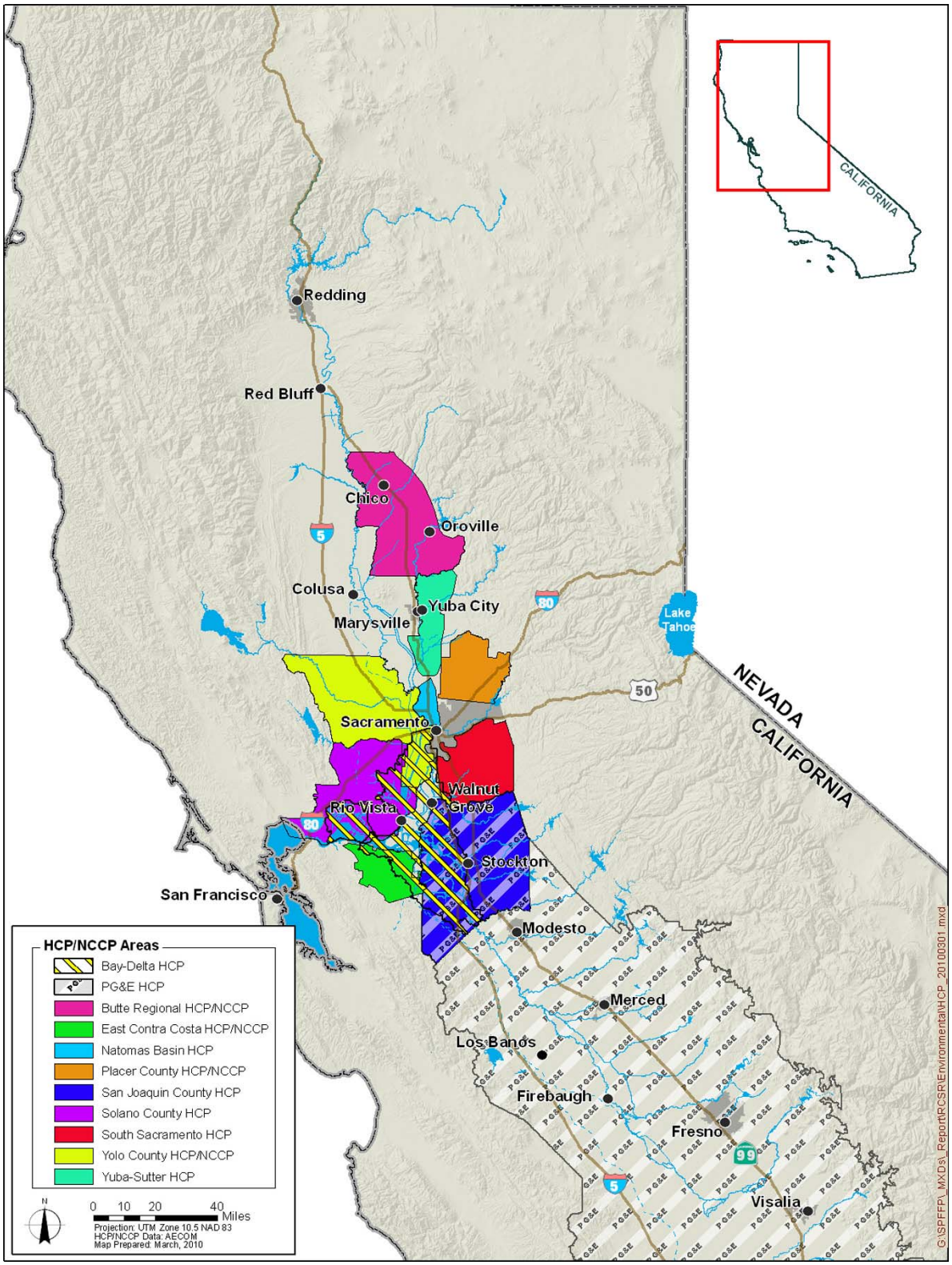


Figure 2-17. Habitat Conservation Plan and Natural Community Conservation Areas

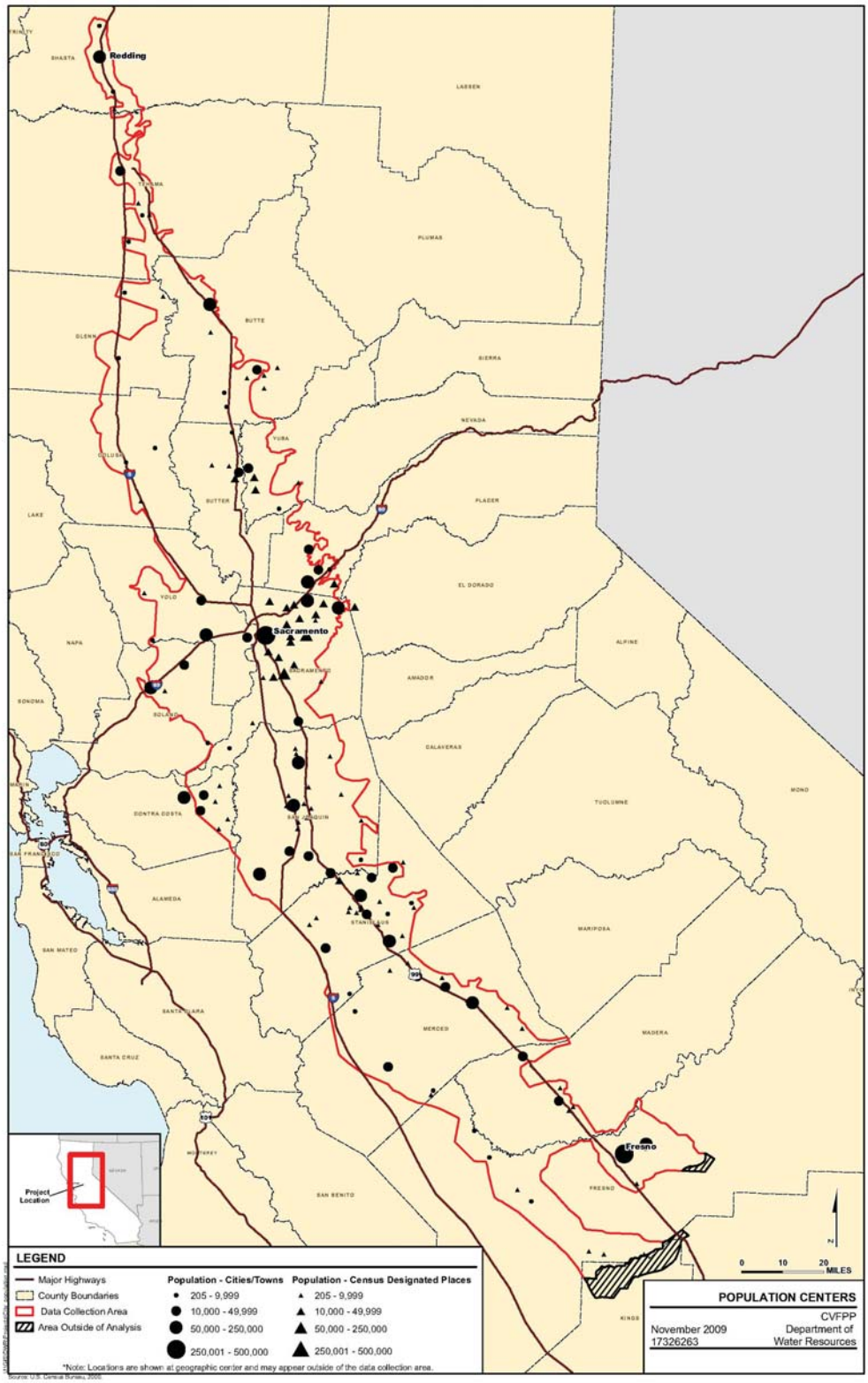
2.1.4 Social and Economic Conditions

This section describes existing social and economic conditions for the Central Valley.

Population

California is home to a rapidly growing population that may reach 60 million by 2050 (DWR, 2009e). California's population growth presents a major challenge to the State's flood management system. Most SPFC facilities are located within the Central Valley, which is experiencing some of the most rapid population growth in California.

Existing Population This section focuses on the existing populations within the study region. The CVFPP has been broken down into counties within the Central Valley Floodplain Evaluation and Delineation Program Data Collection Area (DCA). As discussed below, with the exception of Sutter County, each county's boundaries extend outside the DCA, shown on Figure 2-18. Data and relative comparisons should therefore not be assumed to be reflective of the DCA as a whole, but as representative of the counties in the DCA. Counties participating in a regional council are discussed at a county level but are also referenced in following sections under the appropriate council (e.g., Sacramento Area Council of Governments (SACOG)). The following describes the population trends within each geographic area.



Source: U.S. Census Bureau, 2000

Figure 2-18. Population Centers

San Joaquin Regional Policy Council
The San Joaquin Regional Policy Council is composed of the councils of governments (COG) for San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Tulare, and Kern counties.

The San Joaquin River Basin is projected to grow by half to 7.3 million by 2050 (San Joaquin Regional Policy Council, 2009). On April 1, 2009, the San Joaquin Valley Regional Policy Council reviewed the collaborative work of the participating COGs on the Blueprint, a 2-year planning effort to support a long-range regional planning process. The San Joaquin Valley Regional Policy Council adopted a list of Smart Growth Principles to be used as the basis of the Blueprint planning process and adopted Scenario B+ as the Preferred Blueprint Growth Scenario for the San Joaquin River Basin to the Year 2050. This preferred scenario will serve as guidance for the valley's local jurisdictions with land use authority as they update their general plans.

The counties and cities within the DCA and within the participating San Joaquin River Basin COGs are discussed in more detail below.

Sacramento Area Council of Governments
SACOG is composed of El Dorado, Placer, Sacramento, Sutter, Yolo, and Yuba counties, and 22 cities within the region. SACOG has identified the following communities as the fastest-growing by population in the SACOG region from 2005 to 2035, based on 2008 projections: Rancho Cordova, Vineyard (Sacramento County), Roseville, North Natomas, and Lincoln (SACOG, 2009).

The SACOG counties and cities within the DCA are discussed below.

County Population Data Population profiles for the counties within the DCA are detailed in Tables 2-5 through 2-10. Table 2-5 shows populations and racial demographics; Table 2-6 identifies gender populations; Table 2-7 identifies age distribution; Table 2-8 shows total housing units; Table 2-9 shows total average household size; and Table 2-10 shows income profiles. All tables are based on the 2000 U.S. Census (U.S. Census Bureau, 2000).

Additional county information is detailed below. Population centers are shown on Figure 2-18.

