

MODULE 3

UNDERSTANDING POPULATION DYNAMICS

SUMMARY:	Students will evaluate population estimates and population growth rates and learn why population projections are important for the sustainability of environmental and natural resources.
ACTIVITIES:	Visualize the current population by city and town. Evaluate land ownership in relation to urban development. Examine the population growth rates of cities and towns. Calculate the population density of cities and towns.
SCIENCE STANDARDS:	Utah Science Core 9-12 - Earth Science: Standard 5, Objectives 2b and 2d Utah Social Studies Core 9-12: Utah Studies Strand 5, Standards 5.2 and 5.4 Utah Social Studies Core 9-12: World Geography Strand 2
MODULE LINKS:	https://arcg.is/0um5aj https://factfinder.census.gov

GLOSSARY

Census Designated Place:	A concentration of population defined by the United States Census Bureau for statistical purposes only. These boundaries do not have any legal status.
City/Town/Municipality:	An urban or administrative division having corporate status and local government.
Land Ownership:	The owner or proprietor of land, generally categorized as federal, private, state, or tribal.
Population:	The total number of individuals occupying an area or region.
Population Density:	The number of individuals living in a specified unit of area.
Population Dynamics:	A branch of life sciences that studies the size, composition, and structures of populations over time.
Population Estimate:	An estimate of the current population.
Population Growth Rate:	The rate at which the population increases or decreases in a given time period.
Population Projection:	An estimate of the future population.
United States Census Bureau:	The principal agency of the federal government that is responsible for producing data about the American population and economy.
Urban Planning:	The technical and political process concerned with the development and design of urban environments.

INTRODUCTION

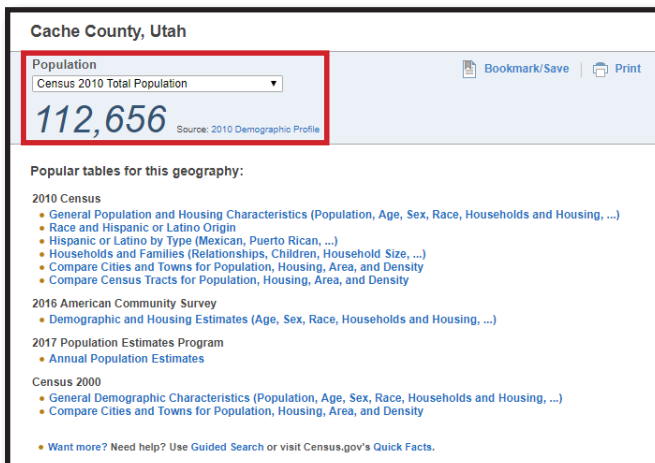
The **population**, or total number of individuals occupying an area or region, is frequently evaluated by urban planners and city managers because the size of a population influences the environment through the use of natural resources, such as water and wildlife habitat, through impacts to water and air quality, and through the production of garbage and sewage. By understanding the **population dynamics** of a city or region, urban planners and city managers can support **urban planning** activities that enhance the natural environment and improve the quality of life for residents.

In this module, the population dynamics for Cache County, Utah, will be evaluated. Measures of population dynamics, such as total population, can be obtained from the **United States Census Bureau**. Total population counts for states, counties, **cities**, **towns**, and **census designated places (CDPs)** are generated by the United States Census Bureau on a decennial basis (or every 10 years). **Population estimates** are calculated on an annual basis using current data on

births, deaths, and migration. Total population counts and population estimates are available from the United States Census Bureau American FactFinder. To identify the population of Cache County, Utah, go to American FactFinder at <https://factfinder.census.gov>. Under Community Facts, type in Cache County, Utah. Hit enter on your keyboard or click on Go.

