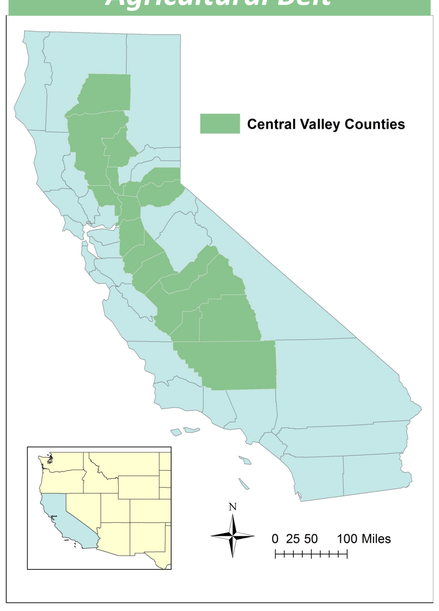
Linking Cancer Incidence and Pesticide Exposure in California's Central Valley

INTRODUCTION

California's Central Valley is known as one of the most agriculturally fertile regions in the world. Stretching over 450 miles long and encompassing 18 counties, the Valley is the world's largest plot of class 1 soil – agriculturally speaking, the best soil there is. The Valley is home to over 230 diverse crops and produces ½ of all fruits, nuts, and vegetables grown in the United States. In 2014, California's crop exports raked in 21.24 billion dollars in revenue. To meet annual crop yield, Valley farmers have turned to agricultural pesticides to optimize productivity and increase profit. Benefits of pesticides and herbicides include decreased susceptibility to disease, increased resilience, and decreased vulnerability to invasive weeds and insects. The effects of pesticides on human health, however, remain largely unknown.

Agricultural Belt



In recent years, researchers have sought to evaluate the effects of agricultural pesticides used in Central Valley farming on surrounding residential communities. Epidemiological studies indicate high incidence of cancer near areas of agricultural pesticide use. Ultimately, long-term pesticide exposure induces neurodegenerative processes within the body that may lead to the development of chronic diseases such as cancer.

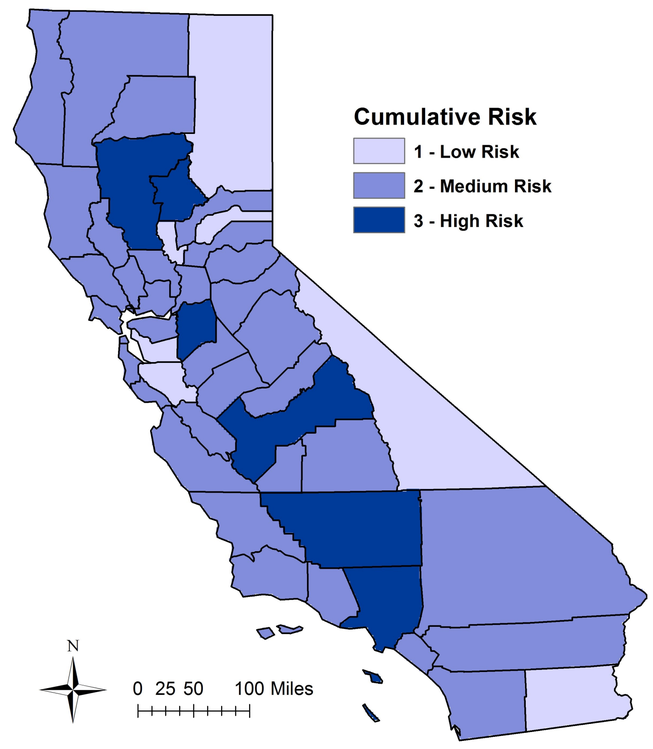
The intent of my project is to assess geospatial patterns between annual pesticide use and incidence of cancer throughout the state of California.

METHODS

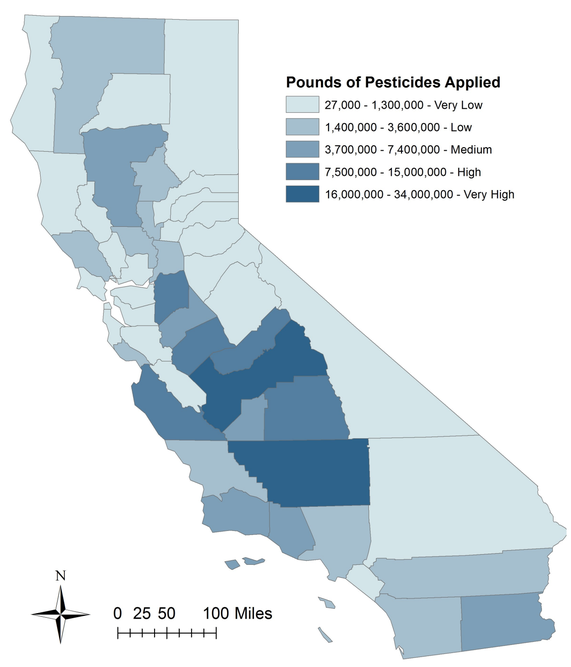
Primary data layers include population-based cancer incidence data from the California Cancer Registry (CCR) and annual pesticide use density from California's Department of Pesticide Regulation (CDPR). Additionally, data was derived from the US census to provide information on county boundaries, total sum of crop acres, and total population.

