Exercise

Making Predictions: Particulate Matter Exposure

Section 6 Exercise 1

08/2020

esri
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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 platform. The screenshots that you see in course materials may differ slightly from the version of ArcGIS Online that you will use.

Time to complete

Approximately 90-120 minutes

Introduction

This exercise presents an approach to interpolating sample points to create a surface to analyze. The result is a map showing long-term particulate matter exposure. Although the data is real, the scenario, analysis, and resulting decisions are hypothetical.

The purpose of this exercise is to show how you can use a GIS to perform interpolation.

Exercise scenario

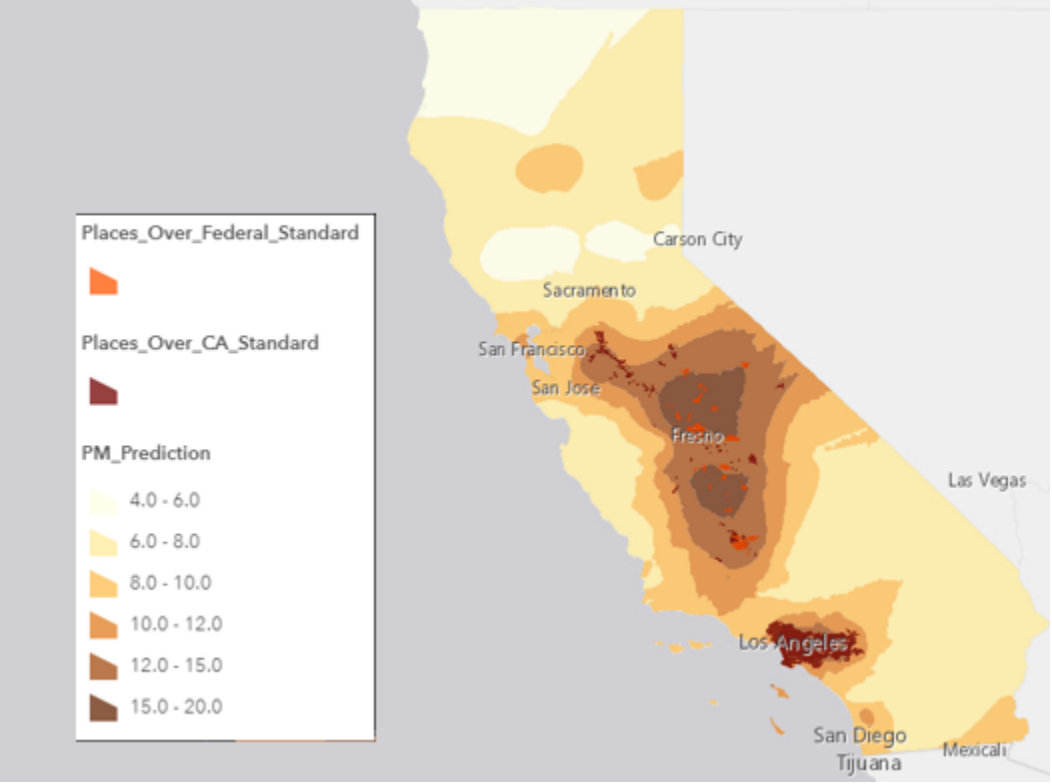
Grant funding is being made available for cardiopulmonary rehabilitation programs across California. These programs offer chronic disease management with proven cost-effectiveness, yet such programs are frequently underused.

The funding body believes that underuse may be due to lacking services in certain areas or due to physicians not referring enough people. Organizers want to ensure that future programs are fully utilized. They have commissioned you to perform some environmental analyses and research. The body 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.

Human-made sources of PM2.5 contribute more than natural sources, with emissions of PM2.5 from road vehicles being particularly significant. Levels of PM2.5 close to roadsides are often much higher than levels in background locations. Other sources 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.

What to analyze?

Certain populations, such as children and the elderly, are more susceptible to harm from fine particulate matter. The funding body has requested a report that shows populations living in areas where exposure exceeds state and federal standards for ambient air quality. PM2.5 monitors are required in large metropolitan areas. Small cities and rural areas have supplementary monitors, some of which provide measurements of the long-range transport of fine particles. Monitoring is focused on the most heavily polluted or densely populated areas so that these monitors can establish peak concentrations.



Map showing predicted particulate matter exposure values for places in California.

In this exercise, you will use the ArcGIS Online mapping platform to perform the following tasks:

- Work with map layers.
- Change feature symbology.
- Create a choropleth map.
- Examine attribute data.
- Find locations.
- Calculate statistics.
- Filter layer data.
- Interpolate points.

Approach

GIS is a tool that can provide you with information to help you answer questions.

Frame the question
When approaching your analysis, the first task is to frame the question.

In this exercise, the analysis question can be framed as follows:

Where are people more exposed to air pollution?

Define analysis criteria
The next task is to consider the criteria associated with the question. What information do you need to answer this question? How can you use the GIS to represent, analyze, and assess the criteria?

Your map must show locations with higher particulate matter exposure levels, as well as populations of a certain age group.

Based on the scenario and criteria, you will need to accomplish these tasks:

- Determine which areas within the study area have particulate matter levels exceeding state regulation values.
- Determine which areas within the study area have particulate matter levels exceeding federal regulation values.
- Determine the ages of the population living in these areas.
- Identify areas that have higher particulate matter levels and larger elderly populations.

Note: This exercise focuses primarily on particulate matter exposure and the elderly. You could perform the same analyses with children as the target population, because this group is also harmed by PM2.5 exposure.

Now, start to think in terms of spatial analysis. Ask yourself the following:

What information do I need to address this question?

For this exercise, the layers provide information related to the analysis question, including the following:

- The study area boundary to define the area of interest
- The location of particulate matter pollution monitoring sites (sites have monitoring stations)
- Places people live based on U.S. Census locations

Which layers do I need for this map?

For this exercise, you need several layers:

- A layer containing the state of California boundaries
- An annual particulate matter monitoring sites layer
- A layer of populated places defined by the U.S. Census Bureau

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 and the exercises that follow.
2. Use the latest version of Google Chrome, Mozilla Firefox, or Microsoft Edge. Other web browsers may not display your maps and apps correctly.

Note: For information on supported browsers for ArcGIS Online, go to https://doc.arcgis.com/en/arcgis-online/reference/browsers.htm (https://bit.ly/2pIIN2T).

Step 1: Sign in and open the map

Using ArcGIS Online, you can create a map with the identified layers that you can then use for your analysis. For this exercise, the initial map has already been created.

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

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

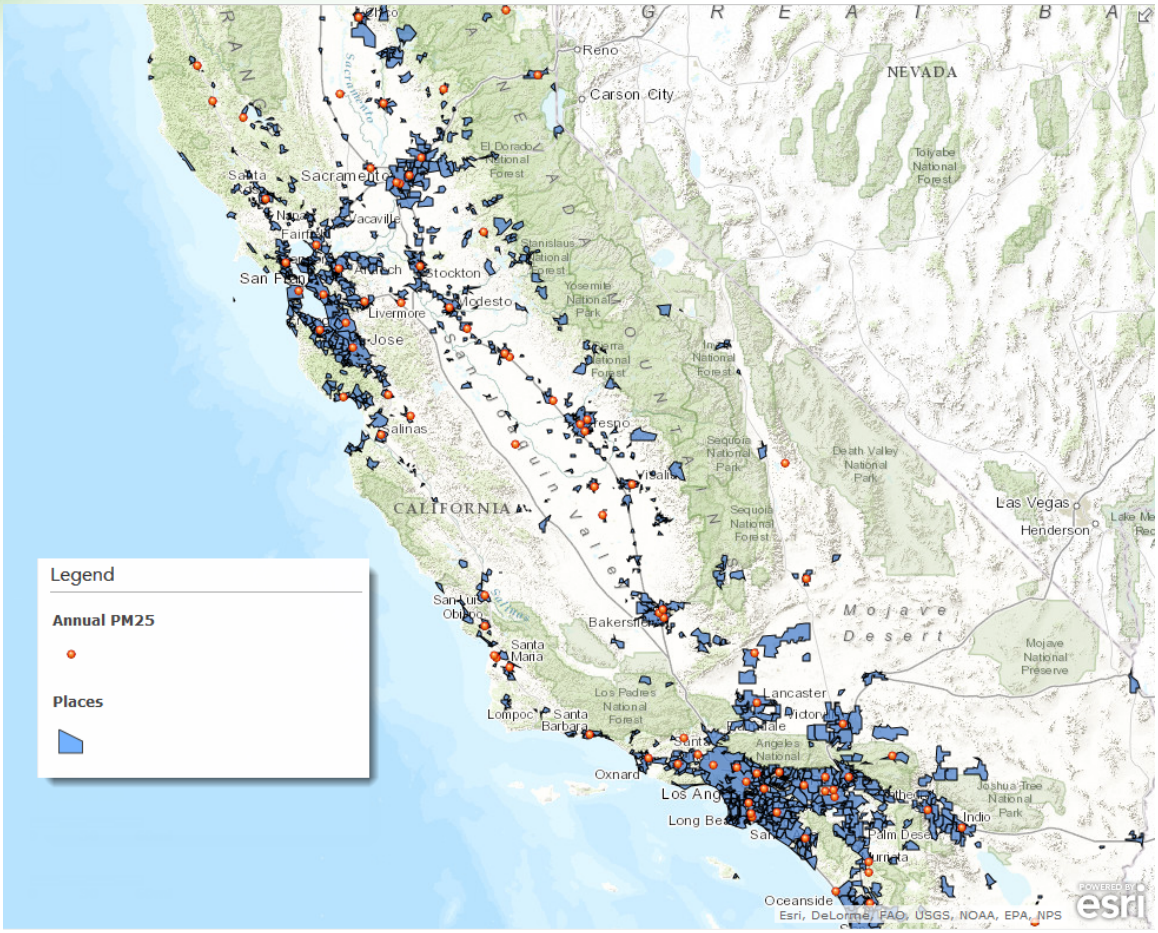
b. In your private or incognito browser window, go to https://www.arcgis.com/home/item.html?id=69fa8e03d3954a49b17b9ea0b6d421af (https://bit.ly/3jdo546)

c. Sign in to ArcGIS Online using the credentials explained at the start of this course.

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

d. Click the thumbnail image to open the map.

A map of the area of interest (https://bit.ly/2StKhwr) opens. This map shows particulate matter monitoring sites in the state of California. The map also shows areas with a population of 200 or more elderly people (aged 65 or older).



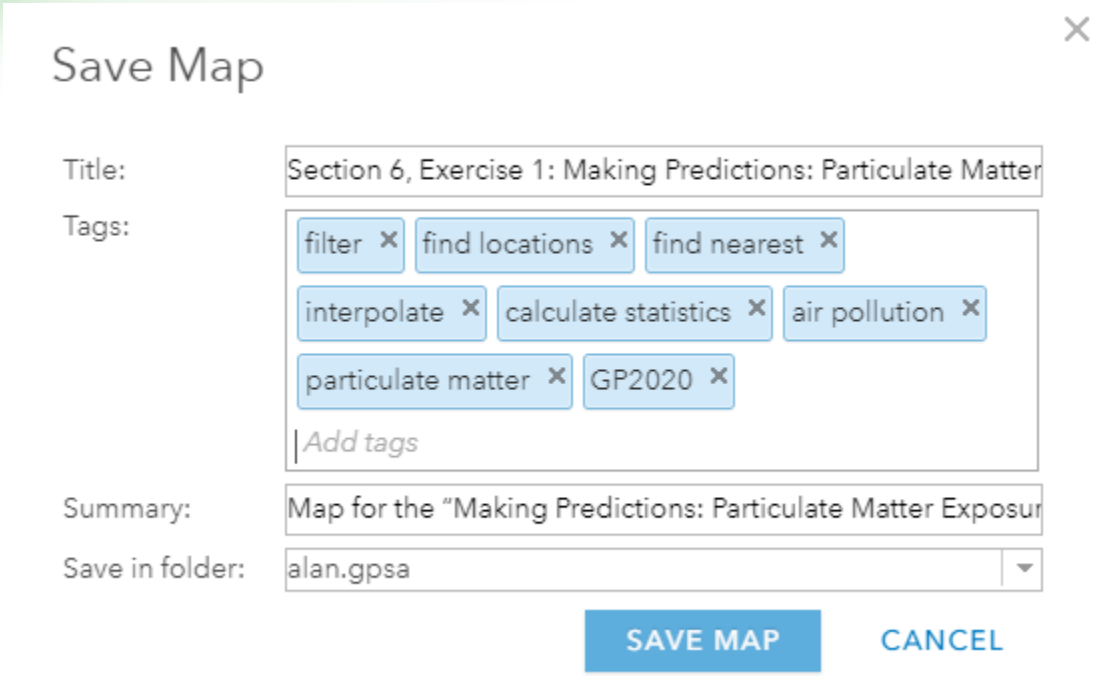
Initial map showing locations of particulate matter monitoring stations in the state of California. Legend shown for context.

Step 2: Save a copy of the map

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

a. In 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.



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 In the ribbon above the map, click Basemap.

b From the gallery, choose Light Gray Canvas.

The Light Gray Canvas basemap has a neutral background with minimal colors, labels, and features. It helps draws attention to your thematic content.

With this new basemap selected, the features on the map become easier to see.

Step 4: Change layer names

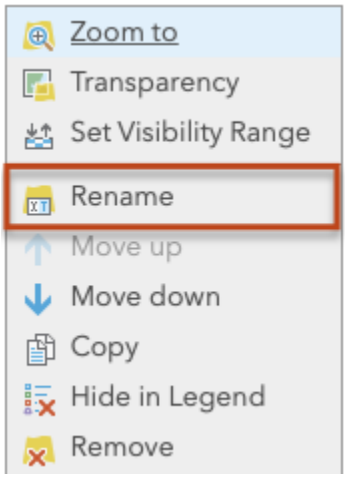
It is helpful to have layer names that provide meaning for your analysis. You can rename layers to support the intent of your map.

In this step, you will provide more intuitive names for two layers.

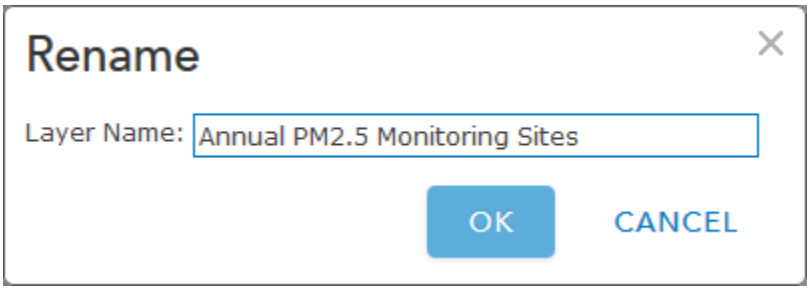
a. In the left-side pane, click the Content tab to activate the Contents pane.

b. In the Contents pane, point to the Annual PM25 layer name and click the More Options button ••• .

c. From the context menu, choose Rename.



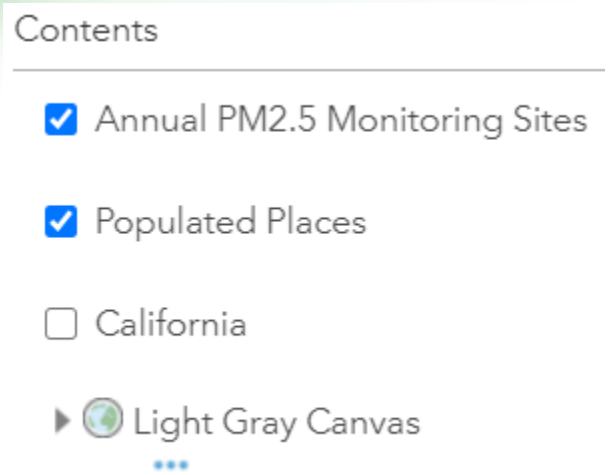
d. In the Rename dialog box, type **Annual PM2.5 Monitoring Sites**.



e. Click OK.

The new layer name is reflected in the Contents pane.

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



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 because it represents only those places with an elderly population of more than 200 people.

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.