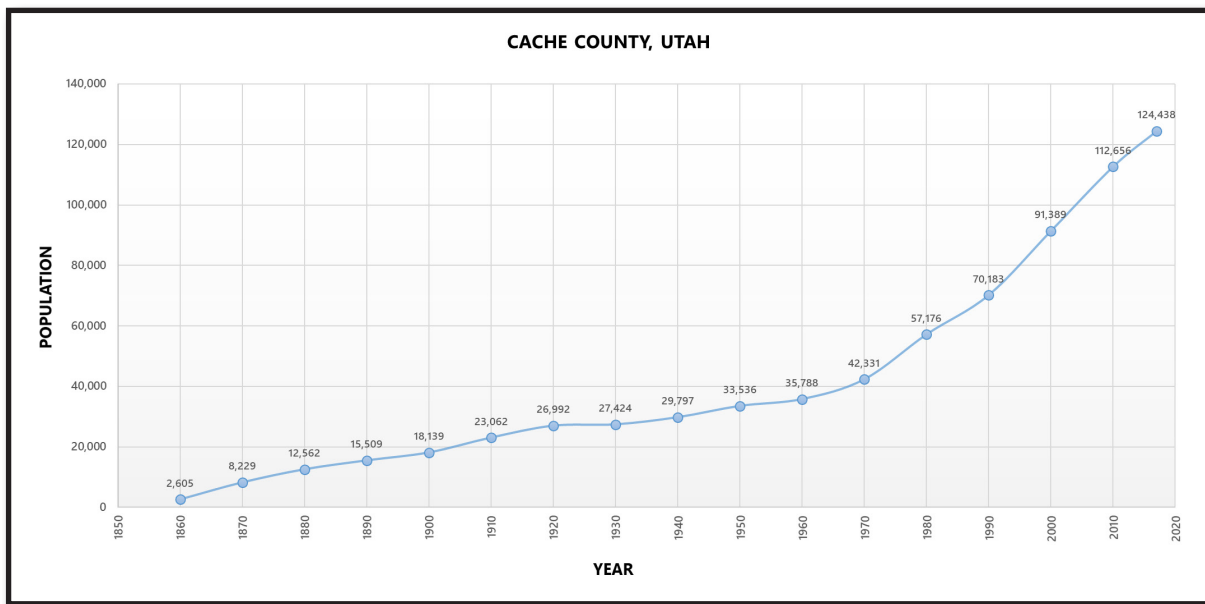


After you have typed in a location (state, county, city, town, or zip code), a box will appear that displays the most recent decennial population count and several links to other population and demographic data. In this example, the *Census 2010 Total Population* for Cache County, Utah, is 112,656. You may note that there is a dropdown menu under the *Population* heading. This will allow you to select other population counts, such as the *2017 Population Estimate* or *2016 ACS 5-Year Population Estimate*. While the *2017 Population Estimate* is just an estimate, it shows that the population of Cache County has increased by nearly 12,000 people during the time period from 2010 to 2017.



In fact, Cache County has experienced rapid population growth in the past few decades. Rapid population growth in Cache County can be attributed to many factors, including the proximity to the highly urbanized Wasatch Front (Salt Lake City and Ogden City), lower property values, and recreational and scenic amenities. Cache County is also globally recognized by technology and manufacturing companies and it is home to Utah State University, a land and space grant university with extensive academic and research programs and opportunities.

Between 1980 and 2010, the population in Cache County nearly doubled in size. In 1980, the population was 57,176. In 2010, the population was 112,656. During this time, many small agricultural communities have grown to become major communities with several thousand residents. For example, Nibley City, located in south-central Cache County, had a population of 1,036 people in 1980. The 2017 Population Estimate indicates a population of 6,917 residents. This represents a seven-fold increase in population or an overall growth rate of 568 percent.



Rapid population growth can be a challenging issue for urban planners and city managers to address because large increases of residents require the development of comprehensive city plans, waste management plans, water and infrastructure networks, transportation plans and networks, and commercial and residential areas. With minimal time to develop comprehensive plans, rapid and unplanned population growth can lead to sprawling development that impacts environmental, natural, and agricultural resources. By understanding the population dynamics of a region or city, urban planners and city managers can anticipate population growth and can support and implement urban planning activities that promote environmental sustainability and stewardship.

INTERACTION

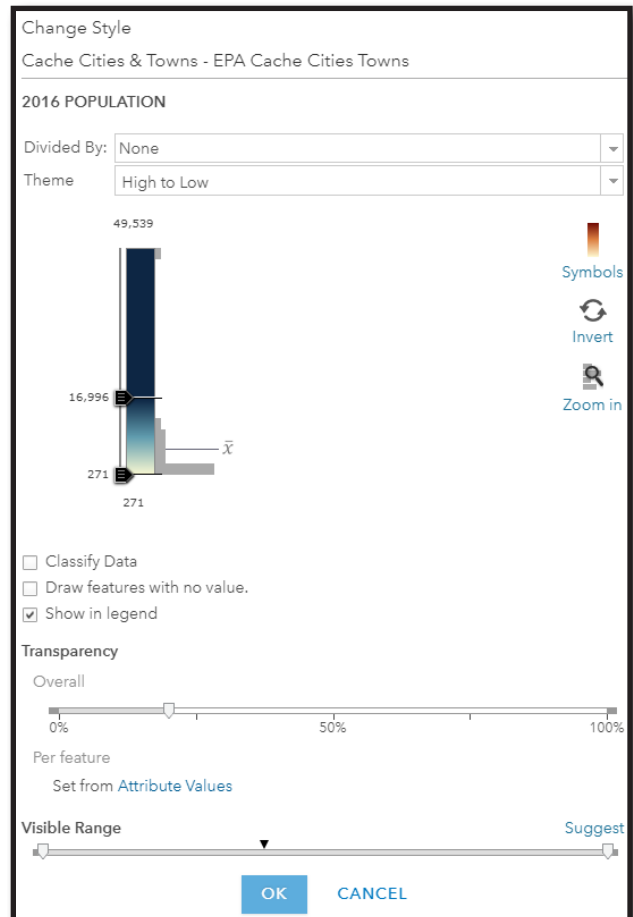
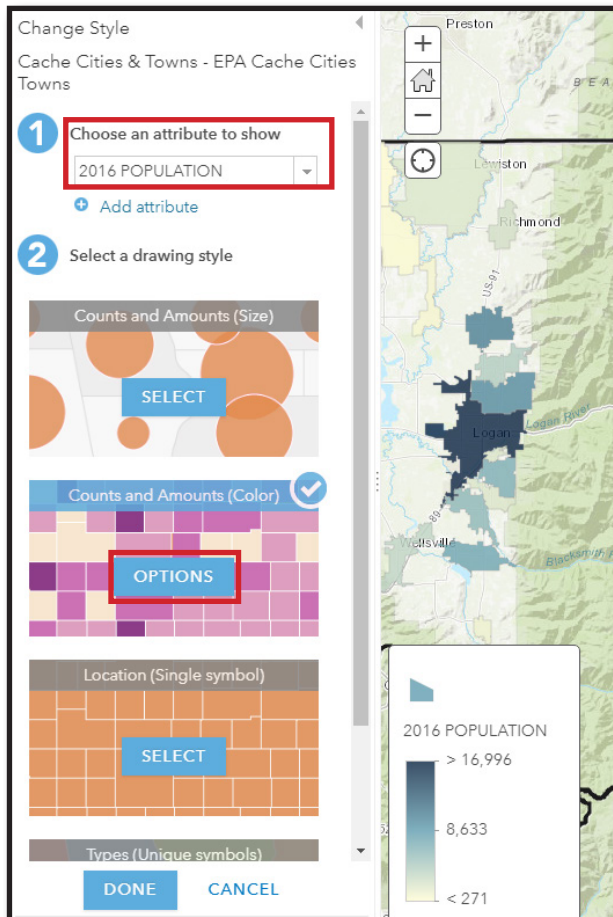
Open the map titled *Module 3 - Understanding Population Dynamics* (<https://arcg.is/0um5aj>). This ArcGIS Online map contains four data layers: *Cache County*, *Cache Cities & Towns*, *Cache CDPs*, and *Cache Land Ownership*. The *Cache County* data layer depicts the Cache County boundary. The *Cache Cities & Towns* data layer depicts the city and town (or municipal) boundaries. **Cities**, **towns**, and **municipalities** are incorporated areas with local governments. The *Cache CDPs* data layers depicts census designated places in Cache County. **Census designated places**, or CDPs, are areas that have concentrations of rural populations, but they do not have administrative or legal status. The *Cache Land Ownership* data layer represents the most basic classification of land ownership in Cache County.

