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Drought and Groundwater Sustainability in California's Farming Regions

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Highlights

- As the Sustainable Groundwater Management Act (SGMA) approaches its tenth anniversary, California is making progress towards implementation—but the 2020–22 drought shows that much work still lies ahead.
- Drought poses a particular challenge for SGMA compliance in many farming regions. Increased groundwater use keeps crops irrigated when surface water is scarce, but it can cause undesirable impacts such as dry wells, infrastructure damage from land subsidence (sinking lands), and increased rates of seawater intrusion.
- While SGMA allows some flexibility for extra groundwater pumping during droughts, it also requires local agencies to guard against these undesirable impacts.
- A portfolio of strategies—such as improving groundwater accounting, incentivizing groundwater recharge and demand reduction, and bolstering mitigation measures—can help farming regions prepare for drought while improving groundwater stewardship.

Progress towards groundwater sustainability is underway, but drought is a concern

Groundwater is a vital source of irrigation and drinking water for urban and rural communities across much of California. It is also a critical component of the state's struggling freshwater ecosystems. But unsustainable pumping—especially during droughts—has created numerous long-term problems, including land subsidence, dry wells, seawater intrusion, and ecosystem harm.

The Sustainable Groundwater Management Act (SGMA) requires local agencies to develop and implement plans to bring their basins into long-term balance by the early 2040s—and to prevent significant undesirable results along the way. Most major agricultural regions are now subject to SGMA.

SGMA was enacted in 2014, during the historic 2012–16 drought. Rapidly falling groundwater levels, dry drinking water wells, and damage to major aqueducts from sinking lands helped convince legislators that it was time for California to join other western states in regulating groundwater use. Then in 2020, just as the first groundwater sustainability plans (GSPs) mandated by SGMA were getting underway, the state experienced another historic drought: 2020–22 was California's driest three-year period on record.

Drought is costly to the state, and especially to its large agricultural sector. Over a billion dollars of economic output and thousands of jobs were lost in both 2021 and 2022, relative to an average year, from cropland fallowing and yield losses.

Drought also complicates SGMA implementation, as it can exacerbate the very problems SGMA was designed to address. In this policy brief, we look at the early years of SGMA implementation, which coincided with a historic drought, and highlight areas of progress as well as areas of ongoing concern. We draw on other recent research, a range of data, and focus group discussions with agricultural water managers in several major regions where SGMA is underway.

Drought exacerbates problems related to groundwater use in California's agricultural regions

Pumping more groundwater is a common response to drought when surface water supplies decline—and SGMA allows some flexibility during drought periods. However, SGMA does require that local agencies guard against the significant undesirable impacts of pumping. Unfortunately, drought also stresses basins by reducing natural replenishment, and increased pumping can accentuate a host of negative impacts. These include:

- **Land subsidence.** In areas of the Central Valley that host key water conveyance infrastructure such as the Friant-Kern Canal, the California Aqueduct, and the Delta-Mendota Canal, subsidence is a major concern. Some flood control, energy, and transportation infrastructure is also affected. Aquifer collapse can permanently reduce an aquifer's ability to store water.
- **Dry wells.** Increased pumping causes groundwater levels to fall, making it harder to keep drinking water and irrigation wells operational.
- **Seawater intrusion.** Seawater intrusion in coastal aquifers tends to worsen as pumping increases.
- **Other undesirable results.** Drought can reduce groundwater quality by concentrating contaminants or causing pollutants to migrate towards wells. And in areas with relatively healthy aquifers, pumping can siphon flows away from overlying streams and cause harm to ecosystems and surface water users.

In the recent drought, the acreage devoted to perennials continued to grow . . .