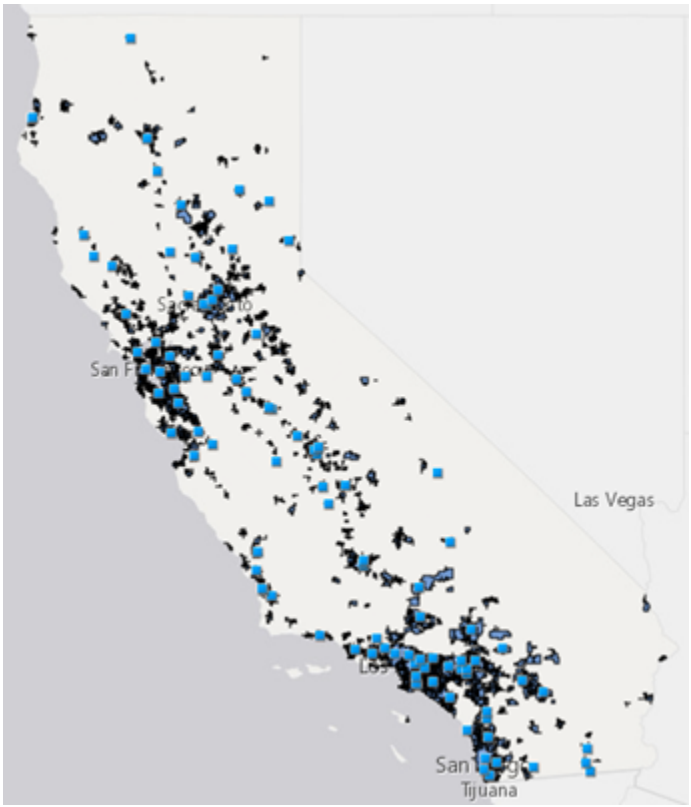
a Zoom out to see the entire state of California, which represents your study area.

Note: The default map extent does not include the entire state. To view the entire study area, you need to zoom out.

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

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

- In the Contents pane, point to 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 drawing style, under Location (Single Symbol), click Options.
- Click Symbols.
- In the pop-up window, for Shape, select the blue square.
- Change Symbol Size to 16 px.
- Click OK to close the pop-up window.
- In the Change Style pane, click OK, and then click Done.



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.

To show more and less populated areas across the state, you will symbolize the features in the Populated Places layer as choropleth.

Step 6: Create a choropleth map

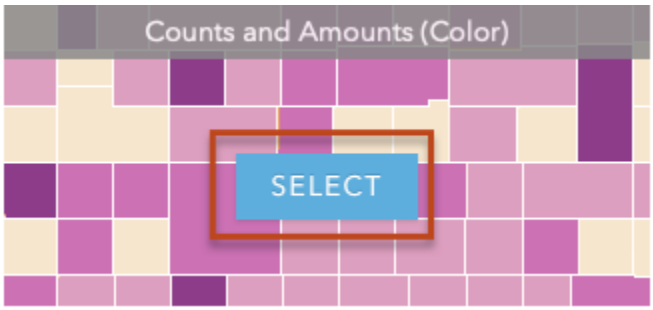
Choropleth maps can reveal data patterns, showing the distribution of a phenomenon within a selected area. Exploring the distribution of population across the state will highlight more and less populated areas.

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 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 drawing style, under Counts And Amounts (Color), click Select.



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. Confirm that the theme is set to High To Low.

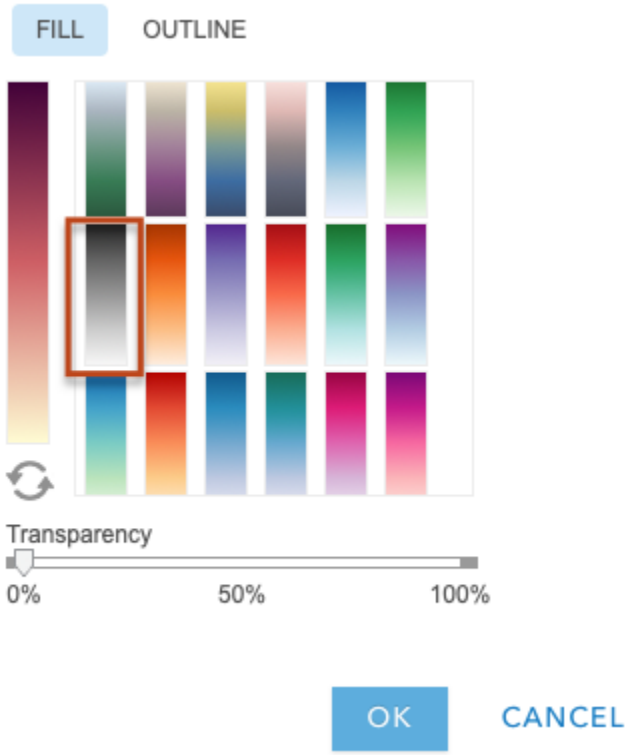
To show color ranges based on value, you will use a grayscale color ramp.

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 pop-up window, click the Fill tab, if necessary.

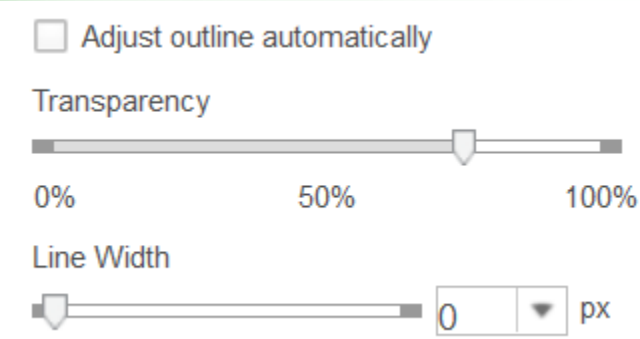
i. Scroll down and choose the grayscale color ramp.



j. On the Outline tab, 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.



m. Click OK to close the pop-up window.

To further generalize your map, you will classify the data using the 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.

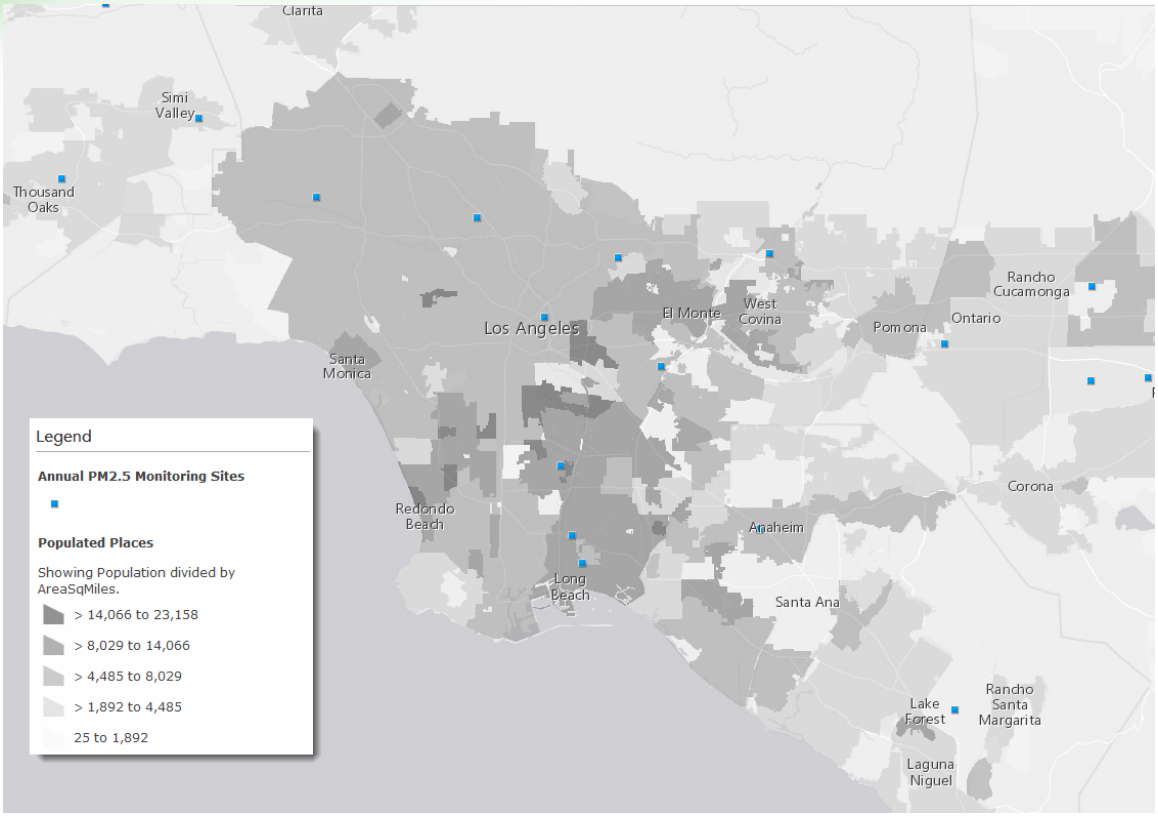
p. For Transparency, move the slider to approximately 50%.

q. 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 initially be difficult to see the areas.

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



Choropleth map showing graduated colors representing population normalized by square miles for places with at least 200 people classified as elderly living in them.

The initial analysis included places with elderly population (people aged 65 and older) of at least 200 people. Places are areas with a concentration of population, designated by the U.S. Census Bureau. Places include cities, towns, villages, and boroughs.

You want to determine how many areas in California have more than 200 elderly people living nearby and also contain monitoring sites.

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 elderly populations will help identify where cardiopulmonary rehabilitation centers should be established. Doing so may also highlight areas where increased referral rates would be expected.

You can see that most places with population in this age group are covered by a monitoring site. 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 or stations located nearby.

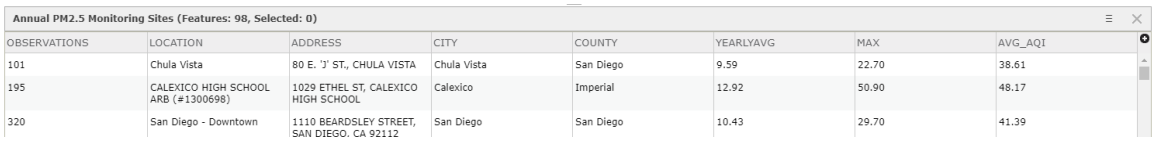
Step 7: Examine the data

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

Hint: Point to the layer name and click the Show Table button .



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

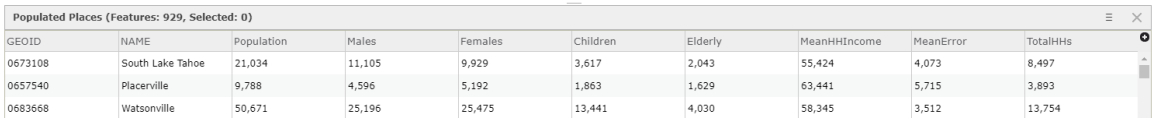
OBSERVATIONS	LOCATION	ADDRESS	CITY	COUNTY	YEARLYAVG	MAX	AVG_AQI
101	Chula Vista	80 E. 'J' ST., CHULA VISTA	Chula Vista	San Diego	9.59	22.70	38.61
195	CALEXICO HIGH SCHOOL ARB (#1300698)	1029 ETHEL ST, CALEXICO HIGH SCHOOL	Calexico	Imperial	12.92	50.90	48.17
320	San Diego - Downtown	1110 BEARDSLEY STREET,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

According to the table, there are 98 particulate monitoring sites (or stations) 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://bit.ly/2dcjCeZ), or AQI.

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

b Close the table for the Annual PM2.5 Monitoring Sites layer.

c Open the table for the Populated Places layer.



Populated Places (Features: 929, Selected: 0)

GEOID	NAME	Population	Males	Females	Children	Elderly	MeanHHIncome	MeanError	TotalHHs
0673108	South Lake Tahoe	21,034	11,105	9,929	3,617	2,043	55,424	4,073	8,497
0657540	Placerville	9,788	4,596	5,192	1,863	1,629	63,441	5,715	3,893
0683668	Watsonville	50,671	25,196	25,475	13,441	4,030	58,345	3,512	13,754

According to the table, there are 929 places (cities, towns, villages, or boroughs) in the state with an elderly population of at least 200 people. The table includes each place's unique geographic identifier, total population, and population demographics, including the number of elderly residents.

To confirm that the data only includes those places with an elderly population of at least 200 people, you can sort the values in the Elderly column.

d Sort the Elderly 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. You want to use all the values in the table, because they all meet the criterion. The Populated Places layer includes only areas with at least 200 elderly residents.

e. Close the table.

As part of your analysis, you want to find out how many PM2.5 monitoring sites are located in areas with an elderly population of at least 200 people.

Step 8: Find locations with monitoring sites

You can use the ArcGIS Online Find Existing Locations tool to select features in the Annual PM2.5 Monitoring Sites layer that meet the population criteria.

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

b. Expand Find Locations.

c. Click Find Existing Locations.

d. In the Find Existing Locations pane, create a spatial query expression to find populated places that have monitoring sites.

Note: First, try creating the spatial query expression on your own. If needed, the 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.

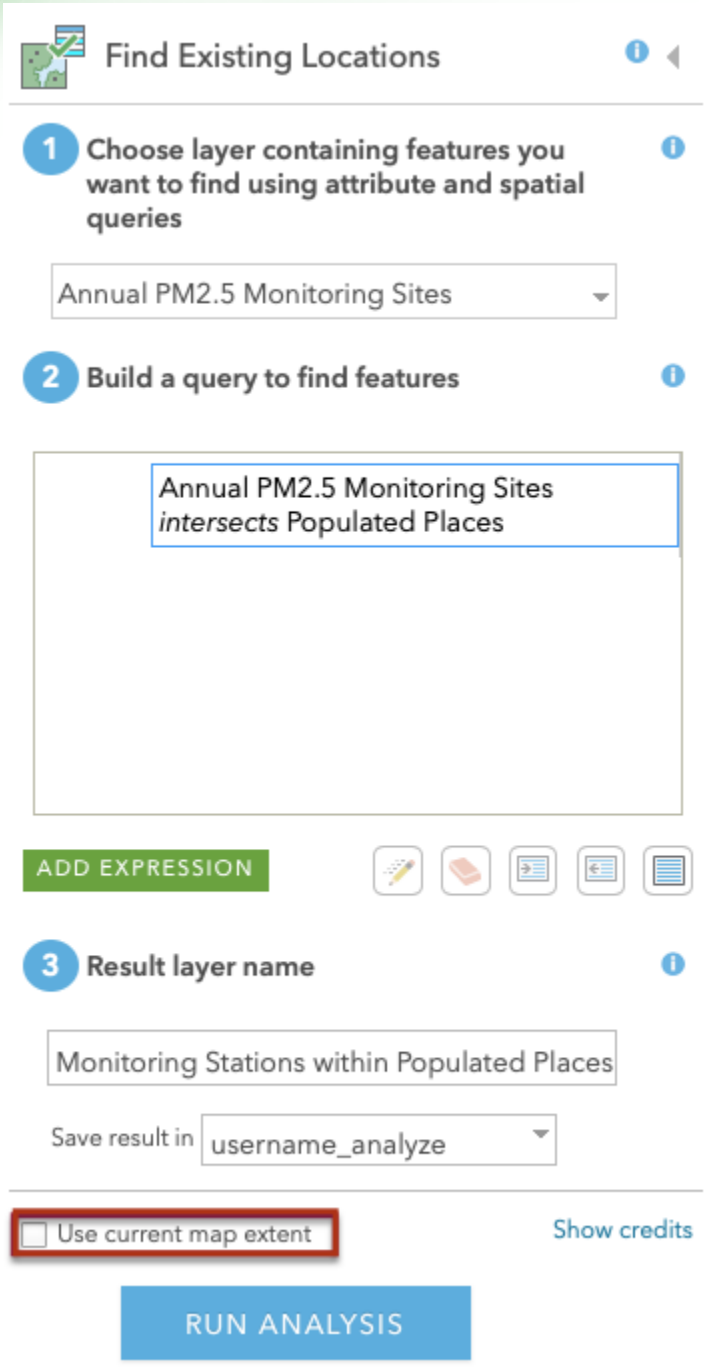
e. Click Add to add the expression to the Find Existing Locations pane.

f. For Result Layer Name, type **Monitoring Stations within Populated Places_yourfirstandlastname**.

Note: If you run the analysis multiple times, you will need to give 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.

g. At the bottom of the Find Existing Locations pane, uncheck the box for Use Current Map Extent.



The box for Use Current Map Extent is checked by default. This setting limits the results to your current map extent. The map extent (https://bit.ly/2StbI9J) refers to the portion of the map displayed on screen at a given moment.