Table 2-5. Total Population by Race and Ethnicity in Study Area

	Population	White	Black	American Indian/Alaska Native	Asian	Hawaiian/ Pacific Islander	Other	Hispanic	Multi-Race
California	33,871,648	20,170,059	2,263,882	333,346	3,697,513	116,961	5,682,241	10,966,556	1,607,646
County									
Alameda	1,443,741	704,334	215,598	9,146	295,218	9,142	129,079	273,910	81,224
Butte	203,171	171,728	2,816	3,866	6,752	296	9,790	21,339	7,923
Colusa	18,804	12,090	103	439	228	74	5,017	8,752	853
Contra Costa	948,816	621,490	88,813	5,830	103,993	3,466	76,510	167,776	48,714
El Dorado	156,299	140,209	813	1,566	3,328	209	5,547	14,566	4,627
Fresno	799,407	434,045	42,337	12,790	64,362	1,000	207,061	351,636	37,812
Glenn	26,453	18,988	155	552	893	35	4,810	7,840	1,020
Kings	129,461	69,492	10,747	2,178	3,980	250	36,611	56,461	6,203
Madera	123,109	76,612	5,072	3,212	1,566	210	29,979	54,515	6,458
Mariposa	17,130	15,234	114	602	122	22	457	1,329	579
Merced	210,554	118,350	8,064	2,510	14,321	396	55,013	95,466	11,900
Placer	248,399	220,053	2,031	2,199	7,317	386	8,432	24,019	7,981
Sacramento	1,223,499	783,240	121,804	13,359	134,899	7,264	91,541	195,890	71,392
San Joaquin	563,598	327,607	37,689	6,377	64,283	1,955	91,613	172,073	34,074
Shasta	163,256	145,826	1,225	4,528	3,048	178	2,790	8,998	5,661
Solano	394,542	222,387	58,827	3,110	50,299	3,078	31,612	69,598	25,229
Stanislaus	446,997	309,901	11,521	5,676	18,848	1,529	75,187	141,871	24,335
Sutter	78,930	53,291	1,509	1,225	8,884	161	10,232	17,529	3,628
Tehama	56,039	47,518	318	1,178	440	55	4,631	8,871	1,899
Yolo	168,660	114,129	3,425	1,953	16,614	507	23,214	43,707	8,818
Yuba	60,219	42,537	1,904	1,569	4,519	123	5,989	10,449	3,578

Source: U.S. Census Bureau, 2000.
Notes:
White, African-American, Native American, Asian, Pacific Islander, Two or More Races and Other = Total Population. Persons identifying themselves as Hispanic listed separately from racial categories. Hispanic not included in Total Population.

Table 2-6. Total Population by Gender in Study Area

	Population	Male	Female
California	33,871,648	16,874,892	16,996,756
County			
Alameda	1,443,741	709,300	734,441
Butte	203,171	99,546	103,625
Colusa	18,804	9,559	9,245
Contra Costa	948,816	463,270	485,546
El Dorado	156,299	77,963	78,336
Fresno	799,407	400,476	398,931
Glenn	26,453	13,373	13,080
Kings	129,461	74,332	55,129
Madera	123,109	58,911	64,198
Mariposa	17,130	8,762	8,368
Merced	210,554	104,931	105,623
Placer	248,399	121,892	126,507
Sacramento	1,223,499	598,815	624,684
San Joaquin	563,598	281,627	281,971
Shasta	163,256	79,572	83,684
Solano	394,542	198,694	195,848
Stanislaus	446,997	219,912	227,085
Sutter	78,930	39,061	39,869
Tehama	56,039	27,692	28,347
Yolo	168,660	82,451	86,209
Yuba	60,219	30,346	29,873

Source: U.S. Census Bureau, 2000.

Table 2-7. Age Distribution by Age Groups

	Population7	Under 5	5 to 17	18 to 21	22 to 29	30 to 39	40 to 49	50 to 64	65 and Above	Median Age	Median Age Male	Median Age Female
California	33,871,648	2,486,981	6,762,848	1,946,127	3,963,444	5,500,264	5,002,390	4,613,936	3,595,658	35	34	37
County												
Alameda	1,443,741	98,378	256,194	77,553	177,789	252,573	226,869	206,794	147,591	35	34	36
Butte	203,171	11,637	37,130	16,933	22,816	24,090	28,404	30,105	32,056	36	34	38
Colusa	18,804	1,517	4,420	1,187	1,882	2,537	2,661	2,465	2,135	32	31	33
Contra Costa	948,816	66,128	185,666	43,088	87,314	151,153	156,012	152,183	107,272	36	35	38
El Dorado	156,299	8,946	31,846	6,763	10,771	21,528	29,495	27,616	19,334	39	39	40
Fresno	799,407	67,827	188,598	52,898	92,002	114,894	106,552	97,427	79,209	30	29	31
Glenn	26,453	1,992	6,149	1,403	2,445	3,636	3,653	3,744	3,431	34	33	35
Kings	129,461	10,437	27,091	8,454	18,319	23,527	18,205	13,871	9,557	30	31	30
Madera	123,109	9,443	27,024	7,231	13,173	18,126	17,755	16,761	13,596	33	31	34
Mariposa	17,130	754	2,949	775	1,137	2,112	2,929	3,534	2,940	43	42	44
Merced	210,554	18,693	53,991	13,257	22,288	30,027	27,248	25,046	20,004	29	28	30
Placer	248,399	15,924	49,834	10,754	19,136	37,479	42,094	40,618	32,560	38	37	39
Sacramento	1,223,499	88,922	248,680	66,277	137,368	193,082	184,085	169,210	135,875	34	33	35
San Joaquin	563,598	44,960	129,609	34,691	57,888	83,370	79,713	73,568	59,799	32	31	33
Shasta	163,256	9,643	33,031	8,600	12,477	20,706	25,433	28,505	24,861	39	38	40
Solano	394,542	28,784	83,068	21,057	41,527	63,169	63,862	55,649	37,426	34	33	35
Stanislaus	446,997	35,582	103,640	26,381	47,119	66,353	63,224	58,001	46,697	32	31	33
Sutter	78,930	5,728	17,141	4,296	7,919	11,454	11,029	11,608	9,755	34	33	35
Tehama	56,039	3,534	11,840	2,787	4,360	7,403	7,991	9,201	8,923	38	37	39
Yolo	168,660	10,964	31,515	20,437	22,609	23,748	22,809	20,796	15,782	30	29	30
Yuba	60,219	4,960	13,730	3,812	6,544	8,591	8,138	8,034	6,410	31	30	33

Source: U.S. Census Bureau, 2000.

Table 2-8. Total Housing Units

	Population	Total Housing Units	Vacant	Owner Occupied	Renter Occupied
California	33,871,648	12,214,549	711,679	6,546,334	4,956,536
County					
Alameda	1,443,741	540,183	16,817	286,277	237,089
Butte	203,171	85,523	5,957	48,336	31,230
Colusa	18,804	6,774	677	3,853	2,244
Contra Costa	948,816	354,577	10,448	238,449	105,680
El Dorado	156,299	71,278	12,339	44,019	14,920
Fresno	799,407	270,767	17,827	142,795	110,145
Glenn	26,453	9,982	810	5,855	3,317
Kings	129,461	36,563	2,145	19,253	15,165
Madera	123,109	40,387	4,232	23,934	12,221
Mariposa	17,130	8,826	2,213	4,615	1,998
Merced	210,554	68,373	4,558	37,483	26,332
Placer	248,399	107,302	13,920	68,372	25,010
Sacramento	1,223,499	474,814	21,212	263,819	189,783
San Joaquin	563,598	189,160	7,531	109,667	71,962
Shasta	163,256	68,810	5,384	41,910	21,516
Solano	394,542	134,513	4,110	84,994	45,409
Stanislaus	446,997	150,807	5,661	89,886	55,260
Sutter	78,930	28,319	1,286	16,632	10,401
Tehama	56,039	23,547	2,534	14,214	6,799
Yolo	168,660	61,587	2,212	31,506	27,869
Yuba	60,219	22,636	2,101	11,105	9,430

Source: U.S. Census Bureau, 2000.

Table 2-9. Total Average Household Size

	Households	Average Household Size (people)	One-Person Male Households	One-Person Female Households	Married Households with Children	Married Households No Children	Male Households with Child, No Wife	Female Households with Child, No Husband	Families	Average Family Size (people)
California	11,502,870	2.72	1,212,065	1,496,243	2,989,974	2,887,110	292,346	834,716	7,920,049	3.22
County										
Alameda	523,366	2.71	61,247	74,819	123,145	122,621	10,943	36,674	339,096	3.31
Butte	79,566	2.48	9,038	12,598	14,929	22,201	2,023	5,619	49,386	3.02
Colusa	6,097	3.01	597	711	1,968	1,663	188	366	4,576	3.51
Contra Costa	344,129	2.72	32,125	46,634	91,975	95,638	7,546	22,363	242,233	3.23
El Dorado	58,939	2.63	5,498	6,361	15,341	20,074	1,432	3,369	43,029	3.04
Fresno	252,940	3.09	22,325	29,775	71,371	61,503	8,512	24,351	186,736	3.59
Glenn	9,172	2.84	883	1,139	2,519	2,678	314	660	6,733	3.33
Kings	34,418	3.18	2,600	3,243	11,318	8,630	1,297	3,366	26,989	3.56
Madera	36,155	3.18	2,581	3,394	10,627	11,389	1,204	2,705	28,610	3.52
Mariposa	6,613	2.37	834	921	1,229	2,462	157	305	4,490	2.86
Merced	63,815	3.25	4,919	6,399	20,748	16,106	2,324	5,876	49,760	3.69
Placer	93,382	2.63	8,298	11,562	25,392	30,102	2,208	5,333	67,742	3.06
Sacramento	453,602	2.64	52,198	68,787	100,806	109,572	12,689	39,503	297,596	3.24
San Joaquin	181,629	3.00	16,157	21,493	51,718	46,886	5,949	15,959	134,708	3.48
Shasta	63,426	2.52	6,635	9,015	13,378	20,266	1,833	4,884	44,002	2.98
Solano	130,403	2.90	11,204	14,321	37,117	35,479	3,873	11,054	97,375	3.33
Stanislaus	145,146	3.03	11,678	16,533	42,984	38,339	4,659	12,176	109,517	3.47
Sutter	27,033	2.87	2,435	3,297	7,455	7,963	787	1,997	19,946	3.35
Tehama	21,013	2.62	2,152	2,893	4,727	6,739	636	1,540	14,897	3.08
Yolo	59,375	2.71	6,010	7,819	14,503	13,772	1,368	4,072	37,468	3.25
Yuba	20,535	2.87	2,055	2,401	5,366	5,560	677	1,776	14,801	3.34

Source: U.S. Census Bureau, 2000.

Table 2-10. Income Profiles

	Households	Persons per Household	2007 Median Income (dollars)	1999 Per Capita Money Income (dollars)	Persons below poverty (2007) (percentage)
California	11,502,870	2.87	59,928	22,711	12.4
County					
Alameda	523,366	2.71	68,263	26,680	11.0
Butte	79,566	2.48	39,466	17,517	17.1
Colusa	6,097	3.01	43,882	14,730	12.7
Contra Costa	344,129	2.72	76,317	30,615	8.7
El Dorado	58,939	2.63	64,258	25,560	8.2
Fresno	252,940	3.09	46,547	15,495	20.0
Glenn	9,172	2.84	38,521	14,069	15.8
Kings	34,418	3.18	45,087	15,848	17.2
Madera	36,155	3.18	44,259	14,682	16.9
Mariposa	6,613	2.37	42,757	18,190	12.5
Merced	63,815	3.25	43,369	14,257	19.3
Placer	93,382	2.63	69,667	27,963	6.0
Sacramento	453,602	2.64	56,823	21,142	12.2
San Joaquin	181,629	3.00	51,874	17,365	14.2
Shasta	63,426	2.52	41,980	17,738	13.4
Solano	130,403	2.90	66,575	21,731	9.6
Stanislaus	145,146	3.03	50,367	16,913	13.6
Sutter	27,033	2.87	49,104	17,428	12.2
Tehama	21,013	2.62	36,884	15,793	19.3
Yolo	59,375	2.71	55,988	19,365	14.5
Yuba	20,535	2.87	40,602	14,124	19.2

Source: U.S. Census Bureau, 2000, 2009.

Alameda County
A small unincorporated portion of eastern Alameda County, called East County, is located within the DCA. East County is situated between the denser urban areas of San Francisco Bay and the urbanizing Central Valley east of the Altamont Pass. The East County Area Plan identifies this area as experiencing significant growth pressure (Alameda County, 2000).

