From:	Ryan Berghoff
To:	Dulik, Karen@DWR
Cc:	Adam Keats
Subject:	Monterey Plus - Comments on Draft Revised EIR
Date:	Monday, June 13, 2016 4:43:18 PM
Attachments:	2016-6-13 Comments to Revised KWB EIR_FINAL.pdf

Dear Ms. Dulik,

Please find attached a copy of Comments on the Department of Water Resources 2016 Monterey Plus Draft Revised Environmental Impact Report, submitted by Center for Food Safety (CFS), California Water Impact Network (CWIN), California Sportfishing Protection Alliance (CSPA), Center for Biological Diversity (CBD), Central Delta Water Agency (CDWA), and South Delta Water Agency (SDWA). Please confirm that you received this email.

If you have any questions regarding this matter, do not hesitate to call or email me. You can reach me by phone at (415) 826-2770 or by email at rberghoff@centerforfoodsafety.org.

Best,
Ryan Berghoff
Legal Fellow
Center for Food Safety

CENTRAL DELTA WATER AGENCY SOUTH DELTA WATER AGENCY

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JUN 13 2016
South Central Region

June 13, 2016

California Department of Water Resources
Attn: Karen Dulik
Environmental Program Manager I
3374 E. Shields Ave.
Fresno, CA 93726

Comments on the Department of Water Resources 2016 Monterey Plus Draft Revised Environmental Impact Report – Kern Water Bank Development and Continued Use and Operation

To Department of Water Resources ("DWR"):

The undersigned organizations submit these comments on DWR's 2016 Monterey Plus Draft Revised Environmental Impact Report ("Revised EIR") regarding the Kern Water Bank ("KWB") Development and Continued Use and Operation. These comments are submitted on behalf of the organizations themselves, as well as their members, volunteers, and employees.

The Center for Food Safety ("CFS") is a nonprofit, public interest advocacy organization dedicated to protecting human health and the environment by curbing the proliferation of harmful food production technologies and promoting sustainable agriculture, including impacts to water resources. In furtherance of this mission, CFS uses legal actions, groundbreaking scientific and policy reports, books and other educational materials, and grassroots campaigns on behalf of its 750,000 farmer and consumer members across the country.

The California Water Impact Network ("CWIN") is a nonprofit, public benefit corporation formed under the laws of the State of California for the purpose of protecting and restoring fish and wildlife resources, scenery, water quality, recreational opportunities, agricultural uses, and other natural environmental resources and uses of the rivers and streams of California, including the San Francisco Bay-Delta estuary, also known as the Sacramento-San Joaquin Bay-Delta ("Bay-Delta"), its watershed and its underlying groundwater resources.

The California Sportfishing Protection Alliance ("CSPA") is a nonprofit organization with more than 2,500 members throughout California dedicated to protecting, preserving, and enhancing the fisheries and associated aquatic and riparian ecosystems of California waterways, including the Central Valley rivers leading to the Bay-Delta. CSPA and its members actively

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participate in water rights and water quality processes, engage in education and organization of the fishing community, conduct restoration efforts, and vigorously enforce environmental laws enacted to protect fisheries, habitat, and water quality.

Center for Biological Diversity (”CBD”) is a nonprofit, public interest corporation with over one million members and online activists dedicated to protecting diverse native species and habitats through science, policy, education, and environmental law. CBD and its members have a particular interest in protecting lands affected by the State Water Project, including Bay-Delta, for recreational, wildlife viewing, scientific, and educational purposes.

Central Delta Water Agency (“CDWA”) is a political subdivision of the State of California created under the Central Delta Water Agency Act, Chapter 1133 of the Statutes of 1973 as amended. The CDWA encompasses approximately 120,000 acres within San Joaquin County, all of which is within the Bay-Delta. The water rights pertaining to the lands within CDWA jurisdiction are principally riparian and in-part covered by pre-1914,”prior vested” water rights, which enjoy seniority over post-1914 water rights and those of DWR. CDWA is empowered to assist landowners within its jurisdiction to protect and assure a dependable supply of water of suitable quality sufficient to meet present and future needs.

South Delta Water Agency (“SDWA”) is a political subdivision of the State of California created by the California Legislature under the South Delta Water Agency Act, Chapter 1089 of the Statutes of 1973 as amended. The SDWA encompasses approximately 148,000 acres within San Joaquin County, of which is within the Bay-Delta. The water rights pertaining to the lands are principally riparian and are in-part covered by pre-1914, “prior-vested” water rights, which enjoy seniority over post-1914 water rights and those rights of DWR. SDWA is empowered to assist landowners within its jurisdiction to protect and assure a dependable supply of water of suitable quality to meet present and future needs.

I. INTRODUCTION

In the late 1980s and early 1990s, the State Water Project (“SWP”) started to not be able to fulfill the maximum annual amount of SWP water that each water contractor applied for (then called entitlements, now “Table A amounts”). California experienced a drought from 1986 through 1991, forcing DWR in 1991 to reduce entitlement deliveries to agricultural contractors to zero, pursuant to Article 18(a) of the State Water Project Long-Term Contracts. Article 18(a) provided that in times of short-term deficits, agricultural contractors would have their deliveries cut first, sparing the urban contractors (and their more permanent reliance on the deliveries) from diminished deliveries. This event gave rise to a dispute between agricultural and urban contractors, with the agricultural contractors threatening to invoke Article 18(b) of the long-term contracts. Article 18(b) provided that in the event of a permanent deficit in the SWP system, all contractors’ entitlements would be reduced.

The invocation of Article 18(b) was anathema to the urban contractors, who had grown dependent on the promise—if not the actual delivery—of their full entitlements of SWP water, using this “paper water” (the difference between what was promised as “entitlements” based on a proposed build-out of the SWP system that never occurred and what the SWP could actually

deliver in any given year within the confines of the actually-built-out system) as proof of water supplies in order to approve development projects that would become dependent on SWP water deliveries. With both sides finding fault with different contract provisions, a select group of urban and agricultural contractors secretly met with DWR representatives in Monterey, California, to hash out a compromise.

The real cause of the dispute was neither the drought nor a general growing demand for limited water resources, but rather DWR's continued support for the paper water entitlements contained in the long-term contracts and DWR's failure to consistently and properly invoke both Articles 18(a) and 18(b). Rather than correcting the inflated entitlements (as Article 18(b) required) and consistently applying Article 18(a)'s provisions during drought periods, which not only would have addressed both the agricultural and urban concerns but also brought the SWP system closer to a sustainable operation, the Monterey parties decided to toss out these essential checks-and-balances and to restructure the rest of the contracts. This agreement became known as the Monterey Agreement, and resulted in the Monterey Amendment to the State Water Project Long-Term Contracts.

In addition to deleting Articles 18(a) and 18(b), the Monterey Amendment included a provision (relevant here) that provided for the transfer of the KWB from state control (DWR) to "local" control, in the form of an initial transfer to Kern County Water Agency ("KCWA") followed by a second transfer to the Kern Water Bank Authority ("KWBA"), officially a joint project between private and public entities but in fact an entity majority-controlled by a single corporate agribusiness interest. As citizen watchdogs and activists have since repeatedly argued and demonstrated, the transfer was made in exchange for illusory consideration: primarily the bogus "retirement" of 45,000 acre-feet ("AF") of Table A water amounts held by some of the KWBA member entities.

California has been suffering ever since.

The KWB is an approximately 20,000 acre alluvial groundwater reservoir in southern Kern County. DWR purchased the KWB lands in 1988 as part of a plan to develop a state-owned groundwater storage bank for the SWP, which DWR called the Kern Water Bank. Due primarily to intransigence on the part of the KCWA (which had a legislatively-granted veto over any statewide water facility within its service area), full operation of the KWB stalled. With KCWA holding the KWB hostage, DWR capitulated, agreeing to hand over the valuable resource to the "local" water interests as part of the Monterey Amendment.

The initial KWB Transfer was subject to the California Environmental Quality Act ("CEQA") review, which was performed as part of the review of the entire Monterey Amendment project in 1995. That EIR was challenged in court, and as a result of a successful lawsuit brought by the Planning and Conservation League and others, was decertified in 2003. As part of a settlement agreement in that case, DWR agreed to produce a new EIR, which it completed in 2010. Challenged again in court, this time by a coalition of nonprofit organizations, two Delta water agencies, and two individuals, this second EIR—the Monterey Plus FEIR—was also decertified. (*Central Delta Water Agency v. California Department of Water*, (Jan. 31, 2014) Sacramento Sup. Ct. No. 34-2010-80000561.) The superior court

concluded that DWR violated CEQA by failing to adequately describe, analyze, and (as appropriate) mitigate the potential impacts of the Project associated with the anticipated use and operation of the KWB. The court stated that the failure to include relevant information regarding KWB operations precluded informed decision-making and informed public participation, thereby thwarting the statutory goals of the EIR process.

The superior court ordered DWR back to the drawing board, at least regarding its review to the KWB Transfer, and it is this EIR—the 2016 Monterey Plus Draft Revised EIR—that is the subject of these comments.

The Revised EIR reveals that KWB operations resulted in significant environmental impacts that were not adequately described, analyzed, or properly mitigated. The Revised EIR fails to analyze the significance that converting annual crops to permanent crops has on the water supply and fails to analyze the significant impact that groundwater depletion has on nearby water users and subsidence. The Revised EIR does not analyze any alternatives to avoid or lessen any of the newly-identified significant impacts of the project, and the mitigation measures it analyzes will not make the impacts less than significant.

II. DISCUSSION

An EIR is a "detailed statement prepared under CEQA describing and analyzing the significant effects of a project and discussing ways to mitigate or avoid the effects." (CEQA Guidelines, § 15362.) It must be organized and written in a manner that will be meaningful and useful to decision-makers and to the public. (Pub. Resources Code, § 21003, subd. (b).) To serve this purpose, the EIR must identify and focus on the possible significant environmental impacts of the proposed project. (CEQA Guidelines, §§ 15126, subd. (a), 15126.2, subd. (a); Pub. Resources Code, § 21100, subd. (b)(1).) A significant effect is any "substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic and aesthetic significance." (CEQA Guidelines, § 15382.) At its most basic level, CEQA compels government first to identify the significant environmental effects of projects, and then to mitigate those adverse effects through imposition of feasible mitigation measures or through selection of feasible alternatives. (*Sierra Club v. Board of Forestry* (1994) 7 Cal.4th 1215, 1233.)

The Revised EIR fails to analyze numerous significant effects including the conversion from annual crops to permanent crops facilitated by the KWB transfer; the impacts of groundwater depletion on nearby water users, state water resources, and subsidence; and the cumulative impacts of KWB operations with other current water banking activities and other water users. The Revised EIR also fails to identify feasible alternatives to avoid or lessen the significant impacts, or properly analyze appropriate mitigation measures. For these reasons, the Revised EIR is deficient.

a. Project Decision

The Revised EIR repeats a fundamental error made in the Monterey Plus FEIR, describing DWR's decision on the Project as being "whether or not to continue the use and

operation of the KWB by KWBA, after compliance with CEQA." (Revised EIR at ES-3.) The euphemistic "decision" to "continue the use and operation" represents a fundamental departure from the interactive process of review and decision required under CEQA, which requires the lead agency to complete its environmental review before making its final decision on the project as a whole. (See *County of Inyo v. City of Los Angeles* (1984) 160 Cal.App.3d 1178, 1185 [CEQA requires an "interactive process of assessment and responsive modification that must be genuine"].) As the Revised EIR admits, DWR must make its decision "after compliance with CEQA," which necessarily requires that a project approval follow environmental review, not precede it. (Revised EIR at ES-3.) Without a clear commitment to that process (and all indications in the Revised EIR are that DWR has no intention of following that correct procedure), the entire environmental review process represented by the Revised EIR will be nothing more than a sham.

b. Agricultural Resources

The Revised EIR recognizes that KWB activities can facilitate and may already have facilitated the conversion of annual crops, which can be fallowed in dry years, to permanent crops, which require a dedicated water supply. But the Revised EIR erroneously concludes that this impact is not significant. A shift in crop patterns caused by the Project, even if the Project's contribution is only cumulatively significant, almost certainly impacts the state's water supply, particularly as it relates to groundwater depletion and Delta withdrawals, and the EIR must disclose and analyze this clearly significant impact.

i. Lack of Analysis Regarding Conversion to Permanent Crops

1. Appendix G of the CEQA Guidelines is Not Exhaustive

The Revised EIR must analyze all potentially significant impacts of the Project, even if not listed on Appendix G to the CEQA Guidelines. Appendix G provides an Environmental Checklist Form for assisting in the determination of the potential significance of a project impact. The form explicitly states that "[s]ubstantial evidence of potential impacts that are not listed on this form must also be considered." (CEQA Guidelines, Appendix G, at 1.) Thus, Appendix G serves as a starting point for determining the significance of a project; it is not exhaustive or exclusive. DWR must still identify and analyze all other potentially significant effects.

The Revised EIR identifies a "substantial" change in crop patterns since the transfer of the KWB, resulting in farmers shifting from annual crops to permanent crops. (Revised EIR at 7.6-13.) However, the Revised EIR concludes that the Project's "cumulatively considerable incremental contribution to this shift to permanent crops" is less-than-significant because it "does not exceed any of the Appendix G standards of significance in the CEQA Guidelines related to agriculture and forestry resources." (Revised EIR at 10.1-34.) The Revised EIR opines that this shift does not need to be evaluated because a "shift in crop patterns, in and of itself, is not a significant adverse environmental effect." (*Id.*) But merely because a shift in crop patterns is not listed in Appendix G of the CEQA Guidelines does not relieve DWR of its duty to analyze other potentially significant effects. Here, the Revised EIR identified a "substantial" change in crop

patterns, resulting in a shift from irrigated annual crops that can be "fallowed in dry/critically dry years" to permanent crops that require a "dedicated water supply." (Revised EIR at 7.6-13.) The impacts of this conversion must be analyzed.

2. The Revised EIR Fails to Analyze Any of the Impacts From Conversion of Irrigated Annual Crops to Permanent Crops.

The Revised EIR concludes that "KWB activities could … potentially convert irrigated farmland to orchards, which could cause other indirect effects." (Revised EIR at 7.6-12.) Despite that recognition, the Revised EIR fails to analyze any impacts related to the conversion of crops.

Making unreliable seasonal water "reliable" by storing it in a water bank and knowingly permitting that water to be used for permanent crops is a significant effect that obviously and logically requires analysis. The Revised EIR identifies that there was only a relatively small increase in agricultural acreage in Kern County between 1996 and 2014, but the cropping patterns within the county changed "substantially." (Revised EIR at 7.6-13.) The acreage of total nut crops between 1996 and 2014 increased by approximately 206% and almonds accounted for more than 65% of the total nut crops in 2014. (*Id*; see Exhibits A-E.)[1] Combined acreages of seed crops, field crops, and vegetable crops all decreased during the same time period. (*Id*.; see Exhibit F.)[2] The Revised EIR further recognizes that KWB activities may have increased water supply reliability (at least in the short term, and only for the KWBA member entities), which has potentially resulted in changes from "irrigated crops or annual field crops on land that could be fallowed in dry/critically dry years to permanent crops like orchards and vines that require a dedicated water supply." (*Id*.)

Nonetheless, the Revised EIR does not analyze the effects of this crop conversion, stating that the change in farming practices is "consistent with the county-wide trend [] and with a state-wide trend even in areas that do not depend upon water banks for water storage." (*Id*.) That

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[1] *See* Dale Kasler, *California Almond Growers to Expand Orchards, Despite Drought*, The Sacramento Bee (Apr. 16, 2015) ("[T]he amount of California farmland devoted to almonds has nearly doubled over the past 20 years, to more than 900,000 acres"), http://www.sacbee.com/news/state/california/water-and-drought/article18716937.html (Attached as Exhibit A); *see also* Geissler & Horwath, *Almond Production in California*, UC Davis University of California (Jun. 2016) ("[W]hile the [almond] acreage remained relatively stable between 1985 and 1995, it increased again reaching a new high in 2011 with 760,000 acres of bearing orchards producing 2.02 billion pounds of almonds, which accounted for 84% of the global production."), https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Almond_Production_CA.pdf (Attached as Exhibit B); Robert Rodrigues, *California Almond Acreage Continues to Grow*, The Fresno Bee (Apr. 29, 2016) ("California almonds, ones of the state's largest crops, increased in acreage by 6 percent last year."), http://www.fresnobee.com/news/business/agriculture/article74770332.html (Attached as Exhibit C); Ari Phillips, *Thank Almonds, Pistachios, Wine, and Groundwater for California's Record Harvest*, Fusion (Aug. 27, 2015) ("The total increase in fruit and nut acreage since 2000 was 570,00 acres, or 24%, according to the [Pacific Institute] study." [citing Cooley et al., *Impacts of California's Ongoing Drought: Agriculture*, Pacific Institute (Aug. 2019), http://pacinst.org/app/uploads/2015/08/ImpactsOnCaliforniaDrought-Ag.pdf (Attached as Exhibit E)]), http://fusion.net/story/189826/california-record-harvest-due-to-excessive-groundwater-use/ (Attached as Exhibit D).

[2] *See* Philpott & Lurie, *Here's the Real Problem With Almonds*, New Republic (Dec. 31, 2015) ("California acreage devoted to alfalfa is expected to shrink 11 percent, and cotton acres look set to dwindle to their lowest level since the 1920s. Meanwhile, the market is pushing almonds and other nuts in the opposite direction."), https://newrepublic.com/article/125450/heres-real-problem-almonds (Attached as Exhibit F).

this conversion from annual crops to permanent crops may have been a county-wide trend does not prove that the KWB Transfer did not facilitate this conversion. The KWBA participants are part of Kern County, and their crop production between 1995 and 2014 accounts for more than a quarter of the increased nuts (65,900 acres/203,938 acres), half of the increased fruit (22,096 acres/50,269 acres) and nearly all of the increased citrus (17,442 acres/22,489 acres), all of which are permanent crops. (See Revised EIR at 7.6-7, Tables 7.6-5 and 7.6-6.) Thus, the Revised EIR's statement that conversion to permanent crops is less than significant because the "trend of replacing irrigated annual crops with permanent crops is expected to continue in the future with or without the KWB" is unfounded. (Revised EIR at 7.6-14.) There is a clear connection between the conversion of annual crops to permanent crops within Kern County and the KWB Transfer, and the Revised EIR must analyze the effects of this conversion.

The graphs in Appendix E of the Revised EIR illustrate the clear connection between the KWB Transfer and the region's conversion from annual crops to permanent crops. (See Revised EIR at E-43 to E-46.) This correlation is readily apparent in Tables 1 and 2, below. Table 1 depicts the cumulative growth in the total acreage of almonds in Kern County, based on the U.S. Department of Agriculture ("USDA") Census data from 1982 to 2012,[3] compared to the percentage of allocation (percentage of Table A requests delivered). (Revised EIR at E-44, Table 7.)[4] Table 2 depicts the amount of new almond acreage planted each year in Kern County[5] compared to the percent of SWP allocation. The tables show that the growth in cumulative acreage and increase in newly planted acreage of almonds in Kern County is an almost direct result of the KWB Transfer. (See Table 1 and 2.)

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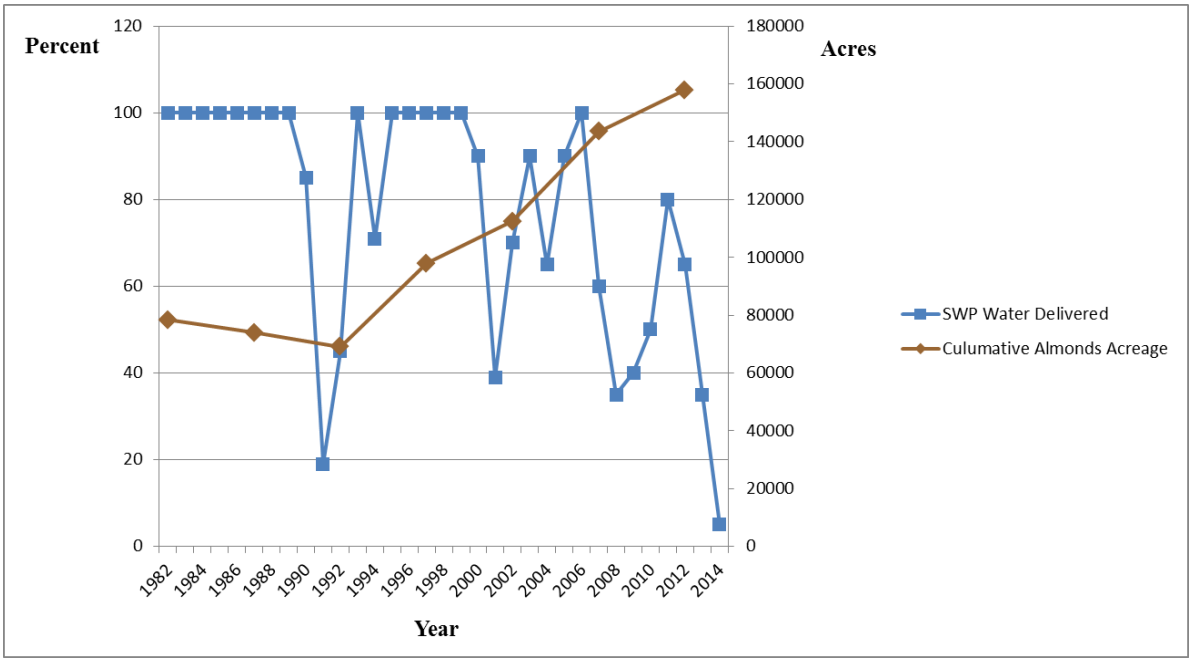
[3] USDA, *Census Publications – Census by State* (1982-2012), https://www.agcensus.usda.gov/Publications/2012/Full_Report/Census_by_State/.

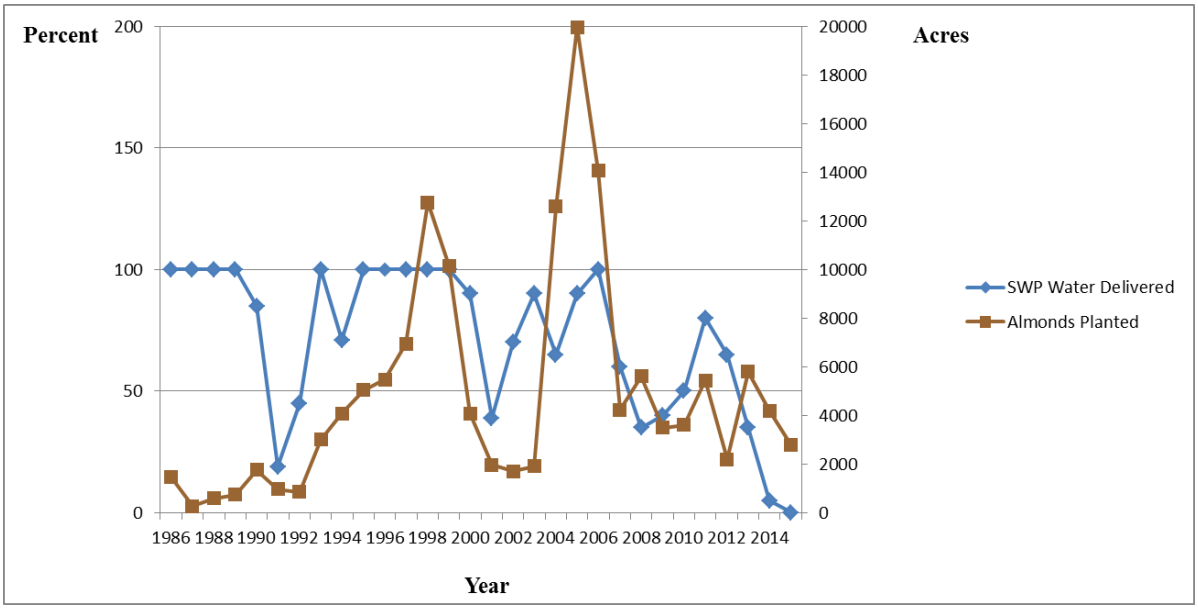
[4] The percent of Table A requests from 1982 to 1994 were calculated from DWR, *CalSim II Simulation of Historical SWP/CVP Operations, Technical Memorandum Report*, at 29 (Table 4) (Nov. 2003), http://baydeltaoffice.water.ca.gov/swpreliability/HistoricalSimulationReport_111203.pdf.

[5] California Department of Food and Agriculture Cooperating with USDA, National Agricultural Statistics Service, Pacific Regional Office, *2015 California Almond Acreage Report* (April 27, 2016), https://www.nass.usda.gov/Statistics_by_State/California/Publications/Fruits_and_Nuts/201605almac.pdf.



(Table 1)

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Cumulative Almonds	78,395					73,869					69,024					97,845					112,492					143,473					157,819		
SWP Water Delivered	100	100	100	100	100	100	100	100	85	19	45	100	71	100	100	100	100	100	90	39	70	90	65	90	100	60	35	40	50	80	65	35	5



(Table 2)

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Almonds Planted	1,454	277	586	746	1,768	963	856	3,009	4,089	5,050	5,473	6,940	12,758	10,156	4,073	1,974	1,705	1,904	12,580	19,963	14,062	4,233	5,616	3,493	3,613	5,441	2,186	5,795	4,186
SWP Water Delivered	100	100	100	100	85	19	45	100	71	100	100	100	100	100	90	39	70	90	65	90	100	60	35	40	50	80	65	35	5

For example, the years 2001 through 2005 witnessed a drought in which the total amount of Table A deliveries that was requested in Kern County was reduced due to a lack of available supply in the SWP system. (Tables 1 and 2.) Nonetheless, during that drought, there was a marked increase in Kern County in both the cumulative acreage as well as the amount of newly planted acreage of almonds. (*Id*.) Table 1 shows that cumulative acreage of almonds in Kern County decreased between 1982 and 1992, but between 1992 and 2012 the acreage of almonds nearly doubled, despite multiple droughts. (Table 1.) Table 2 shows that in 2004 only 65% of Table A requested water was delivered, but 12,580 new acres of almonds were planted. (Table 2.) In 2005, when only 90% of Table A water was delivered, 19,963 new acres of almonds were planted. (*Id*.)

In other words, while much of the state experienced water shortages, presumably leading to the fallowing of annual cropland to match agricultural needs with a diminished water supply, KWBA participants were enabled—by the KWB—to not only maintain their acreages of permanent crops but to plant more new permanent crops. (Table 1 and 2.) These trends continued during the most recent drought between 2007 and 2015, in which the state, for the first time in California history, ordered all urban water districts to reduce their water usage,[6] but KWBA participants maintained their water use and continued planting more permanent crops. (*Id*.; see Exhibit G.) What this means for California's water supply, and the other users throughout the state dependent on it, is not addressed at all in the Revised EIR, despite widespread acknowledgment that a conversion to permanent crops—and in particular almonds—may significantly impact California's water supply. (See Exhibit A, F, H-K.)[7]

Even if the KWB Transfer did not facilitate this conversion of crops—and the data presented indicates that it did—it would not relieve DWR of its duty to analyze the effects of the conversion of crops in the KWBA participants' service area. According to Table 7.6-6, permanent crops such as nuts, citrus, and fruit all increased by over 100%, while all annual crops

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[6] Executive Order B-29-15, https://www.gov.ca.gov/docs/4.1.15_Executive_Order.pdf (Attached as Exhibit G).

[7] *See* Kasler, *supra* note 1 ("[A]lmonds are permanent crops. They can't be fallowed in dry years, unlike rice, tomatoes, and other annual crops. Much of the increased planting in recent years has occurred on the west side of the San Joaquin Valley, where water supplies have become among the most fragile in California."); *see also* Philpott & Lurie, *supra* note 2 ("Unlike other crops, almonds always require a lot of water—even during drought. Annual crops like cotton, alfalfa, and veggies are flexible—farmers can fallow them in dry years. That's not so for nuts, which need to be watered every year, drought or no, or the trees die, wiping out farmers' investments."); *see also* United States Geological Survey (USGS), *Changing California Land Uses Will Shape Water Demand in 2062* (May 18, 2016) ("If past patterns of California land-use change continue, projected water needs by the year 2062 will increase beyond current supply."), https://www.usgs.gov/news/changing-california-land-uses-will-shape-water-demands-2062 (Attached as Exhibit H); *see also* Lei Wang, *California's Insane Nut Boom, in 3 Simple Charts*, Mother Jones (Nov. 3, 2014) ("A single almond requires a gallon of water to grow."), http://www.motherjones.com/environment/2014/11/almonds-water-walnuts-pistachios-california-drought-charts (Attached as Exhibit I); *see also* Eric Holthaus, *Stop Vilifying Almonds*, Slate (Apr. 17, 2015) ("Almonds use about as much water each year as the entire city of Los Angeles does in three, and about two-thirds of those nuts are exported … [a]lmonds use 10 percent of California's agricultural water supply."), http://www.slate.com/articles/business/moneybox/2015/04/almonds_in_california_they_use_up_a_lot_of_water_but_they_deserve_a_place.html (Attached as Exhibit J); *see also* Peter Fimrite, *California Drought: how Water Crisis is Worse for Almonds*, SF Gate (Mar. 4, 2014) ("A huge shift away from annual crops to nut trees has transformed the California farm belt over the past two decades and left farmers perilously vulnerable to the severe drought that is currently gripping the state."), http://www.sfgate.com/science/article/California-drought-How-water-crisis-is-worse-for-5341382.php (Attached as Exhibit K).

decreased by over 50%. (See Revised EIR at 7.6-7, Table 7.6-6.) The Revised EIR recognizes that annual field crops can be fallowed in dry/critically dry years, but permanent crops require a dedicated water supply. (Revised EIR at 7.6-13.) The Revised EIR further acknowledges that the "KWB increases the reliability of water supplies to its participants … [and] it is possible that KWB activities could result in additional land being converted to permanent crops." (Revised EIR at 7.6-14.) Nonetheless, the Revised EIR improperly states that this conversion is less than significant, without actually analyzing the impacts.

Data indicates that at a county scale, annual cropland losses to permanent cropland and development drive net increases in water demand. (Exhibit L.)[8] Net declines in water demand are only projected where losses of annual cropland exceed gains of permanent cropland and new developed land.[9] The Revised EIR shows that the gains in permanent cropland far exceeded the losses of annual cropland subsequent to the KWB Transfer. (Revised EIR at 7.6-7, Table 7.6-6.) In addition, there has been a significant increase in almonds, and almonds are the fourth most water intensive crop in California.[10] The Revised EIR identifies that groundwater resources may be depleted, but fails to analyze how a shifting to permanent crops may contribute to that depletion. (See Revised EIR at 7.1-33; see Exhibit M.)[11] The Revised EIR clearly fails to analyze the significant effects that conversion of annual cropland to permanent cropland has on California's water supply.

Once the Revised EIR recognizes that irrigated annual crops were converted to permanent crops, it must identify and analyze the impacts of that conversion to determine whether it is significant. It is impossible to mitigate the effects of converting to permanent crops that require a dedicated source of water without first identifying the significant environmental impacts of that conversion. (See *Sierra Club v. Board of Forestry* (1994) 7 Cal.4th 1215, 1233 [CEQA compels government first to identify the significant environmental effects of projects, and then to mitigate those effects through imposition of feasible mitigation measures or through selection of feasible alternatives].) The Revised EIR must determine whether there is any effect on the availability of water resources in the region and the flexibility of the water supply. We believe that the significance of this impact is obvious: by making the region's water supply *seemingly* more reliable, at least in the short term (since water bank withdrawals can be used to compensate for large drops in SWP deliveries during short-term droughts), the unfettered operation of the KWB hardens the demand for Delta water pumping. The Revised EIR must

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[8] Wilson et al., *Future Land-Use Related Water Demand in California*, Environ. Res. Lett. 11: 054018, at 8 (May 18, 2016), http://iopscience.iop.org/article/10.1088/1748-9326/11/5/054018 (Attached as Exhibit L); USGS, *supra* note 6 ("Assuming a 'business-as-usual' scenario of future land-use change, we show that the current pattern of increasing development and additional perennial cropland (orchards and vineyards) will lead to loss of grassland habitat and increased water use.").