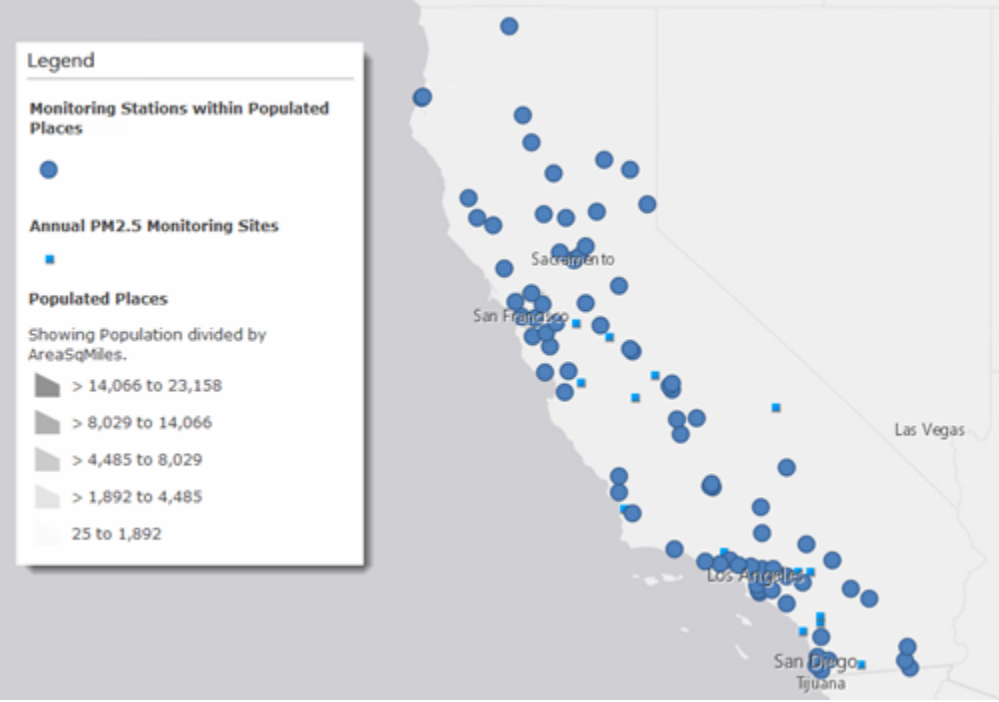
For this analysis, the study area is the entire state of California. You want to run the analysis on all the records in the Annual PM2.5 Monitoring Sites layer—not just what is currently displayed.

h Click Run Analysis.

Processing time for the analysis will depend on several factors, including the number of features in the current extent.

The map display updates to show monitoring stations in places that have a population of at least 200 elderly people. The locations are symbolized with blue circles by default.

i Zoom out to view the entire state of California.



j Save your map.

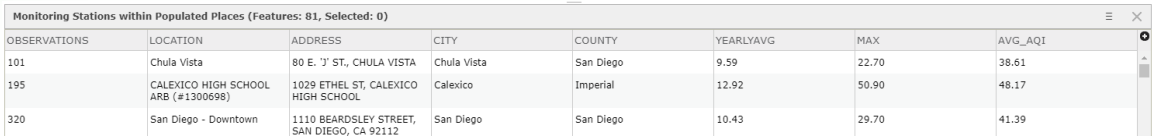
Recall from the original dataset that you had 98 monitoring sites. You can now identify how many of those sites are located within populated places by examining the result layer data.

Step 9: Examine attribute data

In this step, you will review the result data.

a Open the table for the Monitoring Stations Within Populated Places layer.

b. Scroll through the table and examine the data.



Monitoring Stations 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

The analysis shows that there are 81 monitoring stations located in populated areas with at least 200 people classified as elderly.

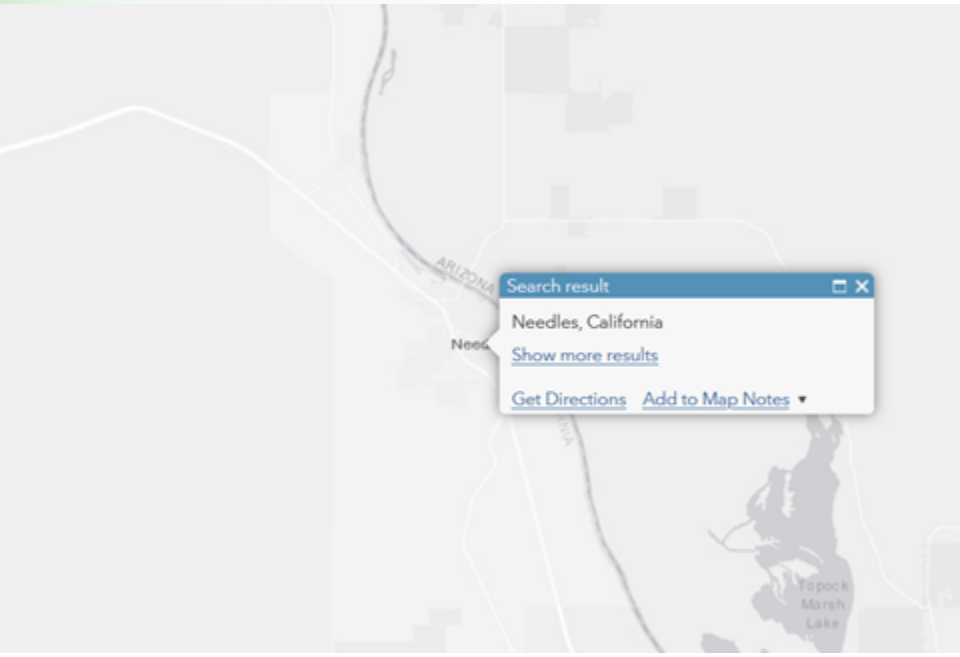
A quick calculation (81 divided by 98 and then multiplied by 100) shows that 83% (when rounded up) of the monitoring stations are located in areas with a substantial elderly population. This calculation helps you feel confident that coverage is typically good across the state.

c. Close the table.

Step 10: Perform a visual assessment

You can see that most monitoring stations are located near populated places. If you zoom and pan the map, a few stations appear to be farther away from their nearest city or town. By gaining a visual understanding of the range of distances from populated places to the nearest monitoring station, you will be better prepared to interpret the results of later analysis steps. For instance, you might consider a measurement from a more distant monitoring station to be less representative than a closer monitoring station. For places where the closest monitoring station is relatively remote, your analysis results would be more uncertain.

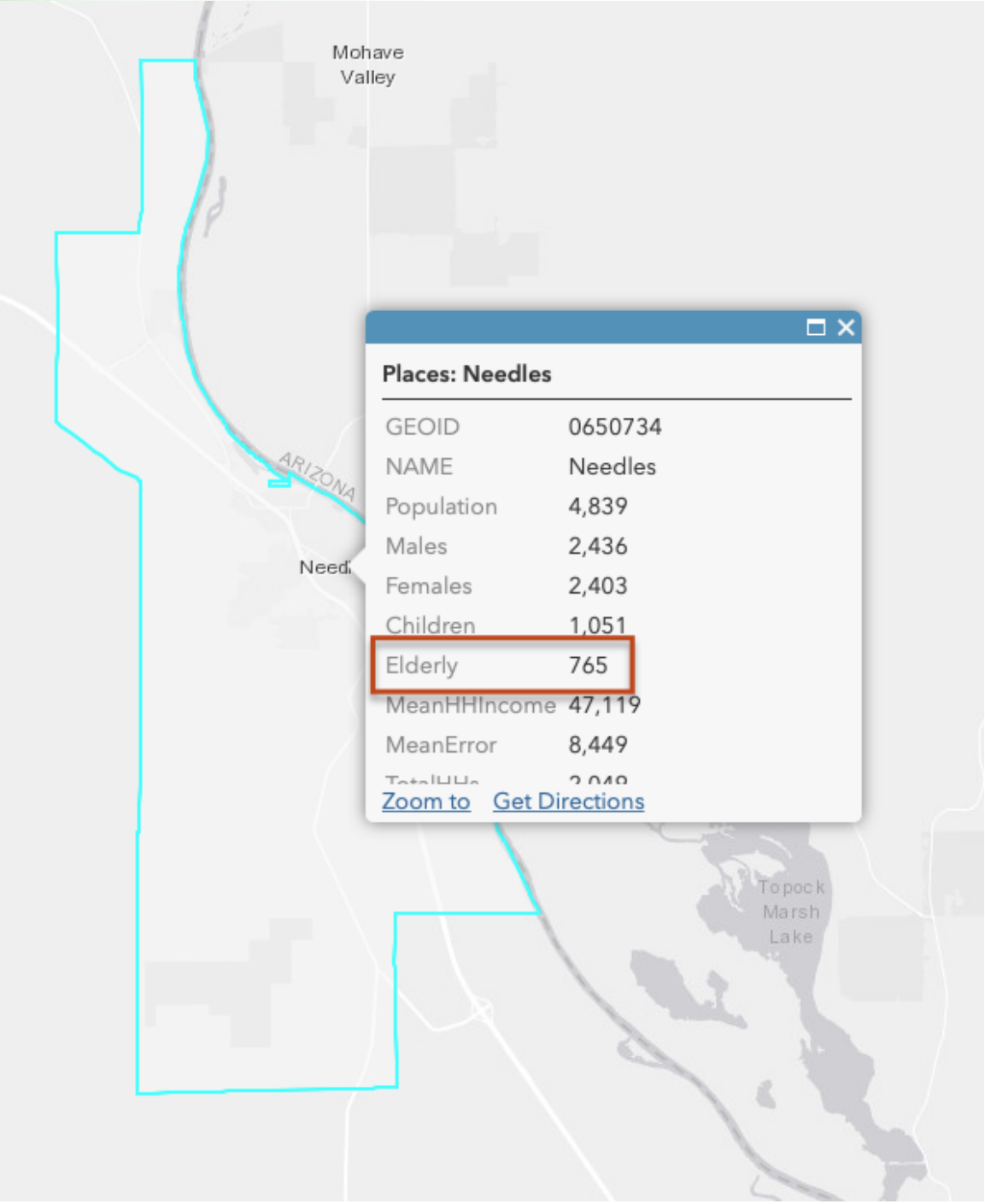
a. In the Find Address Or Place field above the map display, type **Needles, CA** and press Enter.



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 station.

b. Close the Search Result pop-up.

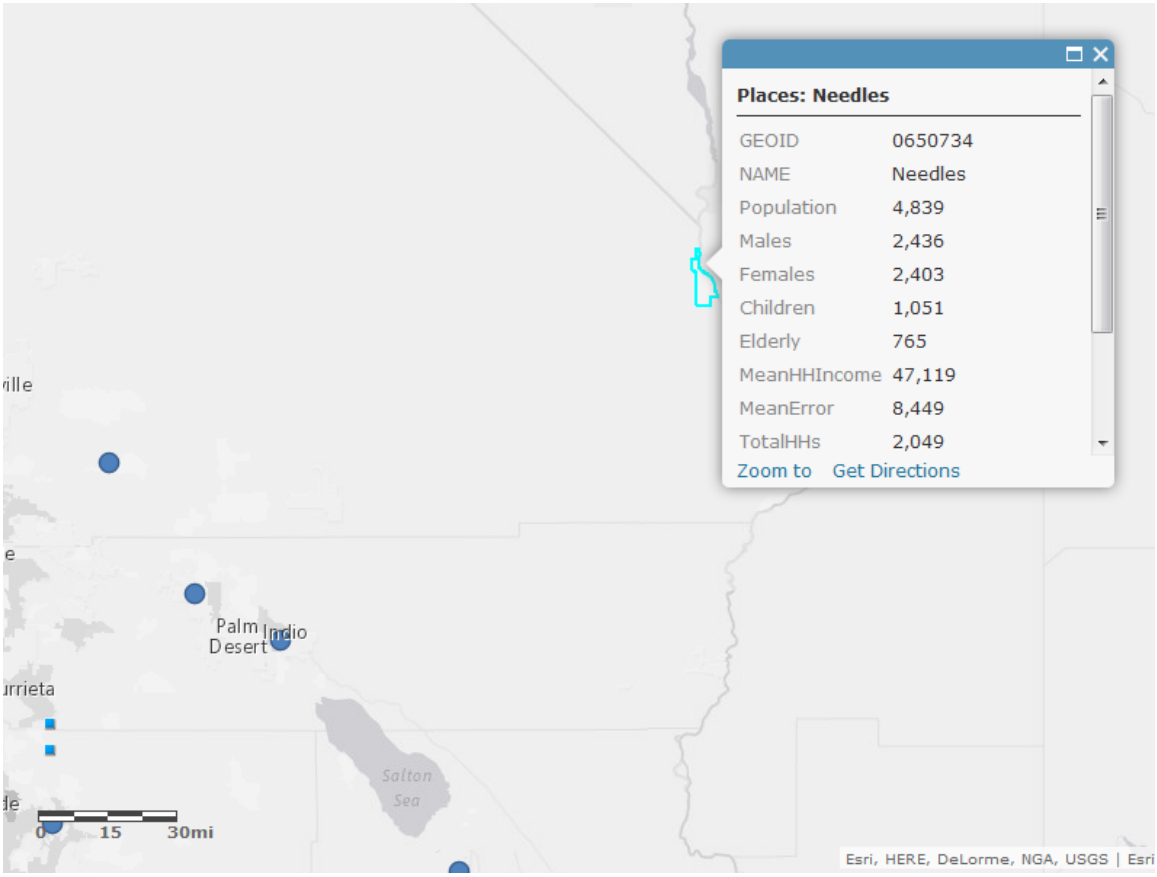
c. Click the city name to view an information pop-up window.



The information pop-up window includes the number of people living in the area who are identified as elderly.

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 stations to the west (about four clicks using the Zoom Out button on the map display).



There are several monitoring stations located approximately the same distance from Needles. You can use the ArcGIS Online Measure tool to measure the distance from the city to a monitoring station.

Step 11: Measure distance

After noticing that Needles, California, is relatively far from any monitoring station, you want to know the approximate distance of that city to the nearest monitoring station. You can use the Measure tool to measure this distance.

In this step, you will measure the straight line, or Euclidean, distance between two features on the map.

a. From ribbon above the map, click Measure .

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

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

The default unit of measurement is Miles.

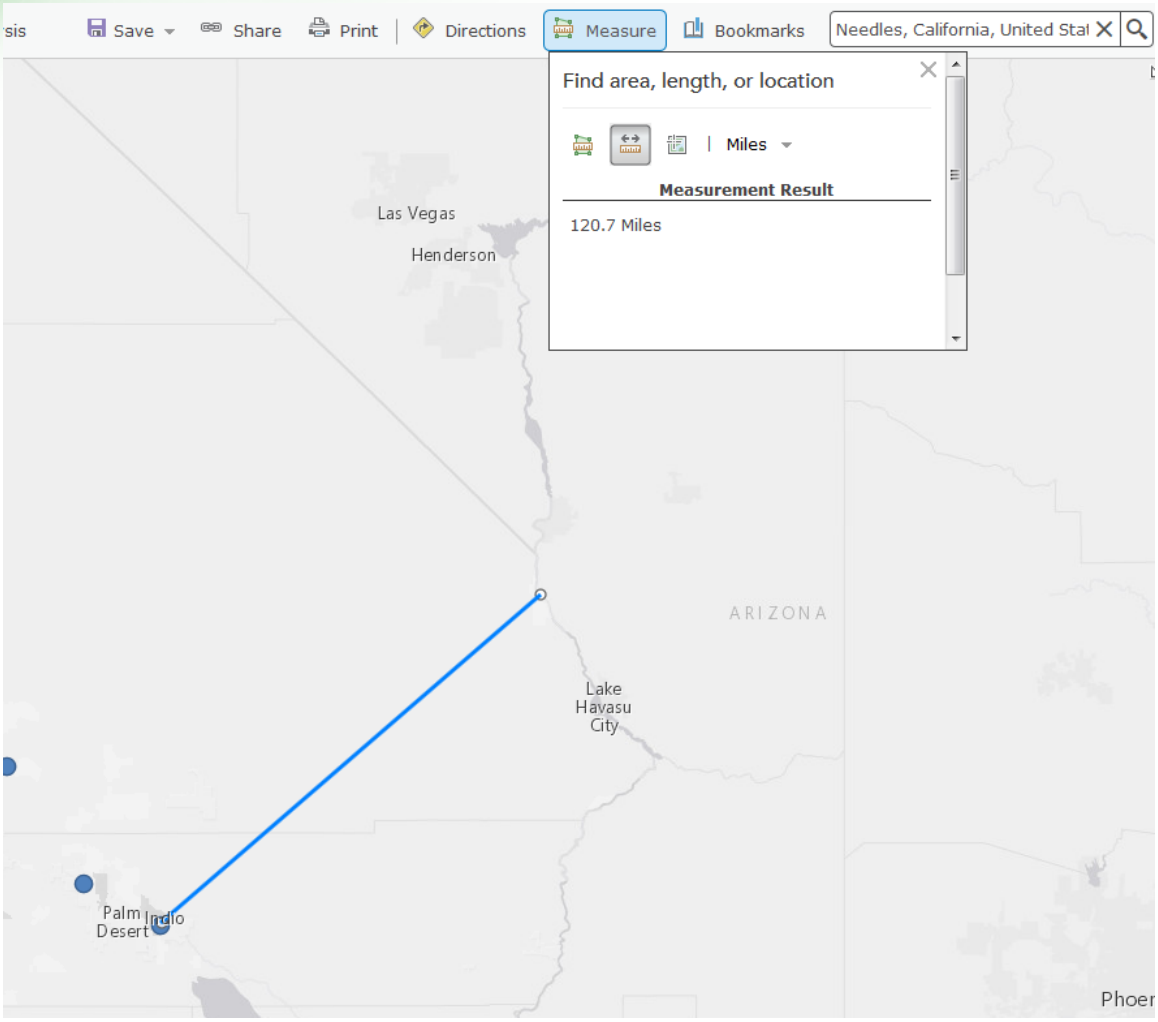
c. Click the map once on the approximate location of the city of Needles, California (near the eastern border of California, just north of Lake Havasu City, Arizona).

