Pumping the Brakes on Air Pollution:

Assessing the Impacts of California's Low Emission Vehicle Standards

Introduction

Due to historically poor air quality, California has the authority under the Clean Air Act to impose stricter vehicle emissions standards on automakers than those set by the federal government. In 1990, the California Air Resources Board adopted its first set of Low Emission Vehicle (LEV) standards to regulate the emissions of light- and medium-duty vehicles sold within state boundaries. Since then, the LEV program has been amended two more times. The first LEV standards applied to model years 1994 through 2003; LEV II applied to model years 2004 through 2010; and LEV III, the most recent amendment to the standards, applies to model years 2015 through 2025. Manufacturers can continue to certify vehicles under the LEV II standards through model year 2019, and beginning with model year 2020, all vehicles must comply with LEV III standards.

Since the LEV III standards are still being phased in, I wanted to assess the impact of the LEV II standards on ambient air quality in California by focusing on changes in particulate matter (PM2.5) and nitrogen dioxide (NO_2) concentrations. PM2.5 and NO_2 are harmful both to human health and the environment, and standards for these two pollutants were significantly strengthened in the LEV II standards. Specifically, I found the spatiotemporal change in average statewide concentrations of particulate matter (PM2.5) and nitrogen dioxide (NO_2) in 2003 and 2017. I then quantified the change in average concentrations at the county level between these two years, and found which counties were out of compliance with California Ambient Air Quality Standards (CAAQS) in 2017 versus 2003.

Table 1. California Air Quality Standards

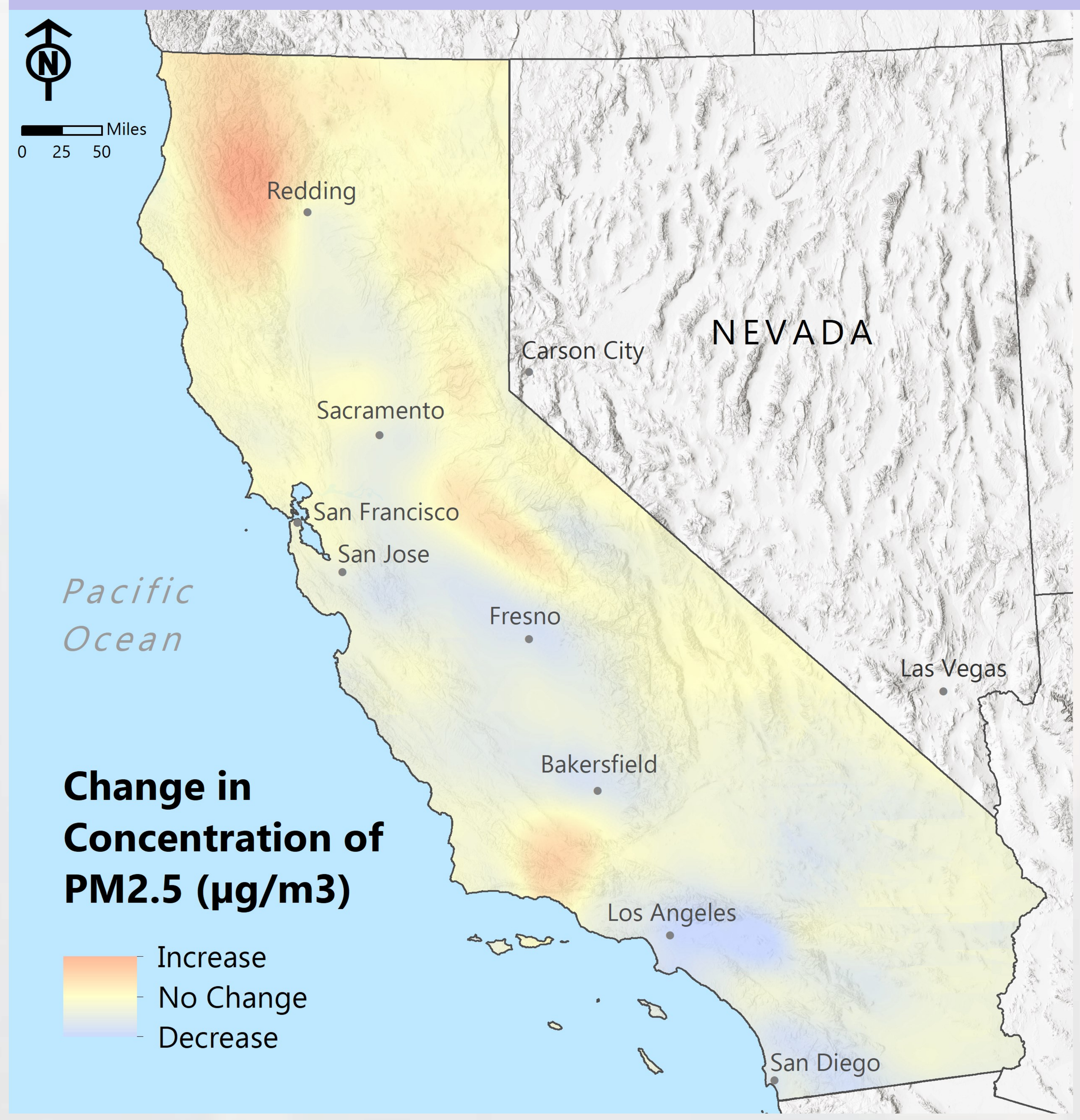
Pollutant	Annual Average Concentration Limit
PM2.5	12 $\mu g/m^3$
NO_2	30 ppb

