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ALSO IN THIS ISSUE:

The Beyem Seyo Wolf Pack: Economic Toll of Unprecedented Livestock Conflict in California

Tina L. Saitone and Tracy K. Schohr

Between March and October 2025, the Beyem Seyo wolf pack created unprecedented livestock conflict in Sierra Valley, California. Conservative estimates place livestock depredation losses at nearly $250,000. When unconfirmed losses and agency intervention costs (exceeding $2 million) are included, the total impacts over seven months reached a minimum of $2.6 million. Despite extensive non-lethal deterrence efforts, the pack became irreversibly dependent on cattle as a food source and habituated to human presence and deterrence measures. The pack was ultimately euthanized in October 2025.

Three decades after gray wolf (*Canis lupus*) reintroduction in central Idaho and Yellowstone (1995–1996), the species has substantially recolonized much of northeastern California. The first wolf was documented entering California in 2011 after a century-long absence. The California Department of Fish and Wildlife (CDFW) confirmed the state's first wolf pack in 2015. Since then, wolf populations have expanded in both number and geographic distribution.

According to the most recent data from the CDFW, ten active packs were present in the state as of June 2025. Year-end tallies confirmed a minimum population of 50 individual wolves as of December 31, 2024. Since the first pack was identified, CDFW has documented 21 litters, comprised of 115 offspring, produced by California wolf packs over the subsequent decade. Although gray wolves have experienced considerable recovery throughout California and the western United States, the species remains protected under both the federal and California Endangered Species Acts.

While some would consider this type of population growth a conservation success for an endangered species, it has generated significant economic and social challenges and, more recently, health and human safety concerns in rural communities. Nowhere has this been truer than in Sierra Valley, CA, in 2025.

Early in 2025, the Beyem Seyo wolf pack began routinely preying upon domestic livestock. In response to its impacts on livestock operations, threats to rural businesses, and public safety concerns, both the Sierra County Board of Supervisors (April 1) and Plumas County Board of Supervisors (April 15) adopted resolutions declaring local states of emergency due to wolf presence and impacts.

By mid-summer, the Beyem Seyo pack had become habituated to livestock as its primary food source and was frequently observed during daylight hours in proximity to residences. In response to substantial political pressure and law enforcement concerns regarding community safety, CDFW initiated a pilot effort (the "Summer Strike Team"), deploying game wardens and biologists to Sierra Valley for 24-hour, seven-day-per-week non-lethal hazing operations aimed at reducing livestock attacks.

Despite heroic efforts by ranchers to protect their livestock, assistance from the Summer Strike Team, and additional hazing support from U.S.

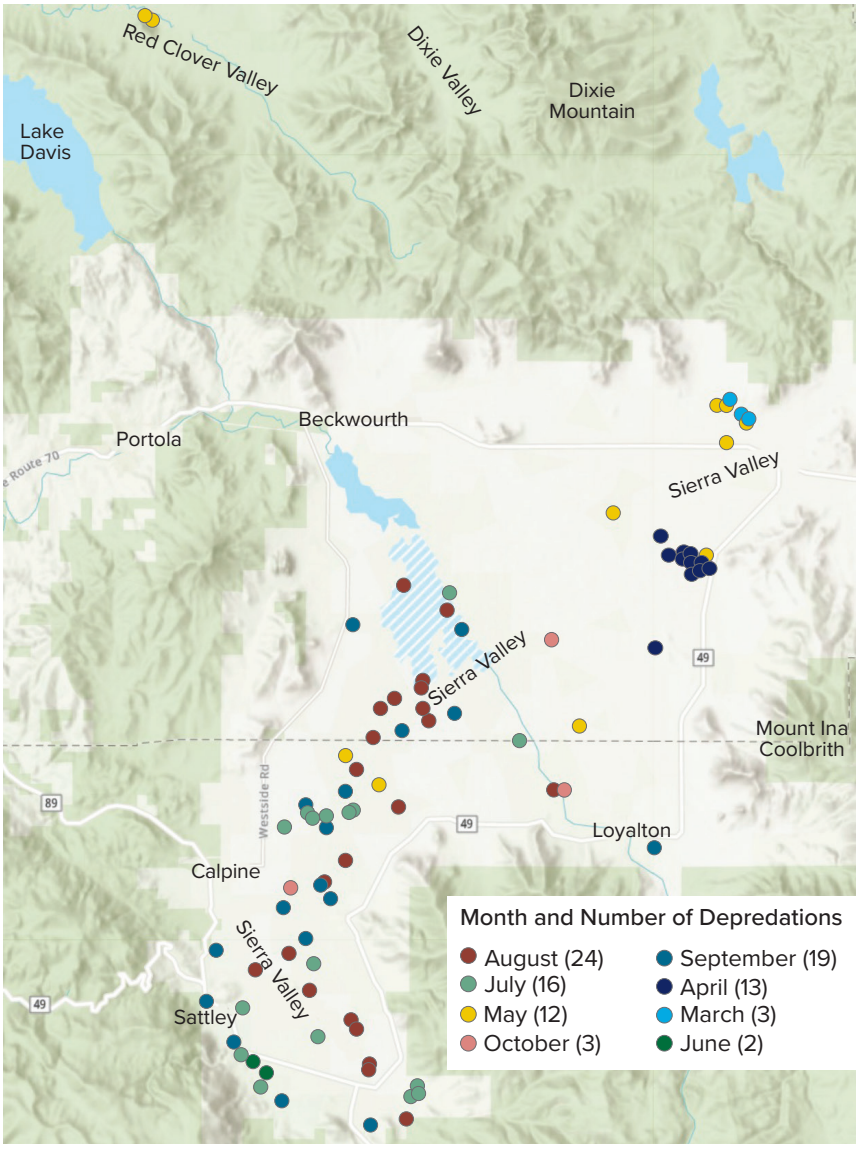
Department of Agriculture (USDA) Wildlife Services drone pilots, livestock predation continued escalating throughout the summer and into the fall. Ultimately, CDFW, in consultation with the U.S. Fish and Wildlife Service, determined that euthanizing the pack was necessary.

This article quantifies confirmed livestock mortality costs, estimates losses from animals that could not be verified under current regulatory criteria, applies loss ratio multipliers used by other states to account for undetected mortalities, and documents agency expenditures related to non-lethal hazing efforts.

The Beyem Seyo Pack

According to CDFW reports, the Beyem Seyo pack was comprised of three adults and six pups during summer 2025. The breeding female (LAS23F) descended from the Lassen pack, which remains active in northern Plumas and southern Lassen counties. Before 2025, the pack's alpha male was LAS19M, a partial sibling to his mate (LAS23F), and the pair successfully reproduced in 2023 and 2024. In December 2024, WHA08M—offspring from the Whaleback pack's 2021 litter in Siskiyou County—was identified as the new alpha male. This leadership change coincided with an unprecedented surge in documented livestock depredations—a term used to describe wolves killing domestic livestock, thereby causing economic harm—and attacks affecting Plumas County and Sierra County producers in 2025.

Figure 1. Location and Month of Confirmed and Probable Depredations, March 7–October 10, 2025



Source: Authors' calculations using ArcGIS online.

Since returning to California, wolves have killed and mortally injured domestic livestock grazing within their territories across Northern California. From 2015 to 2024, CDFW reports that a total of 142 livestock have been depredated by wolves. These depredation statistics represent an absolute lower bound and likely constitute a severe underestimate of wolf-caused livestock mortality. Confirming wolf-caused livestock mortality faces substantial spatial, temporal, logistical, and staffing constraints that severely limit both the number of investigations conducted and confirmations achieved, rendering reported depredations an inadequate measure of the losses and stress experienced by rural communities confronting this issue.

Conflict reached unprecedented levels in 2025 within the Beyem Seyo pack's territory. Between March 7 and October 10, 2025, this pack was confirmed to have killed or injured 92 domestic animals—an average of one animal every 2.4 days over nearly seven months. This figure accounts only for livestock located and investigated, excluding animals killed without detection and carcasses too heavily consumed to permit an official determination.