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

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

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

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



The measurement is not exact; depending on which part of the area 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 station. This measurement gives you a general idea of the distance for one of the stations. However, you want to identify how close the nearest monitoring station 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 pop-up window.

f. Click the Default Extent button .

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 station to each populated place included in your study. Reporting the single closest monitoring station 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 want to find out how close the nearest monitoring station site is to each place.

The ArcGIS Use Proximity tools can be used to help you answer one of the most common questions posed in spatial analysis: What is near what?

a. Turn off the Annual PM2.5 Monitoring Sites layer.

b. Turn off the Monitoring Stations Within Populated Places layer.

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

d. Expand Use Proximity.

You can use the ArcGIS Online Find Nearest tool to find the nearest monitoring station 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.

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 station and one value (air pollution), so you want to find the one station 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, increase the value to **120** miles.

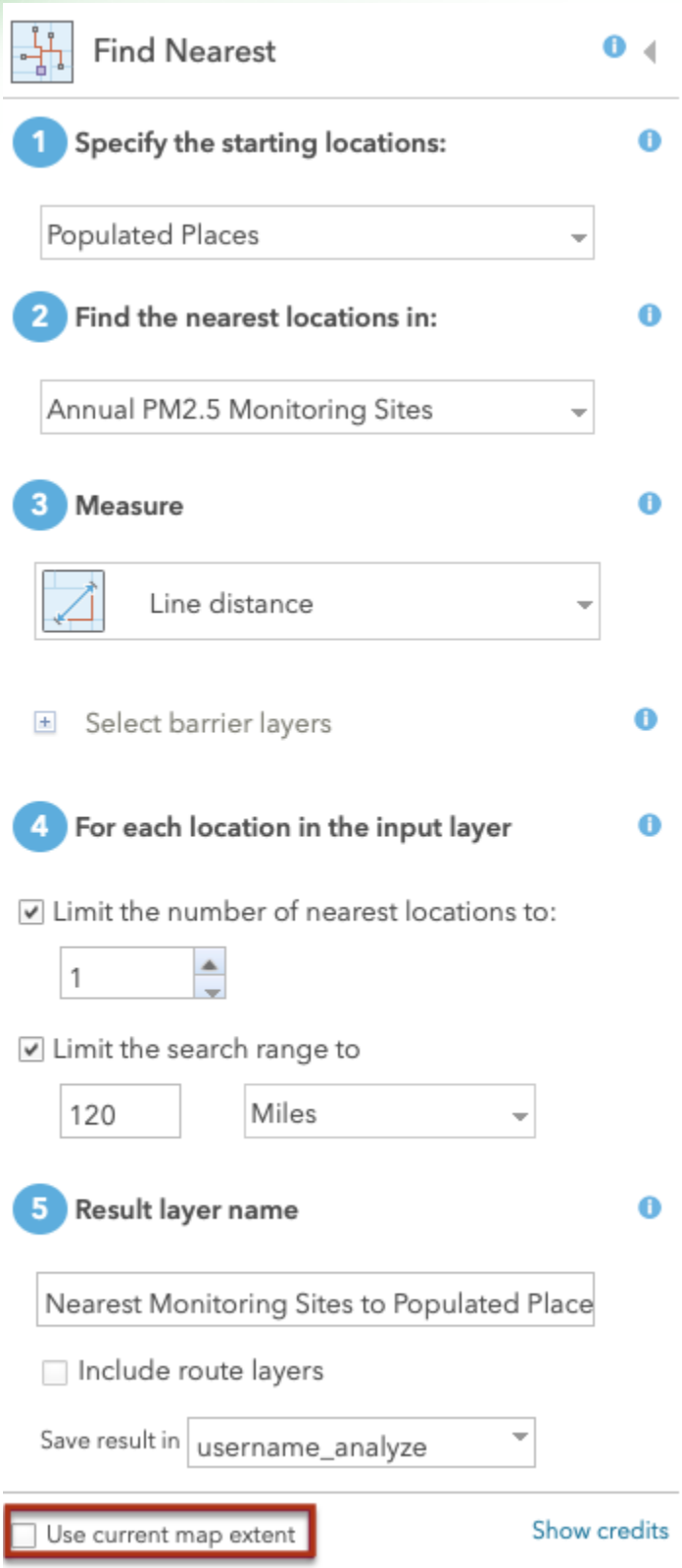
Based on your visual assessment and measurement examples, you decide to slightly increase the search range. This increase will likely ensure that your results include all the monitoring stations from your original dataset.

k. For Result Layer Name, type **Nearest Monitoring Sites to Populated Places_yourfirstandlastname**.

Note: If you run the analysis multiple times, you will need to give 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.



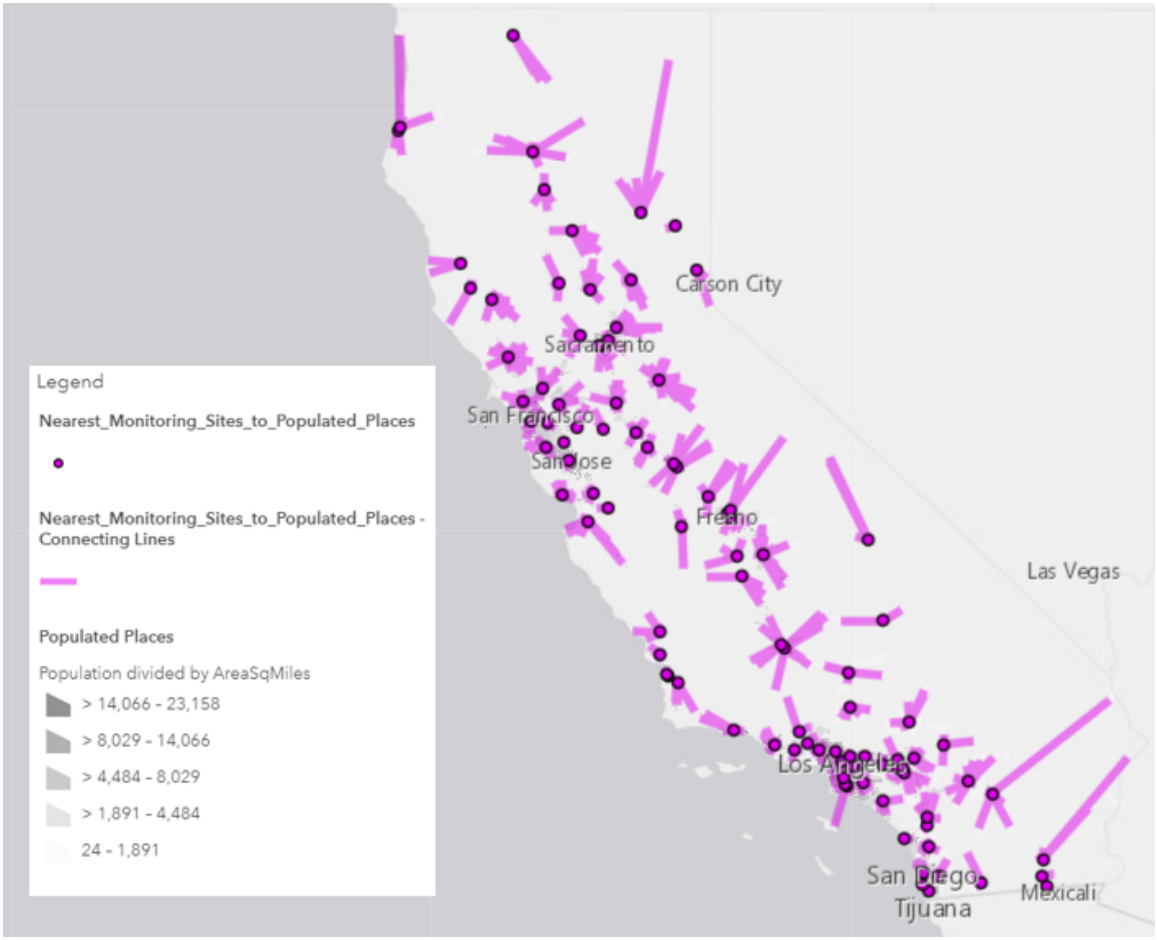
The box for Use Current Map Extent is checked by default. This setting limits the results to your current map extent. The map extent (https://bit.ly/2StbI9J) refers to the portion of the map displayed on screen at a given moment.

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.

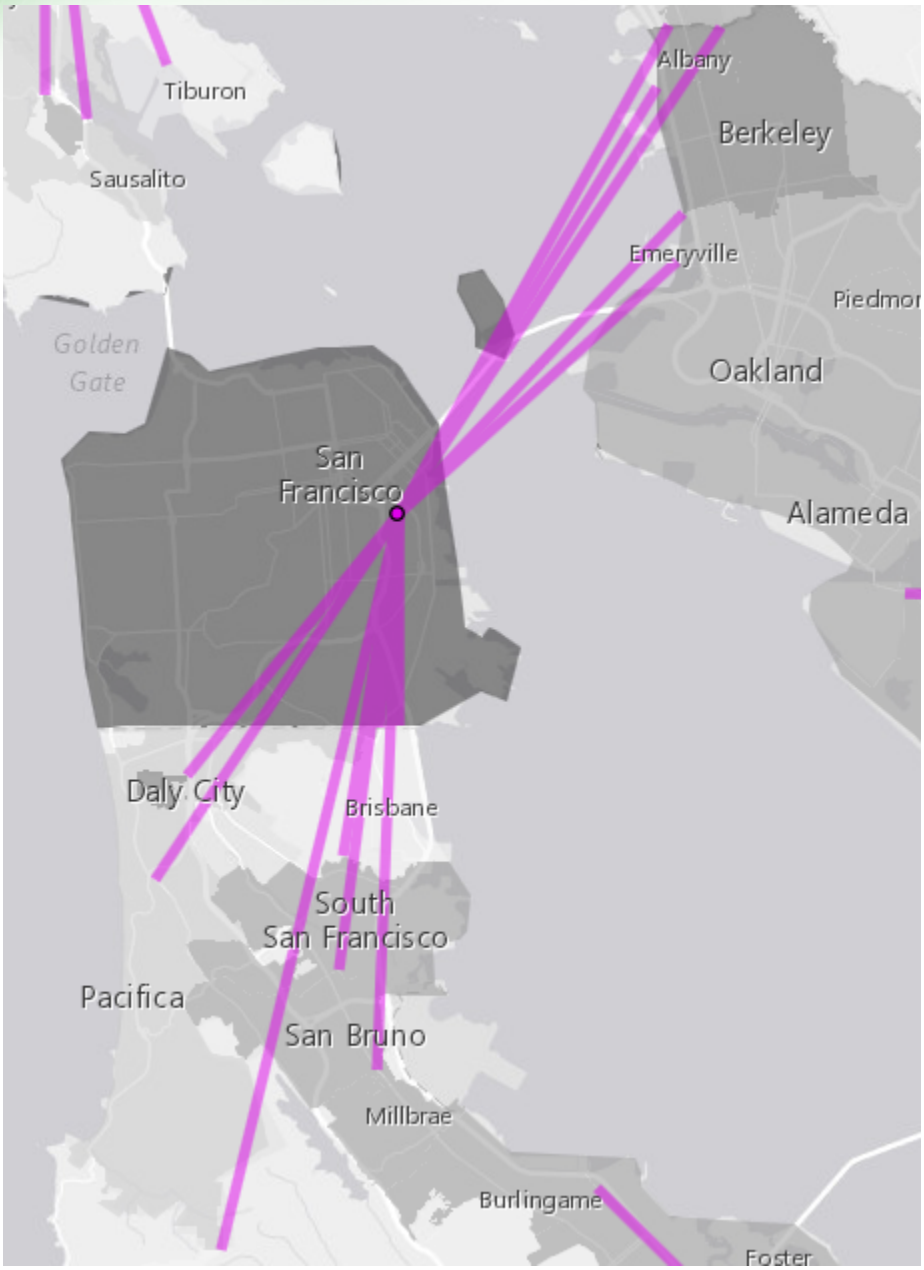
m Click Run Analysis.

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

n View the map legend.



o Zoom in to the area near San Francisco.



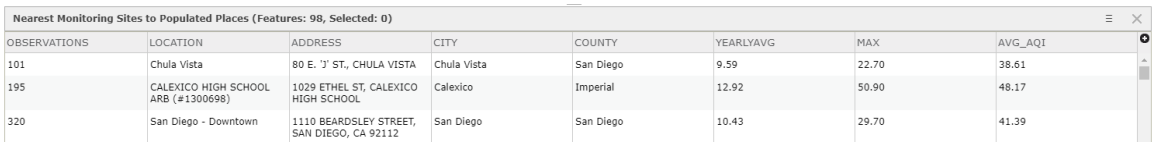
The connecting lines are drawn from the monitoring station point feature to the edge of the nearest place area features.

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 station 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 table for the Nearest Monitoring Sites To Populated Places layer.



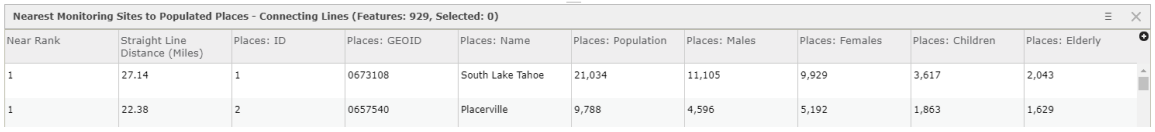
Nearest Monitoring Sites to Populated Places (Features: 98, Selected: 0)

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

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

b. Close the Nearest Monitoring Sites To Populated Places layer table.

c. Open the 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: Children	Places: Elderly
1	27.14	1	0673108	South Lake Tahoe	21,034	11,105	9,929	3,617	2,043
1	22.38	2	0657540	Placerville	9,788	4,596	5,192	1,863	1,629

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

d. Examine the Straight Line Distance (Miles) field.

e. Sort the field in descending order.

This analysis shows that the farthest place (Needles) is about 114 miles (183 km) from the nearest monitor. Other places clearly contain at least one monitor. Some places even have multiple monitors.

f. Sort the field in ascending order.

You now have the range of distance values, from 0 miles to 114 miles. A value of 0 miles indicates that the monitoring station is located in the nearest city.

g. Click a row in the table, and the respective connecting line will show on the map in blue.

Hint: With a row in the table selected, click the table Options button ☰, then click Center on Selection to zoom the map to the selected connecting line.

Note: 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.

Explore the data and the features on the map and in the table. Where are the connecting lines in relation to the monitoring stations? Where are the populated places, and where are the closest monitoring stations?

h. Close the table.

i. Return to the default map extent.

You decide that it would be valuable to report how much air pollution is detected at each location. This report will provide a rough idea of the importance of the distance from a monitoring station to a location.

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 place.

Next, 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 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.

Next, 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 pop-up window, choose a dark pink (such as hex color #E600A0) to match the color used for the monitoring stations.

f. Click OK to close the pop-up window.

g Set the Minimum Size to 1 px.

