From:	Jacob Patterson
To:	Lemos, June
Cc:	Spaur, David; Marie Jones
Subject:	Public Comment -- 5/23/22 CC mtg., Item No. 7B, Proposed Cannabis Ordinance
Date:	Thursday, May 19, 2022 3:54:13 PM

City Council [via BCC],

I reviewed the agenda materials in detail concerning the proposed cannabis ordinance, which already include the written comments I previously submitted concerning the Initial Study and Negative Declaration (IS/ND) for the cannabis ordinance project so I will focus on the proposed ordinance itself in this public comment. I find that the draft ordinance proposed for first reading at this continued public hearing accurately reflects the direction of the council majority from your prior meetings except for one brief provision, which I recommend you direct Marie and staff to remove tonight before potentially proceeding with the first reading because I do not think it reflects your prior direction and also because it presents a serious inconsistency issue with the Inland General Plan and an internal inconsistency issue with the rest of the ILUDC, including other changes included in the proposed ordinance tonight.

As I mentioned in my comments on the IS/ND, the addition of "wholesale" and "distribution" among the potentially permitted accessory uses for cannabis retail within the commercial zoning districts is in direct conflict with the Inland General Plan's provisions concerning the purposes, intent, and permitted uses within the City's commercial districts. Marie discussed this same consistency issue concerning potentially creating a formal microbusiness use type and potentially allowing it in the commercial districts rather than limiting it to the industrial districts. Wholesale and off-site distribution uses are only permitted in the City's industrial districts not our commercial districts and trying to show-horn them into the list of potentially-permitted accessory uses to cannabis retail would first require an amendment to the Inland General Plan. The City hasn't done that as part of this application so those two industrial district appropropriate uses should be removed at this time and later brought forward as part of the companion project you discussed with Marie at your prior meetings concerning this cannabis ordinance update project. If you pair those (future) changes with a corresponding amendment to the Inland General Plan definitions and descriptions of the purposes and intended uses in the commercial districts, you can proceed with that policy direction but what you cannot do is try to ignore the direct conflict between that provision in the draft proposed ordinance and the Inland General Plan or with the other provisions of the ILUDC that are also incompatible with the potential policy decision to make them permissible accessory uses to a cannabis retail primary use and try to include those two industrial uses as potentially permissible accessory uses as part of this ordinance project. Ignoring the direct conflicts and clear inconsistency between the proposed language and the Inland General Plan would constitute an abuse of discretion and is procedurally improper, in my opinion.

There is also an issue with simple logic in trying to allow wholesale or distribution uses as accessory uses to a cannabis retail primary use. Such uses are not logically related to a primary use of cannabis retail nor are they consistent with the ILUDC's definition of accessory uses because neither wholesale nor distribution uses support or are related to storefront retail sales to an end customer since they both serve off-site activities and locations and have nothing to do with the end-customer retail sales of cannabis products to a store's customers. Instead, wholesale and distribution uses support other retail locations elsewhere in California (or on other parcels in the City) and the sales are made to other businesses not end-user customers. In contrast, appropriate and internally consistent accessory uses could logically include

cultivation of non-flowering nursery plants for sale to end-user retail customers or craft manufacturing because that potential accessory use is subordinate to and logically related to the primary use of cannabis retail since the nursery plants being grown or the products being "craft manufactured" on site will still be sold to end-user customers of the retail store. At most, a wholesale or off-site distribution use would be considered separate and distinct business ventures from a cannabis retail use on the same property so neither use could be considered as accessory uses to cannabis retail. Since those uses are also only allowed as primary uses in industrial districts, wholesale and off-site distribution need to be removed from the list of permissible accessory uses to cannabis retail in this proposed ordinance.

To fix this, you simply need to amend the proposed ordinance and potentially adopt it as amended. The specific amendment is to ILUDC section 18.42.057, subdivision C.4.a.i. to read "Office, Nursery (non-flowering) cultivation for on-site sales only; Retail Delivery; On-Site Distribution, and Craft Cannabis Manufacturing – no volatile solvents permitted." [The current draft reads as follows "Office, Nursery (non-flowering) cultivation for on-site sales only; Retail Delivery; On-Site Distribution, Craft Cannabis Manufacturing – no volatile solvents permitted, Distribution, Wholesale." so I simply deleted ", Distribution, Wholesale".]

These two simple words create a huge issue for this proposed ordinance but removing them fully addresses those concerns and fixes a significant related issue with the draft IS/ND as well. Please consider fixing this issue by incorporating my suggested amendment before proceeding with introducing this proposed ordinance.

Although it does not present an Inland General Plan or internal ILUDC consistency issue, I also recommend considering amending the proposed Article 10 definition of "Craft Cannabis Manufacturing" to either remove the reference to washing machines or to specify that only food grade commercial equipment is permitted as part of craft cannabis manufacturing. The reason I make that suggestion is that the relevant state regulations concerning commercial cannabis manufacturing does not permit the use of household equipment like washing machines (or even commercial washing machines) in the manufacturing of cannabis products even if some businesses are currently using washing machines and ice as part of their manufacturing processes. Despite the not uncommon use of washing machines by some licensed cannabis manufacturers, I believe that equipment is not permitted by the California Department of Cannabis Control for licensed commercial cannabis businesses because washing machines are not certified as "food grade" equipment the way the other equipment listed in the current draft definition can be food grade equipment (e.g., blenders and cooking equipment). It makes little sense to list a piece of equipment in our definition of a particular use type that can't legally be used by any licensed commercial cannabis business in California.

Please don't interpret this comment and me supporting the policy direction of the majority of the City Council concerning this proposed ordinance; there are several provisions and majority direction that I disagree with, but I thought my public comments would be more useful if I focused on issues and apparent errors I have identified in the draft ordinance itself rather than trying to lobby you for a particular policy outcome I might prefer over what is proposed based on your prior direction. That said, I respect the public process for the development of our local land use regulations even if my policy preferences are not fully reflected in the final work product that resulted from that policy-development process (unless the process was materially flawed, obviously).

Regards,

--Jacob

EXECUTIVE DEPARTMENT
STATE OF CALIFORNIA

EXECUTIVE ORDER N-7-22

WHEREAS on April 12, 2021, May 10, 2021, July 8, 2021, and October 19, 2021, I proclaimed states of emergency that continue today and exist across all the counties of California, due to extreme and expanding drought conditions; and

WHEREAS climate change continues to intensify the impacts of droughts on our communities, environment, and economy, and California is in a third consecutive year of dry conditions, resulting in continuing drought in all parts of the State; and

WHEREAS the 21st century to date has been characterized by record warmth and predominantly dry conditions, and the 2021 meteorological summer in California and the rest of the western United States was the hottest on record; and

WHEREAS since my October 19, 2021 Proclamation, early rains in October and December 2021 gave way to the driest January and February in recorded history for the watersheds that provide much of California's water supply; and

WHEREAS the ongoing drought will have significant, immediate impacts on communities with vulnerable water supplies, farms that rely on irrigation to grow food and fiber, and fish and wildlife that rely on stream flows and cool water; and

WHEREAS the two largest reservoirs of the Central Valley Project, which supplies water to farms and communities in the Central Valley and the Santa Clara Valley and provides critical cold-water habitat for salmon and other anadromous fish, have water storage levels that are approximately 1.1 million acre-feet below last year's low levels on this date; and

WHEREAS the record-breaking dry period in January and February and the absence of significant rains in March have required the Department of Water Resources to reduce anticipated deliveries from the State Water Project to 5 percent of requested supplies; and

WHEREAS delivery of water by bottle or truck is necessary to protect human safety and public health in those places where water supplies are disrupted; and

WHEREAS groundwater use accounts for 41 percent of the State's total water supply on an average annual basis but as much as 58 percent in a critically dry year, and approximately 85 percent of public water systems rely on groundwater as their primary supply; and

WHEREAS coordination between local entities that approve permits for new groundwater wells and local groundwater sustainability agencies is important to achieving sustainable levels of groundwater in critically overdrafted basins; and

WHEREAS the duration of the drought, especially following a multiyear drought that abated only five years ago, underscores the need for California to redouble near-, medium-, and long-term efforts to adapt its water management and delivery systems to a changing climate, shifting precipitation patterns, and water scarcity; and

WHEREAS the most consequential, immediate action Californians can take to extend available supplies is to voluntarily reduce their water use by 15 percent from their 2020 levels by implementing the commonsense measures identified in operative paragraph 1 of Executive Order N-10-21 (July 8, 2021); and

WHEREAS to protect public health and safety, it is critical the State take certain immediate actions without undue delay to prepare for and mitigate the effects of the drought conditions, and under Government Code section 8571, I find that strict compliance with various statutes and regulations specified in this Proclamation would prevent, hinder, or delay the mitigation of the effects of the drought conditions.

NOW, THEREFORE, I, GAVIN NEWSOM, Governor of the State of California, in accordance with the authority vested in me by the State Constitution and statutes, including the California Emergency Services Act, and in particular, Government Code sections 8567, 8571, and 8627, do hereby issue the following Order to become effective immediately:

IT IS HEREBY ORDERED THAT:

1. The orders and provisions contained in my April 21, 2021, May 10, 2021, July 8, 2021, and October 19, 2021 Proclamations remain in full force and effect, except as modified by those Proclamations and herein. State agencies shall continue to implement all directions from those Proclamations and accelerate implementation where feasible.

2. To help the State achieve its conservation goals and ensure sufficient water for essential indoor and outdoor use, I call on all Californians to strive to limit summertime water use and to use water more efficiently indoors and out. The statewide Save Our Water conservation campaign at SaveOurWater.com provides simple ways for Californians to reduce water use in their everyday lives. Furthermore, I encourage Californians to understand and track the amount of water they use and measure their progress toward their conservation goals.

3. By May 25, 2022, the State Water Resources Control Board (Water Board) shall consider adopting emergency regulations that include all of the following:

    a. A requirement that each urban water supplier, as defined in section 10617 of the Water Code, shall submit to the Department of Water Resources a preliminary annual water supply and demand assessment consistent with section 10632.1 of the Water Code no later than June 1, 2022, and submit a final annual water

supply and demand assessment to the Department of Water Resources no later than the deadline set by section 10632.1 of the Water Code;

b. A requirement that each urban water supplier that has submitted a water shortage contingency plan to the Department of Water Resources implement, at a minimum, the shortage response actions adopted under section 10632 of the Water Code for a shortage level of up to twenty percent (Level 2), by a date to be set by the Water Board; and

c. A requirement that each urban water supplier that has not submitted a water shortage contingency plan to the Department of Water Resources implement, at a minimum, shortage response actions established by the Water Board, which shall take into consideration model actions that the Department of Water Resources shall develop for urban water supplier water shortage contingency planning for Level 2, by a date to be set by the Water Board.

To further conserve water and improve drought resiliency if the drought lasts beyond this year, I encourage urban water suppliers to conserve more than required by the emergency regulations described in this paragraph and to voluntarily activate more stringent local requirements based on a shortage level of up to thirty percent (Level 3).

4. To promote water conservation, the Department of Water Resources shall consult with leaders in the commercial, industrial, and institutional sectors to develop strategies for improving water conservation, including direct technical assistance, financial assistance, and other approaches. By May 25, 2022, the Water Board shall consider adopting emergency regulations defining "non-functional turf" (that is, a definition of turf that is ornamental and not otherwise used for human recreation purposes such as school fields, sports fields, and parks) and banning irrigation of non-functional turf in the commercial, industrial, and institutional sectors except as it may be required to ensure the health of trees and other perennial non-turf plantings.

5. In order to maximize the efficient use of water and to preserve water supplies critical to human health and safety and the environment, Public Resources Code, Division 13 (commencing with section 21000) and regulations adopted pursuant to that Division are hereby suspended, with respect to the directives in paragraphs 3 and 4 of this Order and any other projects and activities for the purpose of water conservation to the extent necessary to address the impacts of the drought, and any permits necessary to carry out such projects or activities. Entities that desire to conduct activities under this suspension, other than the directives in paragraphs 3 and 4 of this Order, shall first request that the Secretary of the Natural Resources Agency make a determination that the proposed activities are eligible to be conducted under this suspension. The Secretary shall use sound discretion in applying this Executive Order to ensure that the suspension serves the purpose of accelerating conservation projects that are necessary to address impacts of the drought, while at the same time

protecting public health and the environment. The entities implementing these directives or conducting activities under this suspension shall maintain on their websites a list of all activities or approvals for which these provisions are suspended.

6. To support voluntary approaches to improve fish habitat that would require change petitions under Water Code section 1707 and either Water Code sections 1425 through 1432 or Water Code sections 1725 through 1732, and where the primary purpose is to improve conditions for fish, the Water Board shall expeditiously consider petitions that add a fish and wildlife beneficial use or point of diversion and place of storage to improve conditions for anadromous fish. California Code of Regulations, title 23, section 1064, subdivisions (a)(1)(A)(i)-(ii) are suspended with respect to any petition that is subject to this paragraph.