These depredation rates are extraordinary not only by California standards, but also unprecedented nationally, even compared to states with wolf populations five times larger. By

comparison, Montana's estimated 1,091 wolves killed 54 domestic animals (35 cattle, 16 sheep, 3 foals) in 2024, prompting the removal of 25 wolves to reduce depredations. Similarly, Wyoming's 352 wolves were confirmed to have killed 49 livestock (41 cattle, 3 sheep, 4 goats, and 1 horse) in 2023.

Figure 1 shows the locations of the confirmed and probable depredations and delineates the timing of the incidents by month when they occurred. The order of the months displayed in the legend indicates the relative frequency. Notably, contrary to inaccurate reports in various media outlets, all of these depredations occurred on privately owned land, not on federally managed Forest Service or Bureau of Land Management allotments.

These depredation statistics are available only through partnership and collaboration with impacted ranchers who voluntarily shared confidential data (e.g., kill locations, livestock ownership) with the authors. Without these data, CDFW reporting delays would prevent policymakers and stakeholders from understanding the full extent of the Beyem Seyo pack's impacts for an indeterminate period.

Economic Costs of Direct Depredation and Missing Animals

The Biodiversity Conservation Program (SB 170) allocated $3 million from the 2021/22 California state budget to establish a pilot Wolf Compensation Program (WCP). SB 170 directed CDFW to develop a grant process for funding: 1) verified (i.e., confirmed and probable) livestock losses, 2) non-lethal deterrence measures near livestock, and 3) compensation for indirect production impacts (e.g., weight reductions, losses in conception). This funding and legislative mandate produced the most comprehensive livestock loss compensation program in the nation, with funding available beginning September 2021.

Due to the extent of wolf-livestock conflict in the state, the initial $3 million allocation was depleted by March 2024, and the program ceased operations until the California State Legislature appropriated $600,000 to CDFW to continue a significantly reduced version of the program. With constrained funding, CDFW limited compensation to verified depredation claims for livestock losses occurring on or after July 1, 2024. Subsequent funding via the 2025 California State Budget (AB 102) allocated $2 million to the WCP, yet the claims process remains limited to direct mortality. California's distinction of operating the nation's most comprehensive compensation program appears to be a thing of the past.

Scientific evidence indicates that wolves impose indirect costs on cattle operations beyond direct predation. Cattle exposed to wolves exhibit increased vigilance, spatial avoidance of certain areas, and heightened flight responses. These behavioral changes can reduce foraging efficiency and weight gain, lower conception rates due to stress, and increase vulnerability to illness. Producers also incur elevated management costs from more frequent livestock monitoring, fence repair, engaging in non-lethal deterrence, and time spent engaged in depredation investigations.

The original WCP was designed to compensate for all these indirect costs. However, insufficient funding and resulting restrictions on eligible grant categories severely limit reimbursement for wolf-related impacts, severely undercompensate producers, and ultimately shift the burden of wolf recovery to livestock producers.

Quantifying the Cost of Direct Depredation

Due to the timing of substantial impacts from the Beyem Seyo pack, Sierra Valley producers are only able to seek compensation for cattle that were investigated by either a USDA Wildlife Services officer or a CDFW biologist and classified as "confirmed" or "probable" wolf kills. From March 7 to October 10, 2025, this included 78 calves, 11 yearlings, and 3 cows. Under the auspices of the WCP, producers can request the fair market value (FMV) of livestock lost at the anticipated time of sale. An informal survey of all wolf-impacted producers in Sierra Valley allows us to generate an estimate of the cost of direct depredation losses.

Wolf-impacted producers indicated that most operations retain calf ownership from birth until sale when animals reach 700 pounds (heifers) or 750 pounds (steers). To quantify losses in this analysis, we assume an anticipated sale weight of 725 pounds for wolf-killed calves—the average of steer and heifer weights—since most investigation reports do not specify calf sex. For calves killed near their anticipated sale date, we use the weight specified in the investigation report when available. Survey results

The Beyem Seyo wolf pack killed or injured 92 domestic animals between March and October 2025.

Photo Credit: Axel Hunnicutt/CDFW.

revealed that calves and yearlings attacked, but not immediately killed, overwhelmingly succumbed to their injuries or required euthanasia. Therefore, we assign these animals the anticipated fair market value at the time of sale, equivalent to the value used for "confirmed" or "probable" kills. This approach is very conservative, as it excludes time, medication, and treatment costs often incurred before death or euthanasia, thereby undercompensating the producer for the true impact.

Sierra Valley producers participate in various management certification and marketing programs when selling calves. Although research confirms these programs command market premiums, survey data were not sufficiently granular to account for individual programs utilized by each producer for each herd. Therefore, when valuing wolf-depredated calves, we use the closing value (October 1, 2025) of the September 2026 feeder cattle futures contract traded on the Chicago Mercantile Exchange—$340.675 per hundredweight (CWT). For yearling cattle depredated, we used the September 2025 feeder cattle futures contract closing value at settlement—$365.040/CWT. These generic contract prices, which exclude premiums from value-added management and marketing programs, underestimate the actual value of most livestock lost to wolf depredation in Sierra Valley.

Some of the yearling cattle subject to wolf depredation were bred (i.e., first calf) heifers, and all of the cows subject to depredation were bred cows. These classes of cattle are not typically sold, so transaction/auction data are limited. Western Video Market (WVM) Auction is a satellite video auction used by cattle producers primarily in the western United States and provides price reports after each of their sales. We use sales reports from September 2025, given its timing relative to the depredations and the availability of sales receipts for animals in those classes. At this sale, bred heifers sold for $3,800/head and bred cows sold for $4,100/head.

Using these prices as proxies for actual fair market value, Sierra Valley producers' confirmed and probable wolf-related losses totaled $234,735 over approximately seven months. Calves, the most frequently depredated livestock class, accounted for 82% ($192,652) of this total. Table 1 breaks down the cost of confirmed and probable losses by each class of livestock in column 1.

Cost of Missing and Unconfirmed Losses

Impacted ranchers collectively reported at least 26 additional animals killed by wolves that could not be verified as wolf depredations under current California regulations. Depredation investigation criteria provided to Wildlife Services agents require observable bite marks consistent with wolf dentition and associated hemorrhaging on the carcass. The unconfirmed animals reported in the survey were instances in which wolf GPS collar data led ranchers to locations with calf bones and blood but no remaining muscle or hide (i.e., no carcass material necessary to meet the required criteria). Most of the carcass locations were identified as “cluster points"—locations where a wolf was in approximately the same place for two consecutive 30-minute intervals. These unconfirmed losses, for which ranchers cannot seek reimbursement, are classified as “unknown” and totaled in Table 1, column 2.

Numerous other animals were injured or killed that failed to meet the stringent confirmation criteria, yet circumstances surrounding their discovery and investigation implicated wolves as the cause (e.g., GPS collar data placing wolves at the location, cattle fleeing through fences into irrigation canals). While these incidents were documented in survey data, they were not included in the cost calculations presented here.

Beyond these observed but unconfirmable losses, surveyed ranchers reported missing cattle presumed dead. This documented phenomenon in wolf-impacted areas reflects producers' inability to locate all affected animal remains. To address these losses, several Western states employ multiplier or ratio compensation approaches.

Table 1. Estimated Fair Market Value (FMV), in Dollars, of Wolf-Related Losses and Possible Multiplier Approaches

	Estimated FMV	Estimated FMV	Wyoming Multiplier	Washington Multiplier	Oregon Multiplier
	Confirmed and Probable	Unknown*	7:1	2:1	7:1 and 3:1
Calves	192,651.71	64,217.14	1,348,561.99	385,303.43	1,348,561.99
Yearlings	29,783.61	—	208,485.30	59,567.23	89,350.84
Cows	12,300.00	—	86,100.00	24,600.00	36,900.00
Total	**234,735.33**	**64,217.14**	**1,643,147.28**	**469,470.65**	**1,474,812.83**

Source: Authors’ calculations.

Note: Multipliers are established and employed to recognize and compensate producers for livestock lost or missing, presumably due to wolf depredation, but unrecovered and therefore unable to be investigated or confirmed. *Unknown = unconfirmed losses.