Alameda County had a population of 1,443,741 people in 2000, making it the most populous county in the DCA. Compared to state population trends, there were more black, American Indian/Alaskan Natives, Asian, Hawaiian/Pacific Islanders, and multi-race individuals by percentage. Based on population percentages, the county contains fewer whites and Hispanics than the state average.

Butte County
Within the DCA are the cities of Biggs, Butte, Chico, Gridley, and Oroville; and unincorporated areas of Butte County, including the census-designated areas of Oroville East, South Oroville, Thermalito, Palermo, and Durham.

Butte County lies in north central California at the northern end of the Sacramento River Basin, approximately 150 miles northeast of San Francisco and 70 miles north of Sacramento. The population of the unincorporated portion of Butte County has generally been declining since 1990, while the total county population has been increasing. The root cause for the unincorporated population decrease is annexation to all of Butte County's municipalities (Butte County, 2009).

Butte County had a population of 203,171 people in 2000. Compared to state population trends, there were greater white and American Indian/Alaskan Native populations by percentage than the state average. All other races were underrepresented in comparison to the state average.

Colusa County
Within the DCA are the cities of Colusa and William; and portions of unincorporated areas of Colusa County, including the census-designated area of Arbuckle.

Colusa County is in the process of updating its 1989 General Plan. The housing element was revised and readopted in 2004. The housing element noted that duck hunting and other recreational activities are seasonal and very popular in the county, and that this could impact vacancy rates in the county. The Housing Element also noted that the county's population increased 15.5 percent between 1990 and 2000, while the unincorporated

area increased 7.6 percent. Between 1980 and 2000, the county experienced more growth than in any previous decade, with a majority of the growth focused in unincorporated communities such as Arbuckle. This was primarily due to outgrowth from the Sacramento region and Arbuckle's proximity to I-5 (Colusa County, 2004).

Colusa County had a population of 18,804 people in 2000. Compared to state population trends, there were greater white, American Indian/Alaskan Native, Hawaiian/Pacific Islander, Hispanic, and other populations by percentage than the state average.

Contra Costa County
Within the DCA are the cities of Antioch, Brentwood, and Oakley; and unincorporated areas of Contra Costa County, including the census-designated areas of Bethel Island, Byron, Knightsen, and Discovery Bay.

Contra Costa County is the ninth most populous county in California. Major factors contributing to attracting residents include rapid transit, proximity to major employment centers in the cities of Oakland and San Francisco, relatively affordable housing prices, and development of new employment centers along the Interstate 680 corridor and the Tri-Valley Area (ABAG, 2009).

While the population of every city in the county increased during the 1990s, population growth was the greatest in the East County (which consists of the cities of Antioch, Pittsburg, Brentwood, Bay Point, Oakley, and rural east Contra Costa County), particularly in the cities of Antioch, Brentwood, and Oakley (ABAG, 2009).

Because of Brentwood's proximity to the job markets of the Bay Area, many of Brentwood's employed residents in 2000 commuted to jobs outside of the city (City of Brentwood, 2009). Oakley and Brentwood have undergone transformation in recent years from agricultural, service-based communities to increasingly desirable residential communities (City of Oakley, 2002).

Contra Costa County had a population of 948,816 people in 2000. Compared to state population trends, there were greater white, black, Hawaiian/Pacific Islander, Asian, and multi-race populations by percentage than the state average.

El Dorado County
A small portion of western El Dorado County is included in the DCA, including the census-designated area of El Dorado Hills.

El Dorado County had a population of 156,299 people in 2000. Compared to state population trends, there were greater white and American Indian/Alaskan Native populations by percentage than the state average.

Fresno County
Within the DCA are the cities of Fresno, Firebaugh, Mendota, San Joaquin, and Clovis; and unincorporated areas of Fresno County, including the census-designated areas of Laton, Tranquillity, Calwa, and Lanare.

Rapid growth in incorporated areas of Fresno County occurred during the 1980s. The unincorporated areas of the county experienced a decrease in population from 1980 to 1996. Currently, more Fresno County residents live in incorporated cities than in unincorporated areas. The cities of Fresno and Clovis have seen the biggest increase in residential growth, and are the two most populous cities in the county (Fresno County, 2000).

Fresno County had a population of 799,407 people in 2000. Compared to state population trends, there were greater American Indian/Alaskan Native, other, and Hispanic populations by percentage than the state average.

Glenn County
Within the DCA are the cities of Willows and Orland; and unincorporated areas of Glenn County, including the census-designated area of Hamilton City.

Glenn County had a population of 26,453 people in 2000. Compared to state population trends, there were greater white, American Indian/Alaskan Native, and other populations by percentage than the state average.

Kings County
A small portion of the northern part of unincorporated Kings County is located in the DCA.

Kings County ranks as California's seventh fastest-growing county in population. The increase in the county's growth rate is inflated due to the opening of Avenal State Prison, Corcoran State Prison I and II, the California Substance Abuse Treatment Facility, and expansion of Lemoore Naval Air Station (Kings County, 2004).

Kings County had a population of 129,461 people in 2000. Compared to state population trends, there were greater black, American Indian/Alaskan Native, other, multi-race, and Hispanic populations by percentage than the state average.

Madera County
Within the DCA are the incorporated cities of Madera and Chowchilla; and unincorporated areas of Madera County, including the census-designated areas of Gustine, Madera Acres, Parksdale, and Parkwood.

The cities of Chowchilla and Madera have a greater percentage of households at lower income levels and a lower percentage of households at the higher income levels than the county as a whole. This indicates that poverty is concentrated in the more urban areas of the county (Madera County, 2004).

The City of Madera's population area encompasses the entire Madera urban area, including the unincorporated development outside the city limits. Only two-thirds of the urban area's population lies within the city limits (Madera County, 1995).

Madera County had a population of 123,109 people in 2000. Compared to state population trends, there were greater white, American Indian/Alaskan Native, other, multi-race, and Hispanic populations by percentage than the state average.

Mariposa County
A small portion of unincorporated southern Mariposa County is included in the DCA.

Like most other Foothill counties (Amador, Calaveras, Tuolumne, and Mariposa) between 1980 and 1990, Mariposa County was one of the fastest growing counties in Northern California on a percentage basis. The county's growth is the result of people moving into the county, rather than from a natural increase (births exceeding deaths) of the resident population (Mariposa County, 2006).

Mariposa County had a population of 17,130 people in 2000, making it the least populous of the counties in the DCA. Compared to state population trends, there were greater white and American Indian/Alaskan Native populations by percentage than the state average.

Merced County
Within the DCA are the cities of Merced, Los Banos, Atwater, Gustine, Dos Palos, and Livingston; and unincorporated areas of Merced County, including the census-designated areas of Winton, Delhi, Hilmar-Irwin, Planada, Le Grand, and South Dos Palos.

Unincorporated parts of the county have grown steadily over the past 15 years. In incorporated areas of the county, Los Banos experienced the

greatest increase in growth in the county from 1990 to 2005 and from 2000 to 2005. The City of Merced also experienced a tremendous amount of growth between 2000 and 2005. Merced's growth mirrors the rest of Merced County, with the bulk of its growth (10,117) occurring since 2000. Growth in Merced County today (Year 2006) is concentrated in the incorporated areas (Merced County, 2007).

Merced County had a population of 210,554 people in 2000. Compared to state population trends, there were greater American Indian/Alaskan Native, other, multi-race, and Hispanic populations by percentage than the state average.

Placer County
Within the DCA are the cities of Roseville, Lincoln, and Rocklin; the Town of Loomis; and unincorporated areas of Placer County, including the census-designated area of Granite Bay.

The majority of the county's population growth occurred in the incorporated areas of the county, particularly in Lincoln, Rocklin, and Roseville. Lincoln was the fastest growing city in the county from 2000 to 2007. The cities of Rocklin and Roseville also experienced significant population increases over this 7-year period (Placer County, 2008).

Placer County had a population of 210,554 people in 2000. Compared to state population trends, there was a greater white population by percentage than the state average.

Sacramento County
Within the DCA are the cities of Sacramento, Citrus Heights, Folsom, Isleton, Galt, Elk Grove, and Rancho Cordova; and unincorporated areas of Sacramento County, including the census-designated areas of Arden-Arcade, Foothill Farms, Rio Linda, La Riviera, Vineyard, Laguna West-Lakeside, Gold River, Wilton, Walnut Grove, Carmichael, North Highlands, Parkway-South Sacramento, Laguna, Fair Oaks, Florin, Orangevale, and Rosemont.

Centrally located in Sacramento County, the City of Sacramento has seen the majority of its employment and residential growth occur in the North Natomas community. The downtown area and surrounding neighborhoods have also experienced infill and redevelopment, much of it in mixed-use format. Additional smaller scale infill has occurred south and east of downtown (SACOG, 2008).

Sacramento County had a population of 1,223,499 people in 2000, making it the second most populous county in the DCA. Compared to state

population trends, there were greater white, black, American Indian/Alaskan Native, Asian, Hawaiian/Pacific Islander, and multi-race populations by percentage than the state average.

San Joaquin County
Within the DCA are the cities of Stockton, Lodi, Tracy, Manteca, Lathrop, Escalon, and Ripon; and unincorporated areas of San Joaquin County, including the census-designated areas of Garden Acres, Country Club, August, Lincoln Village, French Camp, Morada, Kennedy, Lockeford, South Woodbridge, Taft Mosswood, North Woodbridge, Linden, and Farmington.

As a whole, San Joaquin County grew the fastest between 1940 and 1950 and between 1980 and 1990, when the average annual growth rates (AAGR) were 4.1 percent and 3.3 percent, respectively. From 1990 to 2000, the county's AAGR of 1.6 percent was slightly above that of the state's AAGR of 1.5 percent. From 2000 to 2008, San Joaquin County's population grew at a rate of 2.6 percent AAGR. San Joaquin County's incorporated population grew twice as fast (3.1 percent AAGR) as the unincorporated population (1.4 percent AAGR) between 2000 and 2008. However, compared to the unincorporated population (0.41 percent AAGR) from 1990 to 2000, the 2000 to 2008 AAGR indicates a significant increase in population. San Joaquin County's population growth rate from 2000 to 2008 was higher than California's, with an AAGR of 2.5 percent, almost double the statewide AAGR (1.3 percent). Approximately 78 percent of the San Joaquin County's population resides in the cities, and of this number, almost 43 percent are in Stockton. Stockton's population increased by a 2.3 percent AAGR in 2008. The majority of the county's population growth occurred in incorporated areas, particularly in Lathrop, Ripon, Tracy, and Manteca (San Joaquin County, 2009).

San Joaquin County had a population of 563,598 people in 2000. Compared to state population trends, there were greater black, American Indian/Alaskan Native, Asian, Hawaiian/Pacific Islander, and multi-race populations by percentage than the state average.

Shasta County
Within the DCA are the cities of Redding, Anderson, and Shasta Lake; and unincorporated areas of Shasta County, including the census-designated area of Cottonwood.

Shasta County is one of the most populous of California counties in the northern Sacramento River Basin (Shasta County, 2004). In Shasta County, the city of Redding and its surrounding area is the primary trade

and commerce center for the far north central and northeastern portion of California.

Shasta County had a population of 163,256 people in 2000. Compared to state population trends, there was a greater white population by percentage than the state average.

Solano County
Within the DCA are the cities of Dixon, Vacaville, and a small portion of Rio Vista; and unincorporated areas of Solano County, including the census-designated area of Elmira.

Because of Solano County's commitment to focus development within urban areas, about 95 percent of the county's population lives in cities. In 2000, only 19,322 of Solano County's 394,542 residents lived in the unincorporated area (Solano County, 2008). Of the seven cities in Solano County, Rio Vista and Dixon are anticipated to have the highest levels of growth between 2000 and 2035 (City of Dixon, 2009).