2012 Data from the California Cancer Registry, including age-adjusted cancer rate, number of cases, and population at risk, was joined to the California county layer. Although cancer incidence data was organized by county, CCR grouped various counties together and combined the data. The following counties were merged into aggregate areas: Mariposa – Tuolumne, Del Norte-Humboldt, Colusa – Glenn – Tehama, Alpine – Amador – Calaveras, Siskiyou – Trinity, Sierra – Yuba, Lassen – Modoc – Plumas, and Inyo – Mono.

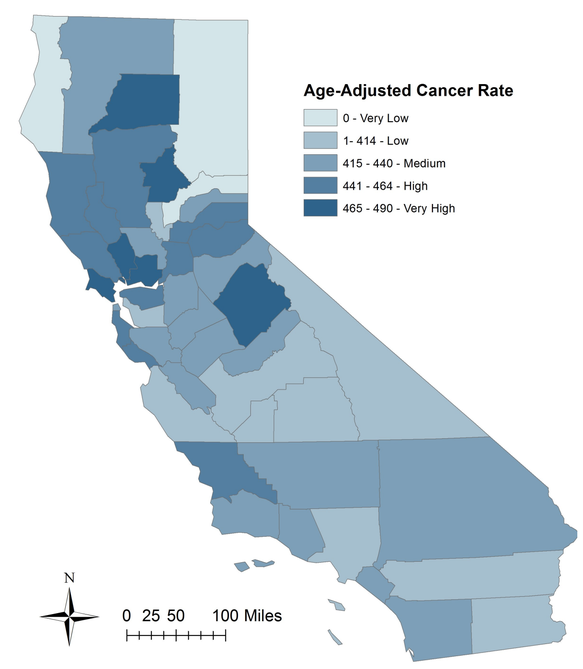
RISK ASSESSMENT



Pounds of Pesticides Applied

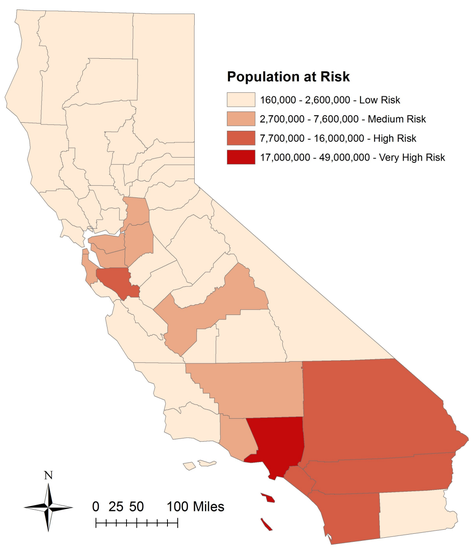


Age-Adjusted Cancer Rate

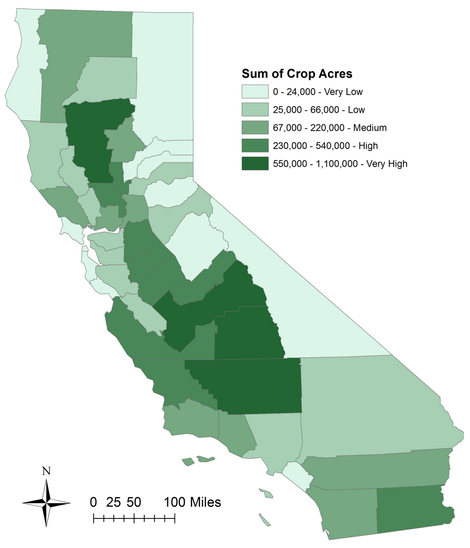


*Age-Adjusted Rate represents number of cases per 100,000 residents

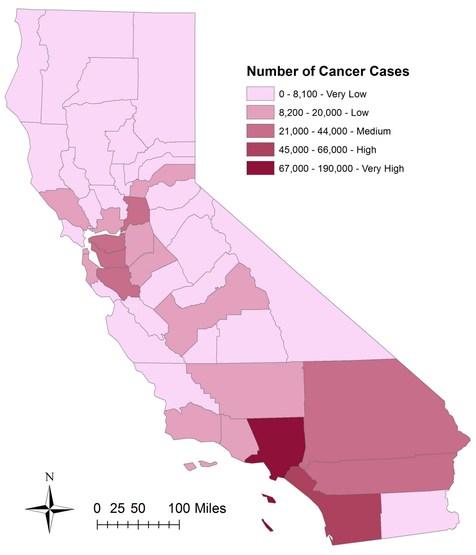
Population at Risk



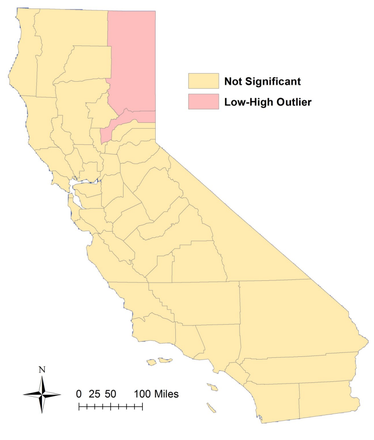
Sum of Crop Acres



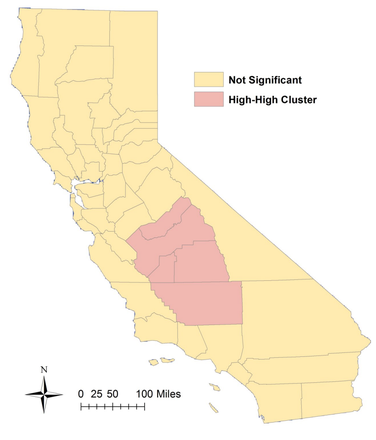
Number of Cancer Cases



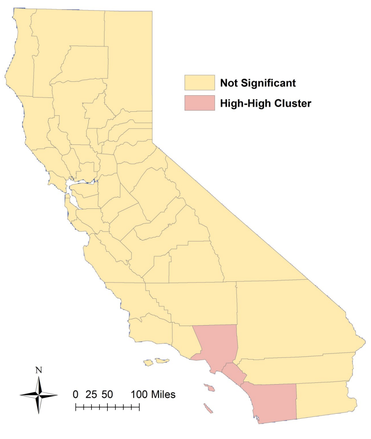
Age-Adjusted Rate



Pounds of Pesticides Applied



Number of Cases



METHODS CONT.

To properly join the CCR data with the California counties layer, I used the dissolve tool to replicate these boundaries and create a new subset of counties. Once this action was complete, I joined 2013 pesticide use data from CDPR to the new county layer. 2010 US census data was also joined to the new layer. Next, I used Local Moran's I to perform cluster analysis. Three maps were created, including age-adjusted cancer rates, number of cases, and pounds of applied pesticides. My next objective was to create a state-wide cancer vulnerability analysis. I converted the following polygons to rasters: age-adjusted cancer rate, number of cancer cases, pesticide density, and sum of crop acres. I then reclassified each of these rasters on a scale of Very Low, Low, Medium, High, and Very High for their respective metrics. In the raster calculator, I aggregated the inputs to create a comprehensive cancer risk analysis. I called this map "Cumulative Risk" and classified it according to Low Risk, Medium Risk, and High Risk.