Wyoming compensates producers at seven times the fair market value (FMV) of confirmed depredations in designated wolf areas where terrain, topography, and vegetation hinder carcass detection. This multiplier derives from early research showing that ranchers typically had seven additional calves missing at season's end for every wolf kill that was found, investigated, and confirmed. Washington reimburses confirmed and probable wolf depredations at two times FMV when grazing sites exceed 100 acres. Oregon's currently proposed legislation (HB 2364) would mandate multipliers of seven times FMV for calves, sheep, and goats, and three times FMV for other cattle. Colorado allows producers to claim FMV for each unrecovered animal individually in known wolf territories through itemized applications. Table 1 details the potential budgetary implications of the multiplier policies employed by Wyoming, Washington, and proposed by Oregon in columns 3–5, respectively.

Agency Costs of Non-Lethal Hazing

On April 2, 2025, CDFW announced California's entry into Phase 2 of the California Gray Wolf Conservation Plan, triggered when the agency confirmed four breeding pairs had successfully reproduced, with two pups surviving to year-end for two consecutive years. While this phase does allow for more aggressive non-lethal hazing techniques (e.g., discharge of non-lethal ammunition from firearms, pursuit using motorized equipment), the tools were not effective in Sierra Valley to deter livestock depredation.

CDFW Summer Strike Team

With significant restrictions still limiting ranchers' ability to protect their livestock, CDFW deployed a "strike team" to Sierra Valley to help prevent wolf attacks. From June through September 2025, CDFW staff spent 18,000 hours over 114 days. Strike team deterrence efforts included non-lethal bean bag rounds, all-terrain vehicle patrols, foot presence, diversionary feeding, and 24-hour, seven-day-per-week field presence across 18 livestock operations enrolled in the program. CDFW reports this effort cost $2 million. During this time, livestock depredations continued, as shown in Figure 1.

USDA Wildlife Services Drone Teams

To supplement ongoing non-lethal hazing efforts, specialized USDA Wildlife Services personnel arrived in the valley on August 22 to deploy unmanned aircraft systems (drones) equipped with night vision, spotlights, and loudspeakers for livestock protection. During their deployment, drone teams conducted 36 nights of operations (exceeding 500 flight hours across 1,000 flights) using 3–4 pilots nightly. Pilots documented at least 70 interventions directed at wolves targeting livestock. While wolf-drone interactions averaged two per night, pilots conducted 10 separate hazing operations in a single night on two occasions. This non-lethal deterrence operation cost $60,000 for slightly over one month of operations.

Conclusion

In 2025, the Beyem Seyo pack imposed substantial costs on both Sierra Valley livestock producers and California taxpayers. Confirmed and probable livestock losses totaled nearly $250,000, conservatively. Including kills that CDFW's depredation incident policies prevented from being classified as wolf-related, and applying multipliers recognized in academic literature and other state programs to account for lost animals, the total wolf-related depredation costs ranged from $533,688 to $1.707 million, depending on methodology.

With over $2 million in agency intervention costs, the Beyem Seyo pack's total economic impact reached a minimum of $2.6 million in 2025, not including the costs of euthanization and the ongoing efforts to capture the two remaining juvenile members of the pack. Economic estimates in this article exclude ranchers' lost income from not bringing stockers to the valley, forgoing forage and shipping cattle early, and the costs of their time, effort, and vehicle depreciation from non-lethal hazing and increased human presence. The authors are engaged in ongoing efforts to more comprehensively quantify these costs.

Despite all expenditures and efforts, three adult pack members and one juvenile were ultimately euthanized in October 2025. In the press release announcing this outcome, the CDFW director aptly summarized the situation: "The Beyem Seyo pack became so reliant on cattle at an unprecedented level, and we could not break the cycle, which ultimately is not good for the long-term recovery of wolves or for people."

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Predicted Impacts to Nutrition Programs in the One Big Beautiful Bill Act

Charlotte Ambrozek

I review the changes to the largest nutrition assistance program in the United States—the Supplemental Nutrition Assistance Program (SNAP)—implemented in the One Big Beautiful Bill Act and the likely negative effects of these changes on low-income Americans' food security and economic well-being. I also discuss the potential negative spillover effects on other safety net programs. I close with the implications of decreased SNAP spending for U.S. agriculture overall.

Signed on July 4, 2025, the One Big Beautiful Bill Act (OBBBA) makes substantial changes to the largest nutrition assistance program in the country—the Supplemental Nutrition Assistance Program (SNAP). SNAP provided 41.7 million people $93.7 billion in benefits to purchase food for at-home consumption in the federal fiscal year (FY) 2024. A substantial body of research shows that SNAP reduces food insecurity for participants and improves schooling and health outcomes for the 40% of participants who are children.

Key changes to SNAP in the bill shift program costs to state budgets, impose work requirements on previously exempt groups, and defund nutrition education. Some of the changes were implemented immediately, while others are scheduled to take effect between FY 2027 and FY 2030. Overall, the changes are expected to decrease SNAP participation. The Congressional Budget Office expects federal SNAP funding to decrease by $186 billion between FY 2026 and FY 2034, the largest cut ever to the SNAP program.

Funding Structure Changes

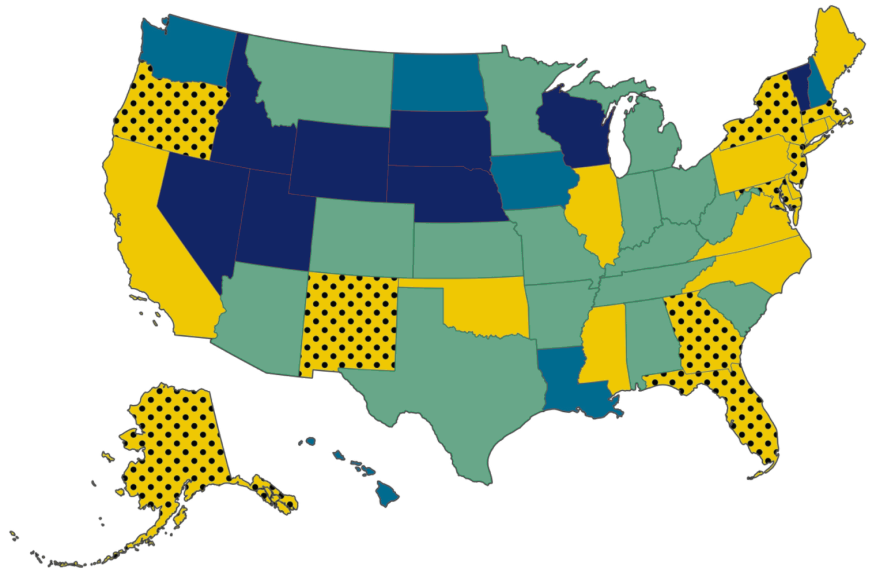
SNAP has two main costs: the cost of food benefits and the cost of administering the program. Currently, the federal government and states split the cost of administering SNAP evenly, and the federal government pays for all of the food benefits. Administrative costs have ranged from 5% and 7% of total SNAP costs annually over the past 5 years. As of FY 2027, states will have to pay 75% of the administrative costs. Starting in FY 2028, states may also have to pay between 5% and 15% of the cost of food benefits.

The amount that states must pay will depend on the rate of payment errors made when distributing benefits. In general, payment errors are not intentional but rather caused by mistakes made by families or administrators. States with a 6% or higher payment error rate—regardless of whether the error is an under- or overpayment—will have to pay at least 5% of their food benefit costs in addition to their higher administrative cost share. This will increase states' SNAP costs by at least two and a half times. Another provision of the OBBBA is that states with very high error rates can delay paying this penalty until FY 2029 or FY 2030, creating an incentive for states to boost their error rates to capitalize on the ability to delay.

Figure 1 shows the cost share percentage each state would have to pay based on its FY 2024 payment error rate. States that would be able to delay based on their FY 2024 rate are marked with dots.