Once you have opened the map, make sure that the *Content* button in the upper left corner is selected. With the *Content* button selected, you can turn the data layers on and off. Evaluate the data layers by turning them on and off and consider how they relate to one another. How can these data layers assist urban planners and city managers in supporting urban planning activities? First, these boundaries identify the geographic locations of cities, towns, and CDPs. Therefore, they provide information about the spatial distribution of people living within Cache County. Second, by pairing this spatial data with population data, such as total population counts and growth rates, it is easier to understand where the majority of the population resides and where the population is likely to increase in size.

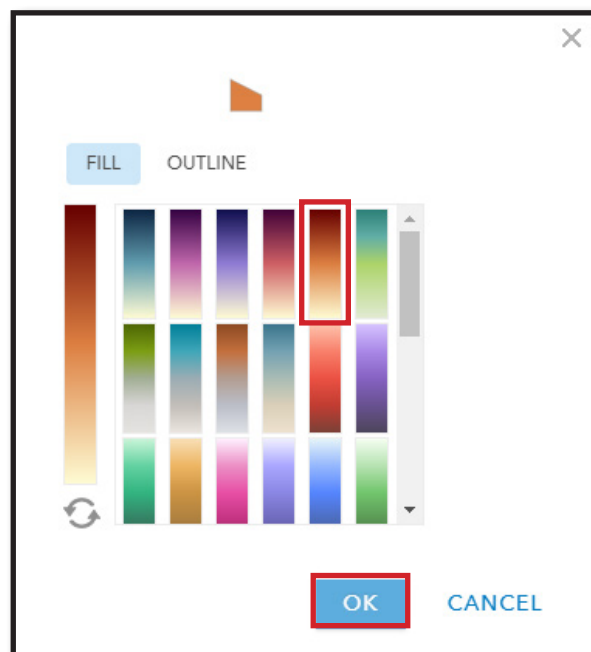
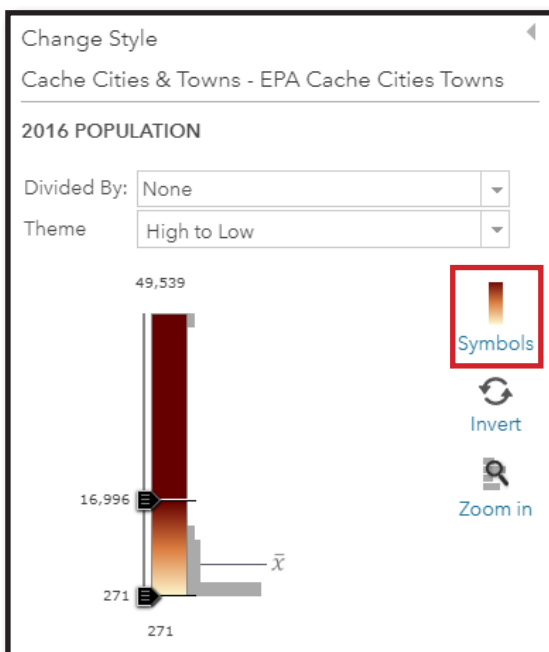
The *Cache Cities & Towns* data layer includes several attributes, including the names of cities and towns, the area (in acres and square miles), several population counts and estimates, average annual growth rates, and population projections. Select a city or town of interest to begin exploring the data and to learn more about the region. Use some of the skills that you learned in the previous module (*Module 2 - Exploring ArcGIS Online*) to evaluate the data by looking at the pop-up windows and the attribute tables.