[9] Wilson, *supra* note 8, at 8.

[10] *Id*. at 9.

[11] *See also* Gillis and Richtel, *Beneath California Crops, Groundwater Crisis Grows*, New York Times (Apr. 5, 2015) ("Even as the worst drought in decades ravages California, and its cities face mandatory cuts in water use, millions of pounds of thirsty crops like oranges, tomatoes and almonds continue to stream out of the state and onto the nation's grocery shelves. But the way that California farmers have pulled off that feat is a case study in unwise use of natural resources, many experts say. Farmers are drilling wells at a feverish pace and pumping billions of gallons of water from the ground, depleting a resource that was critically endangered before the drought."), http://www.nytimes.com/2015/04/06/science/beneath-california-crops-groundwater-crisis-grows.html?_r=0 (Attached as Exhibit M).

explore this impact. It must ask whether permanent crops require greater amounts of water over time, and whether permanent crops have different impacts on water supplies than annual crops.

The Revised EIR must also expand its analysis to consider impacts to the Delta caused by increased Delta pumping that has resulted from and will result from the KWB Transfer. The Revised EIR improperly confines its analysis to the geographic area of KWB lands and groundwater impacts. But the hardening of demand caused by the shift to permanent crops has had devastating impacts on the Delta ecosystem, impacts not previously disclosed or analyzed. Increased demand due to the planting of permanent crops places pressure on SWP deliveries, which in turn increases demand pressures on the Delta, which in turn affects fisheries and in-Delta water right users. Over the past few years of drought, the SWRCB has relaxed minimum in-Delta fishery and other water quality standards, primarily because exports were not decreased in prior years to plan for multiple drought years. The drought also resulted in SWRCB curtailment of senior right holders while exports continued. One cannot separate increased permanent demand created by the KWB from the ongoing stresses in the Delta and Delta water right holders.

Moreover, the recent decision in the Delta Stewardship Council Cases (Coordinated Case No. JCCP 4758, Sacramento Superior Court) concluded that the Delta Plan is required to specify decreases in exports from the Delta and that all areas served by export water were subject to Delta Plan mandates. As the KWB obtains the vast majority of its water from the SWP, it is subject to these mandates. The Revised EIR must therefore consider the Delta Plan and all likely mandated decreases in exports that it mandates, and analyze what impacts that process will have on KWB operations.

As these impacts are directly connected to the new significant impacts identified in the Revised EIR, they must be analyzed. As it stands now, the Revised EIR's analysis on agricultural resources, and in particular its analyses regarding the conversion of irrigated annual crops to permanent crops, is insufficient under CEQA.

ii. The Revised EIR Should Analyze the Significance of Article 21 and the KWB Transfer

The Revised EIR makes no revisions to Section 2, State Water Project; however, new data provided in the Agricultural Resources Section indicates that removal of Article 21(g)(1) from the baseline calculation was a significant impact that needs to be updated. Article 21(g)(1) provided for the delivery of surplus water to SWP contractors, but explicitly limited this water to non-permanent uses: DWR was required to refuse the delivery of such water to the extent that it determined such delivery would tend to encourage the development of an economy within the area served which would be dependent upon the sustained delivery of surplus water. (Monterey Plus FEIR at 6.1-9.) The Monterey Plus FEIR concluded that deletion of Article 21(g)(1) would not have a significant impact on the baseline because there was no difference in the baseline demand before or after the Monterey Amendment. (*Id.*) The FEIR stated that Article 21(g)(1) was designed to prevent the establishment of permanent agricultural crops based on the delivery of *scheduled* surplus water. (*Id.*) Since scheduled surplus water had not been available for about nine years prior to the Monterey Amendment and unscheduled (interruptible) water was

infrequently available in the same period (1987-1995), DWR reasoned that it was unlikely that anyone thought that intermittent Article 21 water would be used to support development of an economy in agriculture or municipal and industrial areas. (*Id*. at 6.1-9 to 6.1-10.)

These earlier conclusions and assumptions must now be revisited. The Revised EIR's data regarding the conversion of annual crops to permanent crops in Kern County, including within the KWBA member agencies' service areas, proves that surplus water—both scheduled and unscheduled/interruptible water—has been and likely will be used for growing permanent agricultural crops. At its core, the development and operation of the KWB facilitates the use of surplus water as irrigation for permanent crops, which is exactly what the Monterey Plus FEIR admits Article 21(g)(1) was intended to prevent. The Monterey Plus FEIR's assumption that it was unlikely that anybody thought that such water would be used for such a purpose has been proven false and the Revised EIR must now address this issue.

Specifically, the data regarding conversion from annual to permanent crops indicates that crop patterns changed substantially within the county between 1996 and 2014. (Revised EIR at 7.6-13.) Nuts, citrus, and fruit—all of which are permanent crops—increased by 189%, 238%, and 141% respectively in that time period in the KWBA participants' service area. (*Id*. at 7.6-7, Table 7.6-6.) What the Revised EIR does not analyze is how much surplus water—water that was formerly subject to Article 21(g)(1)'s restrictions—has been used to recharge the KWB, and thus how much surplus water has been used to irrigate permanent crops. There can be no question that, if Article 21(g)(1)'s restrictions applied to any amount of recharged water stored in the KWB, growers using KWB water may have made different crop selection decisions. The Revised EIR needs to include this data and then disclose and analyze the significant impacts that resulted and will result from the removal of Article 21(g)(1)'s restrictions.

c. Surface Water and Groundwater Hydrology

The Revised EIR admits to possible groundwater depletion as a result of the operation of the KWB, but concludes that this is only a potentially significant impact and that mitigation makes it less than significant. However, the Revised EIR explicitly states that relevant information needed to determine the significance of groundwater depletion on nearby water users was not gathered, despite acknowledgement that some wells have and will become inoperable. (Revised EIR at 7.1-33 and 10.1-19.) Moreover, the proposed mitigation measures only monitor groundwater depletion and pay for the damage after the fact, rather than mitigate the actual impact of a depleting groundwater supply. By rubber-stamping the mitigation measures already agreed to from the settlement agreement with the Rosedale parties, the Revised EIR ignores any possible alternatives that could avoid the significant impacts in the first place. The Revised EIR must identify and analyze alternatives in addition to mitigation measures; that the trial court in the Monterey Plus case found no fault with the Monterey Plus FEIR's alternatives does not absolve DWR from satisfying CEQA with regards to newly-identified significant impacts.

i. Groundwater Depletion

1. Lack of Analysis Regarding Groundwater Depletion

The Revised EIR does not contain the information necessary to determine the significance of groundwater depletion by KWB activities. In the Surface Water and Groundwater Hydrology Section, the Revised EIR recognizes that KWB operations could potentially deplete groundwater supplies so that a lowering of the local groundwater table level would occur (e.g., the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted). (Revised EIR at 7.1-33.) However, the Revised EIR does not analyze the significance that lowering the groundwater table will have on nearby water users. Instead, the Revised EIR asserts that whether KWBA's operations cause an impact that actually is significant at a specific agricultural or domestic well would depend on several factors, such as location of the well, depth of the well, operational depth of the pump, pump efficiency, and pumping rate. (*Id*. at 7.1-38.) The Revised EIR states that since this information for each well is not known, the specific potential impacts of KWB activities with respect to lowering of the local groundwater table at specific wells cannot be determined through modeling alone; the Revised EIR then makes no attempt to gather the necessary information to analyze the significant effects. (*Id*.)

In its analysis of past operations (1995-2014), the Revised EIR recognizes that KWB operations could lower the groundwater table up to fifty-five feet outside of KWB lands. (*Id*. at 7.1-34.) The Revised EIR notes that most private wells are perforated up to approximately 400 feet below ground surface ("bgs") and produce water at rates that meet domestic water use requirements.[12] (*Id*. at 7.1-38.) The Revised EIR estimates that KWB activities lowered groundwater levels to approximately 260 feet bgs at the end of 2007-2009 recovery period and to approximately 300 feet bgs at the end of the 2012-2014 recovery, which left approximately 100 feet of screened well below the water level. According to the Revised EIR, this would provide adequate flow to support operations at sufficient production rates for private wells. (*Id*.) The Revised EIR therefore concludes that KWBA operations are not expected to have a significant effect on operation of neighboring private landowner wells under historical low groundwater conditions except on those wells that are perforated to a depth less than 300 feet. (*Id*.)

The Revised EIR also recognizes that future activities will further deplete groundwater sources. In its analysis of future operations (2015-2035) under existing conditions, the Revised EIR reveals that KWB activities could lower groundwater levels to approximately 340 feet bgs at the end of the 2015 recovery period and to approximately 310 bgs at the end of the 2033-2035 recovery period. (*Id*. at 7.1-39.) This would leave only approximately sixty feet of screened well below the water level, and the Revised EIR again concludes that this provides adequate flow to support operations at sufficient production rates for private wells. (*Id*.) For its future analysis under build out conditions—in which 862 acres of recharge ponds will be developed including additional wells for pumping groundwater—the Revised EIR estimates that KWB activities lower groundwater levels to approximately 360 feet bgs at the end of the 2015 recovery period and to approximately 340 feet bgs at the end of the 2033-2035 recovery period. (*Id*. at 7.1-40.)

[12] No data is provided for the assumption that most private wells are perforated up to approximately 400 feet bgs.

DWR states that this would leave approximately forty feet of screened well below the water level, and again concludes that this would provide adequate flow to support operations at sufficient production rates for private wells. (*Id*.)

Thus, the Revised EIR acknowledges that KWB activities will deplete groundwater sources, but concludes that no matter how much depletion occurs there will be adequate flow to support operations at sufficient production rates for private wells; however, this conclusion is impossible without gathering information for each well that will be impacted, which the Revised EIR explicitly states has not been done. (See *Id.* at 7.1-38.) To the contrary, the Revised EIR presents evidence that indicates the groundwater depletion on private wells is significant and the flow is not adequate to support operations at sufficient production rates for private wells. Even more illuminating is the cumulative impacts analysis, which states that KWB activities "may cause groundwater levels to decrease such that some existing wells in an area immediately outside KWB Lands could become *inoperable*." (*Id*. at 10.1-19)(emphasis added.) The Revised EIR therefore recognizes that its activities may dry up nearby wells, but inexplicably states in its analysis that there will always be an adequate flow.

Evidence in the Revised EIR illustrates that groundwater depletion can be substantial enough to require landowners to make claims regarding significant groundwater impacts. (See *Id.* at 7.1-38) In 2014, KWBA and Rosedale developed and implemented an Interim Operations Plan ("Interim Plan") which designates measures to be employed to prevent, eliminate, or mitigate significant adverse impacts resulting from KWB and Rosedale project operations. (*Id*.) The plan requires the formation of a Joint Operations Committee ("JOC") that oversees implementation of the plan, including the establishment of a process to respond to and evaluate landowner claims associated with project operations including claims made prior to the Interim Plan. (*Id*.) The JOC sent letters in 2010 to those who made claims of groundwater impacts. (*Id*.) The letters alerted them to the potential for groundwater level declines to affect their wells and that the groundwater bank participants may be able to provide funds to help alleviate those impacts. (*Id*.) As of December 31, 2015, the JOC has evaluated claims made prior to the Interim Plan and has received twenty-one new claims from 2015. (*Id*.) Of the pre-Interim Plan claims, the JOC processed eight for payment and eight were rejected. (*Id*.) Of the 2015 claims, thirteen have been processed for payment and six have been rejected. (*Id*.) At this point, the JOC has authorized payments totaling approximately $447,800 as mitigation for the processed claims. (*Id*.)

This information directly contradicts the Revised EIR's claim that current groundwater depletion provides adequate flow to support operations at sufficient production rates for private wells; in fact, it reveals the opposite to be true: groundwater depletion is having a significant effect on nearby landowners, resulting in nearly half a million dollars expended to alleviate the harm caused by that depletion. The Revised EIR states that the money paid out was used to provide a permanent connection to a municipal water supply, lowering pumps in existing wells, and drilling deeper wells, and that any future impacts are less likely to occur because wells vulnerable to declining groundwater levels have already been permanently mitigated. (*Id*. at 7.1-39.) Claiming that the money was used to help fix certain vulnerable wells by no means proves that the problem has been permanently mitigated for those wells, especially considering that the Revised EIR predicts that future KWB activities will continue to lower the groundwater

table. Moreover, since information regarding specific wells in nearby communities is not provided, it is impossible to conclude that all vulnerable wells have been permanently mitigated and future impacts are less likely to occur. This is particularly apparent considering that more than half of the groundwater claims occurred *after* 2015.

Lastly, payment is not adequate mitigation to make the problem less than significant: private landowners may prefer maintaining their water supply instead of losing water in return for payment. Even if one could argue that the mitigation is sufficient, without a proper analysis of alternatives, the public and decision-makers have no way of knowing whether the impacts could be avoided in the first place, without having to resort to costly and possibly insufficient mitigation measures.

The Revised EIR must fully analyze alternatives to and mitigation measures for KWB's impact on groundwater depletion, with the goal of doing more than merely paying people for the Project's harms after the fact. To accurately determine the significance of groundwater depletion on private wells, the Revised EIR must include information regarding those wells. The Revised EIR's conclusions that there is adequate flow for private wells and vulnerable wells are permanently mitigated are erroneous without more information on nearby wells. The information on nearby wells is not difficult to ascertain, and the Revised EIR's analysis of groundwater depletion is insufficient.

2. Lack of Analysis Regarding Subsidence Due to Groundwater Depletion

In addition, groundwater depletion could lead to the significant effect of subsidence, in which the land above groundwater begins to sink, causing permanent damage. (Exhibit N.)[13] Subsidence is a particular concern when annual crops change to permanent crops because there is less flexibility for farmers during droughts, causing them to increase groundwater pumping.[14] The Revised EIR mentions that KWB activities can potentially cause or contribute to subsidence as a result of groundwater extraction, but concludes that this impact is less than significant because no subsidence has occurred in the KWB area. (Revised EIR at 7.8-10 to 7.8-11.) Just because subsidence has not yet occurred in the KWB area does not mean that it will not occur in the future. The Revised EIR models show that groundwater depletion is occurring and will continue to occur, but the Revised EIR does not use those models to evaluate potential subsidence in the area resulting from continued and increased groundwater depletion. The Revised EIR must analyze the potential for continued groundwater depletion to cause subsidence in the KWB and surrounding areas, rather than relying purely on the observation that no subsidence has yet occurred.

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[13] Amy Quinton, *USGS Study: 1200 Square Miles of Central Valley Land is Sinking*, Capital Public Radio News (Nov. 22, 2013) ("[E]xcessive groundwater pumping causes [] subsidence."), http://www.capradio.org/articles/2013/11/22/usgs-study-1200-square-miles-of-central-valley-land-is-sinking/ (Attached as Exhibit N).

[14] *Id*. ("[T]he subsidence area has seen more row crops change to permanent crops. 'That has the effect of providing less flexibility for farmers when there are droughts because these permanent crops will need water during droughts … if you have row crops then perhaps fallowing the land during drought would be an option.")

3. Lack of Cumulative Impact Analysis Regarding the Aquifer Deficit and Groundwater Depletion

The cumulative impact analysis regarding the aquifer deficit and depletion of groundwater supplies is also woefully inadequate. Under the CEQA Guidelines, an impact is cumulatively considerable when the "incremental effects of an individual project are significant when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects." (CEQA Guidelines, § 15064, subd. (h)(1).) The Revised EIR identifies current water banking activities within the area and recognizes that KWB activities may have cumulative impacts on the net aquifer deficit as well as groundwater depletion; yet the Revised EIR only analyzes KWB activities, failing to analyze the impacts of the other current regional water banking activities or activities of other nearby water users. Without analyzing the impacts of the other water banking activities or water users, it is impossible to determine the significant cumulative impacts of KWB activities.

a. Aquifer

The Revised EIR fails to analyze the cumulative impacts KWB operations has on the aquifer used by the KWBA participants. In its cumulative impact analysis regarding whether KWB activities, in combination with regional and local water banking projects, could potentially deplete groundwater supplies so that a net deficit in aquifer volume of stored groundwater would occur, the Revised EIR simply reiterates what it said in its non-cumulative impact analysis. (Revised EIR at 10.1-19.) The Revised EIR claims that there will not be a net deficit in aquifer volume of stored water because at the end of 1995-2014 historical KWB modeled operations, there was an accumulated balance of about 617,000 AF of stored water. (*Id*.) This number is based on a model of past operations between 1995 and 2014, in which DWR estimated a recharge of 2,006,372 AF at the KWB facilities, and estimated a recovery of only 1,389,113 AF, resulting in a net balance of 617,000 AF. (*Id*. at 7.1-30.) However, this number is based only on a model of KWB facilities. No information is provided regarding the other identified operations that use the same aquifer, and thus it is impossible to determine cumulative impacts, even if KWB modeled a net accumulation in its own water use.

More importantly, the Revised EIR does not contain an analysis of the actual needs of the KWBA participants to extract water from the KWB lands for recovery under different hydrologic cycles. As explained above, there is a growing trend in converting annual crops into permanent crops, but no information is presented regarding how that change impacts the water demands of KWBA participants. There is no way to determine how changing trends in crop patterns resulted in the net balance of 617,000 AF in a twenty year period, and whether it can be assumed that the next twenty years will be similar to the 1995-2014 analysis. In relation to the cumulative impacts analysis, the Revised EIR does not identify the other water users who use the aquifer or their changing water demands. Without information about KWBA participants' and other aquifer users' water demands, the Revised EIR cannot determine whether KWB activities are having a significant cumulative impact.

b. Groundwater

The Revised EIR also fails to properly analyze the cumulative impacts that KWB activities have on the depletion of groundwater resources. In its cumulative impact analysis regarding whether KWB activities, in combination with regional and local water banking projects, could potentially deplete groundwater supplies so that a lowering of the local groundwater table level would occur, the Revised EIR again only reiterates what it said in its non-cumulative impact analysis. (Revised EIR at 10.1-19.) The cumulative impact analysis recognizes that KWB activities may decrease water levels such that some existing wells in an area immediately outside KWB Lands could become "inoperable."[15] (*Id*.) But the Revised EIR then gives similar reasoning for why it cannot determine whether the impact is actually significant: "whether the impact actually would be significant (i.e., substantial) would depend on several factors, including the specific field conditions and physical characteristics of the agricultural and domestic wells in the affected area." (*Id*.) The Revised EIR does not present any information regarding other agricultural and domestic wells in the affected area. The Revised EIR then makes the assumption that "all groundwater banks generally have similar operations: recharge when water supplies are available and recovery when water supplies are scarce." According to the Revised EIR, "numerous water banks adjacent to the KWB and in the same region would operate similarly and potentially result in an overall significant cumulative impact. Therefore, this would be a potentially significant cumulative impact." This is the extent of the analysis.

In the preceding groundwater analysis section, the Revised EIR recognizes that KWB activities *alone* will decrease the groundwater table; in fact, it will decrease so much that wells will become inoperable. This determination is made without analyzing other wells in the area or other water banking activities. If other water banking activities have similar impacts to KWB's activities, than it would presumably follow that many wells would become inoperable due to a severe depletion in groundwater. The Revised EIR identifies multiple other nearby banking projects, including the Pioneer Groundwater Recharge and Recovery Project; the Rosedale-Rio Bravo Water Storage District Groundwater Storage, Baking, Exchange, Extraction and Conjunctive Use Program; Rosedale-Rio Bravo Water Storage District/ID4 Joint-Use Groundwater Recovery Program; Rosedale-Rio Bravo Water Storage District/Irvine Ranch Water District Integrated Banking Project; and the West Kern Water District/Buena Vista Water Storage District Joint-Use Recharge Facility; however, the Revised EIR does not provide information regarding the amount of groundwater depletion caused by any of those other water banks. (*Id*. at 10.1-9 to 10.1-10.) The Revised EIR nonetheless assumes that the cumulative impact of KWB activities to groundwater depletion is only a potentially significant impact.

In order to determine the significance of the cumulative impact of KWB activities, the Revised EIR must analyze the rate at which other banking activities and other water users deplete the groundwater. Without providing this information, which should be feasible, the Revised EIR cannot determine the significance of the cumulative impact of KWB activities, and in turn cannot adequately identify necessary mitigation measures.

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[15] It's worth noting that the Revised EIR recognizes wells will become inoperable, without evaluating the impacts of other regional or local water banks, but does not use the term "inoperable" in its preceding analysis of groundwater depletion.

4. Improper Mitigation Measures to Prevent Groundwater Depletion

The Revised EIR fails to adopt proper mitigation measures to prevent depletion of groundwater resources or make the impact less than significant. Agencies are required to adopt feasible mitigation measures in order to substantially lessen or avoid the otherwise significant adverse environmental impacts of proposed projects. (Pub. Resources Code, §§ 21002, 21081, subd. (a); CEQA Guidelines. §§ 15002, subd. (a)(3), 15021, subd. (a)(2), 15091, subd. (a)(1).) Mitigation measures should be capable of: (a) "[a]voiding the impact altogether by not taking a certain action or parts of an action;" (b) "[m]inimizing impacts by limiting the degree or magnitude of the action and its implementation;" (c) "[r]ectifying the impact by repairing, rehabilitating, or restoring the impacted environment;" or (d) "[r]educing or eliminating the impact over time by preservation and maintenance of operations during the life of the action." (CEQA Guidelines, § 15370.) The Revised EIR must set forth mitigation measures that decision-makers can adopt at the findings stage of the planning process. (Pub. Resources Code, § 21100, subd. (b)(3); CEQA Guidelines, §§ 15126, subd. (e), 15126.4.)

Here, the Revised EIR's improper analysis of groundwater depletion and lack of cumulative impact analysis illustrate the deficiency of the proposed mitigation measures. The Revised EIR's mitigation measures include monitoring and reporting groundwater conditions; implementing proactive measures such as identifying at risk wells; providing mitigation and/or compensation for adverse impacts cause by KWB activities; reducing or adjusting pumping at KWBA's option if necessary; and finding other suitable sources of water for a user who is adversely impacted. (Revised EIR at 7.1-49 to 7.1-54.) These mitigation measures do not avoid the impact, minimize the impact, rectify the impact by restoring the impacted environment, or reduce the impact overtime.

The Revised EIR merely commits to monitoring groundwater and essentially paying landowners when groundwater is depleted. The Revised EIR states that it will use a model to calculate a negative potential impact ("NPI") in which KWB operations deplete groundwater by at least thirty feet, but no commitment is made to mitigation measures other than KWBA participants reducing pumping at its option and/or KWBA participants compensating well owners based on submission of a claim. These mitigation measures do not prevent or mitigate the depletion of groundwater identified in the Revised EIR, nor do they make the impacts of KWB operations less than significant. Rather, these mitigation measures are designed to pay-off nearby water users after depletion of groundwater has already occurred. Lastly, the Revised EIR states that "it is possible that a joint long-term agreement will be developed in the near future between KWBA, Rosedale, and the Pioneer Project for the coordinated implementation of a long-term banking operations plan that includes standards that address potential cumulative impacts of the participating water banks." (Revised EIR at 7.1-49.) Twenty years has passed in which these agencies could have identified mitigation measures, and assuming that KWBA may enter into a future long-term agreement to prevent cumulative impacts falls far short of measures necessary to mitigate cumulative groundwater depletion.

5. Failure to Evaluate Alternatives

The Revised EIR fails to analyze any alternatives that could avoid or lessen the significant impacts of the project. An EIR must describe a reasonable range of alternatives to the project, or to the location of the project, that could feasibly attain most of the basic objectives of the project while avoiding or substantially lessening any of the significant effects of the project. (CEQA Guidelines, § 15126.6, subds. (a), (f).) Alternatives analyzed in the EIR need not be actually feasible, but rather need only be "potentially feasible." (CEQA Guidelines, § 15126.6, subd. (f)(1).) The Revised EIR identifies significant and potentially significant impacts from transferring the KWB, but does not include an analysis of any alternatives, relying completely on the alternatives analysis in the Monterey Plus FEIR, which provided four different variations of the "no project" alternative. That analysis fails to consider the significant impacts identified for the first time in the Revised EIR.

The Revised EIR recognizes that the KWB Transfer could result in a conversion of annual crops to permanent crops as well as a depletion of the groundwater table, but does not analyze alternatives that would avoid or lessen the harms caused by those impacts. For issues related to conversion of permanent crops that require a dependable water supply, the Revised EIR must evaluate an alternative that has safeguards for the use of surplus water to prohibit the creation of permanent economies, or limits the use of surplus water that could be used to create permanent economies. An evaluation of alternatives that limits surplus water for use in permanent economies would allow for adequate analysis of the project's impacts on the state water supply. Here, the Revised EIR evaluates no alternatives, ignoring the widespread conversion to permanent crops that has occurred because of the KWB Transfer.

The Revised EIR must also analyze alternatives that avoid or lessen the significant impacts on groundwater resources. The Revised EIR should analyze alternatives that require a certain amount of water to be recharged before recovery, or set limits on the amount of water recovered, to ensure reliability of groundwater and aquifer resources; as it stands, there are no actual limits to the amount of water that KWBA participants may withdraw, which the Revised EIR identifies has potentially significant impacts on the depletion of groundwater and net aquifer deficit.

6. Inadequate "No Project" Alternative

The Revised EIR must also update the "no project" alternatives based on the new data. The purpose of the "no project" alternatives is to allow decision-makers to compare the impacts of approving the proposed project with the impacts of not approving the proposed project. (CEQA Guidelines § 15126.6, subd. (e).) Due to the unique nature of this EIR, in which the project took place prior to approval, there is data in the Revised EIR that will allow decision-makers to make a more informed decision.

Here, the Revised EIR indicates that since 1995 there has been a substantial change in crop patterns, in which annual crops that are capable of being fallowed in dry years have been converted to permanent crops that require a dedicated water supply. That impact must be included in the "no project" alternatives to help decision-makers understand the impacts of approving the project. The Revised EIR additionally recognizes that the KWB transfer resulted

in a depletion of groundwater resources, and that data must be included in the "no project" alternatives.

The lack of alternatives and the insufficient "no project" alternatives are clear deficiencies in the Revised EIR.

III. CONCLUSION

The Revised EIR is inadequate and based on incomplete analyses, lacks critical data, and ignores significant impacts. The Revised EIR's conclusions are erroneous and indicate DWR's failure to properly evaluate the impacts of transferring the KWB under CEQA. DWR must prepare an adequate EIR that evaluates the significant impacts identified, alternatives to avoid significant impacts, and proper mitigation.

Sincerely,

Ryan Berghoff
Center for Food Safety

Carolee Krieger
California Water Impact Network

Bill Jennings
California Sportfishing Protection Alliance

John Buse
Center for Biological Diversity

Dante Nomellini
Central Delta Water Agency

John Herrick
South Delta Water Agency

EXHIBIT A

WATER & DROUGHT APRIL 16, 2015 3:32 PM

California almond growers to expand orchards, despite drought

HIGHLIGHTS

California's almond farmers have been criticized in some quarters for using too much water. A new report says growers will continue to expand their orchards. The Almond Board said the industry shouldn't be blamed for the drought.

1 of 2

BY DALE KASLER
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Almond orchards have become ground zero in the debate over California's epic drought, the focal point of criticism that agriculture uses too much water.

The response? More almond trees.

California's almond farmers are likely to continue planting new orchards in the coming years, increasing production by 2 percent to 3.5 percent a year over the next decade, one of the state's leading farm economists said Thursday.

"Higher prices and good profits for California almond growers will continue to encourage more planting of almond orchards," economist Vernon Crowder, senior vice president at Rabobank, said in a report released by the bank. "Nurseries report very little slowing in orders of new trees."

Representatives of the state's almond farmers defended the decision to expand California's orchards, saying growers with adequate water supplies are making rational economic decisions based on the price they can get for their crop.

"That's the American economic system," said Richard Waycott, chief executive of the Almond Board of California, in a conference call Thursday with reporters.

"It's basically 6,500 farmers making these decisions," he added. "Nobody's telling them to do that."

Agriculture in general is under fire as the drought worsens. Critics say farmers use 80 percent of the water dedicated to human use in California but generate only about 2 percent of the state's economic output. Gov. Jerry Brown has defended his decision to exempt agriculture from his recent executive order mandating a 25 percent cut in consumption by urban water agencies statewide, saying farmers already have had their surface supplies curtailed considerably.

On Thursday, Brown argued against any effort to curtail production of water-intensive crops. "That's a 'Big Brother' move, and we're not in that position," Brown told reporters after a drought-related meeting at the Capitol.

"Agriculture is an important pillar of California," Brown said, "and I think we have to be very slow to be starting to pick" among crops, with policies favoring one over another.

Farmers also say that the 80 percent figure is misleading. When environmental uses are taken into account, agriculture's share of California's water supply falls to around 40 percent.

The state's agricultural industry, and almonds in particular, have nonetheless taken a public relations beating in recent weeks. As the nut's popularity has boomed, the amount of California farmland devoted to almonds has nearly doubled over the past 20 years, to more than 900,000 acres. The state's almond crop is worth more than $4 billion a year as prices have risen to nearly $4 a pound, record territory.

That's proved controversial in an epic drought because almond trees are permanent crops. They can't be fallowed in dry years, unlike rice, tomatoes and other annual crops. Much of the increased planting in recent years has occurred on the west side of the San Joaquin Valley, where water supplies have become among the most fragile in California.

Growers who have planted orchards in the San Joaquin area "are finding out that you can get burned," Crowder said.

What's more, almonds get criticized for using lots of water. An oft-quoted statistic says it takes a gallon of water to produce a single almond. Many in California agriculture say that's too simplistic a statistic.

But there is little dispute that almonds are among the thirstiest crops in California. Almond trees require about 4 acre-feet of water a year for every acre planted, according to data gathered by David Goldhamer, a water management specialist emeritus with the UC Cooperative Extension. Tomatoes and grapes take about half as much water, as does cotton – a crop that has seen its acreage diminish as almond orchards have spread. Among major crops, only alfalfa takes more water per acre than almonds.

Almond farming has hardly been immune to the effects of the drought. Yields fell, and the crop shrank by 12 percent last year despite the growth in acreage, Crowder said.

Nor have farmers been oblivious to the state's water woes, Waycott said. The growers are converting to highly efficient irrigation systems, and some of them have had to rip out their trees when they've been unable to get water.

"We do have areas where people have thrown in the towel and orchards have been abandoned," Waycott said. "That is a trend. It's not a huge trend yet."

The almond boom in California is in many respects an international phenomenon. Almonds have become enormously popular as snack foods and cooking ingredients in Western Europe, China, India and other growth markets. California produces about 80 percent of the world's supply, and exports have grown 40 percent in three years.

Crowder said he expects prices to moderate before too long, but almonds will continue to be a very profitable crop for most farmers. That suggests most farmers will find a way to stay in the almond business.

"These guys are in the business of making money on farming," Crowder said. "They know what they need to do to make a living, and it's selling almonds to the world."

EXHIBIT B

Almond Production in California

Daniel Geisseler and William R. Horwath

Background

Almonds were planted in California as early as 1853 [12]. The varieties used were of European origin. In many locations they seem to be poorly adapted to the climatic conditions and were irregular bearers [12]. Many almond trees, especially those planted in the south, were thus either grafted over into prunes or plums or were made into firewood. The varieties, however, were not alone to blame. The lack of knowledge about the need for cross-pollination also contributed to the unsatisfactory results. In the 1880s, local varieties, more adapted to the climatic conditions, became available and allowed for profitable production of high quality almonds [12]. In 1886 A.T. Hatch of Suisun presented a number of varieties at the Citrus Fair in Sacramento, including Nonpareil and Ne Plus Ultra [12]. These two varieties are still planted today, with Nonpareil still being the dominant variety [1]. Furthermore, the need for cross-pollination with compatible cultivars was established in the early 1900s. This greatly improved production [7].