Dixon's population has grown since its incorporation in 1878, with much of the growth occurring since the 1950s, and continues to grow as more and more families have been attracted by the city's location and rural small town character (City of Dixon, 2009).

Vacaville, as well as the greater Solano County area, continues to be an attractive and affordable place of residence for Bay Area workers. Residential growth was accommodated by the building of numerous subdivisions and multifamily projects in the 1970s through 1990s. Over the past 20 years, the City of Vacaville's AAGR has been about 750 new units built each year (City of Vacaville, 2003).

Solano County had a population of 394,542 people in 2000. Compared to state population trends, there were greater black, Asian, Hawaiian/Pacific Islander, and multi-race populations by percentage than the state average. The black population of Solano County makes up 14.9 percent of 2000's total population, whereas the state average is 6.7 percent.

Stanislaus County
Within the DCA are the cities of Modesto, Turlock, Ceres, Riverbank, Oakdale, Hughson, Newman, Waterford, and Patterson; and unincorporated areas of Stanislaus County, including the census-designated areas of Salida, West Modesto, Shackelford, Bret Harte, Keyes, Bystrom, Empire, Denair, and East Oakdale.

As a whole, Stanislaus County is one of the 10 fastest growing counties in California (Stanislaus County, 2003). During the 1990s, the population of the county of Stanislaus increased 22 percent. A major factor contributing to rapid population growth was the continued influx of San Francisco Bay Area commuters who were priced out of the local housing market but were able to find affordable housing in Stanislaus County. The majority of the population increase in Stanislaus County occurred in the nine incorporated cities rather than the unincorporated area of the county. The incorporated population increased 24 percent, and the population of unincorporated Stanislaus County increased 11.2 percent. The population living in the unincorporated areas represents 25 percent of the total county population (Stanislaus County, 2003).

Stanislaus County had a population of 446,997 people in 2000. Compared to state population trends, there were greater white, American Indian/Alaska Native, other, and multi-race populations by percentage than the state average.

Sutter County

Sutter County is the only county completely within the DCA. The county includes the cities of Yuba City and Live Oak; and unincorporated areas, including South Yuba City, Tierra Buena, and Sutter.

As a whole, Sutter County's prospects for growth are closely tied to the growth potential of the SACOG region, differentiating it from other counties in the northern Sacramento River Basin. An increasing share of the county's total population lives in a city. Local governments in the county have directed increasing amounts of its growth into the county's two incorporated cities, Live Oak and Yuba City, so that the population living in these cities grew from 40 percent in 1970 to 75 percent in 2007. Yuba City is the most populous city in the county. Although residential uses tend to be clustered in the cities and rural communities, approximately 8,800 acres of residential uses are scattered throughout the remainder of the county. Most of these residential uses are located in unincorporated areas surrounding the cities, including the spheres of influence, and outside of the boundaries of the rural communities. Other clusters of residential land use occur along major transportation corridors, such as SR 99 and SR 20, as well as along each of the rivers and surrounding the Sutter Buttes (Sutter County, 2008).

Sutter County had a population of 78,930 people in 2000. Compared to state population trends, there were greater white, American Indian/Alaska Native, and Asian populations by percentage than the state average.

Tehama County
Within the DCA are the cities of Red Bluff, Corning, and Tehama; and unincorporated areas of Tehama County, including the census-designated areas of Los Molinos and Gerber-Las Flores.

A large part of the county's population, approximately 34 percent, reside in the cities of Red Bluff and Corning, with the remainder distributed throughout the City of Tehama and several unincorporated communities and rural areas throughout the county. Tehama County is largely rural in nature, with isolated pockets of population primarily concentrated along the valley's major transportation corridors. As the county extends westward and eastward from these populated areas and into the county's margins, large ranches and government land holdings dominate the terrain (Tehama County, 2009).

Tehama County had a population of 56,039 people in 2000. Compared to state population trends, there were greater white and American Indian/Alaska Native populations by percentage than the state average.

Yolo County
Within the DCA are the cities of Davis, Woodland, Winters, and West Sacramento; and unincorporated areas of Yolo County, including the census-designated area of Esparto.

According to the Yolo County General Plan, the county has successfully directed growth to the incorporated areas, with the cities and towns in the county housing 93 percent of the population, but accounting for less than 6 percent of the total area (Yolo County, 2009).

Yolo County had a population of 168,660 people in 2000. Compared to state population trends, there were greater white, American Indian/Alaska Native, and multi-race populations by percentage than the state average.

Yuba County
Within the DCA are the cities of Marysville and Wheatland; and unincorporated areas of Yuba County, including the census-designated areas of Linda, Olivehurst, and Beale Air Force Base.

As a whole, the county has experienced rapid population growth during the present decade, and this growth is forecast to continue. The majority of Yuba County's population (77 percent) resides in unincorporated areas (Yuba County, 2008).

Yuba County had a population of 60,219 people in 2000. Compared to state population trends, there were greater white, American Indian/Alaska Native, and multi-race populations by percentage than the state average.

Demographics The 2000 Census shows the gender ratio in California at 49.8 percent male and 50.2 percent female. Table 2-6 shows gender by population in California and the counties located within the DCA. The counties of Alameda (49.1 percent male to 50.9 percent female), Butte (49.0 percent male to 51.0 female), Contra Costa (48.8 percent male to 51.2 percent female), El Dorado (49.9 percent male to 50.1 percent female), Madera (47.9 percent male to 52.1 percent female), Merced (49.1 percent male to 50.9 percent female), Placer (49.1 percent male to 50.9 percent female), Sacramento (48.9 percent male to 51.1 percent female), Shasta (48.7 percent male to 51.3 percent female), Stanislaus (49.2 percent male to 50.8 percent female), Sutter (49.5 percent male to 50.5 percent female), Tehama (49.4 percent male and 50.6 percent female), and Yolo (48.9 percent male to 51.1 percent female) have similar gender ratios, with more women than men. San Joaquin County had an equal amount of men and women (50.0 to 50.0 percent, respectively). The counties of Colusa (50.8 percent male to 49.2 percent female), Fresno (50.1 percent male to 49.9 percent female), Glenn (50.6 percent male to 49.4 percent female), Mariposa (51.2 percent male to 48.8 percent female), Solano (50.4 percent male to 49.6 percent female), and Yuba (50.4 percent male to 49.6 percent female) have more men than women, with Kings County having significantly more men (57.4 percent) than women (42.6 percent) based on population.

The 2000 Census reported that the median age in California is 35 years. Merced County has the youngest median age (29 years) and Yolo the second youngest (30 years) of the counties in the DCA. The oldest median aged counties are Mariposa (43 years), and El Dorado and Shasta (39 years). Table 2-7 shows the age distribution for California and each county in the DCA.

Housing The 2000 Census reported that California has 12,214,549 housing units. Of these, 711,679 (5.8 percent) were vacant. Vacancy rates in the counties of El Dorado, Mariposa, and Placer greatly exceeded the state average (17.3, 25.1, and 13.0 percent, respectively). The lowest vacancy rates existed in Contra Costa and Solano counties (2.9 and 3.1 percent, respectively). For the state, approximately 53.6 percent of housing is owner occupied and 40.6 percent is renter occupied. Only Alameda, Fresno, Kings, Mariposa, and Yuba counties had a percentage of owner-occupied units lower than the state average. Yuba City had a significantly lower percentage of owner-occupied units at 49 percent. Table 2-8 shows the breakdown of housing units by occupancy.

The 2000 Census reported that in California the average number of people per household is 2.7. Average household sizes in the counties in the DCA range from 2.4 people (Mariposa County) to 3.3 people (Merced County). Consistent with the state trend, there are more one-person female households than one-person male households in all of the DCA counties. Average family size in California is 3.2 people, and average family size in the DCA counties ranged from 2.9 people (Mariposa County) to 3.6 people (Fresno and Kings counties). Table 2-9 shows household size and characteristics for California and the counties in the DCA.

The U.S. Census Bureau reported that the 2007 median income in California was $59,928. Median income in DCA counties ranged from $36,884 (Tehama County) to $76,317 (Contra Costa County). Table 2-10 shows income profiles for California and the counties in the DCA.

Future Population Preliminary future population calculations completed by DWR for the DCA have been provided below. The population estimates for the DCA by county for 2000, 2010, and 2030 are shown in Table 2-11 and the number of single- and multifamily housing units in the DCA are shown in Table 2-12.

Table 2-11. Population in DCA

County	2000	2010	2030
Alameda	104	104	104
Butte	132,757	150,516	220,865
Colusa	17,164	21,501	31,110
Contra Costa	67,442	98,665	135,754
El Dorado	62	139	190
Fresno	602,505	754,538	1,119,602
Glenn	21,914	25,394	37,180
Kings	457	557	610
Madera	79,427	102,889	172,324
Mariposa	0	0	0
Merced	205,239	266,106	427,360
Placer	154,540	234,283	367,723
Sacramento	1,210,433	1,424,356	1,768,546
San Joaquin	552,713	720,353	1,165,074
Shasta	109,599	128,855	177,680
Solano	94,086	109,250	148,008
Stanislaus	438,393	544,054	826,831
Sutter	78,930	101,560	181,363
Tehama	37,583	44,868	63,219
Yolo	166,366	201,895	270,019
Yuba	45,604	62,456	117,878
Total	4,015,318	4,992,339	7,231,440

Table 2-12. Housing Units in the DCA

County	2000		2010		2030	
	Single-Family	Multi-Family	Single-Family	Multi-Family	Single-Family	Multi-Family
Alameda	56	7	56	7	56	7
Butte	32,965	20,692	38,905	22,381	60,586	28,814
Colusa	4,758	1,319	5,739	1,635	8,423	2,324
Contra Costa	20,605	2,819	27,597	3,371	37,823	3,625
El Dorado	23	0	28	0	36	0
Fresno	139,359	69,958	171,743	77,851	269,199	102,134
Glenn	5,925	2,345	6,633	2,587	9,840	3,430
Kings	121	24	153	25	251	27
Madera	17,509	5,185	22,155	6,138	38,990	9,651
Mariposa	0	0	0	0	0	0
Merced	49,151	17,320	63,001	20,115	100,138	30,053
Placer	47,085	12,636	70,309	17,730	111,696	23,463
Sacramento	325,245	144,596	386,783	163,801	486,772	204,145
San Joaquin	137,446	47,828	181,088	53,746	301,641	76,688
Shasta	30,740	15,090	36,409	16,054	55,699	18,275
Solano	25,667	7,589	30,616	8,917	42,847	11,413
Stanislaus	114,070	33,585	143,323	35,423	220,082	48,711
Sutter	21,001	7,318	27,459	8,155	52,325	11,422
Tehama	9,892	5,766	11,559	6,574	16,429	9,509
Yolo	38,112	22,483	47,363	26,024	63,331	33,017
Yuba	10,973	5,505	14,533	6,559	25,738	10,428
Total	1,030,703	422,065	1,285,452	477,093	1,901,902	627,136

Alameda County

The Association of Bay Area Governments (ABAG) predicts that the population of Alameda County will reach 1.9 million by 2035 (ABAG, 2009). Based on preliminary DWR projections, the population and number of single- and multifamily housing units in the DCA in Alameda County by Year 2030 would remain unchanged.

Butte County

Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 220,865 (approximately 40 percent) and the

number of single- and multifamily housing units in Butte County would increase by 46 and 28 percent, respectively.

Colusa County
The Housing Element of the General Plan predicted that the unincorporated area of the county would have a population of 13,044 by 2020 (Colusa County, 2004).

Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 31,110 (approximately 45 percent) and the number of single- and multifamily housing units in Colusa County would increase by 44 and 43 percent, respectively.

Contra Costa County
During the 1990s, the City of Brentwood was among the fastest growing cities in California, with a population increase of approximately 208 percent between 1990 and 2000. ABAG has recently projected that the rate of population growth in Brentwood will greatly exceed that of Contra Costa County as a whole during the period of 2000 through 2020 (ABAG, 2009; City of Brentwood, 2009).

ABAG predicts that the population of Contra Costa County will reach more than 1.3 million by 2035. In the Scattered Success Scenario, ABAG projected that local and regional policymakers would make limited progress in developing more transportation-efficient projects, and that over the next 25 years Brentwood's population would increase by 36 percent and Oakley's population would increase by 23 percent. These three communities, along with Byron and Discovery Bay, are anticipated to absorb 31 percent of Contra Costa County's total growth (ABAG, 2009).

Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 135,754 (approximately 50 percent) and the number of single- and multifamily housing units in Contra Costa County would increase by 46 and 22 percent, respectively.

El Dorado County
SACOG projects that by 2035, the population of El Dorado County will be 225,289 (a growth of 5.5 percent between 2005 and 2035) (SACOG, 2009).

Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 190 (approximately 67 percent) and the number of single-family housing units in El Dorado County would increase by 36 percent. No multifamily units are located within the DCA within El Dorado County.

Fresno County
Based on Appendix A of the Fresno General Plan, General Plan Growth Assumptions, between 1996 and 2020 the population of the City of Fresno is projected to grow to 675,981 (61 percent); the City of Firebaugh to 7,757 (33 percent); the City of Mendota to 11,838 (37 percent); the City of Clovis to 111,534 (61 percent); and the City of San Joaquin to 6,291 (69 percent) (Fresno County, 2000). Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 1,119,602 (approximately 46 percent) and the number of single- and multifamily housing units in Fresno County would increase by 48 and 32 percent, respectively.

Glenn County
The Glenn County General Plan projected that increased population in the county would be due more to births than to net migration into the county (Glenn County, 1993).

Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 37,180 (approximately 41 percent) and the number of single- and multifamily housing units in Glenn County would increase by 40 and 32 percent, respectively.

Kings County
The Kings County General Plan predicts that, unlike in previous decades, the majority of population growth will be due to non-institutional population growth. Population growth is anticipated in the fringe areas of Hanford and within Lemoore's present boundaries on undeveloped sites. The Kings County Association of Governments, in conjunction with local jurisdictions (Avenal, Corcoran, Hanford, Lemoore, and Kings County), has developed a Regional Housing Needs Allocation Plan for Years 2001 through 2008. This plan attempted to direct new housing to where adequate infrastructure and public services can accommodate projected growth (Kings County, 2004).

Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 610 (approximately 25 percent) and the number of single- and multifamily housing units in Kings County would increase by 52 and 11 percent, respectively.

Madera County
Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 172,324 (approximately 40 percent) and the number of single- and multifamily housing units in Madera County would increase by 54 and 46 percent, respectively.

Mariposa County
Currently there are no populations located within in the DCA in Mariposa County and none are forecasted for 2030. As such this population and housing trends are not discussed further.

Merced County
Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 427,360 (approximately 52 percent) and the number of single- and multifamily housing units in Merced County would increase by 51 and 42 percent, respectively.

Placer County
SACOG projects that by 2035, the population of Placer County will be 570,709 (a growth of 20.9 percent between 2005 and 2035). Between 2005 and 2035, the City of Lincoln is projected to grow to 112,209 (6.4 percent); the City of Roseville to 172,500 (5.4 percent); the City of Rocklin to 69,155 (1.5 percent); the Town of Loomis to 8,336 (0.1 percent); and unincorporated areas of the county to 186,278 (7.1 percent) (SACOG, 2009).

Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 367,723 (approximately 58 percent) and the number of single- and multifamily housing units in Placer County would increase by 58 and 46 percent, respectively.

Sacramento County
Though most new growth during the first half of the Metropolitan Transportation Plan (MTP) planning period (set to 2035) will occur through development in the city's new growth areas (particularly build-out of North Natomas), a substantial minority of new housing and employment will also occur through infill and redevelopment (SACOG, 2008).

SACOG projects that by 2035, the population of Sacramento County will be 1,986,543 (a growth of 54.4 percent between 2005 and 2035). Between 2005 and 2035, the City of Sacramento is projected to grow to 642,257 (16.6 percent); the City of Rancho Cordova to 162,825 (8.7 percent); the City of Elk Grove to 192,889 (6.3 percent); the City of Folsom to 101,461 (3.4 percent); the City of Galt to 39,429 (1.2 percent); the City of Citrus Heights to 94,308 (0.8 percent); the City of Isleton to 2,239 (0.1 percent); and unincorporated areas of the county to 751,135 (17.3 percent) (SACOG, 2009).

Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 1,768,546 (approximately 32 percent) and the

number of single- and multifamily housing units in Sacramento County would increase by 33 and 29 percent, respectively.

San Joaquin County
The Draft Background Report for the General Plan Update forecasts that the City of Stockton will continue to be the largest population center in San Joaquin County through 2030. Other cities such as Escalon, Lathrop, and Ripon are projected to receive moderate growth but maintain populations under 50,000 residents. Unincorporated San Joaquin County will continue to grow at 1.2 to 1.9 percent AAGR, and by 2015 reach a population of 166,696, or a 15 percent increase from 2008. The Year 2030 growth projection represents a strong bias toward assigning growth to the incorporated cities in the county, especially Stockton (San Joaquin County, 2009).

Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 1,165,074 (approximately 53 percent) and the number of single- and multifamily housing units in San Joaquin County would increase by 54 and 38 percent, respectively.

Shasta County
Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 177,680 (approximately 38 percent) and the number of single- and multifamily housing units in Shasta County would increase by 45 and 17 percent, respectively.

Solano County
Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 148,008 (approximately 36 percent) and the number of single- and multifamily housing units in Solano County would increase by 40 and 34 percent, respectively.

Stanislaus County
Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 826,831 (approximately 47 percent) and the number of single- and multifamily housing units in Stanislaus County would increase by 48 and 31 percent, respectively.

Sutter County
SACOG projects that by 2035, the population of Sutter County will be 134,266 (a growth of 4.1 percent between 2005 and 2035). Between 2005 and 2035, the City of Yuba City is projected to grow to 94,571 (2.7 percent); the City of Live Oak to 14,028 (0.5 percent); and unincorporated areas of the county to 25,667 (0.8 percent) (SACOG, 2009).

Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 181,363 (approximately 56 percent) and the number of single- and multifamily housing units in Sutter County would increase by 60 and 36 percent, respectively.

Tehama County
Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 63,219 (approximately 41 percent) and the number of single- and multifamily housing units in Tehama County would both increase by 40 percent.

Yolo County
SACOG projects that by 2035, the population of Yolo County will be 278,786 (a growth of 8.2 percent between 2005 and 2035). Between 2005 and 2035, the City of West Sacramento is projected to grow to 87,402 (3.6 percent); the City of Woodland to 76,132 (2.1 percent); the City of Davis to 76,665 (1.1 percent); the City of Winters to 12,360 (0.4 percent); and unincorporated areas of the county to 26,227 (0.9 percent) (SACOG, 2009).

Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 270,019 (approximately 38 percent) and the number of single- and multifamily housing units in Yolo County would increase by 40 and 32 percent, respectively.

Yuba County
Yuba County's projected growth rate through 2050 is the second-highest in the state after neighboring Sutter County. Yuba County is expected to add 130,582 new residents by 2050, for a total of 201,327 (Yuba County, 2008).

SACOG projects that by 2035, the population of Yuba County will be 154,498 (a growth of 6.9 percent between 2005 and 2035). Between 2005 and 2035, the City of Wheatland is projected to grow to 23,056 (1.5 percent); the City of Marysville to 13,336 (0.2 percent); and unincorporated areas of the county to 118,106 (5.3 percent) (SACOG, 2009).

Based on preliminary DWR projections, by Year 2030 the population in the DCA would increase to 117,878 (approximately 61 percent) and the number of single- and multifamily housing units in Yuba County would increase by 57 and 47 percent, respectively.

Land Use

Historical Land Use Socioeconomic and public policy history in California has been an important influencing factor in land use and flood management in the Central Valley. Major population growth in California,

spurred by the discovery of gold in the Sierra Nevada in 1848, drove development of multiple industries that impacted land use and the effects of flood events in the Central Valley.

As Spanish missionaries and explorers settled in California before the discovery of gold, they forcibly moved indigenous peoples from small scattered villages (which the Spaniards termed rancherias) to central communities called pueblos. Pueblos, usually sited around a military presidio or Franciscan mission, used small-scale water development projects to provide community-owned water. Water development structures included minor dams and ditches to divert water for irrigated agriculture. In addition to pueblos, the Spanish monarchy also gave grants of private property, ranchos, to politically favored individuals. Ranchos primarily included water rights only for watering livestock, although some small-scale irrigation was also conducted.

Despite construction of these developments throughout California, the population was still sparse, and water development techniques relatively primitive. As a result, Spanish settlement resulted in only limited changes to California's rivers and streams. As populations grew in the late 1700s and early 1800s, logging, farming, and grazing activities increased, but these operations were small in scale and had little impact (Mount, 1995).

The discovery of gold lured gold prospectors to the Sierra Nevada and increased the population between 1850 and 1900. Hydraulic mining for gold and other mineral resources caused a dramatic increase in erosion from the Sierra Nevada mountains and foothills. Sediment flushed downstream increased the severity of flooding in the Central Valley and hampered navigation (Mount, 1995).

Spurred by the Gold Rush, grazing and agriculture developed throughout the foothills and Central Valley to provide food for the rapidly growing population of California. The Central Valley became the most productive farmland in the State. A majority of the early levee systems in the Sacramento and San Joaquin river basins and the Delta were built to maximize agricultural development in the fertile floodplains (Mount, 1995).

Shipping and transportation activities that supported the growing population and agricultural development drove navigation requirements along the Sacramento and San Joaquin rivers. Navigation along the Sacramento River was hampered by an increased sediment load resulting from hydraulic mining. Early levees built immediately adjacent to the river channel locally increased the scouring/flushing of hydraulic mining debris

from the channels, and improved navigation in the late 1800s and early 1900s (Mount, 1995).

Before the 1960s, land uses in the Sacramento and San Joaquin river basins were principally agriculture and open space, with urban uses limited to small farm communities. Although agriculture and food processing are still the region's major industries, expansion from the Bay Area and local industrial growth over the past 30 years have resulted in the creation of major urban centers throughout the region. Agricultural acreage peaked around 1959, and has since gradually declined as urban areas have expanded into the floodplains of the Sacramento and San Joaquin rivers.

Before 1850, the Delta was essentially a broad expanse of water-based habitat and natural channels. Large-scale reclamation of the Delta for agriculture began in 1868 and by 1900 most of the lands with mineral-organic soils, around the Delta's exterior, were reclaimed. The final period of Delta reclamation occurred between 1900 and 1920 on lands in the Delta's interior. The result of these reclamation efforts is largely what is seen as the Delta today – approximately 700 miles of meandering waterways and 1,100 miles of levees protecting more than 538,000 acres of farmland, homes and other structures. Historically, asparagus, corn, pasture, alfalfa, and sugar beets were the dominant crops in the Delta (DWR, 2005c).

Current Land Use There are 63 cities, one town, and 86 census-designated areas in 21 counties within the DCA, as shown in Table 2-13. Cities in the DCA include the urban areas of Sacramento and Fresno, as well as many smaller communities throughout the Central Valley. Existing land uses are shown on Figure 2-15.

