



# Fog, Drought, Strawberries, and LEGO

## - Modeling the Effect of Coastal Fog on the Growth of Strawberries -

Anh Vo <sup>a</sup>, Jennifer Harfman<sup>b</sup>, and Ian Faloon<sup>a b</sup>

<sup>a</sup>. Woodland High School, 21 N. West, Woodland, CA 95695

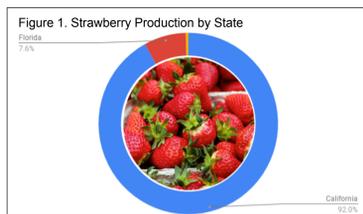
<sup>b</sup>. Department of Land, Air, and Water Resources, University of California Davis, 1 Shields Ave, Davis, CA 95616



### Introduction

In 2017, California agriculture contributed \$20.56 billion to the state's economy, and continues to be a major exporter of almonds, dairy, pistachios, and strawberries. 11.2% of US agricultural products are grown in California. The State produces 91% of the nation's strawberry crop, valuing nearly \$3.5 billion a year. <sup>1</sup>

Today, irrigation for California's agriculture demands 40% of the state's water supply. California's primary source for water depends on the annual precipitation rate, however in recent years, drought conditions have caused a significant water shortage threatening crop yields.



In particular fruits with shallow root systems, for example strawberries, are susceptible to drought and extended water-stress conditions.<sup>2</sup> When strawberry plants do not receive the required amounts of water from the beginning of the growing season to harvest, the total fruit production can be decreased by up to 80%.<sup>3</sup> To increase crop yields properly installed irrigation systems are needed to offset the transpiration rate of surface water. However, irrigation, despite being fundamental for strawberry crops, is limited by the current rise in water demand.<sup>4</sup> As a result, there is a need for the development of better water management practices and an improved understanding of local weather conditions, in order optimize plant water use efficiency.



Fog and all other weather occur in the troposphere, the lowest layer of the earth's atmosphere. Coastal Fog is a near ground marine stratocumulus sheet of Fog (see satellite image on left), a blanket of clouds formed by the rise of cold ocean water. Summertime fog is very unique for California and created by the cold coastal water temperatures meeting the warm soil inland.

### Goal

The goal of this project is to study the impact of coastal fog on the growth of strawberries in California.

### Research Question

Does coastal fog have an impact on strawberry production in California?

### Hypothesis

I hypothesize that coastal fog events will enhance the growth of strawberries. The areas with increased production of strawberries will geographically overlap with the locations and occurrence of coastal fog.

### Materials and Methods

- GIS map:
  - Computer installed with ArcGIS Version 10.4.1
- 3-Dimensional Lego Model Map:
  - Plywood board (4"x 7'6")
  - Over 32,000 individual single Lego pieces, plates and decorations
- Fog Machine:
  - Dry Ice, Cooler, Hose, Duct Tape, Boiling Water, Hammer, Safety Glove

The first part of my project was to use Geographic Information System (GIS) to digitally color a 5 km raster size elevation map of California to make the different elevation profiles more easily recognizable. I then imported the United States Geological Survey's (USGS) 2006 National Land Cover Data (NLCD) Map into the software and reclassified the land cover classes to match the color code of the available Lego pieces.

Secondly, I built a dry ice fog machine to simulate the path coastal fog was taking from sea further inland. I was able to do so by using the 3 Dimensional Lego map model to observe the regions where the stimulated fog enters and accumulates. The final step was literature research on strawberry water-use related to plant growth in California.

### Results

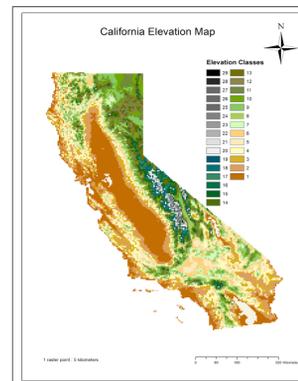


Figure 2. Map 1: 5 km resolution map showing the different elevation profiles in 150 m vertical increments.



Figure 3. United States Geological Survey's National Land Cover Database based upon Landsat 5 Satellite Imagery.