7. To facilitate the hauling of water for domestic use by local communities and domestic water users threatened with the loss of water supply or degraded water quality resulting from drought, any ordinance, regulation, prohibition, policy, or requirement of any kind adopted by a public agency that prohibits the hauling of water out of the water's basin of origin or a public agency's jurisdiction is hereby suspended. The suspension authorized pursuant to this paragraph shall be limited to the hauling of water by truck or bottle to be used for human consumption, cooking, or sanitation in communities or residences threatened with the loss of affordable safe drinking water. Nothing in this paragraph limits any public health or safety requirement to ensure the safety of hauled water.

8. The Water Board shall expand inspections to determine whether illegal diversions or wasteful or unreasonable use of water are occurring and bring enforcement actions against illegal diverters and those engaging in the wasteful and unreasonable use of water. When access is not granted by a property owner, the Water Board may obtain an inspection warrant pursuant to the procedures set forth in Title 13 (commencing with section 1822.50) of Part 3 of the Code of Civil Procedure for the purposes of conducting an inspection pursuant to this directive.

9. To protect health, safety, and the environment during this drought emergency, a county, city, or other public agency shall not:

    a. Approve a permit for a new groundwater well or for alteration of an existing well in a basin subject to the Sustainable Groundwater Management Act and classified as medium- or high-priority without first obtaining written verification from a Groundwater Sustainability Agency managing the basin or area of the basin where the well is proposed to be located that groundwater extraction by the proposed well would not be inconsistent with any sustainable groundwater management program established in any applicable Groundwater Sustainability Plan adopted by that Groundwater Sustainability

Agency and would not decrease the likelihood of achieving a sustainability goal for the basin covered by such a plan; or

b. Issue a permit for a new groundwater well or for alteration of an existing well without first determining that extraction of groundwater from the proposed well is (1) not likely to interfere with the production and functioning of existing nearby wells, and (2) not likely to cause subsidence that would adversely impact or damage nearby infrastructure.

This paragraph shall not apply to permits for wells that will provide less than two acre-feet per year of groundwater for individual domestic users, or that will exclusively provide groundwater to public water supply systems as defined in section 116275 of the Health and Safety Code.

10. To address household or small community drinking water shortages dependent upon groundwater wells that have failed due to drought conditions, the Department of Water Resources shall work with other state agencies to investigate expedited regulatory pathways to modify, repair, or reconstruct failed household or small community or public supply wells, while recognizing the need to ensure the sustainability of such wells as provided for in paragraph 9.

11. State agencies shall collaborate with tribes and federal, regional, and local agencies on actions related to promoting groundwater recharge and increasing storage.

12. To help advance groundwater recharge projects, and to demonstrate the feasibility of projects that can use available high water flows to recharge local groundwater while minimizing flood risks, the Water Board and Regional Water Quality Control Boards shall prioritize water right permits, water quality certifications, waste discharge requirements, and conditional waivers of waste discharge requirements to accelerate approvals for projects that enhance the ability of a local or state agency to capture high precipitation events for local storage or recharge, consistent with water right priorities and protections for fish and wildlife. For the purposes of carrying out this paragraph, Division 13 (commencing with section 21000) of the Public Resources Code and regulations adopted pursuant to that Division, and Chapter 3 (commencing with section 85225) of Part 3 of Division 35 of the Water Code and regulations adopted pursuant thereto are hereby suspended to the extent necessary to address the impacts of the drought. This suspension applies to (a) any actions taken by state agencies, (b) any actions taken by local agencies where the state agency with primary responsibility for the implementation of the directives concurs that local action is required, and (c) permits necessary to carry out actions under (a) or (b). The entities implementing these directives shall maintain on their websites a list of all activities or approvals for which these provisions are suspended.

13. With respect to recharge projects under either Flood-Managed Aquifer Recharge or the Department of Water Resources Sustainable

Groundwater Management Grant Program occurring on open and working lands to replenish and store water in groundwater basins that will help mitigate groundwater conditions impacted by drought, for any (a) actions taken by state agencies, (b) actions taken by a local agency where the Department of Water Resources concurs that local action is required, and (c) permits necessary to carry out actions under (a) or (b), Public Resources Code, Division 13 (commencing with section 21000) and regulations adopted pursuant to that Division are hereby suspended to the extent necessary to address the impacts of the drought. The entities implementing these directives shall maintain on their websites a list of all activities or approvals for which these provisions are suspended.

14. To increase resilience of state water supplies during prolonged drought conditions, the Department of Water Resources shall prepare for the potential creation and implementation of a multi-year transfer program pilot project for the purpose of acquiring water from willing partners and storing and conveying water to areas of need.

15. By April 15, 2022, state agencies shall submit to the Department of Finance for my consideration proposals to mitigate the worsening effects of severe drought, including emergency assistance to communities and households and others facing water shortages as a result of the drought, facilitation of groundwater recharge and wastewater recycling, improvements in water use efficiency, protection of fish and wildlife, mitigation of drought-related economic or water-supply disruption, and other potential investments to support short- and long-term drought response.

IT IS FURTHER ORDERED that as soon as hereafter possible, this Order be filed in the Office of the Secretary of State and that widespread publicity and notice be given of this Order.

This Order is not intended to, and does not, create any rights or benefits, substantive or procedural, enforceable at law or in equity, against the State of California, its agencies, departments, entities, officers, employees, or any other person.

IN WITNESS WHEREOF I have hereunto set my hand and caused the Great Seal of the State of California to be affixed this 28th day of March 2022.

GAVIN NEWSOM
Governor of California

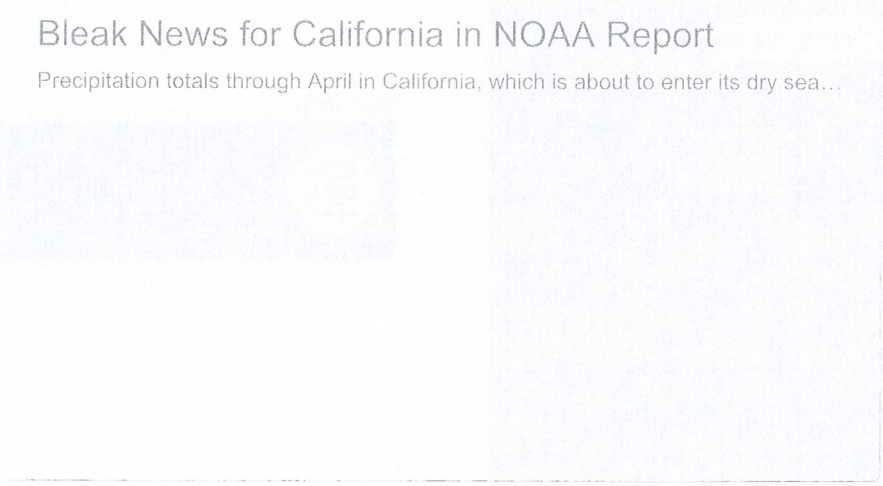
ATTEST:

SHIRLEY N. WEBER, PH.D.
Secretary of State

CLIMATE AND WEATHER

2022 Is California's Driest Year on Record So Far – an Ominous Sign for Summer and Fall

By Jonathan Erdman · May 13, 2022



At a Glance

- The first four months of 2022 were the driest on record in California.
- California is about to enter its dry season.
- Much of the Southwest and Plains have been much drier than usual, fueling drought.

California had its driest start to a year since the late 19th century, raising drought and wildfire concerns heading into the summer.

In data released Monday, NOAA's National Centers for Environmental Information found January through April precipitation in the state was the lowest on record dating to 1895.

The statewide precipitation of 3.25 inches was only 25% of average, topping the previous record-dry January through April from 2013, according to NOAA statistics.

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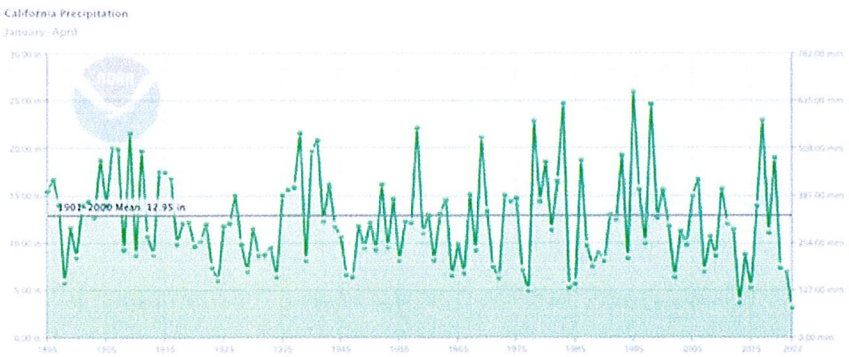


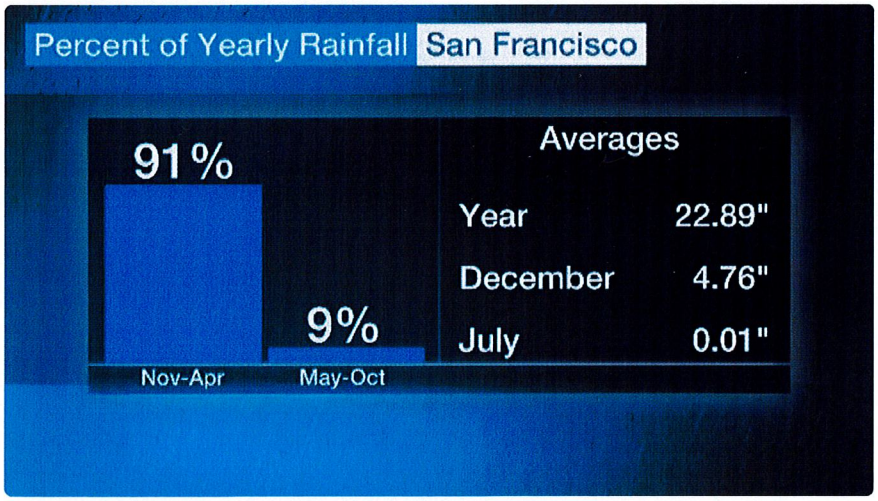
California statewide January-April precipitation by year since 1895. The record dry 2022 is shown at the rightmost edge of the graph.

(NOAA/NCEI)

This is troubling on several fronts.

First, this unusually dry stretch happened during much of the state's wet season, when the majority of precipitation usually falls.

San Francisco picks up over 90% of its annual precipitation from November through April, when the jet stream typically pushes moisture-laden Pacific storms into the West Coast.

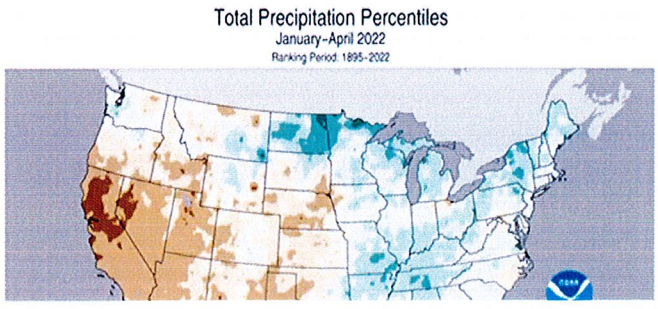


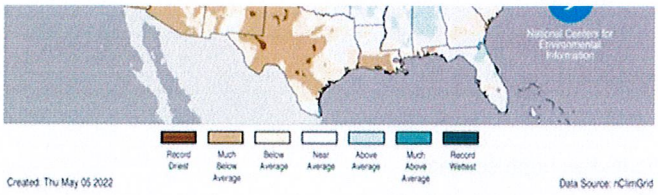
Average rainfall in downtown San Francisco in the wet season vs. the dry season.

(Data: NOAA/NWS)

Secondly, California is headed into its dry season.

From late spring through early fall, the jet stream moves well north, and aside from occasional, isolated summer thunderstorms, much of the state is dry.





January through April precipitation rankings in 2022. Areas in darkest brown were record-dry in 2022 for any January-April period dating to 1895.

(NOAA/NCEI)

During the dry season, runoff from snowmelt in the high country – particularly the Sierra – typically recharges the state's rivers, reservoirs and aqueducts, supplying almost one-third of the state's water for cities and agriculture.

But this year, the snowpack was paltry, began melting early and wasn't generating much runoff.

According to the May 6 update by the California Department of Water Resources (CDWR), the state's snowpack peaked March 8 at only 57% of average and over three weeks earlier than usual.