Thirty-four states and the District of Columbia cannot carry over a deficit in their operating budget year-to-year,

Figure 1. Cost Share Requirement and Implementation Timing Using Fiscal Year 2024 Payment Error Rate



Source: Author's calculations using data on payment errors from the Fiscal Year 2024 SNAP Quality Control report on payment error rates. Available at: https://tinyurl.com/24pd7f5w.

meaning that costs cannot be greater than revenues. If state SNAP costs increase, either other funding will have to decrease, or the state will have to reduce SNAP costs. Generally, states have two mechanisms to reduce SNAP costs: polices that restrict eligibility (reduce the number of people who can participate in SNAP) and polices that reduce income deductions (effectively reducing the level of benefits for each SNAP participant).

Work Requirements

One set of changes that will take effect immediately is stricter work requirements for older adults, adults in households with children, veterans, and homeless people. Under prior SNAP rules, adults ages 18 to 54 who did not have a disability and did not live with a child under age 18 had to work or participate in work training at least 80 hours a month to receive benefits for more than three months in a three-year period. Veterans, young adults formerly in foster care, and those experiencing homelessness were excluded from the work requirement. The OBBBA removes these exclusions. Also, it increases the age range on work requirements to cover adults ages 18 to 64. Lastly, under the OBBBA, only those who live with a child under the age of 14 are exempt from work requirements. By expanding the age range for adults, removing exemptions, and narrowing the age range for children, the Congressional Budget Office (CBO) estimates that 1.4 million people will lose access to SNAP benefits.

Formerly, states could waive work requirements for counties if local unemployment rates were high (above 10%) or the county did not have enough jobs, indicating that participants may be out of work for reasons beyond their control. The OBBBA removes states' ability to waive work requirements during periods of high unemployment, except in Alaska and Hawaii. Individuals who are out of work during recessions or live in localities with high unemployment will thus not be able to access SNAP. The CBO estimates that 1 million people per month will miss out on SNAP benefits due to this restriction.

Overall, nearly two and a half million people per month who would have received SNAP benefits under previous program rules will now lose access to SNAP under the OBBBA. Prior work studying SNAP and work requirements indicates that these individuals will not respond to stricter work requirements by re-entering the labor force or finding employment, but will rather leave SNAP and remain unemployed.

Other Changes

The OBBBA also removes all funding for nutrition education through SNAP, known as SNAP-Ed. Research shows that SNAP-Ed-funded programs increase fruit and vegetable consumption, raise knowledge of healthy foods and nutrition, and increase physical activity. These improvements in healthy behaviors lead to lower long-term health care costs, with estimates indicating $1 spent on SNAP-Ed decreases health care costs by more than $5 in the future. Cutting SNAP-Ed is expected to increase health care costs for SNAP participants—many of whom are also on Medicaid—thereby increasing total costs to taxpayers in the long run.

Other changes to the OBBBA affect how the level of SNAP benefits is calculated for all households based on the cost of a healthy diet, as well as households' earnings and expenditures. Historically, the value of SNAP benefits is tied to a minimum cost healthy diet, known as the Thrifty Food Plan (TFP), determined by nutritionists and economists. Annually, the cost of this diet is measured and used to update benefits. Going forward, if the cost of a healthy diet rises by more than overall prices, measured by the Consumer Price Index (CPI) for urban consumers, the increase in SNAP benefits will be limited by the overall urban CPI. For instance, if the cost of the TFP increases by 5% in a year but the overall urban CPI increases by only 3%, then SNAP benefits will only be allowed to increase 3%. This erodes the purchasing power of SNAP benefit recipients. If food prices rise more than overall prices, as they have in the past few years, SNAP benefits will not be able to increase to keep up. SNAP benefits will buy less food for households and not go as far to reducing food insecurity.

Further, some deductions for utility costs, including internet, were removed from benefit calculations, reducing the benefits people receive, even if they remain eligible for SNAP This change reverses efforts to ensure that all households have access to the technology needed to fully participate in the economy, including online education, job trainings, and job applications.

Implications for Other Nutrition Assistance Programs

Other nutrition assistance programs like the National School Lunch Program (NSLP), National School Breakfast Program (NSBP), the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), the Food Distribution Program on Indian Reservations (FDPIR), and the Child and Adult Care Feeding Program (CACFP) were not explicitly cut as part of the OBBBA. However, participation in these programs may decrease after the changes to SNAP.

This decrease in participation is due to adjunctive eligibility—a policy by which individuals who are found to be eligible for SNAP or Medicaid are automatically conferred eligibility in other assistance programs. For instance, children whose families are eligible for SNAP are automatically

eligible for free school lunch and school breakfast. Pregnant women on SNAP or Medicaid are automatically eligible for WIC. This reduces barriers to enrollment for eligible populations. Since the OBBBA cuts both SNAP and Medicaid, people who no longer have adjunctive eligibility through either program may not participate in WIC, school lunch, or other nutrition programs.

About 5 million students per year receive free school lunch because they are SNAP participants—more than a quarter of all free lunch recipients in the country. Older children, in particular, will be likely to lose SNAP coverage as the OBBBA imposes work requirements on adults in households with children aged 14 or older. Figure 2 shows the number of students who receive free school lunch through direct certification from SNAP each year compared to the total number of free school lunch participants. Even with increasing coverage of SNAP participant children through other free lunch provisions (like the Community Eligibility Provision), direct certification remains an important mechanism for ensuring that SNAP-participating students have access to free school lunch and breakfast.

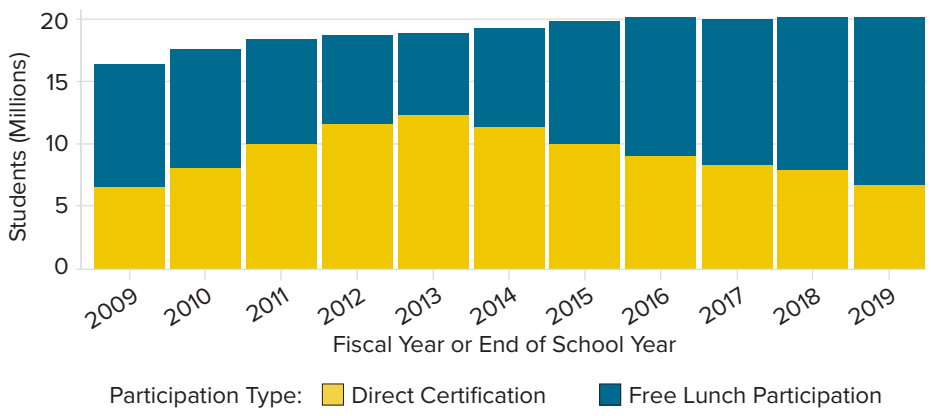
What Do These Changes Mean for U.S. Agriculture?

Historically, SNAP has supported additional food demand in the United States, with USDA estimates of the economic multiplier from SNAP suggesting that spending on food at home increases by about $0.30 for each additional dollar of SNAP benefits. This means that spending on food at home was $28 billion higher in FY 2024 than it would have been without SNAP—a 2.7% increase over a base level of $1.06 trillion. The remaining $0.70 of each additional SNAP dollar is spent on other goods and services.

This, in turn, generates spillover effects throughout the economy, including in food away from home and other sectors that demand agricultural products. The total multiplier effect is 1.5—an additional dollar of SNAP raises GDP by $1.50. Focusing on agriculture and other industries in the food supply chain, $1 billion spent on SNAP benefits generates 480 new jobs on farms and $32 million in new agricultural income, along with 1,540 jobs in manufacturing, including food processing ($218 million in income), 4,450 jobs in trade and transportation, including food retail and wholesale ($406 million in income), and 1,080 jobs in food services ($151 million in income).

The changes to SNAP in the OBBBA will likely reduce both SNAP participation and SNAP benefit levels. This means fewer SNAP dollars going into the farm economy, and shrinking domestic food demand. These changes are expected to lower demand for agricultural products and inputs all along the food supply chain, resulting in lower agricultural sales.

Figure 2. National School Lunch Program (NSLP) Participation and Direct Certification



Source: Author's calculations using data on free lunch participation in the NSLP from USDA FNS Child Nutrition Program Data Tables and data on direct certification.

Available at: https://tinyurl.com/mr2bjcny and https://tinyurl.com/tddbt72b, respectively.