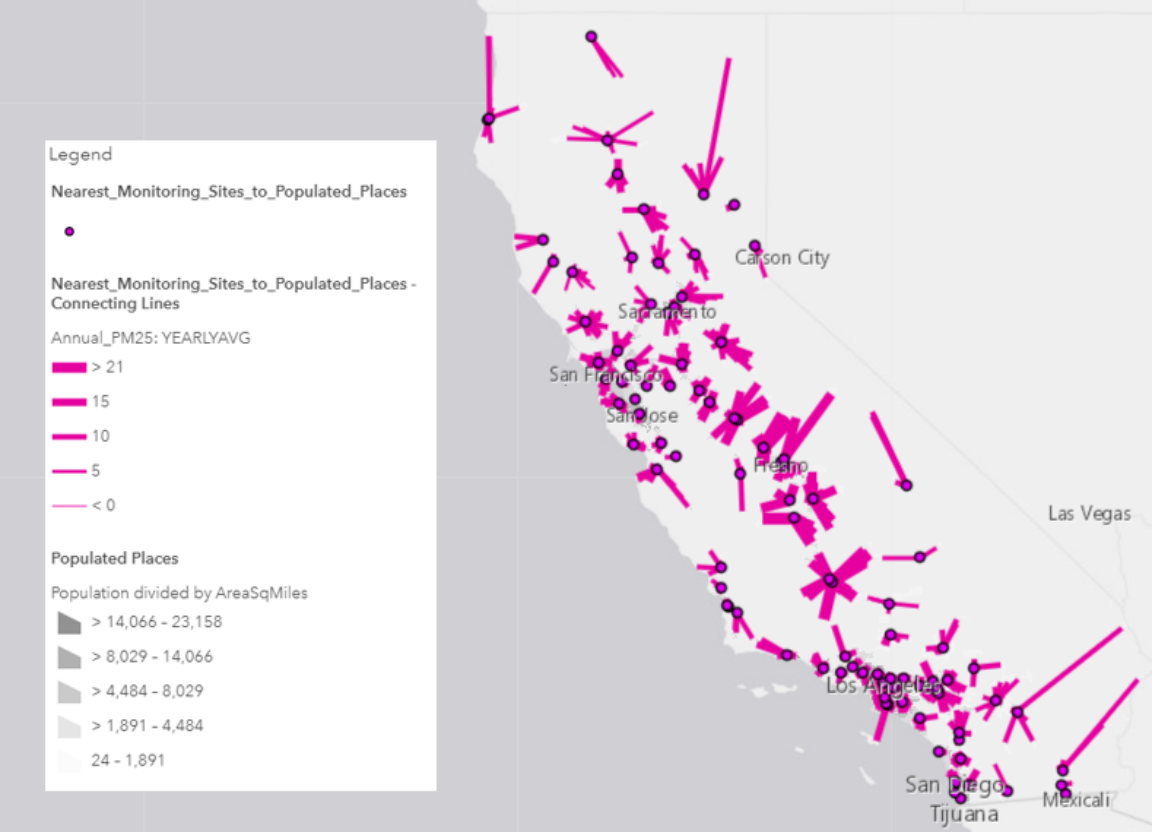
h Set the Maximum Size to 9 px.

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

i 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.

j View the map legend.



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 stations to these places.

k 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 both California and other states to see the difference in potentially affected population sizes between the two standards. Using the value from the nearest monitor, 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

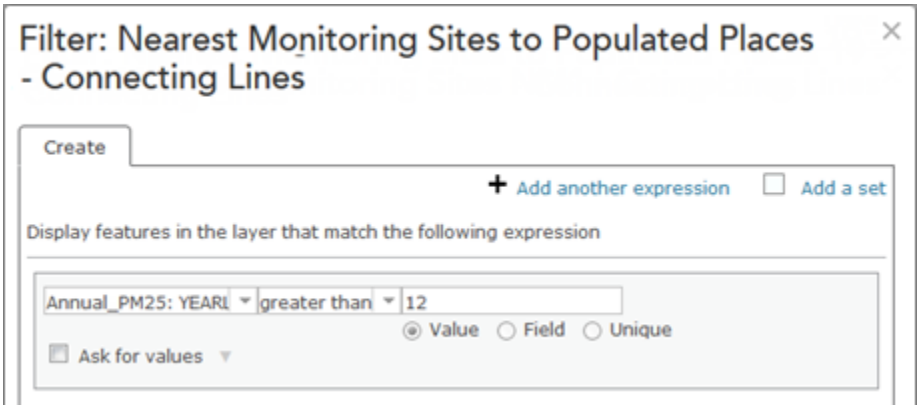
You would like your report to include a map that shows populations living where exposure exceeds state and federal ambient air quality standards for particulate matter.

You can filter the data to find areas where exposure is greater than these values.

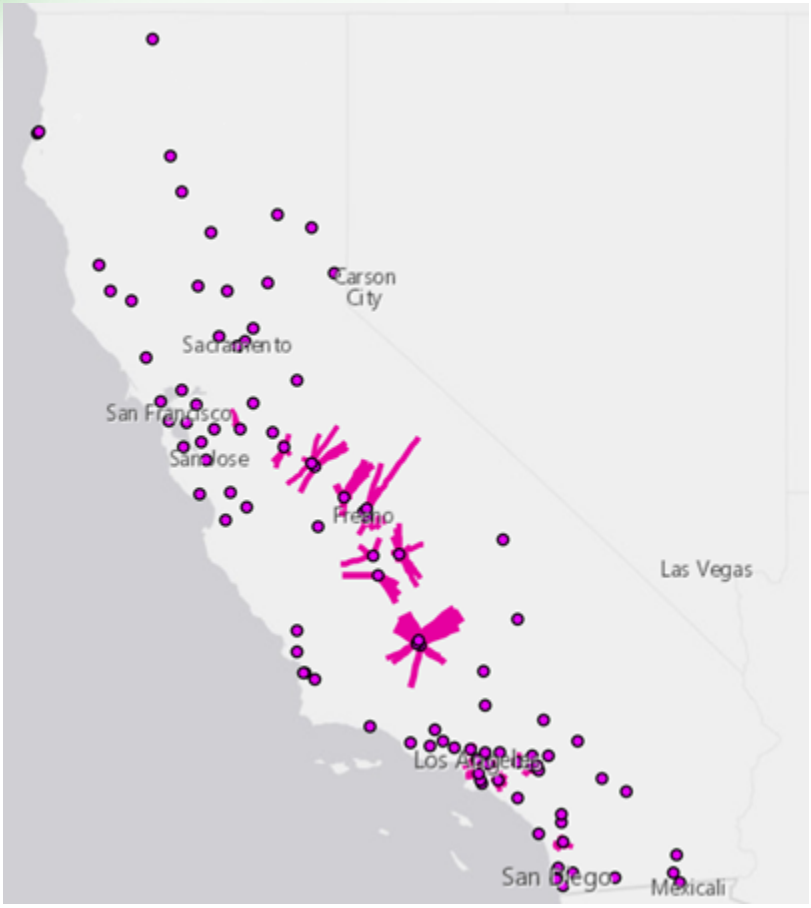
a. Create a filter to identify the populated places where the annual PM value exceeds the state ambient air quality standard of 12 micrograms.

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

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



b. Click Apply Filter.



Areas where the annual PM2.5 particulate matter exposure is greater than 12 ;g/m3.

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 get statistics to identify the total potential exposed population.

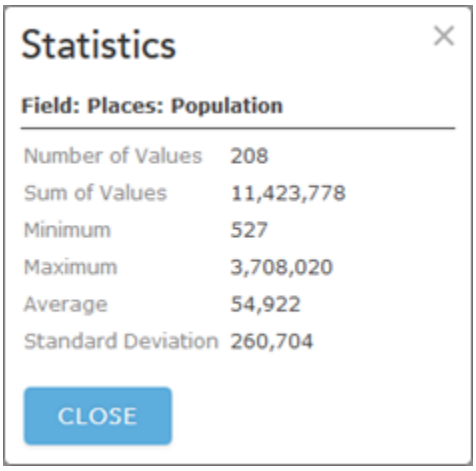
a. Open the table for the Nearest Monitoring Sites To Populated Places - Connecting Lines layer.

Nearest Monitoring Sites to Populated Places - Connecting Lines... (208 features, 0 selected) Options ▾

Near Rank	Straight Line Distance (Miles)	Places: ID	Places: GEOID	Places: NAME	Places: Population	Places: Males	Places: Females	Places: Children	Places: Elderly
1	0.00	26	0614218	Clovis	95243	45981	49262	22156	9859
1	0.00	182	0627000	Fresno	485798	237654	248144	123273	44273

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.



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 pop-up window.

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

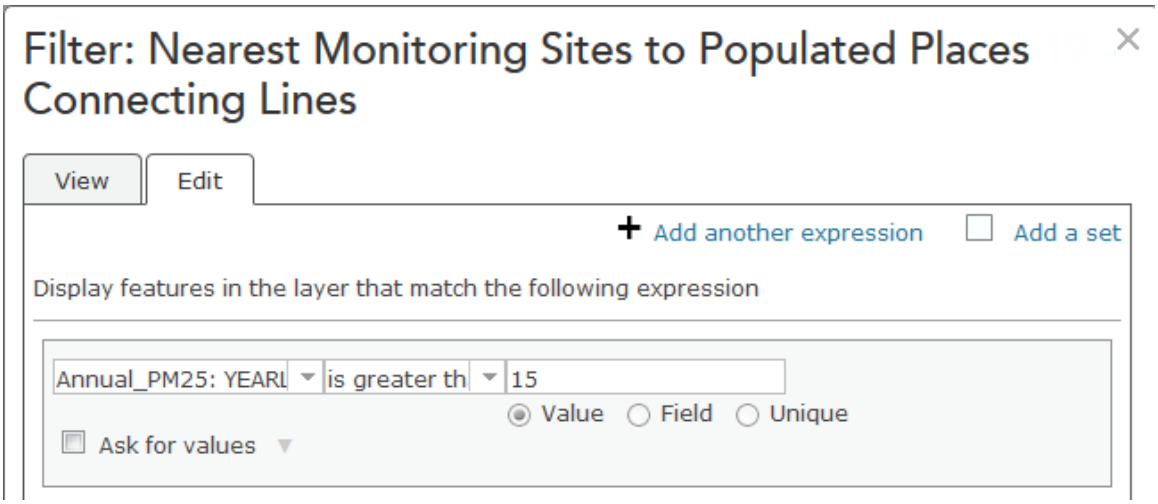
Step 17: Edit a filter

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

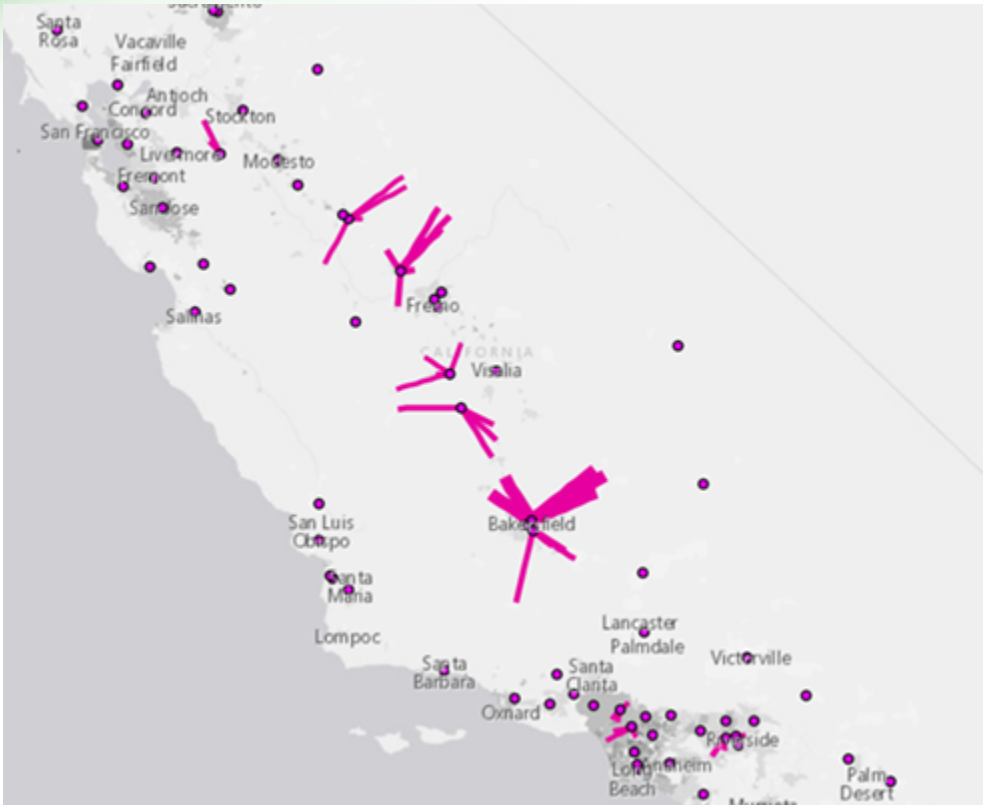
a. Edit the filter so that places with an annual PM value that exceeds the federal standard value of 15 are used for the subsequent analysis.

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

- In the Contents pane, point to 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**.



b. Click Apply Filter.



Areas where the annual PM2.5 particulate matter exposure is greater than 15 ;g/m3.

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).

c Examine the 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: Children	Places: Elderly
1	0.00	21	0646898	Merced	77,878	38,059	39,819	20,776	6,583
1	22.31	25	0619612	Dos Palos	4,922	2,419	2,503	1,289	513

There are 58 locations in the state where people are potentially exposed to air pollution greater than federal standards. You are pleased to see that 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.

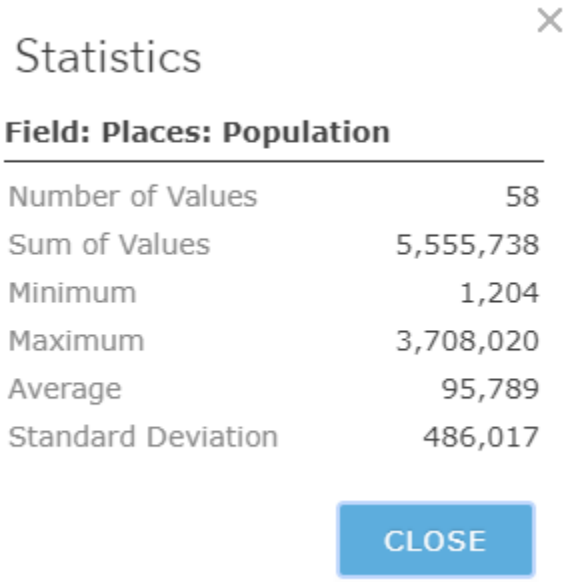
Your report will also identify how many people are living in places where exposure exceeds federal standards. You need to obtain statistics for these results.

Step 18: Calculate statistics

In your report, you want to include the total population living in the areas, as well as the number of children and elderly.

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

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



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

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 monitors are located some distance from populated places, and the population numbers are low. In Los Angeles, there are several monitors; distances to the nearest monitor are much shorter, and affected populations are much larger.

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

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

b Close the Statistics pop-up window.

c Close the table.

Your concern with the approach of using the nearest monitor is based on your knowledge of the sources of PM2.5. You know that it will vary spatially, and 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.

A different approach

Next, you will use a different approach to try to get a better understanding of true exposure risks using geostatistical interpolation (https://bit.ly/31N3j3D). Because particulate matter is wind-blown, exposure can vary. Simply living in an area with a monitoring station or nearby a monitoring station 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.

Step 19: Interpolate values

You decide to interpolate the particulate values from monitoring sites using the sample point collected values at monitoring stations—the same ones you used for straight line distance.

a In the Contents pane, point to 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 Move the optimizer 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. Currently, Esri is updating the optimization for accuracy in ArcGIS Online. If you try the accuracy or midway options on the slider, you may find that the analysis will not complete, even after a few hours.

g. Check the box for Output Prediction Errors.

Checking this box will ensure that a layer of standard errors for the interpolation predictions is created. This 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 will ensure 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**.

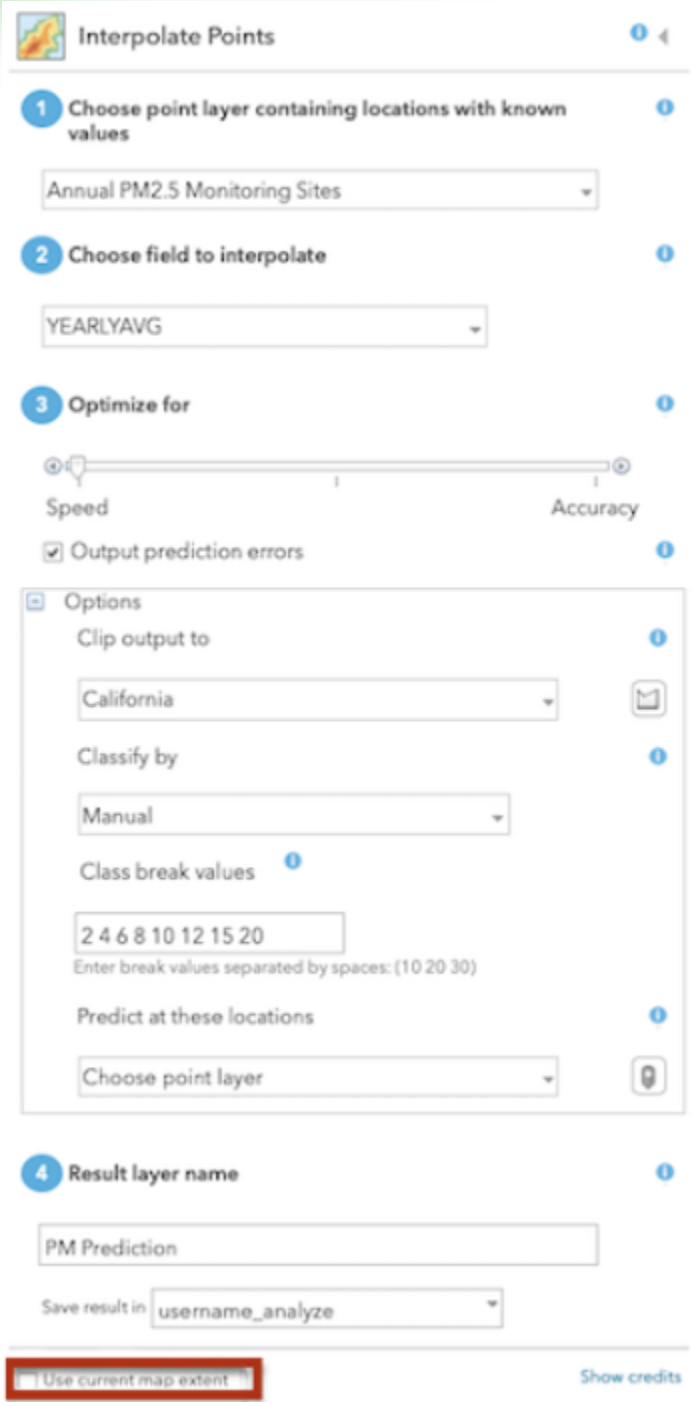
Note: These values should be separated by a space. It is important that values cover all the ranges in your data and include the two values of interest: state and federal exposure limits.

l. For Result Layer Name, type **PM Prediction_yourfirstandlastname**.