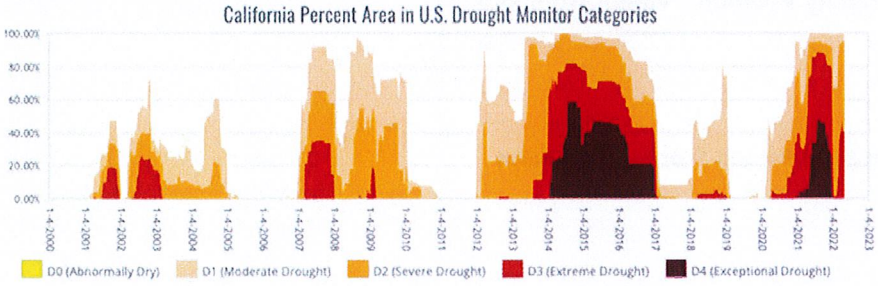
While some more recent systems dumped modest snow in the Sierra, the state's snowpack was only 21% of average as of May 9.

And the modest snowmelt that's happening is seeping into dry ground rather than running off into reservoirs, according to Desert Research Institute climatologist Dan McEvoy.

According to the CDWR update, the state's reservoirs were at 71% of average storage for early May, in better overall shape than this time in 2015, during California's exceptional mid-2010s drought.

But California's two largest reservoirs are at "critically low levels," according to the May 5 Drought Monitor summary. Shasta Lake is at its lowest early May level since the drought of 1976-77, while Lake Oroville is only 70% of its early May average.

California is in its third year of the latest drought, which accelerated in early 2020.



Timeline of drought in California this century, as analyzed by the Drought Monitor. The current three-year drought is shown near the rightmost edge.

(NDMC/USDA/NOAA)

Given the upcoming dry season, the state will have to wait until late fall or winter for significant drought relief to arrive.

In late April, the Metro Water District of Southern California issued an unprecedented water shortage emergency, with outdoor watering restricted to one day a week in parts of the Los Angeles Basin beginning June 1.

California is one of many western states facing a difficult summer of wildfires given the widespread multi-year drought.

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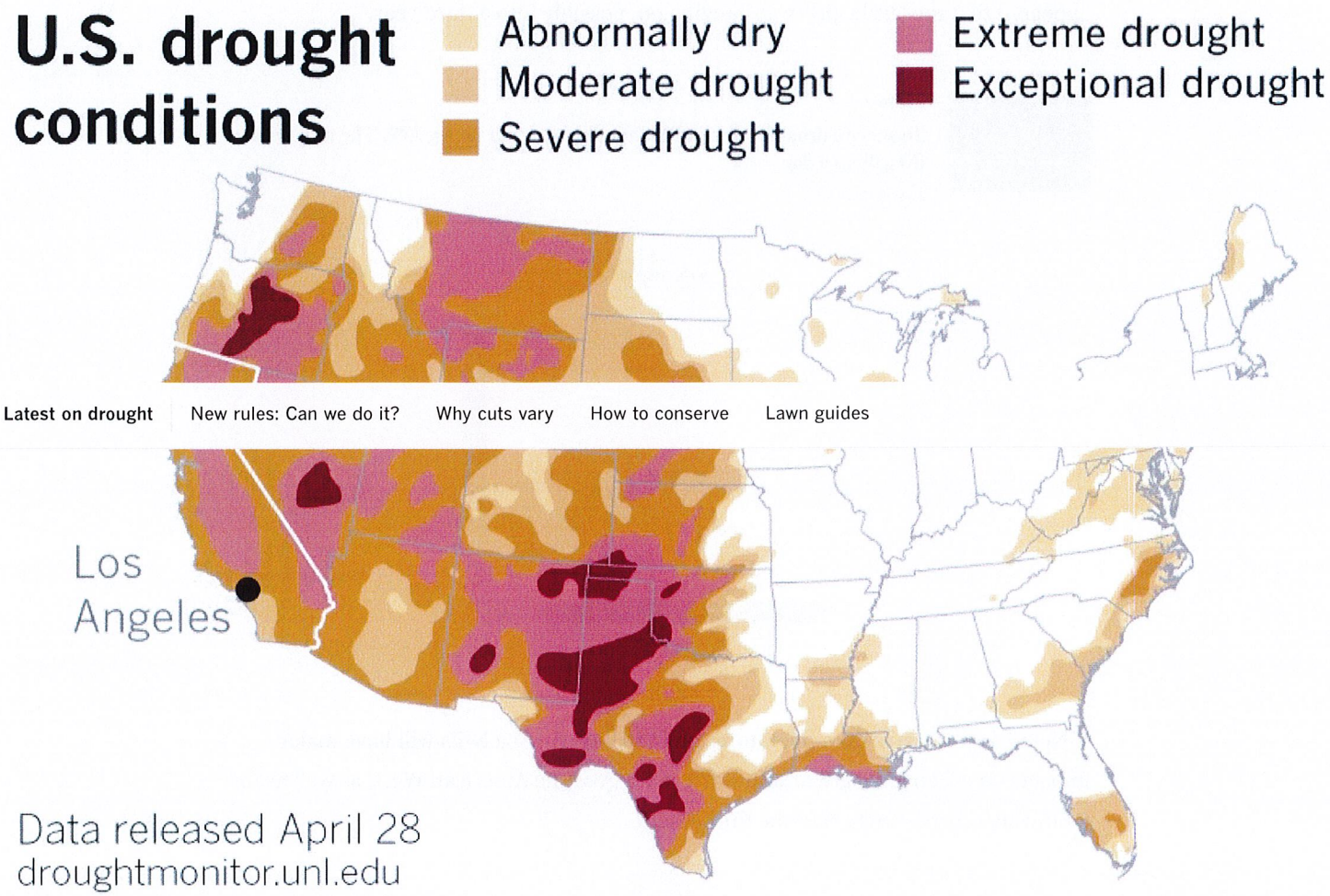
CLIMATE & ENVIRONMENT

With water running out, California faces grim summer of dangerous heat, extreme drought



California faces severe and extreme drought after two consecutive La Niña years, and the hot, dry summer season hasn't even started. (Paul Duginski / Los Angeles Times)

BY PAUL DUGINSKI, ALEX WIGGLESWORTH

MAY 4, 2022 **UPDATED** 7:22 AM PT

Heat waves. Severe drought. Extreme wildfires.

As Southern California braces for unprecedented drought restrictions, long-range forecasts are predicting a summer that will be fraught with record-breaking temperatures, sere landscapes and above-average potential for significant wildfires, particularly in the northern part of the state.

"The dice are loaded for a lot of big fires across the West," said Park Williams, a climate scientist at UCLA. "And the reason for that is simple: The vast majority of the western U.S. is in pretty serious drought."

Recently, the National Oceanic and Atmospheric Administration said the temperature outlook for the transition from spring into summer this year calls for above-normal readings for most of the West.

At the same time, the agency also reported that while long-range forecasts had suggested the climate phenomenon known as La Niña was dissipating — raising a glimmer of hope that California might experience a normal winter in 2022 — it now appeared that the "little girl" was hanging on, possibly into a third year.

CALIFORNIA

To survive drought, parts of SoCal must cut water use by 35%. The new limit: 80 gallons a day

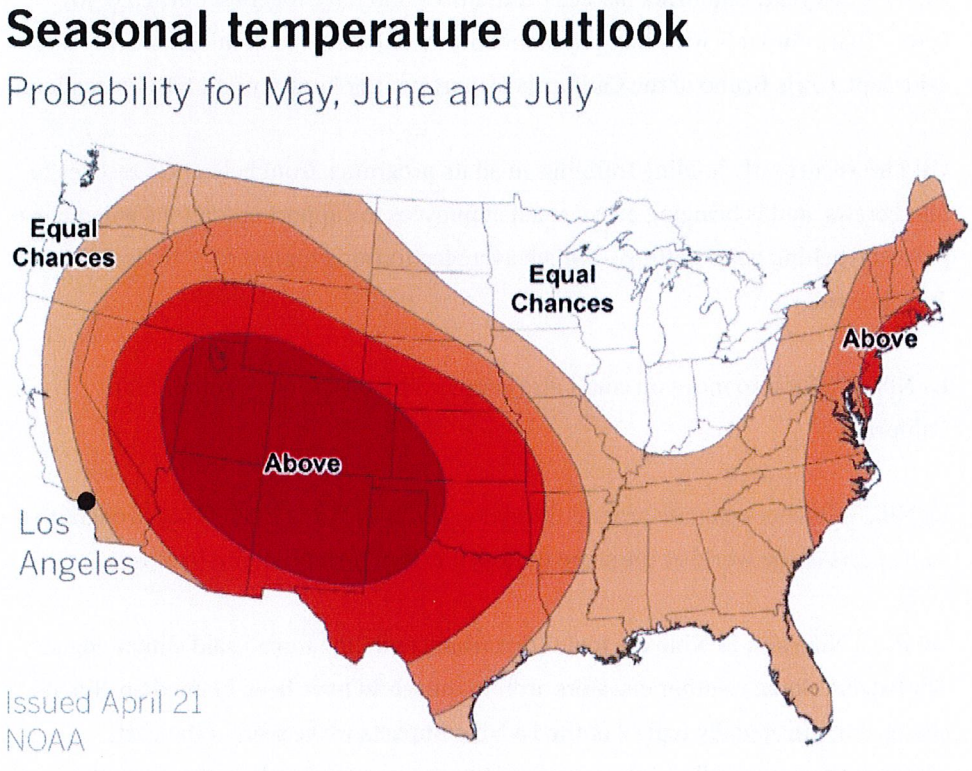
April 30, 2022

If NOAA is correct, high temperatures and the lingering La Niña will have major impacts on urban and agricultural water use across the American West, as well as for California's increasingly extreme fire season.

Already, the federal government has announced that it will delay water releases from Lake Powell, the nation's second-largest reservoir, as a result of worsening drought conditions along the Colorado River. In an effort to boost the shrinking reservoir, the U.S. Bureau of Reclamation said Tuesday that it plans to hold back water to reduce risks of the lake falling below a point at which Glen Canyon Dam would no longer generate electricity.

Unlike its wetter and better known sibling, El Niño, La Niña typically brings dry winters to Southern California and the Southwest.

Now, with California's rainy season largely in the rearview mirror and a hot dry summer rapidly approaching, forecasters say La Niña has a 59% chance of continuing through the summer, and up to a 55% chance of persisting through the fall.



The seasonal outlook from NOAA calls for a hot summer in the West. (Paul Duginski / Los Angeles Times)

Experts say this summer could be a repeat of last year, when fires burned more than 2.5 million acres across California — more than any other year except 2020.

"Last year, one thing that made the fire season especially active were the extreme heat waves that occurred across the West during summertime," Williams said. "So we're in a similar situation this year, where we're going into summer with extremely dry conditions, but we don't yet know whether there are going to be more record heat waves this year. That's why there's still a lot of uncertainty in how the fire season is actually going to play out."

Warming of the planet due to human activity has increased the likelihood of severe heat waves, and hotter temperatures also worsen drought by causing snowpack to melt earlier in the year, and causing more precipitation to fall as rain, instead of snow.

"The chances of having record-breaking heat waves this year are higher than normal," Williams said. "But there's still room for hope that we get lucky."

CLIMATE & ENVIRONMENT

Southern California 'cannot afford green lawns' as drought forces unprecedented water cuts

April 28, 2022

Already this year, California has seen 1,402 fires that have together burned 6,507 acres. That compares with 1,639 fires that burned 4,779 acres at this time last year, said Capt. Chris Bruno of the California Department of Forestry and Fire Protection.

Cal Fire is currently holding trainings in all its programs, from helicopter rescues to hand crews, and is bringing on seasonal employees to support operations with an eye toward reaching peak staffing — which averages 10,000 employees — by June or July, he said.

La Niña's refusal to move on could also cause problems for places other than California.

La Niña influences climate around the globe, and is cyclical. It can bring drought to some parts of the world at the same time as it brings torrential rain to others.

"Both La Niña and El Niño are major disturbances in 'the force'" said climatologist Bill Patzert. Some weather disasters around the world have been blamed on climate change but are actually typical of the La Niña impacts we've seen in the past, although they may well be intensified or changed by warming brought on by the burning of fossil fuels, he said.

"La Niña and El Niño have always had large global footprints," Patzert said.

CALIFORNIA

While California had its driest January, February and March on record, Alaska and the Pacific Northwest were wet. Across the Pacific Ocean, Australians were fleeing record flooding. Prolonged drought gripped equatorial eastern Africa, raising the specter of famine for millions of people in the Horn of Africa. At the same time, parts of South Africa, such as Durban, received record rainfall. Torrential downpours triggered flooding and landslides in Rio de Janeiro.

There are other influences as well. La Niñas usually weaken wind shear in the Caribbean and tropical Atlantic, contributing to increased hurricane activity in the Atlantic Basin. Both 2020 and 2021 were active hurricane seasons, with 2020 going into the record books as the year with the most named storms of any season on record.

This year, forecasters at Colorado State University have predicted 19 named storms, including nine hurricanes. This would be the
seventh consecutive above-average Atlantic hurricane season, according to Patzert.