Since the primary objective of this module is to understand the population dynamics of a region, it is helpful to use maps and symbology to display the distribution of population. With your mouse, hover over the *Cache Cities & Towns* data layer. Click on the *Change Style* button. Below (1) *Choose an attribute to show*, select *2016 POPULATION*. By selecting the *2016 POPULATION*, the symbology methods, or drawing styles, will change. Below (2) *Select a drawing style*, select *Counts and Amounts (Color)*. Click the *SELECT* button.

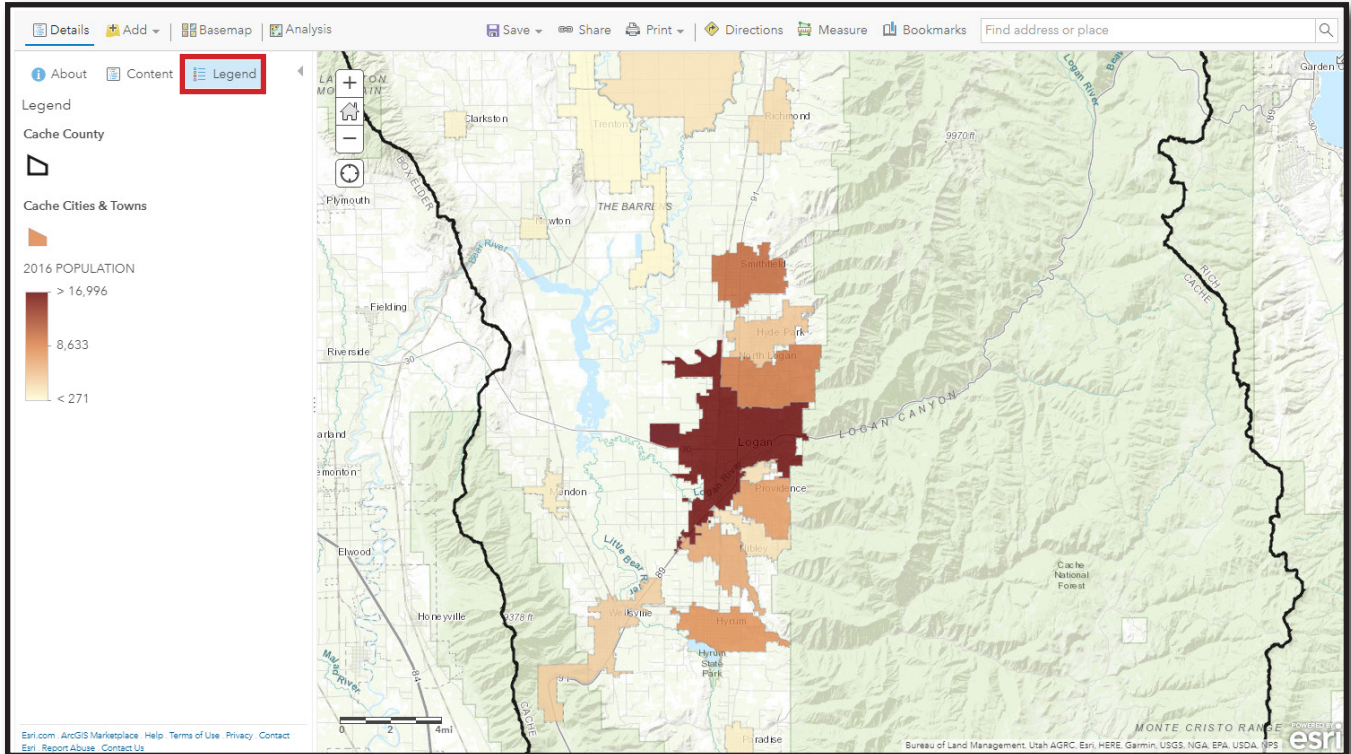
By clicking the *SELECT* button, the symbology will change. However, the symbology can be customized. To customize the symbology, click the *OPTIONS* button that replaced the *SELECT* button located below *Counts and Amounts (Color)*.



Several different symbology options are available to represent the population data. In this exercise, you will select a yellow to dark orange color ramp to symbolize the *2016 POPULATION*. To do this, click on the *Symbols* button located on the right side of the *Change Style* window. This will bring up a series of color ramps. Select the dark orange to yellow color ramp. Click *OK* to apply the changes. Then click *DONE* to close the *Change Style* window.

