Exercise 1: Making Predictions: Particulate Matter Exposure

Instructions
Use this guide and ArcGIS Online to reproduce the results of this exercise on your own.

Note: ArcGIS Online is a dynamic mapping solution. The screenshot graphics that you see in course materials may differ slightly from the version of ArcGIS Online that you will use.

Introduction

This exercise presents the spatial analysis approach using ArcGIS to interpolate sample points, creating a continuous or prediction surface. The result will be a map showing long-term particulate matter exposure. The purpose of this exercise is to show how you can use GIS to perform interpolation. Although the data is real, the scenario, analysis, and resulting decisions are hypothetical.

Scenario

A grant-funding agency would like to establish where populations in California are more exposed to air pollution, especially PM2.5 particulates. PM2.5 particulates are extremely fine particles (smaller than 2.5 micrometers in diameter) in the atmosphere that pose serious health risks. PM2.5 particulates contribute to lung disease and cancer.

Levels of PM2.5 close to major roadways are often much higher than levels in other locations due to increased vehicle emissions. Other sources of PM2.5 include industrial emissions, the use of non-smokeless fuels, and wildfires. PM2.5 particulates are light; they can remain in the air for a long time and travel hundreds of miles. Given these characteristics, there will always be a continuous background level of PM2.5, but it will vary spatially.

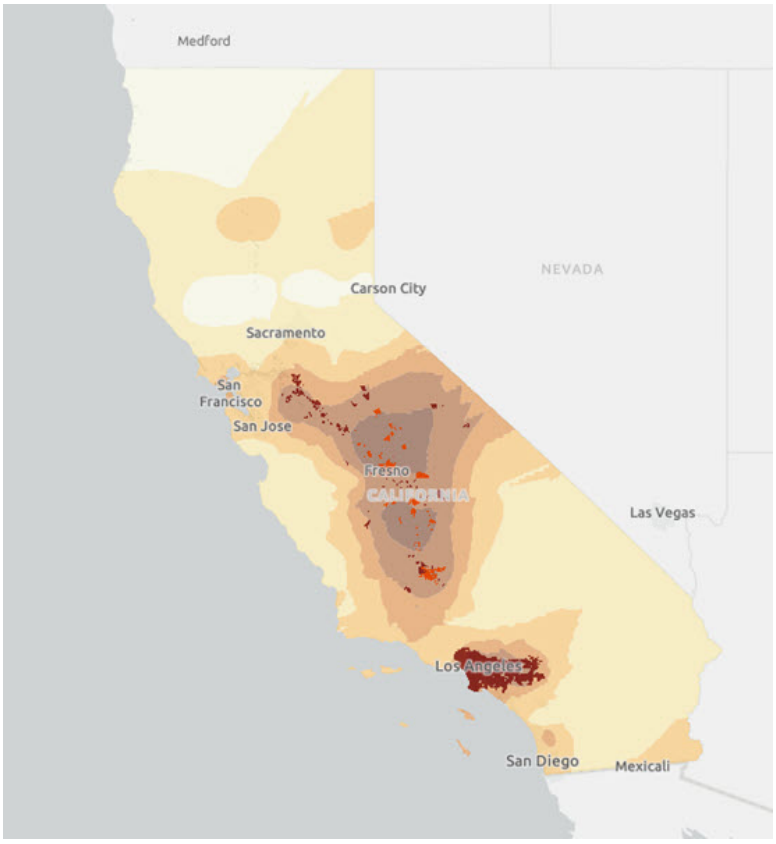
Certain populations, such as people over the age 65, are more susceptible to harm from fine particulate matter. The grant-funding agency has commissioned you to perform some environmental analyses and research. They requested a report that shows populations living in areas where exposure exceeds state and federal standards for ambient air quality. Your map must show locations with higher particulate matter exposure levels, as well as populations of a certain age group.

You will begin the spatial analysis approach by asking questions.

Where are people more exposed to air pollution in California?

What information do you need to answer this question? How can you use GIS to represent, analyze, and assess the criteria?

- Which areas have particulate matter levels exceeding state regulation values?
- Which areas have particulate matter levels exceeding federal regulation values?
- Where are the areas that have higher particulate matter levels and have high populations of people over the age of 65?



Note: This example provides a start point. In the real world, an analysis like this would likely involve more factors and criteria.

Technical notes

1. You will make full use of web mapping services throughout this course. You will need a robust web connection to complete this exercise.
2. Use the latest version of Google Chrome or Microsoft Edge. Other web browsers may not display your maps and apps correctly.

   Note: For information on supported web browsers, see ArcGIS Online Help: Supported browsers (https://esriurl.com/browsers).

Estimated completion time: Approximately 90-120 minutes

- Step 1: Open the map

Using ArcGIS Online, you will create a map with the provided layers to use for your analysis. For this exercise, the initial map has already been created, showing locations of particulate matter monitoring sites in the state of California. However, before opening the map, you will sign into ArcGIS Online.

a Open a new private or incognito web browser tab or window.

To help prevent confusion between your ArcGIS Online accounts, we recommend that you open a private or incognito web browser window for all course work.

b In your private or incognito web browser window, go to https://www.arcgis.com/home/item.html?id=864777fad8414ace832fc705c36035af (https://esriurl.com/Sec6Map).

c On the top right of the page, click Sign In.

d Sign in to ArcGIS Online using your course ArcGIS credentials.

Note: Section 1, Exercise 1 explains how to determine your course ArcGIS credentials (username and password). If you have trouble signing in, please refer to the Common Questions list on the course Help tab.

e Click the thumbnail image to open the map.

Step 1e: Open the map.

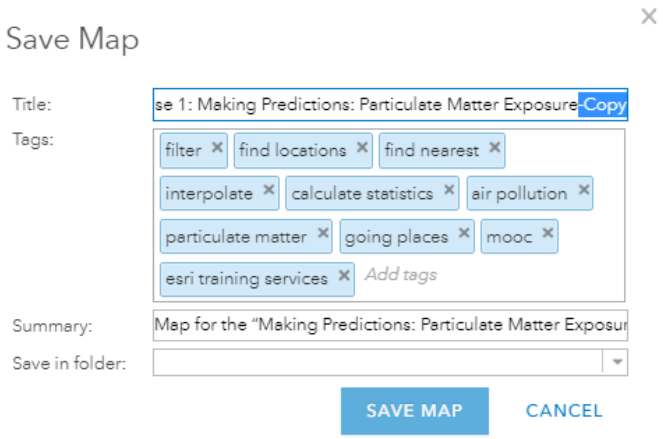
The map opens showing locations of particulate matter monitoring sites in the state of California; the legend is shown for context. The map also shows areas with a population of 200 or more people aged 65 or older.

- Step 2: Save a copy of the map

For the purposes of this exercise, you will save a working copy of the map.

a On the ribbon above the map, click Save and choose Save As.

b In the Save Map dialog box, for Title, replace -Copy at the end of the name with your initials, as indicated in the following graphic.



c Click Save Map.

A copy of the map will be saved to your My Content collection.

Note: ArcGIS Online does not automatically save maps; therefore, you should periodically save your map as you are working.

- Step 3: Select a basemap

The initial map uses the default Topographic basemap. A different basemap would better represent the thematic nature of the map data for this analysis. In this step, you will select a different basemap.

a On the ribbon above the map, click Basemap.

b From the basemap gallery, choose Light Gray Canvas.

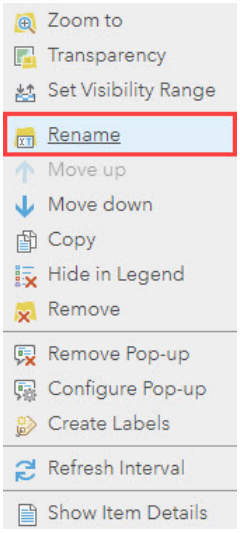
The Light Gray Canvas basemap has a neutral background with minimal colors, labels, and features. It helps draw attention to your thematic content. With this new basemap selected, the features on the map become easier to see.

- Step 4: Change layer names

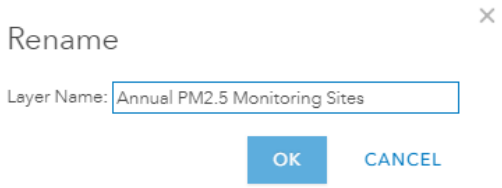
In this step, you will provide more intuitive names for two layers. It is helpful to have layer names that provide meaning for your analysis. You can rename layers to support the intent of your map.

a In the Details pane, click Content to activate the Contents pane.

b In the Contents pane, point to or click the Annual PM25 layer name, click the More Options button ••• , and choose Rename, as indicated in the following graphic.



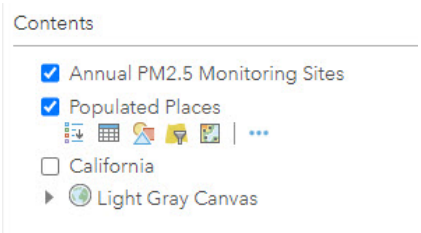
c In the Rename dialog box, type **Annual PM2.5 Monitoring Sites**.



d Click OK.

The new layer name is reflected in the Contents pane.

e Rename the Places layer to **Populated Places**.



Step 4e: Change layer names.

The Populated Places layer already includes concentrations of population, such as cities and towns. The layer used in this analysis is a subset of all populated places in California. For the purposes of this exercise, the data has already been filtered to represent only the places where populations with 200 or more people aged 65 years and older live.

Next, you will change the feature display to create a more visually appealing map.

- Step 5: Change the map style

In this step, you will change the style associated with the air pollution monitoring site features to make them more visible throughout your analysis.

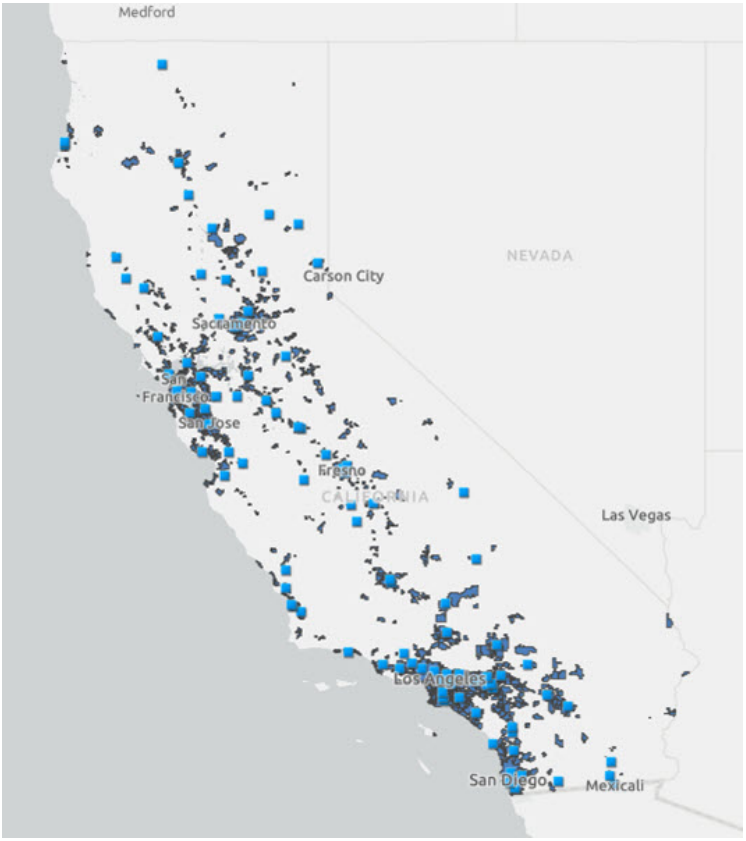
a If necessary, zoom out to see the entire state of California, which represents your study area.

b Change the symbol that shows the location of the monitoring sites to a 16-px blue square.

- Hint

First, try changing the symbol on your own. If needed, the detailed steps are as follows:

- In the Contents pane, point to or click the Annual PM2.5 Monitoring Sites layer name and click the Change Style button .
- In the Change Style pane, for Choose An Attribute To Show, confirm that Show Location Only is selected.
- For Select A Drawing Style, under Location (Single Symbol), click Options.
- Click Symbols.
- In the Change Symbols window, for Shape, select the blue square.
- Change Symbol Size to 16 px.
- Click OK to close the Change Symbols window.
- In the Change Style pane, click OK, and then click Done.



Step 5b: Change the map style.

The map display updates to show the locations of particulate matter monitoring sites, as symbolized by blue squares. The monitoring sites tend to be located in areas where people live. This result is expected because the purpose of the sites is to monitor air pollution exposure.

- Step 6: Create a choropleth map

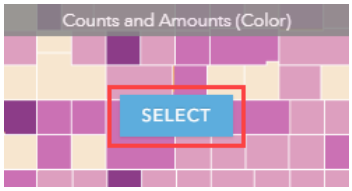
Choropleth maps can reveal data patterns, showing the distribution of a phenomenon within a selected area. Exploring the distribution of population across the state will highlight more and less populated areas.

In this step, you will use graduated colors to represent the range of population as choropleth. Remember that the range of population is contextual information that may help you interpret the results of your analysis.

a In the Contents pane, point to or click the Populated Places layer name, and click the Change Style button .

b In the Change Style pane, for Choose An Attribute To Show, choose Population.

c For Select A Drawing Style, under Counts And Amounts (Color), click Select, as indicated in the following graphic.



The Counts And Amounts (Color) drawing style uses a color gradient to represent numerical data.

d Click Options.

e For Divided By, choose AreaSqMiles.

This choropleth map shows population normalized by area, or population density. To turn the raw population data into population density, you can normalize by choosing either AreaSqMiles or AreaSqKm.

Note: Totals should never be mapped by area; they should always be normalized.

f For Theme, confirm that High To Low is selected.

To show color ranges based on value, you will use a grayscale color ramp.

Note: Again, the population range is contextual information, so the choice of a grayscale color ramp will help emphasize the most important part of the map: the PM2.5 values.

g Click Symbols.

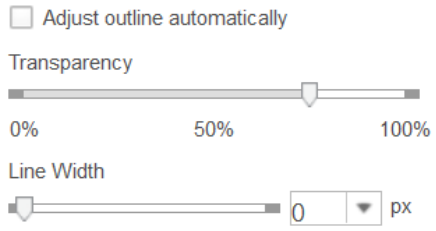
h In the Change Symbols window, click the Fill tab, if necessary.

i Scroll down and choose the grayscale color ramp, as indicated in the following graphic.

j Click the Outline tab and accept the default Outline Color.

k Uncheck the box for Adjust Outline Automatically.

l For Line Width, set the value to 0 px so that you can see the gray values represented.



Step 6l: Create a choropleth map.

m Click OK to close the Change Symbols window.

To further generalize your map, you will first classify the data using the default, Natural Breaks classification method. This method is useful for grouping similar values to maximize the differences between the classes.

n In the Change Style pane, check the Classify Data box.

o Classify using Natural Breaks with 5 classes.

p Examine the visualization in the map and corresponding legend.

q Adjust the class breaks manually to understand the distribution of the data.

Notice how the classification method has now switched from Natural Breaks to Manual Breaks.

r Change the classification method to Natural Breaks or adjust the the classes manually until you are satisfied with the visualization.

s For Transparency, move the slider to approximately 50%.