Note: Direct certification is decreasing after the FY 2013/SY 2012–2013 peak because of increasing free lunch coverage of students who participate in SNAP through the Community Eligibility Provision, reducing the need for direct certification.

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California Now Allows More Ethanol In Gasoline: Is This Going to Save Drivers Money?

Aaron Smith

Legislation passed in October 2025 allows the sale of E15 (15% ethanol and 85% petroleum) in an effort to lower gasoline prices. However, little E15 is likely to be sold in the state and even widespread adoption would have only a limited effect on prices.

"Thanks to our work with the legislature, we have averted billions of dollars in higher costs at the pump by avoiding the kinds of severe gasoline price spikes we saw a few years ago."

—California Governor
Gavin Newsom , October 2, 2025

Californians pay the highest gasoline prices in the United States, a fact that has grown more politically salient amid rising affordability concerns. On October 2, 2025, Governor Newsom signed legislation that proponents claimed could reduce gasoline prices by up to $0.20 per gallon, thereby saving California drivers as much as $2.7 billion annually.

The new legislation allows gas stations to sell fuel that contains 15% ethanol and 85% petroleum, known in the industry as E15. At present, almost all California gasoline is E10; it contains 10% ethanol and 90% petroleum.

In this article, I explain why drivers are likely to be disappointed. First, it is likely that very little E15 will be sold in the state. Second, if E15 were widely adopted, it would not cause large drops in gas prices.

Background on Ethanol in Gasoline

Ethanol has a long history as a motor fuel. In 1920, the U.S. Geological Survey estimated that peak petroleum production would be reached within a few years. Two years later, Henry Ford advocated for using ethanol as fuel. At the time, corn prices were low because European supply had recovered after being decimated during World War 1.

Then they discovered cheap oil in Texas, and ethanol disappeared until the 1970s, when oil prices rose again. Ethanol did not become significant until the Renewable Fuel Standard (RFS) mandates in the 2000s. For more background, I highly recommend episode 2 of the Corn Saves America podcast produced by Agricultural Economic Insights. (Listen to all the episodes, but episode 2 covers the ethanol origin story.)

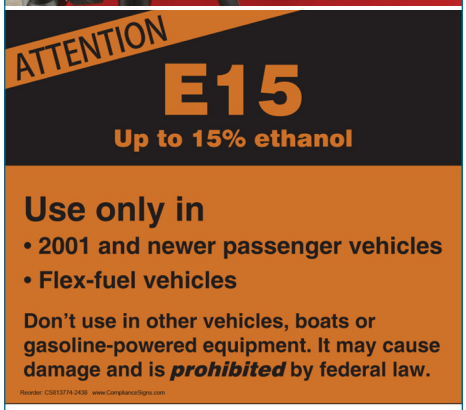
Under the RFS, about a quarter of U.S. corn is used to make ethanol, which makes up 10% of almost every gallon of U.S. gasoline. That is, almost all gasoline in the United States is E10.

Why E10 and Not Some Other Percentage?

The answer to why we use 10% ethanol (versus a different percentage) lies in a set of arcane air-quality rules. When gasoline evaporates, it releases smog-forming chemicals, and evaporation increases in summer heat. To limit this pollution, the Environmental Protection Agency (EPA) requires summer gasoline to be formulated so it evaporates less.

Evaporation potential is regulated through a metric known as Reid vapor pressure (RVP). The EPA requires that summer gasoline has an RVP of less than 9 pounds per square inch. It requires even lower RVP in some regions. This includes areas with severe ozone pollution, which are required to use reformulated gasoline, a specialty formulation that burns more cleanly than conventional gasoline, with fewer smog-forming and toxic pollutants. California has its own RVP standard that is tighter than in reformulated gasoline regions. Research shows that requiring clean gasoline dramatically improves air quality and health. There is no RVP requirement for winter gasoline.

Here's the rub: Adding ethanol to gasoline increases the RVP. If you take regular gasoline with an RVP equal to 9 and mix it with ethanol to make E10, then the RVP increases to 10. This would seem to preclude E10. However, in 1978, during an energy crisis, congress issued a waiver specifically for summer E10 to have an RVP of 10.



Top: Casey's gas pump in Mt. Carmel, IL shows blue for unleaded 88 or E15. Below: Fuel pumps dispensing E15 are required to include labels with restrictions.

Photo Credit: Ann Thompson, WVXU.

That's why E10 gasoline could be sold year-round, but E9, E11, or E15 could not.

Ironically, E15 has very similar smog-causing potential to the E10 it would replace, yet the RVP waiver essentially banned E15 in the summer while allowing E10. Because there are no RVP requirements in winter, E15 can be sold then.

RVP requirements are not the only restrictions on E15. Many carmakers have approved it for use in their cars in the past decade, but some still recommend against it. The EPA has approved it for sale in any 2001 or newer model of car, but prohibits it from use in motorcycles, boats, lawnmowers, snowmobiles, and similar machines. Moreover, fuel pumps dispensing E15 are required to include a label stating these restrictions.

How Would E15 Be Sold in California?

California's new legislation specifies that "blends of gasoline containing 10.5% to 15% ethanol by volume may be sold in the state" until the California Air Resources Board (CARB) completes an evaluation of these fuels. At that point, the state will either adopt a regulation establishing the specifications for these fuels or, if they are found to be incompatible with air quality regulations, cease their sale.

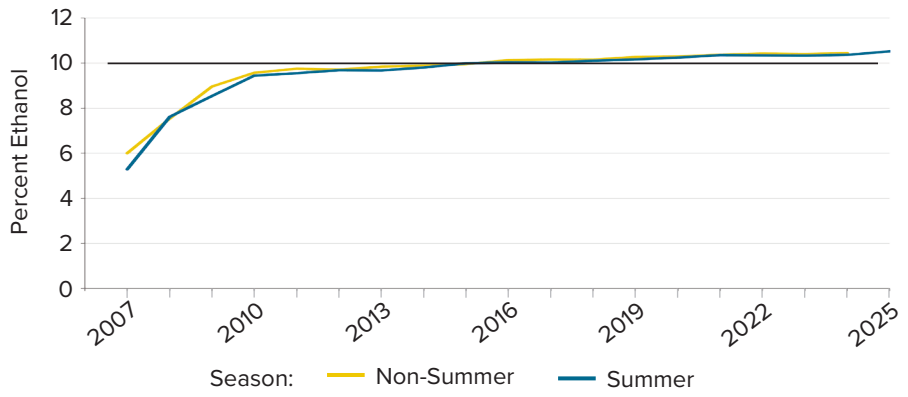
A study from scientists at UC Riverside found that increasing the ethanol blend rate to 15% would not adversely affect air pollution. These findings suggest it is likely that E15 will pass the CARB evaluation.

In an October 2025 webinar, CARB staff outlined two options to establish specifications for E15. First, it could redefine the specifications of standard California gasoline (known as CaRFG) to allow E15. Under this option, gas stations could stock E15 in their regular pumps as long as they posted the EPA-mandated label.

Switching to E15 everywhere would likely require oil refiners to reformulate the gasoline they produce so that the final blend meets technical and environmental specifications. For example, refiners currently produce 84-octane gasoline, which comes up to 87 octane when blended with 10% ethanol. Achieving 87-octane E15 would require refiners to produce an 82-octane gasoline.

The second option is to develop a new specification for E15 as an alternative fuel, a category that includes hydrogen, natural gas, and E85. Staff indicated that they are leaning towards the second option. This option would require retailers to install pump infrastructure if they want to dispense this alternate fuel in addition to standard gasoline.

Figure 1. Percent of U.S. Gasoline that is Ethanol Does Not Vary by Season



Source: Energy Information Administration (EIA). Available at: agdatanews.substack.com.
Note: The black line indicates E10. Most gasoline is either E0 or E10. Beginning in 2005, the RFS mandates required more ethanol to be used, which squeezed E0 out of the market.

E15 Did Not Expand in Other States When It Was Allowed

The federal government has allowed E15 to be sold as an alternative fuel every summer since 2019. Moreover, federal regulations have long allowed E15 to be sold during the winter in most of the country.