Figure 5. Dimensional Elevation Map Model built out of 32,000 individual Lego pieces to represent CA's Land Cover Types. The map is not to scale being 5 km per Lego Piece with an elevation of 150 meters per piece. Unfortunately due to the limited amount of Lego pieces and the plywood board size available we were not able to use the same vertical and horizontal resolution.

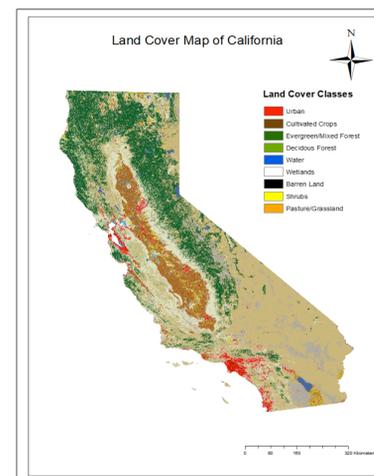


Figure 4. Land Cover Type Map of California, representing 9 different Land Cover Types to match the available Lego color pieces.

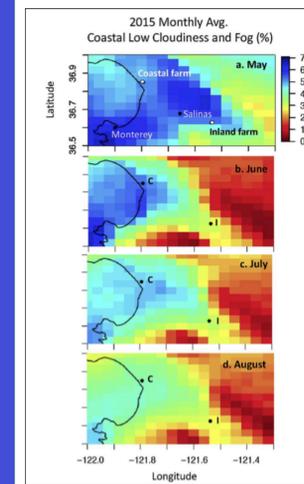


Figure 7. Average monthly summertime fog climatology for Monterey Bay in 2015. Average coastal low cloudiness and fog (CLCF, %) was calculated for each month between May and August in 2015.

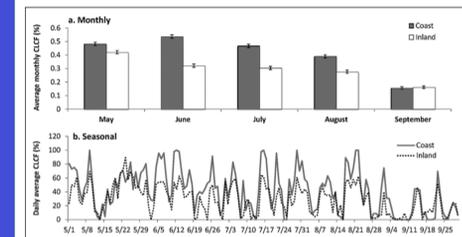


Figure 8. Average (a) monthly, (b) seasonal, values of coastal low cloudiness and fog (CLCF, %) observations derived from satellite imagery at the coastal and inland farm locations in 2015.

The figures above are from the paper "Coastal low cloudiness and fog enhance crop water use efficiency in a California agricultural system" and demonstrate that fog is present within the strawberry growing region throughout the growing season. The second figure shows the difference of cloudiness and fog between the coastal and inland region. The authors showed that coastal farm regions have preferable growing conditions due to the reduced water demand of strawberry crops as a result of fog events. This clearly explains why in Figure 9. (below) the Monterey Bay, where fog is majorly present, is a primary growing region for strawberries.

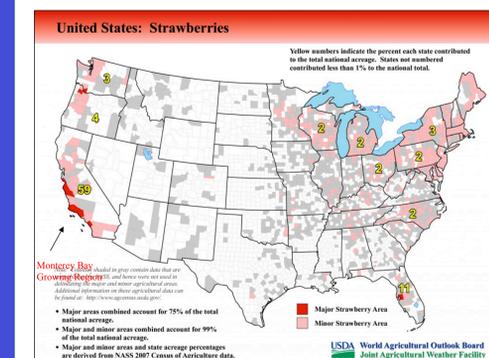


Figure 9. Strawberry Production areas of the United States.

### Conclusion

In my study I was able to demonstrate that coastal fog has a significant influence on strawberry production. There are two major effects contributing to the enhanced plant growth and strawberry yields.

- The first one is the fog buffers the drying of soil by increasing the region's humidity. Strawberry plants consequently demand less water during fog events and experience reduced atmospheric water stress. As a result increasing water uptake from the air enables the adjustment of irrigation systems accordingly to the plants water needs. This decreases the need of irrigation water supply.
- Secondly, the shading effect by fog increases crop water use efficiency due to the reflection and scattering of light back into the atmosphere. This lowers the evapotranspiration rates of water, decreasing irrigation water use.

### References:

- Baguskas, Sara A., et al. "Coastal Low Cloudiness and Fog Enhance Crop Water Use Efficiency in a California Agricultural System." *Agricultural and Forest Meteorology*, vol. 252, 2018, pp. 109-120. doi:10.1016/j.agrformet.2018.01.015.
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### Acknowledgements

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