In the northern United States, La Niñas are typically associated with colder, stormier-than-average conditions and increased precipitation. In the southern U.S., they're known for warmer, drier and less stormy conditions.

Thankfully, La Niña doesn't last forever.

Both La Niña and El Niño are part of what is called the El Niño Southern Oscillation, or ENSO. Between them is a neutral phase, which is what forecasters had thought we were headed toward this spring.

In the meantime, forecasters say, the dryness in the western U.S. has a silver lining, at least for Southern and Central California. While the National Interagency Fire Center is predicting that much of the northern portion of the state will see an above-normal potential for significant fires through August, meteorologists are calling for near- to below-normal fire activity in the southern reaches.

That's because there hasn't been enough rain to grow the grasses that often serve as fuel for Southern and Central California's lower-elevation fires, said U.S. Forest Service meteorologist Matt Shameson.

"I'd say the fine fuels are about ankle to calf high," he said. "Normally, they're about knee to waist high."

The region has seen no significant grass fires so far this year, which normally start across the lower elevations in the middle of April, he added.

Northern California has received more rain, particularly at the end of March through April, so there is a more robust grass crop, which helps spread fire by carrying it up into larger fuels like trees, he said. In addition, Northern California has more vegetation in general, so fires there are typically not limited by the amount of fuel available.

"I think that this year is going to pretty much mimic last year — very similar conditions are expected," Shameson said. Southern California had fewer significant fires than average and saw less acreage burned, while Northern California shattered records, with the Dixie fire scorching nearly 1 million acres and burning across the Sierra Nevada for the first time in recorded history.

"I can tell you: They're expecting another big fire season up north," he said.

The effects of these repeated large, severe fires have the potential to be ecologically devastating and pose a real risk of compromising the state's climate goals, experts say. The Sierra Nevada and Southern Cascade ranges, which currently store close to half of California's captured carbon, lost 1.1 million tons of stored carbon to wildfire, drought and invasive pests from 2018 to 2019 alone, according to recently published research by scientists at UC Berkeley.

"That's a 35% reduction in just a year," said author Alexis Bernal, a research specialist at UC Berkeley's Stephens Lab. "And we know that these disturbances are only going to increase in frequency and intensity with climate change."

She and other scientists are calling for land managers to increase forest resiliency by thinning vegetation and increasing the use of prescribed fires to reduce the density of forests so that blazes burn less severely through them.

Absent intervention, she said, it's projected that the Sierra Nevada and Southern Cascade region will lose over 75% of its above-ground carbon stocks by 2069, sending about 860 million metric tons of carbon dioxide into the air.

"That means the Sierra Nevada and Southern Cascade region will no longer be a carbon sink, as it is now," she said. "It will be a carbon source."

Large, high-severity burn patches can also result in ecosystem collapse by converting forests into grass and shrublands, she added.

"These landscapes may no longer function as forests anymore," she said. "They may function as something else, which would be pretty devastating for all living things, including ourselves, that rely on these forests to survive."

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What If California's Drought Continues?

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Summary

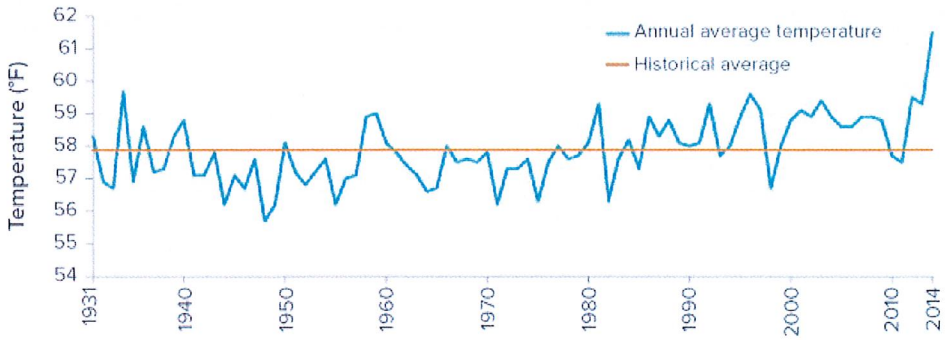
California is in the fourth year of a severe, hot drought—the kind that is increasingly likely as the climate warms. Although no sector has been untouched, impacts so far have varied greatly, reflecting different levels of drought preparedness. Urban areas are in the best shape, thanks to sustained investments in diversified water portfolios and conservation. Farmers are more vulnerable, but they are also adapting. The greatest vulnerabilities are in some low-income rural communities where wells are running dry and in California's wetlands, rivers, and forests, where the state's iconic biodiversity is under extreme threat. Two to three more years of drought will increase challenges in all areas and require continued—and likely increasingly difficult—adaptations. Emergency programs will need to be significantly expanded to get drinking water to rural residents and to prevent major losses of waterbirds and extinctions of numerous native fish species, including most salmon runs. California also needs to start a longer-term effort to build drought resilience in the most vulnerable areas.

Introduction

In 2015, California entered the fourth year of a severe drought. Although droughts are a regular feature of the state's climate, the current drought is unique in modern history. Taken together, the past four years have been the driest since record keeping began in the late 1800s.[1] This drought has also been exceptionally warm (Figure 1). Heat amplifies the effects of drought. It reduces snowpack, a major component of natural seasonal water storage. It decreases soil moisture, stressing natural vegetation and increasing irrigation demands. And it raises water temperatures, stressing fish and other species that live in rivers and lakes.

The combination of low flows and high temperatures make this a "drought of the future"—the type of drought California is increasingly likely to experience as the region's climate warms.[2]

Figure 1. California is experiencing record heat



SOURCE: National Oceanic and Atmospheric Administration.

NOTES: The figure shows annual average temperatures and the historical average for the period 1931 to 2014. For a breakdown by summer and winter months, see technical appendix, Figure A2.

Californians have been working hard to limit the drought's impacts on the state's economy, society, and environment. Since Governor Brown's January 2014 declaration of a statewide drought emergency, an Interagency Drought Task Force has met weekly to coordinate drought management.[3] The state and federal governments have funded emergency drought relief and water system investments intended to boost drought resiliency (Table 1). Local water agencies are collaborating to lessen regional water shortages. And farmers, nonfarm businesses, and residents across the state are stretching available supplies.

Table 1. Drought funding from state and federal sources (millions of dollars)

	State	Federal
Emergency community assistance	$200	$358
Impacted communities, workers (food, housing, training)	$102	$78
Safe drinking water systems	$90	$17
Technical guidance and planning	$8	$14
Feed subsidies for livestock producers*	$0	$250
Emergency ecosystem support	$66	$67
Emergency fire protection	$131	$4
Water system investments**	$2,609	$104
Total	**$3,006**	**$534**

SOURCES: Legislative Analyst's Office and White House fact sheets.

NOTES: The table includes funding from fiscal years 2013–14, 2014–15, and 2015–16. For details, see technical appendix tables A2 and A3.

*In 2015, more than $1 billion was announced to support livestock producers in all western states. We assume California's share will be equal to its 2014 allocation ($125 million).

**Most state water system investment support comes from voter-approved state bond funds. Many of these investments will take some time to implement.

These efforts have helped limit the economic impacts of the drought so far. But the experience is also revealing major gaps in California's preparedness to cope with the social and environmental impacts of extended, warm droughts. Too many decisions are being made on an emergency basis with the hope that the next winter will bring much-needed rain.

It would not be prudent to count on El Niño to end the drought.[4] To stand ready, the state needs to understand what impacts this drought has already had, what impacts to expect if it continues, and what steps may be warranted to prepare for this possibility.

This report provides insights into these questions. We focus on three areas of California's economy and society—cities, farms, and rural communities—and three acute ecosystem management challenges: waterbirds, fish, and forests. The analysis is informed by wide-ranging data sources and by conversations with officials, businesses, and stakeholders on the frontlines of drought management.[5] Table 2 summarizes the likely impacts and management challenges of continued drought, as described here. A technical appendix provides further details.

Table 2. Likely impacts and management challenges if the drought continues

Water availability	
Runoff and storage	Reduced runoff (between 25–40% of average) due to low rainfall and snowpack. Fall reservoir storage at 50% of historic average. Impacts vary regionally depending on precipitation patterns.
Deliveries and curtailments	Supply reduced for farms (8.5–9.0 million acre-feet/year) and cities (2.0–2.5 million acre-feet/year) compared to normal years. Central Valley Project and State Water Project allocations remain at 2015 levels. Surface water shortages require extensive curtailment of water rights, including many senior pre-1914 and riparian rights. Hydropower generation remains at half of recent average, increasing energy costs ($500 million/year or ~2%).
Groundwater	Central Valley continues heavy reliance on groundwater. Excess pumping of 6 million acre-feet/year (with $650+ million additional energy cost for pumping). Increase in dry wells; acceleration of widespread land subsidence and damage to infrastructure.
Water quality	Low flows and high air temperatures cause widespread decline in water quality in rivers and streams. Low reservoirs make managing Delta salinity increasingly difficult.
Cities and suburbs	
Large metropolitan areas have reasonably secure supplies, but require continued conservation efforts and some new supply investments. Isolated communities with a single water source face shortages and require alternative supplies. Some water- and snow-sensitive industries that rely heavily on water (e.g., boating, skiing) face financial hardships, but not enough to dampen statewide economic growth.	
Farms	
Net water shortfall of 2.5–3.0 million acre-feet/year results in roughly 550,000 acres fallowed annually; economy-wide economic losses of more than $2.8 billion, loss of more than 10,000 full-time, part-time, and seasonal farm jobs, and more than 21,000 jobs economy-wide.	
Rural communities	
Increasing number of rural water districts and homes that rely on shallow wells need emergency assistance as wells go dry. Fallowing of farmland exacerbates poor air quality in some parts of the Central Valley and increases economic hardship in farmworker communities.	
Ecosystems	
Native fishes	Record-low flows and high temperatures continue to degrade habitat for native fishes. As many as 18 native fishes face likelihood of near-term extinction, including delta smelt, most salmon runs, and several species of trout. Economic losses for commercial and recreational fisheries.
Waterbirds	Dramatic declines in fall and winter habitat for waterbirds of the Pacific Flyway from reduced water for wetlands and flooded farmland. Bird populations reduced by limited food supplies and disease from overcrowding.
Forests	Extreme wildfire hazard due to high temperatures, dry conditions, and increased tree mortality in California's forests. Severe wildfires (comparable to the 2013 Rim Fire) occur, impacting local communities, watersheds, wildlife, infrastructure, and air quality. Risks of permanent loss of conifer forest ecosystems in burned areas.

SOURCE: See technical appendix Table A10 for details.

NOTES: Assumes two to three more years of 2014 conditions. Reductions in water availability are relative to a normal rainfall year.

Public discussions often frame drought policy in terms of trade-offs among different areas—for instance, cities versus farms, or farms versus fish. And to be sure, the drought is forcing difficult trade-offs. Drought preparedness cannot eliminate all costs and consequences of water scarcity, but it can help lessen vulnerabilities and enable society to handle trade-offs in a transparent and balanced way. Leadership from government, business, and civil society is needed to set priorities and navigate the trade-offs.

Water Availability in a Hot, Dry Time

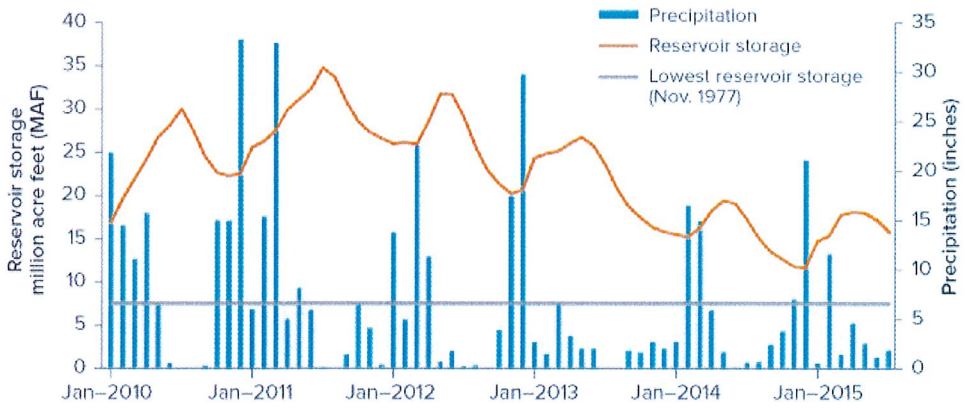
During droughts, California relies on water stored in surface reservoirs and especially groundwater basins to help offset shortfalls in precipitation. This drought is stressing both types of reserves and affecting the amount and quality of water for farms, cities, hydropower, and the environment.