The Trump administration allowed it to be sold during the summers of 2019–2021. In 2021, the U.S. Court of Appeals for the District of Columbia Circuit ruled that in lifting the seasonal restriction, Trump's EPA had overstepped its legal authority. The Biden administration issued waivers to allow E15 in the summers of 2022–2024. It believed it was on firmer legal footing because it used an emergency waiver due to a "fuel supply emergency" caused by Russia's invasion of Ukraine. The Trump administration issued a similar emergency waiver in 2025. Congress could remove the impetus for repeated emergency waivers by extending the E10 RVP waiver to include E15, but as yet it has not done so.

E15 is currently available in about 3,000 of the 145,000 gas stations in the United States, mainly in corn-belt states. Gas stations have sold very little of it, as can be seen in Figure 1, which shows 1) the ethanol blend rate has been the same in the winter when E15 was allowed as in the summer when it was not allowed, and 2) an ethanol blend rate eking up to 10.5% in the last couple of years.

E15 Is Not a Lower Cost Fuel

Figure 2 shows the difference between the wholesale prices of ethanol and petroleum gasoline. It shows two lines: the difference between the prices in dollars per gallon (unadjusted) and the difference after accounting for the fact that petroleum gasoline contains 50% more energy per gallon than ethanol. This means that a gallon of E15 contains about 1.7% less energy than a

gallon of E10. In road trials, cars running on E15 get 1% to 2% fewer miles per gallon than those burning E10.

Unadjusted ethanol prices have been below petroleum gasoline prices for much of the last 15 years. Yet fuel suppliers did not voluntarily expand ethanol blends in 2018 when ethanol was $0.70 cheaper than gasoline. The energy-adjusted plot (Figure 2b) shows a major reason why. After adjusting for energy content, we see that ethanol has been more expensive than gasoline for almost all of the last 20 years.

This analysis focuses only on ethanol's energy content and ignores other key properties, especially octane. E10 became cost-effective partly because oil refiners could produce cheaper, lower-octane gasoline and rely on ethanol to raise the final fuel to the required standards. Today, refiners blend 84-octane gasoline with 10% ethanol to make 87-octane fuel. If E15 became common, refiners could make 82-octane gasoline and still meet the 87-octane standard after blending with ethanol. However, it is unclear how much money refiners would actually save by switching from 84- to 82-octane gasoline.

Evidence of this value can be seen in 2017 and 2018 when the EPA exempted "small refiners" from complying with the renewable fuel mandates, allowing E0 for these refiners. These exemptions totaled 8.6% of the petroleum fuel supply in 2017 and 6.7% in 2018, thereby reducing the mandate by these same percentages. The industry could have blended below 10% in those years, but it chose not to, as can be seen in Figure 1.

Policy incentives could also reduce the price of E15 to California consumers. The retail price of a gallon of E10 in the state includes about $0.39 towards climate change mitigation programs. It includes $0.24 for the state's cap and invest program, which requires sellers of gasoline (but not ethanol) to purchase emissions permits. It also includes about $0.02 towards the federal RFS and $0.13 towards the state low carbon fuel standard. These two programs simultaneously levy a fee on petroleum and subsidize ethanol.

Compared to E10, a gallon of E15 would include additional policy incentives of $0.08. Specifically, there would be $0.013 less for cap and invest permits, and it would generate additional net subsidies of $0.057 in the federal RFS and less than a cent in the state low carbon fuel standard.

In summary, for consumers of E15 in California, an additional $0.08 per gallon of subsidies and potential octane benefits could offset the higher cost of ethanol per unit of energy, but the cost differences do not support the notion that E15 would be substantially cheaper than E10 for consumers.

Why Is E15 Priced Lower Than E10 in Other States?

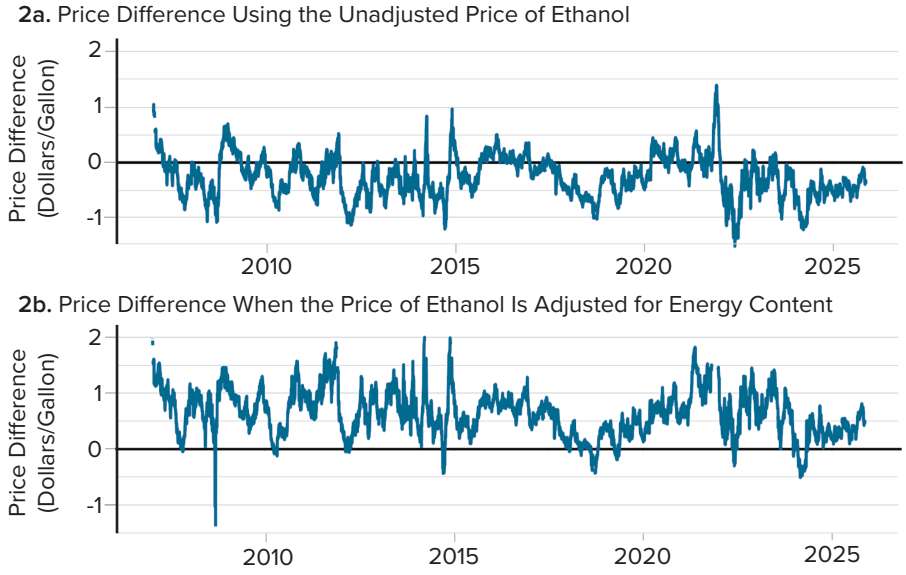
A recent study by Kaplan and Zilberman showed that fuels with higher ethanol blends are priced lower than E10. This study has been used by ethanol advocates and California politicians to claim that allowing E15 will lower gas prices for Californians by about $0.20 per gallon. This same information can be seen in the map in Figure 3 on page 12. It shows E15 prices $0.25, or 8.4%, less per gallon on average.

The Kaplan and Zilberman study uses regression analysis to investigate differences in retail prices between E10, E15, and E85 fuels. The study uses state-level data over a 20-year period. It estimates that fuels are priced lower if they have more ethanol, lower energy content, or lower estimated greenhouse gas emissions—which are just three different ways of saying that high-blend ethanol fuels have lower retail prices.

The lower price of E15 does not reflect a lower cost of production. In fact, even if the extra ethanol in E15 were free to produce, the cost of production would drop by only $0.13. The ethanol is not free, however. As shown in Figure 2b, it typically costs slightly more than gasoline to produce, after adjusting for the lower energy content.

So, if it is not supply, then it must be demand. When sellers wish to sell a product that consumers are not enthusiastic to buy, then the price has to drop to clear the market. In short, most people don't want to buy it. If

Figure 2. Price of Ethanol Minus the Price of Petroleum Gasoline, 2007–2025



Source: EIA and Iowa State University. Available at: agdatanews.substack.com.
Note: Unadjusted=Ethanol-Petroleum Gasoline; Adjusted=(1.5xEthanol)-Petroleum Gasoline.

demand were to increase to the point that E15 became a viable fuel, then the price would rise.

Climate Impacts

Although it may be bad news for consumers that gas prices will not drop substantially following this new law, what about E15's impact on the climate? Renewable fuel policies operate on the assumption that biofuels such as ethanol have lower greenhouse gas emissions than petroleum. However, some recent studies cast renewed skepticism on this assumption.

Increasing the demand for corn to make ethanol raises corn prices, which incentivizes farmers to plant more corn. Some of that corn will be planted on land that would otherwise have been in soybeans or another crop. Some of it will be planted on land converted from forest or rangeland to crops. When new cropland is cleared, the loss of biomass and disturbed soils creates large one-time carbon emissions.

In Lark et al., my co-authors and I found that when we add our estimated land-use change emissions to other sources of emissions from ethanol, ethanol is worse for the climate than petroleum gasoline. Previous studies were projecting into the future, so they relied heavily on modeling. We had the benefit of hindsight, which enabled us to see how actual land use changed.

The genie is out of the bottle. The federal RFS forced ethanol into the system, but now it is a relatively low-cost source of octane, and supply chains are set. Ethanol would stay at 10% of gasoline in the medium term if the RFS went away. But this research implies that expanding ethanol mandates in the future would be unlikely to provide climate or environmental benefits.