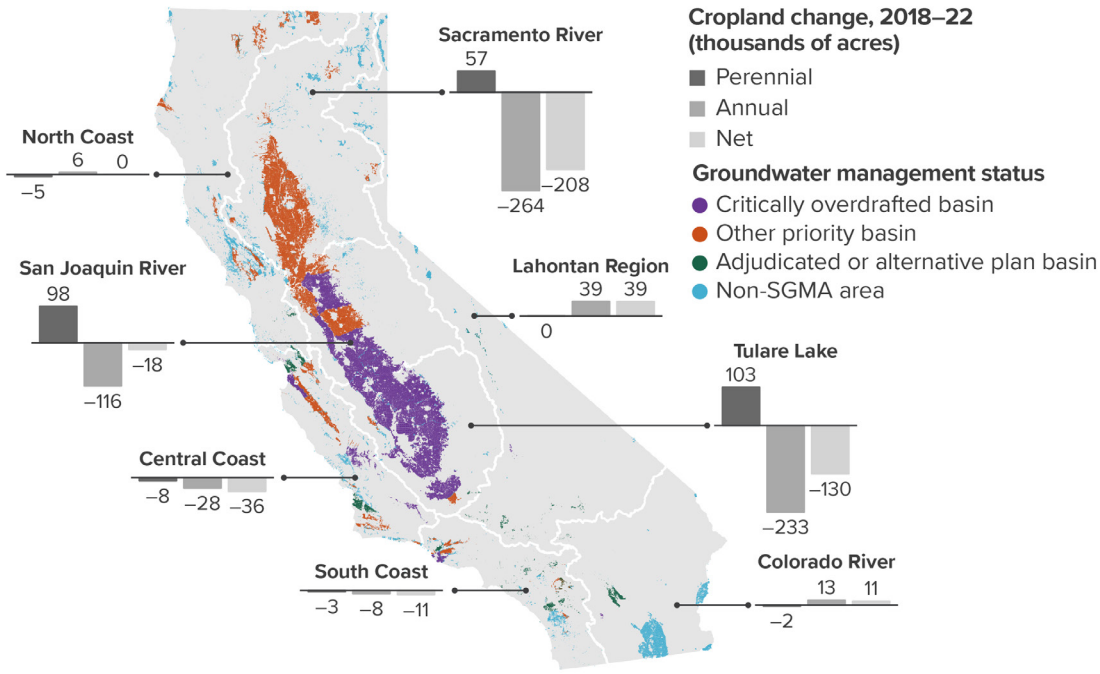
Growers often adapt to drought by fallowing some land to reduce water demands. Responding to economic incentives, they tend to leave unplanted some lands used for annual field crops—and may also remove perennial orchards and vines that are near the end of their economically profitable lives.

In the 2020–22 drought, growers temporarily fallowed several hundred thousand acres of Central Valley cropland—mainly rice and cotton. Federal crop insurance may have mitigated their losses. But alongside this overall reduction in acreage, they continued to expand the acreage of perennials (and especially nut trees)—a trend that has been underway for several decades.

This is concerning because water use by perennials is less flexible than water use for annual crops. Growers can lose their investments in trees and vines if they fail to irrigate them, so these crops tend to harden water demands.

While perennials have long offered a relatively profitable opportunity for many California growers, additional perennial plantings can also make it more difficult to meet future requirements to pump less, which are all but guaranteed as some basins implement SGMA. For example, PPIC estimates that at least 500,000 acres of irrigated land in the heavily overdrafted San Joaquin Valley (San Joaquin River and Tulare Lake regions) will need to come out of production by 2040 to end overdraft.

While total cultivated acreage fell, perennial orchard planting continued to rise