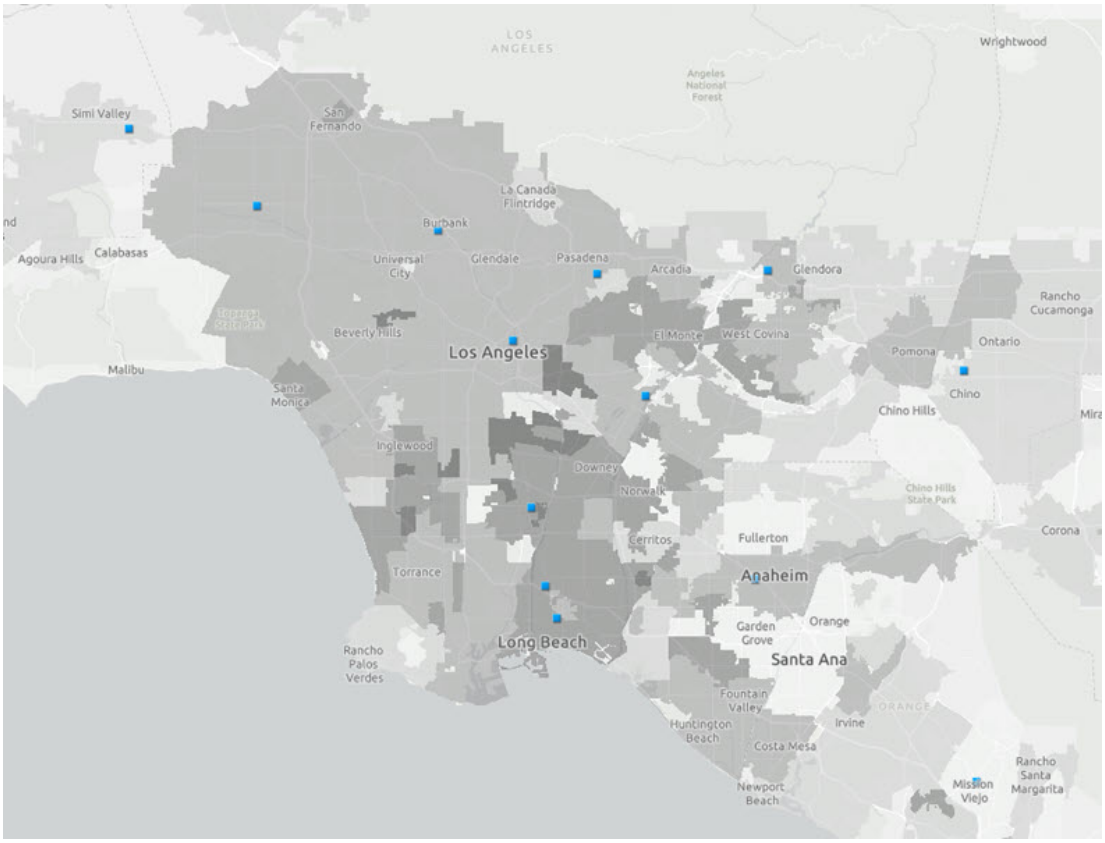
t Click OK, and then click Done.

The map display updates, and places are now represented in shades of gray, from light to dark, indicating population density.

Note: With the map zoomed out, it may be difficult to see the areas.

u Zoom in to the Los Angeles area to see the more densely populated areas clearly.

v Click Legend.



Step 6v: Create a choropleth map.

The choropleth map shows graduated colors representing population normalized by square miles for places where 200 or more people aged 65 and older live.

Researchers have found that the biggest impact of particulate air pollution on public health comes from long-term exposure to PM2.5. Long-term exposure increases age-specific mortality risk, particularly from cardiovascular causes. Identifying areas with large populations of people 65 years and older will help identify where cardiopulmonary rehabilitation centers should be established. Therefore, you want to determine how many areas in California have 200 or more people aged 65 years and older living nearby, and also have monitoring sites.

You can see that most places with populations in this age group have a monitoring site nearby. But how can you quantify that observation? Using spatial analysis, of course! Next, you will determine how many of these populated areas (places) have monitoring sites located nearby.

- Step 7: Examine the data

Before performing your analysis, you will first want to understand the data. In this step, you will examine the attribute data for the layers in the map.

a Click Content.

b Open the attribute table for the Annual PM2.5 Monitoring Sites layer.

- Hint

  Point to or click the layer name and click the Show Table button .

Annual PM2.5 Monitoring Sites (Features: 98, Selected: 0)

OBSERVATIONS	LOCATION	ADDRESS	CITY	COUNTY	YEARLYAVG	MAX	AVG_AQI
101	Chula Vista	80 E. 'J' ST., CHULA VISTA	Chula Vista	San Diego	9.59	22.70	38.61
195	CALEXICO HIGH SCHOOL ARB (#1300698)	1029 ETHEL ST, CALEXICO HIGH SCHOOL	Calexico	Imperial	12.92	50.90	48.17
320	San Diego - Downtown	1110 BEARDSLEY STREET, SAN DIEGO. CA 92112	San Diego	San Diego	10.43	29.70	41.39

Step 7b: Examine the data.

According to the attribute table, there are 98 particulate monitoring sites in the state. The table includes each site's location, address, yearly average particulate matter exposure, maximum PM2.5 exposure reading, and average reading for Air Quality Index (https://esriurl.com/AQI), or AQI.

Next, you will examine the data for the Populated Places layer.

c Close the attribute table for the Annual PM2.5 Monitoring Sites layer.

d Open the attribute table to examine the Populated Places layer; continue to scroll all the way to the right.

According to the attribute table, there are 929 places (cities, towns, villages, or boroughs) in the state where there are 200 or more people who are 65 years and older. The table includes each place's unique geographic identifier, total population, and population demographics, including the number of residents 65 years and older.

To confirm that the data only includes those places where there are 200 or more people who are 65 years and older, you can sort the values in the Pop65AndOlder column.

e Sort the Pop65AndOlder column in ascending order.

- Hint

  Click the column heading and choose Sort Ascending.

The lowest number in the field is 201. This result confirms that the Populated Places layer contains the data that you need, only areas with 200 or more residents aged 65 years and older. You want to use all the values in the table because they all meet the criterion.

f Close the attribute table.

- Step 8: Find locations with monitoring sites

As part of your analysis, you want to find out how many PM2.5 monitoring sites are located in areas with a population of 200 or more people aged 65 years and older. In this step, you will select features in the Annual PM2.5 Monitoring Sites layer that meet the population criteria.

a In the Contents pane, point to or click the Annual PM2.5 Monitoring Sites layer name and click the Perform Analysis button .

b Expand Find Locations, and then click Find Existing Locations.

The Find Existing Locations tool selects existing features in your study area that meet a series of criteria you specify.

c In the Find Existing Locations pane, create an expression to find populated places that have monitoring sites.

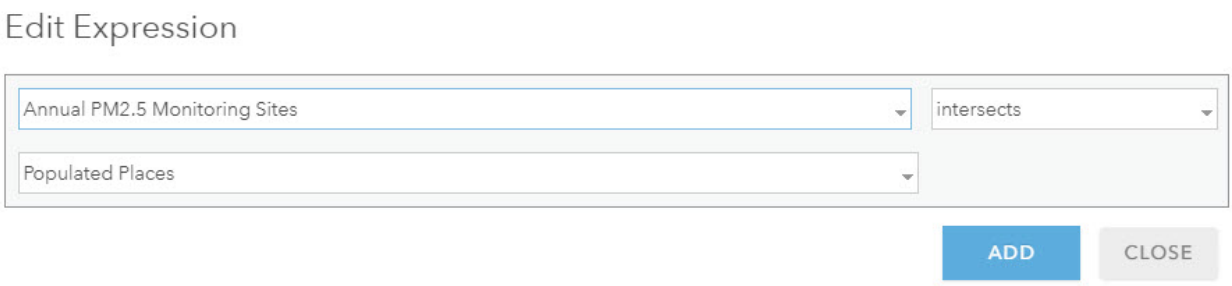
- Hint

First, try creating the expression on your own. If needed, the detailed steps are as follows:

- For Choose Layer Containing Features You Want To Find Using Attribute And Spatial Queries, confirm that Annual PM2.5 Monitoring Sites is selected.
- Click Add Expression.
- For the first field, confirm that Annual PM2.5 Monitoring Sites is selected.
- For the second field, choose Intersects as the spatial expression type.

Note: In an intersect, if a feature in the first layer intersects a feature in the second layer, the feature in the first layer is included in the output. A feature in the first layer passes the intersect test if it overlaps any part of a feature in the second layer, including touches (where features share a common point).

- For the third field, confirm that Populated Places is selected.



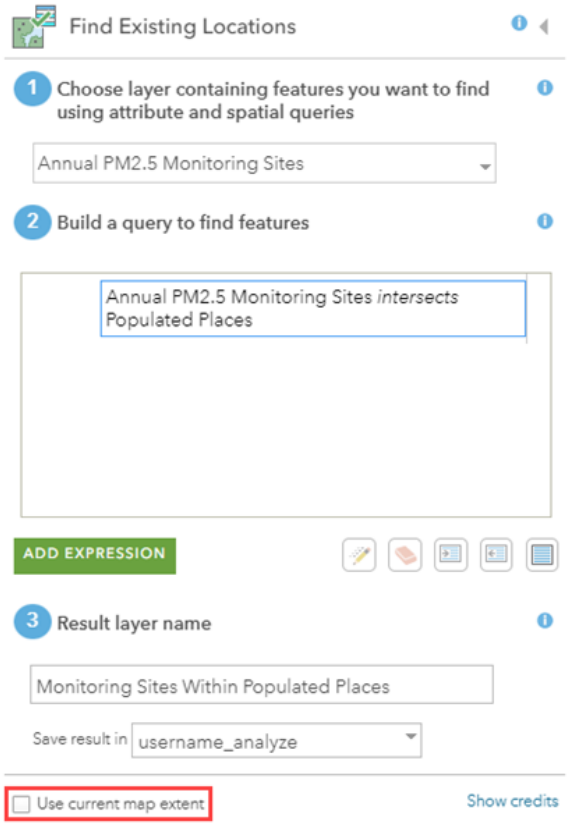
- Click Add to add the expression to the Find Existing Locations pane.

For Result Layer Name, type **Monitoring Sites within Populated Places_<your first and last name>**.

Note: If you run the analysis multiple times, you will need to provide a unique result layer name each time.

The Save Result In field defaults to your account name; you do not need to change this value.

d At the bottom of the Find Existing Locations pane, uncheck the box for Use Current Map Extent, as indicated in the following graphic.

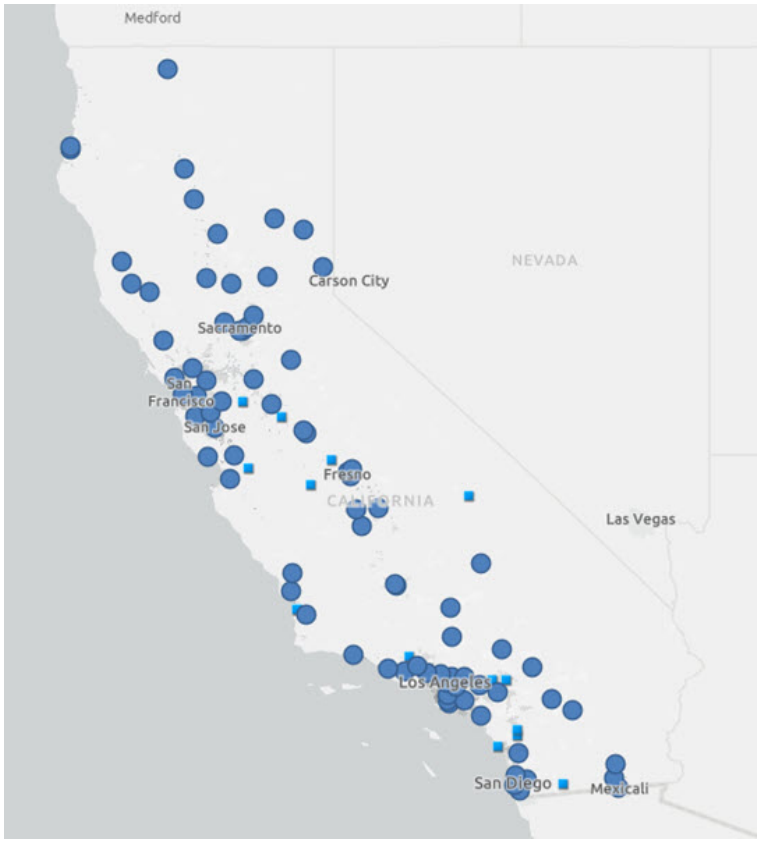


For this analysis, the study area is the entire state of California. You want to run the analysis on all the records in the Annual PM2.5 Monitoring Sites layer—not just what is currently displayed.

e Click Run Analysis.

Note: If your analysis is not complete after 4 minutes, try saving the map and refreshing the page. You can also exit ArcGIS Online and try again later.

f Zoom out to view the entire state of California.



Step 8f: Find locations with monitoring sites.

The map display updates to show monitoring sites in places that have a population of 200 or more people who are aged 65 years or older. The locations are symbolized with blue circles by default.

g Save your map.

- Step 9: Examine attribute data

In this step, you will review the result data. If you recall, the original dataset had 98 monitoring sites. You can now identify how many of those sites are located within populated places by examining the result layer data.

a Open the attribute table for the Monitoring Sites Within Populated Places layer.

b Scroll through the table and examine the data.

Monitoring Sites within Populated Places (Features: 81, Selected: 0)

OBSERVATIONS	LOCATION	ADDRESS	CITY	COUNTY	YEARLYAVG	MAX	AVG_AQI
101	Chula Vista	80 E. 'J' ST., CHULA VISTA	Chula Vista	San Diego	9.59	22.70	38.61
195	CALEXICO HIGH SCHOOL ARB (#1300698)	1029 ETHEL ST, CALEXICO HIGH SCHOOL	Calexico	Imperial	12.92	50.90	48.17
320	San Diego - Downtown	1110 BEARDSLEY STREET, SAN DIEGO, CA 92112	San Diego	San Diego	10.43	29.70	41.39
116	El Cajon	1155 REDWOOD AVE., EL	El Cajon	San Diego	10.84	27.70	42.97

Step 9b: Examine attribute data.

The analysis shows that there are 81 monitoring sites located in populated areas with 200 or more people classified as 65 years or older.

A quick calculation (81 divided by 98 total monitoring sites and then multiplied by 100) shows that approximately 83 percent of the monitoring sites are located in areas that have 200 or more people aged 65 years or older. This calculation helps you feel confident that coverage is typically good across the state.