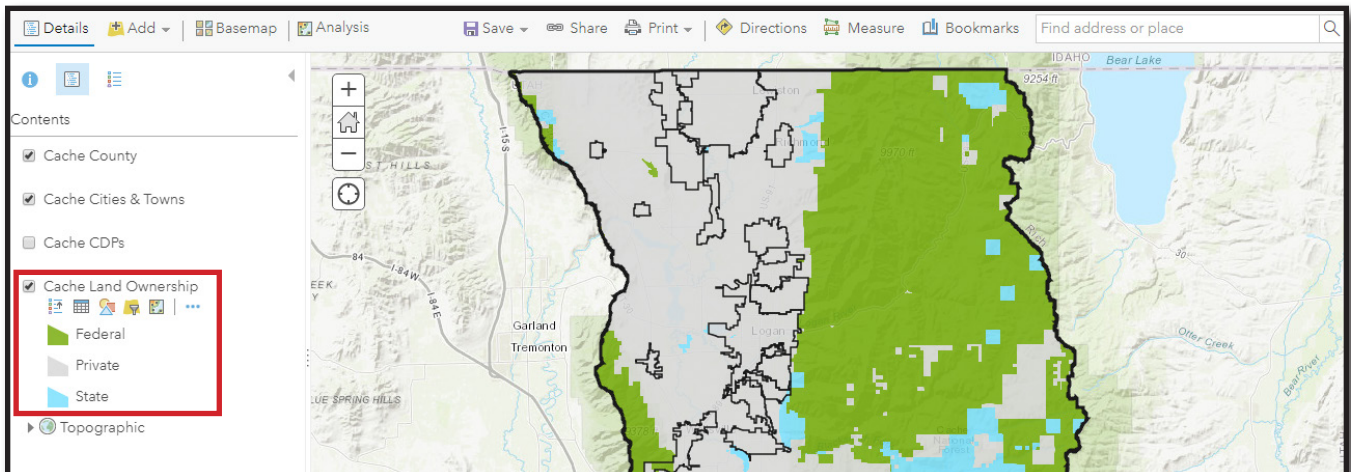


Now, click the *Legend* button in the ArcGIS Online map viewer window. The symbology for the *Cache Cities & Towns* data layer should have updated to reflect the symbology changes. By changing the symbology, the map becomes more understandable. The darker colors represent cities and towns with higher populations and the lighter colors represent cities and towns with lower populations. In this example, Logan City clearly has the highest population in Cache County. However, it may be difficult to determine what city or town has the lowest population because there are a few with lighter colors. You can add labels to the map or explore the attribute table to provide more information and to better understand the data.

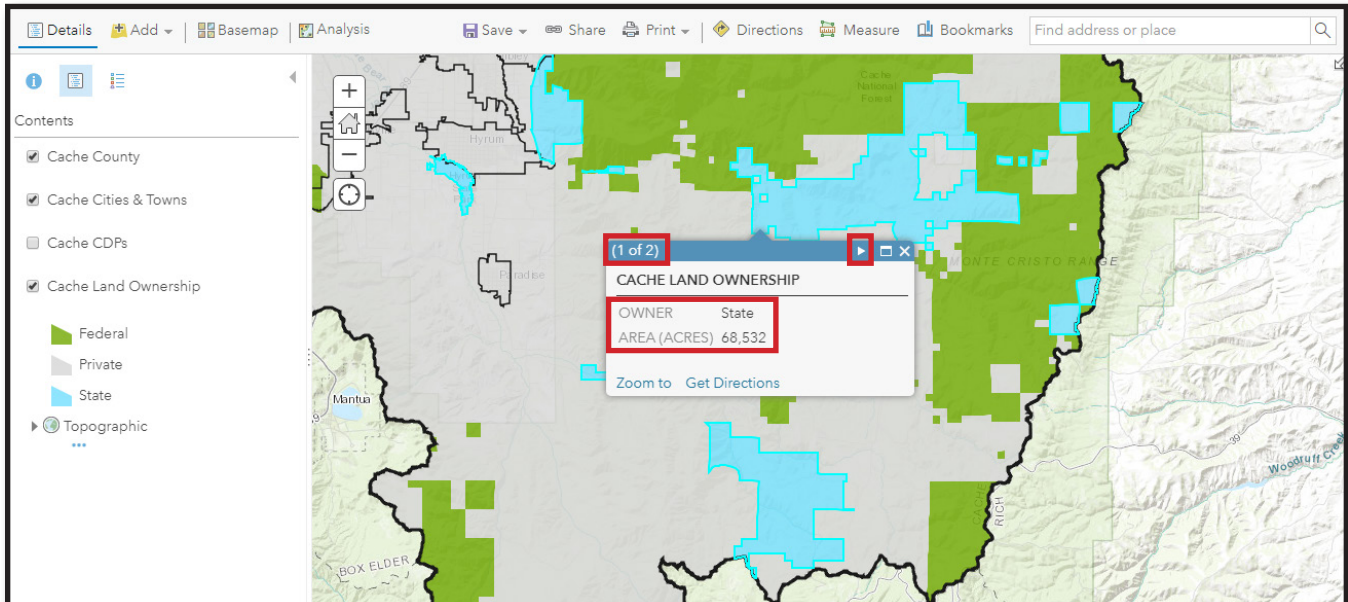


To view the attribute table, click the *Content* button. Hover over the *Cache Cities & Towns* data layer and click the *Show Table* button. If you recall from *Module 2 - Exploring ArcGIS Online*, you can sort headings in either ascending or descending order to answer questions. In this example, you can sort the *2016 POPULATION* in ascending order to identify the town with the smallest population. The town of Cornish had the smallest population in 2016.