Table 2-13. Cities, Towns, and Census-Designated Areas Within Counties in the Data Collection Area

County	Cities/Towns/Census Designated Areas
Alameda	Not Applicable – No towns in portion of county within DCA.
Butte	Biggs, Butte, Gridley, Chico, Oroville, Oroville East, South Oroville, Thermalito, Palermo, Durham
Colusa	Colusa, Williams, Arbuckle
Contra Costa	Antioch, Oakley, Brentwood, Bethel Island, Byron, Knightsen, Discovery Bay
El Dorado	El Dorado Hills
Fresno	Fresno, Clovis Firebaugh, Mendota, San Joaquin, Laton, Tranquillity, Calwa, Lanare
Glenn	Orland, Willows, Hamilton City
Kings	Not Applicable- No towns in portion of County within DCA.
Madera	Madera, Chowchilla, Gustine, Madera Acres, Parksdale, Parkwood
Mariposa	Not Applicable – No towns in portion of county within DCA.
Merced	Merced, Los Banos, Atwater, Livingston, Dos Palos, Winton, Delhi, Hilmar-Irwin, Planada, Le Grand, South Dos Palos
Placer	Roseville, Rocklin, Lincoln, Loomis, Granite Bay
Sacramento	Sacramento, Citrus Heights, Folsom, Galt, Isleton, Arden-Arcade, Foothill Farms, Rio Linda, La Riviera, Vineyard, Laguna West-Lakeside, Gold River, Wilton, Walnut Grove, Elk Grove, Rancho Cordova, Carmichael, North Highlands, Parkway-South Sacramento, Laguna, Fair Oaks, Florin, Orangevale, Rosemont
San Joaquin	Stockton, Lodi, Tracy, Manteca, Lathrop, Ripon, Escalon, Garden Acres, Country Club, August, Lincoln Village, French Camp, Morada, Kennedy, Lockeford, South Woodbridge, Taft Mosswood, North Woodbridge, Linden, Farmington
Shasta	Redding, Anderson, Shasta Lake, Cottonwood
Solano	Vacaville, Dixon, Rio Vista, Elmira
Stanislaus	Modesto, Turlock, Ceres, Riverbank, Oakdale, Hughson, Newman, Waterford, Patterson, Salida, West Modesto, Shackelford, Bret Harte, Keyes, Bystrom, Empire, Denair, East Oakdale, Del Rio, Riverdale Park, Grayson, Westley, Hickman
Sutter	Yuba City, Live Oaks, South Yuba City, Tierra Buena, Sutter
Tehama	Red Bluff, Corning, Tehama, Los Molinos, Gerber-Las Flores
Yolo	Davis, Woodland, West Sacramento, Winters, Esparto
Yuba	Marysville, Wheatland, Linda, Olivehurst, Beale AFB

Key:
AFB = Air Force Base
DCA = Central Valley Floodplain Evaluation and Delineation Program Data Collection Area

Urbanized areas comprise approximately 12 percent of the DCA, and are generally located along the major transportation corridors, such as SR 99 and I-5 (Table 2-14). Land use in the majority of the DCA is agricultural (approximately 66 percent), reflecting the area's substantial agricultural production. Approximately 21 percent of the DCA comprises native classes; of the area categorized as native class, 12 percent is surface water (e.g., rivers, streams, channels, lakes). Only a very small portion of the DCA (0.05 percent) has not been surveyed; this includes small portions of El Dorado, Merced, Solano, Stanislaus, and Yolo counties.

Table 2-14. Summary of Land Use by Category Within Data Collection Area (acres)

Land-Use Category				Total
Urban	Agricultural Land	Native Classes	Not Surveyed	
704,503	3,787,811	1,213,712	3,021	5,708,868
12%	66%	21%	< 1%	100%

Sacramento River Basin

Land uses in the Sacramento River Basin are still principally agricultural and open space, with urban development focused in and around the City of Sacramento. Except in Sacramento County, there is generally contains large quantities of parkland, forests, and other open space and has preserved its traditionally rural nature.

Irrigated agricultural acreage in the Sacramento River Basin peaked during the 1960s and has since declined. The main reason for this decline is the conversion of irrigated agricultural lands to urban development and managed wetlands. Managed wetlands are areas taken out of agricultural production, which can create substantial economic losses to local communities. Urban use occurs in smaller areas of the basin and is dispersed along the major transportation routes. More than half the basin's population lives in the greater metropolitan Sacramento area. Other fast-growing communities include Vacaville, Dixon, Redding, Chico, and several Sierra Nevada foothill towns. Urban development along major highway corridors in Placer, El Dorado, Yolo, Solano, and Sutter counties has resulted in some irrigated agricultural land being taken out of production. Suburban ranchette homes on relatively large parcels surround many of the urban areas and often include irrigated pastures or small orchards. Urban development accounts for approximately 863,000 acres (about 4 percent) of total land use in the river basin (DWR, 2005c).

In the Sacramento River Basin, close to 50,000 acres are managed by the State and federal governments. Federal lands include the Sacramento, Delevan, Colusa, Sutter, and Sacramento River NWRs. State lands include the Yolo Bypass Wildlife Area, and Gray Lodge, Upper Butte, and Oroville wildlife management areas (WMA). Together with private duck clubs, these State and federal lands provide essential habitat for wintering waterfowl and shorebirds (USACE, 2001).

San Joaquin River Basin

Agriculture remains the dominant land use of the San Joaquin River Basin. Agricultural production, processing, packaging, handling, shipping, and the sales of goods and services supporting agriculture represent a major economic and land0use activity. The valley floor of the San Joaquin River Basin is primarily privately owned agricultural land.

Urban activities are increasing as growing cities such as Stockton, Tracy, Manteca, Galt, Lodi, Modesto, Turlock, Merced, Los Banos, and Madera expand into surrounding agricultural lands. Pacheco and Altamont passes serve as commuting corridors into the Bay Area and fuel growth of valley "bedroom communities." Nonetheless, vast tracts of productive agricultural land surround these cities. Urban land use in 1996 totaled approximately 375,000 acres (CALFED, 2000c). The western side of the region, south of Tracy, is sparsely populated. Small farming communities provide services for farms and ranches in the area, all relatively close to I-5.

Much of the Sierra Nevada, located on the east side of the San Joaquin River Basin, is national forest. Government-owned public lands include the El Dorado, Stanislaus, and Sierra national forests and Yosemite National Park. Public lands amount to about one-third of the San Joaquin River Basin's total land area. The national forest and park lands include more than 2.9 million acres. U.S. Department of the Interior, Bureau of Land Management, and military properties occupy more than 200,000 and 5,100 acres, respectively. State parks, recreational areas, and other State property occupy about 80,000 acres (DWR, 2009e).

Public wildlife refuges in the San Joaquin River Basin include the San Luis NWR, which encompasses 26,340 acres; the San Joaquin River NWR with 2,875 acres; Merced NWR with 8,280 acres; Los Banos Wildlife Area with 5,586 acres; Volta Wildlife Area with 2,891 acres; the North Grasslands Wildlife Area with 7,069 acres; the White Slough Wildlife Area with 969 acres; and the Isenberg Sandhill Crane Reserve at 361 acres. Toward the northern end of this river basin, the Cosumnes River Preserve is managed by The Nature Conservancy and has become the largest refuge area in the river basin at 36,300 acres. Additionally, many private duck clubs are maintain wetland habitat (CALFED, 2000c).

Delta

Of the nearly 750,000 acres in the Delta, about 641,000 acres are rich farmland. Most of this area is classified as prime farmland, farmland of statewide importance, and unique farmland, or land with high statewide significance for agricultural production (CALFED, 2000c). The Delta's rich peat and mineral soils support several types of agriculture. Approximately 71,000 acres (about 8 percent) in the Delta Region are urbanized, with most of the development on the periphery of the region in Sacramento, San Joaquin, and Contra Costa counties. Much of the urbanization in the region is centered in incorporated cities, such as Antioch, Brentwood, Isleton, Pittsburg, Rio Vista, Sacramento, and West Sacramento. Fourteen unincorporated communities also are in the Delta Region: Discovery Bay, Oakley, Bethel, Courtland, Freeport, Hood, Ryde, Walnut Grove, Byron, Terminous, Thornton, Hastings Tract, and Clarksburg.

The Delta was given a legal boundary (CWC Section 12220) in 1959 with the passage of the Delta Protection Act. Anticipating the potential effects of urban development on the Delta, the original act was refined in 1992 to provide primary and secondary zones within the previously defined legal Delta. The Delta Protection Act of 1992 provides for regional coordination by establishing the Delta Protection Commission. The commission is to develop a long-term resource management plan for the area designated as the Delta Primary Zone. All local general plans for areas within this zone are required to be consistent with the regional plan (DWR, 1995).

The Delta Primary Zone was delineated to eliminate incorporated cities (DPC, 1995). The Delta Primary Zone is under the jurisdiction of five Delta counties: Contra Costa, Sacramento, San Joaquin, Solano, and Yolo. Land-use decisions are based primarily on the county general plans, required under State law and containing seven mandatory elements: (1) land use (2) circulation and transportation, (3) housing, (4) open space, (5) conservation, (6) safety, and (7) noise. Many areas are currently being used for agricultural purposes and have value as agricultural lands (DPC, 1994).

The five Delta counties designate Delta Primary Zone lands for agriculture or special Delta resources in their respective general plans. The zoning codes allow a variety of uses in the Delta Primary Zone: agriculture and agriculturally oriented uses; outdoor recreation; wildlife habitat; public facilities; and limited areas for commercial, industrial, and rural residential development. The parcel sizes specified in the general plans and zoning codes range from 5 to 160 acres, with most of the Delta Primary Zone in the 20- to 80-acre minimum parcel sizes (DPC, 2009).

The Delta Secondary Zone includes areas within incorporated cities or within the sphere of influence of cities (DPC, 1994). Isleton and portions of Stockton, Rio Vista, Antioch, Oakley, Sacramento, West Sacramento, Elk Grove, Tracy, Lathrop and Pittsburg, are located within or just outside the Delta Secondary Zone (DPC, 2009). These areas have a high likelihood of being developed for residential or other urban uses in the future (DPC, 1994).