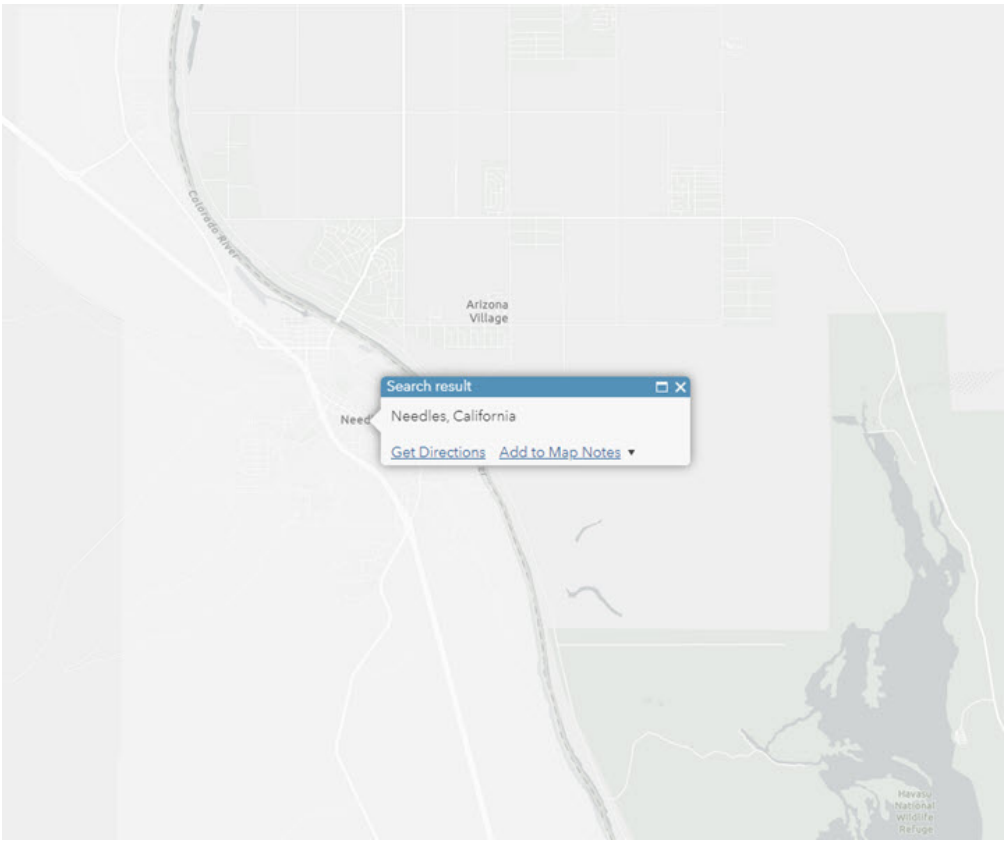
c Close the attribute table.

- Step 10: Perform a visual assessment

In this step, you will visually analyze the locations of the monitoring sites throughout the state. By gaining a visual understanding of the range of distances from populated places to the nearest monitoring site, you will be better prepared to interpret the results of later analysis steps.

You can see that most monitoring sites are located near populated places. If you zoom and pan the map, a few sites appear to be farther away from their nearest city or town.

a Above the map display, in the Find Address Or Place field, type **Needles, CA** and press Enter.



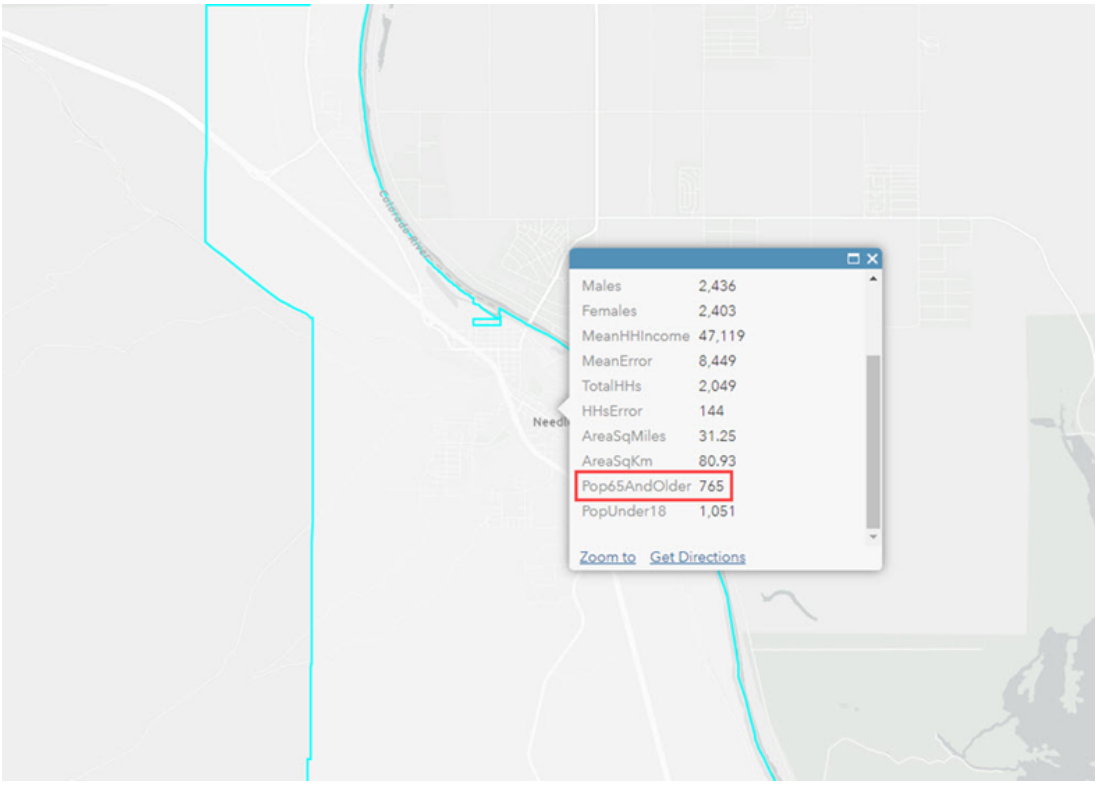
Step 10a: Perform a visual assessment.

Needles is a small town in the southeastern part of the state near the border of California and Arizona that appears to be some distance from the nearest monitoring site.

b Close the Search Result pop-up window.

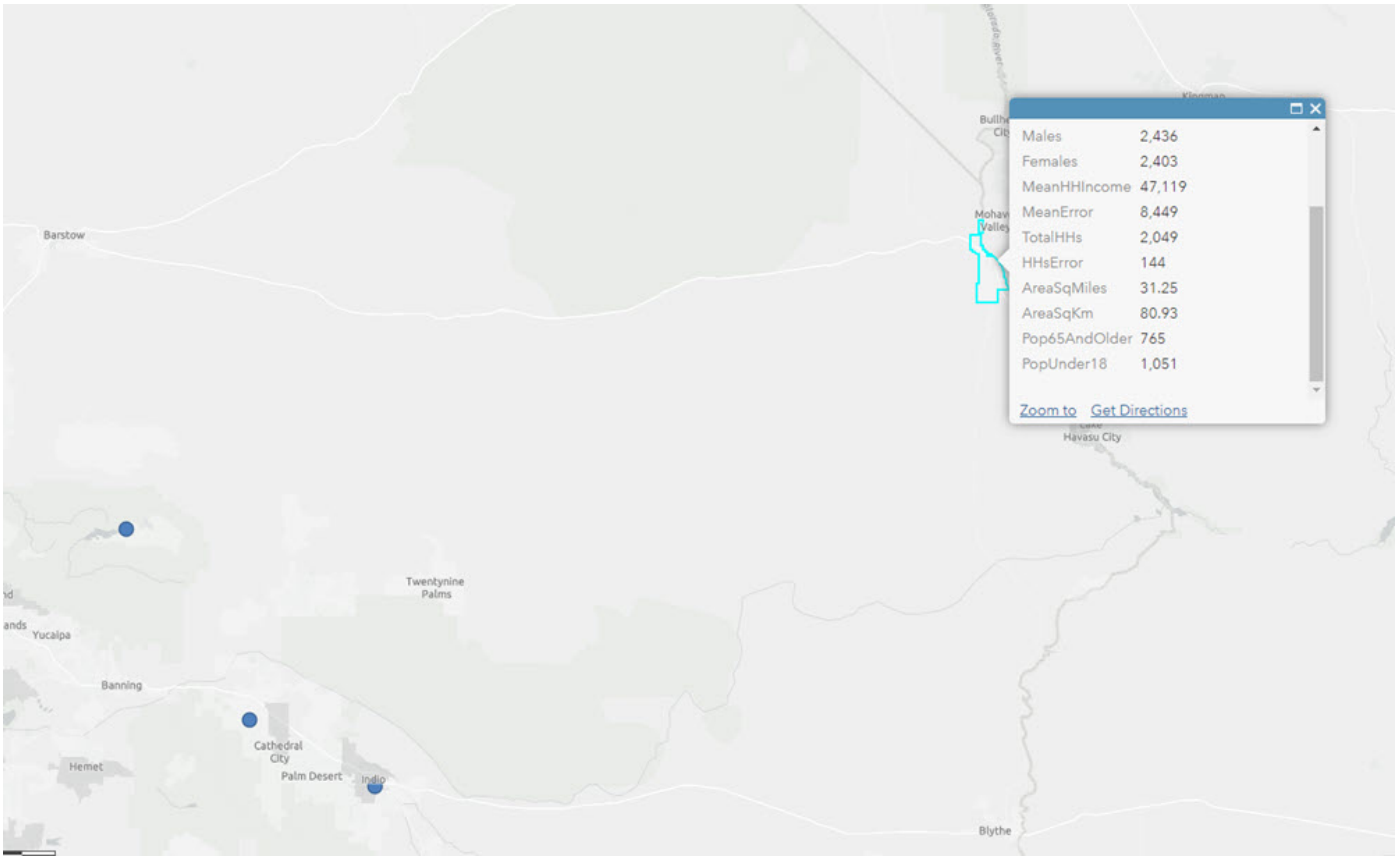
c Click the city name to view an information pop-up window.

The information pop-up window includes the number of people living in the area who are identified as 65 years or older, as indicated in the following graphic.



Note: If you close the information pop-up window, the city of Needles will no longer be selected on the map.

d Zoom out until you see the locations of nearby monitoring sites to the west (about four or five clicks using the Zoom Out button — on the map display).



Step 10d: Perform a visual assessment.

There are several monitoring sites located approximately the same distance from Needles. Next, you will measure the distance from the city to a monitoring site.

- Step 11: Measure distance

After noticing that Needles, California, is relatively far from any monitoring site, you want to know the approximate distance of that city to the nearest monitoring site. In this step, you will measure the distance between two features on the map.

a On the ribbon above the map, click Measure .

Note: The information pop-up window is automatically closed.

You will use the ArcGIS Online Measure tool to measure the distance from the city to a monitoring site.

b In the Find Area, Length, Or Location window, click the Distance button .

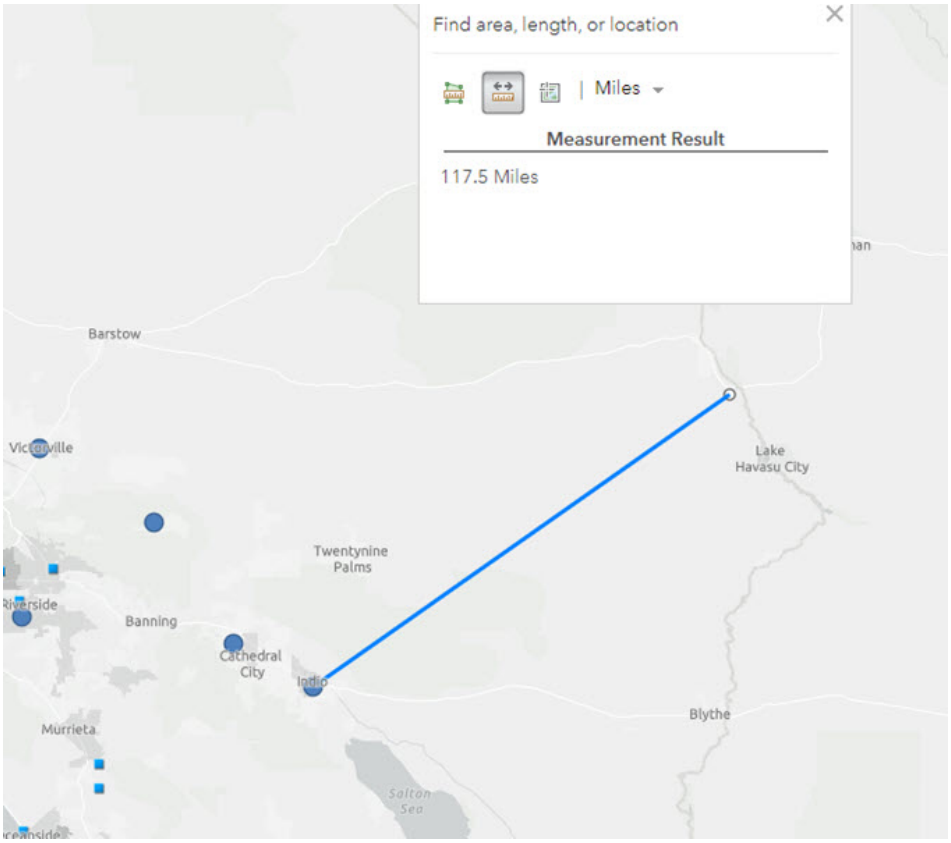
The default unit of measurement is Miles.

c Click the map once on the approximate location of the city of Needles, California (near the eastern border of California, just north of Lake Havasu City, Arizona).

A small circle appears, along with a blue line that represents the distance measurement.

d Double-click the blue monitoring site circle that looks as if it is nearest to the city of Needles, California.

Note: You may need to pan the map to see the monitoring sites.



Step 11d: Measure distance.

The distance in miles is displayed in the Measurement Result area of the Find Area, Length, Or Location window.

The measurement is not exact; depending on which part of the area that you clicked, the result may vary by a few miles. Most measurements will be between 112 and 120 miles from the populated area to the nearest monitoring site. This measurement gives you a general idea of the distance for one of the sites. However, you want to identify how close the nearest monitoring site is to each populated place in the study area. Manually measuring each of these distances would be tedious.

e Close the Find Area, Length, Or Location window.

f Zoom out so that you can see all of California.

Distance is an important piece of information. You can determine the distance between geographic features on a map using proximity analysis. You decide to use distance measurements to identify the closest monitoring site to each populated place included in your study.

Reporting the single closest monitoring site measurement for each populated place will not give you a complete picture of PM2.5 exposure. However, it will help you start to understand where exposed populations are located.

- Step 12: Find the nearest feature

Next, you will locate the nearest monitoring site to each place.

ArcGIS Online provides a set of tools that help you answer one of the most common questions posed in spatial analysis: What is near what?

a In the Contents pane, turn off the Annual PM2.5 Monitoring Sites layer.

b Turn off the Monitoring Sites Within Populated Places layer.

c Point to or click the Populated Places layer name and click the Perform Analysis button .

d Expand Use Proximity.

You will use the ArcGIS Online Find Nearest tool to find the nearest monitoring site to each place that meets the population criterion. The Find Nearest tool finds the nearest features and reports and ranks the distance to the nearby features. It returns a layer containing the nearest features and a line layer that links the start locations to their nearest locations. The line layer contains information about the start and nearest locations and the distances between.

e Click Find Nearest.

f In the Find Nearest pane, for Specify The Starting Locations, choose Populated Places, if necessary.

g For Find The Nearest Locations In, choose Annual PM2.5 Monitoring Sites.

h For Measure, accept the default Line Distance.