Initially, almonds were mainly planted on higher lands in coastal valleys, free from fog and protected from direct wind, as well as in the interior valleys and foothills. Almonds were recommended to be planted on light soil. They were expected to produce good crops on soils that are too sandy and dry to grow peaches or nectarines. Most often, almonds were produced without irrigation [12]. With adapted varieties available, almond production increased steadily. While the statewide production was about 250 tons in 1888, it averaged 2250 tons between 1910 and 1914 and 4600 tons between 1915 and 1919 [10, 13]. Even though it was recognized early that irrigated almond trees produce larger crops, growers did not start to apply irrigation water until the 1930s [14]. The almond acreage continued to increase slightly, reaching 100,000 acres of bearing almond trees in 1964. In this period fell the shift from hand to mechanical harvest [6]. A mayor expansion of almond production took place between 1964 and 1985 when the area increased to more than 400,000 acres. Product development and marketing contributed significantly to this increase in acreage, with innovative new products leading to expanded markets of almond products [4]. A second factor was the increase in the irrigated area in the San Joaquin Valley, where soils and climatic conditions are ideal for almond production [4].

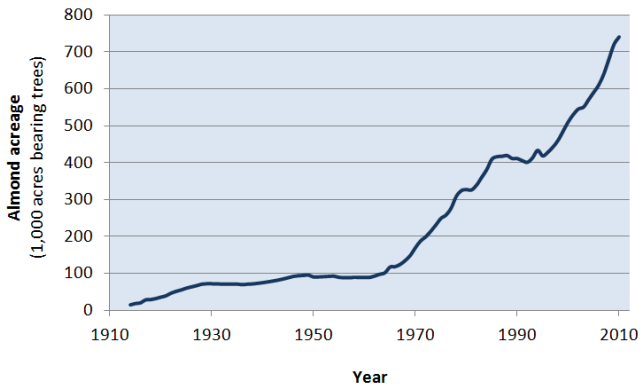

Figure 1: Area of bearing almond trees in California since 1914 [10, 14].

While the acreage remained relatively stable between 1985 and 1995, it increased again reaching a new high in 2011 with 760,000 acres of bearing orchards producing 2.02 billion pounds of almonds, which accounted for 84% of the global production [1].

Production area

In the 1930s, almonds were grown from Shasta county in the north to Riverside and San Diego counties in the south, with the main production areas being the Sacramento Valley, San Luis Obispo county and the northern San Joaquin Valley [14]. In 1950, 50% of California's almonds were still produced in the Sacramento Valley, while the San Joaquin Valley and the coastal counties contributed 25% each [5]. However, by 1970, the major areas of almond production had moved to the San Joaquin Valley, and most of the expansion since then has taken place there [4]. Today, Kern, Fresno, Stanislaus, Merced and Madera counties together produce three thirds of California's almonds (Figure 3) [11]. The shift in production was due California Water Project, which increased the availability of irrigation water in the San Joaquin Valley [4]. Better soils and a more favorable climate with less rainfall and warmer temperatures at bloom have also contributed to the popularity of almonds in the San Joaquin Valley [4].

Figure 3: Location of the five leading almond producing counties in California [11].

Yield

The early almond plantings were seen as unreliable and did not seem to be adapted to California's conditions [2]. The development of local varieties and the recognition, that almond are self sterile, were two important steps towards stable yields and profitable almond production. The yield of almonds has increased tremendously over the years. From 1915 to 1935 the average yields in California's almond orchards remained relatively stable at approximately 210 lbs/acre shelled almonds [10]. By 1960, the yield had more than tripled. The increased use of irrigation contributed significantly to the higher yields during this period. Since the 1960s, the yield has increased even faster, reaching an average of 2100 lbs/acre in the period from 2006 to 2010 [10]. The relatively large yield fluctuations are mainly due to the effects of varying late winter and spring weather conditions, with rain and cool temperatures during bloom resulting in lower yields [7].

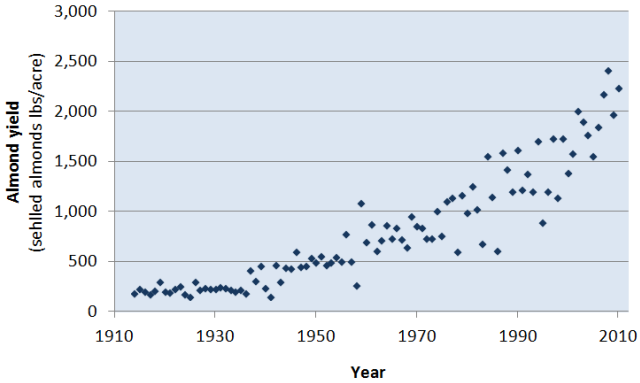

Figure 2: Almond yield since 1914 in California [10, 14].

Several factors have contributed to the astonishing yield increase, including practices to maximize cross-pollination, selection of adapted rootstocks, as well as improved fertilization, irrigation and pest management [4, 2]. Compared to many other crops, the genetic improvement of varieties is likely of lesser importance. The major variety "Nonpareil", which accounts for 39% of the almonds produced in 2011/12 [1], was already introduced in 1886 [12].

Fertilization

Different surveys about almond fertilization have been carried out since the late 1990s. Based on a survey conducted by the USDA in 1999, California almond growers applied some 134 lbs N/acre. In the same year, the potassium (K_2O) and phosphate (P_2O_5) applications reached 127 and 85 lbs/acre [9]. Nitrogen was applied by more than 90% of the growers, while potassium and phosphorus were applied by one out of four growers [9].

In a FREP-funded survey conducted in the San Joaquin Valley in 1999, King found that all growers interviewed applied N fertilizer to almonds between March and September. The application rate ranged from 50 to 350 lbs/acre, averaging 150 lbs/acre [3]. The most widely used fertilizer was UN32, followed by CAN 17. More than half of the growers applied N via a pressurized irrigation system, while a third used broadcast application. Shanking the N in or applying it with flood irrigation were other practices reported. About a third of the growers reported applying N during the winter months with an average application rate of 70 lbs/acre [3]. Similar results in terms of preferred N fertilizers and application time were obtained in a survey carried out in 2007 by a research team led by Patrick Brown among California Almond growers [8]. In addition, the survey revealed that potassium sulfate was the preferred K fertilizer, followed by potassium thiosulfate and potassium chloride. The proportion of growers using fertigation had grown to two thirds and 80 to 90% of growers reported applying foliar N, P and K at least once a year [8].

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This document is available online at https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Almond_Production_CA.pdf

Last update: June, 2016

EXHIBIT C

AGRICULTURE APRIL 29, 2016 4:18 PM

California almond acreage continues to grow

HIGHLIGHTS

California almond acreage grew by 6 percent in 2015

Fresno County is one of the leading almond growers in the state

But Fresno County farmer George Goshgarian raises alarms about industry's immediate future

BY ROBERT RODRIGUEZ
brodriguez@fresnobee.com

California almonds, one of the state's largest crops, increased in acreage by 6 percent last year.

Statewide, a recent federal survey estimates the acreage to be 1.1 million acres. Of that, 890,000 acres of trees are producing nuts and 220,000 acres are young trees.

The leading almond growing counties include Kern, Fresno, Stanislaus, Merced and Madera. The five counties represent 73 percent of the producing acreage in the state.

In 2015, Fresno County had 110,995 acres of trees in production and 15,552 acres of non-bearing trees. Madera had 79,092 bearing acres and 10,039 non-bearing acres.

Almond industry officials say the growth represents strong demand from domestic and overseas consumers. But that red-hot market began to cool last year as the industry's major export markets, including China and India, bought less. A strong U.S. dollar also hurt sales.

Fresno County farmer George Goshgarian estimates the price of a pound of almonds has tumbled at least 60 percent since September.

"Right now, we may be averaging about $2," Goshgarian said. "And some guys are getting really close to being in the negative."

And it remains to be seen if the decline in prices will significantly slow the planting of new acreage.

60 percent

Drop in the price of processed almonds since September, Fresno County farmer George Goshgarian estimates

The preliminary acreage estimate for 2016 is 900,000, according to the U.S. Department of Agriculture's National Agricultural Statistics Service.

Goshgarian hopes the foreign markets will rebound, and he isn't convinced prices have stabilized.

Many in the industry are waiting for the USDA's "subjective" estimate of the 2016 crop. That report, expected May 10, will help dictate the direction of the market.

Later in the season, the government will issue a more thorough estimate known as the "objective" estimate. That is due in June.

One factor that could slow almond expansion is the availability of water. The state recently emerged from four consecutive dry years that cost farmers deeply. With a lack of surface water, farmers spent millions to dig new wells or repair old ones. The industry also suffered from a public backlash for how much water it used to grow nuts.

Industry officials have tried to combat the bad publicity with figures showing that the shift to higher value crops, like almonds, has not led to a rise in agricultural water use.

According to figures from the California Department of Water Resources, water used by agriculture has held steady since 2000 and declined over a longer period of time because of higher efficiency irrigation systems.

"Because of the industry's commitment to research and efficiency, growers use 33 percent less water to grow a pound of almonds than they did two decades ago," said Richard Waycott, chief executive officer of the Almond Board of California.

Robert Rodriguez: 559-441-6327, @FresnoBeeBob

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EXHIBIT D

REAP WHAT YOU SOW 8 (http://fusion.net/2015/08/)/27 (http://fusion.net/2015/08/27/)/15 (http://fusion.net/2015/) 1:19 PM

Thank almonds, pistachios, wine, and groundwater for California's record harvest

By Ari Phillips (http://fusion.net/author/ari-phillips/)

(http://fusion.net/video/308961/tcgs-paul-scheer-jason-mantzoukas/)

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Lin-Manuel Miranda says Donald Trump is spreading 'a virulent strain of a virus' (http://fusion.net/story/301594/lin-manuel-miranda-hamilton-puerto-rico/)

By Ari Phillips (http://fusion.net/author/ari-phillips/)

By Ari Phillips (http://fusion.net/author/ari-phillips/)

A new study (http://pacinst.org/wp-content/uploads/sites/21/2015/08/ImpactsOnCaliforniaDrought-Ag.pdf) this week from the Pacific Institute, an Oakland-based environmental think tank, has found that even as California undergoes an extreme drought, agricultural output—which accounts for (http://www.washingtonpost.com/blogs/govbeat/wp/2015/04/03/agriculture-is-80-percent-of-water-use-in-california-why-arent-farmers-being-forced-to-cut-back/) 80% of California's water use—is at a record level.

The report determined that crop revenue peaked in 2013 at $34 billion, the highest level in the state's history, before declining slightly in 2014 by 1.4%, still the second-highest year on record. These numbers are good for industry jobs and

economic indicators—the state is the country's largest agricultural producer—but they are built upon an unstable foundation, according to the report, which concludes that:

> California's agriculture sector has exceeded expectations during the most severe drought in recorded history at the cost of massive but unsustainable groundwater pumping. Continued groundwater overdraft…has shifted the burden to others, including current and future generations forced to dig deeper wells, find alternative drinking water sources, and repair infrastructure damaged by subsidence.

Evidence of excessive groundwater use in California has recently been documented by sinking farmland (http://www.christiantoday.com/article/california.is.sinking.faster.than.thought.as.drought.leads.to.massive.groundwater.loss/63104.htm) in the Central Valley, where the massive pumping of well water has led to land subsistence, or sinking, of up to two inches a month in some areas.

The Pacific Institute study, which is the first comprehensive analysis of the impacts of the drought on California agriculture through 2014, also determined that crop revenue stability is not only a result of groundwater overdraft, but also a shift to higher-value crops such as almonds, pistachios, and wine grapes. The total increase in fruit and nut acreage since 2000 was 570,000 acres, or 24%, according to the study. Nut orchards, unlike vegetable crops, can't be left fallow during dry years, which presents a long-term challenge for agricultural water use in the region.

"In the longer term, we really do need to make sure that we recharge groundwater in wetter years," Jay Lund, director of the Center for Watershed Sciences at UC Davis, told (http://www.usatoday.com/story/money/business/2015/08/26/california-drought-agriculture/32443709/) the AP. "So that we have it available to keep these much more profitable permanent crops going through dry years."

"The drought has certainly bitten us, but California agriculture by and large is still thriving in most places," Lund continued. "We think that both the jobs and the revenues would be quite a bit more if it weren't for the drought."

There are a number of other factors feeding into this perseverance. Crop productivity, or tonnage per acre, has also increased for some important crops, such as strawberries, tomatoes, and walnuts, according to the study. Crop prices have also generally increased over the last decade.

Increases in efficiency, which include a shift towards drip irrigation, have actually made it so that a full million acres less of cropland was harvested in 2014 compared to 2000, according to the study. In 2014, farmers harvested 640,000 fewer acres, or nearly 10%, less than when compared to pre-drought levels, even as revenue remained strong.

The Pacific Institute also estimated that farmers choosing to voluntarily sell their water to non-agricultural users such as municipalities, industries, and environmental flows, boosted revenue by at least $66 million in 2014.

When it comes to jobs, the study found that statewide agriculture-related jobs also reached a record-high of 417,000 people in 2014. However a recent study (http://www.scribd.com/doc/275033974/Aug-2014-Final-Drought-Report) from the University of California, Davis, found that more than 21,000 farm workers are out of work in 2015 due to California's drought. It also found that those with a job are working harder and making less money. A big part (http://www.npr.org/sections/thesalt/2015/08/27/434763709/farmworkers-see-jobs-earnings-shrivel-in-california-drought) of this problem is smaller fruit, due to the drought, which takes longer to gather and yields less value. The analysis determined that losses to all economic sectors because of the 2105 drought will be as high as $2.74 billion.

Regardless the authors of the Pacific Institute study state that "ultimately, California agriculture is changing in many ways to withstand the ongoing drought."

"The study's authors provide critical insight into how the state can maintain a healthy agriculture sector in a future likely to see less water, more extreme weather, and greater uncertainty," they state.

to see less water, more extreme weather, and greater uncertainty," they state.

There may be some short term relief in sight, as forecasters are predicting (http://news.yahoo.com/drought-plagued-california-readies-el-nino-storms-060555034.html) a record-setting El Niño, or warming of the Pacific Ocean, to bring heavy rain to the drought-ridden state over the winter. Mike Halpert, deputy director of the National Oceanic Atmospheric Administration's Climate Prediction Center, told (http://news.yahoo.com/drought-plagued-california-readies-el-nino-storms-060555034.html) the AP that California would need 1.5 times its average rainfall to emerge from the extended drought, an amount he thinks is unlikely.

Some things that are likely if there is a strong El Niño: flooding, landslides, and a return to the current hot and dry conditions that scientists have confirmed have been heavily influenced by climate change. Just last week a comprehensive study was released (http://thinkprogress.org/climate/2015/08/20/3692972/quantifying-climate-change-in-californias-drought/) showing that climate change was likely responsible for worsening the current drought by 15 to 20%.

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EXHIBIT E

IMPACTS OF CALIFORNIA'S ONGOING DROUGHT: Agriculture

Heather Cooley
Kristina Donnelly
Rapichan Phurisamban
Madhyama Subramanian

PACIFIC INSTITUTE

August 2015

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The Pacific Institute envisions a world in which society, the economy, and the environment have the water they need to thrive now and in the future. In pursuit of this vision, the Pacific Institute creates and advances solutions to the world's most pressing water challenges, such as unsustainable water management and use, climate change, environmental degradation, food, fiber, and energy production, and basic lack of access to fresh water and sanitation.

Since 1987, the Pacific Institute has cut across traditional areas of study and actively collaborated with a diverse set of stakeholders, including leading policy makers, scientists, corporate leaders, international organizations such as the United Nations, advocacy groups, and local communities. This interdisciplinary and independent approach helps bring diverse groups together to forge effective real-world solutions.

More information about the Pacific Institute and its staff, board of directors, and programs can be found at www.pacinst.org.

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INTRODUCTION

California is one of the world's most productive agricultural regions. The state is the nation's largest agricultural producer, supplying both U.S. and international markets with more than 400 different farm products. In 2013, total California farm output was valued at $50.2 billion, or about one-tenth of the total for the entire nation.[1] Of this amount, $33.5 billion was from crops; $13 billion from livestock, poultry, and livestock products; and $2.4 billion from nursery, greenhouse, and floriculture (NASS 2015a, 2015b). California is the nation's largest agricultural exporter, with exports reaching a record $21.5 billion in 2013 (CDFA 2015).

Several factors are putting pressure on the state's agricultural economy: California has the most variable climate in the United States (Dettinger et al. 2011) and is prone to extreme hydrologic events, including multiyear droughts. The most significant statewide droughts have occurred during the six-year period from 1929 to 1934, the two-year period from 1976 to 1977, and the six-year period from 1987 to 1992 (DWR 2015a). More recently, California experienced a relatively modest drought from 2007 to 2009 and, as of this writing, is in the midst of a major drought that began in 2012.

The current drought is the most severe in nearly 120 years of instrumental record.[2] California has a Mediterranean climate, receiving very little precipitation during the summer months. California's "water year" starts on October 1 and ends on September 30. The 2014 water year was the third driest on record, and 2012–2014 was the driest three-year period in the instrumental record. At 25% of average, the snowpack in 2014 was then the lowest ever recorded, but even this record was broken in 2015, when the snowpack reached a new low of 5% of average. The drought has also been extraordinarily warm. Dry conditions across the state have been exacerbated by high temperatures, with 2014 the hottest year on record and 2012–2014 the hottest three-year period on record (Mann and Gleick 2015).

Droughts have wide-ranging effects. However, assessing their impact is challenging because there is no standard methodology for measuring and comparing diverse impacts, data are often lacking, and it is difficult to isolate drought from other factors. Despite these difficulties, several studies have conducted retrospective analyses of the impacts of past droughts on the state's agricultural sector (e.g., Gleick and Nash 1991; Christian-Smith

1 All monetary values have been adjusted for inflation and are stated in year 2015 dollars, unless specified otherwise.

2 While some weather data are available from the mid-1800s and even earlier, consistent, high-quality instrumental data on temperature and precipitation typically date from around 1895. These data are maintained by the National Climate Data Center of the National Oceanic and Atmospheric Administration, www.ncdc.noaa.gov

et al. 2015; Michael et al. 2010; Dziegielewski et al. 1993). Most recently, Christian-Smith et al. (2015) evaluated the agricultural acreage, yield, and revenue during the 2007–2009 drought, which at the time was the state's 12th driest three-year period on record. The authors found that in 2009, gross revenue from California farms and ranches was the third highest on record, behind only 2007 and 2008. Not surprisingly, however, impacts varied within and between counties. For example, gross revenue increased by 2% in Fresno County during the drought years but declined by 9% and 19% in neighboring Kern and Kings Counties, respectively.

The resilience of the agricultural sector during the 2007–2009 drought was due to several factors, including the sector's strong financial position before the drought began, high crop prices, and the variety of response strategies employed. In particular, growers changed crops, improved their irrigation practices, fallowed land, engaged in water transfers, received insurance payments, and pumped more groundwater. These strategies helped buffer the state's agricultural sector from drought-period losses and contributed to far fewer job losses than had been projected (Michael et al. 2010; Howitt et al. 2011). Christian-Smith et al. (2011), however, noted that "some of the response strategies such as groundwater mining were short-term fixes that would not provide water security in the face of a longer or more severe drought."

The current drought is much more severe than the 2007–2009 drought, and its full impacts are not yet known. In a recent modeling effort, Howitt et al. (2014) projected that the 2014 drought would reduce surface water availability for agriculture by 6.6 million acre-feet but that these reductions would be partially offset by increased groundwater pumping of 5.1 million acre-feet. They then projected that the resulting water shortage of 1.5 million acre-feet would cause losses of $810 million in crop revenue and $203 million in dairy and other livestock value and that the added groundwater pumping would impose additional costs of $454 million on agriculture. Those projections did not incorporate the financial impact of crop and insurance programs or declines in other expenses (such as chemical, fertilizer, or labor costs), nor did it attempt to estimate the economic costs and benefits of market trades in water. That modeling study was completed in July 2014, but no detailed assessment of the actual agricultural impacts has yet been completed until this current study.

SCOPE AND OBJECTIVE

This report examines the impacts of the ongoing drought on California's agricultural sector through 2014. This analysis reports acreage (harvested cropland) and gross crop revenue (the total market value of agricultural products) for 2000–2014, based on data from the USDA National Agricultural Statistics Survey. All monetary values here are reported in year 2015 dollars. The value of production represents the gross revenue of agricultural commodities—the units produced multiplied by their per-unit market value in a given year. It does not include other sources of income (e.g., direct payments from the government, sales of farm-related goods and services, or noncash income such as the value of home consumption of self-produced food). Nor does it include cash and noncash expenses. It therefore does not reflect net farm income.

We limit our analysis to impacts on three major crop categories: field crops; vegetables and melons; and fruits and nuts.[3] We do not examine

3 Field crops are crops other than fruits and vegetables that are grown for agricultural purposes and include corn, alfalfa, cotton, rice, grains, etc.

the impacts on animal products (e.g., livestock and dairy) or nursery products, because complete data for 2014 are not yet available for these sectors. Moreover, we focus on data aggregated at the state level because complete county and regional data are not yet available. We note, however, that there will certainly be important differences between and within counties due to water availability. As these data are made available, we will provide a more detailed analysis of regional impacts.

BACKGROUND: WATER SUPPLIES FOR CALIFORNIA AGRICULTURE

Water for California agriculture comes from three key sources: surface water, groundwater, and recycled water. Of these, surface water is the largest source, providing about 60% of the agricultural water supply in an average year. While some farmers and irrigation districts hold surface water rights, which are administered by the State Water Resources Control Board, others have contracts from the federal Central Valley Project (CVP) or the State Water Project (SWP). Those contracts are administered by the U.S. Bureau of Reclamation (USBR) and the California Department of Water Resources (DWR), respectively. Contracts do not represent a water right. Rather, a contract is signed between a water right holder and an entity taking delivery of the water diverted under a particular water right. For example, the SWP district has a contract with DWR specifying the amount of water it is entitled to if full allocations are available. The SWP district then has contracts with landowners for distribution of the water it receives.

Total demand for water in the form of water rights claims greatly exceeds surface water availability in all years (Grantham and Viers 2014), and the allocation of available water is largely determined by California's complex water rights system. Under this system, senior water rights holders (those with riparian rights and pre-1914 appropriative water rights) are given higher priority than junior water rights holders.[4] During a drought, those with junior water rights (also referred to as post-1914 water rights) are more likely to be subject to cutbacks to protect senior right holders. Likewise, there is a hierarchy of water contracts within the CVP and SWP (Table 1). Nearly all the users who receive priority deliveries from the CVP are agricultural users, and while USBR may reduce their supply during drought conditions, it has done so only six times since 1977. Similarly, while some users of SWP water will receive less than their contracted amount, the supply to others is near guaranteed even in times of drought. Even during a prolonged drought, substantial volumes of surface water are delivered through the state and federal systems (Table 2).

Groundwater is the second key water source for California farmers, accounting for nearly 40% of the water used for irrigation in 2010 (USGS 2014). State totals, however, hide regional dependence on groundwater. Groundwater accounts for more than 90% of irrigation withdrawals in ten counties, most of which are located along the coast. Large volumes of groundwater are also used for irrigation in Tulare, Kern, and Fresno Counties, which together account for more than a quarter of the state's irrigated area. During drought years, when surface supplies are limited, groundwater becomes an important supplemental supply for farmers. However, the current use of groundwater far exceeds the natural rate of recharge. This has resulted in a decline of groundwater levels across large parts of the state, saltwater intrusion and other water-quality impairments, land subsidence, lost storage, and increased energy costs, among

4 Riparian rights are tied to property that is connected to a stream or river. Appropriative water rights are based on the "first in time, first in right" principle, in which pre-1914 rights have priority over post-1914 rights.

Table 1.

Comparison of senior and junior CVP contract holders' annual water supply allocations received as a percentage of maximum contract quantities, 2005–2014

CVP Contractor (Sacramento Valley Water Year Hydrologic Classification)	2005 (AN)	2006 (W)	2007 (D)	2008 (C)	2009 (D)	2010 (BN)	2011 (W)	2012 (BN)	2013 (D)	2014 (C)
San Joaquin Exchange/ Sacramento River Settlement Contractors	100%	100%	100%	100%	100%	100%	100%	100%	100%	65%/75%
Friant Division										
Class I	100%	100%	65%	100%	77%	100%	100%	50%	62%	0%
Class II	100%	100%	0%	5%	18%	15%	20%	0%	0%	0%
Other Contractors										
North-of-Delta Agriculture	100%	100%	100%	40%	40%	100%	100%	100%	75%	0%
North-of-Delta Urban	100%	100%	100%	75%	75%	100%	100%	100%	100%	50%
South-of-Delta Agriculture	85%	100%	50%	40%	10%	45%	80%	40%	20%	0%
South-of-Delta Urban	100%	100%	75%	75%	60%	75%	100%	75%	70%	50%

Notes: Sacramento Valley hydrologic classification abbreviations: W: wet; AN: above normal; BN: below normal; D: dry; C: critical. The Friant Division delivers water to contractors from Millerton Reservoir, and that water is allocated according to two classes: Classes 1 and 2. Class 1 water is the firm supply of up to 800,000 acre-feet, while Class 2 is the next increment of supply of up to 1,400,000 acre-feet and is only allocated once Class 1 needs are met.

Source: USBR 2015a

Table 2.

Total annual deliveries from the SWP and contract deliveries from the CVP, 2005-2014 (in acre-feet)

Year	State Water Project	Central Valley Project
2005	4,726,363	6,375,091
2006	4,827,082	6,237,911
2007	4,061,696	5,586,232
2008	2,838,128	5,316,167
2009	2,918,056	4,900,789
2010	3,505,140	5,590,610
2011	4,630,798	6,328,195
2012	3,967,453	4,648,840
2013	3,343,134	4,764,307

Note: An acre-foot is a quantity of water that would flood an acre of land one foot deep, or 325,851 gallons. The CVP data shown here are for contract deliveries only and exclude deliveries for other types of water, e.g., 215 water, spill water, well water, water rights-storage, and water transported under the Warren Act, because these are not considered contracted deliveries. The SWP data shown here cover all deliveries, including Table A, Article 21, Feather River diversions, and other SWP water deliveries.

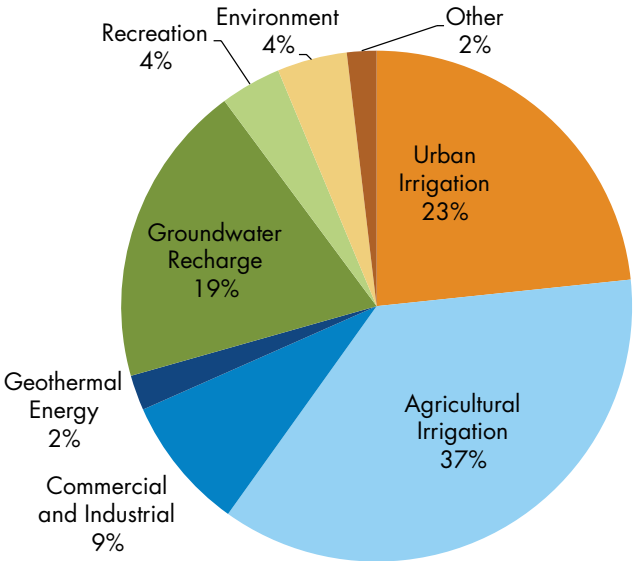
Source: USBR 2015b; DWR 2015b; SWP data for 2013–2014 provided by DWR

other adverse impacts. According to DWR (2014), "about 76 percent of the average annual groundwater extraction goes toward agricultural uses, with about 22 and 2 percent going toward urban and managed wetland uses, respectively."

Recycled water also represents a modest additional water supply for California agriculture. The most recent statewide recycled-water survey, conducted in 2009, found that the annual reuse of municipal wastewater was 670,000 acre-feet, of which 245,000 acre-feet (37%) was for agriculture (Newton et al. 2012) (Figure 1).[5] Additionally, recycled water used to recharge groundwater basins near agricultural areas indirectly supplies irrigation water to farmlands. Although agriculture is the single largest user of recycled water and has been using it as a supply for more than 100 years, it currently meets less than 1% of total agricultural water demand.

Figure 1.

Municipal wastewater recycling by end use, 2009



Source: Newton et al. 2012

5 An acre-foot is the quantity of water that would flood an acre of land one foot deep, or 325,851 gallons.

AGRICULTURAL PRODUCTION AND THE DROUGHT

California's agricultural sector is dynamic, responding to a host of local, national, and global conditions that change over time. We focus here on recent trends affecting harvested acreage, cropping patterns, production, and revenue. We also describe the impacts of the drought on food prices and employment.

HARVESTED ACREAGE

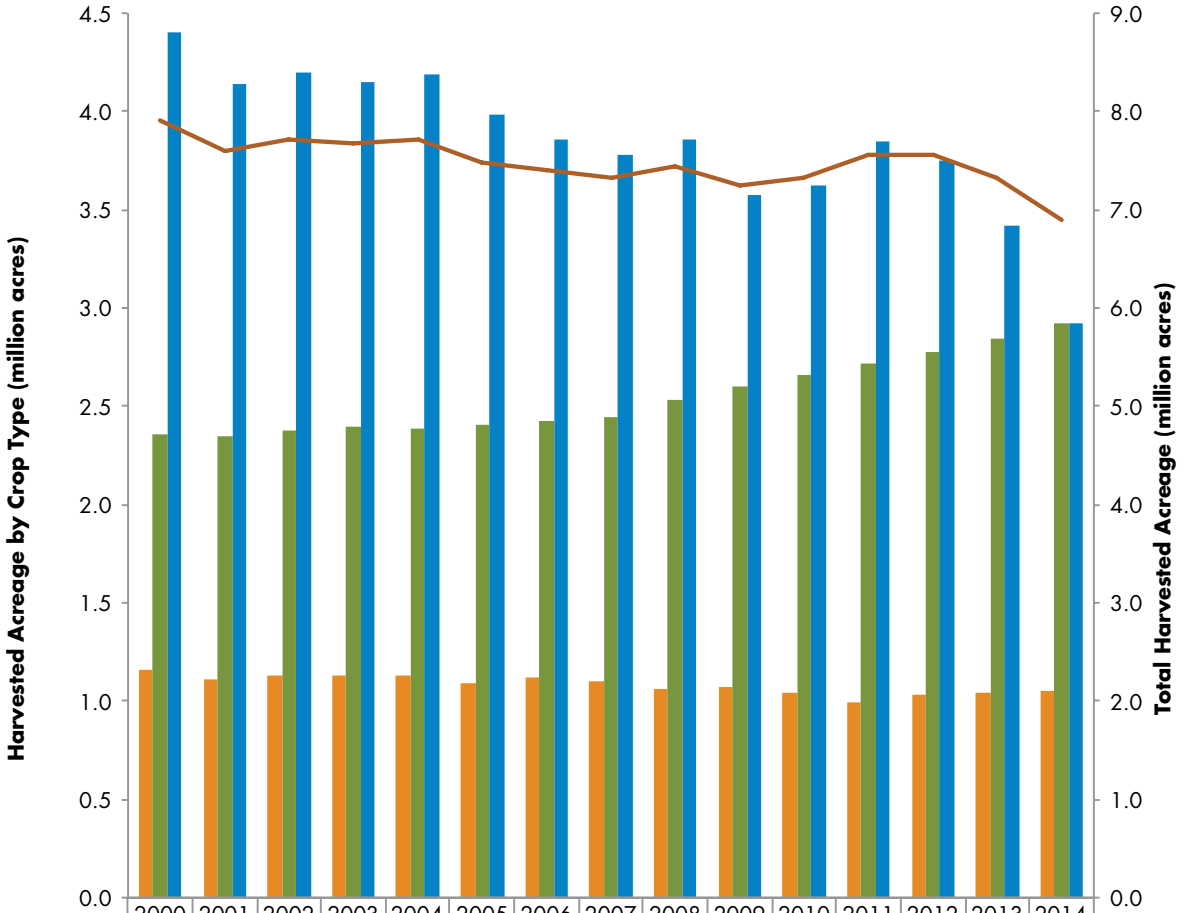
In 2000, nearly 7.9 million acres of land were harvested in California for a wide variety of vegetable, fruit and nut, and field crops (Figure 2). Between 2000 and 2011, annual harvested acreage averaged 7.5 million acres, with a slight downward trend over this period. Compared to this 12-year average, harvested acreage was 23,000 acres higher in 2012 but down by 216,000 acres in 2013 and 640,000 acres in 2014. By 2014 harvested acreage was 6.9 million acres, its lowest level in the past 15 years.