DISCUSSION AND LIMITATIONS

Little conclusive research has been made on the carcinogenic properties of pesticides. California's growing population has pushed residents from urban metropolises into rural areas proximal to large agricultural plots. It is certain that cumulative exposure to high quantities of pesticides increases susceptibility to the development of chronic diseases later in life. However, it is difficult to monitor individual exposure due to the transient nature of pesticides. My analysis did not account for the phenomenon of "pesticide drift," which may alter rates of exposure of California residents. Individuals who live relatively far from agricultural plots may experience unknown levels of exposure through groundwater contamination and air pollution. Additionally, there is no universal metric to quantify "high exposure" to agricultural pesticides. Ideally, access to point data of cancer cases, rather than number of cases by county, would provide for a more accurate analysis. Due to privacy restrictions, this data was not available. A more robust analysis would asses individual levels of exposure based on duration of residency, in lieu of aggregate data by county. Nonetheless, preliminary analysis revealed spatial correlation between high pesticide density and high incidence of cancer. High risk counties included Tehama, Butte, Fresno, San Joaquin and Kern. Fresno and Kern were categorized as "Very High" in terms of agricultural pesticide density while San Joaquin was categorized as "High" density.

Future research endeavors will require advanced statistical analysis and stringent individual monitoring to determine a causal relationship between pesticide exposure and incidence of cancer.

Tufts UNIVERSITY

Projection: NAD_1983_California_Teale_Albers

Data Sources: California Cancer Registry (CCR), 2012; California's Department of Pesticide Regulation (CDPR), 2013; U.S. Census, 2010

Cartographer: Jamie Cordova, GIS 101, Fall 2015