You only want to find the nearest monitoring site and one value (air pollution), so you want to find the one site closest to each place.

i For Limit The Number Of Nearest Locations To, accept the default of 1.

j For Limit The Search Range To, update the value to **120** Miles.

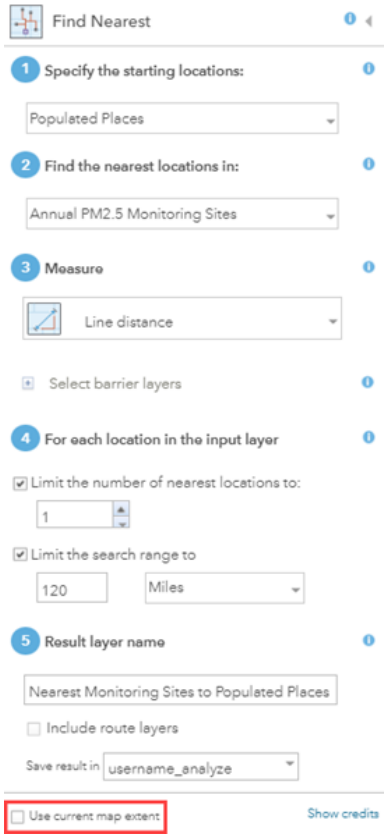
Based on your visual assessment and measurement examples, you decide to slightly increase the search range. This increase will likely ensure that your results include all the monitoring sites from your original dataset.

k For Result Layer Name, type **Nearest Monitoring Sites to Populated Places_<your first and last name>**.

Note: If you run the analysis multiple times, you will need to provide a unique result layer name each time.

The Save Result In field defaults to your account name; you do not need to change this value.

l At the bottom of the Find Nearest pane, uncheck the box for Use Current Map Extent, as indicated in the following graphic.



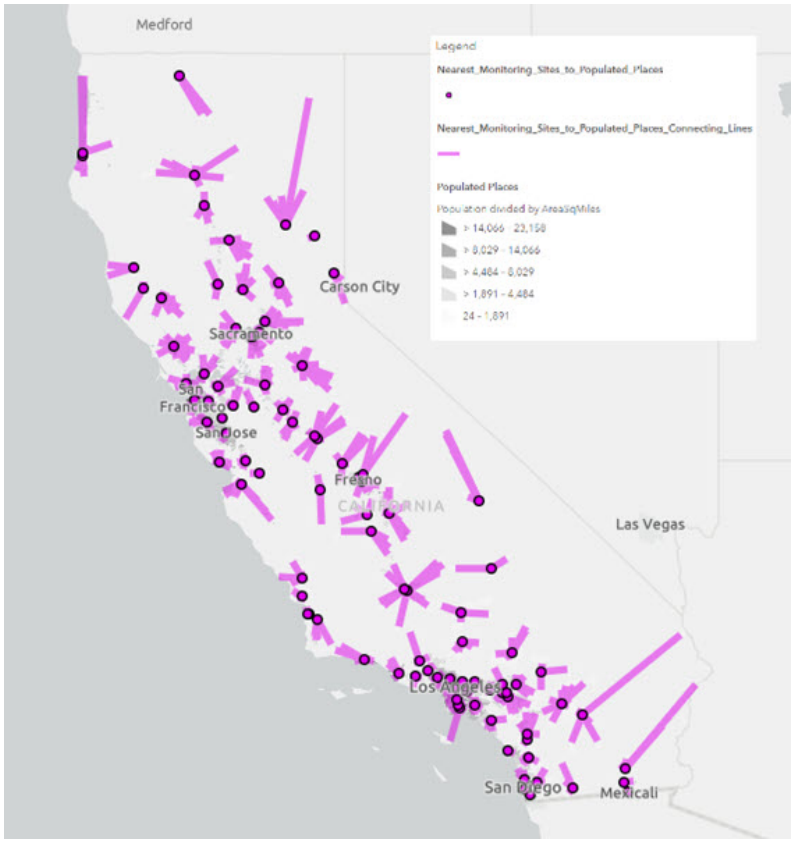
For this analysis, the study area is the entire state of California. You want to run the analysis on all the records in the Populated Places layer, not just what is currently displayed.

m Click Run Analysis.

Note: If your analysis is not complete after 4 minutes, try saving the map and refreshing the page. You can also exit ArcGIS Online and try again later.

The map display updates, and the result shows connecting lines from the monitoring site to places. In the Contents pane, two results layers appear: one representing the nearest monitoring sites and the other representing the connecting lines from the monitoring sites to the places that are nearest to them.

n View the map legend.



Step 12n: Find the nearest feature.

- Zoom in to the area near San Francisco.

Step 12o: Find the nearest feature.

- Save your map.

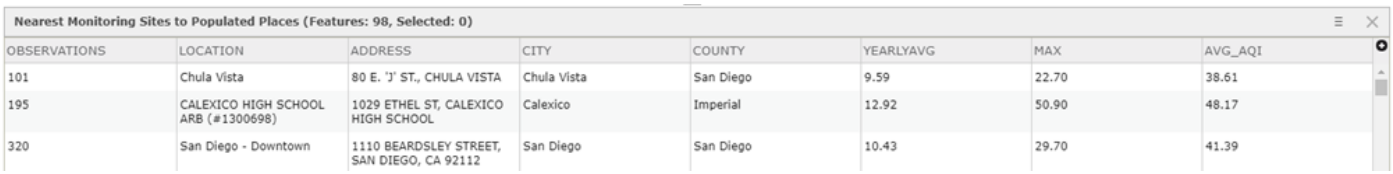
The connecting lines are drawn from the monitoring site point feature to the edge of the nearest Populated Places features.

- Step 13: Examine the data

It is important to verify that the number of features in the result layer table matches the number of input features. In the original analysis, there were 98 features representing the monitoring sites.

In this step, you will look at the result layer table to confirm that the number of features in both layers matches.

a Open the attribute table for the Nearest Monitoring Sites To Populated Places - Nearest Features layer.



Nearest Monitoring Sites to Populated Places (Features: 98, Selected: 0)

OBSERVATIONS	LOCATION	ADDRESS	CITY	COUNTY	YEARLYAVG	MAX	AVG_AQI
101	Chula Vista	80 E. 'J' ST., CHULA VISTA	Chula Vista	San Diego	9.59	22.70	38.61
195	CALEXICO HIGH SCHOOL ARB (#1300698)	1029 ETHEL ST, CALEXICO HIGH SCHOOL	Calexico	Imperial	12.92	50.90	48.17
320	San Diego - Downtown	1110 BEARDSLEY STREET, SAN DIEGO, CA 92112	San Diego	San Diego	10.43	29.70	41.39

Step 13a: Examine the data.

This data is from the original Annual PM2.5 Monitoring Sites layer. The number of features should be 98.

b Open the attribute table for the Nearest Monitoring Sites To Populated Places - Connecting Lines layer.

Nearest Monitoring Sites To Populated Places - Connecting Lines (Features: 929, Selected: 0)

Near Rank	Straight Line Distance (Miles)	Places: ID	Places: GEOID	Places: Name	Places: Population	Places: Males	Places: Females	Places: MeanHHIncome	Places: MeanError
1	27.14	1	0673108	South Lake Tahoe	21,034	11,105	9,929	55,424	4,073
1	22.38	2	0657540	Placerville	9,788	4,596	5,192	63,441	5,715
1	10.13	3	0683668	Watsonville	50,671	25,196	25,475	58,345	3,512

Step 13b: Examine the data.

The number of features is the same as the number of features in the original Populated Places layer: 929.

c Examine the Straight Line Distance (Miles) field.

d Sort the field in ascending order.

A value of 0 miles indicates that the monitoring site is located in the nearest city.

e Sort the field in descending order.

This analysis shows that the farthest place (Needles) is about 114 miles (183 km) from the nearest monitoring site. Other places clearly contain at least one monitoring site. Some places even have multiple monitoring sites. You now have the range of distance values, from 0 miles to 114 miles.

f Click a row in the table.

g With a row in the table selected, click the Table Options button ☰, and then click Center On Selection to zoom the map to the selected connecting line.

The respective connecting line shows on the map in blue.

Note: Choose a value with greater than 0 distance miles. Those connecting lines with a straight line distance of 0 miles will not show on the map. Because some connecting lines are relatively short, it may be difficult to see when you click the associated row in the table. You may need to zoom or pan the map.

h Close the attribute table.

i Zoom out so that you can see all of California.

You decide that it would be valuable to report how much air pollution is detected at each Populated Place that is within 120 miles of a monitoring site location. This report will provide a rough idea of the importance of the distance from a monitoring site to the populated places features.

- Step 14: Change the map style

You can change the style of the connecting lines to reflect the PM2.5 particulate matter value at each monitoring site and the nearest populated place feature.

In this step, you will change the line feature style to use the width of the lines to represent the particulate matter values.

a In the Contents pane, point to or click the Nearest Monitoring Sites To Populated Places - Connecting Lines layer name and click the Change Style button .

b In the Change Style pane, for Choose An Attribute To Show, choose Annual_PM25: YEARLYAVG.

By default, the drawing style is set to Counts And Amounts (Size). This map style uses an orderable sequence of different sizes to represent your numerical data or ranked categories.

You will change the size and color of the line symbol.

c Click Options.

d In the Change Style pane, click Symbols.

e In the Change Symbols window, choose a medium pink (such as hex color #E600A9) to match the color used for the monitoring sites.

f Click OK.

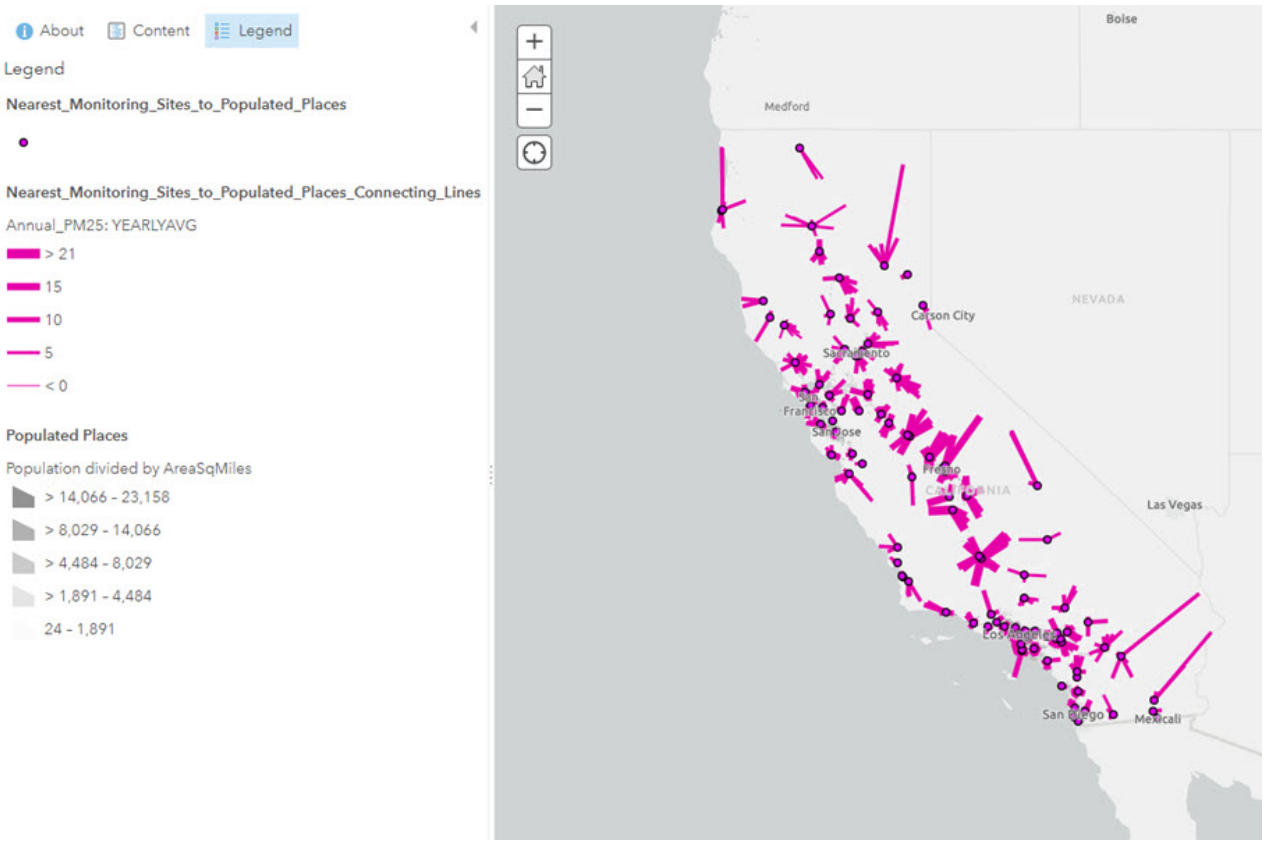
g For Size, set Min to 1 px and Max to 9 px.

Note: You can preview style changes in the map legend preview box.

h Click OK, and then click Done.

The map display updates, and the connecting lines are shown in varying widths representing the pattern of pollution. By simply changing the width of lines based on the PM2.5 value, you can better understand the pattern of annual average PM2.5 pollution in the state.

i View the map legend.



Step 14i: Change the map style.

Your map now shows areas with higher annual average pollution values (represented by thicker connecting lines). It shows areas with lower annual average pollution values (represented by thinner connecting lines). Finally, it shows the distance from the monitoring sites to these places.

j Save your map.

Given the difference between the federal and state regulations, you think that it would be valuable to report results using both PM2.5 standards. Doing so will allow California and other states to see the difference in potentially affected population sizes between the two

standards. Using the value from the nearest monitoring site, you can estimate the population size where the value exceeds relevant standards: the state of California ambient air quality standards for outdoor air (12 µg/m^3) or federal ambient air quality standards (15 µg/m^3).

- Step 15: Filter the data

You would like your report to include a map that shows populations living where exposure exceeds state and federal ambient air quality standards for particulate matter.

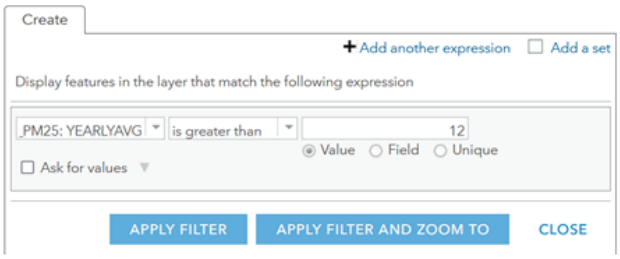
In this step, you will filter the data to identify the populated areas where the annual PM value exceeds 12 micrograms.

a Create a filter to identify the populated places where the annual PM value exceeds the state ambient air quality standard of 12 micrograms.