Note: If you run the analysis multiple times, you will need to give 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.



The box for Use Current Map Extent is checked by default. This setting limits the results to your current map extent. The map extent (https://bit.ly/2StbI9J) refers to the portion of the map displayed on screen at a given moment.

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.

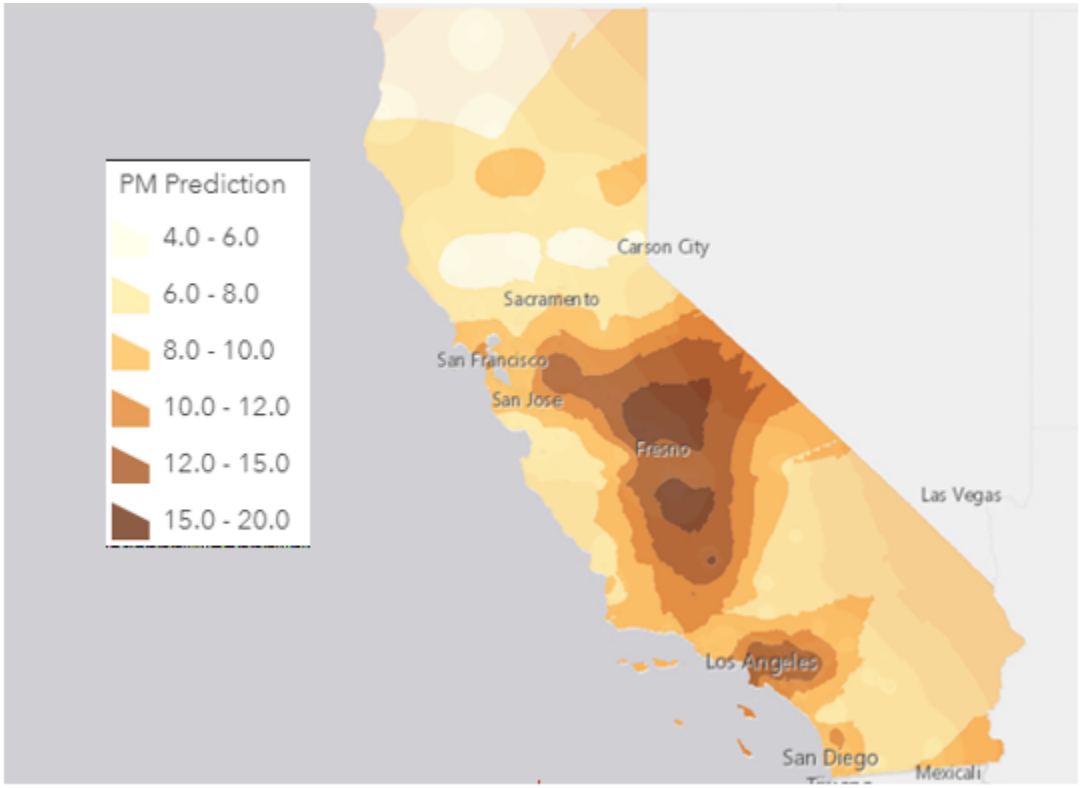
n. Click Run Analysis.

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

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

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

q. View the map legend.



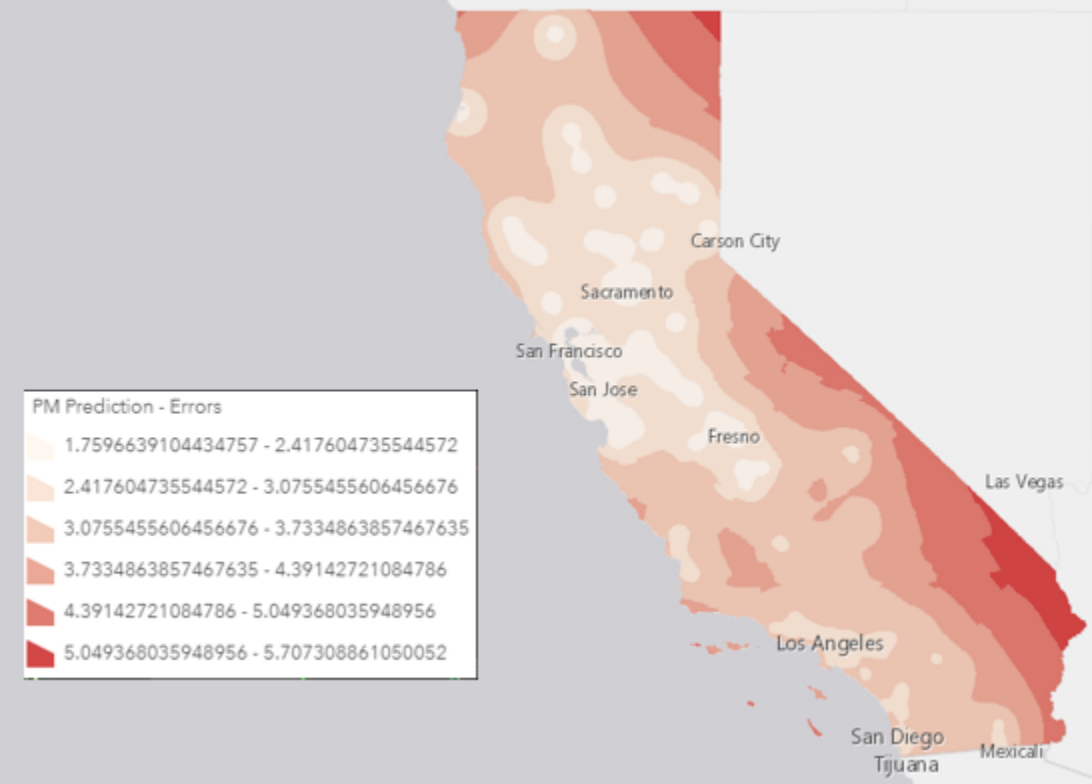
The map results show the prediction surface with prediction errors in the layer beneath it. Areas with higher predicted exposure values appear in a darker color.

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.

a Turn off the PM Prediction layer to view the 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 values at each location (less uncertainty), and red areas have much less accuracy (more uncertainty). You can compare this prediction error surface to the monitoring station layer. You can see that areas of lower uncertainty are generally also areas with denser distribution of monitoring stations.

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

b. In the Contents pane, turn the PM Prediction layer back on.

c. Save your map.

Next, you want to find places that have predicted PM2.5 values that exceed the state standard of 12 micrograms, followed by areas that exceed the federal standard of 15 micrograms.

Step 21: Find existing locations - State levels

You will again use location analysis to find the areas that have predicted values that are at or exceeding the state and federal standard exposure levels. The Find Existing Locations tool can be used for selecting existing features to identify areas that meet the specified criteria.

First, you will focus on the state exposure levels.

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

b. Expand Find Locations.

c. Click Find Existing Locations.

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

Note: First, try creating the spatial query expression on your own. If needed, the 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.
- For the second field, choose Intersects.
- For the third field, choose the PM Prediction layer.

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

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

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

- Click Add Expression.
- For the first field, choose the PM Prediction 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 12 micrograms or greater.

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

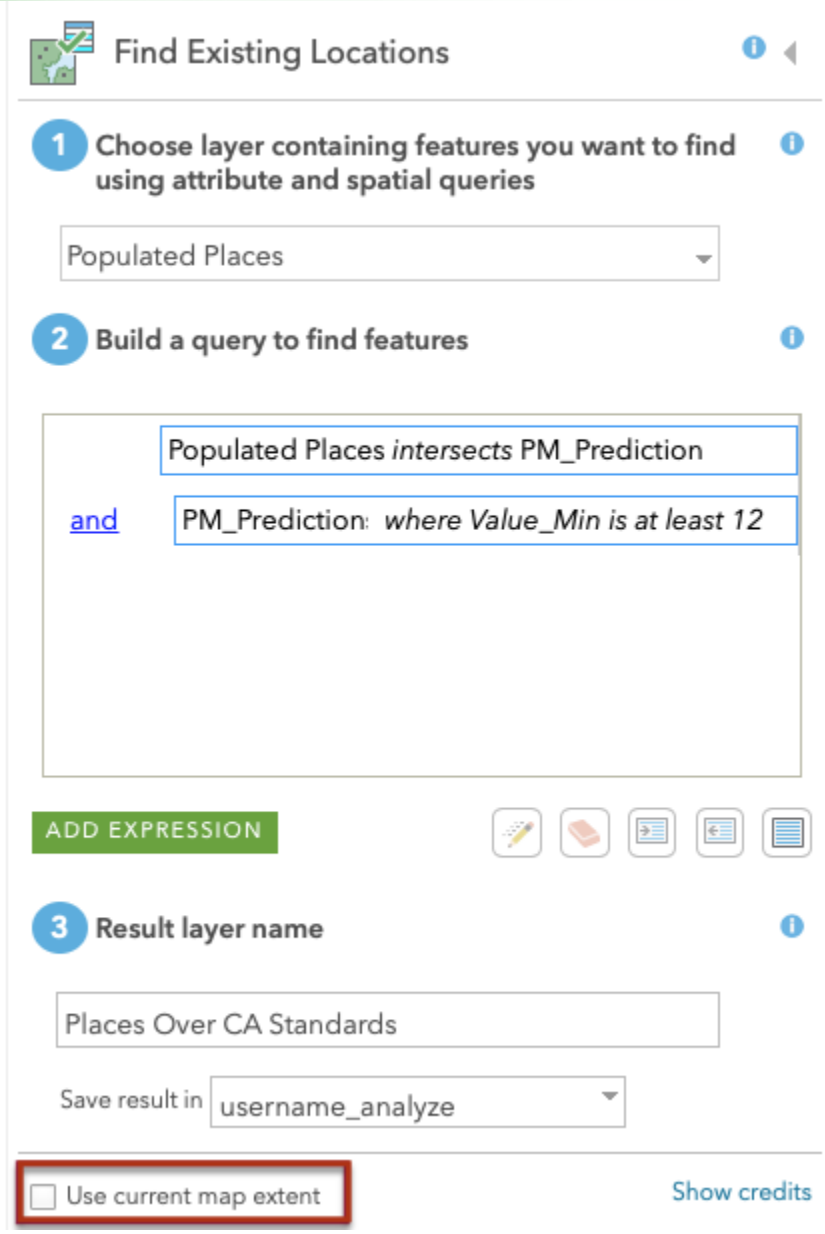
g. Click Add to add the expression to the Find Existing Locations pane.

h. For Result Layer Name, type **Places Over CA Standards_yourfirstandlastname**.

Note: If you run the analysis multiple times, you will need to give 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.

i. At the bottom of the Find Existing Locations pane, uncheck the box for Use Current Map Extent.



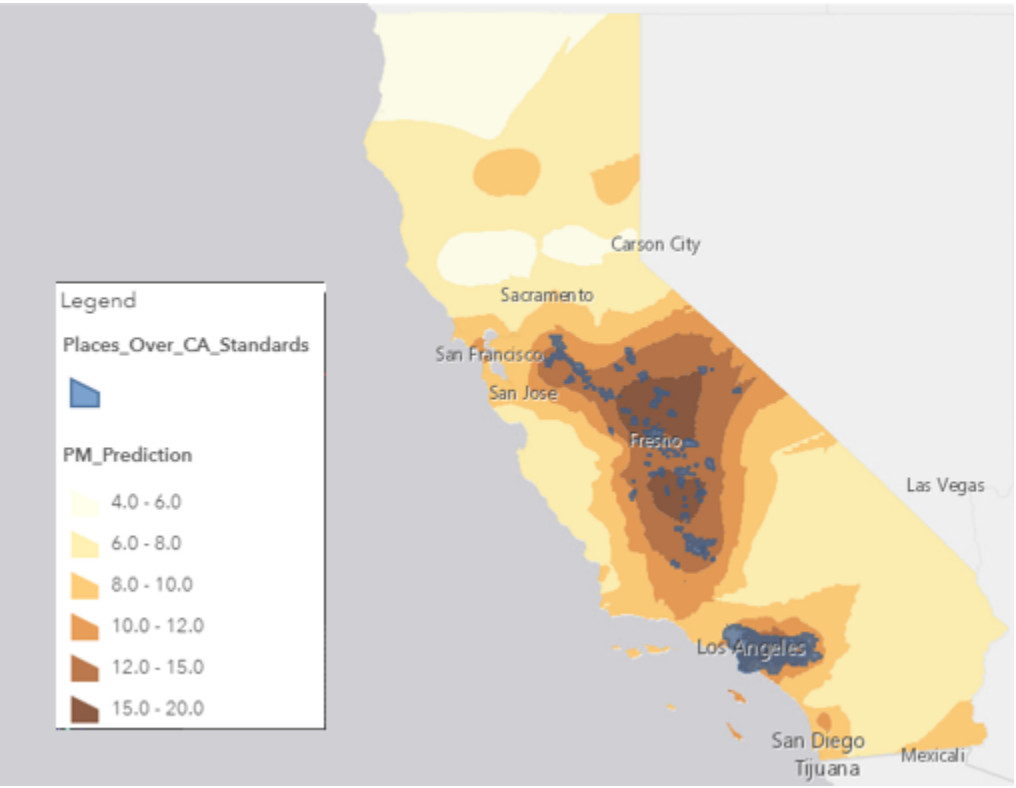
The box for Use Current Map Extent is checked by default. This setting limits the results to your current map extent. The map extent (https://bit.ly/2StbI9J) refers to the portion of the map displayed on screen at a given moment.

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.

j Click Run Analysis.

k Turn off the PM Prediction - Errors layer.

l View the map legend.



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).

m Zoom and pan the map to examine the results.

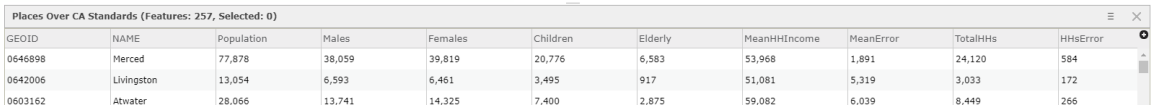
As you examine the results, you notice that some of the areas extend beyond the identified exposure range areas (the interpolated values) in the PM Prediction layer. When you are working with population data known for places (as area data), if any part of the area is intersected by the identified exposure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

a Open the table for the new Places Over CA Standards layer.

There are 257 locations in the study area where exposure levels are predicted to be greater than state standards.

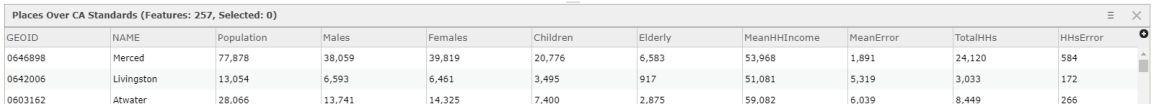


Places Over CA Standards (Features: 257, Selected: 0)

GEOID	NAME	Population	Males	Females	Children	Elderly	MeanHHIncome	MeanError	TotalHHs	HHsError
0646898	Merced	77,878	38,059	39,819	20,776	6,583	53,968	1,891	24,120	584
0642006	Livingston	13,054	6,593	6,461	3,495	917	51,081	5,319	3,033	172
0603162	Atwater	28,066	13,741	14,325	7,400	2,875	59,082	6,039	8,449	266

The funding body will ask certain obvious questions about how many people live in these areas and how many of those people are children or elderly. Examining statistics will provide the answers.