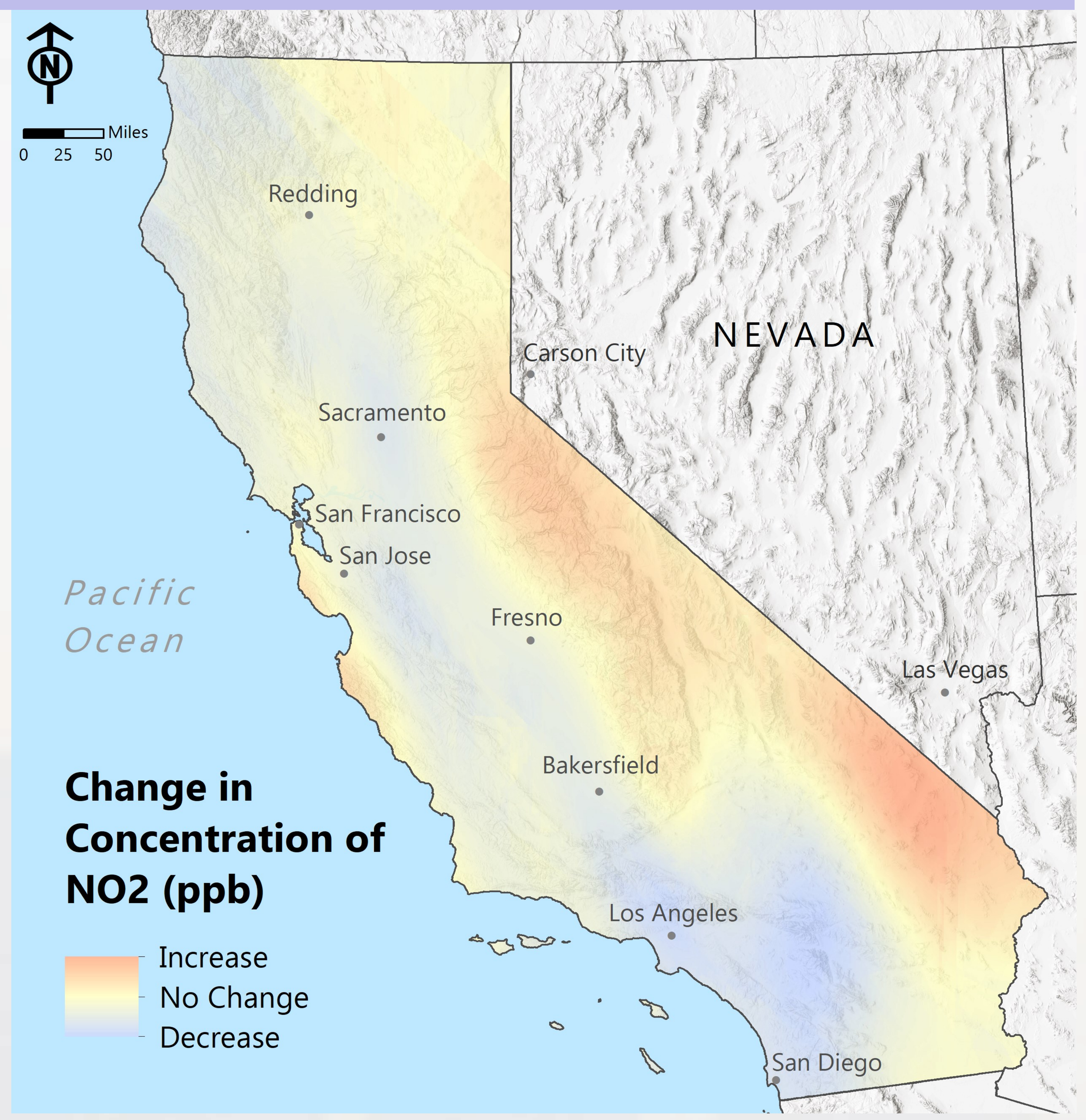
Methodology

Daily air quality measurements from the EPA served as the primary source of data for my project. I downloaded the daily measurements of PM2.5 and NO_2 for 2003 and 2017 from air quality monitoring stations in California, Oregon, Nevada, and Arizona. Since air pollution knows no boundaries, I included the states surrounding California to improve the accuracy of my model.

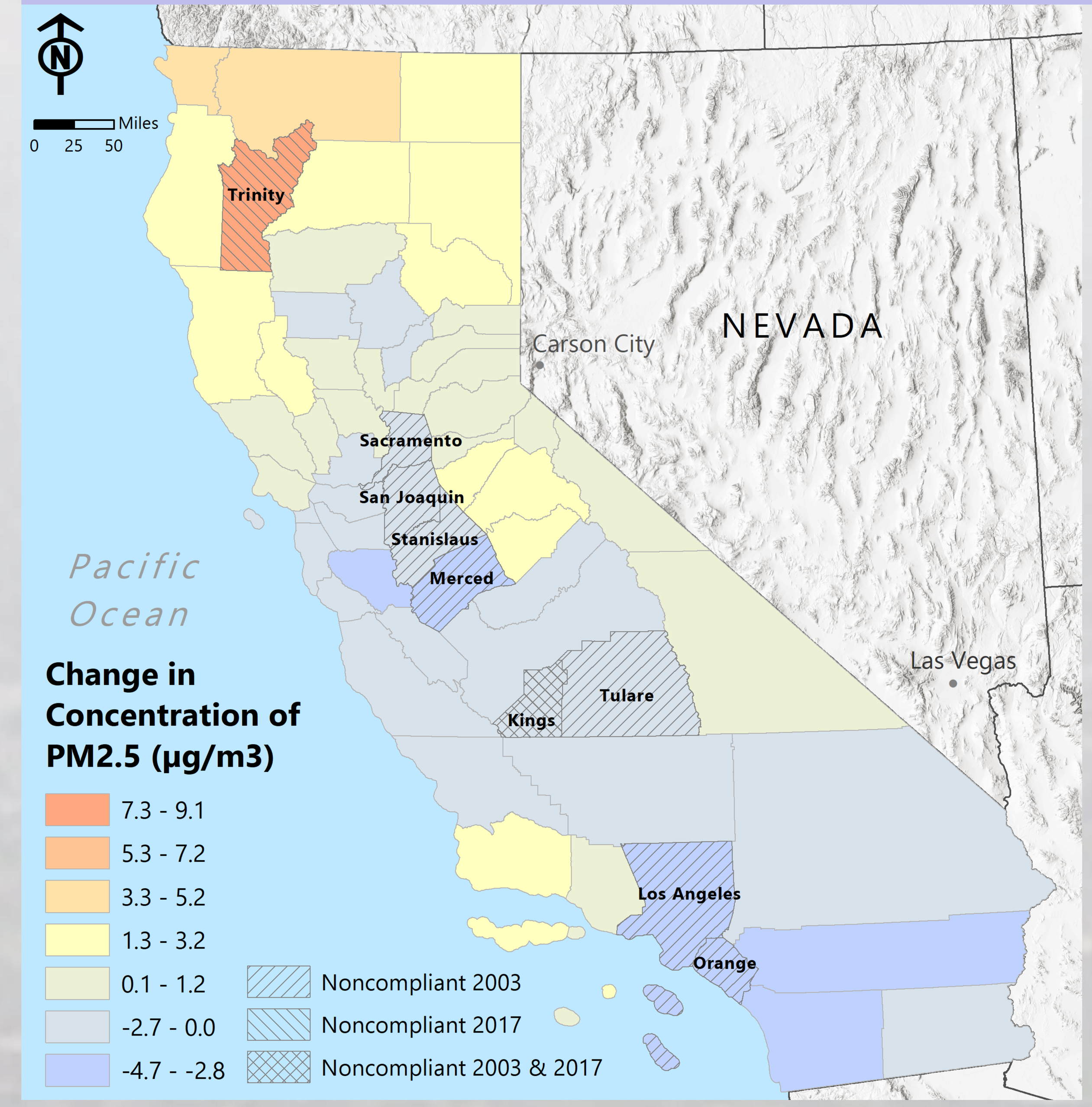
In Access, I created a SQL query to find the annual average concentration at each monitoring station in the four states for both pollutants. I then geocoded the stations in ArcMap and used Geostatistical Analyst to interpolate the annual average concentrations between all monitoring stations for both pollutants. I used the ordinary Kriging interpolation method and assumed anisotropy. I then implemented a model in Model Builder to clip my interpolation raster to California county boundaries and calculate the annual average concentration of each county using Zonal Statistics. I used the Field Calculator to calculate the difference in average concentration between the two years, and Select by Attribute to select counties whose annual average concentration was out of compliance with CAAQS. Finally, I used Raster Calculator to find the difference between the interpolated statewide annual average concentrations of each pollutant.