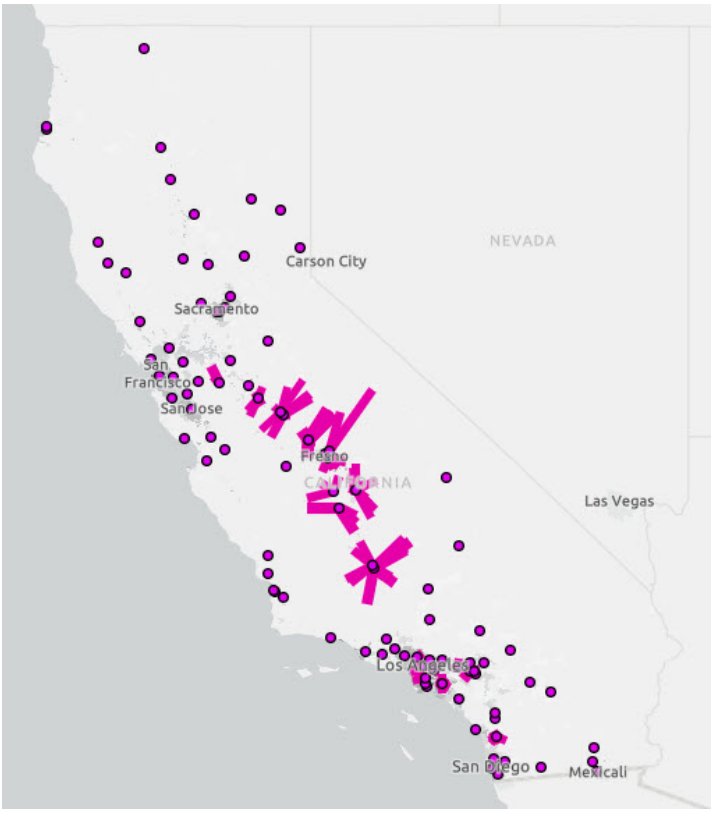
- Hint

First, try creating the filter on your own. If needed, the detailed steps are as follows:

- In the Contents pane, point to or click the Nearest Monitoring Sites To Populated Places - Connecting Lines layer name and click the Filter button .
- In the Filter dialog box, choose Annual_PM25: YEARLYAVG as the field to filter on.
- For the second field, choose Is Greater Than.
- For the third field, type **12**.



- Click Apply Filter.



Step 15a: Filter the data.

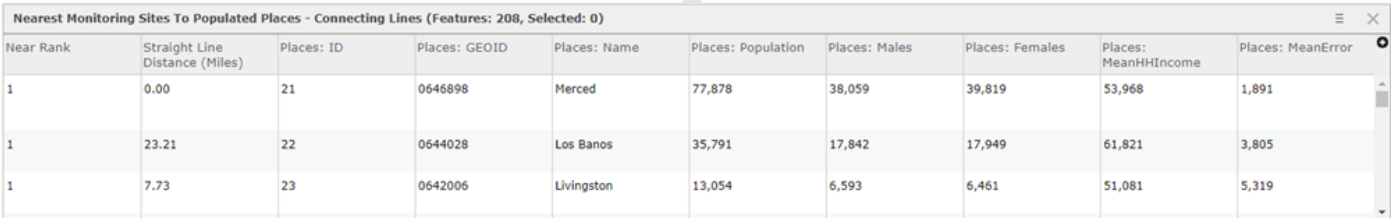
The map display updates. Now, it shows only areas where annual average PM2.5 particulate matter exposure is greater than 12 micrograms (exceeding California ambient air quality standards).

The report should identify how many people are living in places where exposure exceeds state standards. Your next task is to obtain statistics for these results.

- Step 16: Calculate statistics

In this step, you will calculate statistics to identify the total potential exposed population.

a Open the attribute table for the Nearest Monitoring Sites To Populated Places - Connecting Lines layer.



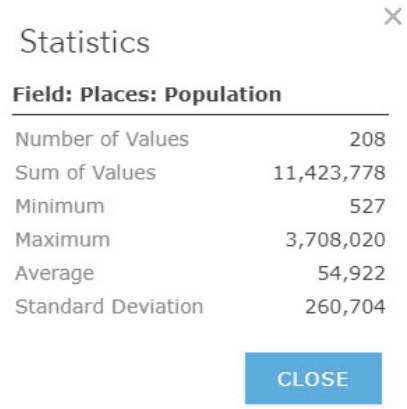
Nearest Monitoring Sites To Populated Places - Connecting Lines (Features: 208, Selected: 0)

Near Rank	Straight Line Distance (Miles)	Places: ID	Places: GEOID	Places: Name	Places: Population	Places: Males	Places: Females	Places: MeanHHIncome	Places: MeanError
1	0.00	21	0646898	Merced	77,878	38,059	39,819	53,968	1,891
1	23.21	22	0644028	Los Banos	35,791	17,842	17,949	61,821	3,805
1	7.73	23	0642006	Livingston	13,054	6,593	6,461	51,081	5,319

Step 16a: Calculate statistics.

There are 208 locations in the state where people are potentially exposed to air pollution greater than state standards.

b Click the Places: Population field heading and choose Statistics.



Statistics

Field: Places: Population

Number of Values	208
Sum of Values	11,423,778
Minimum	527
Maximum	3,708,020
Average	54,922
Standard Deviation	260,704

CLOSE

Step 16b: Calculate statistics.

The sum of values represents the total population in the 208 areas. There are 11,423,778 people living in areas where PM2.5 particulate matter exposure exceeds state-recommended levels.

c Close the Statistics window.

Next, you will check the federal standards so that you can include that information in your report.

- Step 17: Edit a filter

Because you have already created a filter, you simply need to edit it to change the PM value.

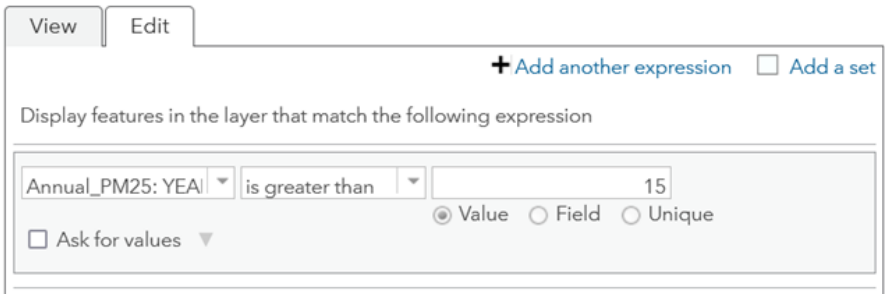
In this step, you will edit a filter to identify the populated areas where the annual PM value exceeds the federal standards of 15 micrograms.

a Edit the filter so that places with an annual PM value that exceeds the federal standards value of 15 are used for the subsequent analysis.

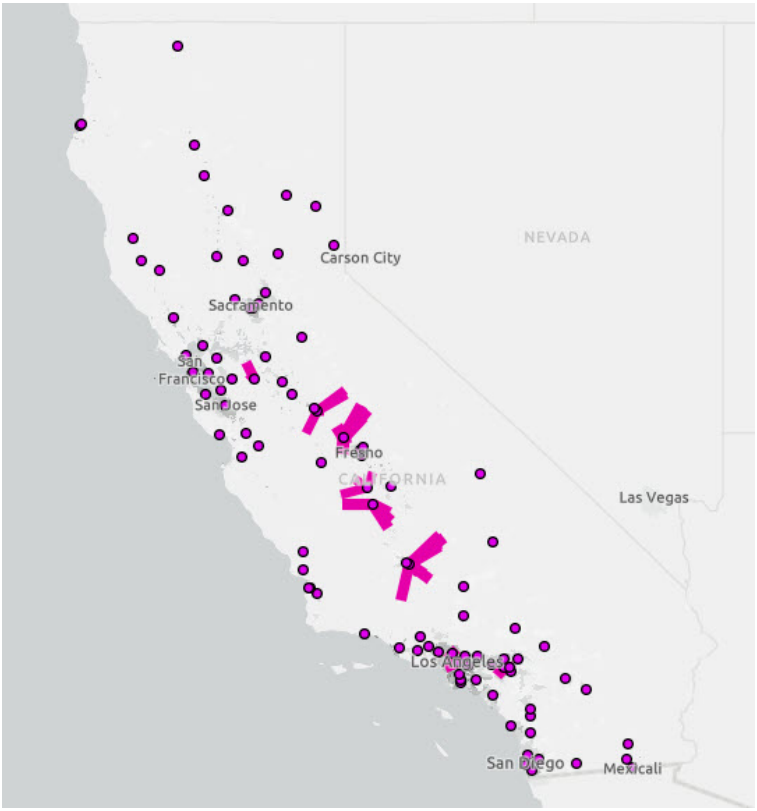
- Hint

First, try editing the filter on your own. If needed, the detailed steps are as follows:

- If necessary, in the Contents pane, point to or click the Nearest Monitoring Sites To Populated Places - Connecting Lines layer name and click the Filter button .
- In the Filter dialog box, click the Edit tab.
- For the third field, type **15**.



- Click Apply Filter.



Step 17a: Edit a filter.

The map display updates. Now, it shows only areas where annual average PM2.5 particulate matter exposure is greater than 15 micrograms (exceeding federal ambient air quality standards).

b Examine the attribute table for the Nearest Monitoring Sites To Populated Places - Connecting Lines layer.

Nearest Monitoring Sites To Populated Places - Connecting Lines (Features: 58, Selected: 0)

Near Rank	Straight Line Distance (Miles)	Places: ID	Places: GEOID	Places: Name	Places: Population	Places: Males	Places: Females	Places: MeanHHIncome	Places: MeanError
1	0.00	21	0646898	Merced	77,878	38,059	39,819	53,968	1,891
1	22.31	25	0619612	Dos Palos	4,922	2,419	2,503	41,234	5,030
1	6.65	48	0641152	Lemoore	24,514	12,199	12,315	69,305	4,479

Step 17b: Edit a filter.

There are 58 locations in the state where people are potentially exposed to air pollution greater than federal standards. The number of places where particulate matter exposure exceeds federal standards is smaller than the number of places that exceed state standards. You would expect that the total population number will also be smaller.

Your report will also identify how many people are living in places where exposure exceeds federal standards. You need to obtain statistics for these results.

- Step 18: Calculate statistics

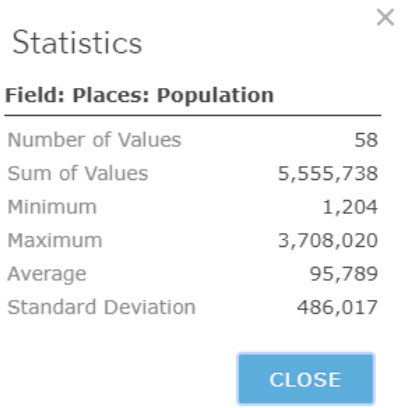
In your report, you want to include the total population living in the areas, as well as the number of people 65 years and older.

In this step, you will calculate statistics to identify the population potentially exposed to particulate matters exceeding federal standards.

a Examine the statistics to determine how many people are living in these areas.

- Hint

  Click the Places: Population field heading and choose Statistics.



Step 18a: Calculate statistics.

There are 58 places with 5,555,738 people living in those areas where PM2.5 particulate matter exposure exceeds the federal standards.

Displaying the population for the places allows you to add more information to the map. You can see the area around Bakersfield and through the middle belt of California where annual average values are highest. However, in these areas, many of the monitoring sites are located some distance from populated places and the population numbers are low. In Los Angeles, there are several monitoring sites; distances to the nearest monitoring site are much shorter and serve larger populations.

This analysis uses the particulate matter value from the nearest monitoring site. This method is a common way of assessing air pollution exposure.

Particulate matter values are only known at sample locations, where monitoring sites are located. Proximity to the nearest site may not be the best estimate of particulate values in another location.

b Close the Statistics window.

c Close the attribute table.

Your concern with the approach of using the nearest monitoring site is based on your knowledge of the sources of PM2.5. You know that it will vary spatially and that Euclidean distance may not be the only factor affecting the distribution. You think that you could use a geostatistical interpolator with the data from the monitoring sites. This method will allow you to use the statistical properties of the measured PM2.5 samples to predict values across the state.

- Step 19: Interpolate values

A different approach

You will use a different approach to try to get a better understanding of true exposure risks using geostatistical interpolation (https://esriurl.com/Interpolation). Because particulate matter is wind-blown, exposure can vary. Simply living in an area with a monitoring site or nearby a monitoring site does not necessarily mean that the exposure rates or levels are perfectly accurate. There are other factors, such as whether you live near heavily traveled roads within your location and which sources of particulate matter are nearby. Consequently, straight line distance is not entirely the best method. Using interpolation, you can create a predicted surface of PM air pollution.

In this step, you will interpolate the particulate values from monitoring sites using the sample point collected values at monitoring sites—the same ones you used for straight line distance.

a In the Contents pane, point to or click the Annual PM2.5 Monitoring Sites layer name and click the Perform Analysis button .

b Expand Analyze Patterns.

The Analyze Patterns tools help you identify, quantify, and visualize spatial patterns in your data. You will use the ArcGIS Online Interpolate Points tool to predict values at new locations based on measurements found in a collection of points. Your analysis will return areas classified

by predicted values.

c Click Interpolate Points.

d In the Interpolate Points pane, for Choose Point Layer Containing Locations With Known Values, confirm that Annual PM2.5 Monitoring Sites is selected.

e For Choose Field To Interpolate, choose YEARLYAVG.

f For Optimize For, move the slider to Speed.

Note: You can optimize for either speed or accuracy. In this case, to save time, you will choose to optimize for speed.

g Check the box for Output Prediction Errors.

Checking this box ensures that a layer of standard errors for the interpolation predictions is created, which is useful because the errors provide information about the reliability of the predicted values.

h Expand Options.

i For Clip Output To, choose California.

Clipping the output ensures that the interpolated surface does not extend beyond the state boundary.

j For Classify By, choose Manual.

You are interested in analyzing people who are potentially being exposed to the higher PM2.5 levels. That information is defined by the state and federal standards (12 and 15 micrograms), so you want those values as break points. The Manual setting will allow you to identify areas that exceed standards.

k For Class Break Values, type **2 4 6 8 10 12 15 20**.

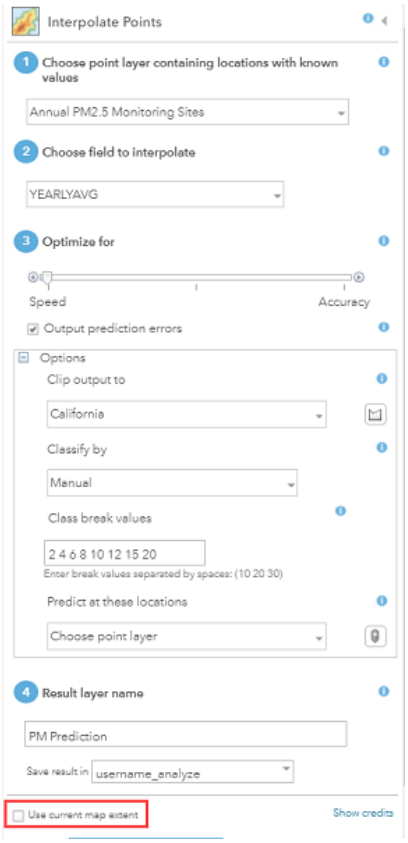
Note: These values should be separated by a space. It is important that values cover all the ranges in your data and include the two values of interest: state and federal exposure limits.

l For Result Layer Name, type **PM Prediction_<your first and last name>**.

Note: If you run the analysis multiple times, you will need to provide a unique result layer name each time.

The Save Result In field defaults to your account name; you do not need to change this value.

m At the bottom of the Interpolate Points pane, uncheck the box for Use Current Map Extent, as indicated in the following graphic.