The types of crops grown in California have changed over the past 15 years, with reductions in the land area devoted to field crops, vegetables, and melons and an expansion of fruit and nut acreage. Between 2000 and 2011, total field crop acreage declined by 550,000 acres, or 13%. While the area planted with some types of field crops increased during this period (e.g., corn, wheat, and rice), others experienced large reductions. For example, cotton lost 460,000 acres, a 50% reduction; alfalfa lost 140,000 acres, a 14% reduction; and sugar lost 67,000 acres, a 73% reduction. During the drought, these trends accelerated, with field crops declining by an additional 930,000 acres (or 24%) between 2011 and 2014.

Vegetable and melon acreage has also been declining. Between 2000 and 2011, vegetable and

Figure 2.

California harvested acreage by crop type, 2000–2014 (in million acres)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Vegetables and Melons	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
Fruits and Nuts	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.5	2.6	2.7	2.7	2.8	2.8	2.9
Field Crops	4.4	4.1	4.2	4.2	4.2	4.0	3.9	3.8	3.9	3.6	3.6	3.9	3.8	3.4	2.9
Total	7.9	7.6	7.7	7.7	7.7	7.5	7.4	7.3	7.4	7.2	7.3	7.6	7.6	7.3	6.9

Source: See Appendix 1 for data sources

melon acreage declined by about 160,000 acres, or 14%. During this period, the largest reductions were for melons (32,000 acres), tomatoes (28,000 acres), and asparagus (26,000 acres). Since 2011, however, vegetable and melon acreage has increased by 48,000 acres, much of which can be attributed to a large increase (34,000 acres) in tomato acreage. The increase in vegetable and melon acreage during the drought was not sufficient to offset the losses that occurred before the drought, resulting in an overall reduction in vegetable and melon acreage since 2000.

Fruit and nut acreage has increased steadily over the past 15 years, even during the current drought. In 2000, fruit and nut bearing acreage was 2.4 million acres, and by 2011, this number had increased to 2.7 million acres, a 15% increase. Between 2011 and 2014, fruit and nut acreage increased by an additional 210,000 acres, or 8%. The total increase in fruit and nut acreage since 2000 has been 570,000 acres, or 24%. While the bearing acreage of some types of fruit and nut crops declined (e.g., raisins and prunes), these losses were offset by large increases in acreage

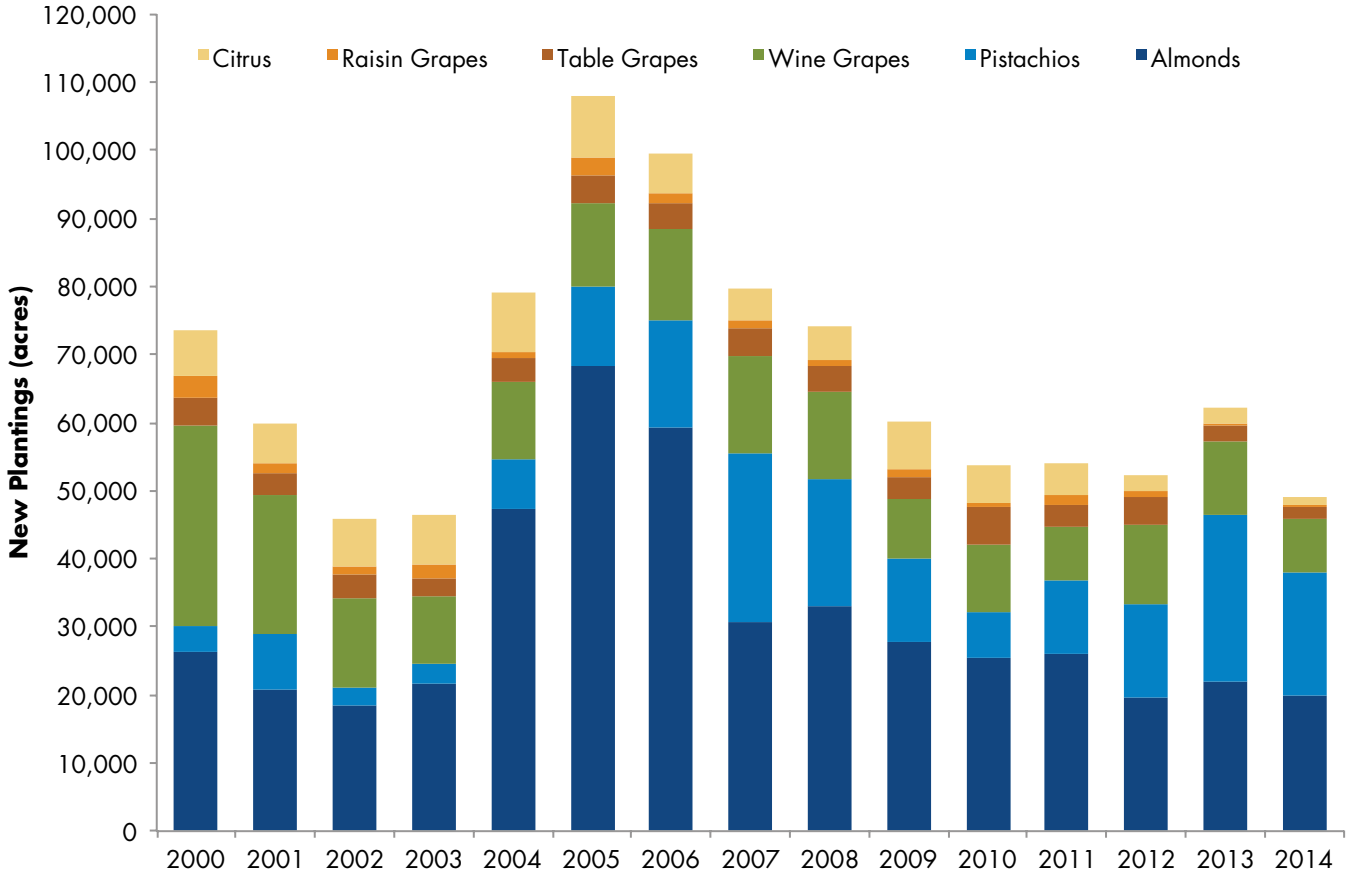
for other fruit and nut crops, especially almonds, pistachios, and wine grapes.

It is important to note that some of the increase in bearing acreage seen during the drought was the result of plantings in previous years. It often takes several years for trees and vines to become established and bear a crop that can be harvested (in what is referred to as "bearing acres"). Therefore, the change in the number of bearing trees and vines from year to year reflects young trees and vines going from "nonbearing" to "bearing" and old trees and vines being taken out of production. While data on new plantings are limited, information is available for some crops, including almonds, grapes, pistachios, and citrus (Figure 3). We found that new plantings have occurred every year since 2000, although there have been fewer new plantings during drought years for all of these crops, except pistachios. It is unclear to what extent these new plantings represent new acreage under development or whether they simply replaced old or unproductive trees and vines.

Both the type and the extent of harvested acreage in California are dynamic, affected to some degree by water availability and price but also by global

Figure 3.

New plantings for selected crops, 2001–2014 (in acres)



Note: These are gross, not net, annual plantings. Some of these plantings contribute to the expansion of fruit and nut acreage seen across the state, but others reflect the replacement of trees that are no longer productive.

Source: See Appendix 1 for data sources

market conditions, including crop prices. The long-term trends include a slight reduction in harvested acreage and large changes from field to fruit and nut crops. These trends have accelerated during the drought. Much of the recent reductions in harvested acreage are due to short-term fallowing. Farmers fallow land for a variety of reasons, including a lack of water, low crop prices, and soil recovery. They may even sell water to another user. Most fruits and nuts are perennials that require water year-round and remain productive for many years. Thus, they cannot be fallowed when water is limited. Most field, vegetable, and melon crops, by contrast, are annuals that can be fallowed if needed. While vegetables and melons can be fallowed, they are generally of higher value than field crops and are thus less likely to be fallowed. Indeed, nearly all of the reductions in harvested acreage that have occurred since 2011 were field crops.

CROP REVENUE

Revenue from crops has increased markedly over the past 15 years. Figure 4 shows California's crop revenue between 2000 and 2014 (adjusted for inflation and shown in year 2015 dollars). Between 2000 and 2011, crop revenue increased from $21 billion to $28 billion. During 2012 and 2013—the first two years of the drought—crop revenue continued to grow, reaching a record high of $34 billion in 2013. In 2014, crop revenue declined by $480 million, representing a 1.4% reduction from 2013 levels. Thus even during the most severe drought on record, agricultural revenue from crop production in 2013 and 2014 was the highest and second highest, respectively, in California history.

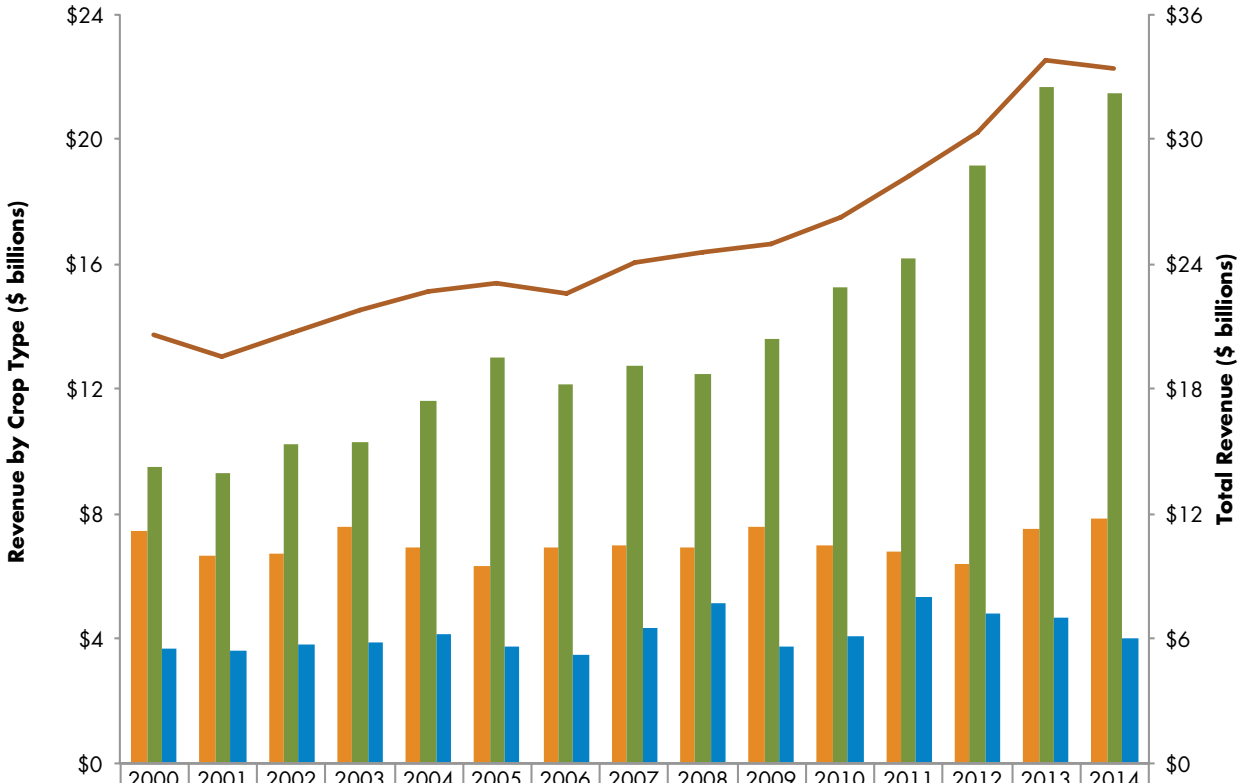
Higher crop revenue can largely be attributed to the expansion of fruit and nut crop acreage and strong market prices. Revenue from fruit and nut crops increased from $9.5 billion in 2000 to $16 billion in 2011. Fruit and nut revenue continued to grow in 2012 and 2013, but declined slightly (by $140 million, or less than 1%) from 2013 to 2014. Despite this decline, fruit and nut revenue in 2014 was still higher than it was during the pre-drought period. Much of the increased revenue between 2000 and 2014 can be attributed to almonds (whose revenue increased by $5.0 billion) and to a lesser degree walnuts ($1.4 billion), strawberries ($1.4 billion), pistachios ($1.3 billion), citrus ($1.1 billion), and table grapes ($980 million).

By contrast, revenue from vegetables and melons has been fairly steady over the past 15 years, increasing in some years and decreasing in others. For example, in 2011, vegetable and melon revenue was down slightly from 2000 levels but then increased moderately in 2013 and 2014. Prior to the drought, revenue from field crops had generally been increasing despite reductions in field crop acreage; since 2011, however, field crop revenue has declined every year, although it remained higher in 2014 than it has been in seven of the past 15 years.

The long-term increase in crop revenue was driven by several factors. First, as noted above, there has been a shift from lower- to higher-value crops, as evidenced by the reduction in field crop acreage and the expansion of fruit and nut acreage. In 2014, for example, field crops generated $1,300 per acre, while vegetables generated $7,600 per acre and fruits and nuts generated $7,300 per acre. Second, the productivity—as measured by the tonnage produced per acre—has increased for some key crops, including almonds, rice, strawberries, tomatoes, and walnuts. Tomato productivity, for example, was 35 tons per acre in 2000 but increased to 45 tons per acre in 2014. Third, crop prices have increased for most crops grown in California. For example, almonds generated $2,600 per ton in 2000 but $6,400 per ton in 2014. Likewise, table

Figure 4.

California crop revenue, by crop type, 2000–2014 (in billions of dollars)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Vegetables and Melons	$7.5	$6.6	$6.7	$7.6	$6.9	$6.3	$6.9	$7.0	$6.9	$7.6	$7.0	$6.8	$6.4	$7.5	$7.9
Fruits and Nuts	$9.5	$9.3	$10.2	$10.3	$11.6	$13.0	$12.1	$12.7	$12.5	$13.6	$15.2	$16.2	$19.1	$21.6	$21.5
Field Crops	$3.7	$3.6	$3.8	$3.9	$4.1	$3.8	$3.5	$4.3	$5.1	$3.7	$4.1	$5.3	$4.8	$4.7	$4.0
Total	$20.6	$19.5	$20.7	$21.8	$22.7	$23.1	$22.6	$24.1	$24.5	$24.9	$26.3	$28.2	$30.3	$33.8	$33.4

Note: All values have been adjusted for inflation and are shown in year 2015 dollars. Revenue from livestock, poultry, and products, as well as from nursery, greenhouse, and floriculture are not included here because these data are not yet available for 2014.

Source: See Appendix 1 for data sources

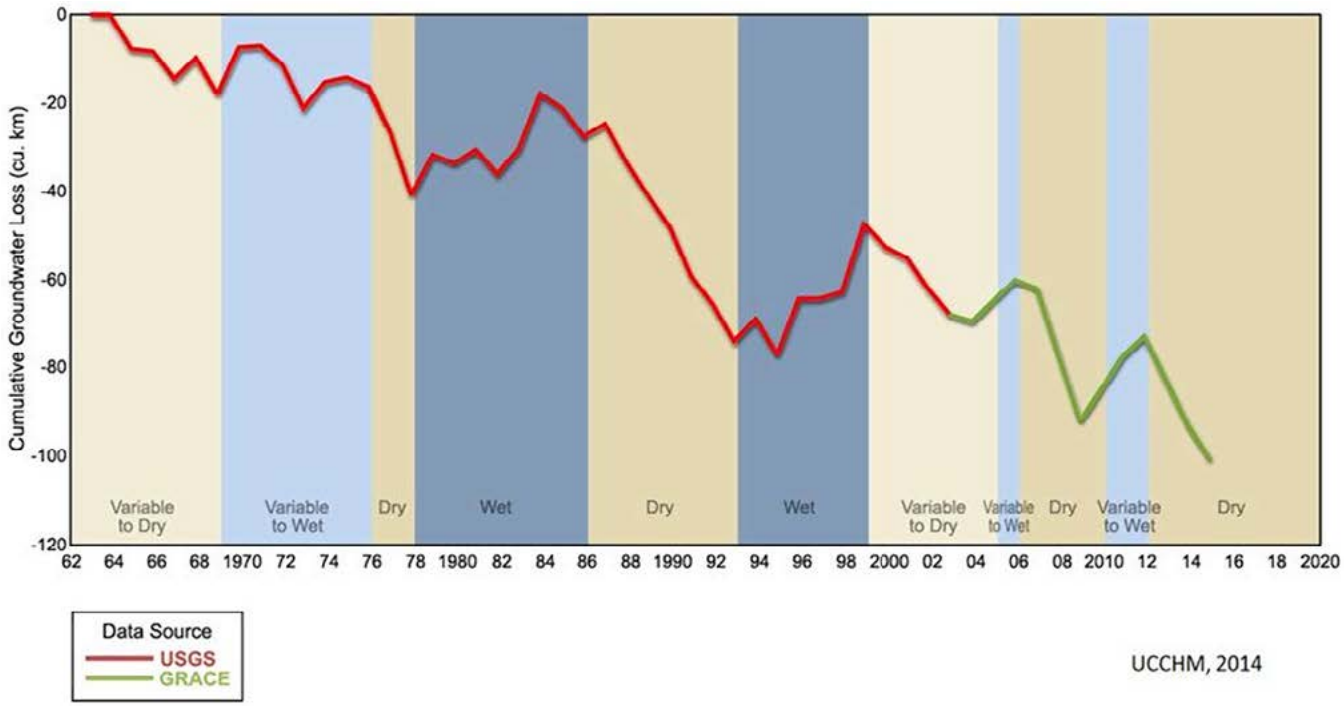
grapes generated $780 per ton in 2000 and $1,400 per ton in 2014. These factors have helped buffer the agricultural sector from the impacts of water shortages during the current drought.

In addition to these economic factors, farmers have increased groundwater pumping. California agriculture relies on groundwater for 40% of its water supply in average years and much more in dry years. Indeed, Howitt et al. (2014) projected that groundwater extraction in 2014 would increase by 5.1 million acre-feet statewide to offset an estimated 6.6 million acre-feet reduction in surface water availability. While data on actual groundwater usage are not available, recent satellite data indicate significant groundwater depletion in some areas both over the long term and especially in response to the current drought (Figure 5). Long-term declines in groundwater levels and a host of associated adverse impacts have underscored the fact that current levels of groundwater use in California are unsustainable.

Continued groundwater overdraft, while reducing

Figure 5.

Cumulative groundwater depletion in the Central Valley since 1962 (in cubic kilometers)



Note: The red line shows data from USGS-calibrated groundwater model simulations (Faunt 2009) from 1962 to 2003. The green line shows GRACE-based estimates of groundwater storage losses from Famiglietti et al. (2011) and updated through November 2014. Background colors represent periods of drought (dark tan), of variable to dry conditions (light tan), of variable to wet conditions (light blue), and of wet conditions (dark blue).

Source: Figure courtesy of Jay Famiglietti, University of California at Irvine and NASA Jet Propulsion Laboratory. USGS data from Claudia Faunt.

the economic impacts of the drought for the agricultural sector now, has shifted the burden to others. Individuals and communities whose wells have run dry have been forced to dig deeper wells or find alternative drinking water sources. Municipalities and other public entities must repair infrastructure damaged by subsidence. Moreover, future generations will pay more to access groundwater from greater depths and have less water available to meet their needs. The economic costs of these additional impacts are not included in this analysis, and no good estimate is available.

DROUGHT AND FOOD PRICES

California is a major agricultural producer, and for some crops, such as broccoli, grapes, almonds, and pistachios, the state accounts for more than 90% of the nation's production (Table 3). Thus, concerns have been raised about the impact of the drought on food prices, especially as agricultural lands are fallowed and production costs rise (Koba 2014). Despite this concern, the U.S. Department of Agriculture (USDA) Economic Research Service (ERS) found that crop prices have seen both increases and decreases, but no evidence that increases are associated with the drought:

"Increases in the retail prices for fresh fruits and vegetables in 2014 were primarily driven by an increase in the price for citrus fruit. However, rising citrus prices were reflective of two factors unrelated to the California drought. The first was the ongoing greening disease of Florida citrus commodities, which has damaged or destroyed substantial portions of the orange crop. The second was the December 2013 freeze in southern California that reduced the U.S. fresh orange crop. In 2014 fresh vegetable prices deflated 1.3 percent, despite the drought. Prices for fresh vegetables fell in 2014 after seeing higher than average price increases in 2013" (USDA 2015a).

While final data on 2015 food prices are not yet available, the USDA ERS projects that retail food price inflation will be normal to slightly lower than average due in part to the strength of the U.S. dollar and lower oil prices (USDA 2015a).

AGRICULTURAL EMPLOYMENT

An initial modeling effort by Howitt et al. (2014) projected that the drought would result in a loss of 17,100 seasonal and part-time jobs. New employment data from 2014 suggest that the actual impact of the drought on agricultural employment was much less than had been initially projected. Indeed, in 2014, California

Table 3.

California share of U.S. production for select fruit, nut, and vegetable crops (in percentages)

	California share of U.S. production		California share of U.S. production		California share of U.S. production
Artichokes*	100%	Strawberries*	90%	Oranges	27%
Dates*	100%	Cauliflower*	88%	Onions *	26%
Figs*	100%	Leaf lettuce, *	86%	Pears	25%
Kiwifruit*	100%	Avocados*	86%	Cabbage	25%
Olives*	100%	Carrots*	83%	Sweet potatoes	24%
Almonds*	100%	Romaine lettuce*	76%	Sweet cherries	22%
Pistachios*	100%	Head lettuce*	75%	Sweet corn	22%
Walnuts*	100%	Honeydew*	73%	Squash	17%
Garlic*	98%	Peaches*	72%	Watermelon	17%
Plums and prunes*	97%	Tangerines and mandarins*	69%	Pumpkins	16%
Broccoli*	95%			Grapefruit	14%
Celery*	95%	Spinach*	63%	Snap beans	13%
Lemons*	93%	Chili peppers*	60%	Cucumbers	10%
Apricots*	90%	Raspberries*	57%	Blueberries	8%
Tomatoes	90%	Bell peppers*	56%	Potatoes	3%
Grapes*	90%	Asparagus*	47%	Apples	3%

Notes: Calculated based on production in 2011–2013. Crops shown with an asterisk indicate those for which California ranks first in U.S. production.

Source: USDA 2015b

agriculture employed a record-high 417,000 people (California Employment Development Department 2015a). According to the California Employment Development Department (2015b), agricultural employment in the third quarter of 2014—the period of peak farm employment—increased by 3,100 jobs from the same quarter in 2013. The agency further found that agricultural employment has increased every year since 2010 by an average of 9,000 jobs per year, although the increase in 2014 was less than in other years during that period. Agricultural employment was higher in 2014 than 2013 in the state's coastal and desert areas, as well as in the Sacramento Valley. In an example of the regional differences in drought impacts, agricultural employment was lower in the San Joaquin Valley, which had more land fallowed than other parts of the state.

While employment data suggest that overall agricultural employment has reached record-high levels, agricultural employment would likely have been even higher if there had been less fallowing. Water availability, however, is only one factor affecting agricultural employment. The total number of jobs also depends on the types of crops grown. As shown in Figure 6, the shift away from field crops and toward tree crops and tomatoes, for example, has likely contributed to the growth in agricultural employment. Moreover, as recently as 2012, a survey by the California Farm Bureau Federation found that "farmers in every growing region of California reported having a difficult time hiring enough employees to work in agriculture and harvest their crops" (California Farm Bureau 2012).

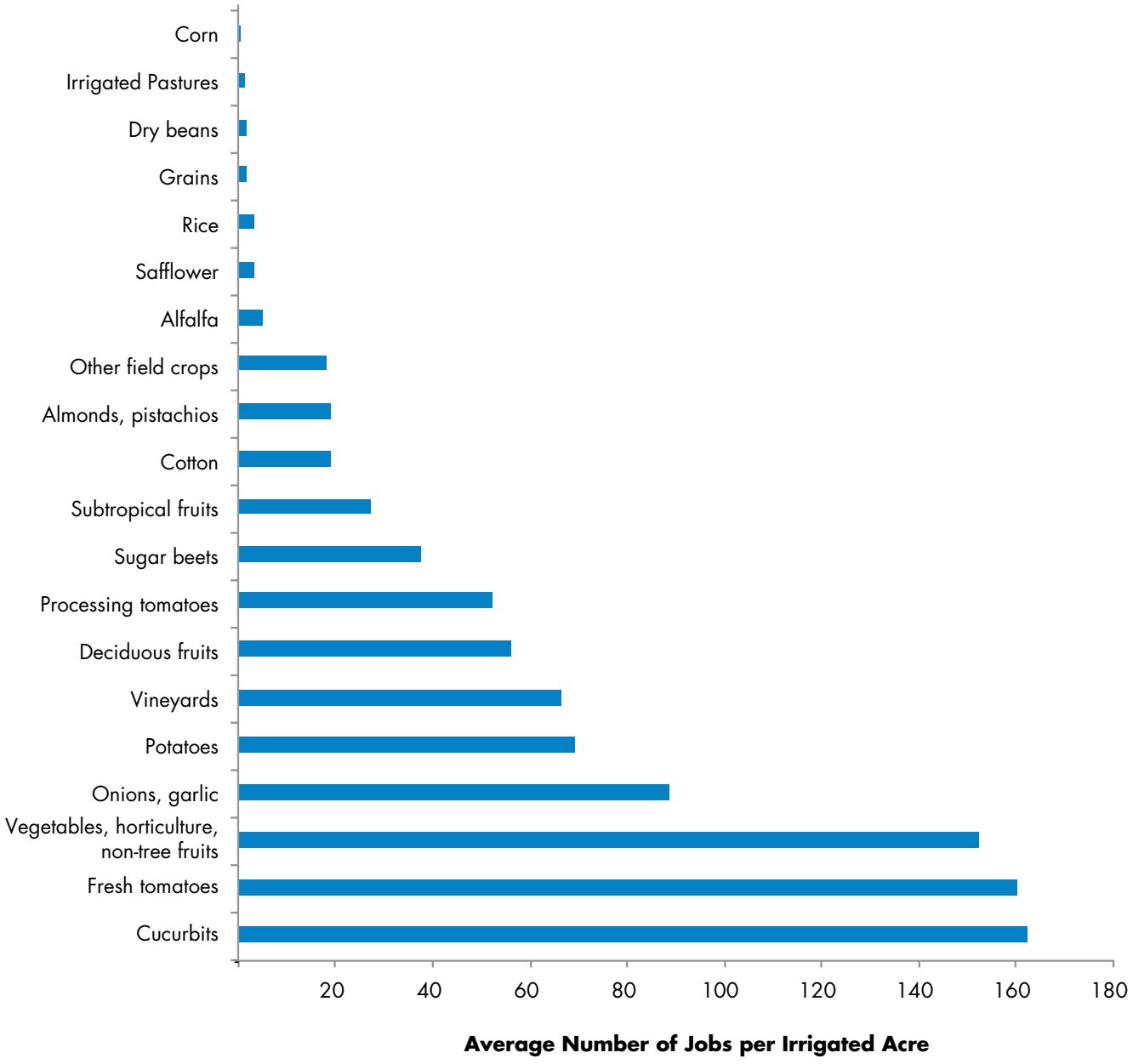
WATER TRANSFERS

Some California water analysts have proposed using expanded water markets and water transfers as tools for addressing water shortages and improving allocations. California has for several decades maintained a limited water market that allows for the temporary, long-term, or permanent transfer of the right to use water in exchange for compensation. Early efforts to facilitate the trade of water began in the late 1970s in response to a severe drought (DWR 1978). Market activity was slow in the early 1980s, with an annual average of 100,000 acre-feet in traded volume. Spurred by state and federal agencies' dry-year purchases of water for resale and environmental protection, a voluntary water market expanded significantly after the 1987–1992 drought. Between 2003 and 2011, an average of 2.1 million acre-feet was committed annually for sale or lease, with 1.4 million acre-feet actually moving between parties (Hanak and Stryjewski 2012). The volume of water traded was 3.2% of statewide water use during that period. Hanak and Stryjewski (2012) found that long-term and permanent trades are becoming more common, accounting for more than half of the water actually traded and three-quarters of the water committed. An informal market also operates in California whereby farmers may sell their water to other farmers within the same region, but data on these trades are not available because farmers are not required to report to, or gain approval from, water authorities to complete these transactions.

For this analysis, we examine the extent to which water transfers have been used to mitigate the economic impact of the current drought on California's agricultural sector. Since the onset of the drought, efforts have been made to improve the water-transfer process. For example, in May 2013, Governor Jerry Brown issued an executive order to streamline approvals for water transfers. However, the lack of a statewide database on water transfers is a major barrier to a comprehensive analysis of the voluntary reallocation of water between competing uses. Our analysis relies

Figure 6.

Average number of jobs produced per acre of irrigated land, by major crop type



Note: Crop categories are defined by DWR. Cucurbits refer to melons, squash, and cucumbers. Other field crops include flax, hops, grain sorghum, sudan, castor beans, miscellaneous fields, sunflowers, hybrid sorghum/sudan, millet, and sugar cane. Deciduous fruits include apples, apricots, cherries, peaches, nectarines, pears, plums, prunes, figs, walnuts, and miscellaneous deciduous. Subtropical fruits include grapefruit, lemons, oranges, dates, avocados, olives, kiwis, jojoba, eucalyptus, and miscellaneous subtropical fruit.

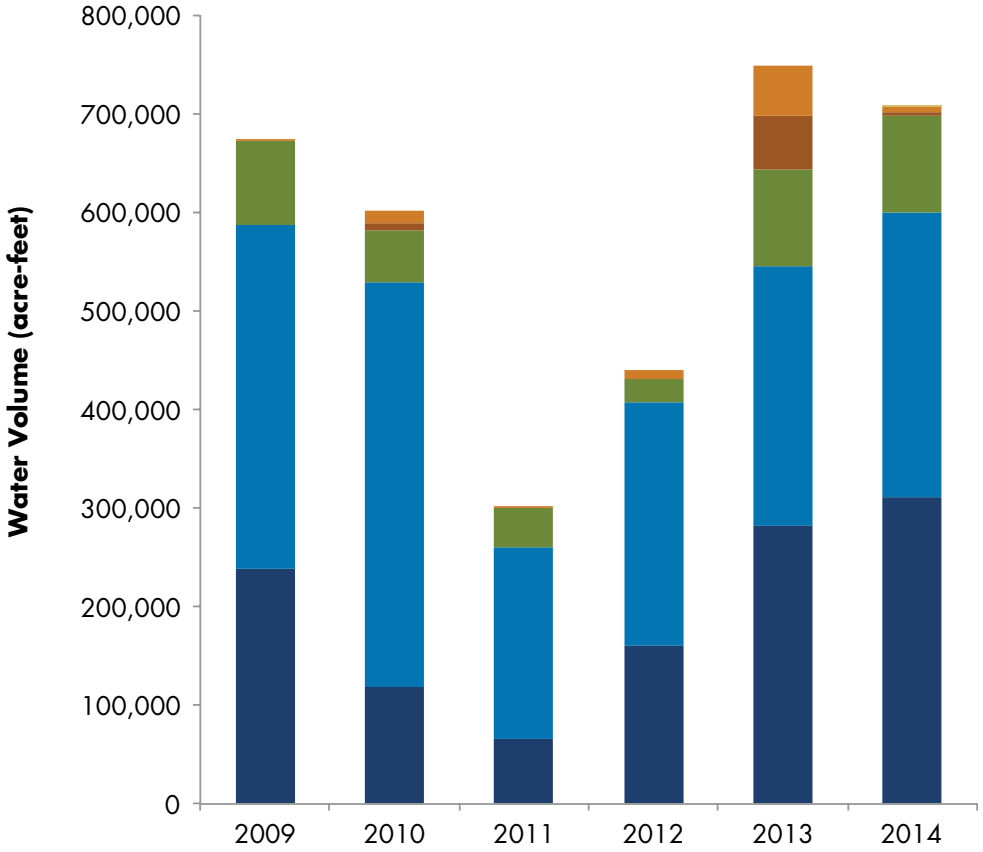
Source: Data on irrigated crop acreage for 2010 are from the DWR. Employment estimates are from Medellin-Azuara et al. 2015 and based on data from the California Employment and Development Department and IMPLAN economic model.