Change in Annual Average Concentration of PM2.5 and NO2





Change in Annual Average Concentration of PM2.5 and NO2 by County



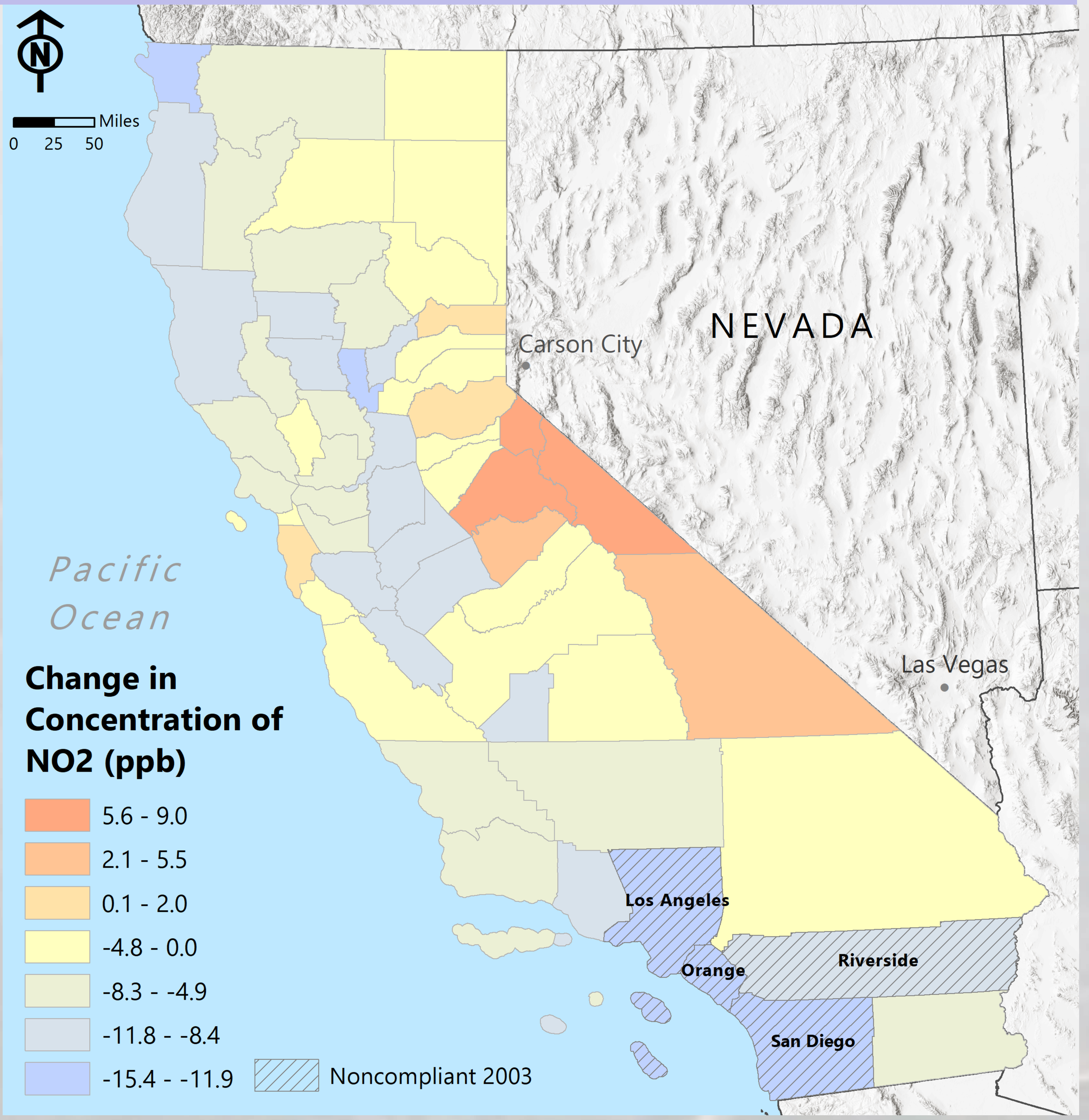


Table 2. Summary of Changes in Average Annual Concentrations of PM2.5 and NO2

Pollutant	Counties that Experienced a	County with the Greatest Decrease	Magnitude of Decrease	Counties that Experienced an	County with the Greatest Increase	Magnitude of Increase
PM2.5	28	Orange	4.7 $\mu g/m^3$	30	Trinity	9.1 $\mu g/m^3$
NO_2	50	Orange	15.4 ppb	8	Alpine	9.0 ppb

Conclusion

The results of this project show that, overall, there have been improvements in air quality in California since the LEV II standards were implemented in 2003. Southern California, which has had particularly poor air quality historically, has experienced significant improvement. However, there has been an increase in PM2.5 concentrations in the northwest, and an increase in NO_2 concentrations in the east.

When comparing the change in annual average concentrations of each pollutant at the county level, it appears that LEV II standards have had a larger impact on NO_2 concentrations than PM2.5 concentrations. However, it is important to note that the interpolated values for the statewide annual average concentration of PM2.5 were more accurate than those of NO_2. The Kriging method used to determine the annual average concentrations had lower root mean square errors for PM2.5 (3.07 for 2003 and 2.7 for 2017) than NO_2 (8.32 for 2003 and 6.93 for 2017). For PM2.5, eight counties were noncompliant in 2003, and in 2017, seven of these became compliant. However, Kings County (Southern California) remains noncompliant, and Trinity County (Northern California) has become noncompliant. As shown in Table 2 Orange