IMPACTS AND ADAPTATIONS SO FAR

Surface Water

Thanks to an unusually wet 2011, the drought began with most surface reservoirs quite full. But these reserves are now significantly depleted (Figure 2). Since 2014, two of the state's largest water providers—the Central Valley Project (CVP) and the State Water Project (SWP)—have dramatically reduced water deliveries to agricultural and urban customers.[6] Deliveries from many local projects have also decreased.[7] Hydropower generation, which relies on releases from reservoirs, is at its lowest level since 1977 (technical appendix Figure A6).

Figure 2. Water stored in surface reservoirs is low



SOURCE: California Department of Water Resources.

NOTE: Precipitation is measured as the sum of the Northern Sierra 8-station and San Joaquin 5-station precipitation indices to account for most rainfall available for reservoir storage. Reservoir storage is the sum of monthly storage in 154 major reservoirs within the state (excluding storage in the Colorado River Basin).

Reduced flows and high temperatures have also affected both the quantity and quality of environmental flows. Water releases from large Sacramento Valley reservoirs help keep salty ocean water from intruding into the Sacramento–San Joaquin Delta, thereby maintaining water quality for agricultural and urban exports and supporting habitat for estuarine fishes such as delta and longfin smelt. These reservoirs are also the primary source of cold water needed by salmon and steelhead that spawn just downstream of the dams. Other water releases—including treated discharges from wastewater facilities—are also important for maintaining environmental flows. Since early 2014, water agencies across the state were granted emergency permits to change the volume, timing, or quality of required outflows 35 times (technical appendix Table A1). As described below, insufficient environmental flow releases at above-normal temperatures have put some fish species on the brink of extinction.

The drought has also exposed weaknesses in the state's technical capacity to forecast the effects of management decisions under extreme conditions of high temperatures and low flows. This has complicated the management of cold water in reservoirs, among other things.

And the drought is revealing strains in the state's surface water allocation system. In California's "first-in-time, first-in-right" system of surface water rights, those with more recent—or junior—rights generally have lower priority in times of shortage. In 2014, the State Water Resources Control Board, which administers water rights and quality standards, ordered curtailment of water diversions by many junior water-rights holders for the first time since 1977; these orders were extended to more senior rights holders in 2015, and the board has also begun issuing fines for non-compliance. Some senior rights holders are challenging the board's legal authority to curtail their diversions.[8] The process has revealed significant gaps in information needed to administer surface water rights in a timely and transparent manner.[9]

Groundwater

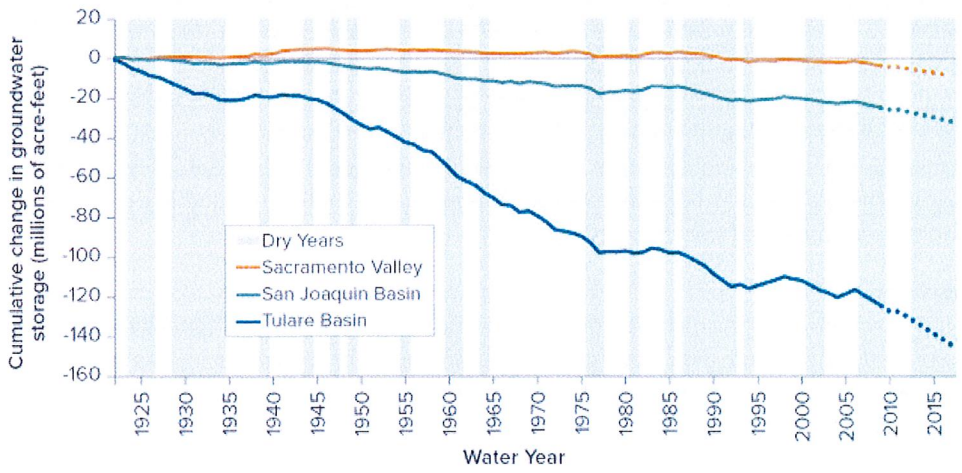
California's groundwater basins have considerably more dry-year storage capacity than its surface reservoirs, and many farms and cities are pumping additional groundwater to meet demands.[10] In a typical year, groundwater supplies about a third of total farm and urban water use. Since 2014, this share has exceeded 50 percent.[11]

Until recently, groundwater has been only loosely regulated by the state. Many urban areas now have well-developed groundwater programs that regulate and charge for pumping to keep groundwater basins from experiencing long-term declines. In contrast, groundwater oversight in most agricultural areas is still limited, and many basins have experienced overdraft—excess pumping that reduces long-term reserves and lowers the water table. Consequences include sinking lands, higher pumping costs, drying up of wells, and drying of some rivers and wetlands fed by groundwater.

Extra pumping during this drought has exacerbated these symptoms of chronic overdraft. Land levels in parts of the southern Central Valley have been falling by more than half a foot annually, causing damage to various types of infrastructure, including bridges, reservoirs, and major water arteries like the Delta Mendota Canal.[12] Falling water tables are raising pumping costs and drying up drinking water wells in some rural communities. In many places, the additional groundwater now being pumped is of poor quality, which lowers crop yields. Conditions are particularly acute in the Tulare Basin—the major agricultural region that includes Fresno, King, Tulare, and Kern Counties—where groundwater supplies have been declining for decades (Figure 3).

Widespread concern over the trajectory of many rural groundwater basins led to the enactment of the Sustainable Groundwater Management Act (SGMA) in September 2014. The act requires water users in the most stressed basins to develop sustainable groundwater management plans by 2020 and reach sustainability by 2040.[13]

Figure 3. Groundwater depletion is a growing challenge in the southern Central Valley



SOURCE: Historical data through 2009 from the California Department of Water Resources; author estimates after 2009.

NOTE: For changes after 2009, we assumed continued depletion of groundwater storage at the same rate as 2008–09, the third year of the last drought. The exception was 2011, a very wet year, for which we assumed that levels remained stable. Since surface water availability has been tighter during this drought, this method may underestimate recent depletions.

WHAT IF THE DROUGHT CONTINUES?

To consider the impacts of continued drought, we assume that the dry, hot conditions of the past two years will persist for at least another two to three years. One caveat is that worse conditions—and worse impacts—are possible. For instance, 1977 was drier than the driest years of the current drought (technical appendix Figure A1). Another caveat is that droughts often have considerable geographic variability. For example, 2015 saw record-low snowpack in the Sierra Nevada and near-record-low runoff in the Central Valley. Yet conditions in some North Coast communities improved dramatically thanks to isolated, intense winter and spring rains.

Continued drought will put additional stress on both surface and groundwater resources (technical appendix Table A10). Because the state's major Central Valley reservoirs have already drawn down most of the reserve built up by the 2011 rains, surface water deliveries from the CVP, SWP, and local projects will have to primarily rely on annual precipitation, as they did this past year. This means water deliveries will stay at least as low as currently—and possibly even fall lower—depending on decisions made regarding reservoir management for fish and wetlands and salinity in the Delta. Low flows and high temperatures will exacerbate declines in water quality in rivers and streams.

Groundwater will remain the primary drought reserve. But in some parts of the agricultural heartland, this will come at increasing costs, including more energy for pumping, more dry wells, reduced crop yields as water quality falls, and more damage to infrastructure from sinking lands.

Four Key Areas of Concern

The drought has left no part of California untouched, and continued drought will pose added—and in some cases acute—challenges. The severity of threats varies across management areas, reflecting both underlying vulnerabilities to water scarcity and the degree to which managers have prepared for and adapted to drought. Cities and their suburbs, where most Californians live and work, have been adapting fairly well. Farms—the economy's largest water user—have also been adapting, but they are inherently more vulnerable. Rural communities are home to the most vulnerable Californians, facing both job losses and drinking water shortages. California's ecosystems are in crisis. Fish and waterbirds that rely on freshwater in rivers, estuaries, and

wetlands are under extreme stress, and extinctions are likely. And trees in California's forests are dying at record rates, raising risks of devastating wildfires.

CITIES AND SUBURBS

If this drought has one bright spot, it is that California's cities and suburbs—home to 95 percent of California's population and an even higher share of economic activity—have become considerably more resilient since the 1987–92 drought, despite the addition of more than eight million residents since that time.[14]

Impacts and Adaptations So Far

Whatever impacts the drought may be having on the California economy, they have not been significant enough to derail a strong economic expansion fueled by other economic advantages in the state. Since 2011, California's real GDP and nonfarm employment have been growing at a faster pace than the national economy as a whole.

In part, the economy's drought resilience reflects the small share of farming in the state's economy (1–2%), and the fact that California now has relatively few nonfarm industries that are particularly water sensitive. But it also reflects the preparation urban water utilities have made to withstand droughts.

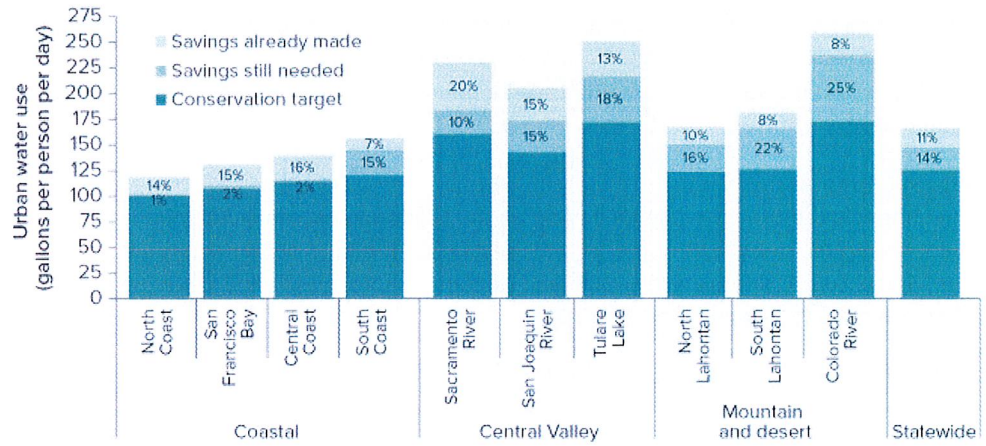
If this drought has one bright spot, it is that California's cities and suburbs have become considerably more resilient.

Since the early 1990s, water utilities have invested heavily in indoor conservation, surface and underground storage, new interconnections that enable supply sharing with neighboring agencies, use of recycled wastewater and stormwater, and water purchases through the state's water market.[15] This more-diversified portfolio enabled cities to enter this drought in good shape.

Improved regional cooperation is also helping cities cope. Water utilities are regularly sharing information and infrastructure and—where needed—supplies. As an example, Sacramento area agencies are collaborating to improve access to shared groundwater reserves as a back-up source for communities reliant on Folsom Reservoir, where water levels are low and falling.

Increased conservation is also a staple of the urban drought management toolkit. In May 2015, the State Water Board introduced a statewide urban conservation mandate, requiring 25 percent average savings compared to 2013. The mandate went further than many utilities would have gone on their own this year, given their local supply conditions. Statewide, utilities were nearly half way there (11%) by the time the mandate went into effect (Figure 4). In high-water-use regions the board set higher standards for water conservation. Attaining the target will require large reductions in outdoor water use, which often exceeds half of the urban total.[16] Although this will entail some initial costs and inconvenience, it need not diminish quality of life in California communities. The popularity of turf buyback programs—which give rebates to replace thirsty lawns with plants that use less water—suggests that Californians may be ready to permanently reduce urban outdoor water demand.[17]

Figure 4. Some communities are still well above state water conservation targets



SOURCE: Author estimates, using monthly urban water supply data from the State Water Resources Control Board. (See technical appendix Table A4 for details.)

NOTE: The figure shows per capita urban water use, including residential and commercial, institutional, and industrial customers. The "conservation target" is the targeted water use under the new state mandate, which went into effect in June 2015. "Savings already made" is the difference between water use in 2013 and the 12 months ending in May 2015. The North Lahontan region covers most of the northeastern Sierra; South Lahontan covers the eastern Sierra and high desert including Mono, Inyo, and parts of Kern, Los Angeles, and San Bernardino Counties; and the Colorado River region covers the southeastern portion of the state including Imperial and parts of Riverside, San Bernardino, and San Diego Counties.

If the Drought Continues

Can California's cities remain resilient? This question really has two parts: First, are water solutions available to avoid extreme scarcity? And second, will water management remain flexible enough to avoid large economic and social consequences?

Based on our conversations with water managers in major regions of the state,[18] the answer to the first question generally seems to be "yes." Many water utilities still have significant supplies in storage,[19] and their conservation programs are reducing near-term demands. Efforts are now underway to accelerate new investments in recycled wastewater, stormwater capture, groundwater clean-up, improved conveyance, and other measures.