For this analysis, the study area is the entire state of California. You want to run the analysis on all the records in the Annual PM 2.5 Monitoring Sites layer, not just what is currently displayed.

n Click Run Analysis.

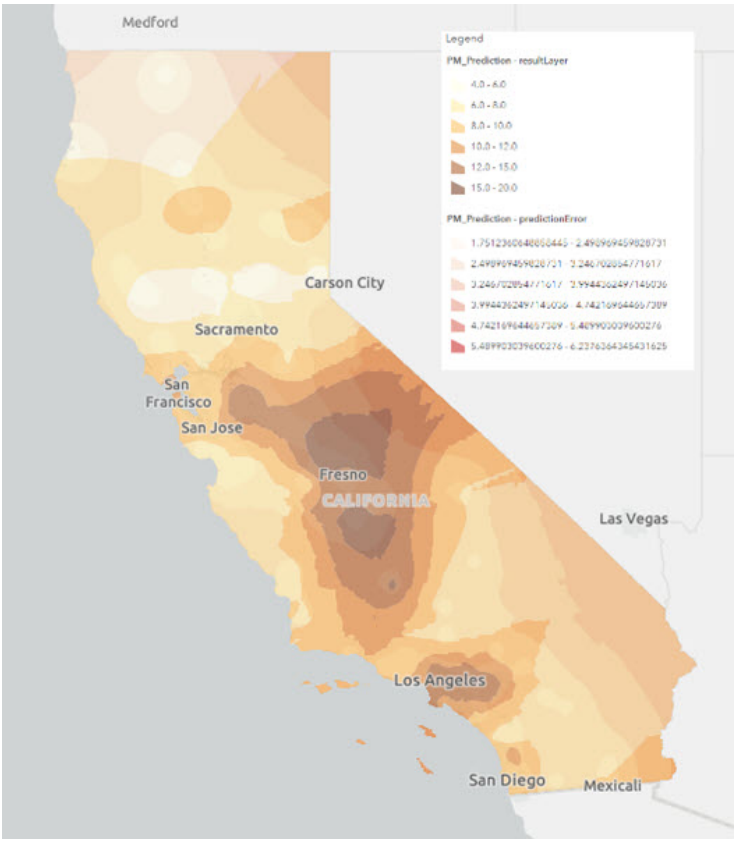
Note: If your analysis is not complete after 4 minutes, try saving the map and refreshing the page. You can also exit ArcGIS Online and try again later.

The map display updates and shows the range of predicted PM exposure values.

o Turn off Nearest Monitoring Sites To Populated Places, Nearest Monitoring Sites To Populated Places - Connecting Lines, and Populated Places layers.

p If necessary, zoom out so that the full study area is visible.

q Click Legend.



Step 19q: Interpolate values.

The map results show the prediction surface with prediction errors in the layer beneath it. Areas with higher predicted exposure values appear in a darker color.

Interpolating the points allows you to clearly see the pattern of PM2.5 levels across the entire area. To view even more information about the prediction, you will look at the prediction errors.

- Step 20: View prediction errors

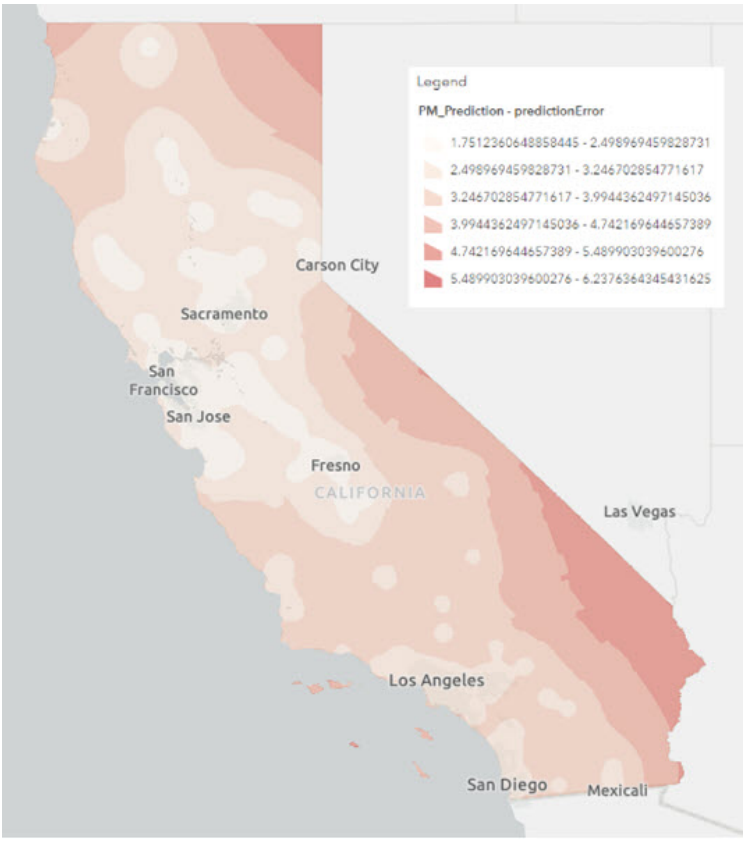
The prediction standard error quantifies the uncertainty of the prediction. Examining the prediction errors can be useful to determine error variance.

In this step, you will view the prediction errors.

a Click Content.

b In the Contents pane, turn off the PM Prediction -resultLayer layer to view the prediction errors.

c Click Legend.



Step 20c: View prediction errors.

The accuracy of each location's prediction can be measured by comparing predicted values to measured values. The map of prediction errors shows the square root of the prediction variance (standard error) associated with the difference between the true and predicted values at each location.

In this map's symbology, lighter-colored areas have a more accurate prediction value at each location (less uncertainty), and red areas have less accuracy (more uncertainty). If you compare this prediction error surface to the monitoring site layer, you can see that areas of lower uncertainty are generally also areas with denser distribution of monitoring sites.

Notice that the greatest errors are in the eastern part of the state, as you would expect because there are fewer monitoring sites. The prediction variability tends to be smaller where measurements are denser and larger where observed data is more sparse. Using this surface will allow others to clearly see areas of higher uncertainty and then better interpret the maps.

d Click Content.

e Turn the PM Prediction - resultLayer layer back on.

f Save your map.

- Step 21: Find existing locations

You want to find places that have predicted PM2.5 values that exceed the state standards of 12 micrograms, followed by areas that exceed the federal standards of 15 micrograms. You will again use location analysis to find the areas that have predicted values that are at or exceed the state and federal standard exposure levels.

In this step, you will focus on the state exposure levels.

a In the Contents pane, point to or click the Populated Places layer name and click the Perform Analysis button .

b Expand Find Locations, and then click Find Existing Locations.

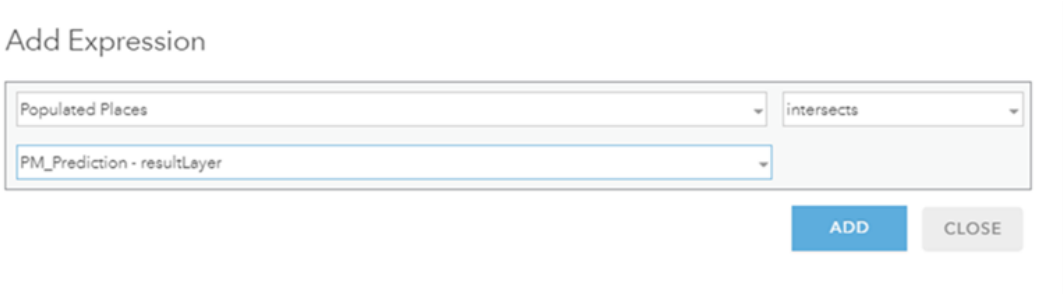
The Find Existing Locations tool can be used for selecting existing features to identify areas that meet the specified criteria.

c Add a spatial query expression to find areas that intersect with the predicted exposure values.

- Hint

First, try creating the spatial query expression on your own. If needed, the detailed steps are as follows:

- For Choose Layer Containing Features You Want To Find Using Attribute And Spatial Queries, confirm that Populated Places is selected.
- Click Add Expression.
- For the first field, choose the Populated Places layer, if necessary.
- For the second field, choose Intersects.
- For the third field, choose the PM_Prediction - resultLayer layer, if necessary.



- Click Add to add the expression to the Find Existing Locations pane.

d Next, add an attribute query expression to select only those areas where the predicted yearly average values are 12 micrograms or greater.

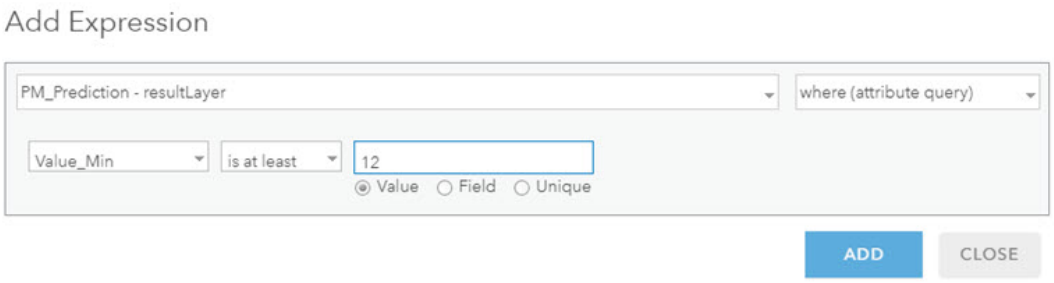
- Hint

First, try creating the attribute query expression on your own. If needed, the detailed steps are as follows:

- Click Add Expression.
- For the first field, choose the PM_Prediction - resultLayer layer.
- For the second field, choose Where (Attribute Query), if necessary.
- For the attribute, choose Value_Min.
- For the fourth field, choose Is At Least.

This setting ensures that the results include areas where exposure levels are 12 micrograms or greater.

- For the fifth field, type **12**.



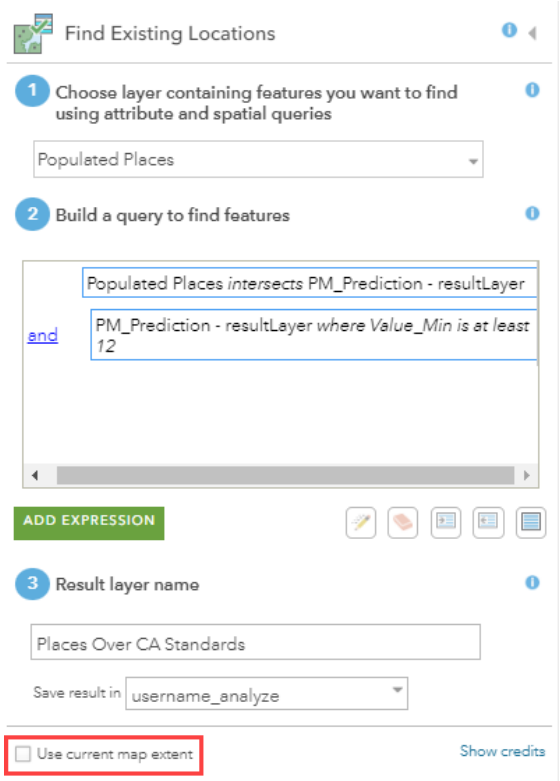
- Click Add to add the expression to the Find Existing Locations pane.

e For Result Layer Name, type **Places Over CA Standards_<your first and last name>**.

Note: If you run the analysis multiple times, you will need to provide a unique result layer name each time.

The Save Result In field defaults to your account name; you do not need to change this value.

f At the bottom of the Find Existing Locations pane, uncheck the box for Use Current Map Extent, as indicated in the following graphic.



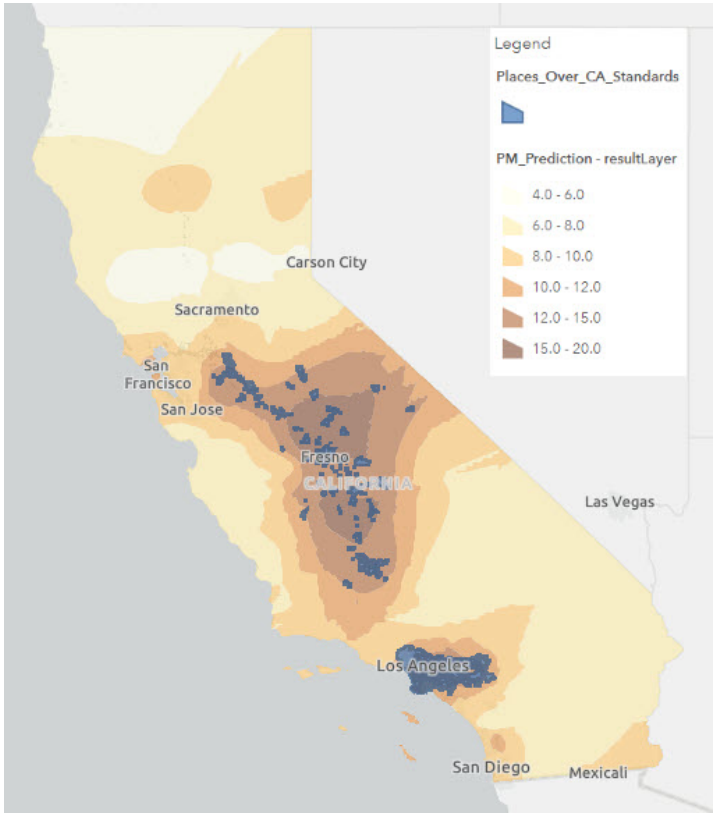
For this analysis, the study area is the entire state of California. You want to run the analysis on all the records in the Populated Places layer, not just what is currently displayed.

g Click Run Analysis.

Note: If your analysis is not complete after 4 minutes, try saving the map and refreshing the page. You can also exit ArcGIS Online and try again later.

h Turn off the PM Prediction - predictionError layer.

i Click Legend.



Step 21i: Find existing locations.

The results show populated areas where there is predicted PM2.5 particulate matter exposure of 12 micrograms per year or greater (exceeding California state standards).

j Zoom and pan the map to examine the results.

As you examine the results, you notice that some of the areas extend beyond the identified exposure range areas (the interpolated values) in the PM Prediction layer. When you are working with population data known for places (as area data), if any part of the area is intersected by the identified exposure range, then the whole place is treated as potentially exposed to that level.

- Step 22: Examine the data

To better understand the results, you will examine the data to view how many locations there are in the study area where exposure levels are predicted to be greater than state standards and how many people live in these areas.

a Click Content.

b Open the attribute table for the new Places Over CA Standards layer.

Places Over CA Standards (Features: 256, Selected: 0)

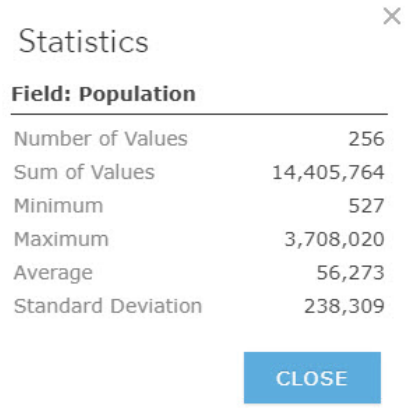
GEOID	NAME	Population
0646898	Merced	77,878
0642006	Livingston	13,054
0603162	Atwater	28,066
0641152	Lemoore	24,514

Step 22b: Examine the data.