Conclusion

The outcomes of California's new E15 law will depend on how CARB chooses to regulate E15 under the new law. If it adds an alternative fuel specification for ethanol, as seems most likely, then I expect the results to be the same as in other states when the EPA allowed summer E15: Few gas stations will offer it, and few drivers will buy it. Consumers don't understand it and may be wary of it; gas stations will be averse to paying for the labeling and new fuel dispensers.

If CARB were to update the CaRFG specifications to include E15, though it has indicated it will not, then there would be more scope for consumer adoption. Gas stations could provide it without investing in new infrastructure, but not at a substantially lower cost relative to E10. Either way, the new law will not avert billions of dollars in higher costs at the pump.

Suggested Citation:
Smith, Aaron. 2025. "California Now Allows More Ethanol in Gasoline: Is This Going to Save Drivers Money?" *ARE Update* 29(2): 9–12. University of California Giannini Foundation of Agricultural Economics.

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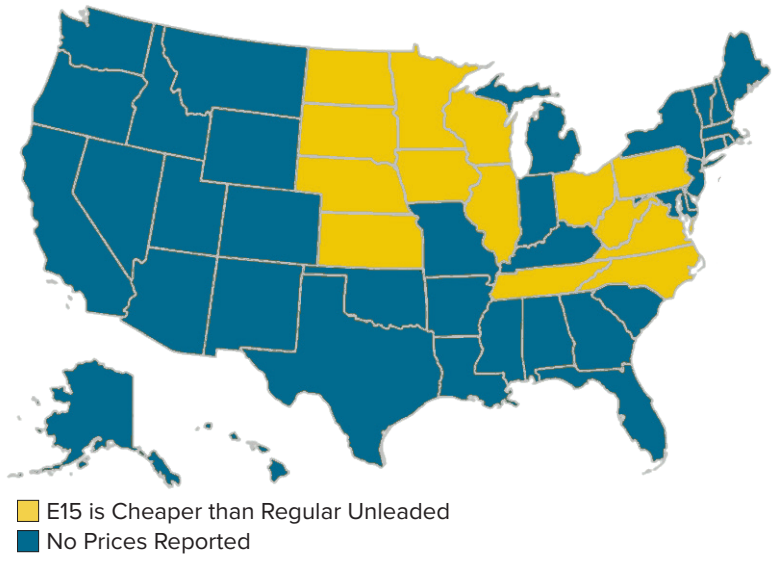
Figure 3. Difference Between E15 and E10 Prices by State



Source: E15prices.com.
Note: The average E10 price is $2.96; the average E15 price is $2.71. The average price spread of E15 compared to E10 is 8.4%.

For additional information, the author recommends:

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Estimating Extended Flood Damage to California's Agricultural Lands Using Remote Sensing

Siddharth Kishore, Boya Zhang, Lisa Wu, Erin Hestir, Alvar Escriva-Bou, and Josué Medellin-Azuara

We estimate the damage to California's agricultural crops caused by flooding events in 2023. Using Sentinel satellite-derived remote-sensed data, this paper quantifies and maps the extent of flood damage to crops in California in 2023. We find that the 2023 floods in California had a negative impact on nearly 79,494 acres of cropland associated with annual crops and 2,510 acres associated with perennial crops. This translated into a loss of $270 million in gross revenues.

Extended flooding can have immediate, and mostly negative, effects on crops and communities. While floodwater may benefit ecosystem functions and groundwater recharge, extended inundation of cropland may result in reduced crop viability and delayed or forgone crop planting, with accompanying economic consequences. Additionally, soil damage may occur if ponded water remains for prolonged periods, resulting in increased soil salinity.

Most of California's crops are neither tolerant nor resistant to excessive irrigation and therefore can be put at risk immediately due to unintended, extended periods of flooding. Yet, the economic impact of floods on California cropland is less well-documented. Using Sentinel satellite-derived remote-sensed data, this paper quantifies and maps the extent of flood damage to crops in California in 2023. We used crop-specific critical periods to evaluate the crops' vulnerabilities to standing water in their life cycles. Specifically, to assess the extent of crop losses caused by flooding, we compared cropland from 2020 as a reference year—a normal year in terms of water supplies and planting decisions—and flood-induced cropland in 2023.

We found that the flooding in California in 2023 caused the greatest crop damage in the southern part of the Central Valley. Kings County was particularly affected, with its cultivated field crops (such as tomatoes, cotton, safflower, and corn) suffering relatively more damage than perennial crops.

Estimated Flood Damage to California Crops

To quantify the crop-specific acreage that was impacted by the 2023 floods in California, and estimate economic damage, we first utilized satellite-derived flooding data for the year 2023 and cropland data obtained from Land IQ for the years 2020 (comparison year) and 2023 (year of interest). Specifically, we used remote-sensed data that detects waterlogging in cropland in California that was collected every five or six days between January 1, 2023 and April 15, 2023. Second, we used a crop calendar that provides a time range for various stages of plant growth for waterlogged crops to translate flooding data into crop yield loss and thus revenue loss.

For example, we assumed corn was vulnerable between April 10 and September 30. Likewise, we assumed tomatoes were vulnerable between March 15 and May 4. During this vulnerable timeframe, there is a critical period where flooding has the greatest impact. The suggestive critical period for corn is 8 days, with a critical period of 4 days for tomatoes. During these critical days, waterlogging can cause harm to crop health and result in potential crop yield loss. Similarly, we apply exclusionary thresholds for other crops based on their vulnerable, critical periods to estimate crop-specific flood damage.

Using Land IQ cropland data for the years 2020 and 2023, we find that perennial crops accounted for 4.02 million acres of cropland in California in 2023, a slight decrease of 2,710 acres from 2020. In addition, about 4.16 million acres of annual crops were planted in 2023 compared to 4.45 million acres in 2020, a decline of 293,385 acres (6.5% of total cropland in 2020).

Tables 1 and 2 on page 14 show 1) the 2023 planted acres, 2) the estimated acres with actual flood damage from the maximum potential flood damage, and 3) the estimated acreage loss for perennial and annual crops. Column 2 of Table 1 shows the crop-specific inundated cropland, which we define as the maximum potential flood damage. Not all waterlogged cropland results in a loss of crop yield. The estimated acres of actual flood damage to crops are shown in column 3 of Table 1.

Almonds were the perennial crop most affected by 2023 flooding (2,177 acres, or 0.14% of total almond cropland in 2020), followed by subtropical fruit trees (161 acres, or 0.04%), and orchards (116 acres, or 0.04% of all orchard land). In summary, we estimate that 2,509 acres of perennial crops were harmed by the 2023 floods, which translated into a loss of $8.07 million in gross revenues.

Table 2 shows the planted acres and the estimated loss in acreage for annual crops. Cotton was the most affected (26,315 acres, or 14.70% of total cotton cropland in 2020), followed by rice (14,464 acres, or 2.8%),

field and grain crops (12,748 acres, or 1.97%), tomatoes (7,949 acres, or 3.49%), corn (6,038 acres, or 1.02%), and safflower (4,460 acres, or 11.90%). The impact on alfalfa was 2,028 acres (or less than 0.5% of total alfalfa cropland) and pasture was 2,698 acres (or 0.32%). The impact on onions, garlic, cucurbits, dry beans, potatoes, and truck crops ranged from 84 acres to 971 acres (or 0.1% to 3.2%). In total, 79,494 acres of annual crops were impacted, which translated into a loss of $262.16 million in gross revenues.

Table 1. Estimated Flood-Induced Acreage Damage and Revenue Loss for Perennial Crops

Selected Crop	2023 Planted Acreage	Potential Flood-Damaged Acreage	Estimated Actual Flood-Damaged Acreage	Gross Revenue Per Acre (Dollars/Acre)	Estimated Revenue Loss (Thousands of Dollars)
Almonds	1,513,038.1	7,755.2	2,177.1	2,874	6,257
Orchards	308,617.4	626.9	116.1	8,538	991
Subtropical Fruit Trees	366,998.4	253.9	161.0	5,149	829
Total Perennial Crops	**4,022,990.0**	**12,711.7**	**2,509.3**	**—**	**8,077**

Source: Authors' calculations based on remote-sensed data derived from Land IQ for the years 2020 and 2023, flood data for 2023, and total value (in dollars) and harvested acreage from the 2023–2024 California Agricultural Statistics Review.