Drought fixes to existing infrastructure are also in the mix. Examples include installing a lower water intake on Folsom Reservoir and pumping water upstream on the California Aqueduct and the Delta Mendota Canal to deliver water to locations north of Kern County groundwater banks and San Luis Reservoir.[20]

Lost hydropower production will have economic costs—on the order of $500 million in 2015—but recent increases in renewable energy sources have helped make up for shortfalls. And new efforts are reducing other water-related vulnerabilities of California's power grid—for instance, by making sure thermal power plants have adequate and diverse supplies for cooling, including recycled wastewater.[21]

For water utility managers, key issues appear to be cost (in particular, avoiding the most expensive solutions until necessary) and the pace of regulatory approvals for new projects. Recent legislation providing exemptions to the California Environmental Quality Act (CEQA) for recycled water project standards will help in this regard.[22] The state's emergency drought funding program (Table 1) has also aimed to speed up the disbursement of state bond funds to support new water projects.

Implementation of the conservation mandate sheds light on the second question: Will drought water management be flexible enough to avoid large costs? The mandate was adopted as an emergency measure, and its water savings will make it easier for many communities to weather a longer

drought. But it also raises some economic and social challenges. Because utilities lose money when water sales fall quickly, the mandate creates a fiscal crunch: net revenues are expected to fall by $500 to $600 million in 2015.[23] This will tap financial reserves when new investments to boost supplies may be needed. Sooner or later, utilities will need to adjust rates to make up the shortfall. Since a recent court ruling regarding Proposition 218 (a constitutional amendment that affects water pricing), utilities face new legal constraints in setting higher rates for higher levels of use.[24] And if they recoup their losses by raising fixed service fees rather than per-gallon charges, there are equity concerns because fixed fees hit lower-income households hardest.[25]

There can also be broader economic consequences if utilities indiscriminately apply conservation mandates to businesses. California is fortunate not to have many nonfarm businesses that require large volumes of water, and many businesses still have considerable room to conserve. But businesses that use water in their production processes—such as food and beverage processing—often have less flexibility than households to reduce water use without affecting competitiveness.[26] The new state mandate does not account for the fact that some communities have a much higher share of commercial and industrial water use than others.[27] Although larger utilities generally appear to be avoiding cutbacks that would cost jobs, utilities in some middle-sized, high-water-use communities have imposed across-the-board cuts on residents and businesses alike.

If the drought continues, both the state and water utilities should maintain some flexibility in applying conservation targets. Additional regulatory streamlining for urban supply projects may be warranted, as well as reform of the legal framework for rate setting. Urban areas—like farmers—would also benefit from improvements in the state's water market, which is not sufficiently transparent or flexible as a drought-management tool.[28] Over the longer term, the state should be encouraging utilities to continue to bolster supply investments as well as conservation efforts. Rigid conservation mandates can discourage such investments, because they can prevent communities from taking full advantage of the increased supplies.

FARMS

California's productive farm sector requires large volumes of water for irrigation, typically four times the annual use of cities.[29] This strong water dependency—along with the sector's sheer size—makes farming inherently vulnerable to droughts. Adaptation options are also more limited than for cities, which can generally afford higher-cost water supplies.

Impacts and Adaptations So Far

Like cities, California farmers have been adapting to water scarcity over the past few decades. They have made major investments in irrigation efficiency and shifted toward crops that generate higher revenues per unit of water used.[30] Some places (notably Kern County) have also invested in storing water in groundwater basins for use by local farmers and partner agencies in urban areas.[31]

California's productive farm sector requires large volumes of water for irrigation, typically four times the annual use of cities.

Yet with the exception of new groundwater storage, these adaptations have generally not boosted drought resilience. In most places, irrigation efficiency has improved crop yields and quality, but not overall water availability.[32] That is because irrigation water in less efficient systems generally is not wasted; water not consumed by crops either returns to streams, where it is reused by others, or else percolates through soils to recharge aquifers.[33] Meanwhile, the long-term shift to high-revenue perennial nuts, fruits, and vines has made agricultural water demands more rigid, because these orchards must be watered every year to maintain farmers' investments.

As a result, farmers have been hit hard by reduced surface water deliveries.[34] In 2014, Central Valley farms lost roughly a third of normal surface water supplies, or 6.5 million acre-feet (maf). In 2015, the deficit may rise to 8.7 maf. Economic losses from this cutback have been relatively modest so far because farmers in many places—including the southern Central Valley—have been able to pump additional groundwater: an extra 5 maf statewide in 2014 and as much as 6 maf in 2015.

Water trading has also helped keep the most profitable crops in production.[35] Strong commodity prices have also bolstered the farm economy during the drought, even encouraging new plantings of permanent crops such as almonds.

Statewide, farmers fallowed approximately 5 percent of cropland in 2014—mostly more flexible and lower-revenue field crops like rice—and that share is likely to increase slightly this year. The costs of fallowing and extra groundwater pumping—including the spillover effects on the rest of the economy—were on the order of $2.2 billion in 2014 and $2.7 billion in 2015. Direct costs for farmers were 3–4 percent of the roughly $47 billion in annual farm revenues.

Fallowing land also has both on- and off-farm effects on employment. Total farm employment has actually been increasing slightly despite the drought because the higher-revenue crops farmers are focusing on generally employ more people than the lower-revenue field crops that farmers are scaling back.[36] But with normal water supplies, California would have had an additional 7,500 full-, part-time, or seasonal farm jobs in 2014 and an additional 10,100 farm jobs this year. Taking into account spillover effects on the rest of the economy, there would have been an additional 17,000 jobs economy-wide in 2014 and 21,000 this year.

If the Drought Continues

A sharp fall in revenues or jobs statewide is unlikely. Instead, California should expect progressive increases in economic losses, particularly in the Central Valley, as yields on perennial crops decline from reduced watering and use of lower quality groundwater (Table 2 and technical appendix Table A5). Although groundwater pumping is becoming more costly, there are still abundant reserves in many places, and high commodity prices make this extra pumping affordable.

Over the longer term, implementation of the 2014 Sustainable Groundwater Management Act (SGMA) will make California farming more resilient to future droughts.

Over the longer term, implementation of the 2014 Sustainable Groundwater Management Act (SGMA) will make California farming more resilient to future droughts. The concept, already used by many urban agencies, is to pump less—and recharge basins more—in wet and normal years. This makes groundwater more readily available (at lower cost) during droughts. And it lessens the threat of external costs in terms of local infrastructure damage from sinking lands and drying of shallower wells. Management actions under SGMA do not have to start until 2020, but banks are already changing their long-term farm lending practices with SGMA in mind—a sign that the market may help quicken the pace of implementation.[37]

In the near term, extra groundwater pumping is an important drought mitigation tool to reduce agricultural losses. But there is no system in place to mitigate the external costs of pumping. If the economic benefits from pumping outweigh these costs—as they well may—it could make sense to charge a mitigation fee to cover them rather than limit pumping during droughts.[38] If this proves too difficult, counties may wish to enact emergency ordinances that restrict new or deeper wells in areas of special concern.[39]

As with cities, farming would also benefit from improvements in the water market. Although trading has already helped somewhat, a more transparent, streamlined approval process could help move scarce water to the most economically productive farming areas, boosting both revenues and jobs.

RURAL COMMUNITIES

The drought is increasing hardship for California's small rural communities, which are already some of the state's most disadvantaged.

Impacts and Adaptations So Far

Farmland fallowing has cut jobs in some rural communities, and others have been hurt by declines in water-based recreational activities such as fishing and boating.[40] Drinking water supplies—already a problem in some areas because of contaminants such as nitrate—have been further

compromised by the drought.[41] Many rural households rely on shallow domestic wells or small, poorly funded community water supply systems. As of early July 2015, more than 2,000 dry domestic wells were reported, mostly in the Central Valley and Sierra, with more than half in Tulare County (technical appendix Table A7). Emergency water supply needs have also been identified for more than 100 small water community water systems around the state (technical appendix Table A6). Particulate air pollution from a combination of heat, dust, and fires has also increased in the San Joaquin Valley, likely exacerbating asthma and other health problems.[42]

State and federal governments recognized the vulnerability of rural communities early on and made emergency funding available for food and other support for impacted workers and for safe drinking water (Table 1).

Over the past two years, the state has significantly improved its emergency response for communities lacking drinking water. The multiple agencies involved have strengthened coordination to identify needs and deliver help.[43] Some community systems have gotten new wells and pipelines. In a few cases, people with dry domestic wells have been hooked up to local water systems. But in most cases, the solutions are stopgap: trucking in bottled water or delivering water to temporary holding tanks.[44] And in many places, the process for getting water to households in need is still too slow and difficult.

Farmland fallowing has cut jobs in some rural communities, and others have been hurt by declines in water-based recreational activities such as fishing and boating.

Only some counties (including Tulare) have a system for collecting information on dry wells, so it is likely that the scale of the problem is much larger than suggested by state data. State and federal funding rules are cumbersome, making it difficult to move quickly even on stopgap solutions. And the wait times to schedule well drillers to deepen or replace dry wells is very long—now typically 18 months.

If the Drought Continues

Community and domestic wells will run dry at an increasing pace, and emergency support programs will need to expand and improve. One priority is to make it easier for individuals to seek help if their wells run dry. Another is to strengthen the tracking system for addressing problems once they are identified. Longer-term solutions will also be needed to durably address both water supply and quality in these communities because many dry wells are unlikely to return to normal even after the rains return. The state has recently improved its institutional capacity to provide longer term assistance, and some new bond funds are available, but a long-term funding source is still needed to tackle this problem.[45]

ECOSYSTEMS

The most acute and severe impacts of this drought so far are on California's freshwater habitats and forested lands and on the biodiversity they support. These impacts stem, in part, from the severity of the drought and its combination of low flows and heat. More than a century of water and land practices have increased vulnerability by undermining the natural capacity of these ecosystems to handle occasional droughts.[46]

The environment doesn't have the same kinds of adaptation tools as other sectors—it generally can't pump more groundwater in dry times, for example.[47] But this troubling situation also reflects less investment in building drought resilience for the environment. California was unprepared for this environmental drought emergency and is now struggling to implement stopgap measures.

Here, we focus on three major management challenges of continued drought: risks to waterbirds of the Pacific Flyway from loss of wetlands, risks to native fishes from conditions in rivers and streams, and the growing potential for extreme wildfires.[48] Near-term water and land management changes can help address the urgent problems for waterbirds and fish, but this will require additional emergency funding.

WATERBIRDS

California is home to diverse populations of ducks, geese, shorebirds, and herons and is an essential stopping point on the Pacific Flyway. Wetlands in northeastern California and the Central Valley provide winter habitat for more than five million waterbirds.[49] Twentieth century land development drained most natural wetlands, so these birds now rely on a network of managed wetlands—intentionally flooded areas in federal and state refuges and on private lands.[50] They also make extensive use of flooded farmland, most notably rice farms that are flooded in the fall and winter to break down rice straw.[51]

Impacts and Adaptations So Far

The drought has dramatically reduced the amount of waterbird habitat. Water deliveries to refuges —already tight in normal times—were cut by 25 percent or more, and the sharp drop in rice acreage reduced the availability of flooded farmland.[52] In addition to reducing food supplies, reduced wetland habitat increases risk of disease because crowding can decrease water quality.

So far, management actions and lucky timing of late spring rains have helped stave off major declines in bird populations. Close coordination between wildlife refuges across California in the past year has also helped ensure that limited water is distributed to wetlands when it can provide the greatest habitat value for birds.

> California was unprepared for this environmental drought emergency and is now struggling to implement stopgap measures.

Another promising effort is paying farmers to make small adjustments in the timing and duration of flooding fields. For modest amounts of money, these "pop-up habitats" can be strategically located to make the most use of limited water availability. The Nature Conservancy's BirdReturns is one such program, supported to date with philanthropic sources.[53] Federal funds support a similar program run by the Natural Resources Conservation Service.[54] These programs are prime examples of adaptively managing scarce resources to create a high return on investment.

If the Drought Continues

Risks of high bird mortality are increasing as the drought wears on. The Nature Conservancy estimates that refuges may face larger water cutbacks this coming winter, and that temporary wetlands in rice fields may be reduced by more than 85 percent.[55] Absent rains, food for ducks and geese will become critically scarce this coming fall precisely during the peak of bird migration.[56]

A continuation of current management efforts can help reduce ongoing drought impacts, but this will require dedication of both refuge water supplies and funds for purchasing farm water, which may become more costly as the drought wears on.

NATIVE FISHES

California is home to 129 species of freshwater fish, two-thirds of which are found only in the state. One hundred of these fishes are either already listed as threatened or endangered under federal and state Endangered Species Acts or in decline and on their way to being listed in the future.[57] Many are highly vulnerable to low flows and higher water temperatures, and this drought is taking a major toll.

Impacts and Adaptations So Far

Since 2013, rivers and streams throughout the state have been at record or near-record lows, with many waterways that would normally flow year-round becoming a series of disconnected pools or drying up (technical appendix Figure A4). Higher temperatures have increased stress on fishes, most notably salmon and trout, as well as some amphibians. Survey counts for estuarine fish such as delta smelt and longfin smelt are at or near record lows.

