

RESEARCH BRIEF

KEY POINTS FOR DECISIONMAKERS

► **Clean air laws in California have greatly benefitted agricultural yields in the state.** Since 1980, decreases in ground-level ozone have increased California perennial crop production in recent years by \$600 million per year. But ozone damages may still be \$1B per year; future air quality improvements could greatly boost production of some crops such as grapes and stone fruits.

► **There is not a significant temperature trend 1980-2015.** Perennial yields don't show a strong relationship to historical temperatures, with the possible exception of 2010–2015, during which a warming period reduced yields of walnuts and almonds.

► **Changes in future scenarios will be a mixed bag for perennial crops in California.** Projected decreases in ozone will help crops, while warmer temperatures will hurt them. On net, yields of many crops may increase somewhat (e.g., table grapes), whereas yields of more temperature-sensitive crops like almonds and walnuts may decline.

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California perennial crops are susceptible to air pollution

California supplies two-thirds of the nation's fruits and nuts, and over one-third of the nation's vegetables. In 2015, the value of the state's agricultural output was \$59.4 billion, 13% of the U.S. total.

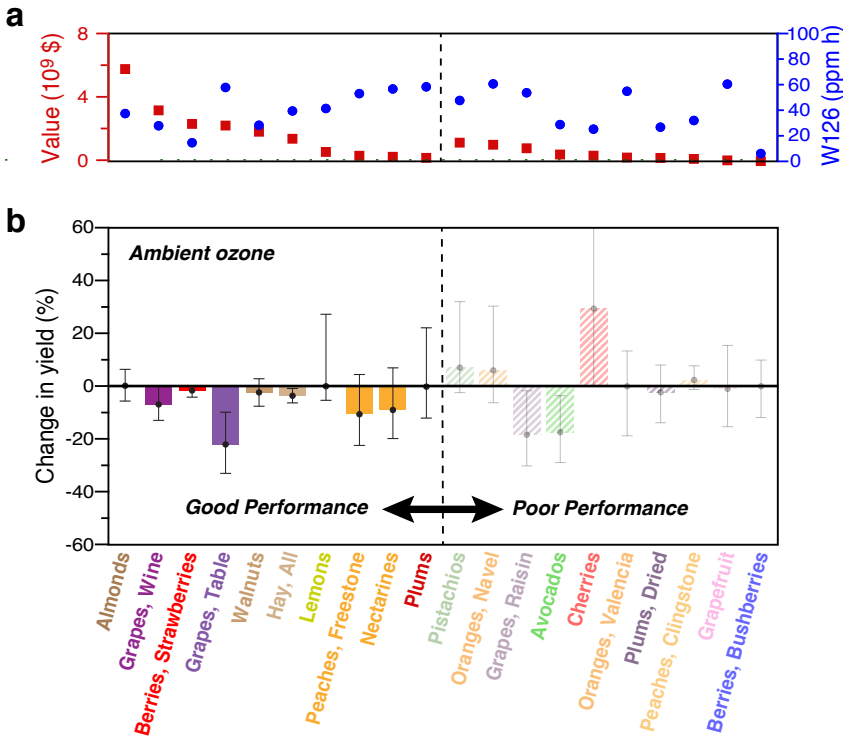
We analyzed temperature, precipitation, ozone exposure and agricultural yields 1980-2015, focusing on key California perennial crops such as almonds, grapes, nectarines, peaches, strawberries and walnuts.

Our results suggest that for most perennial crops, ozone damage to yields may be more substantial than warming effects. Indeed, we estimate losses due to ozone damage can be as high as \$1 billion per year. We find yield losses of 5–15% for crops such as grapes and stone fruits are still occurring. In contrast to ozone, temperature trends have not clearly affected yields.

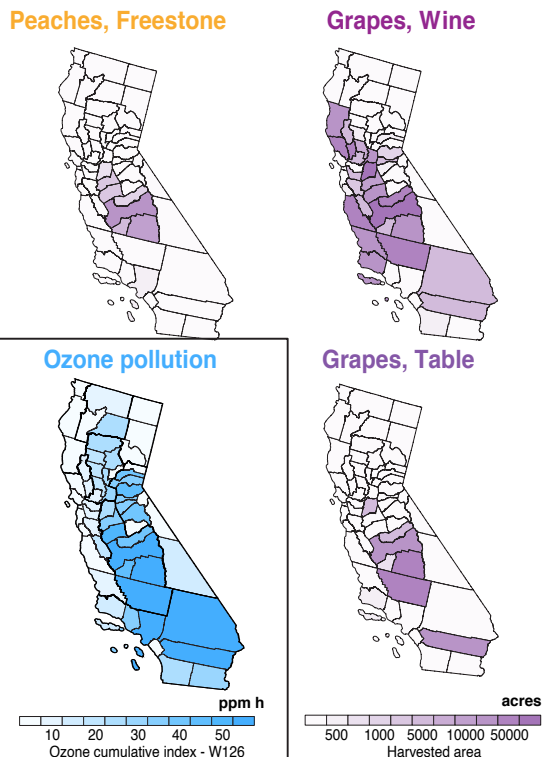
Clean air policies have been an unheralded but particularly effective and practical option to secure perennial crop production, and that collaboration among agricultural policymakers, air quality managers and climate policymakers can thus help to ensure the future productivity of perennial crops in California in a changing climate.



California almonds

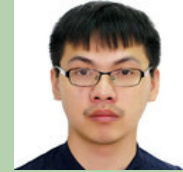


Yield responses of California perennial crops to ambient ozone. Panel a shows the value (red) and average ozone exposure (blue) of the 20 most-valuable California perennial crops. Bars in panel b show the percentage change in yields due to ozone exposure, with good performing models at left and poorly performing models at right.



Distribution of ozone pollution and most-affected crops. Maps show the geographical concentration of some of the crops most-affected by ozone pollution (purple) and the cumulative ozone index (blue).

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Blooming almond trees, Central Valley

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