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



Places Over CA Standards (Features: 257, Selected: 0)

GEOID	NAME	Population	Males	Females	Children	Elderly	MeanHHIncome	MeanError	TotalHHs	HHsError
0646898	Merced	77,878	38,059	39,819	20,776	6,583	53,968	1,891	24,120	584
0642006	Livingston	13,054	6,593	6,461	3,495	917	51,081	5,319	3,033	172
0603162	Atwater	28,066	13,741	14,325	7,400	2,875	59,082	6,039	8,449	266

According to your initial analysis, the population currently 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 Standard (14,434,417) varies, which is not unexpected. You used the Find Nearest tool in the first set of analyses. The population value using the Find Existing Locations analysis, based on a model adjusted for speed is larger. You expect that there would be overestimating.

Note: You can determine the number of children or elderly living in these areas by getting statistics on the Children and Elderly fields in the table.

c. Close the Statistics pop-up window.

d. Close the table.

e. Turn off the Places Over CA Standards layer.

f. Zoom 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 - Federal levels

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

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

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

- In the Contents pane, point to the Populated Places layer name and click the Perform Analysis button .
- Expand Find Locations.
- 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 layer.

b. Add the expression to the Find Existing Locations pane.

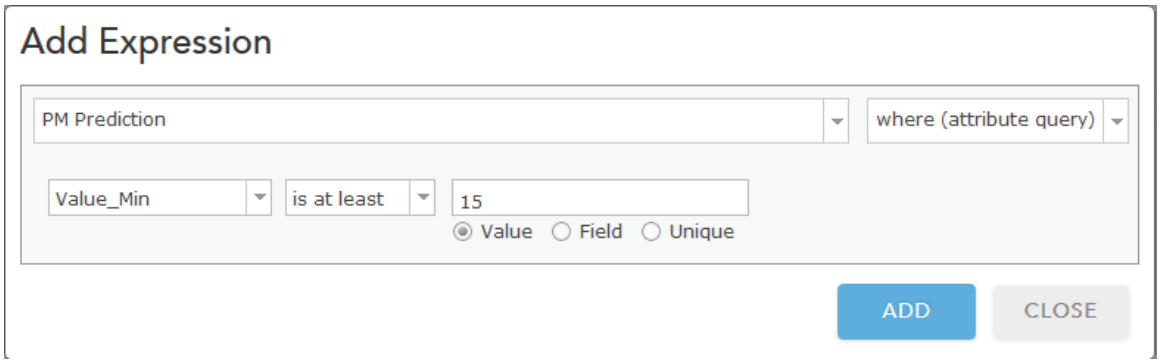
c. Next, add an attribute query expression to select only those areas where the predicted yearly average values are greater than 15 micrograms.

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

- Click Add Expression.
- For the first field, choose the PM Prediction 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**.

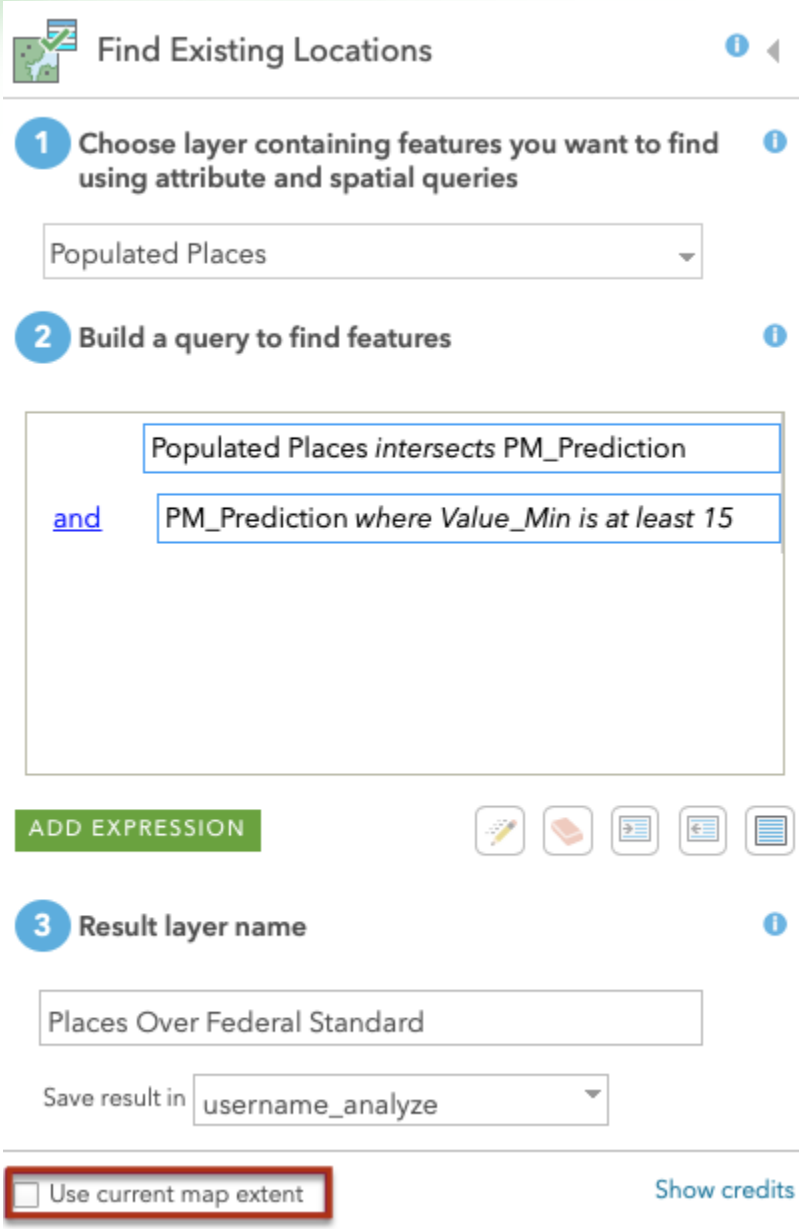


d. Add the expression to the Find Existing Locations pane.

e. For Result Layer Name, type **Places Over Federal Standards_yourfirstandlastname**.

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.

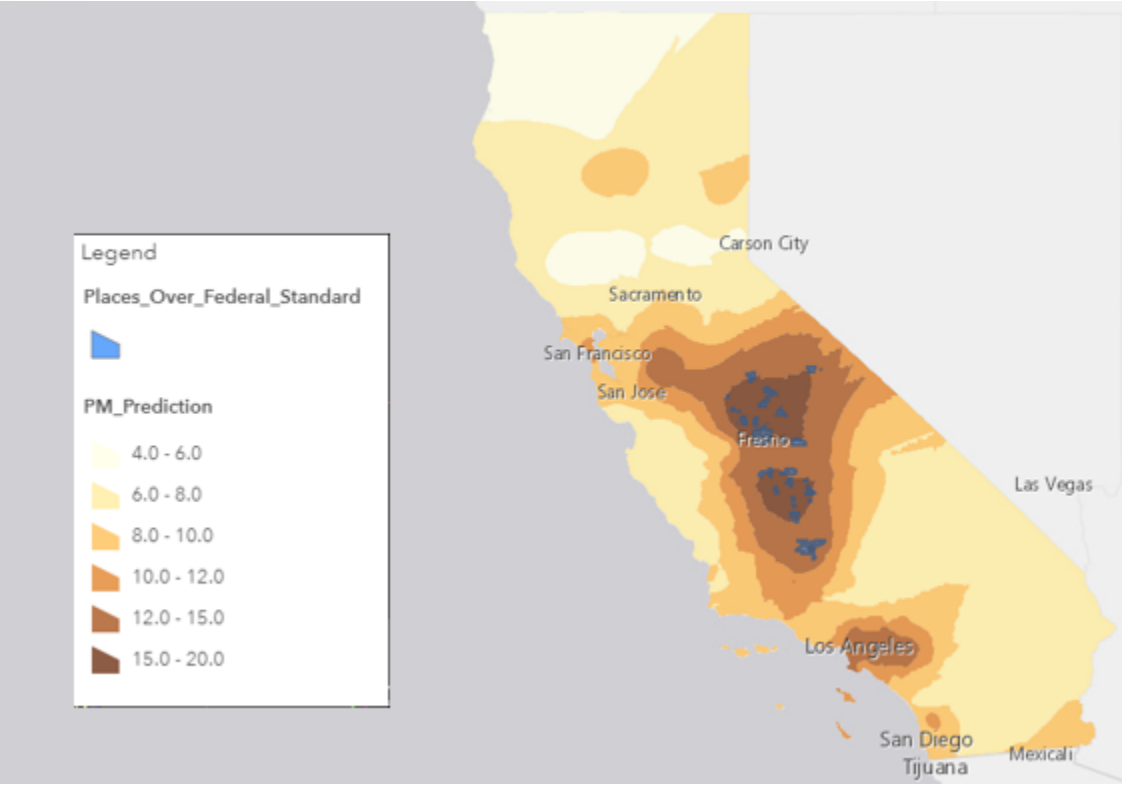


The box for Use Current Map Extent is checked by default. This setting limits the results to your current map extent. The map extent (https://bit.ly/2StbI9J) refers to the portion of the map displayed on screen at a given moment.

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.

h View the map legend.



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

i Zoom and pan the map to examine the results.

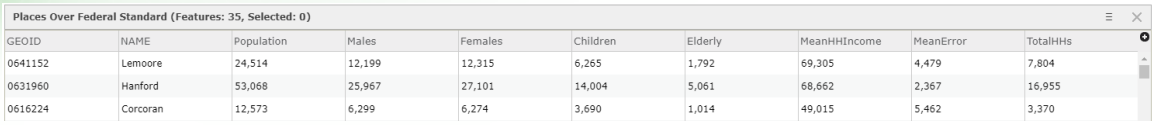
Using the interpolated annual average values, you can find the places and estimate the number of people who live where the PM2.5 levels are greater than 12 $\mu g/m^3$ and 15 $\mu g/m^3$. You will next identify how many people live in the areas with predicted exposure values exceeding federal standards.

Step 24: Examine the data

To better understand the results and to obtain the values needed for your report, you will examine the data.

a Open the table for the new Places Over Federal Standards layer.

There are 35 locations in the study area where exposure levels are predicted to be greater than federal standards.



Places Over Federal Standard (Features: 35, Selected: 0)

GEOID	NAME	Population	Males	Females	Children	Elderly	MeanHHIncome	MeanError	TotalHHs
0641152	Lemoore	24,514	12,199	12,315	6,265	1,792	69,305	4,479	7,804
0631960	Hanford	53,068	25,967	27,101	14,004	5,061	68,662	2,367	16,955
0616224	Corcoran	12,573	6,299	6,274	3,690	1,014	49,015	5,462	3,370

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

b Get 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 currently living in areas with exposure levels greater than federal standards is 5,555,738. The total population in the prediction results (1,473,139 people) varies significantly compared to those obtained using the nearest monitor.

Using the nearest monitor, 58 places have monitored values of over 15 µg/m^3. On the other hand, when using interpolation, only 35 features are located in an area with PM2.5 values that exceed 15 µg/m^3.

c Close the Statistics pop-up window and the table.

Preparing results

You decide to show the values for each analysis method in a table and provide an explanation for the different values.

Standards for ambient air quality	Nearest monitor (first analysis)	Interpolated surface (second analysis)
California standard (12 µg/m^3)	11,423,778	14,434,417
Federal standard (15 µg/m^3)	5,555,738	1,473,139

The potentially exposed population is much greater for federal standards (15 µg/m^3) when taking the PM value from the nearest monitor than when using the interpolated values. Many monitoring stations 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 station. The nearest station 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 standard, because the high PM2.5 values occur across a smaller area than the more stringent California standard.

The variation over the area is perhaps better represented using interpolation. Interpolation, however, relies on some monitoring stations 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.

You now have two layers that represent predictions for exposure to PM2.5 particulate matter based on state and federal standards. You want to use these layers to support your findings. You decide to make changes to create a better visual representation of the results.

Step 25: Change the map style

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 the Places Over CA Standards layer on.

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.

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

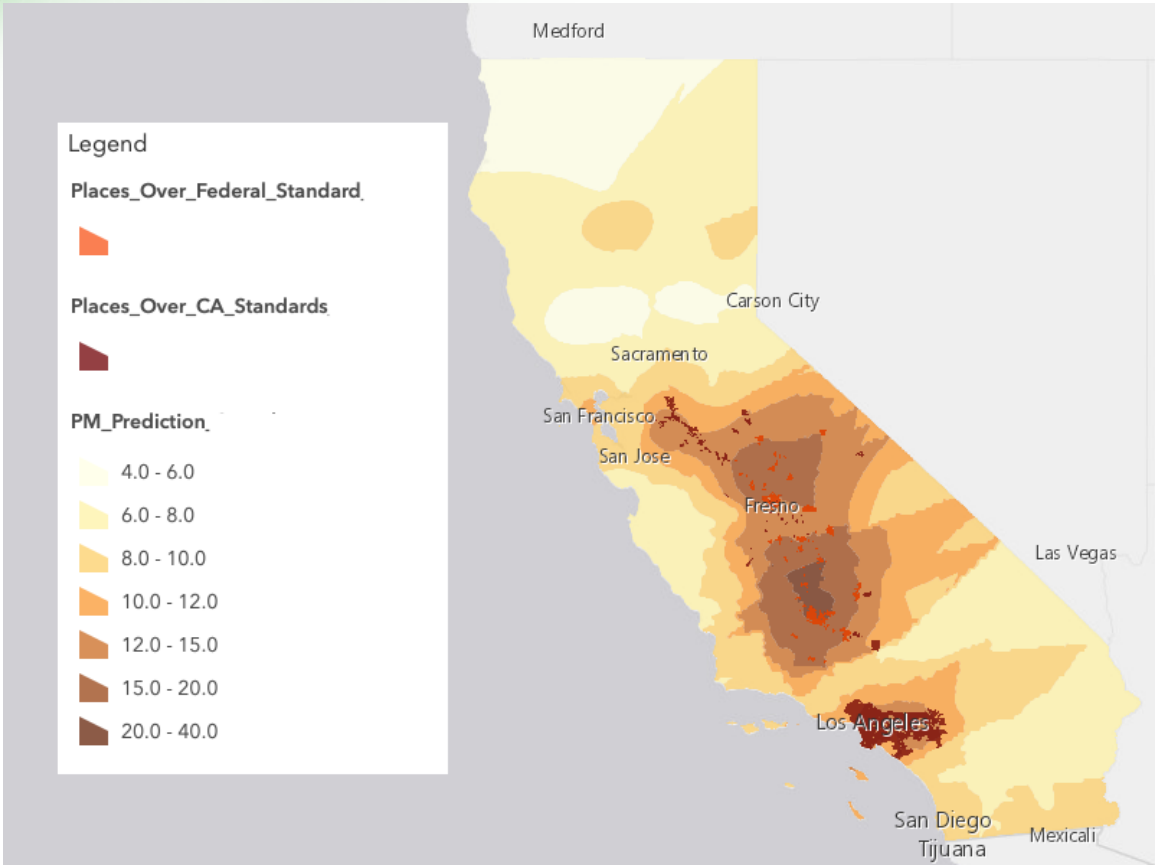
- In the Contents pane, point to the Places Over CA Standards layer name and click the Change Style button  .
- For Choose An Attribute To Show, confirm that Show Location Only is selected.
- For drawing style, under Location (Single Symbol), click Options.
- Click Symbols.
- At the top of the pop-up window, click the Fill tab if necessary.
- Choose a dark red color (such as hex color #730000).
- At the top of the pop-up window, click the Outline tab and set the line width to 0 px.
- Click OK to close the pop-up 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 solid orange (such as hex color #FF5500) instead of dark red.

d. Turn off the Populated Places layer.

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



The results show the places 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 attribute display 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. In the Contents pane, point to the Places Over CA Standards layer name and click the More Options button ••• .

b. From the context menu, choose Configure Pop-up.

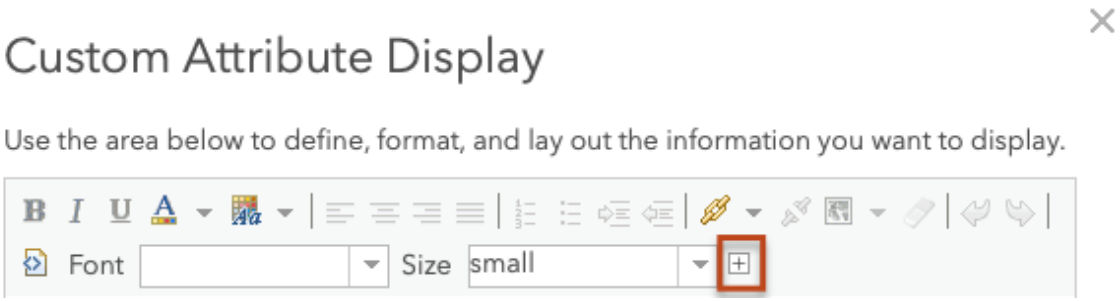
c. In the Configure Pop-up pane, for Pop-up Title, accept the default title.