Emergency management actions have included drought-stressor monitoring and rescue operations by the Department of Fish and Wildlife (technical appendix Table A8). In several key salmon and steelhead streams, the State Water Board has ordered some water users to stop diversions or to reduce groundwater pumping that was depleting surface flows.[58] But, as noted above, the board

has also relaxed environmental flow standards on 35 occasions to accommodate urban and farm users (technical appendix Table A1).

While water managers have sought to manage the timing of flows in ways that benefit both fish and other water users, they have not always had that option. The drought has posed difficult trade-offs in managing scarce surface water, where goals of water supply, water quality, and fish flows often compete. This is best illustrated by ongoing efforts to preserve the 2015 cohort of winter-run Chinook salmon below Shasta Reservoir. Unplanned releases of warm water in 2014 caused a near-complete loss of wild-spawning winter-run eggs and fry.[59] Decisions made this year are likely to lead to a similar result, pushing this species very close or possibly to extinction. Restrictions on releases from Shasta Reservoir to try to correct these mistakes are affecting operations of Oroville and Folsom Reservoirs, reducing agricultural and urban supplies and making it difficult to meet salinity standards for water exports from the Delta.

If the Drought Continues

Eighteen native fish species appear to be at high risk of extinction in the wild, including most runs of salmon and steelhead and a diverse group of other fishes that reside in watersheds across the state.[60] Reasons include loss of rearing or spawning habitat due to reduced flows (an issue for all 18 species) and increased water temperatures (an issue for salmon, steelhead, and several other fish including delta smelt). The drought is also favoring conditions for invasive species that reduce the quality of habitat for some fish. For some salmon runs, an added stressor is the release of large numbers of hatchery-bred fishes, which can harm drought-stressed wild fish through competition, predation, or interbreeding that reduces the fitness of their offspring.

Beyond the fish rescue and monitoring efforts noted above, there is no comprehensive plan to address the potential for extinctions.

The drought has posed difficult trade-offs in managing scarce surface water, where goals of water supply, water quality, and fish flows often compete.

Near-term options for improving habitat in the wild are limited but could help in some cases. For instance, managing some smaller watersheds as refuges by restricting diversions and focusing restoration efforts could help some salmon runs. Better enforcement efforts may also help, especially where illegal diversions to marijuana farms and vineyards are depleting North Coast streams.[61]

And more generally, allowing a greater margin of safety on environmental flows for fish earlier in the season could improve chances of fish survival, though this would reduce availability of water for farms and cities. Creative approaches to acquire water and use it strategically, as in the BirdReturns case, could reduce conflict. Although the Department of Fish and Wildlife has tried to secure additional flows through voluntary agreements, the response has been limited. A sustained effort utilizing emergency funding to purchase water in selected watersheds may be needed to prevent extinctions.[62]

For many of these fish, it will also be prudent to develop a plan for protecting the species in captivity and rebuilding populations following the drought. This would mean expanding the state's program of conservation hatcheries—those specifically run to protect biodiversity. This would require rapid and substantial investments of resources because the state currently lacks the facilities, funding, and technical expertise to systematically pursue such an approach.[63] This approach would also be controversial because it would likely require shifting most current hatcheries away from producing fish for commercial and recreational fisheries, which are already taking a financial hit from fewer fish during this drought.[64]

FORESTS AND WILDFIRES

Conifer and hardwood forests cover roughly a quarter of California. These forests are naturally wildfire prone, and a century of suppressing fires has made them much denser, increasing the likelihood of large, devastating fires.[65]

Impacts and Adaptations So Far

Hotter temperatures, moisture deficits, and insect infestations are killing trees at a rapid pace. These conditions lead to severe wildfires, posing significant threats to public safety, power lines and other infrastructure, water supply, air quality, and wildlife. Since the start of this drought, California has experienced two of the three largest fires in recorded history (technical appendix Figure A9). When fires burn hot over large areas—as in the 2013 Rim Fire in and near Yosemite National Park—there is also a concern that conifer forest ecosystems may not recover.

CALFIRE's strategy for this drought, in partnership with federal and local authorities, is to reduce the potential for large, destructive fires by suppressing fires as quickly as possible.

If the Drought Continues

California faces significant risk of more devastating fires like the Rim Fire over the next two to three years.

Given the scale of wildfire risk, CALFIRE's fire suppression strategy is the only real near-term option. But this strategy could become harder as the drought wears on and forest conditions degrade. Management options to reduce severe fire risk will be of limited value in the short term, given the problem's vast scale. Fuel reduction efforts that can reduce fire intensity—including thinning and reintroduction of more frequent, low-intensity fires—require sustained efforts over large areas for decades. Although some efforts are underway on private lands, fuel reduction efforts on federal land—roughly half the forested lands in California—have proven difficult for a variety of reasons, including permitting.[66]

Building Drought Resilience

The ongoing drought has served as a stress test for California's water management systems, and continuing drought will test them further. Managers and businesses are employing an array of tools and strategies. Many of these have helped California reduce drought impacts. Others will need refinement and further investment.

Current drought actions fall into three general categories: those that are working well and may need minor improvements; those that are still works in progress, requiring support and refinement; and those that require substantial policy reforms or investments.

WHAT'S WORKING

- **Diversified water portfolios:** Historic investments in diversifying water supply sources and managing demand have yielded great benefits. Further investments could be aided by streamlined permitting, as with recent CEQA exemptions for recycled wastewater standards.
- **Regional infrastructure:** Coordinated infrastructure development among multiple agencies has built regional diversity in water supplies and reduced vulnerability.
- **Coordinated emergency response:** Unprecedented coordination among state, federal, and local agencies has improved emergency response and reduced the economic costs of the drought.

WORKS IN PROGRESS

- **Mandatory conservation:** Although highly successful at reducing urban use, statewide conservation mandates can have unintended economic and social consequences if they are not implemented with some flexibility. They can reduce local financial capacity and appetite for new supply investments, and they can cost jobs if they are not considerate of business water use. They can also convey an overly negative impression about urban water conditions in the state—potentially dampening future business investments.
- **Water pricing:** Many urban utilities have encouraged conservation with tiered water pricing, but they now face significant uncertainty about the legality of these rates. Low-income households are vulnerable if utilities make up for lost water revenues with higher fixed monthly fees. Legal reforms to Proposition 218 may be needed to support both efficient and equitable pricing.[67]

- **Rural community supplies:** Some domestic and small community water supplies will always be vulnerable during droughts, and emergency response has improved. But the mechanisms to report dry wells should be strengthened and response times shortened for getting water to affected residents. Continued progress is also needed to provide long-term safe water solutions to rural communities.

- **Groundwater management:** Groundwater is a vital drought reserve, and extra pumping has reduced the economic costs of the drought. The new Sustainable Groundwater Management Act will boost the long-term drought resilience of California's farming sector and reduce negative impacts of unsustainable pumping. State and federal support for key technology and tools—such as groundwater models and well metering—can enable locals to move faster in implementing the law.[68] Addressing acute short-term impacts of pumping, such as infrastructure harm from sinking lands, may require charging new pumping fees or limiting new wells in some areas.

- **Water trading:** Water trading has helped reduce the economic costs of the drought so far, and it will be vital if the drought continues. But the market is not sufficiently transparent or flexible. Processes for approving trades are complex and often opaque. Little information is publicly available about trading rules, volumes, or prices.[69]

- **Waterbird management:** The risks to waterbird populations can be reduced by coordinating the management of water on refuge wetlands and flooded farm fields. State and federal investment in creative approaches, such as programs that pay farmers to flood fields, can yield great benefits with limited water and funds.

DIFFICULT WORK AHEAD

- **Improving the curtailment process:** In principle, California's seniority-based water-rights system is designed to handle droughts. But making it work well will require better information on water availability and use, clearer state authority, and more effective enforcement.

- **Modernizing water information:** To facilitate all facets of water management—including trading, curtailments, and environmental flows—the state will need to make major investments in the collection, analysis, and reporting of water information.[70] This includes updating models to consider the extreme temperature and flow conditions of modern droughts.

- **Managing wildfires:** The stopgap measure of suppressing fires during drought may work in the short-term, but a long-term strategy of improved forestry and fire management—with strong federal participation—is needed.

- **Managing surface water trade-offs:** The state and federal governments have not gone through the difficult exercise of defining and prioritizing objectives among competing uses of scarce supplies, especially when managing reservoirs. The difficulties of managing Shasta Reservoir to protect wild salmon highlight the need to do better forecasting and build in a margin of safety for environmental flows.

- **Avoiding extinctions of native fish:** Continued drought will likely lead to multiple extinctions of native fish species in the wild, and California lacks a plan to address this. More cautious strategies to save reservoir water for environmental flows may help, and purchasing water to boost flows could reduce conflicts. It may also be prudent to make immediate investments in conservation hatcheries.

- **Building environmental resilience:** Beyond stopgap measures, California also needs to invest in improving the capacity of our native biodiversity to weather droughts and a changing climate. This requires a plan and the funding to put it into action.[71]

Conclusion

Since statehood, California has developed water supply infrastructure and supporting laws to manage water scarcity during droughts. Yet the intensity and duration of the ongoing drought is stress-testing the state's management systems. In many respects, this drought is California's dry run for a drier, warmer future.

Californians at all levels have shown a commitment to reducing the economic, social, and environmental harm from the drought with many successes. Yet if the drought continues for another two to three years, the challenges will grow. Addressing the most pressing threats will require stopgap measures—for instance, delivering drinking water supplies to rural residents with dry wells, setting up conservation hatcheries to prevent fish extinctions, and making spot decisions about tough trade-offs. But the state also needs to leverage the lessons of the past four years to build longer-term drought resilience. That way, we will be more prepared for future droughts and have less need for stopgap, emergency solutions.

NOTES

1. See technical appendix Figure A1 and related discussion.
2. J. Mount and D. Cayan. "A Dry Run for a Dry Future" (PPIC blog, May 27, 2015).
3. A list of state drought actions.
4. Some long-range models indicate that a strong El Niño may improve rainfall in California next winter, but the reliability of these forecasts is low and the relationship between El Niño and precipitation in Northern California is weak. See D. Cayan and J. Mount, "Don't Count on El Nino to End the Drought," (PPIC blog, July 9, 2015).
5. We spoke with close to 50 individuals, representing 11 state and federal agencies, urban water agencies in five regions, agricultural water supply, food processing, and lending activities, and nonprofits working on rural water supply and environmental management.
6. CVP settlement and exchange contractors, a group of agricultural districts that usually get 100 percent of their contractual amounts, received 75 percent in 2014, and may receive just 55 percent in 2015. CVP urban customers south of the Delta, including Santa Clara Valley Water District, were cut from the usual 75 percent to 25 percent. Some CVP agricultural contractors have received 0 percent of their contracts since 2014 (down from a 2008–13 average of 64% for those located north of the Delta and 39% for those located south of the Delta). SWP Feather River Settlement Agreement holders, agricultural districts that usually get 100 percent of their contracts, got only 50 percent in 2015. Regular SWP urban and agricultural contractors, who received an average of 50 percent from 2008–13, got just 5 percent in 2014 and 20 percent in 2015.
7. For instance, the Los Angeles Aqueduct, which conveys water to LA from Mono Lake and Inyo County, is projected to deliver just 32,000 acre-feet this year: the lowest since its construction (mostly from pumped groundwater rather than snowmelt runoff). Deliveries since 2008 have averaged 150,000 acre-feet/year.
8. See for instance D. Kasler and R. Sabalow, "Water Rights Ruling a Setback for California Drought," *Sacramento Bee*, July 10, 2015.
9. See for instance F. Nirappil, "California Drought: Regulators Say First Water Diversion Prosecution Aided by Detailed Records," Contra Costa Times, July 23, 2015. For a discussion of information needs, see J. Mount et al., *Policy Priorities for Managing Drought* (PPIC, 2015).
10. California's groundwater basins hold at least three times as much usable water as state surface reservoirs, and a large share of surface reservoir storage is for seasonal uses, not carryover storage for dry years. See J. Lund et al., *California's Water: Storing Water* (PPIC, 2015).
11. For groundwater use from 1998 to 2010, see C. Chappelle et al., *Reforming California's Groundwater Management* (PPIC, 2015). Recent estimates of more than 50 percent are based on work by R. Howitt et al., described in technical appendix Table A5.
12. For a general overview, see California Department of Water Resources, *Summary of Recent, Historical, and Estimated Potential for Future Land Subsidence in California*, 2014. During the drought of the late 2000s, the US Geological Survey found land sinking, or subsidence, rates ranging from 1 to 21 inches over a three-year period. These rates are likely to be accelerating with the pumping now occurring. (M. Sneed et al., *Land Subsidence along the Delta–Mendota Canal in the Northern Part of the San Joaquin Valley, California, 2003–2010*: US Geological Survey Scientific Investigations Report 2013-5142.) For a discussion of impacts to Sack Dam, where continued subsidence will cost local farmers $10 million to move water, see "California farmers dig deeper for water, sipping their neighbors dry," *New York Times*, June 5, 2015. Subsidence-related damage to a bridge over a canal in Fresno County will cost $2.5 million to repair. See "Groundwater pumping causing Central Valley bridges to sink," KSFN, July 21, 2015.
13. Basins identified as critically overdrafted need to meet this timeline. Other priority basins have an additional two years to adopt and start implementing their plans. The law gives local agencies the authority to implement the plans, including the ability to measure use and charge fees for pumping. The State Water Board can intervene if it deems local efforts inadequate.
14. The urban population share is from the 2010 US Census. For a discussion of the economic statistics in this section, including the urban economy's share of economic activity and recent GDP and employment trends, see the technical appendix discussion of nonfarm economic impacts.