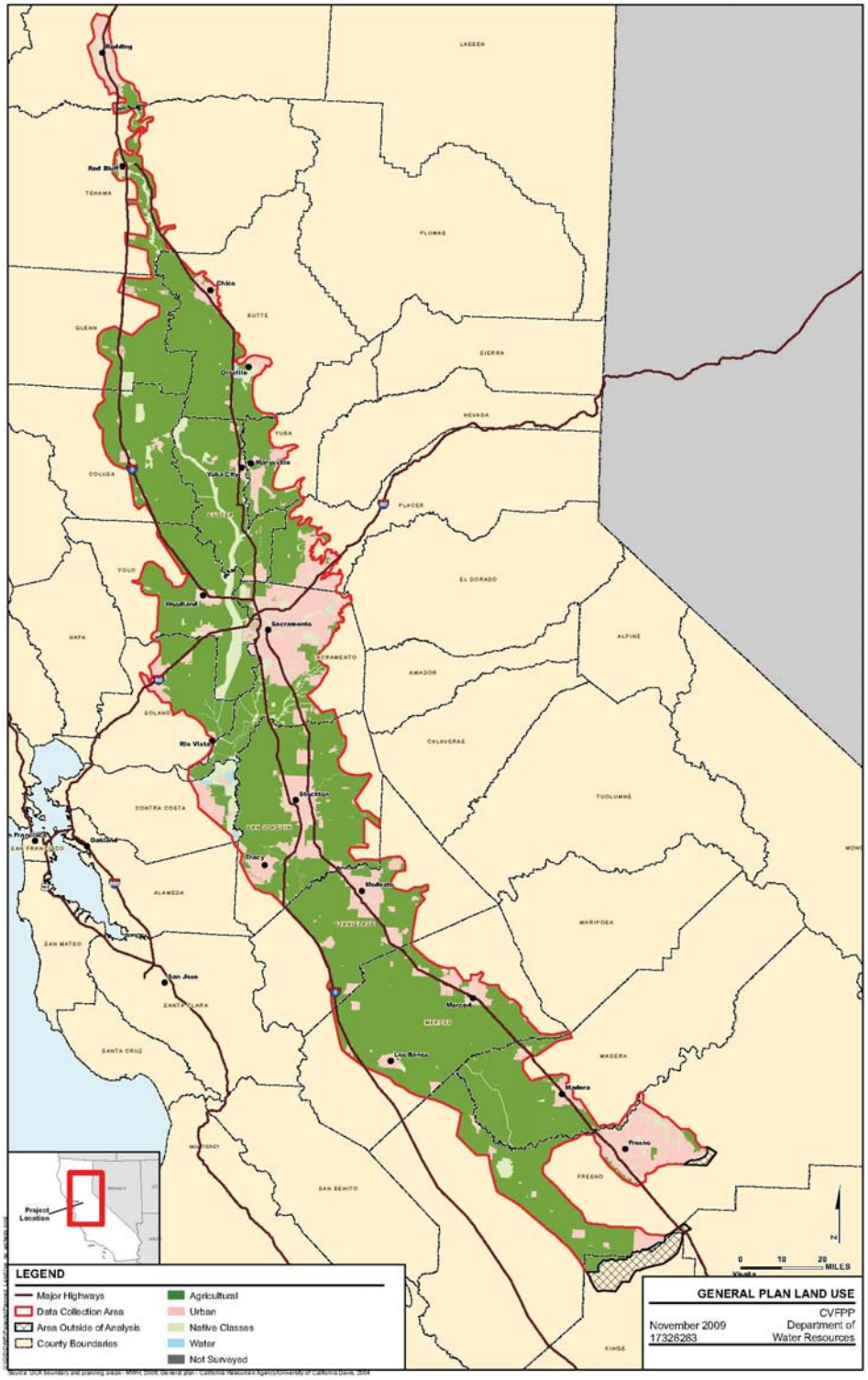
Since 1990, urban and other land uses have gained substantial acreage while agricultural land use has declined. Acquisition of farmed land, and subsequent retirement of that land, affects the economic base for farm-support industries; the economic base for community businesses that rely on patronage from citizens working in farm or farm-support industries; the tax and assessment base for special districts, counties, and the State; and existing wildlife use patterns that have adapted to agricultural land-use patterns.

The periphery of the Delta is undergoing rapid urbanization associated with substantial population growth. Current and future population growth will increase the demand for developable land, particularly near the Bay Area, Stockton, and Sacramento. This demand results in the conversion of open space, primarily agricultural land, to residential and commercial uses. In the recent past, thousands of acres of agricultural lands were developed for residential and other urban uses. Between 1990 and 2004, about 40,000 acres of agricultural land were converted to urban and conservation uses in the Delta (DPC, 1995). Estimates prepared by the Board indicate that as many as 130,000 new homes could be constructed within the legal Delta within the next decade (DPC, 2009).

Changes in land use from agriculture are proposed on several islands covering several thousand acres to improve water quality. Both Twitchell and Sherman islands may be converted to year-round wildlife habitat. Twitchell and Sherman islands are examples of areas now restricted to the public. Stone Lakes NWR has begun acquiring land for conversion to wildlife habitat. Medford Island is now a mitigation bank, managed for both agriculture and wildlife habitat. Prospect Island may be converted to wildlife habitat. The proposed Delta Wetlands project would convert four islands totaling 20,000 acres into two reservoirs and two wildlife habitat areas. At least 4,000 acres in the Yolo Bypass Wildlife Area have been restored to managed, seasonal wetlands. This acreage is part of 16,000 acres comprising agricultural and public lands, providing managed, permanent and semipermanent wetland habitat. Other projects propose 20 Delta Primary Zone lands be acquired for upland disposal of treated wastewater and biosolids, and for mitigation of environmental impacts (DPC, 2009).

Future Land Use

Projected future land use was primarily based on geographic information system (GIS) data from the California Resources Agency/University of California Davis (U.C. Davis, 2004). According to the associated metadata, the GIS data incorporates all county general plans in California, as well as many city general plans. Because each county and city plan developed and used its own land-use categories and criteria, the California Resources Agency converted data into 13 different classes. To create a meaningful comparison with the existing land-use data provided by DWR, these classes were further refined into land-use categories that paralleled the categories used to describe and characterize the existing land use. Based on available GIS data, urban areas within the DCA are expected to expand. Development would convert both native classes and agricultural land uses (Figure 2-19). Additionally, agricultural land use is anticipated to encroach on areas that are currently native classes. This conversion is most pronounced in Merced County, and in the area near the convergence of Butte, Glenn, Colusa, and Sutter counties; in these areas, existing large contiguous native classes areas would be lost. However, land categorized as native classes is expected to locally increase to create a congruent corridor along the Sacramento River.



Source: DCA boundary and planning areas – MWH, 2009, General plan – California Resources Agency/University of California Davis, 2004

Figure 2-19. Future Land Use

In addition to the GIS data, which incorporates all county-level general plans, regional planning documents were reviewed. The SACOG Board of Directors' *Preferred Blueprint Scenario for 2050* (2004) and the San Joaquin Regional Policy Council's *Draft Regional Blueprint Vision* (2009) were reviewed. It is important to note that these blueprints provide a planning framework, but do not restrict or direct the planning efforts of counties or other local governments.

The SACOG Blueprint is the guide for future growth in the Sacramento region. The Blueprint consists of a Base Case, which illustrates how the region would develop through the Year 2050 if the existing growth patterns continue (growth would continue to expand outward into rural areas on the edges of existing development). The Preferred Blueprint Scenario differs from the Base Case in that it relies on smart growth principles to encourage more compact development and conservation of natural resources. In terms of land use, the Preferred Blueprint Scenario would reduce the amount of additional urbanized land and the amount of land converted from agricultural to urban uses, and result in 304 square miles of additional urbanized land and 102 square miles of agricultural land converted to urban uses. The SACOG Blueprint Project also includes preparing a 2035 growth forecast and land-use allocation for the SACOG MTP. The MTP, published in 2008, provides updated information from local jurisdictions. The data include general plans and specific plans, and for some jurisdictions reflects the implementation of the Blueprint smart growth principles. The MTP concluded that while projected growth would occur in the central core and inner suburbs of the Sacramento region, some outlying communities would experience faster growth than what was projected.

The San Joaquin Regional Policy Council Draft Regional Blueprint Vision is to establish a long-range scenario to the Year 2050. The Draft Blueprint considers general plans for the area and proposes Guiding Principles for future development. The preferred Blueprint Vision's housing strategy calls for a net increase in housing density to meet the projected increase in population, as well as providing more land for agriculture and "other rural and urban open space purposes" (San Joaquin Regional Policy Council, 2009).

Lands Protected by SPFC The SPFC protects more than half a million people, 2 million acres of cultivated land and approximately 200,000 structures with an estimated value of $47 billion (DWR, 2005c). Figure 1-1, shows the extent of the lands protected by SPFC facilities.

Impact of Changes in Land Use Population growth in California creates demand for land resources for residential, commercial, and infrastructure

uses. As population increases, urbanization converts substantial amounts of land from agriculture, wetland, open space, and other land-use categories to urban uses. This ongoing rapid rate of urbanization is expected to generate significant land-and water-use challenges for the Central Valley, including adequate drought-period water supplies, growth in floodplains, conversion of productive farmland, and preservation of sensitive environmental habitats. Urbanization alters flow pathways, water storage, pollutant levels, rates of evaporation, groundwater recharge, surface runoff, timing and extent of flooding, sediment yield of rivers, and suitability and viability of aquatic habitats (DWR, 2009e). Many of California's levees were built more than 100 years ago to protect agricultural land and were not designed to protect the fast-growing urban areas they now protect.

Rural and Legacy Communities Rural and legacy communities are an integral part of the Central Valley's unique heritage. A rural community is a city, town, or settlement outside urban and urbanizing areas with an expected population of less than 10,000 within the next 10 years. Legacy communities are rural communities that are registered as Historic Districts by either State or federal entities. These communities provide historic and cultural value and add to the character of the landscape. These communities also serve as social and service centers for surrounding farms, and historically served as shipping sites for products. Rural and legacy communities reflect the diverse heritage of the Central Valley and the independence of country living (DPC, 2009).

Urban Urban land use consists of residential, commercial, industrial, urban landscape, and vacant areas, as defined by DWR (2005c). Residential areas comprise single- and multiple-family units, including trailer courts. Commercial use includes office, retail, hotel/motel, institutions (e.g., hospitals, prisons), schools, and community facilities (e.g., churches, stadiums, and parks). Industrial use includes manufacturing, storage, distribution, mills, plants, processing centers, waste sites, and energy features (e.g., wind farms and solar collectors). Urban landscape (e.g., irrigated lawns, golf courses, ornamental landscaping, and cemeteries) and vacant (e.g., paved areas, transportation corridors, airport runways, and undeveloped areas within urban areas) uses are also considered within the urban land use category.

As shown in Table 2-15, urban land uses comprise 704,503 acres (12 percent) of the DCA. Sacramento County includes both the largest area (183,109 acres) and percentage (38 percent) of urban land use. The county contains the greatest number of cities/census designated places (19) within the DCA (Table 2-16); urban uses are generally concentrated in the greater City of Sacramento area. Fresno County includes the second largest urban area (102,496 acres), which is overwhelmingly concentrated near the cities

of Fresno and Clovis. Within the DCA, Shasta County consists of 37 percent urban land use. This is reflective of the specific limits of the DCA boundary, which is generally located around development in the City of Redding.

Table 2-15. Land Use in the Data Collection Area by County (Acres)

County	Urban	Agriculture Land	Native Classes	Not Surveyed	Total
Alameda	30	602	98	0	**730**
Butte	34,975	231,612	93,198	0	**359,784**
Colusa	9,253	260,035	69,210	0	**338,498**
Contra Costa	11,141	45,851	31,127	0	**88,119**
El Dorado	0	0	0	178	**178**
Fresno	102,496	371,705	80,603	0	**554,804**
Glenn	8,257	188,471	43,151	0	**239,880**
Kings	367	12,218	1,365	0	**13,949**
Madera	17,152	276,141	59,310	0	**352,603**
Mariposa	0	0	44	0	**44**
Merced	40,307	446,535	199,686	103	**686,631**
Placer	25,234	46,634	69,979	0	**141,847**
Sacramento	183,109	166,791	133,260	0	**483,160**
San Joaquin	83,845	542,521	84,023	0	**710,388**
Shasta	28,434	14,010	33,668	0	**76,112**
Solano	19,889	148,791	48,371	42	**217,094**
Stanislaus	70,112	298,589	37,084	1	**405,786**
Sutter	16,226	293,546	79,577	0	**389,350**
Tehama	13,348	49,470	60,784	0	**123,602**
Yolo	29,634	310,187	49,685	2,696	**392,201**
Yuba	10,695	84,103	39,487	0	**134,285**

Table 2-16. Relative Land Use by Category Within Data Collection Area

County	Urban (%)	Agriculture (%)	Native Classes (%)	Not Surveyed (%)
Alameda	4	82	13	0
Butte	10	64	26	0
Colusa	3	77	20	0
Contra Costa	13	52	35	0
El Dorado	0	0	0	100
Fresno	18	67	15	0
Glenn	3	79	18	0
Kings	3	88	10	0
Madera	5	78	17	0
Mariposa	0	0	100	0
Merced	6	65	29	<1
Placer	18	33	49	0
Sacramento	38	35	28	0
San Joaquin	12	76	12	0
Shasta	37	18	44	0
Solano	9	69	22	<1
Stanislaus	17	74	9	<1
Sutter	4	75	20	0
Tehama	11	40	49	0
Yolo	8	79	13	1
Yuba	8	63	29	0

Note:
Values may not total 100 percent due to rounding.