There are 256 locations in the study area where exposure levels are predicted to be greater than state standards.

The grant-funding agency will ask certain questions about how many people live in these areas and how many of those people are 65 years and older. Examining statistics will provide the answers.

c In the table, click the Population field heading and choose Statistics.



Step 22c: Examine the data.

According to your initial analysis, the population living in areas with exposure levels greater than California standards is 11,423,778. The total population in the prediction results layer called Places Over CA Standards (14,405,764) varies from your initial analysis, which is expected. You used two different methods of analyses so you would expect there to be a difference in the results.

Note: You can determine the number of people 65 years and older living in these areas by getting statistics from the 65AndOlder field in the table.

d Close the Statistics window.

e Close the attribute table.

f Turn off the Places Over CA Standards layer.

g If necessary, zoom or pan the map so that the entire state of California is visible.

To complete your report, you will repeat this same analysis for the federal values.

- Step 23: Find existing locations

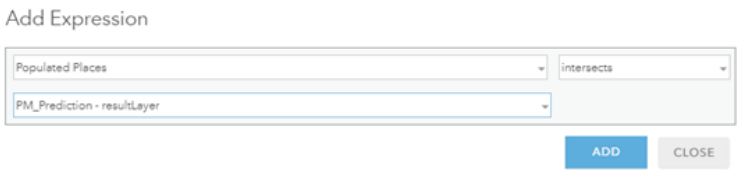
In this step, you will use location analysis to find the areas that have predicted values at or exceeding federal standards.

a Create a spatial query expression to find areas that intersect with the predicted exposure values.

- Hint

First, try creating the spatial query expression on your own. If needed, the detailed steps are as follows:

- In the Contents pane, point to or click the Populated Places layer name and click the Perform Analysis button .
- Expand Find Locations, and then click Find Existing Locations.
- Click Add Expression.
- For the first field, choose the Populated Places layer.
- For the second field, choose Intersects.
- For the third field, choose the PM_Prediction - resultLayer layer.



- Click Add to add the expression to the Find Existing Locations pane.

b Next, add an attribute query expression to select only those areas where the predicted yearly average values are greater than 15 micrograms.

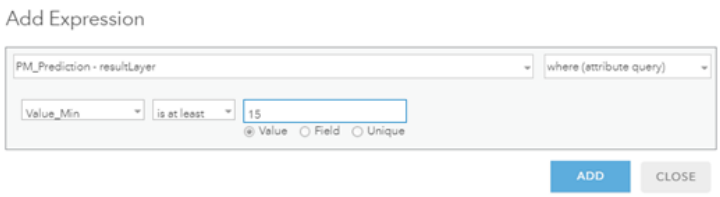
- Hint

First, try creating the attribute query expression on your own. If needed, the detailed steps are as follows:

- Click Add Expression.
- For the first field, choose the PM_Prediction - resultLayer layer.
- For the second field, choose Where (Attribute Query).
- For the attribute, choose Value_Min.
- For the fourth field, choose Is At Least.

This setting will ensure that the results include areas where exposure levels are 15 micrograms or greater.

- For the fifth field, type **15**.

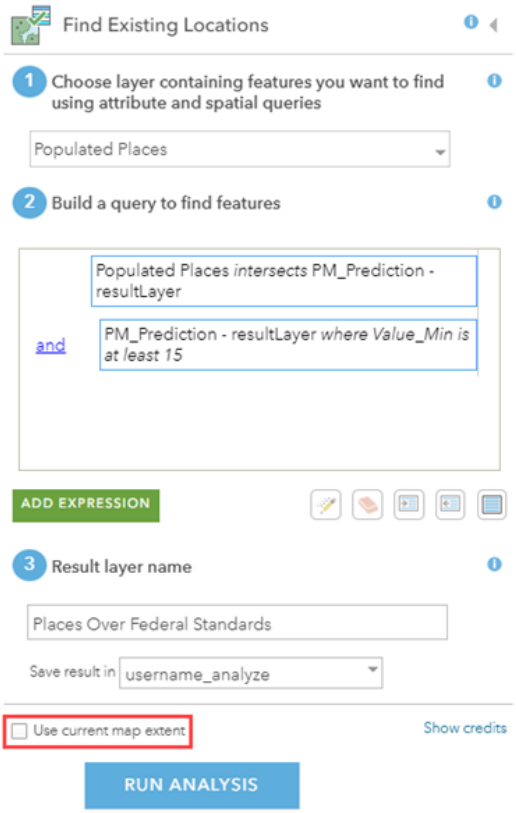


- Click Add to add the expression to the Find Existing Locations pane.

c For Result Layer Name, type **Places Over Federal Standards_<your first and last name>**.

The Save Result In field defaults to your account name; you do not need to change this value.

d At the bottom of the Find Existing Locations pane, uncheck the box for Use Current Map Extent, as indicated in the following graphic.

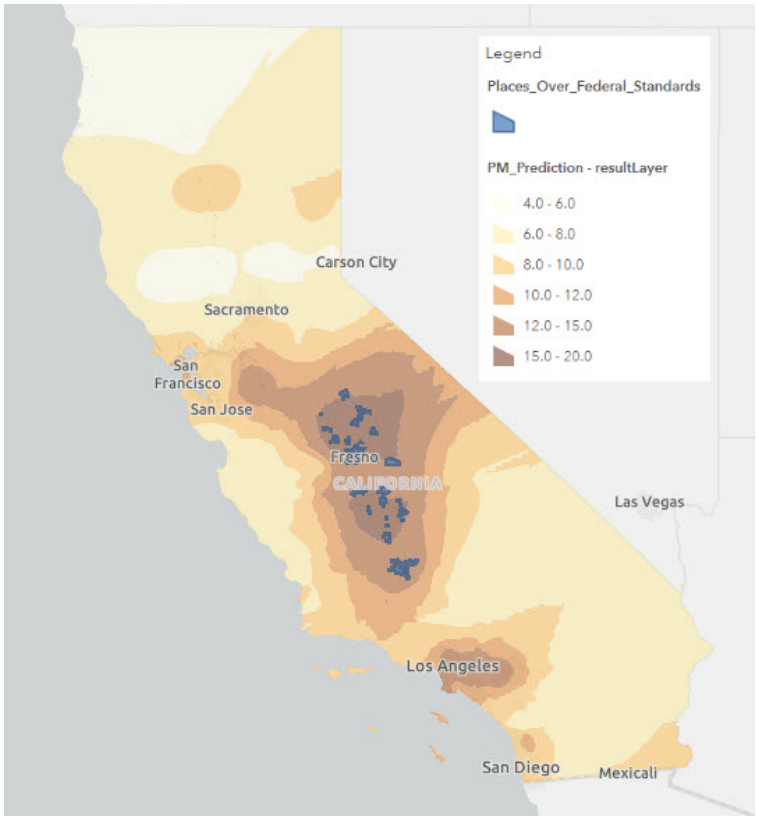


For this analysis, the study area is the entire state of California. You want to run the analysis on all the records in the Populated Places layer, not just what is currently displayed.

e Click Run Analysis.

Note: If your analysis is not complete after 4 minutes, try saving the map and refreshing the page. You can also exit ArcGIS Online and try again later.

f Click Legend.



Step 23f: Find existing locations.

The results show populated areas where there is predicted PM2.5 particulate matter exposure of 15 micrograms per year or greater (exceeding federal standards).

g Zoom and pan the map to examine the results.

Using the interpolated annual average values, you can find the places and estimate the number of people who live where the PM2.5 levels are greater than 12 $\mu g/m^3$ and 15 $\mu g/m^3$. Next, you will identify how many people live in the areas with predicted exposure values exceeding federal standards.

- Step 24: Examine the data

To better understand the results and to obtain the values needed for your report, you will examine the data to identify how many locations in the study area have exposure levels predicted to be greater than federal standards and how many people live in these areas.

a Click Content.

b Open the attribute table for the new Places Over Federal Standards layer.

Places Over Federal Standards (Features: 34, Selected: 0)

GEOID	NAME	Population
0641152	Lemoore	24,514
0631960	Hanford	53,068
0616224	Corcoran	12,573
0682954	Visalia	123,116

Step 24b: Examine the data.

There are 34 locations in the study area where exposure levels are predicted to be greater than federal standards.

To find out how many people live in these areas, you will examine the statistics.

c Open and view the statistics on the population in these areas.

- Hint

In the table, click the Population field heading and choose Statistics.

According to your initial analysis, the population living in areas with exposure levels greater than federal standards is 5,555,738. The total population in the prediction results (1,465,063 people) varies significantly compared to those obtained using the nearest monitoring site.

Using the nearest monitoring site, 58 places have monitored values of more than 15 µg/m^3. On the other hand, when you use interpolation, only 34 features are located in an area with PM2.5 values that exceed 15 µg/m^3.

d Close the Statistics window and close the attribute table.

Now that you have your results for each analysis method, you are able to report your results and provide an explanation for the different values.

Standards for ambient air quality	Nearest monitoring site (first analysis)	Interpolated surface (second analysis)
California standards (12 µg/m^3)	11,423,778	14,405,764
Federal standards (15 µg/m^3)	5,555,738	1,465,063

The potentially exposed population is much greater for federal standards (15 µg/m^3) when taking the PM value from the nearest monitoring site than when using the interpolated values. Many monitoring sites are located where PM values are expected to be high and therefore are being monitored. Background locations, where the PM values will be lower, are less likely to have a nearby monitoring site. The nearest site for many areas where the PM values will be lower will, in fact, be several miles away and located where high values are recorded. The variation in population is more pronounced using the federal standards because the high PM2.5 values occur across a smaller area than the more stringent California standards.

The variation over the area is perhaps better represented using interpolation. Interpolation, however, relies on some monitoring sites being located where background levels are monitored (as in this example). The geostatistical interpolation can use the variation of sampled values to create a predicted surface.

- Step 25: Change the map style

To support your analysis findings, you have two layers that represent predictions for exposure to PM2.5 particulate matter based on state and federal standards. You decide to make changes to create a better visual representation of the results. The default style for the layers uses blue to identify the areas that meet the criteria. In this step, you will change the style of the features for clarity.

a Turn on the Places Over CA Standards layer.

b Change the symbol for the Places Over CA Standards layer to a solid dark red (such as hex color #730000) shape with no outline.

- Hint

First, try changing the feature symbology on your own. If needed, the detailed steps are as follows:

- In the Contents pane, point to or click the Places Over CA Standards layer name and click the Change Style button .
- For Choose An Attribute To Show, confirm that Show Location Only is selected.
- For Select A Drawing Style, under Location (Single Symbol), click Options.
- Click Symbols.
- At the top of the Change Symbols window, click the Fill tab, if necessary.
- Choose a dark red color (such as hex color #730000).
- At the top of the Change Symbols window, click the Outline tab and set the Line Width to 0 px.
- Click OK to close the Change Symbols window.
- In the Change Style pane, click OK, and then click Done.

c Change the symbol for the Places Over Federal Standards layer to a solid orange (such as hex color #FF5500) shape with no outline.

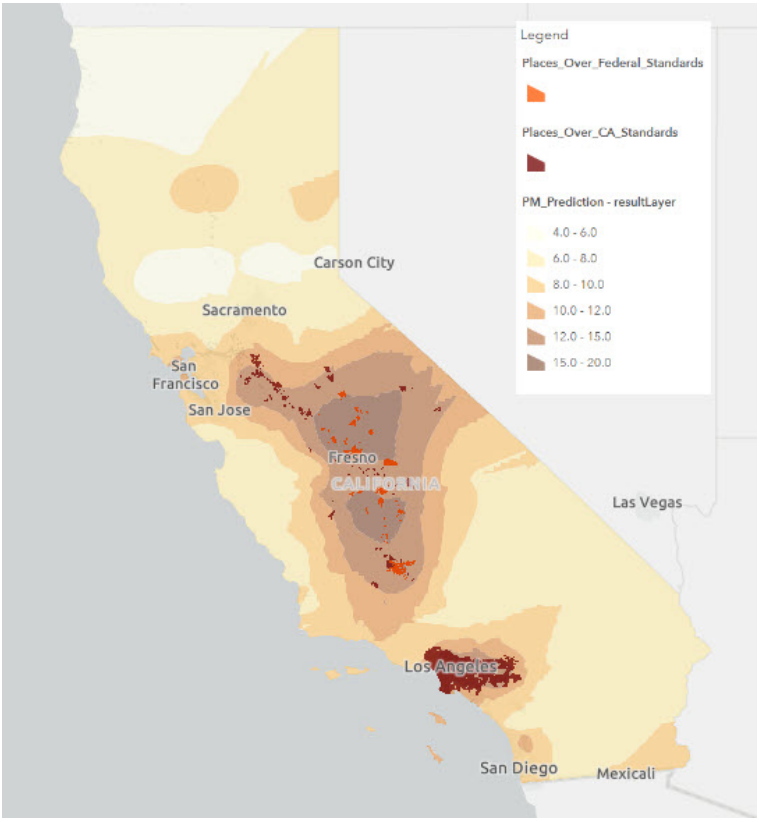
- Hint

Repeat the previous steps, using a solid orange color (such as hex color #FF5500) instead of dark red.

d Turn off the Populated Places layer.

e Click Legend.

Note: You may need to zoom in to see the symbolized places.



Step 25e: Change the map style.

The results show the places that are over the state and federal exposure standards. Now, you want to provide more details about the areas with exposure values exceeding standards. You will create a custom attribute display (the information pop-up window) that displays when users click a feature in your map.

- Step 26: Create a custom pop-up

ArcGIS Online provides functionality to customize the information pop-up window associated with the features in your map. You want to provide more details for the features that represent areas with pollution exposure values exceeding state and federal standards.

In this step, you will customize the information pop-up window for the features in your map to provide more details.

a Click Content.

b In the Contents pane, point to or click the Places Over CA Standards layer name, click the More Options button ••• , and choose Configure Pop-Up.

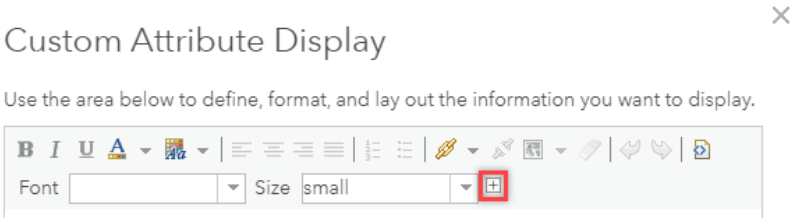
c In the Configure Pop-Up pane, for Pop-Up Title, type **Places over CA Standards: {NAME}**.

d For Display, choose A Custom Attribute Display from the drop-down list.

Note: The Show Pop-Ups box will be automatically checked when you choose this option.

e Click Configure.