Another data layer that is important for urban planners and city managers is land ownership. Land ownership often determines where and how cities grow. In most instances, private lands are more likely to be developed for urban land uses. Turn on the *Cache Land Ownership* data layer to evaluate the types and distribution of land ownership in Cache County. This data layer represents a basic classification of land ownership, including federal lands (green), private lands (gray), and state lands (blue).



If a county planner or official was interested in determining the total area of state lands in Cache County, they would need to inspect the attributes associated with the data layer. This can be done by clicking on a feature in the map or by reviewing the attribute table. Using your mouse, click on any blue state polygon within Cache County. You will note that all state lands are highlighted with a blue line and a pop-up window appears. The pop-up window indicates that there are 68,532 acres of state land in Cache County. In the upper left corner of the pop-up window, you should also see that you are viewing result (1 of 2). This implies that there are overlapping data layers. In this example, the *Cache Land Ownership* data layer is the first result and the *Cache County* data layer is the second result. Try clicking on the arrow in the upper right of the pop-up window to view the results for the other data layer.

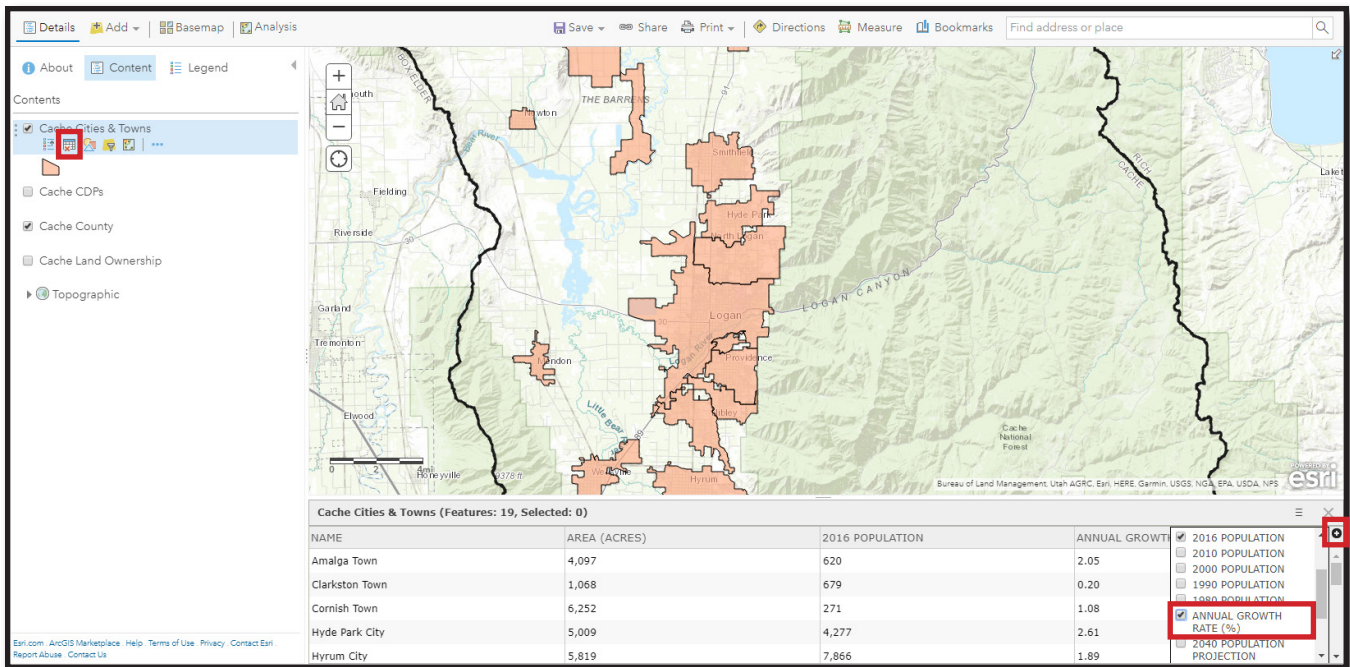


Urban planners, city managers, and county officials keep track of past, present, and future populations of cities and towns to calculate population growth rates, population density, and population projections. **Population growth rates**, or the rates at which a population increases or decreases in a specified period of time, are generated using a mathematical formula that includes past and present population counts. The **population density** is a measurement of population per unit of area, such as the number of inhabitants per square mile of land area. **Population projections**, or estimates of the future population, are calculated based on average growth rates.

Average annual population growth rates are important indicators of how rapidly cities or towns are growing. Growth rates give urban planners and city managers a way to predict where population growth and urban development will occur. If a county planner wanted to evaluate which of the 19 cities and towns in Cache County had the highest average annual population growth rate, they would need to examine past and present populations and then calculate the growth rates. Fortunately, the growth rates for cities and towns in Cache County have been calculated and they are available in the attribute table of the *Cache Cities & Towns* data layer.

To view the average annual population growth rates for cities and towns in Cache County, you will need to add the attribute *ANNUAL GROWTH RATE (%)* to the attribute table. This can be done using two different approaches. In *Module 2 - Exploring ArcGIS Online*, you learned how to add attributes to the table by configuring pop-up windows and attributes. If you recall, the *More Options* button under the *Cache Cities & Towns* data layer is selected. *Configure Pop-up* is selected, and then *Configure Attributes* is selected. In the *Configure Attributes* window, you will need to select *ANNUAL GROWTH RATE (%)*.