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.

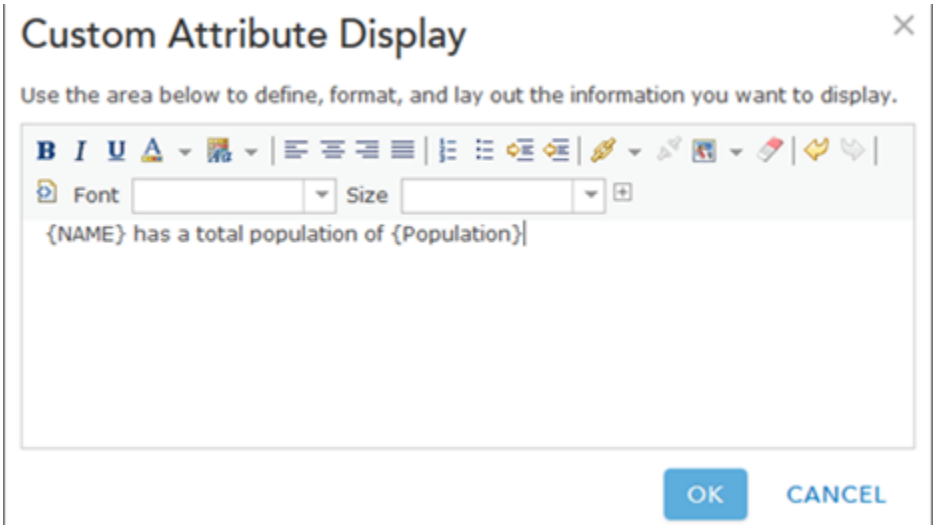
f. In the Custom Attribute Display window, to the right of the font size, click the Add Field Name button as shown in the following graphic.



g. Choose NAME {NAME} from the context menu.

h. In the area below the toolbar, click after {NAME}, add a space, 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 funding body will be interested in the number of children and elderly in each selected place. You will add a chart to display these values in the pop-up window.

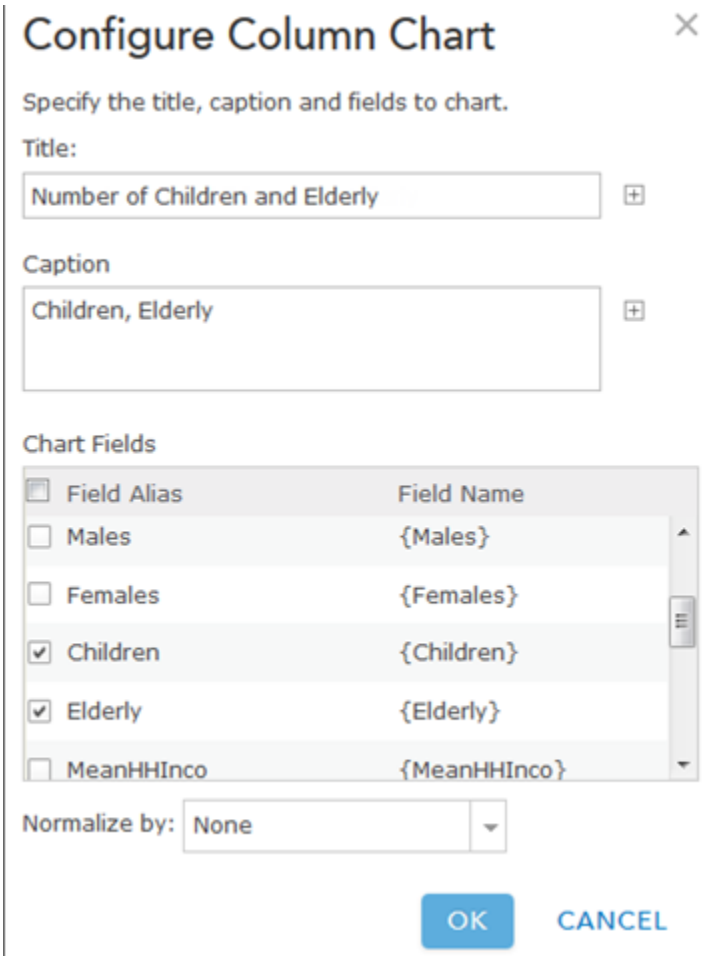
k. In the Pop-up Media section, click Add and choose Column Chart.

l. In the Configure Column Chart window, for Title, type **Number of Children and Elderly**.

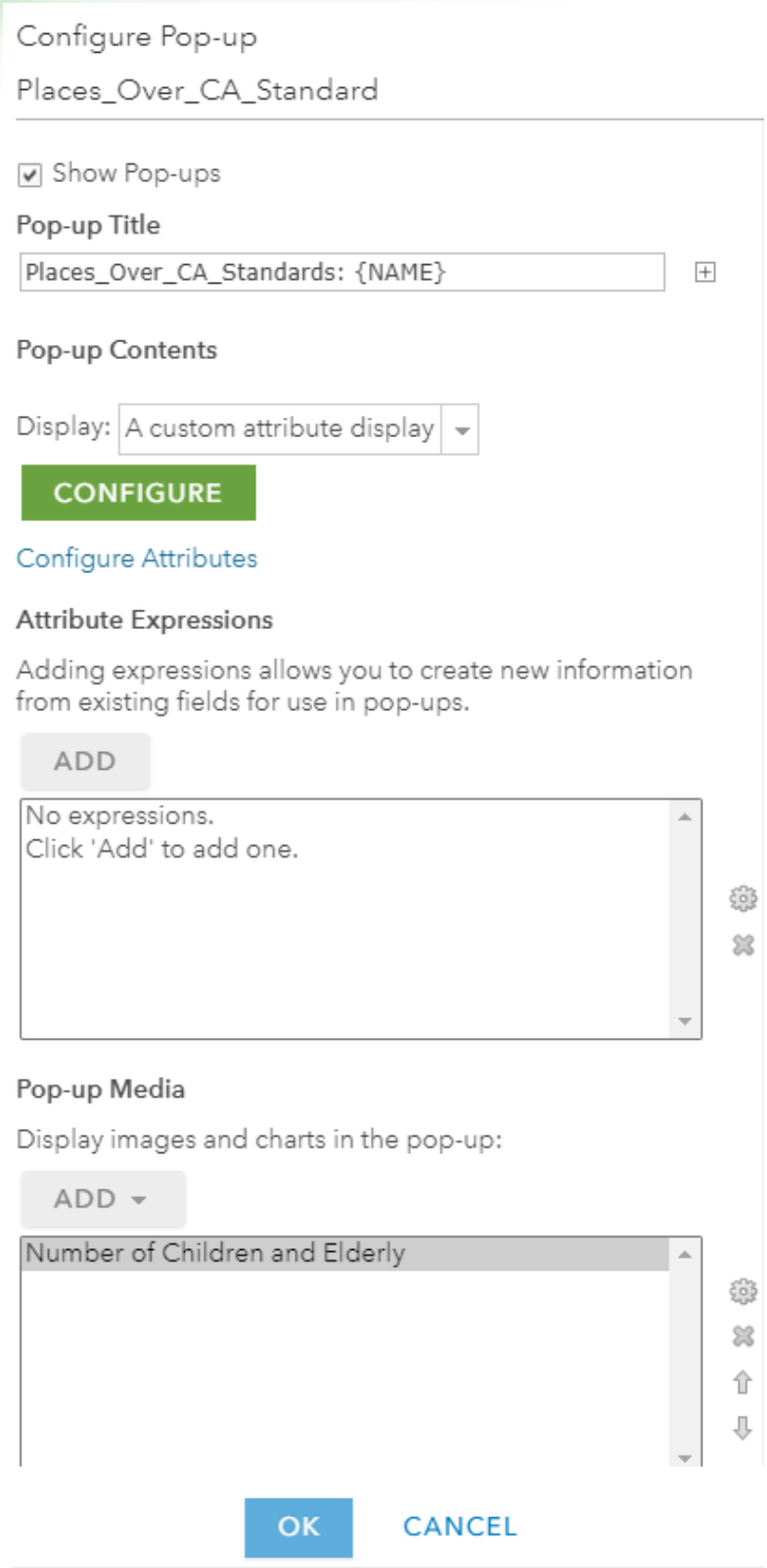
m. For Caption, type **Children, Elderly**.

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

n. In the Chart Fields section, check the Children and Elderly boxes.

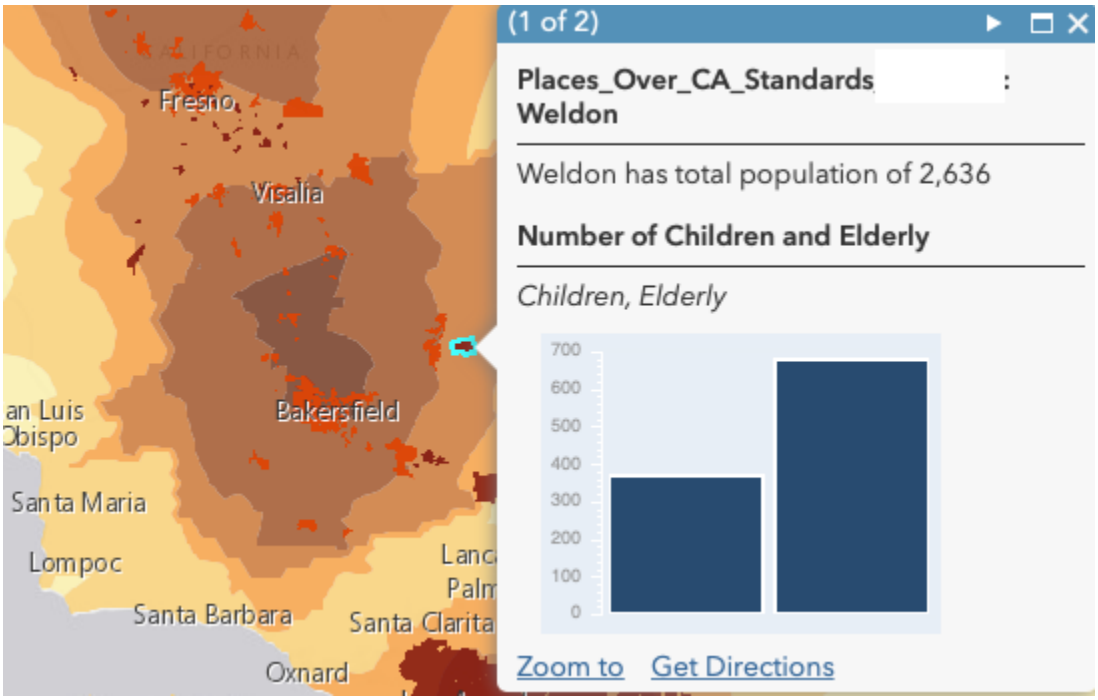


o. Click OK.



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

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



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 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 by clicking the x in the top right of the window.

Next, you will repeat the process and create a custom information pop-up window for the Places Over Federal Standards layer.

Step 27: Create another custom attribute display pop-up

You will create a second custom information pop-up window, this time for the Places Over Federal Standards layer.

a. In the Contents pane, point to the Places Over Federal Standards layer name and click the More Options button ••• .

b. From the context menu, choose Configure Pop-up.

c. In the Configure Pop-up pane, for Pop-up Title, accept the default title.

d. For Display, choose A Custom Attribute Display.

e. Click Configure.

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

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

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

i. Click OK.

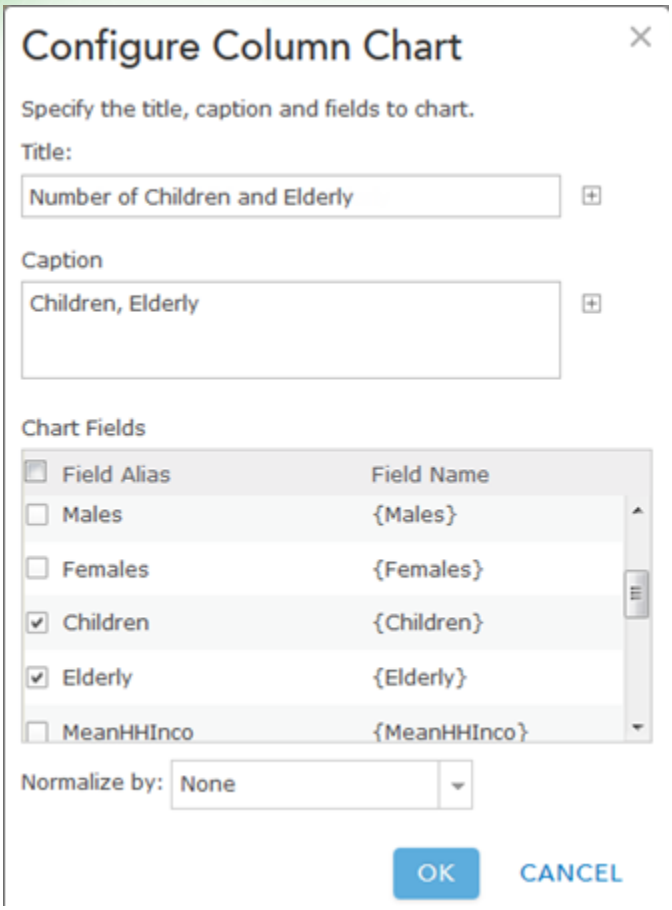
j. In the Pop-up Media section, click Add and choose Column Chart.

k. In the Configure Column Chart window, for Title, type **Number of Children and Elderly**.

l. For Caption, type **Children, Elderly**.

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

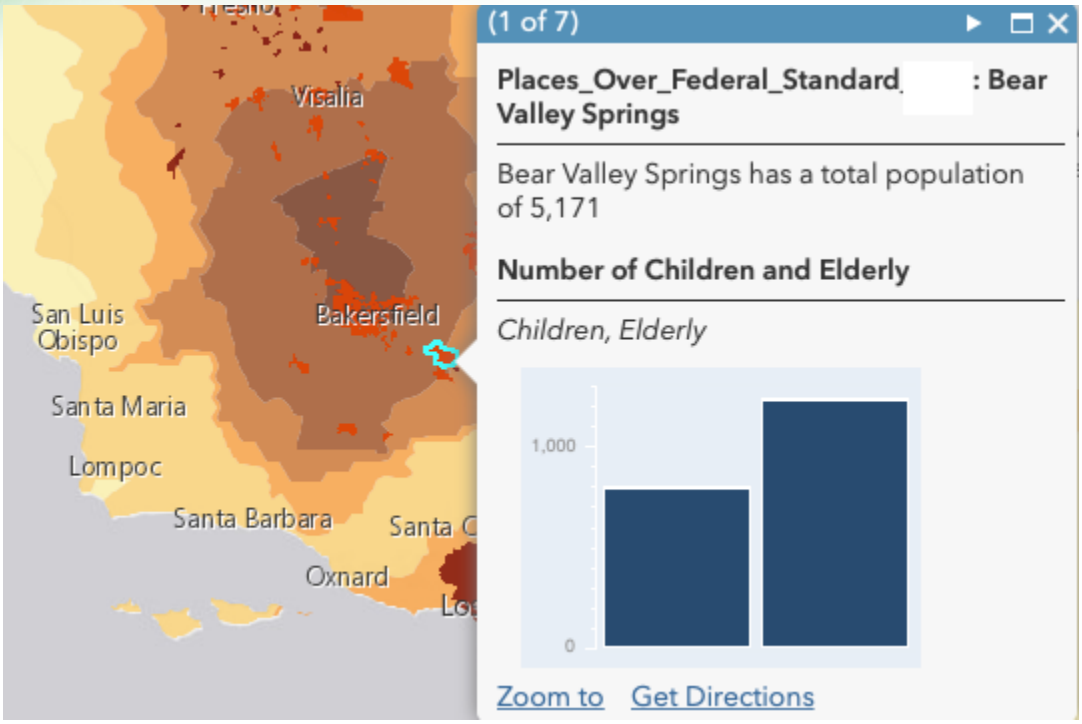
m. In the Chart Fields section, check the Children and Elderly boxes.



n. Click OK.

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

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



q. 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 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.

r. Close the pop-up by clicking the x in the upper right of the window.

Step 28: Save the map

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 station. You can also use interpolated values across the whole state together with a measure of uncertainty.

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. In the ribbon above the map, click Save, and then choose Save.

The map will be saved to your My Content collection.

c. Close your private or incognito browser window.

Conclusion

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. You hope that this information will support decisions related to future cardiopulmonary rehabilitation programs.

In this exercise, you looked at an example of the type of problem that can be addressed by applying predictive analysis and interpolation.