Native Classes The native classes category consists of areas of vegetation, surface water, and barren and wasteland areas, as defined by DWR (2005c). Vegetation includes native vegetation (e.g., grass land, brush, brush and timber, forest, and oak woodland), riparian vegetation (e.g., marsh, meadows, streamside, and watercourse vegetation), surface water (e.g., rivers, streams, channels, and lakes), and barren and wasteland areas (e.g., dry stream channels, mine tailings, barren land, salt flats, and sand dunes).

Portions of each county within the DCA include native classes, ranging from a low of 9 percent in Stanislaus County to 100 percent in the small portion of Mariposa County located in the analysis area. With the exception of Mariposa County, each county has surface water land use within the native classes category. The greatest native classes area is located in Merced County; the 199,686 acres of this land use is generally

located between I-5 and SR 99. Within the DCA, Merced County contains 66,426 acres more native classes than the county with the next largest amount, Sacramento County. As shown on Figure 2-15, native classes in Sacramento County are generally concentrated around the urban area associated with the City of Sacramento. Stanislaus and Kings counties contain the smallest relative percentage of native classes land uses; however, only a small portion of Kings County (13,949 acres) is in the DCA and, as previously mentioned, these data may not be reflective of use within the county as a whole.

Agriculture This category consists of both agricultural and semi-agricultural classes as defined by DWR (2005c). For the purposes of this analysis, varying levels of sub-classes and types were selected by DWR. The category includes grain and hay crops (e.g., barley, oats); rice; field crops (e.g., cotton, corn, beans); pasture (e.g., alfalfa); truck, nursery and berry crops (e.g., onions and garlic); deciduous fruits and nuts (e.g., almonds and pistachios); citrus and subtropical (e.g., dates); vineyards (e.g., table, wine, and raisin grapes); and idle areas (e.g., fallow fields). In addition, as directed by DWR, this category includes semi-agricultural classes (e.g., dairies, livestock feed lots), which for the purposes of this analysis were designated as nonirrigated agricultural land.

As shown in Table 2-17, no single agricultural type dominates the DCA. According to the California Research Bureau, “although agriculture is widespread throughout the (central) valley, crops vary, and there is not even a unified ‘agricultural community’ encompassing the entire area. Instead, there are many agricultural interests with different concerns and whose common concerns (water and environmental issues, for example) are not unique to the valley” (Umbach, 1997).

Table 2-17. Summary of Agricultural Land in Data Collection Area

Agricultural Detail	Acres	% of Agricultural Land	% of Total Land
Alfalfa	379,786	10	7
Almond and pistachio	324,888	9	6
Corn	374,683	10	7
Cotton	172,552	5	3
Cucurbits	49,544	1	1
Dairy	23,406	1	<1
Dry Beans	68,567	2	1
Fallow and idle	153,135	4	3
Grain	253,075	7	4
Grapes	257,399	7	5
Nonirrigated agricultural land	131,243	3	2
Onions and garlic	3,999	<1	<1
Other deciduous	368,737	10	6
Other field	59,192	2	1
Other truck	63,782	2	1
Other Pasture*	236,308	6	4
Potatoes	4,391	<1	<1
Rice	555,534	15	10
Safflower	85,472	2	2
Other Semi-agricultural	107,837	3	2
Subtropical	22,090	1	<1
Sugar beets	28,206	1	<1
Tomatoes	195,230	5	3

Notes:
Values may not total 100 percent due to rounding.
*Non-alfalfa pasture (e.g., grass, clover)

Rice is the crop most commonly cultivated, representing 15 percent of all agricultural land in the DCA and 10 percent of all land analyzed. Alfalfa, corn, and other deciduous crops are the next largest types, each comprising 10 percent of the agricultural lands, and 6 to 7 percent of the total land in the DCA. Potatoes, onions, and garlic are the least common agricultural type. These crops, as well as sugar beets, subtropical plants, and dairies, each represent less than 1 percent of the total land in the DCA. Three percent of the DCA, encompassing 153,135 acres, was reported as fallow or idle; 2 percent of the DCA is comprised of other semi-agricultural land, such as livestock feed lots.

Table 2-18. Agricultural Land (in acres) by County–Detail

	Alameda	Butte	Colusa	Contra Costa	El Dorado	Fresno	Glenn	Kings	Madera	Mariposa	Merced
Alfalfa	242	3,056	7,631	3,740	–	56,946	7,309	3,673	37,137	–	82,948
Almond and pistachio	–	43,964	12,565	385	–	24,034	12,912	762	48,673	–	59,436
Corn	–	500	2,322	8,799	–	17,924	12,793	696	19,030	–	73,236
Cotton	–	20	1,661	–	–	83,374	730	3,890	25,952	–	51,026
Cucurbits	–	1,242	7,837	205	–	4,741	2,430	–	306	–	2,243
Dairy	–	27	10	101	–	2,268	465	119	2109	–	7,505
Dry beans	–	427	4,543	98	–	869	3,226	–	357	–	5,111
Fallow and idle	–	7,925	15,718	5,129	–	20,719	6,729	345	7,851	–	9,007
Grain	32	7,077	24,965	4,671	–	19,466	3,520	941	14,142	–	29,920
Grapes	–	21	1,576	786	–	57,308	–	50	87,148	–	8,197
Nonirrigated agricultural land	328	3,715	5,768	1,065	–	10,110	12,769	271	8,791	–	22,887
Onions and garlic	–	6	316	102	–	584	37	156	784	–	4
Other deciduous	–	44,314	8,517	4,667	–	19,739	16,483	631	10,130	–	16,024
Other field	–	3,782	3,072	386	–	4,127	7,181	–	2,207	–	4,731
Other truck	–	804	444	1,881	–	7,539	64	–	933	–	11,599
Other Pasture*	–	6,755	3,525	6,563	–	7,543	12,277	200	9,064	–	35,371
Potatoes	–	–	–	–	–	11	–	–	–	–	–
Rice	–	104,433	133,895	–	–	2,762	85,024	–	65	–	4,437
Safflower	–	1,559	9,957	3,039	–	465	1,953	234	70	–	–
Other semi-agricultural land	328	3,688	5,758	964	–	7,842	12,304	152	6,682	–	15,382
Subtropical	–	1,345	5	4	–	12,196	2,305	–	940	–	113
Sugar beets	–	670	–	200	–	7,715	508	218	621	–	4,518
Tomatoes	–	–	15,719	4,129	–	13,533	222	151	1,940	–	25,727
Grand Total	**602**	**231,612**	**260,035**	**45,851**	–	**371,705**	**188,471**	**12,218**	**276,141**	**0**	**446,535**

Table 2-18. Agricultural Land (in acres) by County–Detail (Contd.)

	Placer	Sacramento	San Joaquin	Shasta	Solano	Stanislaus	Sutter	Tehama	Yolo	Yuba
Alfalfa	14	7,053	60,587	525	34,640	32,218	6,045	2,764	32,394	864
Almond and pistachio	119	16	36,358	21	2,198	69,541	5,811	3,977	2,548	1,567
Corn	558	39,292	85,997	4	8,879	50,983	7,709	584	44,662	715
Cotton	–	–	–	–	–	16	1,142	–	4,741	–
Cucurbits	–	214	9,619	41	1,186	2,115	8,059	431	8,535	341
Dairy	45	852	3,174	49	160	6,471	–	51	–	–
Dry beans	–	709	20,294	–	2,725	17,001	8,719	426	4,065	–
Fallow and idle	6,825	11,738	13,422	1,369	2,273	8,006	15,567	3,058	12,328	5,126
Grain	1,174	17,209	45,499	851	26,186	2,851	8,740	1,692	43,249	889
Grapes	71	17,378	69,103	–	1,810	7,376	25	–	6,550	–
Nonirrigated Agricultural land	8,133	5,884	9,860	276	5,039	15,703	11,188	1,482	6,410	1,564
Onions and garlic	–	71	1,483	–	176	12	113	–	155	–
Other deciduous	1,747	8,064	61,506	1,507	9,168	41,458	60,068	21,946	11,232	31,535
Other field	446	4,194	3,626	112	8,056	1,984	4,466	381	10,139	301
Other truck	262	2,703	29,010	209	899	4,115	1,131	152	1,982	56
Other Pasture*	9,119	25,190	23,097	8,792	28,579	28,259	6,387	8,955	7,300	9,334
Potatoes	–	673	3,707	–	–	–	–	–	–	–
Rice	18,094	10,689	2,128	–	–	499	135,601	104	26,594	31,209
Other semi-agricultural	8,088	5,032	6,686	227	4,879	9,232	11,188	1,431	6,410	1,564
Safflower	–	7,185	18,658	102	6,501	86	4,180	489	30,903	91
Subtropical	70	189	254	201	46	454	344	3,029	96	497
Sugar beets	–	2,820	6,544	–	–	118	–	–	4,273	–
Tomatoes	–	5,522	41,767	–	10,433	15,791	8,251	–	52,031	14
Grand Total	**46,634**	**166,791**	**542,521**	**14,010**	**148,791**	**298,589**	**293,546**	**49,470**	**310,187**	**84,103**

Note:
* Non-alfalfa pasture (e.g., grass, clover)

Agricultural types within each county are presented in Table 2-18. San Joaquin and Merced counties include the largest areas of agricultural lands. San Joaquin County contains the most agricultural land (542,521 acres) in the DCA, approximately 100,000 more acres than Merced County. Portions of San Joaquin County in the DCA were cultivated with almost 86,000 acres of corn and more than 60,000 acres of each of the following: alfalfa, grapes, and other deciduous fruit and nuts (e.g., cherries, figs). Subtropical types were the least cultivated (254 acres) in that county. San Joaquin County agricultural land included all types of agricultural lands considered in this analysis except cotton. Within the DCA, Merced County encompasses the second largest area of cultivated land (446,535 acres). Alfalfa is the primary crop cultivated in the county (82,948), although substantial land is also devoted to corn (73,236 acres); pistachios and almonds (59,436); and cotton (51,026 acres). Within the county, onions and garlic comprise only 4 acres of the agricultural land; no potatoes or safflower are produced.

Alameda, El Dorado, and Mariposa counties include the smallest areas of agricultural lands (i.e., 602 acres, 0 acres, and 0 acres); this correlates to the fact that only very small portions of these counties (730 acres, 178 acres, and 44 acres) are located in the DCA. Within the DCA, Shasta and Kings counties both contain fewer than 15,000 acres of agricultural land; both also contain a variety of agricultural types. Of the 14,010 acres of agricultural land in Shasta County, more than half is pasture land (8,792 acres). In Kings County, alfalfa and cotton each comprise more than 3,000 acres of agricultural land; a variety of other types are each cultivated in areas totaling fewer than 1,000 acres.

Not Surveyed Not surveyed areas are those areas that have not been mapped by DWR. For future analysis, aerial photographs could be used to identify appropriate land use categories. Only a very small portion of the DCA (0.05 percent) has not been surveyed; the largest unsurveyed area (2,696 acres) is in southern Yolo County near its border with Solano County. El Dorado, Merced, Solano, and Stanislaus counties also include small areas that have not been surveyed.