The second approach for adding an attribute to the attribute table is to use the *Show/Hide Columns* function. To use this function, click on the *Show Table* button under the *Cache Cities & Towns* data layer. This will bring up the attribute table. In the upper right corner of the attribute table, you will see a white plus symbol surrounded by a black circle. Click on this symbol to reveal the *Show/Hide Columns* function. A menu option will appear that identifies all available attributes. Scroll down and select *ANNUAL GROWTH RATE (%)*. Click on the plus symbol again to close the menu. The *ANNUAL GROWTH RATE (%)* attribute should appear within the attribute table. However, it should be noted that by adding an attribute using this approach, the attribute will not show up in the pop-up window.



By sorting this attribute, an urban planner or city manager can identify the cities and towns with the highest and lowest growth rates. In this example, the town of Trenton has the lowest annual growth rate. In fact, the growth rate is negative. What do you think this means for the town population if it remains negative for a long period of time? It likely suggests that the population will continue to decrease and that fewer people will live within the town.

NAME	AREA (ACRES)	2016 POPULATION	ANNUAL GROWTH RATE (%)
Trenton Town	9,517	451	-0.11
Clarkston Town	1,068	679	0.20
Newton Town	983	795	0.72
Richmond City	3,966	2,546	1.02
Cornish Town	6,252	271	1.08
Lewiston City	29,435	2,077	1.18
Logan City	21,011	49,539	1.60

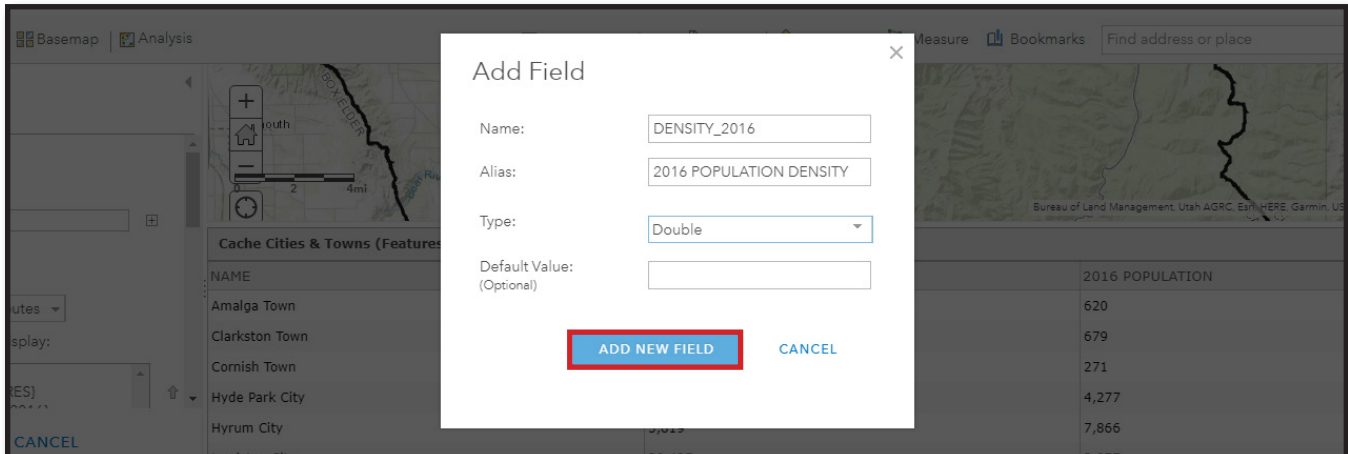
In addition to understanding population growth rates, the **population density** of a city or town is an important factor to consider. The size of a population relative to the size of a city or town can have differing impacts on natural, environmental, and agricultural resources. Cities and towns with high population densities and minimal open space may have greater adverse impacts on the local environment and natural resources. By understanding the population densities of cities and towns within a county, urban planners, city managers, and county officials can engage in planning activities that support environmental sustainability.

The population density of a city or town can be calculated by dividing the population of an area by the area of the city or town. The formula is: **Population Density = Population/Land Area**. If an urban planner or county administrator was interested in researching the cities and towns with the highest and lowest densities within the county, they would need to know the current population and the current area of cities and towns. The *Cache Cities & Towns* data layer contains both of those values. However, it does not include a population density attribute. By knowing this formula, the population density can be calculated from the *2016 POPULATION* and *AREA (SQUARE MILES)* attributes.