Figure 7.

Total volume of water transfers, 2009–2014 (in acre-feet)

- M&I to F&W
- M&I to M&I
- M&I to Ag
- Ag to F&W
- Ag to M&I
- Ag to Ag

Note:
Ag = agriculture
M&I = municipal and industrial
F&W = fish and wildlife



on data from several sources. They include the State Water Board's temporary water transfer orders; DWR's record of transfers that used SWP Delta export facilities;[6] purchases by State Water Contractors;[7] the Mojave Basin Watermaster; and major water sellers and buyers (e.g., Glenn Colusa Irrigation District, Yuba County Water Agency, Kern County Water Agency, Merced Irrigation District, and the San Luis and Delta Mendota Water Agency). While we have attempted to capture key data sources, actual transfer volumes likely exceed our current estimates. Thus, our results are minimum estimates of water transfer activities for the agricultural sector over the past six years.

Figure 7 shows the water transfer volumes between 2009 and 2014. Water transfer volumes are variable and are typically higher in dry years. From the available data, we estimate that water transfers in 2014 exceeded 710,000 acre-feet, which was 40,000 acre-feet less than was transferred in 2013 but more than in previous years. Of the transfers in 2014, 45% (or 310,000 acre-feet) were within the agricultural sector (i.e., between farmers or irrigation districts), while 38% (or 290,000 acre-feet) were transfers from agriculture to municipal and industrial users and 14% (97,000 acre-feet) from agriculture to fish and wildlife. A small amount of water was transferred between municipal and industrial users (4,800 acre-feet) and even less (4,000 acre-feet) from municipal and industrial users to agriculture.

Figure 8 shows water transfer volumes by hydrologic region. Note that all regions have had transfers at some time during this six-year

6 Only available for 2014. These kinds of transfers can occur only when the DWR has met all operational and regulatory requirements and additional conveyance is available.

7 Only available for 2014 from the State Water Contractors. Other records were obtained from sellers transferring water to the agency's members.

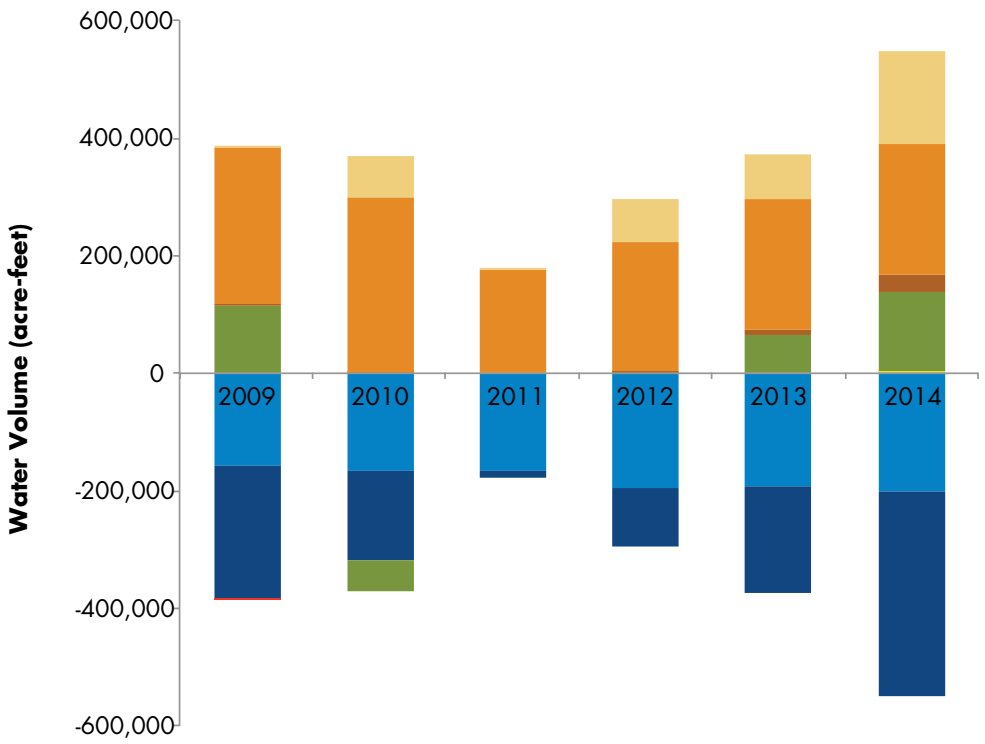


Figure 8.

Water transfers by hydrologic region, 2009–2014 (in acre-feet)

- Tulare Lake
- South Lahontan
- South Coast
- SF Bay Area
- San Joaquin River
- Sacramento River
- North Coast
- Colorado River
- Central Coast

Note: Transfers involving the 2009 Water Bank, pools, or multiple entities where sources and destinations of water could not be identified have been excluded from this chart. Negative values indicate net water exporters, and positive values indicate net water importers.

period. In some cases, transfers were into a region, sometimes out of a region, and many times both. We show here the net transfers, with negative values indicating net water exporters, and positive values net water importers. Given California's unique hydrology and relatively abundant surface water supplies in the northern and mountainous areas of the state, much of the water transferred is from users in the Sacramento River region. For example, in 2014, net water transfers out of the Sacramento River region were 350,000 acre-feet, 92% more than in 2013. Net transfers from the Colorado River hydrologic region, largely a result of long-term water transfer contracts, have ranged from 165,000 to 200,000 acre-feet over the past six years. As the drought has intensified, the number of regions importing water from other parts of the state has increased. In particular, a large volume of water has been transferred to the Tulare Lake and San Joaquin River regions, the nation's leading agricultural areas. However, the South Coast is the largest net importer of water, averaging 230,000 acre-feet per year. While transfers to the San Francisco Bay hydrologic region are generally small, they increased considerably during 2013 and 2014 in response to the drought.

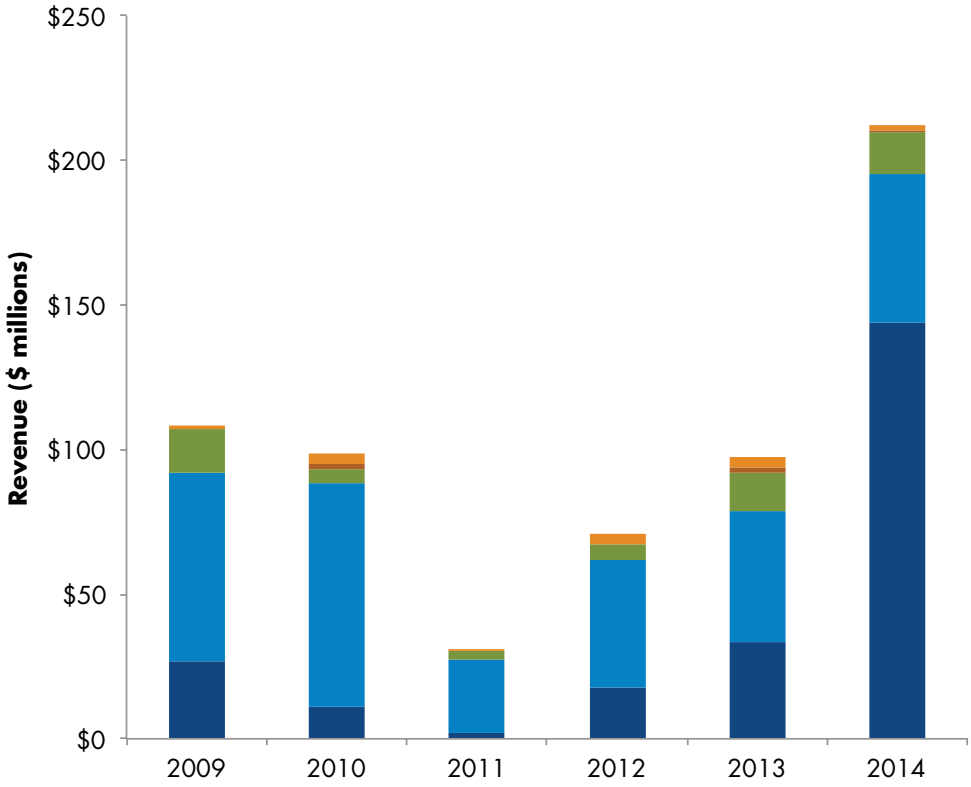
Water markets serve as a mechanism to mitigate drought-induced losses. Figure 9 shows the value of water transfers between 2009 and 2014, where the value is based on the volume of water sold and the price for that water. The value of water transfers in 2014 was $210 million, much higher than in previous years, even though the volume of transferred water was less than it was in 2013 and only slightly more than it was in 2009. This was due to the relatively high price for water in 2014. The average price for water transfers in 2014 was $370 per acre-foot; it was $170 per acre-foot in 2013.

Figure 9.

Revenue generated from water transfers, 2009–2014 (in millions of dollars)

- M&I to M&I
- M&I to Ag
- Ag to F&W
- Ag to M&I
- Ag to Ag

Note: All values have been adjusted for inflation and are shown in year 2015 dollars.
Ag = agriculture
M&I = municipal and industrial
F&W = fish and wildlife



As described earlier, the agricultural sector was involved in about 99% of the water transfers in 2014, in some cases as buyers but in other cases as sellers. Of the $210 million in water transfers in 2014, nearly 70% (or $144 million) represented a transfer within the agricultural sector, likely from lower- to higher-value crops, helping to minimize losses in agricultural revenue. While agriculture paid nearly $640,000 to purchase water from municipal and industrial users, agriculture received nearly $66 million by selling water to other users. This represents another source of revenue for the agricultural sector that offset some of the crop revenue losses seen in 2014.

SUMMARY AND CONCLUSIONS

California is one of the most productive agricultural regions in the world, and that productivity has been made possible by a vast and integrated water infrastructure network that provides large volumes of water to the agricultural sector. The state, however, is prone to multi-year droughts. Indeed, California is in the midst of the most severe drought in nearly 120 years of instrumental record. The drought, which began in 2012, is having far-reaching effects that will intensify as the drought continues. This report examines the impacts of the ongoing drought on California's agricultural sector through 2014. Our focus is on changes in total harvested acreage, gross crop revenue, and agricultural employment over the past 15 years and is based on data from the USDA National Agricultural Statistics Survey and the California Employment Development Department. We do not examine production costs, impacts on animal or nursery products, or regional impacts, as these data are not yet available.

We find that while harvested acreage in California has declined during the drought, agricultural revenue remains high. In 2014, harvested acreage was 6.9 million acres, lower than at any time in the

past 15 years. Reductions in field crops accounted for nearly all the cuts in harvested acreage since 2011. Bearing fruit and nut acreage, however, continued to increase, especially for almonds, pistachios, and wine grapes. While some of these were planted before the drought began, farmers have continued to plant new fruit and nut crops throughout the drought. Crop revenue was at its highest level in California's history, peaking in 2013 at $34 billion. In 2014, crop revenue declined by $480 million, but it remained the second highest ever recorded.

California farmers have employed a range of strategies to respond to the drought, including under-irrigating their fields, fallowing land, shifting crops, purchasing insurance, and pumping more groundwater. Water transfers have also mitigated the impact of the drought. In some cases, farmers with lower-value crops sold their water to farmers with higher-value crops, thereby reducing total losses in agricultural revenue. Some farmers also sold their water for use by municipalities, industry, or the environment. These sales represent another source of revenue for the agricultural sector. Although data are incomplete, we estimate that voluntary sales from agriculture to non-agricultural users boosted agricultural revenue by at least $66 million in 2014, offsetting some of the losses from fallowing. These water transfers, however, may have resulted in socio-economic and environmental impacts that are not well understood or quantified. For example, while farmers may have received compensation for selling water, a farm worker may simply be out of a job. The impacts of water markets on California's agricultural sector, society, and the environment are not well established and require further analysis.

Concerns have also been raised about the impacts of the drought on agricultural employment and food prices. Employment has increased in every year since 2010 by an average of 9,000 jobs, although the annual increase in 2014 was less than in other years during that period. By 2014, California's agricultural sector employed a record-high 417,000 people. However, as an example of the regional differences, agricultural employment was up in the state's coastal and desert areas and in the Sacramento Valley, but down in the San Joaquin Valley. Food prices appear to be largely unaffected by the drought. Although final data on 2015 food prices are not yet available, the USDA projects that retail food price inflation will be normal to slightly lower than average due in part to the strength of the U.S. dollar and lower oil prices.

It is important to note that statewide and even regional estimates can hide local variability. State agricultural revenue and employment remain high, but there are undoubtedly winners and losers. County-level acreage and revenue data are not yet available; however, the drought is very likely having a real impact on local economies in some areas, especially those areas with extensive fallowing. Fallowing means fewer employment opportunities for farm workers in those areas, and while some may be able to find work elsewhere, others may not.

Pressures on California agriculture are not merely a result of the drought. Rather, the drought is highlighting water management problems that have persisted for decades. For example, it is widely recognized that groundwater pumping rates are unsustainable in some major agricultural centers, such as the Tulare Lake and southern San Joaquin River hydrologic regions. In these areas, pumping will have to be slowed and recharge expanded to bring these aquifers back to a more sustainable balance. Moreover, climate change is making California's temperature and precipitation patterns more variable, leading to more frequent

and intense floods and droughts and even higher crop water demands.

We conclude that the impacts of the drought on California's agricultural sector through 2014 were less than expected. The current boon can be explained in part by the increased, but unsustainable, groundwater pumping. Continued groundwater overdraft, while reducing the economic impacts of the drought for the agricultural sector now, has shifted the burden to others, including current and future generations forced to dig deeper wells, find alternative drinking water sources, and repair infrastructure damaged by subsidence. Water transfers have also played a role; however, the broader social and environmental impacts of these transfers are not well understood. Finally, short- and long-term shifts in the types of crops grown and improvements in irrigation technologies and practices have also improved the resilience of the state's agricultural sector to extreme weather events. The impacts of the drought on California agriculture and its response provide insight into how the state can maintain a healthy agricultural sector in a future likely to see less water, more extreme weather, and greater uncertainty.

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APPENDIX 1:
Data Sources

FIGURE 2 – HARVESTED ACRES

- Vegetable and melon acreage totals represent the sum of harvested acreage for the state's principal fresh market and processing vegetable crops.
  - 2000–2012 data are contained in the report "Vegetables - Final Estimates," published every five years by NASS (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1525).
  - 2013 and 2014 data are contained in the 2015 report "Vegetables Annual Summary" (https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1183).
- Field crop acreage totals represent the sum of harvested acreage for the state's principal field crops.
  - 2000–2012 data are contained in the report "Field Crops Final Estimates," published every five years (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1529).
  - 2013 and 2014 data are contained in the January 2015 report "Crop Production Annual Summary" (https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1047).
- Fruit and nut acreage was calculated by summing individual acreage for the following crops (values indicate acres bearing unless otherwise specified): almonds, apples, apricots, avocados, blueberries (acres harvested), sweet cherries, citrus (oranges, grapefruit, lemons, tangelos, and tangerines), dates, figs, grapes (raisin, table, and wine), kiwifruit, nectarines, olives, peaches, pears, pecans, pistachios, plums, prunes, raspberries (acres harvested), strawberries (acres harvested), english walnuts.
  - 2000–2012 data are contained in the reports "Citrus Fruits - Final Estimates" (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1515) and "Noncitrus Fruits and Nuts - Final Estimates" (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1511). Avocado acreage was not available in 2012. Therefore, acreage value was carried forward from the previous year.
  - 2013 and 2014 data are contained in the reports "Citrus Fruits" (https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1031) and "Noncitrus Fruits and Nuts" (https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1113).

FIGURE 3 – NEW PLANTINGS

- Grapes: California Grape Acreage Bulletins, 2007–2015. http://www.nass.usda.gov/Statistics_by_State/California/Publications/Grape_Acreage/Reports/index.asp.
- 2014 California Almond Acreage Report, 2015. http://www.nass.usda.gov/Statistics_by_State/California/Publications/Fruits_and_Nuts/201505almac.pdf.

- Pistachio Report from the Administrative Committee for Pistachios. http://www.acpistachios.org/pdf/2014Statistics.pdf.
- California Citrus Acreage Reports, 2006–2014. http://www.nass.usda.gov/Statistics_by_State/California/Publications/Acreage/index.asp. Citrus includes grapefruit, lemons, limes, oranges, pummelos and hybrids, and mandarins and mandarin hybrids.

FIGURE 4 – REVENUE

- Revenue totals by crop type:
  - 2000–2012 data taken from "Crop Values Final Estimates," published every five years (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1513).
  - 2013 and 2014 data taken from "Crop Value Annual Summary Reports" (https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1050)
- Vegetable and melon revenue totals for each individual crop:
  - 2000–2012 data taken from "Vegetables Final Estimates," published every five years (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1525)
  - 2013 and 2014 data taken from "Vegetables Annual Summary" (https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1183).
- Field crop revenue totals for each individual crop:
  - 2000–2012 data taken from "Crop Values Final Estimates," published every five years (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1513).
  - 2013 and 2014 data taken from "Crop Values Annual Summary" (https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1050). Sugarbeet revenue was not available for 2014. Sugarbeet revenue was estimated using 1,003,000 tons at $52 per ton (2012 and 2013 price = $52.10) (NASS 2015a; NASS 2015c). Corn silage revenue was excluded from field crop revenue totals as it is generally just used on the farm and not sold as a product.
- Fruit and nut revenue totals for each individual crop:
  - 2000–2012 data are contained in the reports "Citrus Fruits - Final Estimates" (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1515) and "Noncitrus Fruits and Nuts - Final Estimates" (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1511). Avocado acreage was not available in 2012. Therefore, revenue value was carried forward from the previous year.
  - 2013 and 2014 data are contained in the reports "Citrus Fruits" (https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1031) and "Noncitrus Fruits and Nuts" (https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1113).

PRODUCTION

- Vegetable and melon production totals for each individual crop:
  - 2000–2012 data taken from "Vegetables Final Estimates," published every five years (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1525)
  - 2013 and 2014 data taken from "Vegetables Annual Summary" (https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1183).
- Field crop production totals for each individual crop:
  - All production data from "Crop Production Annual Summary" (https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1047).
- Fruit and nut production totals for each individual crop:
  - 2000–2012 data are contained in the reports "Citrus Fruits - Final Estimates" (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1515) and "Noncitrus Fruits and Nuts - Final Estimates" (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1511). Avocado production was not available in 2012. Therefore, production value was carried forward from the previous year.
  - 2013 and 2014 data are contained in the reports "Citrus Fruits" (https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1031) and "Noncitrus Fruits and Nuts" (https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1113).
  - The following conversion factors were used to convert all production values into tons:
    - 1 hundredweight (cwt) = 0.05 short ton
    - 1 pound (lb) = 0.0005 short ton
    - 1 bushel barley = 48 lbs = 0.024 short ton
    - 1 bushel oats = 0.016 short ton
    - 1 bushel corn grain = 56 lb = 0.028 short tons
    - 1 bushel wheat = 60 lb = 0.03 short tons
    - 1 bushel oats = 32 lb = 0.016 short tons
    - 1 bale cotton = 480 lb = 0.24 short tons

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EXHIBIT F

RAVEENDRAN/AFP/Getty Images

Here's the Real Problem With Almonds

BY **TOM PHILPOTT** AND **JULIA LURIE**

December 31, 2015

Almonds: crunchy, delicious, and…the center of a nefarious plot to suck California dry? They certainly have used up a lot of ink lately—partly inspired by Mother Jones's reporting over the past year. California's drought-stricken Central Valley churns out 80 percent of the globe's almonds, and since each nut takes a gallon of water to produce, they account for close to 10 percent of the state's annual agricultural water use—or more than what the entire population of Los Angeles and San Francisco use in a year.

As *Grist*'s Nathanael Johnson put it, almonds have become a scapegoat of sorts—"the poster-nut for human wastefulness in California's drought." Or, as Alissa Walker put it in *Gizmodo*, "You know, ALMONDS, THE DEVIL'S NUT." It's not surprising that the almond backlash has inspired a backlash of its own. California agriculture is vast and complex, and its water woes can't hang entirely on any one commodity, not even one as charismatic as the ~~devil's nut~~ almond.

And as many have pointed out, almonds have a lot going for them—they're nutritious, they taste good, and they're hugely profitable for California. In 2014, almonds brought in a whopping $11 billion to the state's economy. Plus, other foods—namely, animal products—use a whole lot more water per ounce than almonds.

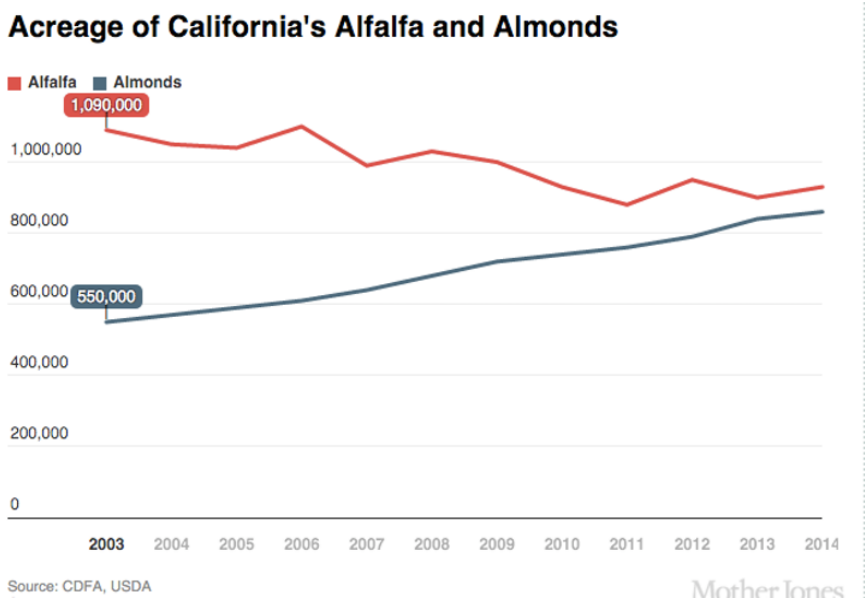
So almonds must be worth all the water they require, right? Not so fast. Before you jump to any

conclusions, consider the following five facts:

1. Most of our almonds end up overseas. Almonds are the second-thirstiest crop in California—behind alfalfa, a superfood of sorts for cows that sucks up 15 percent of the state's irrigation water. *Gizmodo*'s Walker—along with many others—wants to shift the focus from almonds to the ubiquitous feed crop, wondering, "Why are we using more and more of our water to grow hay?" Especially since alfalfa is a relatively low-value crop—about a quarter of the per acre value of almonds—and about a fifth of it is exported.

It should be noted, though, that we export far more almonds than alfalfa: About two-thirds of California's almond and pistachio crops are sent overseas—a de facto export of California's overtapped water resources.

2. While alfalfa fields are shrinking, almond fields are expanding—in a big way. The drought is already pushing California farmers out of high-water, low-value crops like alfalfa and cotton, and into almonds and two other pricey nuts, pistachios and walnuts. This year, California acreage devoted to alfalfa is expected to shrink 11 percent, and cotton acres look set to dwindle to their lowest level since the 1920s.



Mother Jones

Meanwhile, the market is pushing almonds and other nuts in the opposite direction. At a confab in California's nut-rich, water-challenged San Joaquin County, Stewart Resnick, chief of Paramount Farms, by far the state's largest nut grower, explained why in a speech, as documented by an account in the trade journal *Western Farm Press*. Almonds, he said, deliver

farmers an average net return of $1,431 per acre. Pistachios, another fast-expanding nut hotly promoted by the Paramount farming empire, net even more: $3,519 per acre.

Given that Paramount reportedly manages 50,000 acres of combined almonds and pistachios, it's safe to say there's big profits in growing those nuts. And the company, which also buys and processes nuts from other farmers and sells them under the Wonderful brand, plans to expand by 50 percent in the next five years. Currently the company farms 30,000 acres on its own and buys pistachios from farms occupying another 100,000 acres. By 2020, the company's "goal is 150,000 partner acres, 33,000 Paramount acres," which would be a 40 percent jump in just five years. And that's on top of the 118 percent expansion in pistachio acres over the past decade, according to figures Resnick delivered at the conference.

3. Unlike other crops, almonds always require a lot of water—even during drought. Annual crops like cotton, alfalfa, and veggies are flexible—farmers can fallow them in dry years. That's not so for nuts, which need to be watered every year, drought or no, or the trees die, wiping out farmers' investments.

Already, strains are showing. Back in 2013, a team led by US Geological Survey hydrologist Michelle Sneed discovered that a 1,200-square-mile swath of the southern Central Valley—a landmass more than twice the size of Los Angeles—had been sinking by as much as 11 inches per year, because the water table had fallen from excessive pumping. In an interview last year, Sneed told me the ongoing exodus from annual crops and pasture to nuts likely played a big role.

4. Some nut growers are advocating against water regulation—during the worst drought in California's history. "I've been smiling all the way to the bank," one pistachio grower told the audience at the Paramount event, according to the *Western Farm Press* account. As for water, that's apparently a political problem, not an ecological one, for Paramount. "Pistachios are valued at $40,000 an acre," Bill Phillimore, executive vice president of Paramount Farming, reportedly told the crowd. "How much are you spending in the political arena to preserve that asset?" Apparently, he meant: protect it from pesky regulators questioning your water use. He "urged growers to contribute three-quarters of a cent on every pound of pistachios sold to a water advocacy effort," *Western Farm Press* reported.

5. Mostly, it's not small-scale farmers that are getting rich off the almond boom. With their surging overseas sales, almonds and pistachios have drawn in massive financial players hungry for a piece of the action. As *Mother Jones* reported last year, Hancock Agricultural Investment Group, an investment owned by the Canadian insurance and financial services giant Manulife

Financial, owns at least 24,000 acres of almonds, pistachios, and walnuts, making it California's second-largest nut grower. TIAA-CREF, a large retirement and investment fund that owns 37,000 acres of California farmland, and boasts that it's one of the globe's top five almond producers.

Then there's Terrapin Fabbri Management, a private equity firm that "manages more than $100 million of farm assets on behalf of institutional investors and high net worth clients" and says it's "focused on capitalizing on the increasing global demand for California's agricultural output." In a piece earlier this year, *The Economist* pointed out that Terrapin had "bought a dairy company and some vineyards and tomato fields in California, and converted all to grow almonds, whose price has soared as the Chinese have gone nuts for them." The magazine added that "such conversions require up-front capital"—e.g., to drop wells—"and the ability to survive without returns for years." Those aren't privileges many small-scale farmers enjoy.

This story was originally published by Mother Jones and is reproduced here as part of our Climate Desk collaboration.

EXHIBIT G

Executive Department
State of California

EXECUTIVE ORDER B-29-15

WHEREAS on January 17, 2014, I proclaimed a State of Emergency to exist throughout the State of California due to severe drought conditions; and

WHEREAS on April 25, 2014, I proclaimed a Continued State of Emergency to exist throughout the State of California due to the ongoing drought; and

WHEREAS California's water supplies continue to be severely depleted despite a limited amount of rain and snowfall this winter, with record low snowpack in the Sierra Nevada mountains, decreased water levels in most of California's reservoirs, reduced flows in the state's rivers and shrinking supplies in underground water basins; and

WHEREAS the severe drought conditions continue to present urgent challenges including: drinking water shortages in communities across the state, diminished water for agricultural production, degraded habitat for many fish and wildlife species, increased wildfire risk, and the threat of saltwater contamination to fresh water supplies in the Sacramento-San Joaquin Bay Delta; and

WHEREAS a distinct possibility exists that the current drought will stretch into a fifth straight year in 2016 and beyond; and

WHEREAS new expedited actions are needed to reduce the harmful impacts from water shortages and other impacts of the drought; and

WHEREAS the magnitude of the severe drought conditions continues to present threats beyond the control of the services, personnel, equipment, and facilities of any single local government and require the combined forces of a mutual aid region or regions to combat; and

WHEREAS under the provisions of section 8558(b) of the Government Code, I find that conditions of extreme peril to the safety of persons and property continue to exist in California due to water shortage and drought conditions with which local authority is unable to cope; and

WHEREAS under the provisions of section 8571 of the California Government Code, I find that strict compliance with various statutes and regulations specified in this order would prevent, hinder, or delay the mitigation of the effects of the drought.

NOW, THEREFORE, I, EDMUND G. BROWN JR., Governor of the State of California, in accordance with the authority vested in me by the Constitution and statutes of the State of California, in particular Government Code sections 8567 and 8571 of the California Government Code, do hereby issue this Executive Order, effective immediately.

IT IS HEREBY ORDERED THAT:

1. The orders and provisions contained in my January 17, 2014 Proclamation, my April 25, 2014 Proclamation, and Executive Orders B-26-14 and B-28-14 remain in full force and effect except as modified herein.

SAVE WATER

2. The State Water Resources Control Board (Water Board) shall impose restrictions to achieve a statewide 25% reduction in potable urban water usage through February 28, 2016. These restrictions will require water suppliers to California's cities and towns to reduce usage as compared to the amount used in 2013. These restrictions should consider the relative per capita water usage of each water suppliers' service area, and require that those areas with high per capita use achieve proportionally greater reductions than those with low use. The California Public Utilities Commission is requested to take similar action with respect to investor-owned utilities providing water services.

3. The Department of Water Resources (the Department) shall lead a statewide initiative, in partnership with local agencies, to collectively replace 50 million square feet of lawns and ornamental turf with drought tolerant landscapes. The Department shall provide funding to allow for lawn replacement programs in underserved communities, which will complement local programs already underway across the state.

4. The California Energy Commission, jointly with the Department and the Water Board, shall implement a time-limited statewide appliance rebate program to provide monetary incentives for the replacement of inefficient household devices.

5. The Water Board shall impose restrictions to require that commercial, industrial, and institutional properties, such as campuses, golf courses, and cemeteries, immediately implement water efficiency measures to reduce potable water usage in an amount consistent with the reduction targets mandated by Directive 2 of this Executive Order.

6. The Water Board shall prohibit irrigation with potable water of ornamental turf on public street medians.

7. The Water Board shall prohibit irrigation with potable water outside of newly constructed homes and buildings that is not delivered by drip or microspray systems.

8. The Water Board shall direct urban water suppliers to develop rate structures and other pricing mechanisms, including but not limited to surcharges, fees, and penalties, to maximize water conservation consistent with statewide water restrictions. The Water Board is directed to adopt emergency regulations, as it deems necessary, pursuant to Water Code section 1058.5 to implement this directive. The Water Board is further directed to work with state agencies and water suppliers to identify mechanisms that would encourage and facilitate the adoption of rate structures and other pricing mechanisms that promote water conservation. The California Public Utilities Commission is requested to take similar action with respect to investor-owned utilities providing water services.

INCREASE ENFORCEMENT AGAINST WATER WASTE

9. The Water Board shall require urban water suppliers to provide monthly information on water usage, conservation, and enforcement on a permanent basis.

10. The Water Board shall require frequent reporting of water diversion and use by water right holders, conduct inspections to determine whether illegal diversions or wasteful and unreasonable use of water are occurring, and bring enforcement actions against illegal diverters and those engaging in the wasteful and unreasonable use of water. Pursuant to Government Code sections 8570 and 8627, the Water Board is granted authority to inspect property or diversion facilities to ascertain compliance with water rights laws and regulations where there is cause to believe such laws and regulations have been violated. 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.