Note: The gross revenue per acre is calculated by using the total value and acres harvested. We multiply the estimated acres with actual flood damage and the gross revenue per acre to calculate the estimated revenue loss. Orchard crops include apples, apricots, avocados, sweet cherries, dates, nectarines, peaches, pears, plums, and prunes. Subtropical fruit trees include grapefruit, kiwifruit, lemons, olives, oranges, tangerines, mandarins, tangelos, and tangors.

Table 2. Estimated Flood-Induced Acreage Damage and Revenue Loss for Annual Crops

Selected Crop	2023 Planted Acreage	Potential Flood-Damaged Acreage	Estimated Actual Flood-Damaged Acreage	Gross Revenue Per Acre (Dollars/Acre)	Estimated Revenue Loss (Thousands of Dollars)
Alfalfa	662,132.9	2,446.3	2,027.6	1,014	2,056
Corn	592,960.7	8,995.1	6,038.3	7,804	47,123
Cotton	178,857.7	32,877.9	26,314.9	3,324	87,471
Cucurbits	62,503.2	514.2	488.5	8,491	4,148
Dry Beans	30,544.6	971.8	971.8	3,017	2,932
Field and Grain	646,706.7	27,614.1	12,747.6	792	10,096
Onions and Garlic	68,269.7	1,575.7	771.9	10,282	7,936
Pasture	834,952.5	5,719.3	2,698.2	753	2,032
Potatoes	48,923.2	302.2	84.3	13,935	1,174
Rice	523,721.5	22,835.2	14,464.0	1,944	28,118
Safflower	37,458.3	5,922.5	4,459.8	820	3,657
Tomatoes	227,799.2	10,900.4	7,948.5	7,401	58,827
Truck	165,396.0	912.9	478.2	13,779	6,589
Total Annual Crops	**4,453,137.0**	**124,419.0**	**79,493.6**	**—**	**262,159**

Source: Authors' calculations based on remote-sensed data derived from Land IQ for the years 2020 and 2023, flood data for 2023, and total value (in dollars) and harvested acreage from the 2023–2024 California Agricultural Statistics Review.

Note: The gross revenue per acre is calculated by using the total value and acres harvested. We multiply the estimated acres with actual flood damage and the gross revenue per acre to calculate the estimated revenue loss. Field and grain crops are comprised of barley, corn, oats, wheat, and other field crops. Cucurbits include cucumbers, melons, cantaloupe, pumpkins, and squash. Truck crops include artichokes, broccoli, carrots, cauliflower, celery, and other vegetables.

Estimated Revenue Losses

Next, we present the estimated revenue losses for each crop type in column 5 of Tables 1 and 2. The gross revenue per acre is calculated by using the total value (in dollars) and acres harvested obtained from the 2023–2024 California Agricultural Statistics Review. Then, we multiply the estimated acres with actual flood damage and the gross revenue per acre to calculate the estimated revenue loss. We estimate the total economic damage caused by flooding to perennial crops at $8.08 million. Almonds account for the highest estimated revenue loss, at nearly $6.3 million, followed by orchards and subtropical fruit trees, which account for approximately $1 million and $0.8 million, respectively.

Flooding to annual crops had an estimated economic damage of $262.16 million, around thirty-two times the loss incurred to perennial crops. The agricultural crops that suffered the highest revenue losses include cotton ($87.5 million), tomatoes ($58.8 million), corn ($47.1 million), rice ($28.1 million), and field and grains ($10 million). Alfalfa, cucurbits, dry beans, garlic, onions, pasture crops, potatoes, safflower, and truck crops are estimated to have losses in the range of $1 million to $8 million.

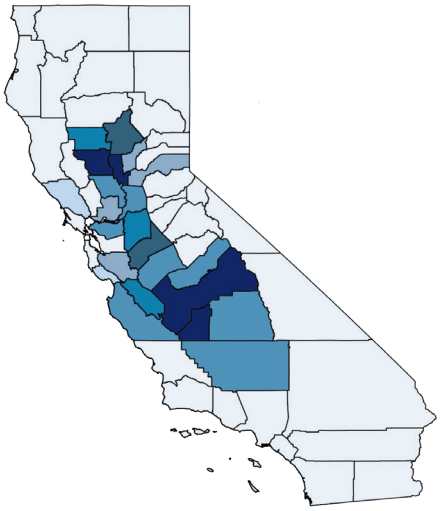
Column 4 shows the gross revenue per acre. It is worth noting that our revenue loss estimates are based on flooded, uncultivated land that was not planted in 2023 but was planted in 2020, hence it may overestimate losses, as these are not profits per acre.

Figure 1 shows the estimated revenue loss by county across crop types due to heavy rainfall and flooding events in California in 2023. Kings County experienced an estimated

flood-induced revenue loss of $144.7 million (6.7% of the total agricultural output of Kings County in 2023) across alfalfa, corn, cotton, field and grain, onions and garlic, orchards, pasture, safflower, tomatoes, and truck crops. Fresno County experienced an estimated revenue loss of $22.1 million across alfalfa, almonds, corn, cotton, cucurbits, field and grain, onions and garlic, orchards, pasture, tomatoes, and truck crops.

Contra Costa, Colusa, Sutter, and Butte counties experienced an estimated revenue loss of $18.1 million, $12.5 million, $12.1 million, and $8.6 million, respectively, across corn, field and grain, almonds, rice, tomatoes, dry beans, and cucurbits. Tulare County experienced an estimated revenue loss of $8.3 million across alfalfa, corn, cotton, and field and grain crops. Stanislaus County experienced an estimated revenue loss of $7.5 million across alfalfa, almonds, dry beans, corn, tomatoes, pasture, and field and grain crops.

Figure 1. Estimated Economic Loss Across Crop Types Caused by 2023 Flooding in California



Source: Authors' calculations.

The revenues lost in Madera, Yolo, Merced, San Benito, Glenn, Sacramento, and San Joaquin counties ranged from $3 million to $5 million across, almonds, corn, cotton, field and grain, potatoes, tomatoes, pasture, rice, safflower, onions and garlic, and truck crops. Placer, Solano, Kern, and Monterey counties experienced an estimated revenue loss of between $1 and $2 million. The estimated revenue loss for Sonoma, Santa Clara, and Yuba counties was less than $1 million.

To summarize, the 2023 floods in California had a negative impact on less than 0.1% of cropland (2,509.3 acres out of 4.02 million acres) associated with perennial crops. However, 1.79% (79,493.6 acres out of 4.45 million acres) of annual crops were harmed by the 2023 floods, suggesting planting locations could be more vulnerable to extended flooding or excessive waterlogging. While 2020 was a normal year, a comparison of acreage between 2020 and 2023 does not necessarily mean the difference is due to flooding. Many other unobservable factors are likely also affecting the planting decisions in both years.

Conclusion

The Central Valley of California is becoming increasingly susceptible to extreme precipitation events such as droughts and floods. Remote-sensed spatial data can be used to evaluate agricultural lands for inundation analyses and thus strengthen preparedness in the future.

Our research on statewide crop loss due to the 2023 floods showed that extended flooding had a negative impact on roughly 82,000 acres—79,494 acres of annual crops (out of 4.45 million acres statewide) and 2,509 acres of perennial crops (out of 4.02 million acres statewide). These flood-induced crop losses translated into an estimated loss of $270.23 million in gross revenues. Of this, $262.16 million was associated with annual crops and $8.08 million was associated with perennial crops. Almonds, cotton, tomatoes, and rice crops account for the greatest revenue losses. A significant portion of the damage was concentrated in the San Joaquin Valley, the largest and most productive agricultural region in the United States.

Our results highlight the importance of managing for climate extremes, including floods, and the strategic use of excess water for managed aquifer recharge. This we leave for future research.

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