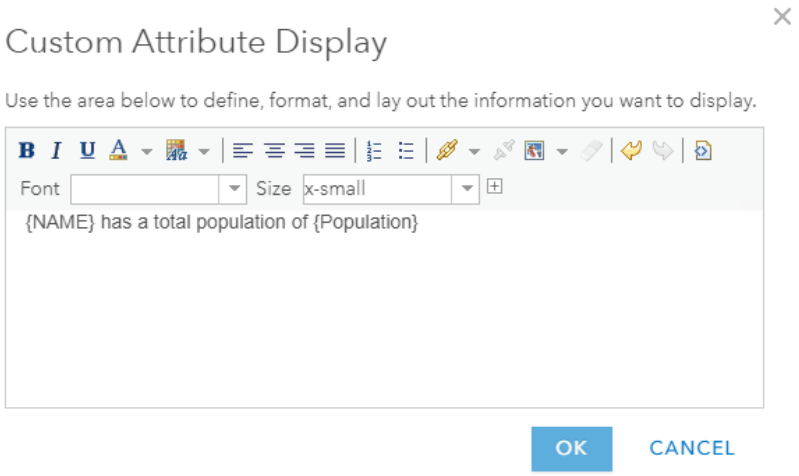
f In the Custom Attribute Display window, to the right of the font size, click the Add Field Name button, as indicated in the following graphic.



g Choose NAME {NAME}.

h In the field below the toolbar, add a space after {NAME}, type **has a total population of**, and then add another space.

i Click the Add Field Name button again and choose Population {Population}.



j Click OK.

The grant-funding agency will be interested in the number of people 65 and older in each selected place. You will add a chart to display these values in the pop-up window.

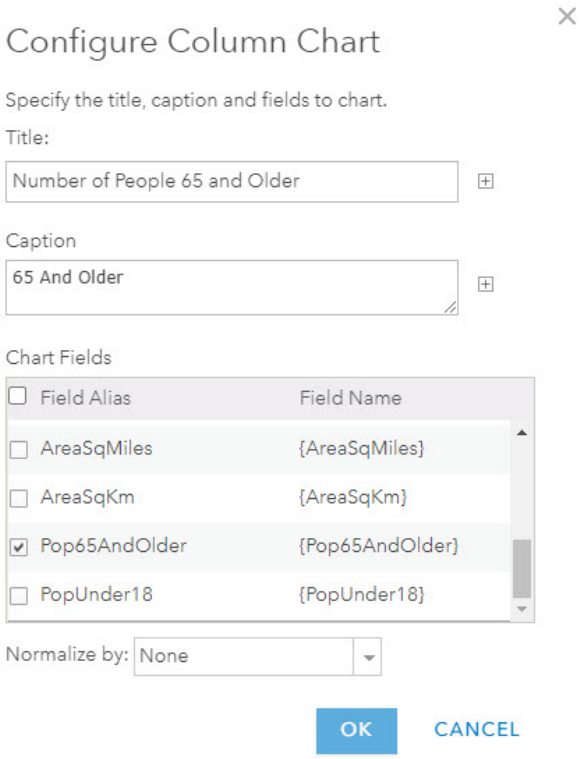
k In the Pop-Up Media section, click Add and choose Column Chart.

l In the Configure Column Chart window, for Title, type **Number of People 65 and Older**.

m For Caption, type **65 And Older**.

Note: The caption entries will become labels for the columns in the chart.

n In the Chart Fields section, check the Pop65AndOlder box.

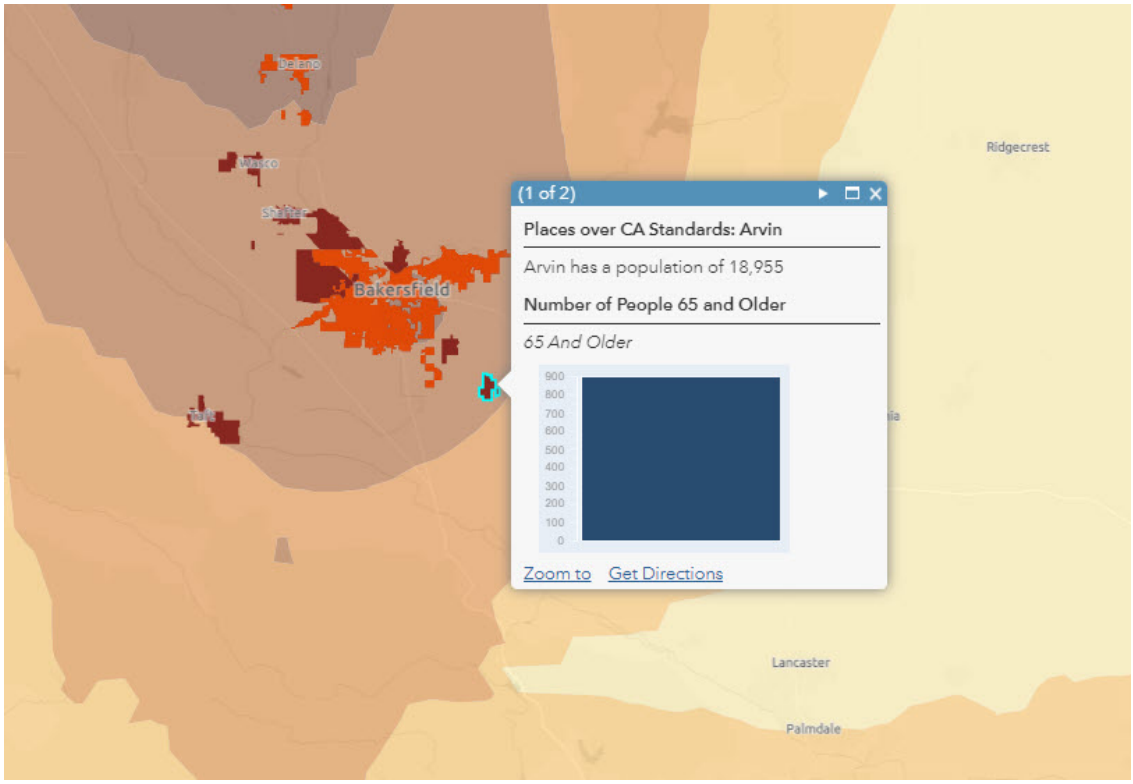


Step 26n: Create a custom pop-up.

- Click OK.

Step 26o: Create a custom pop-up.

- Click OK to close the Configure Pop-Up pane.
- Click an area of the map that is symbolized as a place with values over the state pollution exposure standards.



Step 26q: Create a custom pop-up.

r In the information pop-up window, point to each column in the chart to view the associated population values.

Note: Depending on where you click within an area, two or more records may pop up. You can scroll through the records; in the blue bar at the top of the custom pop-up window, click the right arrow. Some records may be from areas that share a boundary with the area in the Places Over CA Standards layer. Other records may be from the PM Prediction layer.

s Close the pop-up window.

Next, you will repeat these steps for the Places Over Federal Standards layer.

- Step 27: Create another custom pop-up

Now, you will create a custom information pop-up window for the Places Over Federal Standards layer.

a In the Contents pane, point to or click the Places Over Federal Standards layer name, click the More Options button ••• , and choose Configure Pop-Up.

b In the Configure Pop-Up pane, for Pop-Up Title, type **Places over Federal Standards: {NAME}**.

c For Display, choose A Custom Attribute Display.

d Click Configure.

e In the Custom Attribute Display window, click the Add Field Name button and choose NAME {NAME}.

f In the field below the toolbar, add a space after {NAME}, type **has a total population of**, and then add another space.

g Click the Add Field Name button again and choose Population {Population}.

h Click OK.

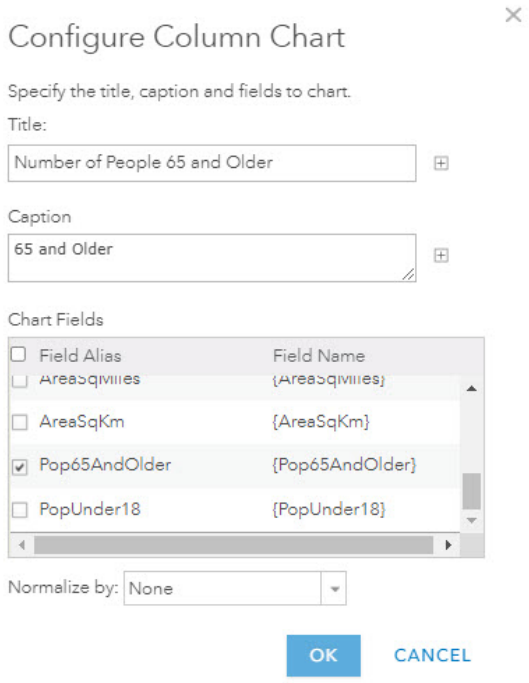
i In the Pop-Up Media section, click Add and choose Column Chart.

j In the Configure Column Chart window, for Title, type **Number of People 65 and Older**.

k For Caption, type **65 and Older**.

Note: The caption entries will become labels for the columns in the chart.

l In the Chart Fields section, check the Pop65AndOlder box.

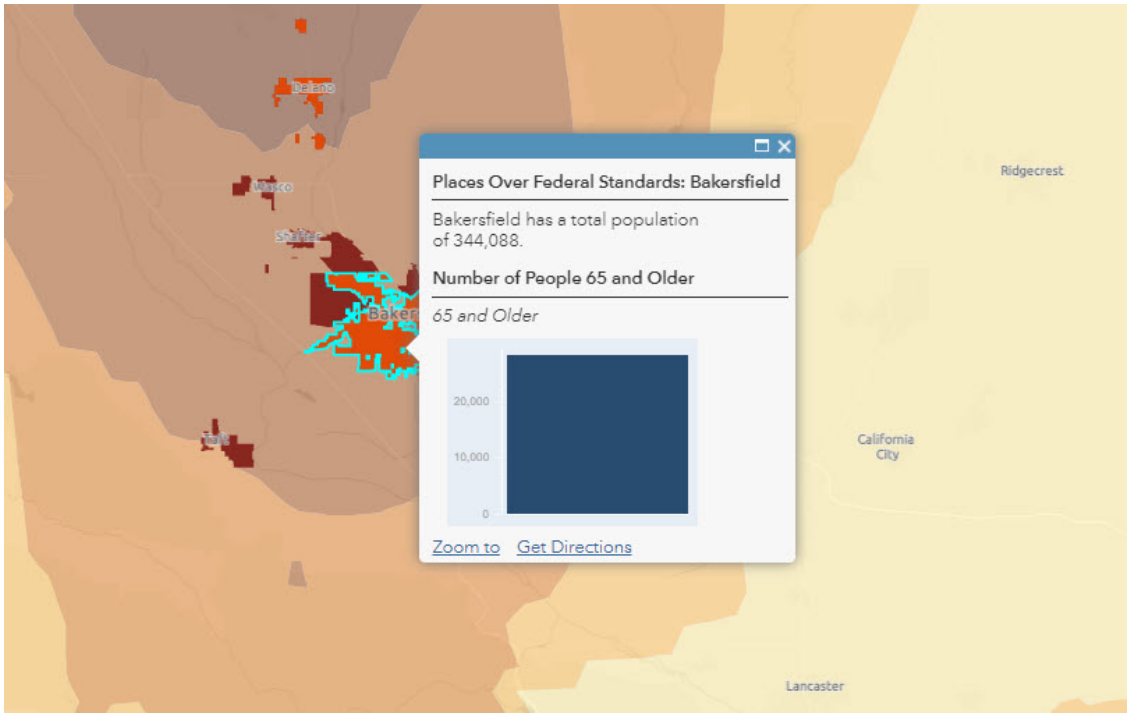


Step 27l: Create another custom pop-up.

m Click OK.

n Click OK to close the Configure Pop-Up pane.

o Click an area of the map that is symbolized as a place with values over the federal pollution exposure standards.



Step 27o: Create another custom pop-up.

p In the information pop-up window, point to the column in the chart to view the associated population values.

Note: Depending on where you click within an area, two or more records may pop up. You can scroll through the records; in the blue bar at the top of the custom pop-up window, click the right arrow. Some records may be from areas that share a boundary with the area in the Places Over Federal Standards layer. Other records may be from the PM Prediction layer.

q Close the pop-up window.

You have successfully configured the information in the pop-ups to show a custom attribute display and a column chart. You used attribute fields that are in your data. When configuring your pop-ups, you also have the option to use custom attribute expressions (https://esriurl.com/attexp) written in the Arcade expression language.

- Step 28: Save the map

To complete your work on this project, you will save the map before exiting ArcGIS Online.

a In the upper left of the map, click the Default Extent button .

b On the ribbon above the map, click Save and choose Save.

The map will be saved to your My Content collection.

You are satisfied that you have enough information for the report. You can now show maps of the predicted value for each populated place in the state using the nearest monitoring site. You can also use interpolated values across the whole state together with a measure of uncertainty.

c Close your private or incognito web browser window.

- Step 29: Conclusion

In this exercise, you looked at an example of the type of problem that can be addressed with the spatial analysis approach by applying predictive analysis and interpolation. Next, you will review how each step of the spatial analysis approach was used throughout this exercise.

Ask questions

Where are people more exposed to air pollution in California?

- Which areas have particulate matter levels exceeding state regulation values?
- Which areas have particulate matter levels exceeding federal regulation values?
- Where are the areas that have higher particulate matter levels and have high populations of people over the age of 65?

Explore and prepare data

You determined that an alternative basemap was needed to better display the thematic results in the upcoming analysis. The layers were renamed to be more meaningful for more effective communication. Additionally, you examined the attributes of the data to understand the data.

Analyze and model

In the exercise, there were multiple steps of analysis to answer your spatial questions. You used Find Existing Locations and Find Nearest tools, and then filtered the data to determine where the annual PM value exceeds 12 and 15 micrograms within a specified distance of each monitoring site.

After determining the straight line distance is not entirely the best method, you used the Interpolate Points tool to predict values at new locations based on measurements found in a collection of points. Using the Find Existing Locations again, you found places that have predicted PM2.5 values that exceed the state standards of 12 micrograms, followed by areas that exceed the federal standards of 15 micrograms. The map style and custom pop-ups were configured to display the number of the associated population values.

Interpret results

The resulting map displays populated areas where there is predicted PM2.5 particulate matter exposure of 12 micrograms per year or greater (exceeding California state standards) and 15 micrograms per year or greater (exceeding federal standards). There are 256 locations where

exposure levels are predicted to be greater than CA standards, greater than 12 µg/m^3, and there are are 34 locations where exposure levels are predicted to be greater than federal standards, 15 µg/m^3. You then configured pop-ups for the resulting Places over CA Standards and Places Over Federal Standards layers. The pop-up displayed the total population and the population broken down by people 65 and older.

Repeat or modify

Because particulate matter is wind-blown, there are other factors, such as whether you live near heavily traveled roads within your location and which sources of particulate matter are nearby. Consequently, straight line distance is not entirely the best method. Using interpolation, you can create a predicted surface of PM air pollution.

In the exercise, you modified your analysis using two different methods and analysis tools: Find Nearest and Interpolate Points tools. The table below highlights the population variation depending on which analysis method was used.

Standards for ambient air quality	Nearest monitoring site (first analysis)	Interpolated surface (second analysis)
California standards (12 µg/m^3)	11,423,778	14,405,764
Federal standards (15 µg/m^3)	5,555,738	1,465,063

Present results

You can now present the maps of the predicted value for each populated place in the state using the nearest monitoring site. You can also use interpolated values across the whole state together.

Make decisions

Collectively, the information from your analyses will allow results to be compared with past findings. Your work will also increase confidence in the interpretation of current findings. The grant-funding agency can use your analysis to determine whether grant funding made available for cardiopulmonary rehabilitation programs across California is underused.

a Close the private or incognito web browser window.