11. The Department shall update the State Model Water Efficient Landscape Ordinance through expedited regulation. This updated Ordinance shall increase water efficiency standards for new and existing landscapes through more efficient irrigation systems, greywater usage, onsite storm water capture, and by limiting the portion of landscapes that can be covered in turf. It will also require reporting on the implementation and enforcement of local ordinances, with required reports due by December 31, 2015. The Department shall provide information on local compliance to the Water Board, which shall consider adopting regulations or taking appropriate enforcement actions to promote compliance. The Department shall provide technical assistance and give priority in grant funding to public agencies for actions necessary to comply with local ordinances.

12. Agricultural water suppliers that supply water to more than 25,000 acres shall include in their required 2015 Agricultural Water Management Plans a detailed drought management plan that describes the actions and measures the supplier will take to manage water demand during drought. The Department shall require those plans to include quantification of water supplies and demands for 2013, 2014, and 2015 to the extent data is available. The Department will provide technical assistance to water suppliers in preparing the plans.

13. Agricultural water suppliers that supply water to 10,000 to 25,000 acres of irrigated lands shall develop Agricultural Water Management Plans and submit the plans to the Department by July 1, 2016. These plans shall include a detailed drought management plan and quantification of water supplies and demands in 2013, 2014, and 2015, to the extent that data is available. The Department shall give priority in grant funding to agricultural water suppliers that supply water to 10,000 to 25,000 acres of land for development and implementation of Agricultural Water Management Plans.

14. The Department shall report to Water Board on the status of the Agricultural Water Management Plan submittals within one month of receipt of those reports.

15. Local water agencies in high and medium priority groundwater basins shall immediately implement all requirements of the California Statewide Groundwater Elevation Monitoring Program pursuant to Water Code section 10933. The Department shall refer noncompliant local water agencies within high and medium priority groundwater basins to the Water Board by December 31, 2015, which shall consider adopting regulations or taking appropriate enforcement to promote compliance.

16. The California Energy Commission shall adopt emergency regulations establishing standards that improve the efficiency of water appliances, including toilets, urinals, and faucets available for sale and installation in new and existing buildings.

INVEST IN NEW TECHNOLOGIES

17. The California Energy Commission, jointly with the Department and the Water Board, shall implement a Water Energy Technology (WET) program to deploy innovative water management technologies for businesses, residents, industries, and agriculture. This program will achieve water and energy savings and greenhouse gas reductions by accelerating use of cutting-edge technologies such as renewable energy-powered desalination, integrated on-site reuse systems, water-use monitoring software, irrigation system timing and precision technology, and on-farm precision technology.

STREAMLINE GOVERNMENT RESPONSE

18. The Office of Emergency Services and the Department of Housing and Community Development shall work jointly with counties to provide temporary assistance for persons moving from housing units due to a lack of potable water who are served by a private well or water utility with less than 15 connections, and where all reasonable attempts to find a potable water source have been exhausted.

19. State permitting agencies shall prioritize review and approval of water infrastructure projects and programs that increase local water supplies, including water recycling facilities, reservoir improvement projects, surface water treatment plants, desalination plants, stormwater capture, and greywater systems. Agencies shall report to the Governor's Office on applications that have been pending for longer than 90 days.

20. The Department shall take actions required to plan and, if necessary, implement Emergency Drought Salinity Barriers in coordination and consultation with the Water Board and the Department of Fish and Wildlife at locations within the Sacramento - San Joaquin delta estuary. These barriers will be designed to conserve water for use later in the year to meet state and federal Endangered Species Act requirements, preserve to the extent possible water quality in the Delta, and retain water supply for essential human health and safety uses in 2015 and in the future.

21. The Water Board and the Department of Fish and Wildlife shall immediately consider any necessary regulatory approvals for the purpose of installation of the Emergency Drought Salinity Barriers.

22. The Department shall immediately consider voluntary crop idling water transfer and water exchange proposals of one year or less in duration that are initiated by local public agencies and approved in 2015 by the Department subject to the criteria set forth in Water Code section 1810.

23. The Water Board will prioritize new and amended safe drinking water permits that enhance water supply and reliability for community water systems facing water shortages or that expand service connections to include existing residences facing water shortages. As the Department of Public Health's drinking water program was transferred to the Water Board, any reference to the Department of Public Health in any prior Proclamation or Executive Order listed in Paragraph 1 is deemed to refer to the Water Board.

24. The California Department of Forestry and Fire Protection shall launch a public information campaign to educate the public on actions they can take to help to prevent wildfires including the proper treatment of dead and dying trees. Pursuant to Government Code section 8645, $1.2 million from the State Responsibility Area Fire Prevention Fund (Fund 3063) shall be allocated to the California Department of Forestry and Fire Protection to carry out this directive.

25. The Energy Commission shall expedite the processing of all applications or petitions for amendments to power plant certifications issued by the Energy Commission for the purpose of securing alternate water supply necessary for continued power plant operation. Title 20, section 1769 of the California Code of Regulations is hereby waived for any such petition, and the Energy Commission is authorized to create and implement an alternative process to consider such petitions. This process may delegate amendment approval authority, as appropriate, to the Energy Commission Executive Director. The Energy Commission shall give timely notice to all relevant local, regional, and state agencies of any petition subject to this directive, and shall post on its website any such petition.

26. For purposes of carrying out directives 2–9, 11, 16–17, 20–23, and 25, Division 13 (commencing with section 21000) of the Public Resources Code and regulations adopted pursuant to that Division are hereby suspended. This suspension applies to any actions taken by state agencies, and for actions taken by local agencies where the state agency with primary responsibility for implementing the directive concurs that local action is required, as well as for any necessary permits or approvals required to complete these actions. This suspension, and those specified in paragraph 9 of the January 17, 2014 Proclamation, paragraph 19 of the April 25, 2014 proclamation, and paragraph 4 of Executive Order B-26-14, shall remain in effect until May 31, 2016. Drought relief actions taken pursuant to these paragraphs that are started prior to May 31, 2016, but not completed, shall not be subject to Division 13 (commencing with section 21000) of the Public Resources Code for the time required to complete them.

27. For purposes of carrying out directives 20 and 21, section 13247 and Chapter 3 of Part 3 (commencing with section 85225) of the Water Code are suspended.

28. For actions called for in this proclamation in directive 20, the Department shall exercise any authority vested in the Central Valley Flood Protection Board, as codified in Water Code section 8521, et seq., that is necessary to enable these urgent actions to be taken more quickly than otherwise possible. The Director of the Department of Water Resources is specifically authorized, on behalf of the State of California, to request that the Secretary of the Army, on the recommendation of the Chief of Engineers of the Army Corps of Engineers, grant any permission required pursuant to section 14 of the Rivers and Harbors Act of 1899 and codified in section 48 of title 33 of the United States Code.

29. The Department is directed to enter into agreements with landowners for the purposes of planning and installation of the Emergency Drought Barriers in 2015 to the extent necessary to accommodate access to barrier locations, land-side and water-side construction, and materials staging in proximity to barrier locations. Where the Department is unable to reach an agreement with landowners, the Department may exercise the full authority of Government Code section 8572.

30. For purposes of this Executive Order, chapter 3.5 (commencing with section 11340) of part 1 of division 3 of the Government Code and chapter 5 (commencing with section 25400) of division 15 of the Public Resources Code are suspended for the development and adoption of regulations or guidelines needed to carry out the provisions in this Order. Any entity issuing regulations or guidelines pursuant to this directive shall conduct a public meeting on the regulations and guidelines prior to adopting them.

31. In order to ensure that equipment and services necessary for drought response can be procured quickly, the provisions of the Government Code and the Public Contract Code applicable to state contracts, including, but not limited to, advertising and competitive bidding requirements, are hereby suspended for directives 17, 20, and 24. Approval by the Department of Finance is required prior to the execution of any contract entered into pursuant to these directives.

This Executive 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.

I FURTHER DIRECT 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 to this Order.

IN WITNESS WHEREOF I have hereunto set my hand and caused the Great Seal of the State of California to be affixed this 1st day of April 2015.

EDMUND G. BROWN JR.
Governor of California

ATTEST:

ALEX PADILLA
Secretary of State

EXHIBIT H

Changing California Land Uses will Shape Water Demands in 2062

Release Date: May 18, 2016

If past patterns of California land-use change continue, projected water needs by the year 2062 will increase beyond current supply.

If past patterns of California land-use change continue, projected water needs by the year 2062 will increase beyond current supply. If historical trends of land use changes to or from urban, agricultural or other uses continue, the result will be increased water-use demand beyond what existing supplies can provide. Large uncertainties associated with weather and climate variability have the potential to exacerbate the problem.

Scientists with the U.S. Geological Survey (http://www.usgs.gov) and the Nature Conservancy (http://www.nature.org) calculated historical trends of land-use change, urbanization, agriculture expansion and contraction from 1992 to 2012, and then used those trends to project future land-use patterns and water demand from 2012 to 2062 in California's Central Valley and foothills, Central Coast and South Coast. These new projections are detailed in the paper, "Future land-use related water demand in California (http://iopscience.iop.org/article/10.1088/1748-9326/11/5/054018)" published this week in the journal Environmental Research Letters.

Assuming no new storage, efficiency or technology is created to improve California's water supply, the study results indicate that the current 25 percent urban water-use restrictions called for in Governor Edmund G. Brown's Executive Orders B-29-15 (https://www.gov.ca.gov/docs/4.1.15_Executive_Order.pdf) and B-37-16 (https://www.gov.ca.gov/docs/5.9.16_Executive_Order.pdf) would need to be maintained through 2062 for future water demand to remain at or below 2012 demand, unless restrictions were put in place on other water uses. Water use in 2012 was already proven unsustainable given the ongoing multi-year drought, which led to mandated statewide urban-use restrictions in 2015.

In the long term, drought, highly variable rainfall from year to year, and the real possibility of future warming and drying of climate combine to create potential water supply limitations. Coupled with population increases and shifting agricultural practices (from annual crops to orchards and vineyards) there can be enormous uncertainty in planning for future water supply and demand.

"Modeling the future based on historical trends is not a prediction of what will happen, though patterns do emerge that can help guide water-use policies," said Tamara Wilson, USGS research geographer and lead author of the study.

"In many ways, the recent drought is prologue to confronting the challenges that climate change presents for all of us. The reality is California's water demands outpace supply, and the precipitation this winter did not change that," said co-author Dick Cameron, Associate Director for Science, Land Conservation Program at the Nature Conservancy in California. "Assuming a 'business-as-usual' scenario of future land-use change, we show that the current pattern of increasing development and additional perennial cropland (orchards and vineyards) will lead to loss of grassland habitat and increased water use."

Projecting land-use change data for California over the 50 years from 2012 to 2062 revealed the following potential changes:

- Large increase in urban area: 2 million acres of newly developed land cover over 50 years – a net increase of 40,000 acres a year – the equivalent of adding an area just larger than the city of Stockton each year.

- Large amount of grassland habitat loss of 1.1 million acres over 50 years, despite continued protection at the historical rate. This loss will also exacerbate challenges in preserving and recharging aquifers.

- An overall 4 percent increase in water supply demand (applied water) within the study area due to urbanization and expansion of orchards and vineyards.

- Large shifts from annual to perennial crops, which removes flexibility in irrigation demand during drought. While annual-crop water demand dropped 30 percent, perennial-crop demand increased 37.5 percent. Given the difference in area between these types, net agricultural water demand decreased nearly 8 percent over current demand.

- There will be a large shift toward developed-land water uses from the agriculture sector: Urban water use in 2062 is projected to increase to 27 percent of overall water use in the study area (from 18 percent in 2012).

- A net increase in overall projected water use in 38 of the 46 California counties in the study area by 2062.

(/media/images/land-use-and-land-cover-change-california)
Land-use and land-cover change for the historical period (1992–2012) and the projected period (2012–2062) in California's Central Valley and Oak Woodlands regions under a business-as-usual scenario.
(/media/images/irrigation-ditch-alongside-agricultural-field-californias-central-valley)
Irrigation systems in Central California Valley Ecoregion: Single-field irrigation ditch.
Public domain
(/media/images/grasslands-and-agricultural-fields-housing-development-hills-beyond)
Conversions of grassland/shrubland and agriculture to developed land were two common land-cover changes in Southern and Central California Chaparral and Oak Woodlands Ecoregion.
Public domain

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EXHIBIT I

Mother Jones

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California's Insane Nut Boom, In 3 Simple Charts

Almonds, walnuts, and pistachios are making bank in the Golden State—but the groundwater supply is paying the price.

LEI WANG NOV. 3, 2014 6:00 AM

mamma_mia (http://www.shutterstock.com/pic-142886560/stock-photo-almonds-walnuts-and-hazelnuts-in-wooden-bowls-on-wooden-background.html?src=X97wO8FlqsCO9q7GM0CTEA-1-1) **/Shutterstock**

California has entered the age of King Nut: The state produces more than 80 percent of the world's almonds, and roughly 30 and 40 percent of the world's pistachios and walnuts, respectively. Most of the production takes place in the Central Valley, a swath of farmland in California's midsection.

A single almond requires a gallon of water (http://www.motherjones.com/environment/2014/02/wheres-californias-water-going) to grow—bad news in the midst of California's worst drought in half a millennium (http://www.motherjones.com/environment/2014/02/california-drought-matters-more-just-california). But with ever-rising demand in a nut-crazed world, farmers continue to expand orchards, pumping water out of the ground to make up for the dried-up surface water. These charts tell the story:

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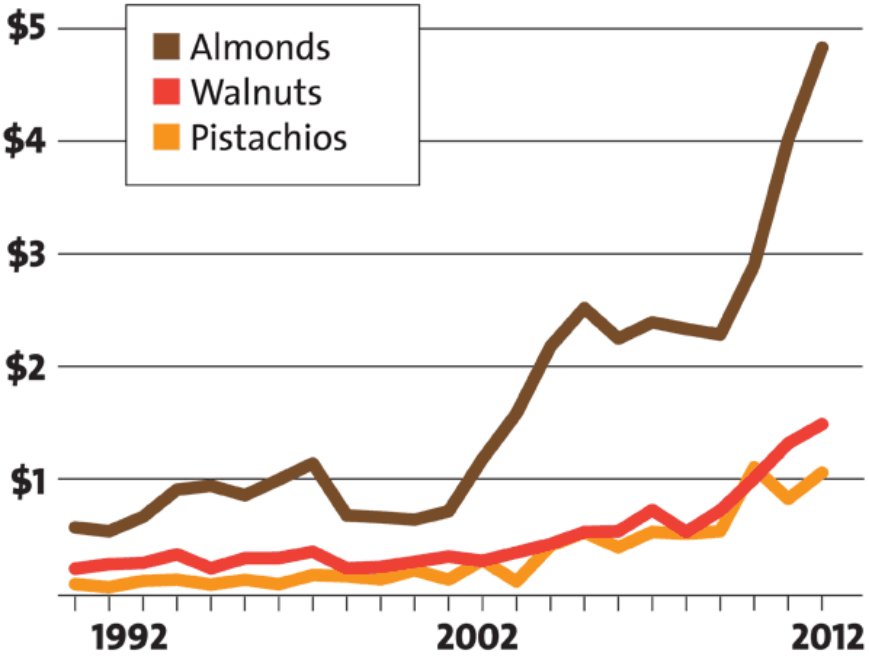
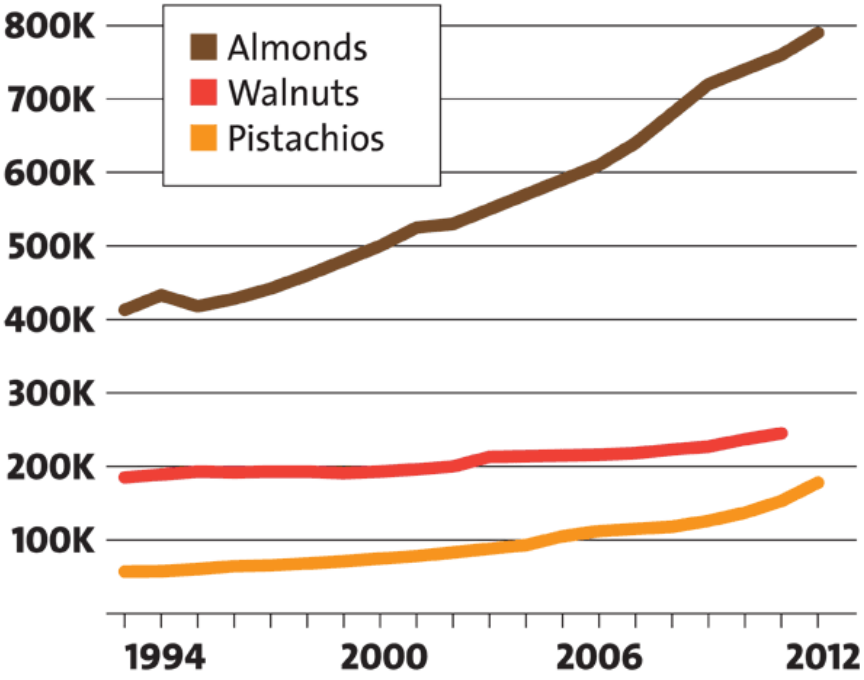
California's Nut Boom
(in billions of dollars)



As the State's Orchards Keep Expanding... (in acres)



...the Central Valley's Groundwater Keeps Dwindling (in acre-feet)

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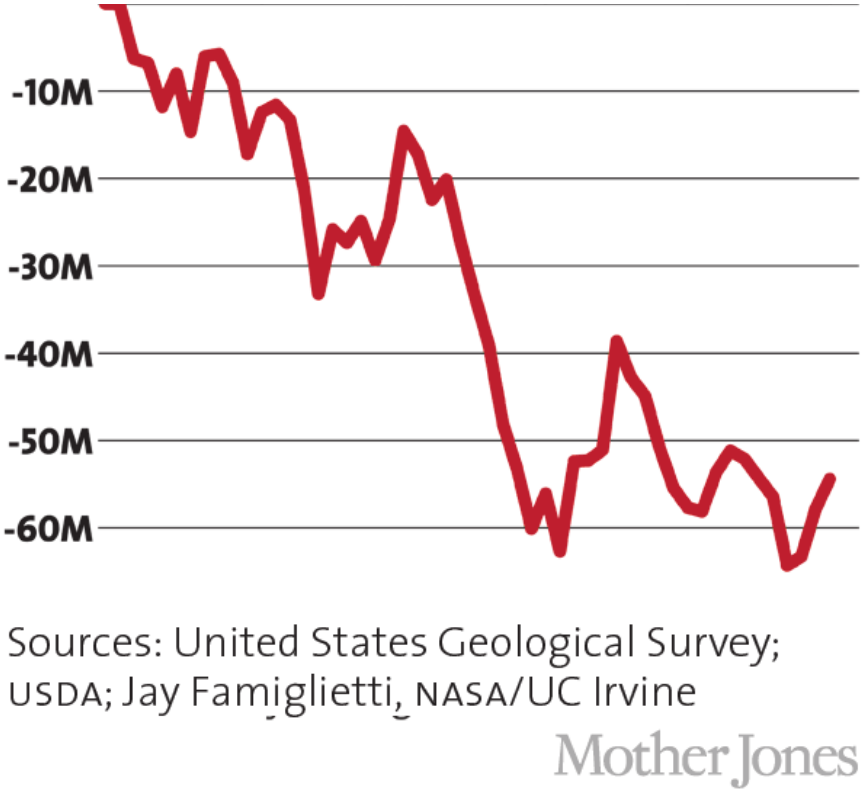

Charts by Lei Wang and Julia Lurie

As my colleague Tom Philpott recently reported (http://www.motherjones.com/tom-philpott/2014/10/caliifornia-groundwater-withdrawal-china-india-middle-east) , Since 2011, central California has lost "more water than all 38 million Californians use for domestic and municipal supplies annually—over half of which is due to groundwater pumping in the Central Valley."

Groundwater is the stuff of centuries: rain percolating for ages through pores of soil and rock, coming to rest in aquifers. In wet seasons, water generally begins its slow trickle-down journey to replenish the aquifers (the small upward spikes in the third chart above). But as Jay Famiglietti, the NASA water scientist who gathered the groundwater data, has stated, "The downs are way bigger than the ups, which means that groundwater levels are on a one-way journey to the very bottom of the Central Valley."

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LEI WANG

Lei Wang is a former editorial fellow at Mother Jones.

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EXHIBIT J

APRIL 17 2015 7:17 PM

Stop Vilifying Almonds

Yes, they use up a lot of water in drought-afflicted California. But the story gets a lot more complicated from there.

By Eric Holthaus

In California, water-intensive almonds have become an easily vilified, easily visualized scapegoat.

Photo by Dolores Giraldez Alonso/Shutterstock

This year's "rainy" season is over, and California is **beginning to accept** its fate: **Business-as-usual** farming in the Golden State **may soon become** a thing of the past. The drought is now **so far** beyond **the bounds of normal** it's become at least temporarily **self-sustaining**. Extreme heat begets more evaporation, and dry ground heats up more quickly than wet soil. Add in a dash of global warming, and you have a recipe for **a megadrought** that may last decades. For a state whose decades-long water-fueled bender has made it the **most important agricultural producer in the country**—one that **leads the nation** in countless water-intensive food crops, that's all pretty terrifying.

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It also explains the heated debate we've been having recently over, of all things, almonds—or "THE DEVIL'S NUT," **as *Gizmodo*** facetiously called them recently. Amid the massive new water restrictions now in place in California, water-intensive almonds have become an **easily vilified**, easily visualized scapegoat.

It's true that California has to get smarter—fast—about using what little water it has left. But we should recognize that the state has other, much sillier uses of water than almonds—like depleting California's desert aquifers to grow hay and corn to fatten cows. (Nebraska already does a pretty good job at that.) I'm by no means an almond apologist, but all this recent **almond-shaming** demands some context. And, in fact, there's a strong case that it makes great sense for almonds to remain central to the future of California agriculture.

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For now, California's unique Mediterranean climate is **almost ideal** for almonds to flourish. Yes, almonds use a lot of water, but that's not necessarily a bad thing. Almonds are much more efficient water-users, per calorie, **than dairy** or **beef**, for example. (As a Wisconsin resident, I feel duty-bound to remind everyone at this point that dairy farming can be done almost anywhere—and indeed, dairies in search of more reliable water **are leaving California** because of the current drought.) Replacing a glass of cow's milk with almond milk is a net gain for the environment. But almond trees, which must be watered even when they're not producing, have been gradually displacing fields of row crops that can be fallowed when the weather turns dry. That means by planting almonds, farmers are locking in future water use for decades to come—a troubling trend.

Mother Jones has owned the almond beat **for more than a year** now. The magazine has helped us learn that it takes **about a gallon of water** to grow a single almond, and the state's **expanding class of almond tycoons** are increasingly eager to use almonds to **convert the state's dwindling water supplies to cash**. Almonds use **about as much water** each year as the entire city of Los Angeles does in three, and **about two-thirds** of those nuts are exported. As long as the world wants almonds, California will be happy to oblige—that fact **is increasingly clear**.

Last year at this time, I was in the midst of **a 12-part series** on water issues in the West. One statistic I calculated during that time has since gone viral: **Almonds use 10 percent** of California's agricultural water supply.

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Hoping to update that statistic, I recently got in touch with the Almond Board of California—a voice for the industry (its Twitter handle is **@almonds**). The group agreed that the statistic was essentially correct—though it stressed that the range is probably somewhere between 8 and 11 percent, depending on how much rain and snow fall in a given year. We put our heads together to come up with an updated version of my calculation, with numbers specific to this winter.

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First, some background. California's agricultural water supply can be broken into **three major sources**: snowpack, reservoirs, and groundwater, which provide roughly equal amounts of water in a normal year. In drought years like this one, farmers rely more intensely on groundwater to make up for what didn't fall from the sky—meaning aquifers are being drained even more quickly.

Here's the amount of water California's agricultural sector has to work with this year, calculated in million acre-feet, one of which equals 325,000,000,000 gallons, 1,200 Empire State Buildings **full of water**: The **snowpack** is at record lows, just **5 percent of normal** (0.75 MAF, 14.25 MAF less than normal). **Reservoirs** are doing a bit better, at about two-thirds of normal (13.2 MAF, 6.8 MAF less than normal). **Groundwater** has made up some of the difference, and is being pumped at a rate about 34 percent above normal (19.8 MAF, 5.1 MAF more than normal). That means the total agricultural water supply this year is 33.75 MAF.

Of the 33.75 million acre-feet of water available to agriculture in 2015 (enough water to supply the entire San Francisco Bay area for more than 30 years), almonds are on track to use 3.6 million acre-feet, or 11 percent.

The California almond industry has doubled its acreage since 2005. But whether almonds are the best use of a dwindling supply, factoring in climate change projections, is a different question. These are trees, remember, which have a productive lifespan of 20 to 25 years. They're going to be there until it's not economical for them to be there anymore.

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Over the last few decades, there's been a shift from low value (cotton, rice) to high value (almonds, pistachios) agriculture in California as the effective cost of water has increased. (Though water typically isn't metered, **it's become extremely expensive** to dig deeper

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wells.) In a real sense, the almond industry is the future of California agriculture—high value, **high efficiency**, but still high consuming. That's not necessarily a bad thing, as it makes most sense to use a scarce resource for the highest value application possible.

The problem is that, thanks to the current drought, the water supply is going away faster than expected. The almond industry is an indicator of how difficult it might be to adapt to climate change, economically and environmentally.

What we're witnessing in California right now is **a glimpse into the future**. California has now endured drought in **11 of the last 15 years**, and there's every reason to believe **this is just the beginning**.

There's a lot of debate over which atmospheric forces **kicked off** this particular round, but there's little doubt that **climate change has made things worse**. A very warm winter pushed the state's snowpack to a **shocking new low**, prompting the first-ever **mandatory statewide water restrictions** earlier this month. But as has been **much-reported**, those new rules **didn't do much** to stem water usage in the state's massive agricultural sector, which currently uses about **80 percent** of California's water supply.

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Here's a shocking statistic that doesn't get enough attention: nearly one-half of California's farms still use "flood irrigation," **a 7,000-year-old technique** for watering crops. That technique is exactly what it sounds like: diverting canals to flood their fields. While that may have worked well in prehistoric Mesopotamia, irrigation technology has come a long way since then.

A **joint study** last summer by the Natural Resources Defense Council and the Oakland-based Pacific Institute found that by instituting basic modern-era water-saving technologies, like wastewater recycling, stormwater capture, drip irrigation and replacement of urban lawns with native landscaping, the state **could save enough water** to reverse its dramatic groundwater decline with loads of water left over.* The problem is, the state's **antiquated system of water rights** isn't giving the most wasteful farmers any incentive to change their ways.

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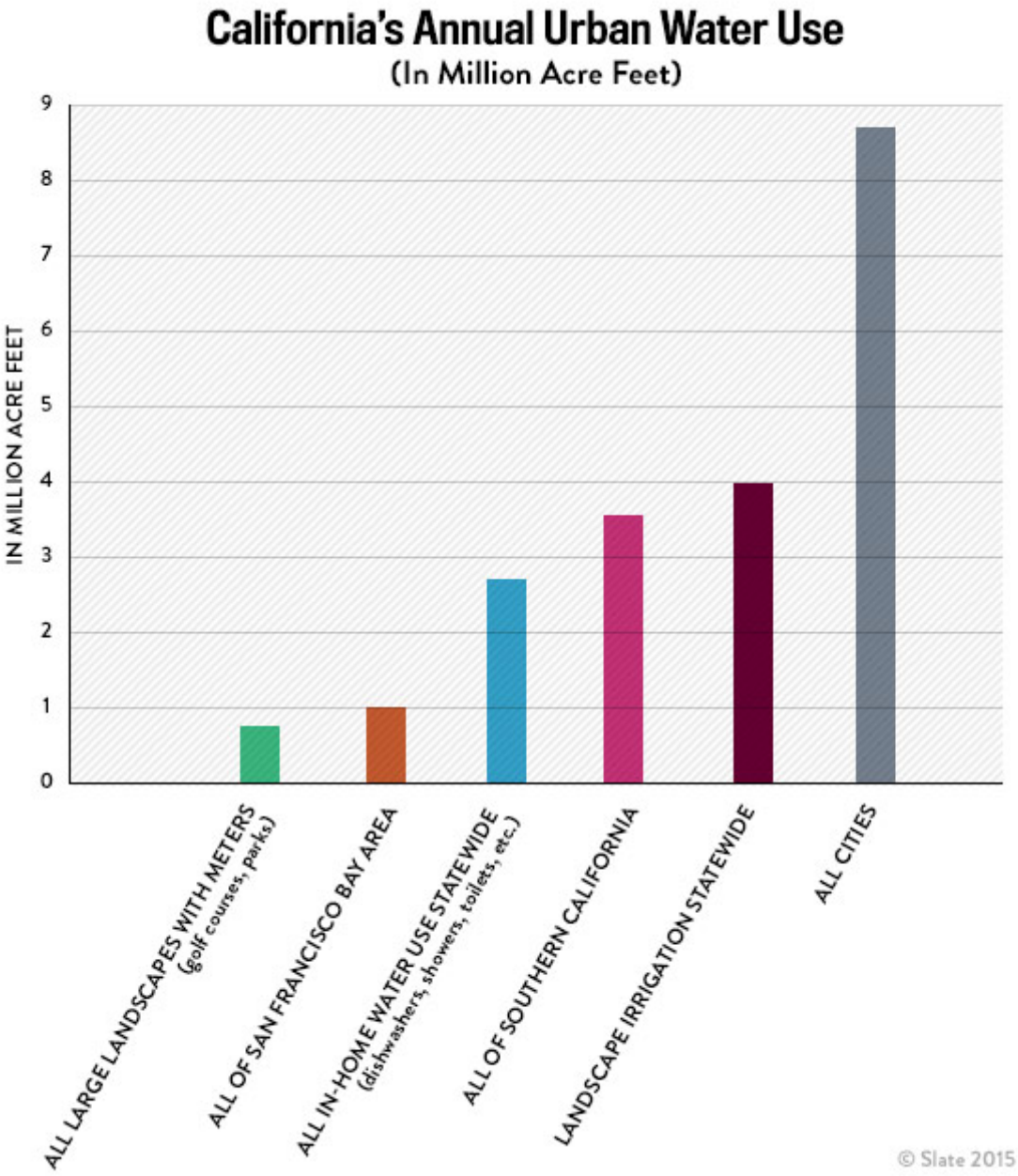

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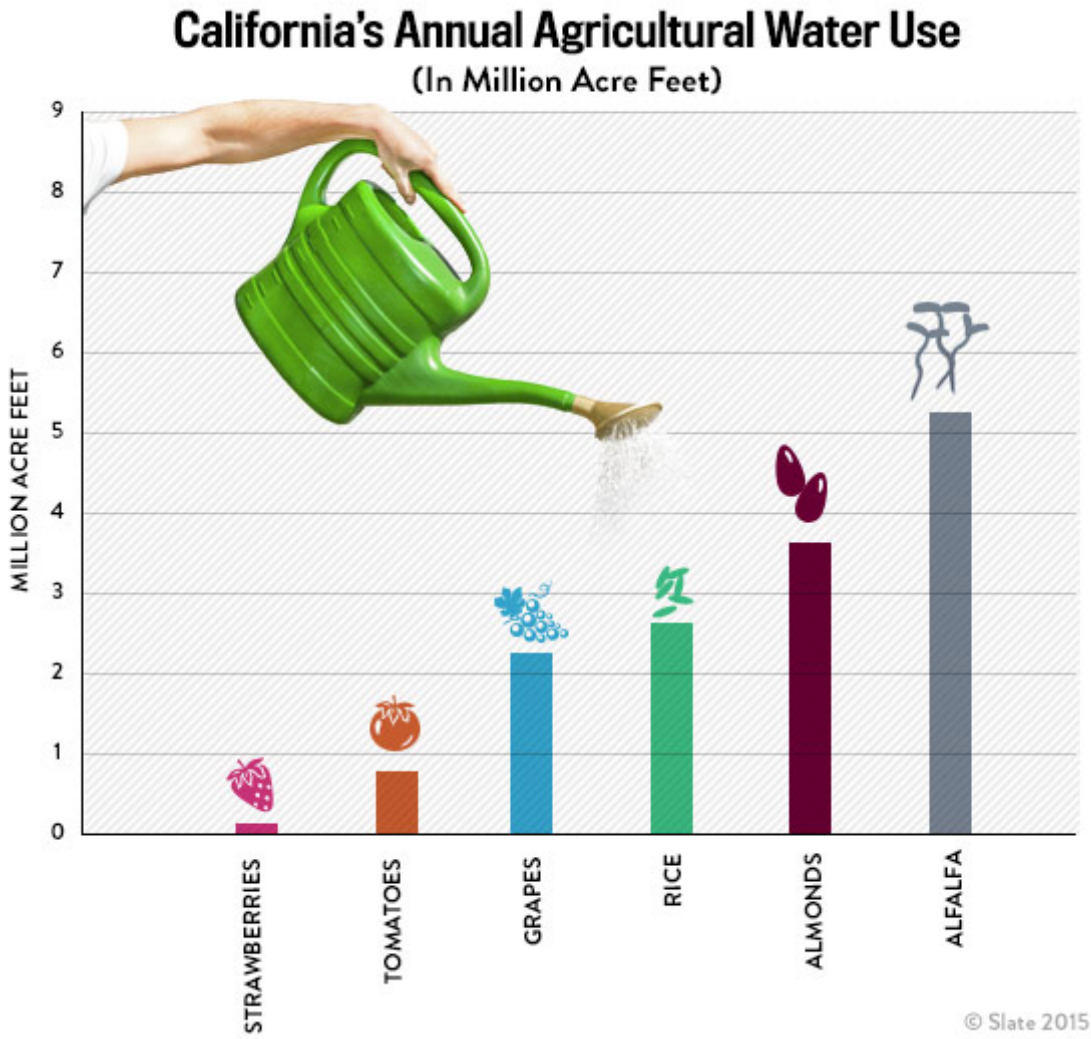

When you remember that all agriculture, despite using 80 percent of the state's water, produces only about 2 percent of the state's GDP, it's easy to make the case that urban water use is much more economically efficient. But then again, we have to eat, right?