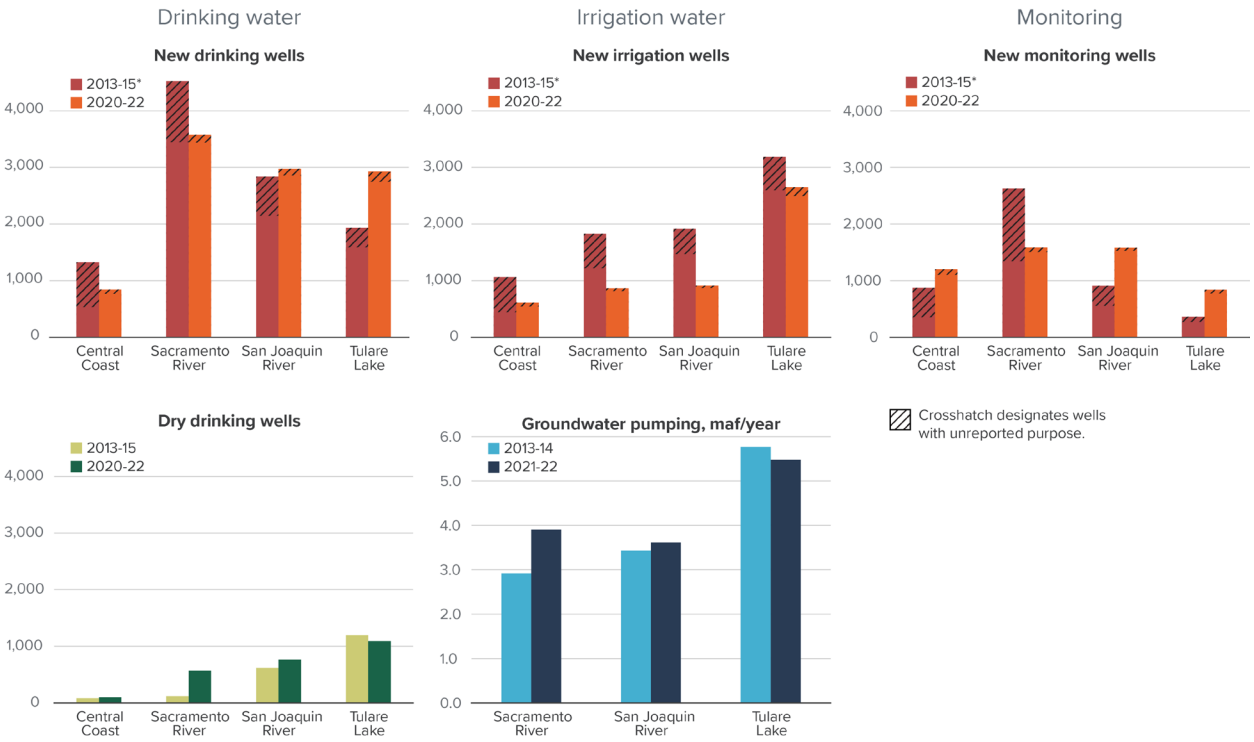
Source: Author calculations using California Department of Water Resources (DWR) Statewide Crop Mapping dataset. For details, see the dataset: PPIC Irrigated Crop Acreage, 2018–22 (Cole 2024).
Notes: The map shows irrigated crop acreage in 2018, a year with near-average water availability, and acreage changes from 2018–22 by hydrologic region. Critically overdrafted basins (purple) were required to submit their first sustainability plans in January 2020. Other priority basins (orange) were required to submit their plans in January 2022. Adjudicated and alternative plan basins (green) are either exempt from SGMA (by virtue of a court-approved adjudication) or have an approved alternative plan (by virtue of other arrangements such as special management districts); two of these—Pajaro Valley and Borrego Springs—are considered critically overdrafted but are shown as formally managed areas. Non-SGMA areas (blue) either do not have usable groundwater (e.g., much of San Diego and Imperial counties) or are in groundwater basins considered at lower risk of overdraft.

- In the San Joaquin Valley, more than 200,000 acres of perennials were added from 2018 to 2022.
- As a share of 2018 acreage, these crops rose from 60% to 65% of the total in this region.
- Perennials have also been expanding in the Sacramento Valley—they are up 57,000 acres and increased from 37% to 40% of irrigated cropland.
- Across the Central Valley as a whole, 8 of 31 basins that are now subject to SGMA have more than 70% of their irrigated acreage in tree crops—a challenge for managing droughts and bringing basins into balance without major adjustment costs.