15. For instance, the Metropolitan Water District of Southern California has increased storage more than 13-fold since the early 1990s (Metropolitan Water District of Southern California, Regional Progress Report. Implementing the Diversified Resource Portfolio. February 2014, p. 3). See our map of per capita water use trends. For a discussion of water trading trends, see technical appendix Figure A5.
16. E. Hanak et al., *California's Water: Water for Cities* (PPIC, 2015).
17. The largest program is run by the Metropolitan Water District of Southern California. Following the success of a $100 million rebate program, Met's board approved an additional $350 million in rebates—enough to replace roughly 4,000 acres of turf. The program was fully subscribed within the first month. M. Stevens and M. Moran, "Southland Water District Ends Popular Lawn-Removal Rebate Program," *Los Angeles Times*, July 10, 2015.
18. We spoke with officials from urban water agencies about conditions in their regions in the Sacramento area, North Coast, San Francisco Bay Area, Fresno area, and Southern California.
19. For many Central Valley cities, this includes substantial groundwater reserves. San Francisco's Hetch Hetchy reservoir, which serves many Bay Area communities, began this summer at 95 percent capacity. Metropolitan Water District of Southern California's reserves were substantially diminished last year, but they began the summer with nearly 1.2 million acre-feet in dry year storage, including surface reservoirs on the Colorado River system and groundwater basins (Metropolitan Water District of Southern California. Report: Water Surplus and Drought Management: Attachment 1 2015 WSDM Storage Detail. April 14, 2015). Met member agencies also have significant underground reserves.
20. The Santa Clara Valley Water District has shelved its plan to ship supplies north from storage in Kern County for the time being. (P. Rogers, "California Drought: Plans to Make State Water Project Flow Backward Shelved for This Year," *Mercury News*, May 4, 2015). But in June 2015, the City of Tracy and some agricultural districts began pumping water north from the San Luis Reservoir through the Delta Mendota Canal (G. Warren, "Emergency Drought Project Reverses Flow in Delta-Mendota Canal," KXTV Sacramento, June 30, 2015.)
21. See the discussion of electricity in the technical appendix. California's dependence on hydropower has significantly declined over time, from more than 30 percent of electricity use in the 1960s to an average of just 12 percent since 2000. The supply of other renewables (solar, wind) has tripled in recent years. Thermal power plants have been reducing water use and transitioning to recycled water since the early 2000s, and recent efforts have focused on reducing vulnerability for plants dependent on unreliable surface water sources.
22. H. McCann and C. Chappelle, "Drought Bills: Small Changes, High Impact" (PPIC blog, June 30, 2015).
23. See the discussion of urban water utilities in the technical appendix. The fiscal challenge for utilities arises because the majority (typically 70-80%) of their costs are fixed, while a similar proportion of their bill is variable, tied to the volume of water sold. The estimate of net revenue losses is from S. Moss et al., *Executive Order B-29-15 State of Emergency Due to Severe Drought Conditions Economic Impact Analysis* (M. Cubed, 2015); it excludes the losses from voluntary conservation already achieved before the mandate went into effect.
24. The case involves tiered water rates in the City of San Juan Capistrano. See the discussion of urban water utilities in the technical appendix.
25. E. Hanak, "The High Cost of Drought for Low Income Californians" (PPIC blog, June 18, 2015).
26. This is especially true for businesses that have already made significant investments in reusing processing water, for instance. For a review of potential impacts of the drought on water-sensitive activities, see the discussion of nonfarm economic impacts in the technical appendix.
27. The conservation tiers for each community were set based on per capita residential use, but the target it is being applied to total urban water use.
28. See the discussion of water markets in the technical appendix, including Figure A5 on market trends.
29. See J. Mount et al., *Water Use in California* (PPIC, 2014) and E. Hanak et al., *California's Water: Water for Farms* (PPIC, 2015).
30. For shifts in crop types, see Figure 3.7 in E. Hanak et al., *Managing California's Water* (PPIC, 2011). For irrigation efficiency trends, see G. Tindula et al., "Survey of Irrigation Methods in California in 2010," *Journal of Irrigation Drainage Engineering*, 2013, Vol. 139(3): 233-238.
31. See E. Hanak and E. Stryjewski, *California's Water Market, By the Numbers: Update 2012* (PPIC, 2012).
32. See J. Lund et al., "Taking Agricultural Conservation Seriously," (Californiawaterblog.com, March 15, 2011).
33. For cities and suburbs, conservation usually results in system-wide savings. Because so many Californians live in coastal areas, saving water indoors reduces outflows of treated wastewater to the ocean. And across the state, saving water outdoors by replacing turf with lower-water landscapes saves water, without reducing economic activity.
34. Data on farm impacts are from analyses done by the UC Davis Center for Watershed Sciences for the California Department of Food and Agriculture. See technical appendix Table A5 and related discussion.
35. See the discussion of water marketing in the technical appendix, including Figure A5 on market trends.
36. J. Medellín-Azuara et al., "California Drought Killing Farm Jobs Even as They Grow" (Californiawaterblog.com, June 8, 2015).
37. For long-term loans, banks are requiring farms to have multiple water sources—not just groundwater. This should limit the expansion of new orchards onto non-irrigated ranchland.
38. Little information is available on the costs of subsidence in agricultural areas. Examples of local infrastructure damage described above (see note 12) suggest these costs may not always be very high—e.g., $2.5 million for a bridge repair, $10 million for conveyance changes from a local reservoir—in part because these areas are not as built up as cities.
39. Such ordinances should be temporary, in anticipation of the adoption of sustainable pumping rules under SGMA. Because the rights to use groundwater in California are not based on seniority, but rather on ownership of land overlying the basin, it does not necessarily make sense for local agencies implementing SGMA to give priority to those with existing wells. Instead, they may wish to apportion pumping rights based on acreage, irrespective of the volumes current being pumped. Either way, a cap and trade system, which facilitates the trading of pumping rights within the basin, can help lessen the overall costs of implementation.

40. For fishing and water-based recreation, see the discussion of nonfarm economic impacts in the technical appendix.
41. For a discussion of drinking water quality issues in rural communities, see E. Hanak et al., *Paying for Water in California* (PPIC, 2014) and T. Harter et al., *Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater.* Report for the State Water Resources Control Board Report to the Legislature. (Center for Watershed Sciences, University of California, Davis, 2012).
42. See discussion of drought-related public health issues in the technical appendix.
43. For the state, this includes the State Water Board, the Department of Water Resources, the Department of Housing and Community Development, the Office of Emergency Services, and the Governor's Office of Planning and Research. County officials are also involved, as well as local non-profits and in some cases nearby water districts.
44. There are legal constraints to providing state funding to directly invest in private property improvements.
45. Recent reforms include the creation of a special office within the State Water Board to support funding for disadvantaged communities and legislation that authorizes the board to require consolidation of small systems. Proposition 1, the new water bond, also contains more than $500 million for small rural water and wastewater systems. State and federal funds are typically restricted to covering capital costs, whereas some systems will also need support for operations. See E. Hanak et al., *California's Water: Paying for Water* (PPIC, 2015). The new law that makes well logs public (Senate Bill 83, June 2015) should also help, because it makes it possible to project likely areas where wells will go dry with falling groundwater levels. This information will be useful for well owners and for focusing emergency state support.
46. See chapter 5 of E. Hanak et al., *Managing California's Water: From Conflict to Reconciliation* (PPIC, 2011).
47. One exception is wetlands, where groundwater can replace lost surface flows.
48. Other species are also vulnerable, including many terrestrial animals and plants. For most species, including some of the populations discussed in the text, the state lacks sufficient monitoring information to either gauge drought impacts or guide management.
49. See Central Valley Joint Venture, accessed July 9, 2015.
50. Managed wetlands account for a relatively small share of water use in California: typically 1.5 million acre-feet, or less than 2 percent of the total (J. Mount et al., *Water Use in California*, PPIC, 2014).
51. N. Seavy et al., "Farms That Help Wildlife," (PPIC blog, April 21, 2015) and J. Mount et al., *California's Water: Water for the Environment* (PPIC, 2015).
52. Rice acreage fell from an average of 567,000 acres in 2010–13 to just 434,000 acres in 2014 (-24%), and acreage in 2015 is projected at 385,000 (-32%) (US Department of Agriculture, National Agricultural Statistics Service, California Acreage Reports, accessed July 28, 2015). Tight water conditions are also reducing the acreage that gets flooded post-harvest.
53. The Nature Conservancy California, "Precision Conservation," accessed July 9, 2015.
54. The program is called the Critical Waterbird Habitat Fund Pool. Whereas the BirdReturns program uses an auction to determine payments, the NRCS program makes fixed payments.
55. Personal communication, Jay Ziegler, The Nature Conservancy, July 8, 2015.
56. Unpublished modeling work, Ducks Unlimited. This modeling was specific to ducks and geese, but the shortfall in habitat could impact shorebirds as well.
57. P.B. Moyle et al., "Rapid decline of California's native inland fishes: a status assessment." *Biological Conservation*, 2014, Vol. 144(10): 2414–2423; P.B. Moyle et al., "Climate change vulnerability of native and alien freshwater fishes of California: a systematic assessment approach," *PLoS One* 2013; and P.B. Moyle et al., *Fish Species of Special Concern in California.* Sacramento: California Department of Fish and Wildlife, 2015.
58. This includes periodic curtailment of diversions on Antelope Creek and Deer Creek since 2014 to support spring-run Chinook salmon, and recent orders to stop groundwater use on landscapes on several creeks in the Russian River watershed to support coho salmon and steelhead.
59. J. Mount, "Better Reservoir Management Would Take the Heat Off Salmon" (PPIC blog, June 23, 2015).
60. See technical appendix TableA9 and related discussion for a list of the species, the methodology used for this assessment, and a discussion of potential management actions.
61. C. Chappelle and L. Pottinger, "California's Streams Going to Pot from Marijuana Boom" (PPIC blog, July 23, 2015).
62. The development of native fish-oriented flow regimes below many dams would also be beneficial. See T. Grantham et al., "Systematic screening of dams for environmental flow assessment and implementation," *Bioscience*, 2014, Vol. 64: 1006–1018.
63. Some species are already kept in captivity with the goal of preventing extinction (such as delta smelt, Central Coast coho salmon, McCloud River redband trout, and Central Valley winter-run Chinook salmon). The use of conservation hatcheries will be more difficult for fish that do not already have captive populations or populations that live outside of their native range. See technical appendix Table A9 and related discussion.
64. For some fishery sector statistics, see technical appendix Figure A8 and related discussion.
65. P.J. McIntyre et al., "Twentieth-century Shifts in Forest Structure in California: Denser Forests, Smaller Trees, and Increased Dominance of Oaks," *Proceedings of the National Academy of Sciences*, 2015, Vol. 112(5): 1458–1463.
66. The federal government owns 55 percent of forests and woodlands in California (California Department of Forestry and Fire Protection: Forest and Rangelands 2010 Assessment). On permitting challenges on federal lands, see M. North et al., "Constraints on Mechanized Treatment Significantly Limit Mechanical Fuels Reduction Extent in the Sierra Nevada," *Journal of Forestry*, 2014, Vol. 113(1): 40–48.
67. See E. Hanak et al., *Paying for Water in California* (PPIC, 2014).
68. The Center for Irrigation Technology at Fresno State University estimates that only about a third of wells are now metered; such metering can be useful for efficient on-farm water use as well as groundwater basin management. See the interview with David Zoldoske in L. Pottinger, "The Challenges of Getting More Crop per Drop," (PPIC blog, July 28, 2015).

69. See the discussion on water markets in the technical appendix.
70. Some promising recent changes in this direction include new reporting and measurement requirements for surface water diversions. See H. McCann and C. Chappelle, "Drought Bills: Small Changes, High Impact" (PPIC blog, June 30, 2015).
71. One promising approach to environmental drought planning comes from Australia. See J. Mount et al., *Policy Priorities for Managing Drought* (PPIC, 2015).

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