The main questions everyone's asking, I think, are: Do I have to give up almonds? Is almond farming compatible with climate change?

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We can imagine a water-constrained future in which groundwater pumping is enforced (no extra pumping in drought years is allowed, as it is now) and a near-zero snowpack becomes the norm. That would probably result in a permanent loss of about one-third to one-half of California's water.

While cities, industry, and the rest of agriculture **have become more efficient** in their water use, total water use for almonds has expanded rapidly over the last decade or so as almond acreage in California doubled. Almonds, too, are **using water more wisely**, but their

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explosive growth has dwarfed efficiency gains. On the other hand, total acreage for hay, including alfalfa—California's No. 1 agricultural water user—is **on a steady decline** as fields become more productive and dairy farmers **bid up the price** in drought years. That long-term trend of fallowing low-value crops (like hay and rice) is leaving more vacant ground for (you guessed it) more almonds.

California is expecting 11 million more people **in the next 20 years**—though at current rates of increasing efficiency, we can expect cities to use about the same amount of water in 2035 as now. At the same time, temperature and precipitation trends point toward an intensification of drought risk **for the forseeable future**. It's clear California will need to do more with less, but that burden will fall almost entirely on agriculture.

Top Comment

I work for a John Deere dealership in the heart of California's San Joaquin Valley. We sell this moisture probe called Field Connect that's absolutely amazing. There are 4-6 sensors on each probe that monitor moisture level at increasing depths. More...

-JStevens

196 Comments **Join In**

If almonds continue to expand, at some point, it becomes a value judgment whether we want to devote 15 or 20 percent of the water in the most productive region of the United States to them. If that comes at the expense of the relatively less efficient uses like the dairy industry, I'm all for it. But if almonds farmers challenge urban areas for water, you can bet they'll be in for a fight.

Correction, April 20, 2015: *This article originally misidentified the Natural Resources Defense Council as the National Resourced Defense Council. (**Retrun**.)*

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California drought: How water crisis is worse for almonds

By Peter Fimrite Updated 10:47 am, Monday, March 24, 2014

IMAGE 1 OF 23 Buy Photo

An almond tree is lifted into a wood chipper after farmer Barry Baker decided to sacrifice 1,000 acres of trees to save water in Firebaugh (Fresno County).

Atwater, -- Merced County - A huge shift away from annual crops to nut trees has transformed the California farm belt over the past two decades and left farmers perilously vulnerable to the severe drought that is currently gripping the state.

California farmers have spent past years busily ripping out lettuce, tomatoes and other annual crops in an attempt to sate the nation's growing appetite for almonds, pistachios and other nuts.

The delicious perennials are lucrative, but the vast orchards that have been planted throughout the Central Valley require decades-long investments, year-round watering and a commitment from Mother Nature that she is evidently unwilling to make.

The crisis is a matter of crop flexibility. During droughts, farmers can fallow fields of lettuce

and other crops, then replant them years later, picking up pretty much where they left off. That's not an option for nut trees, which need 10 years of growing and a steady supply of water before they yield enough to pay for themselves.

"These orchards are more profitable, which is why the farmers do it," said Jay Lund, the director of the Center for Watershed Sciences at UC Davis. "It brings more money into California so there are a lot of good things about it, but the farmers have to be careful because a drought can be very tough on them."

The result is that about one-third of California's agricultural land is, Lund said, "very hard to fallow."

Farmers are scrounging for every drop of water they can find - digging wells, tapping aquifers and finding alternative sources. But some are coming to the stark realization that, no matter what they do, there won't be enough water to keep their trees alive.

Barry Baker has decided to sacrifice 1,000 acres of his Fresno County almond orchard so that he can keep the remaining 4,000 acres alive.

'Huge economic loss'

"It's a huge economic loss," said Baker, who looked on forlornly this past week as workers felled his beloved trees. "That's probably $10 million in revenue I lost right there, but with the price of water today, up to $2,500 per acre-foot, there is no way I could have found the water this year. A lot of guys are going to have to make that decision in the next couple of weeks."

Baker is actually one of the lucky ones. He has enough well water on his property to keep his remaining trees alive without having to break the bank buying overpriced water from irrigation districts. A great many farmers south of the delta don't have that luxury.

"I think we're going to see a lot of trees die," he said. "It's going to break a lot of farmers."

The switchover from annual crops to nuts has, by all accounts, been highly profitable. Nut production in California brings in $7 billion in sales every year, with almonds by far the biggest money maker, at $4.35 billion. Only grapes, which generated $4.45 billion, sold more.

The growth is, at least in part, because of the popularity of the Mediterranean diet, which may also explain why U.S. consumption of olive oil has tripled over the past twenty years. The average American eats 1.8 pounds of almonds, according to the U.S. Department of

Agriculture. That's a 36 percent increase since 2008. Consumption of walnuts, pistachios and pecans has also increased.

Extreme drought areas

Most of the orchards have been planted in areas suffering from what meteorologists call "extreme drought."

"An increase in the planting of permanent crops since California's last drought episode in 2009 is one reason we have concerns that this drought has the potential to be significantly worse," said Steve Lyle, the spokesman for the California Department of Food and Agriculture.

About 3 million of the 9 million or so acres of irrigated agriculture in California are now orchards and vineyards, according to the experts. The Golden State is the nation's top producer of tree nuts, with almonds far outpacing everything else.

There are more than 800,000 acres of almonds in California compared with 418,000 acres in 1995. Production also doubled, from 912 million pounds in 2006 to 1.88 billion in 2013. California produces 82 percent of the world's almonds, which are neck and neck with grapes as the highest valued crop in the United States.

Meanwhile, most field crops have been cut back. There was, for instance, 1.5 million acres of cotton in California 25 or 30 years ago. Now there is only 300,000 to 400,000 acres, said Daniel Sumner, of the Agricultural Issues Center at the University of California at Davis.

Dairymen, ranchers hurt

The situation is also bad for dairy farmers and ranchers, according to Pete Craig, who owns a large cattle ranch near Lake Berryessa. He said the planting of almond orchards has taken thousands of acres of grazing land away from ranchers, many of whom are selling cattle because of a lack of feed.

"My company has lost over 8,000 acres of grasslands that I leased for cattle grazing to almonds in the last year alone," said Craig, who believes it is bad for the environment to replace California's diverse grassland ecosystem with a monoculture. "It is impossible to

compete against a very realistic $5,000 acre net return for a tree farmer, versus a $15 acre return on native rangeland, and perhaps a $100 acre return on irrigated ground to a cattle rancher. If you were a landowner, what would you do?"

Almonds have always been big in California. The Golden State, with its Mediterranean climate, is the world's top producer of the nut. Still, the recent expansion of the almond industry has been unprecedented, and there lies the problem.

Almond trees must get 3 to 4 acre-feet of water per acre every year or nut production will decrease for an extended period of time. An acre-foot is enough water to cover an acre of land in a foot of water.

"When you cut back on water, it stresses the tree, and when an almond tree is under stress, it produces fewer nuts," said David Baker, the director of member relations for Blue Diamond Growers, an agricultural cooperative that specializes in marketing almonds. "The problem is, they will not recover for 3 or 4 years even if the drought breaks."

Replacing almonds with a different crop is not normally a viable option. It costs as much as $6,000 an acre to plant an almond orchard and raise the trees until they are 5 years old, about the time it takes them to begin producing almonds. It takes about a decade before the orchard produces enough almonds to pay for itself, according to farmers.

"Almonds are a huge investment," said Craig Arnold, who grows almonds on 800 acres of his 1,200-acre farm in Atwater (Merced County) that his great grandfather, Lawrence, built after leaving San Francisco following the earthquake in 1906.

The Merced Irrigation District, which gets its water from nearly empty Lake McClure, recently told Arnold he would be getting only about 6 inches of water per acre this year. Arnold said almonds and peaches require at least 30 inches of water per acre, which is the amount he received last year.

Can't afford to let trees die

"We have been trying to figure out what we are going to do," Arnold said recently as he stood near the family farmhouse, which he oversees with his father and uncle. "It's the almonds and the peaches that I worry about. I can choose not to plant everything else for a year, but I can't afford to let the trees die."

Arnold's plan right now is to leave fallow 250 acres of sweet potatoes and squash and use

the water to keep his almonds and peaches alive. He has already converted 75 percent of his orchards to low volume drip or micro sprinkler irrigation and recently hired workers to refurbish an old well on his property that hasn't been used in decades.

Farmers are, in fact, sinking a large number of new wells across the state, but irrigating with well water can be problematic. Harmful salts and minerals from the aquifer can kill

trees and damage crops. Wells can also cause the water table to drop, creating a whole new set of problems.

Nut prices to rise

It is a balancing act that thousands of farmers are now facing. One thing that is certain is that there will be huge economic losses and the price of almonds and other nuts will go up as production goes down.

"I have heard that between 200,000 and 250,000 acres will have significant reductions in production as a result of water shortages," said Dan Cummings, who grows 4,000 acres of almonds in Butte, Colusa and Glenn counties. "California produces almost 2 billion pounds of almonds. Think about it. If 200 million pounds of that is not produced, that's $700 million that doesn't go to the farmer. It's huge."

And it could actually get worse before it gets better.

"Another year of this and you will see even the people who planned ahead getting hurt really bad," said Baker, the farmer who cut down 1,000 acres of orchard just so he could stay afloat another year. "It will really be a disaster next year."

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LETTER

Future land-use related water demand in California

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Supplementary material for this article is available online

Abstract

Water shortages in California are a growing concern amidst ongoing drought, earlier spring snowmelt, projected future climate warming, and currently mandated water use restrictions. Increases in population and land use in coming decades will place additional pressure on already limited available water supplies. We used a state-and-transition simulation model to project future changes in developed (municipal and industrial) and agricultural land use to estimate associated water use demand from 2012 to 2062. Under current efficiency rates, total water use was projected to increase 1.8 billion cubic meters (+4.1%) driven primarily by urbanization and shifts to more water intensive crops. Only if currently mandated 25% reductions in municipal water use are continuously implemented would water demand in 2062 balance to water use levels in 2012. This is the first modeling effort of its kind to examine regional land-use related water demand incorporating historical trends of both developed and agricultural land uses.

1. Introduction

In 2010, California used an estimated 45.6 billion cubic meters (Bm^3) of water for public supplies, irrigation, and livestock [1], more than any other state in the US. Surface water rights are approximately five times the states' mean annual runoff while substantial uncertainty surrounds actual use estimates, especially for groundwater [2]. California's complex, intensively developed water storage and delivery system depends almost entirely on the collection and redistribution of winter precipitation, surface runoff, and groundwater. Persistent drought conditions since 2011 led to passage of the first urban water use restriction law in the state's history [3], mandating a 25% reduction in municipal use. The mandated reduction will minimally impact statewide demand overall as the agriculture sector dominates consumption (~80% of statewide totals, predominantly irrigated in the study region). Developed water use (i.e. urban/suburban residential, commercial, industrial) only consumes an estimated 17.6% [4, 5]. The drought has become so severe that in June 2015, state water board officials mandated cuts to senior agriculture water rights holders for the first time since the 1970s [6]. Longer term management plans are now seen as critical for California's water future as evidenced by the 2014 Sustainable Groundwater Management Act, the first groundwater management legislation in state history. Groundwater supplies an estimated one-third of total statewide water used in an average year, increasing to more than one-half during drought years when other supplies are limited [7].

Water supply and demand imbalances are likely to intensify in coming decades, due to population growth, land-use intensification [8], a projected warming and drying climate [9–11], earlier spring snowmelt [12], increasing likelihood of persistent drought conditions [13–15], existing restrictions in surface-water deliveries [2], and unsustainable groundwater extraction rates [16, 17]. Highly variable annual water supplies will likely increase competition among developed, agriculture, and environmental sectors for both surface water and groundwater resources [8]. California's population is projected to increase to 52.6 million by 2060 [18] from an estimated 38 million in 2012 [19]. Without extensive water use efficiency improvements across sectors, new storage capacity (e.g. reservoirs, groundwater storage),

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new supplies (e.g. desalinization, groundwater recharge), or improved delivery efficiencies, new demand will need to be met by reallocation from existing uses [2]. If not, overall demand could potentially exceed supply this century.

The aim of this research was to quantify future land-use related water demand in California under a 'business-as-usual' (BAU) scenario. The BAU scenario assumes land use and land cover (LULC) dynamics from the historical period persist into the projected period, including historical rates of land conservation. We compiled historical LULC change data as well as water use information from both remote sensing and tabular datasets for use in a state-and-transition simulation model (STSM) [20–22]. Changes in LULC were modeled annually at 1 km by 1 km spatial resolution for the baseline period (1992–2012) using the historical data. For the projection period (2012–2062), the model randomly sampled from the historical distribution of LULC change while tracking water use for developed (municipal and industrial) and agricultural (annual and perennial cropland) land uses. The resulting model output included annual LULC and water use projections to the year 2062 across 40 Monte Carlo simulations. Examination of land-use related estimates of future water demand in California are needed to develop effective water resource management plans, given highly variable inter-annual supplies and future climate uncertainty.

2. Methods

We used the LUCAS STSM [20, 21] to project land-use change over a 70 year period (1992–2062) across 40 Monte Carlo simulations to estimate associated water use demand in Mediterranean California. Projections of land use were developed under BAU conditions where future changes were based on recent historical rates of land-use change and land protection. The LUCAS model is a form of non-stationary, Markov Chain model, where the landscape is divided into a set of simulation cells with each cell assigned a discrete state (i.e. LULC class). Transitions targets were developed using a time-series of historical data describing the rate of change between land-use and land-cover classes and were used within the model to move cells between states over time. For a more thorough description of the STSM framework see Daniel and Frid [22] and Sleeter *et al* [21].

2.1. Study area

The spatial extent of the model included two ecoregions in central and southern California, defined by the US Environmental Protection Agency as the Central California Foothills and Coastal Mountains (hereafter called 'Oak Woodlands') and the Central California Valley (hereafter called the 'Central Valley') [23] (figure 1). Ecoregions were selected as the primary spatial stratification unit as they have proven useful in the analysis of LULC change [24, 25]. Ecoregions are characterized by similar biotic, abiotic, aquatic, and physical characteristics and therefore similar land-use potential [26]. All 46 counties contained within the two ecoregions were used as a secondary spatial stratification unit (figure 1). Overall, the study area was subdivided into 1 km by 1 km simulation cells resulting in a total area of 146 410 km^2, with each cell assigned an ecoregion (primary stratum) and county (secondary stratum).

2.2. State variables

We used the 1992 National Land Cover Dataset (NLCD92) [27] to define our initial LULC state class categories. The 20 original NLCD92 LULC categories were aggregated into primary LULC categories as defined in table 1. To identify areas with high levels of protection, where future land use activities would be limited or prohibited, we used data from the US Geological Survey's Protected Area Database [28] to classify rangeland and forest into protected versus unprotected. The LULC state of each cell was then based on a nearest neighbor resampling of the NLCD92 (30 m) and protected areas maps to 1 km^2. A total of 1104 unique state class combinations were available, as a result of combining 12 LULC classes from table 1 with the two ecoregions and 46 counties. For the perennial cropland class we tracked both age and time-since transition (TST).

2.3. Model process overview

LUCAS simulates transitions between LULC state classes in annual timesteps. For this model we defined 6 transition types and 332 transition pathways (table 2). The processes represented by these pathways include changes between agricultural classes, agricultural expansion, agricultural contraction, orchard removal, urbanization, and protection of rangeland and forest. Within a given timestep, the order at which transitions occur is random for each Monte Carlo simulation.

2.4. Model parameterization

2.4.1. Transition targets

State class transition targets were used to model agricultural expansion, agricultural contraction, urbanization, land protection, and conversions from annual to perennial cropland. Transition targets for the agricultural expansion, agricultural contraction, and urbanization transition types were based on a time series derived from the California Farmland Mapping and Monitoring Project (FMMP), which provides land-use transition amounts for each of the 46 counties in the study area on a biannual basis for the historical 1992–2012 period (figure S1) [34, 35]. The FMMP data was directly used in the model for the 1992–2012 period. For the projected period (2012–2062) we randomly selected one of the FMMP

historical years (and its corresponding change rates) for each timestep in each Monte Carlo. By randomly sampling one of the historical years we preserve the covariance of change rates between counties, as opposed to sampling each county independently.

There were no data available documenting the historical rate of change between annual and perennial cropland in California. Agricultural statistics indicate a trend towards increasing perennial and decreasing annual cropland over the last half of the 20th century [36], however, statistical surveys alone do not indicate the source of these trends, specifically the rate of individual class conversions. Within the model we assumed changes from annual cropland to perennial cropland occur at an average rate of 100 $km^2\,yr^{-2}$ (standard deviation of 50 km^2) from which we sample across every timestep and Monte Carlo simulation.

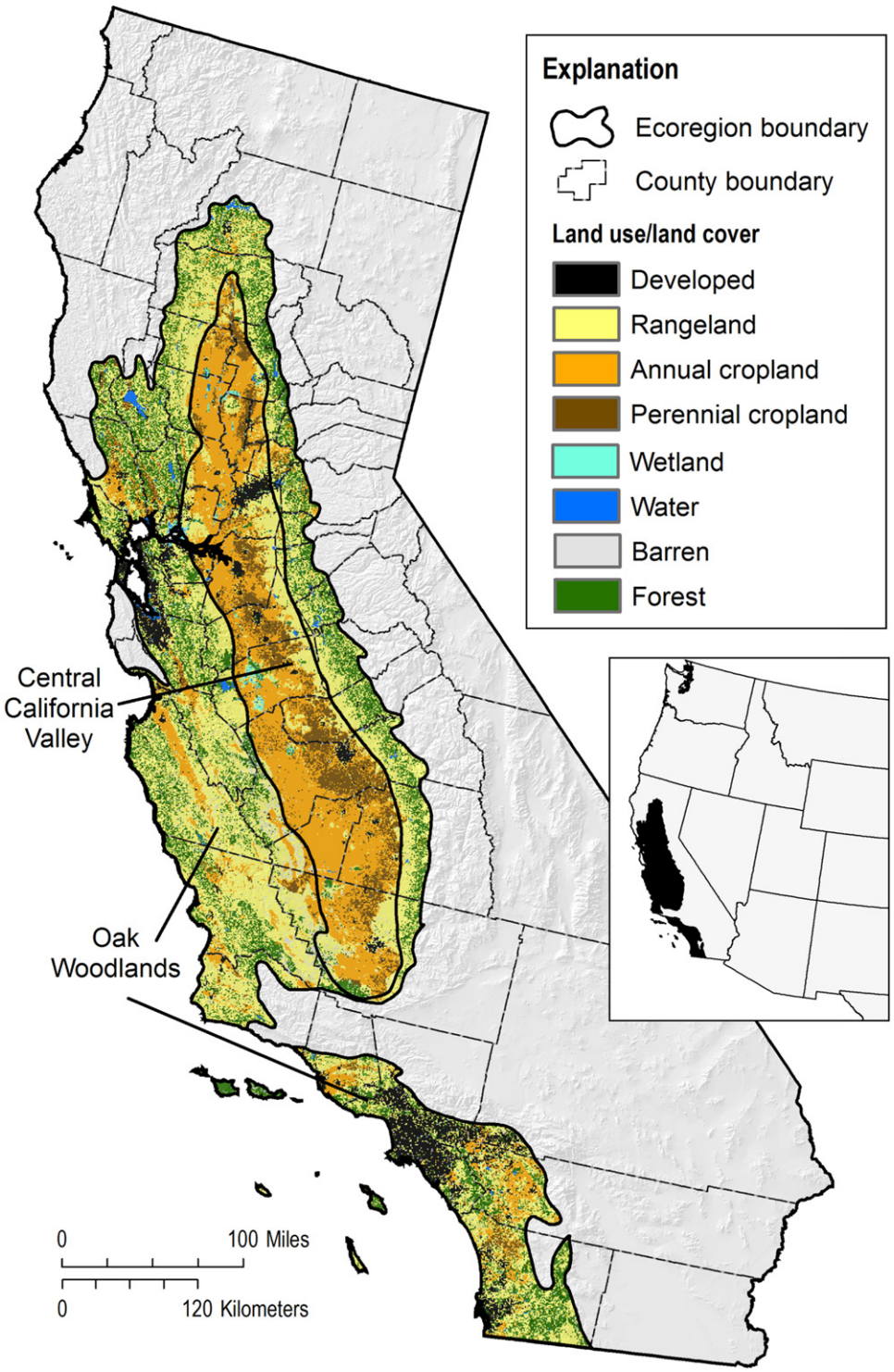

Figure 1. Study region in California including the Central California Valley and Central California Foothills and Coastal Mountains EPA Level III ecoregions [23], associated counties (outlined in light black) included in the study area, and 1992 land use and land cover.

Table 1. State classes and the corresponding classes from the 30 m National Land Cover Dataset. Descriptions closely follow those outlined in Anderson *et al* [33] and Sleeter *et al* [25].

State class	Area (km^2)	% of study region	NLCD classes	Description
Rangeland	52 866	36.1%	Grasslands/herbaceous shrublands	Land where potential natural vegetation is predominantly grasses, grass-like plants, forbs, shrubs, or brush and where natural herbivory was an important influence in its pre-civilization state. The vegetated cover must comprise at least 10% of the area.
Rangeland (protected)	11 217	7.7%	Grasslands/herbaceous shrublands	Same as the rangeland class but set aside for permanent exclusion from conversion to an alternate land-use or land-cover state.
Annual cropland	33 127	22.6%	Pasture/hay row crops small grains, fallow	Non-woody cropland or pastureland in either a vegetated or non-vegetated state used for the production of food and fiber.
Perennial cropland	10 550	7.2%	Orchards/vineyards/other	Woody cropland persisting over multiple growing seasons used for the production of food, drink, and fiber, that does not get destroyed or removed during harvest.
Forest	16 761	11.4%	Deciduous forest, evergreen forest, mixed forest	Tree-covered land where the tree-cover density is greater than 10%.
Forest (protected)	7071	4.8%	Deciduous forest, evergreen forest, mixed forest	Same as the Forest class but set aside for permanent exclusion from conversion to an alternate land-use or land-cover state.
Developed	9500	6.5%	Low intensity residential, high intensity residential, commercial/industrial/transportation, urban recreational grasses	Areas of intensive use with much of the land covered with structures (e.g., high density residential, commercial, industrial, transportation, mining, confined livestock operations), or less intensive uses where the land cover matrix includes both vegetation and structures (e.g., low density residential, recreational facilities, cemeteries, etc), including any land functionally attached to the urban or built-up activity or in a non-native vegetation state for human recreation.
Barren	2642	1.8%	Bare rock/sand/clay	Land comprised of natural occurrences of soils, sand, or rocks where less than 10% of the area is vegetated.
Water	1897	1.3%	Open water	Areas persistently covered with water, such as streams, canals, lakes, reservoirs, bays, or oceans.
Wetland	719	0.5%	Woody wetlands, emergent herbaceous wetlands	Lands where water saturation is the determining factor in soil characteristics, vegetation types, and animal communities. Wetlands are comprised of water as well as vegetation.

Table 2. The set of all possible state class transition pathways developed for the model, organized by transition type, number of pathways, spatial stratification and the 'from' and 'to' LULC state class. The (All) value means that the transition pathways is applied to both the Central Valley and Oak Woodlands ecoregions; the (N/A) value represent a transition pathway not applicable at the given spatial stratification level.

		From states			To state
Transition type	# of Path-ways	Ecoregion	County	State class	State class
Agricultural change	4	(All)	(N/A)	Perennial Annual	Annual Perennial
Agricultural expansion	92	(N/A)	(All)	Rangeland	Annual perennial
Agricultural contraction	92	(N/A)	(All)	Annual Perennial	Rangeland
Urbanization	138	(N/A)	(All)	Annual Perennial Rangeland	Developed
Orchard removal	2	(All)	(N/A)	Perennial	Perennial (age reset to zero)
Protection	4	(All)	(N/A)	Rangeland Forest	Protected rangeland Protected forest

For the protection transition pathway, a map of areas protected between 1992 and 2011 was created and used to constrain the spatial location of rangeland and forest protection over the first 18 years of the simulation [28, 38–40]. For the future projections, a map of critical and priority areas for protection [41] was used to constrain the spatial location of new protected areas. Additionally, historical data on forest and rangeland protection were analyzed to produce a patch size class distribution of protected areas (table S1) to guide patch size of newly protected lands over the model period (2012–2062).

2.4.2. Transition probabilities

For the perennial cropland state class we tracked the age and TST for every cell to project the amount of orchard removal as well as transitions from perennial to annual cropland. No data exists on the age structure of perennial croplands in California, therefore age was initialized randomly for each cell using a uniform distribution between ages 1 and 45. In California, orchards are removed and/or replanted at an average age of 25 years, a decrease from ~35 year old maturity in the 1980s [37]. As a result, the following parameters for orchard removal were established: (1) the minimum age of an orchard is 20, and (2) for each timestep and Monte Carlo simulation, the annual transition probability is sampled from a uniform distribution corresponding to a cumulative transition probability of 0.95 for ages 20 and 45 resulting in transition probabilities of 0.0228 and 0.0950, respectively. We assume orchard removal is followed immediately by replanting resulting in the state class remaining unchanged but with the age reset to zero. For the perennial to annual cropland pathways, we set a transition probability of 0.05 for all cells classified as perennial cropland and with a TST for orchard removal of 1 year. The effect of these parameters results in a 5% probability of orchards converting to annual cropland within 1 year of an orchard being removed. Lastly, we prohibit perennial cropland from transitioning to rangeland (agricultural contraction) or to annual cropland (agricultural change) until they are at least 20 years old.

2.4.3. Spatial multipliers

Spatial multipliers were used to constrain the location of allowable land-use change in two ways. First, we defined spatial adjacency rules for the agricultural change, expansion, contraction, and urbanization pathways. The probability of a cell experiencing any one of those transitions was calculated as a linear function of the proportion of the eight neighboring cells classified as the 'to class'. For example, the probability of a cell converting into developed (urbanization) was calculated based on the number of adjacent cells already classified as developed; the higher the number of adjacent cells classified as developed, the higher the calculated probability. If a cell has no neighbors classified in the 'to class' then the transition probability was set to zero.

In addition to the adjacency multipliers, spatial multipliers were used to constrain transitions on protected and managed lands [29, 30]. Spatial multipliers allow or constrain state class transitions and can be implemented on specific pathways. We set the probability of conversion for the agricultural expansion and urbanization pathways to zero for federal lands, including military installations and tribal lands [31], and protected areas where there was a management plan in place prohibiting anthropogenic land use [28]. In addition, we set the transition probability for urbanization to zero for agriculture lands currently enrolled in the Williamson Act, a conservation program within the State of California which provides

economic incentives to agricultural land holders to maintain an agricultural land use [32].

2.5. Water use

In addition to tracking state class variables, the model was parameterized to track water use by county and state class type. To calculate average county applied water use for the annual and perennial cropland classes we: (1) determined the area of each crop type by county from the USDA Cropland Data Layer (CDL) [42]; (2) 'crosswalked' the CDL cropland types to the cropland categories associated with the California Department of Water Resources Agricultural Land & Water Use 1998–2010 dataset (CDWR) [43] (table S2); (3) collapsed the CDWR data into annual and perennial cropland classes and assigned an area-weighted average applied water use value for each combination of county and state class type (table S3). For the developed class, applied water use was derived from a national dataset of water use by various sectors [1].

Applied water use for the developed state class was calculated as follows:

$$\mathrm{DevAW}_{\mathrm{CTY1..}n} = \frac{\text{Public supply freshwater} + \text{industrial self supplied}}{\sum \text{Developed}},$$

where $\mathrm{DevAW}_{\mathrm{CTY1\ldots}n}$ is developed state class (Dev) average applied water (AW) use for each county ($_{\mathrm{CTY1\ldots}n}$), 'public supply-freshwater' (i.e. public supplied total freshwater withdrawals in kl yr^{-1}) and 'industrial self-supplied' (i.e. industrial self-supplied total freshwater withdrawals in kl yr^{-1}) are categories tracked within the CDWR data corresponding to urban and suburban, commercial, and industrial sectors, and *Developed* corresponds to the total developed area in each county based on the NLCD 2011 [46] developed state class (section 2.2, table 1).

2.6. Simulation experiments

The analysis described in this paper is the result of a single 'BAU' scenario. The BAU scenario was run over 70 timesteps (1992–2062); the first 20 years refer to the baseline historical conditions represented in the years 1992 through 2012. Projections were developed from 2012 through 2062. We ran 40 Monte Carlo simulations of the BAU scenario to reflect the variability in historical change rates and uncertainties associated with various model parameters.

2.7. Model validation

A pixel-level validation of the model used for this analysis was not possible due to the lack of a reference condition time series. The NLCD92 map used to establish initial conditions within the model represents a single date product, not directly comparable to later versions of NLCD due to changes in mapping methodology and classification scheme [27, 44–46]. However, we could validate that the internal calculations of the model functioned as expected by comparing the input transition demand to model simulation output. Additionally, we compared our simulated results over the baseline period with regional-scale data describing trends in land-use classes, providing important insight into the robustness of the modeling framework.

Structurally, the model consistently produces the expected outcome by matching the input transition target amounts. Figure S1 shows a comparison of the transition targets used to derive the BAU projections with the model simulations over the same temporal period (1992–2012). Mean model estimates are consistent with the transition targets; variability around the modeled mean results from the underlying sampling algorithm.

We compared our estimates of cropland (total, annual, and perennial) with statistical estimates from the National Agricultural Statistical Service (NASS) for the period 1992–2009 (figure S2) [36]. NASS estimated a net decline of 3.0% in harvested area, with a 13.6% decline in field crops and a 28.6% increase in fruit and nut crops. For comparison, LUCAS model simulations estimate a 2.4% decline in total agricultural land use, with a 10.2% decline in annual crops and a 22.0% increase in perennial crops. A true comparison is complicated due to definitional differences between crop categories, however, the overall modeled trends in agricultural land use are consistent with the broad trends identified in statistical estimates.