County (Southern California) experienced the greatest improvement in air quality. In addition to experiencing the greatest decrease in both pollutants, it moved from out of compliance with CAAQS in 2003 to in compliance in 2017. Trinity County and Alpine County (Eastern California) experienced the greatest increases in PM2.5 and NO_2, respectively, but only Trinity County moved from in compliance to out of compliance. Alpine County is still in compliance with CAAQS despite the increase in the annual average concentration of NO_2.

Though this project resulted in observable trends, there are several limitations. First, the annual average concentrations are estimated values based on daily readings at air quality monitoring stations that are unequally distributed throughout California and its neighboring states. Second, the Kriging method used to interpolate pollutant concentration across the state does not take into account pollutant dispersion patterns, wind, elevation, and other environmental factors that may affect air quality. Finally, this project did not take into consideration other factors that may affect changes in concentrations of PM2.5 and NO_2, such as other sources of these pollutants and other regulations aimed at reducing emissions of these pollutants. Therefore, proving that any observed reductions are due to LEV II standards is, of course, difficult.

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December 17, 2018
UEP 254: Advanced GIS, Fall 2018

Coordinate System: NAD_1927_California_Teale_Albers (meters)

Projection: Albers

Data Sources: EPA (Air Quality Data); California Open Data Portal (CA Counties); ESRI (US Cities, Hillshade); Tufts M Drive (United States); DIVA-GIS (Mexico); Natural Earth Data (Oceans)