. . . and the data show a mixed picture on wells and water use

Drinking water. During the 2012–16 drought, concerns about drinking water wells going dry in the San Joaquin Valley spurred SGMA's enactment, so it's encouraging that there wasn't an uptick of dry wells in this region during the latest drought. However, dry wells did increase in the Sacramento Valley, where conditions were much drier than in the previous drought. In some regions, more new drinking wells were drilled, perhaps as a precautionary strategy. Groundwater sustainability agencies (GSAs) have been developing well mitigation strategies to address drinking water impacts from drought and ongoing overdraft.

Changes in groundwater wells and pumping over the two most recent droughts show a mixed picture



Source: Compiled by the authors using DWR, Dry Well Reporting System (dry drinking wells); DWR, Well Completion Reports (new wells); California Natural Resources Agency, Groundwater Sustainability Plan Annual Report Data (groundwater pumping). For details on well data by year and basin, see the dataset: PPIC Dry Wells and New Wells (Cole 2024).
Notes: Maf is million acre-feet. For dry and new wells, the charts show cumulative totals over three years, and compare the three most severe years of the 2012–16 drought with the 2020–22 drought. For dry wells, the 2013–15 data may understate the total because this reporting system was new. For new wells, the hatched portions of the bars show our best guess of the purpose of wells whose purpose was not reported; this issue was most prevalent in the earlier years analyzed (for the estimation method, see the PPIC dataset listed above). For groundwater pumping, data availability restricts the comparison to two years in each drought, and the charts show annual averages; San Joaquin River pumping totals exclude the Delta-Mendota basin, and Tulare Lake totals exclude the Kings basin (data was unavailable). Most groundwater pumping is for crop irrigation in all three regions shown.

Irrigation water. Although the declining number of new irrigation wells drilled in the San Joaquin Valley could be construed as good news, the amount of groundwater pumped hasn't declined significantly since the last drought. And many deep wells were drilled in areas where they are likely to exacerbate ongoing subsidence. The number of new irrigation wells also dropped in the Sacramento Valley, but the amount of water pumped rose, reflecting the much drier conditions there in 2020–22.

Monitoring. There is good news here. The general increase in monitoring wells (used to track groundwater flows, levels, and quality) is a sign that local agencies, with state support, are advancing their understanding of their basins under SGMA—and we also heard this from managers. The trends in the Sacramento Valley are less clear because of data issues, but many new monitoring wells are being drilled there as well.

There are other early signs of progress in SGMA implementation

Our review of GSPs showed that the plans acknowledge the additional challenges of complying with SGMA during droughts, which will become increasingly severe in our changing climate. Although the 2020–22 drought caught GSAs before their plans were fully operational, the stress caused by this drought may have spurred faster progress toward groundwater stewardship.

Clarifying vulnerabilities. GSAs and the state are making progress on identifying areas prone to dry wells, subsidence, and seawater intrusion. In the Sacramento Valley, the state has required some GSAs to update their GSPs to better address drought impacts. And some San Joaquin Valley basins risk moving under state management without taking further steps to avoid harm. Efforts are also underway at the state and local levels to better understand how to manage impacts to groundwater quality and surface water—two areas that will be addressed more fully in the five-year updates of GSPs, due in 2025 and 2027. GSAs are also expected to continue refining their climate change analysis and planning.

Establishing focused management areas for subsidence and wells. In response to recent executive orders and legislation, some GSAs are working with counties to limit the drilling of new irrigation wells in some areas to avoid subsidence and protect drinking wells. Some GSAs in the San Joaquin Valley are also creating zones where pumping is restricted to limit damage.

Mitigating seawater intrusion. Coastal basins are addressing this issue through demand reduction programs (e.g., voluntary conservation) and basin replenishment efforts, including encouraging growers to substitute pumping with recycled water.