Additional comparisons were made for the rangeland and developed classes. For developed area we compared model estimates to the total estimated change from the FMMP data. FMMP projected an increase of 3152 km^2 between 1990 and 2010 while our model estimated a net increase of 3328 km^2 between 1992 and 2010. Rangelands were more difficult to compare since the definition of what lands are included in the category often vary. Furthermore, comparison using satellite data are problematic due to the change in mapping method between NLCD92 and versions from 2001 forward. For this reason we compared changes in rangeland (herbaceous grassland and shrub/scrub classes from NLCD) between 2001 [27] and 2011 [46] with our modeled estimates. NLCD estimated a net decline of −0.6% and the model produced an estimated net decline of −1.2%.

3. Results

Between 2012 and 2062 in the BAU scenario, developed land cover was projected to increase 62.9% from an average 12 978 km^2 to an average 21 141 km^2 (figures 2(a) and (b)). Annual cropland was projected to decline an average 30.3% (8822 km^2). Conversion of annual cropland into perennial cropland and encroachment of perennial crops into rangeland resulted in perennial cropland increasing 39.1%

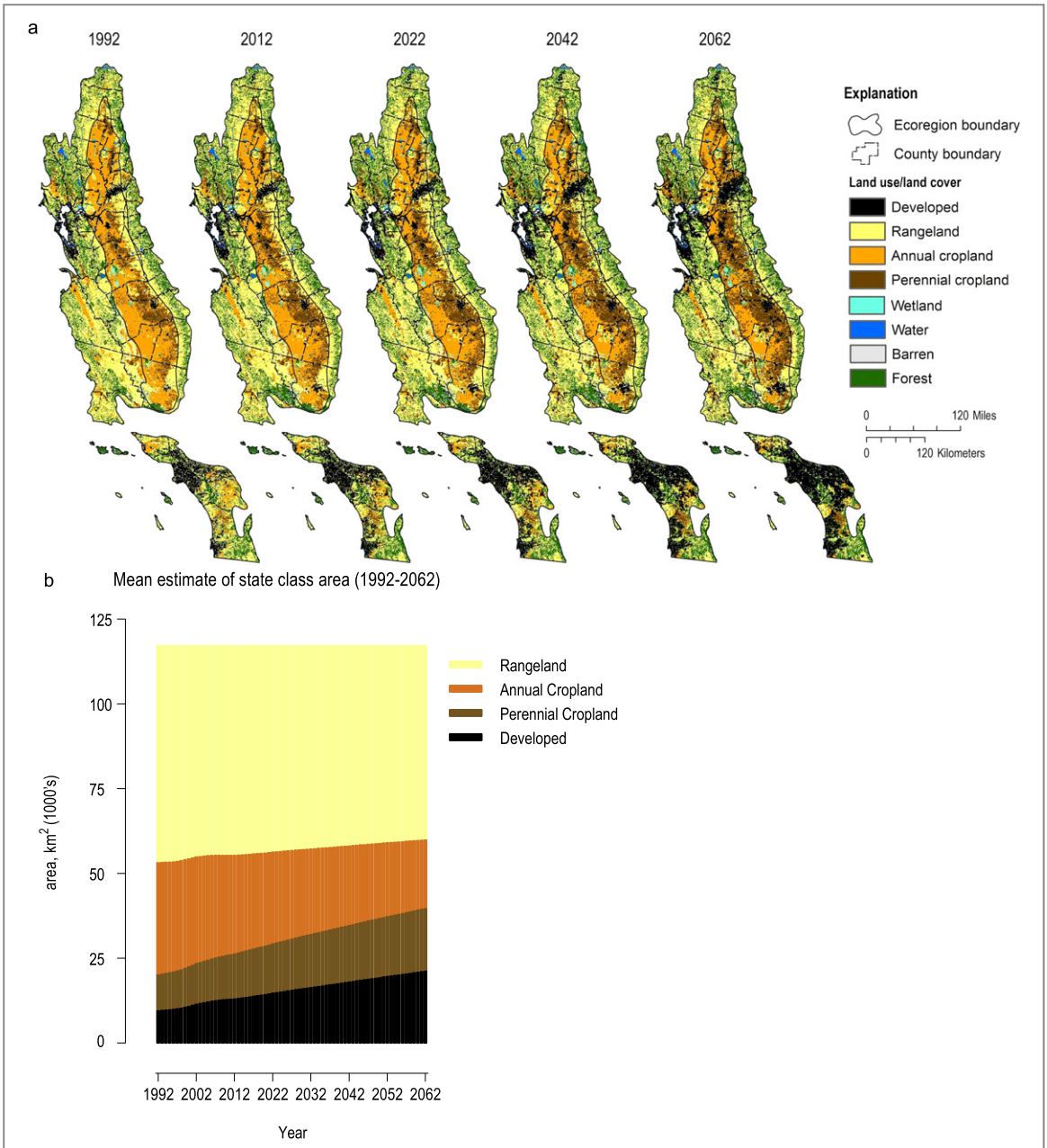

Figure 2. (a) Projected land-use and land-cover (LULC) change for the historical period (1992–2012) and the projected period (2012–2062) in California's Central Valley and Oak Woodlands regions under a business-as-usual (BAU) scenario. The 2012 and 2062 LULC maps represent one out of 40 possible Monte Carlo iterations modeled for each time step. See table 1 for a full explanation of the LULC classification scheme. (b) Trends in mean LULC change over the historical and projected period by LULC class.

(5192 km^2). Overall, anthropogenic land uses increased over 8.2% (4533 km^2) from 2012 levels at the expense of rangelands while total cropland area declined 8.6%. Continued additions of protected rangeland at the historical rate did not abate continued losses through mid-century. Rangelands continued to decline (−7.3%) despite the addition of 3211 km^2 of protected rangeland in the BAU scenario.

Historical land use transitions persisted into the future under the BAU scenario. Conversions into developed land uses came predominantly from rangelands in the Oak Woodlands ecoregion (figure 3(a)) and from annual and perennial cropland in the Central Valley (figure 3(b)). Conversions from annual cropland into perennial cropland had the highest annual average LULC transition rate in the Central Valley. Rangelands across the study area were also converted to agricultural uses, with large amounts of land fluctuating annually between rangeland and annual cropland as some areas are cultivated while others are idled [47, 48].

By 2062, water use was projected to increase by 1.8 billion cubic meters (Bm^3; +4.1%) over current use estimates (figure 4). Within the developed sector, water use demand was projected to increase 4.6 Bm^3 (+59.1%) from an average 7.9 Bm^3 (range of 7.8–7.9 Bm^3) in 2012 to an average 12.5 Bm^3 (range of 12.0–13.0 Bm^3) in 2062. This represents a 9.4%

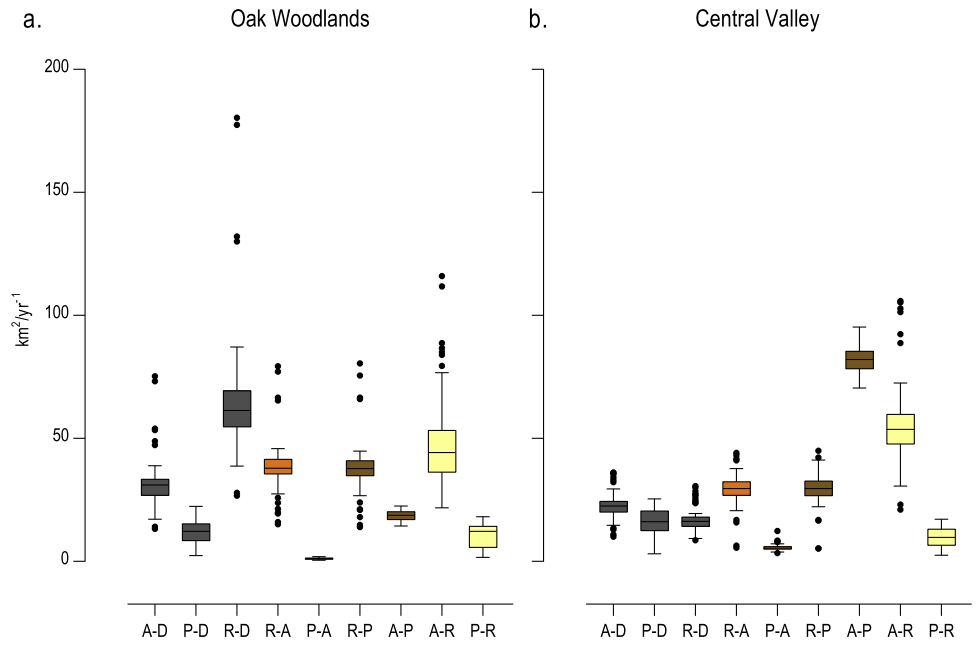

Figure 3. Average annual land-use and land-cover (LULC) change in square kilometers (km^2) over the modeled period (2012–2062) for the (a) Oak Woodlands and (b) Central California Valley ecoregions as defined 'from' and 'to' LULC classes for transitions between annual cropland (A; orange), perennial cropland (P; brown), rangeland (R; yellow), and developed (D; gray) classes (e.g. A–D represents transitions from annual crops to developed land with box fill color representing the 'to' LULC class). Boxes indicate the 'to' LULC class and the 25%–75% range and median (line), box fill color represents the 'to' class for the transition, while whiskers indicate the 5%–95% range and dots represent outlier county values.

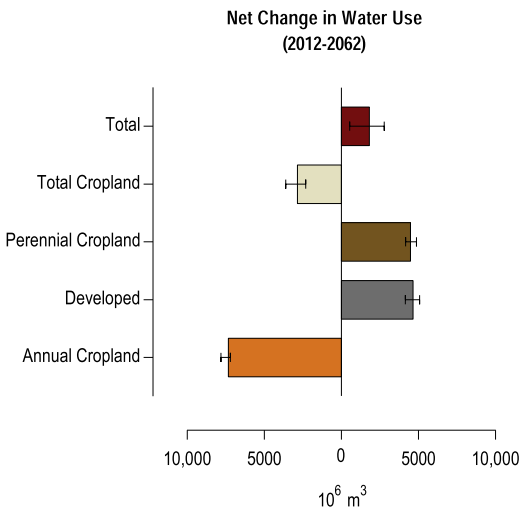

Figure 4. Projected net change in water use demand from 2012 to 2062 for agriculture and developed (municipal and industrial) water use expressed in millions of cubic meters (10^6 m^3), including average (bar) and maximum and minimum value ranges across 40 Monte Carlo simulations.

increase (from 17.8% to 27.3%) in the develop sectors proportion of total regional water use. For the annual cropland sector, water use was projected to decline nearly 30.2% or an estimated 7.3 Bm^3 (range of −6.8 to −7.9 Bm^3) while perennial cropland water use was projected to increase by 4.5 Bm^3 (range of 3.9–5.1 Bm^3) or 37.5%. Combined, total cropland water use was projected to decline 2.8 Bm^3 from an average 36.2 Bm^3 in 2012 to 33.4 Bm^3 in 2062 representing a 7.8% decrease in agriculture water use (figure 4).

At the county scale, annual cropland losses to perennial cropland and development drove net increases in water demand. Large gains in developed land use led to net increases in water use in Alameda, Los Angeles, Orange, Riverside, Sacramento, San Diego, and Ventura counties, where urbanization of rangelands was projected to occur and large population centers already exist (figure 5(a)). San Diego County exhibited the highest net increase in projected water use, almost entirely attributed to the development of rangelands (see also figure 2). In 82% of counties, net demand for water increased (figure 5(b)). Net declines in water demand were projected where losses of annual cropland exceeded gains of perennial cropland and new developed land (e.g. Kern and Kings Counties).

4. Discussion and conclusions

The results presented in this research highlight several key issues likely facing California water users and managers in the future, if current trends persist. In 38 of 46 counties our model results show a net increase in overall projected water use. Our results indicate that currently mandated 25% municipal water use restrictions would need to be maintained through 2062 for future water demand to remain at or below 2012 demand. Water use in 2012 was already proven unsustainable given the ongoing multi-year drought,

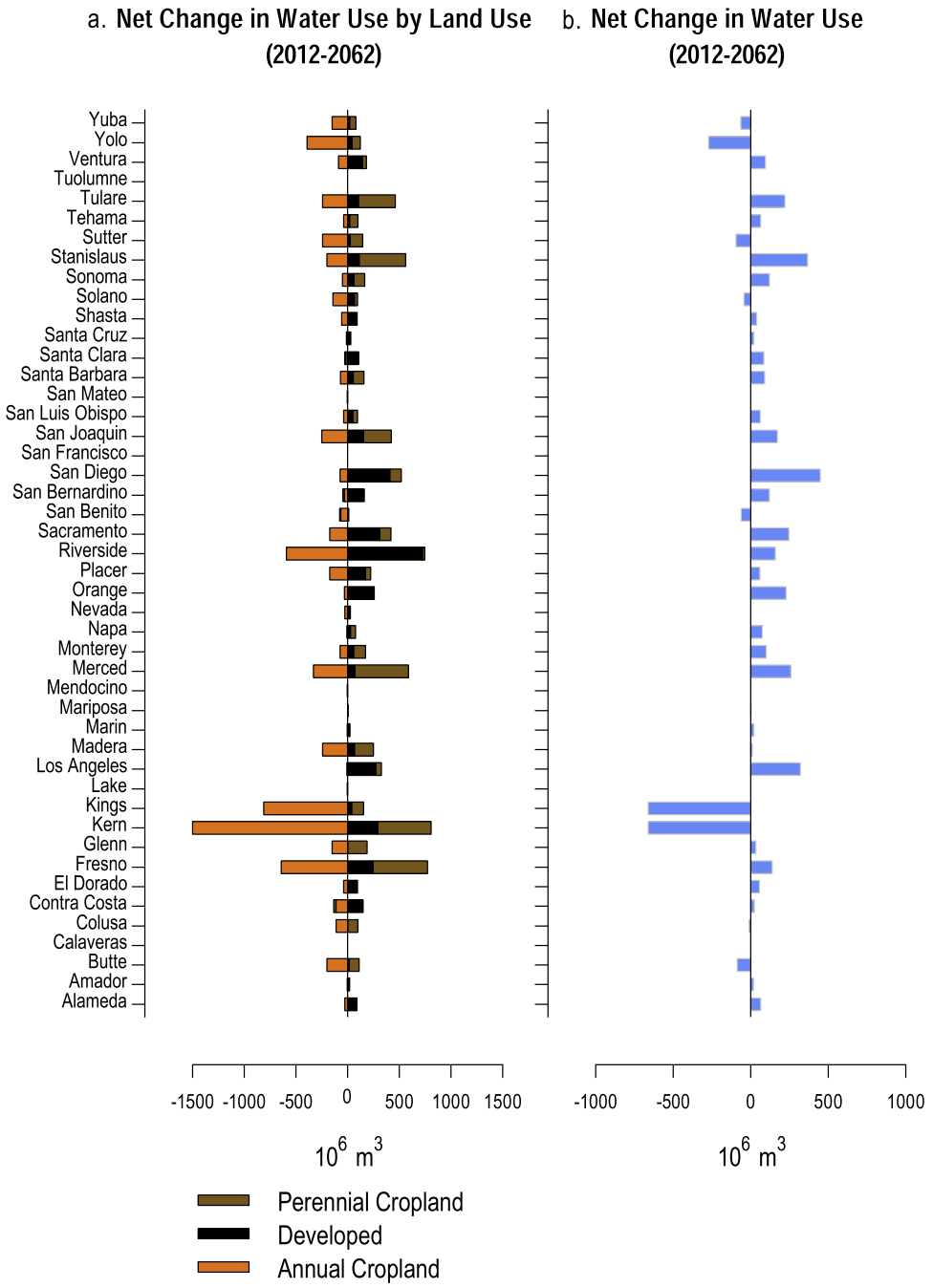

Figure. 5. Average change in water use demand between 2012 and 2062 in cubic meters for each county in the study region by (a) land use category and (b) net change in overall water use. Boxes indicate the mean (+), median (line), and 25%–75% range, while whiskers indicate the 5%–95% range and dots represent outlier county values.

which lead to mandated municipal use restrictions in 2015. Reaching current 2015 use levels in 2062 would require some combination of increased use efficiencies across sectors and/or new supplies [51]. It has been estimated that nearly one-third of municipal water use in California could be saved if all existing technologies were implemented [52]. Current data indicate perennial cropland expansion continues, driven by increases in the total value of almonds from $4.8 billion in 2012 to $6.4 billion in 2013, followed by grapes at $5.6 billion [53]. California's continued population growth projections will undoubtedly lead to new developed land use as well [18]. It is important to note that any new demand for water will also require additional energy for transport and delivery. Storage and redistribution of California's water already consumes nearly 20% of the state's electricity and 30% of its natural gas [54].

The projected trend in declining agricultural water use reflects the observed historical trend of regionally intensive urbanization of farmland, as well as the trend towards more high risk and high value perennial crops [36]. Almonds are the fourth most water intensive crop in California and the state's largest agricultural

export by value, second only to hay in total acreage planted [50]. As a result, in only 16 of 46 counties was historical perennial cropland water use lower than water use for annual crops. Improvements or changes in water use efficiency and crop yields were not considered in this study and reflect a key uncertainty when projecting future water use demand. Since 1992, the water use efficiency of orchards and vineyards has increased 28% and 33% respectively [49] while crop yields have also increased [56]. The BAU scenario assumes no additional improvements in efficiency due to technological advancements.

There was considerable uncertainty associated with transitions within the agricultural sector, specifically the conversion between annual and perennial cropland categories. Additionally, little is known about the current age structure of orchards in California. As orchards reach maturity and decline in production, land owners must decide whether to replant perennial crops or switch to a different land use. Improved mapping techniques using remotely sensed data should be evaluated as they mature to better inform some of the important data gaps associated with LULC change in California.

Future climate variability can also have positive and/or negative impacts on water use, in terms of reduced water availability due to decreased precipitation and higher evaporative loss due to temperature increases, but may also result in increased production due to warming and the effect of CO_2 fertilization. Furthermore, climate can have positive and/or negative feedbacks on future land use (e.g. less precipitation, less water availability, more applied water use per crop, lower potential for agricultural expansion). While the 1992–2012 FMMP land change data do include two drought episodes, including the 2007 onset of the current, extreme drought, land use decisions based on long-term water shortages were not fully captured. These are important considerations which were outside the scope of this study, yet need to be recognized as important limitations and uncertainties which should be incorporated into future work.

Future changes in land use were based on a 20 year historical record which spans a wide range of climatic and socioeconomic conditions. The projections derived from these data cover a wide range of future conditions, but do not represent all future possibilities. Additional work should be undertaken to develop alternative 'what-if' scenarios to explore how significant departures from historical conditions (extreme events) could impact regional water use demand. One such example would be if California entered into a prolonged long-term drought. Even short duration events (4–6 years) have shown to have strong feedbacks on land-use change dynamics [57].

Land-use projections provide a previously unseen view into potential water use futures. This information is essential for water management agencies and a broad array of stakeholders given the state's economic dependency on this already over-allocated resource [2]. Agriculture use values are often grossly underestimated by as much as 20%–30% [49, 55], as they are often not measured directly, but calculated based on crop acreage, crop coefficients, stage ratios, irrigation-system efficiency, and precipitation [1]. Estimates on public water use are generally more accurate and based primarily on site-specific information [1]. Considering probable underestimation, increasing demand for water in coming decades is likely greater than our projections indicate. This may eventually force a reconciling of human and ecosystem water needs, particularly in the face of projected climate-driven declining supplies.

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Model and data access

All modeling for this study was done using the ST-SIM software application which can be downloaded free of charge from APEX Resource Management Solutions (http://apexrms.com). All model parameters are available as (1) a Microsoft Excel file and (2) a database containing all model inputs and outputs (http://geography.wr.usgs.gov/LUCC/).

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EXHIBIT M

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SCIENCE | THE PARCHED WEST

Beneath California Crops, Groundwater Crisis Grows

By JUSTIN GILLIS and MATT RICHTEL APRIL 5, 2015

Even as the worst drought in decades ravages California, and its cities face mandatory cuts in water use, millions of pounds of thirsty crops like oranges, tomatoes and almonds continue to stream out of the state and onto the nation's grocery shelves.

But the way that California farmers have pulled off that feat is a case study in the unwise use of natural resources, many experts say. Farmers are drilling wells at a feverish pace and pumping billions of gallons of water from the ground, depleting a resource that was critically endangered even before the drought, now in its fourth year, began.

California has pushed harder than any other state to adapt to a changing climate, but scientists warn that improving its management of precious groundwater supplies will shape whether it can continue to supply more than half the nation's fruits and vegetables on a hotter planet.

As a drilling frenzy unfolds across the Central Valley, California's agricultural heartland, the consequences of the overuse of groundwater are becoming plain to see.

In some places, water tables have dropped 50 feet or more in just a few years. With less underground water to buoy it, the land surface is sinking as much as a foot a year in spots, causing roads to buckle and bridges to crack. Shallow wells have run dry, depriving several poor communities of water.

Scientists say some of the underground water-storing formations so critical to California's future — typically, saturated layers of sand or clay — are being permanently damaged by the excess pumping, and will never again store as much water as farmers are pulling out.

"Climate conditions have exposed our house of cards," said Jay Famiglietti, a NASA scientist in Pasadena who studies water supplies in California and elsewhere. "The withdrawals far outstrip the replenishment. We can't keep doing this."

Cannon Michael, a farmer who grows tomatoes, melons and corn on 10,500 acres in the town of Los Banos, in the Central Valley, has high priority rights to surface water, which he inherited with his family's land. But rampant groundwater pumping by farmers near him is causing some of the nearby land to sink, disturbing canals that would normally bring water his way.

"Now, water is going to have to flow uphill," said Mr. Michael, who plans to fallow 2,300 acres this year.

In the midst of this water crisis, Gov. Jerry Brown and his legislative allies pulled off something of a political miracle last year, overcoming decades of resistance from the farm lobby to adopt the state's first groundwater law with teeth. California, so far ahead of the country on other environmental issues, became the last state in the arid West to move toward serious limits on the use of its groundwater.

Last week, Mr. Brown imposed mandatory cuts in urban water use, the first ever. He exempted farmers, who already had to deal with huge reductions in surface water from the state's irrigation works. Mr. Brown defended the decision on ABC's "This Week" on Sunday, saying, "They're providing most of the fruits and vegetables of America to a significant part of the world."

In normal times, agriculture consumes roughly 80 percent of the surface water available for human use in California, and experts say the state's water crisis will not be solved without a major contribution from farmers.

California's greatest resource in dry times is not its surface reservoirs, though, but its groundwater, and scientists say the drought has made the need for better controls obvious. While courts have taken charge in a few areas and imposed pumping limits, groundwater in most of the state has been a resource anyone could grab.

Yet putting strict limits in place is expected to take years. The new law, which took effect Jan. 1, does not call for reaching sustainability until the 2040s. Sustainability is vaguely defined in the statute, but in most basins will presumably mean a long-term balance between water going into the ground and water coming out. Scientists have no real idea if the groundwater supplies can last until the 2040s.

"I wish we could do it faster," Mark Cowin, director of California's Department of Water Resources, said in an interview. "I wish we would have started decades ago."

But Mr. Cowin noted that the state, after neglecting groundwater management for so long, had a lot of catching up to do. Years of bureaucratic reorganization and rule-drafting lie ahead. "This is the biggest game-changer of California water management of my generation," Mr. Cowin said.

In the near term, as the drought wears on and the scramble for water intensifies, farmers are among the victims of the drilling frenzy, as well as among its beneficiaries.

Growers with older, shallower wells are watching them go dry as neighbors drill deeper and suck the water table down. Pumping takes huge amounts of electricity to pull up deep water, and costs are rising. Some farmers are going into substantial debt to drill deeper wells, engaging in an arms race with their neighbors that they cannot afford to lose.

"You see the lack of regulation hurting the agricultural community as much as it

hurts anybody else," said Doug Obegi, a lawyer with the Natural Resources Defense Council in San Francisco.

Against this backdrop, water-thirsty crops like almonds are still being planted in some parts of the Central Valley to supply an insatiable global demand that is yielding high prices.

The land devoted to almond orchards in California has doubled in 20 years, to 860,000 acres. The industry has been working hard to improve its efficiency, but growing a single almond can still require as much as a gallon of California's precious water.

The expansion of almonds, walnuts and other water-guzzling tree and vine crops has come under sharp criticism from some urban Californians. The groves make agriculture less flexible because the land cannot be idled in a drought without killing the trees.

Not even the strongest advocates of water management foresee a system in which California farmers are told what they can plant. As the new system evolves, though, the growers might well be given strict limits on how much groundwater they can pump, which could effectively rule out permanent crops like nuts and berries in some areas.

"We want to be careful in dealing with this drought not to go down the command-and-control route if we can avoid it," said Daniel Sumner, professor of agricultural and resource economics at the University of California, Davis. "It interrupts the flexibility, the creativity and the resilience that people in agriculture have already been using to deal with severe water cutbacks."

So far, the over-pumping of groundwater has helped farmers manage through three parched growing seasons.

They were forced to idle only about 5 percent of the state's irrigated land last year, though the figure is likely to be higher in 2015. The farmers have directed water to the highest-value crops, cutting lesser crops like alfalfa.

They have bought and sold surface water among themselves, making the best

use of the available supply, experts like Dr. Sumner say. And the farmers' success at coping with the drought has meant relatively few layoffs of low-income farmworkers.

Still, costs are up and profits are down for many farmers and the thousands of small businesses that depend on them, spreading pain throughout the Central Valley and beyond. "It's been a tough couple of years, and it's just getting tougher in rural parts of California," said Dave Kranz, a spokesman for the California Farm Bureau Federation, a growers' organization.

Because groundwater has helped keep production up, replacing a large proportion of the surface water farmers have lost, the drought has not led to big price increases at the national level, even for crops that California dominates.

Once the drought ends, a growing population and a climate altered by human-caused global warming will continue to put California's water system under stress, experts say. A major question is how to manage the groundwater to get Californians through dry years.

Meeting that goal may have as much to do with how surface water is managed as with how much is pumped from the ground.

Several California experts used the metaphor of a bank account to describe the state's groundwater supply. Deposits need to be made in good times, they said, so that the water can be withdrawn in hard times.

Yet for decades, California farmers have been overdrawing many of the state's water-holding formations — its aquifers — even in years when surface water for irrigation was plentiful, the equivalent of overdrawing a checking account.

That will need to change, the experts said, with pumping being limited or even prohibited in wet years so that the underground water supply can recharge. Some land may need to be flooded on purpose so the water can seep downward.

The need for groundwater recharge may ultimately limit how much water farmers can have from the surface irrigation system, even in flush years — the same way that deposits in a bank account limit how many fancy dinners one can eat. Yet in a state where irrigation rights have been zealously guarded for generations, such

limitations may not go down easily.

"It would be silly to think you are not going to have any fights," said Denise England, the water expert for Tulare County, toward the southern end of the Central Valley. She cited an aphorism of the West: "Whiskey's for drinking, and water's for fighting over."

John Schwartz and Nelson D. Schwartz contributed reporting.

The Parched West: Articles in this series are exploring the impact of the drought that has hit states from the Pacific Coast to the Great Plains.

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USGS Study: 1200 Square Miles of Central Valley Land Is Sinking

Amy Quinton

Friday, November 22, 2013 | Sacramento, CA | Permalink

LISTEN 3:51

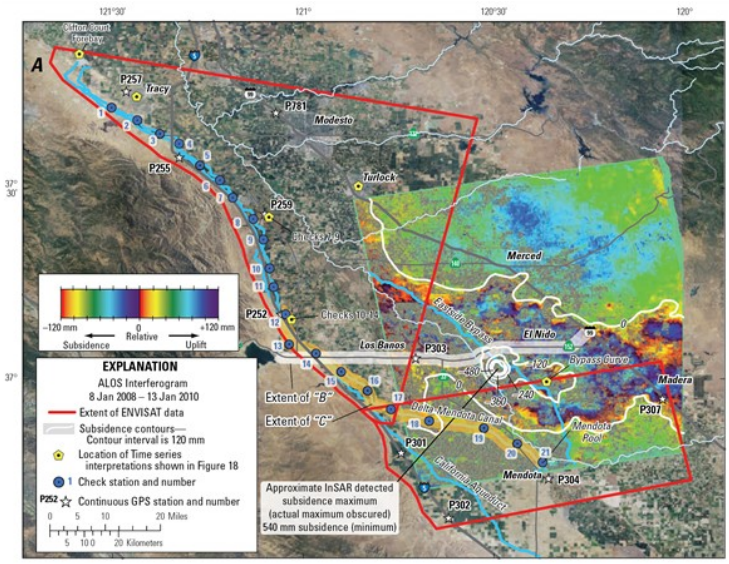
USGS Hydrologist Michelle Sneed stands next to the Delta Mendota Canal in the Central Valley pointing to an area where the concrete lining is cracked and buckled.

Sneed says it's likely caused by subsidence, when the ground sinks.

(Cracks and buckle along Delta Mendota Canal. Photo By Amy Quinton)

But according to her study (http://pubs.usgs.gov/sir/2013/5142/), the center of the subsidence problem is about 15 miles to the north, near a town called El Nido.

"It's so large, it's 1200 square miles that were affected by subsidence over a two year period that we have measurements for," she says. "This area where we're standing now is just on the edge of that bowl so the Delta Mendota Canal is being affected by this large bowl, but it's relatively minor."



(ALOS interferogram with subsidence contours showing vertical changes in land surface in the central San Joaquin Valley area, California, during January 8, 2008–January 13, 2010)

Sneed measures groundwater levels next to the canal using a metal field tape she drops down a well.

“We found in the study, that much of this area, not necessarily where we’re standing now, but closer to the center of the subsidence bowl, water levels have reached historic lows," she says. " That means as long as we’ve been measuring them they’ve never been lower than they have been recently.”

She says excessive groundwater pumping causes the subsidence.

(USGS Hydrologist Michelle Sneed checking data by Delta Mendota Canal. Photo By Amy Quinton)

Drought and regulatory requirements that reduce the amount of surface water sent down the Delta Mendota canal and the California Aqueduct has some farmers turning to groundwater wells.

When releasing her study, Sneed said the subsidence area has seen more row crops change to permanent crops.

“That has the effect of providing less flexibility for farmers when there are droughts because these permanent crops will need water during droughts," said Sneed. "If you have row crops then perhaps fallowing the land during drought would be an option.”

She said it wasn’t just the sheer size of the subsidence area that surprised her about the study.

“We were also surprised by the high rate of subsidence about 11 inches a year, nearly a foot a year is among the fastest rates ever measured in the San Joaquin Valley," said Sneed.

"This is similar to the rates in the 50’s and 60’s before the California Aqueduct became an available water resource.”

(Yellow part of map indicates where new subsidence is occuring. The darkest color near El Nido is where the subsidence rate is highest. USGS)

But finding a solution to the problem won't be easy.

Chase Hurley, General Manager of the San Luis Canal Company in Dos Palos is trying to come up with a plan for his region.

The irrigation company's dam that pushes water into the canal system is sinking six inches a year.

He takes me to farmland on the other side of the San Joaquin River that has no surface water supply.

"A lot of this land has been farmed since the 30's or 40's especially the stuff right along the river," says Hurley. "And they've historically managed it well so that they could use the shallow and deep aquifer."

But he says some of the land was rangeland and is now being used for row crops and the acreage has increased for permanent crops.

"So it's a lot of new demand on a system that historically didn't have it, a groundwater system, so when it gets developed, they were putting in wells both shallow and deep," says Hurley.

Hurley has been trying to organize local farmers to come up with a plan.

"We didn't say you've got to stop doing what you're doing, but you've got to look at the way you're doing it and let's all try to come up with a solution."

He says farmers realize subsidence isn't someone else's problem – it's damaging their wells and pipelines.

"We have guys out here that are spending $200,000 to 300,000 for a deep well and if the well only lasts 3 or 4 years because subsidence is just wrecking it , that's a huge amount of money that he has to reinvest again," says Hurley.

Subsidence already places a significant part of the Central Valley at greater risk for flooding.

Subsidence has damaged crops, stalled restoration projects, and can be a problem for anything built in its path.

Subsidence is spreading, and once it happens, it's permanent.

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