Speeding up incentives to reduce groundwater use. Basin plans in both the San Joaquin and Sacramento valleys tend to emphasize augmenting water supplies as a preferred approach for ending overdraft. But the recent drought accelerated the launch of demand reduction efforts, such as pumping allocations and fees, groundwater markets, and incentives to strategically fallow land.

Incentivizing wet-year recharge. A very wet 2023 brought the 2020–22 drought to a close, creating ample opportunities to replenish depleted basins. In the San Joaquin Valley, PPIC estimates that recharge increased by over 1 million-acre feet (17%) relative to 2017—a year with similar precipitation. New incentives encouraged growers to divert floodwater to their fields, and agencies that had launched pumping allocations leveraged this system to give credits towards future pumping to growers who engaged in recharge. Innovative recharge efforts have also been expanding in some coastal basins. Such efforts will boost the ability to weather future droughts.

State and local policies can support groundwater sustainability and drought resilience

SGMA was designed on the principle that those closest to the problem—local agencies and their constituents—should take the lead on groundwater stewardship, with the state providing implementation support and a regulatory backstop. To date, the state has provided significant technical, planning, and financial assistance, and it has also pushed GSAs to address gaps in their basin plans. Looking ahead, continued local innovation will be key to successfully addressing undesirable results and bringing basins into balance. Local agencies can:

- Continue to refine strategies to avoid or mitigate undesirable results of groundwater use;
- Anticipate drought-induced pumping increases and work to ensure that management strategies adequately offset these increases;
- Improve groundwater accounting, including groundwater allocation and recharge crediting systems, to incentivize both demand reduction and supply enhancement;
- Give growers tools to manage the risks that come with decreased water availability, such as recharge crediting systems and water trading programs;
- Increase collaborative efforts with growers, communities, NGOs, counties, and others to address impacts and allow basins to experiment with new approaches (e.g., incentivizing targeted pumping cutbacks, or recharging in areas that will provide broader benefits); and
- Raise local funding to support these projects.

The state, for its part, should continue to promote local progress through technical and planning assistance, supportive regulations, and financial incentives to reduce demands, augment supplies, and address the harmful impacts of pumping.

Finally, in our increasingly volatile climate—with its growing swings between extreme drought and intense wet years—both local agencies and the state should seek to move away from a framework focused on "disaster response" and towards an approach that recognizes the need to be ready to steward water resources through both the dry and the wet times.

Further Reading

"Addressing Groundwater Overdraft in the Sacramento Valley" (PPIC Blog, 2023)

"Agricultural Land Use in California" (PPIC, 2024)

"Drought and California's Agriculture" (PPIC, 2022)

Economic Impacts of the 2020–22 Drought on California Agriculture (UC Merced, 2022)

"The Future of Agriculture in the San Joaquin Valley" (PPIC, 2023)

"Groundwater in California" (PPIC, 2024)

Improving California's Water Market: How Water Trading and Banking Can Support Groundwater Sustainability (PPIC, 2021)

Managing Water and Farmland Transitions in the San Joaquin Valley (PPIC, 2023)

"Measuring Groundwater Overdraft in the Sacramento Valley" (PPIC Blog, 2023)

Replenishing Groundwater in the San Joaquin Valley: 2024 Update (PPIC, 2024)

"A Review of Groundwater Sustainability Plans in the San Joaquin Valley" (PPIC, 2020)

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Sources and acknowledgements: This policy brief draws on related studies by the research team (linked in the text above), discussions with local water managers in the Central Valley and coastal regions, and new data analysis, as detailed in related datasets: PPIC Dry Wells and New Wells (Cole 2024) and PPIC Irrigated Crop Acreage, 2018–22 (Cole 2024). Special thanks to reviewers of this brief: Stephanie Anagnoson, Brad Franklin, Letitia Grenier, Eric Limas, Brian Lockwood, Kristin Sicke, Stacie Ann Silva, Steven Springhorn, and Dan Sumner; and to editor Sarah Bardeen. The authors would also like to thank local water managers who participated in focus group discussions. The authors alone are responsible for the conclusions and recommendations, and any errors or omissions.