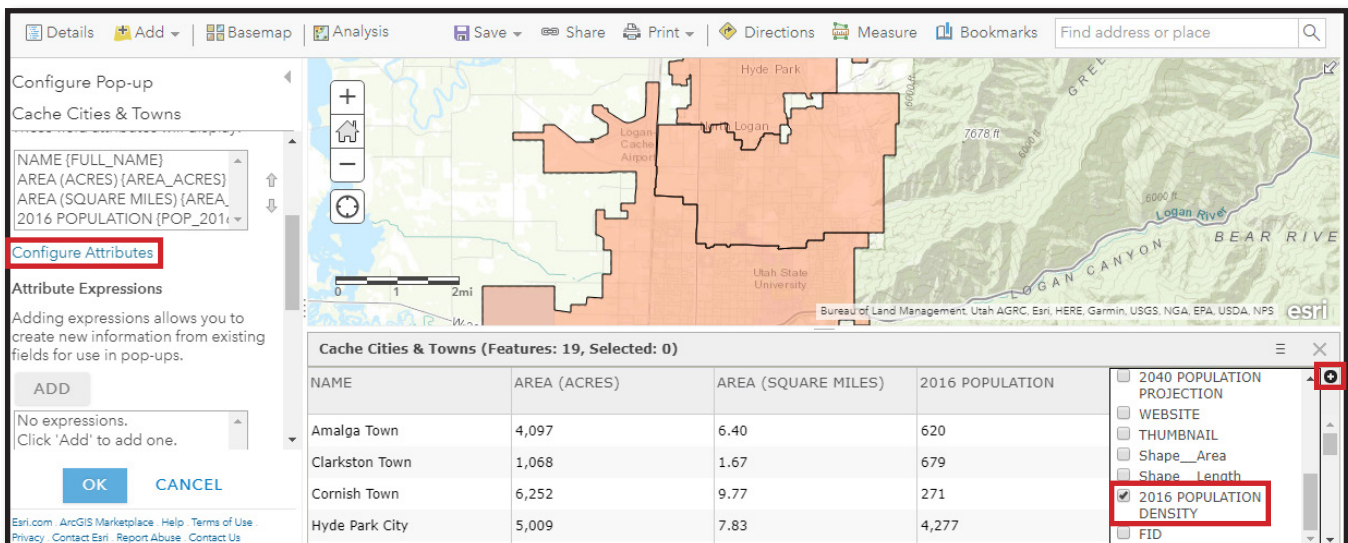
ArcGIS Online allows users to create new attributes by using the *Add Field* function. This will allow you to create a new attribute that represents the population density of each city and town in Cache County. To create a new attribute, click on the *Show Table* button under the *Cache Cities & Towns* data layer. This will bring up the attribute table. In the upper right corner of the attribute table, you will see three parallel lines. This is called the *Options* button. Click the *Options* button, and then click *Add Field*.

NAME	AREA (ACRES)	2016 POPULATION	ANNUAL GROWTH
Trenton Town	9,517	451	-0.11
Clarkston Town	1,068	679	0.20
Newton Town	983	795	0.72
Richmond City	3,966	2,546	1.02
Cornish Town	6,252	271	1.08
Lewiston City	29,435	2,077	1.18
Logan City	21,011	49,539	1.60

A new window called *Add Field* will appear. Give the new field a name of *DENSITY_2016*. Notice the underscore between *DENSITY* and *2016*. Next to *Alias* or *Display Name*, type in *2016 POPULATION DENSITY*. Next to *Type*, click the dropdown arrow and select *Double*. Leave the *Default Value* blank. Click *ADD NEW FIELD*.

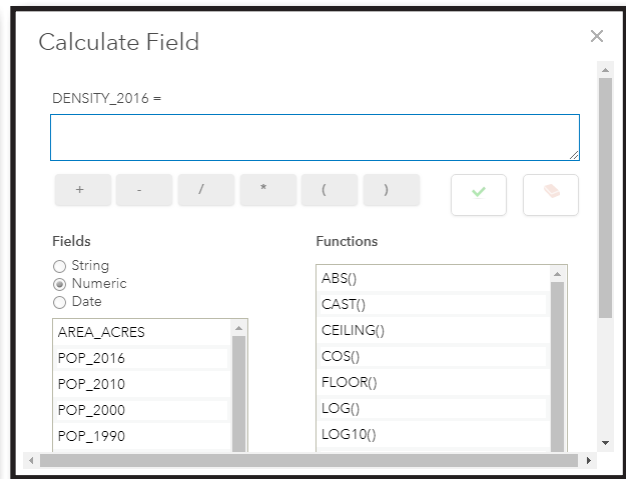
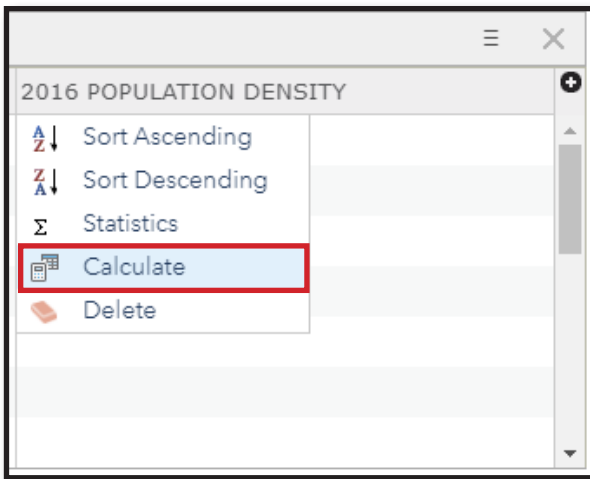


The new field *2016 POPULATION DENSITY* may not automatically show up in the attribute table. You may need to add this attribute to the attribute table by using the *Configure Attributes* window or by using the *Show/Hide Columns* function in the attribute table window.



Recall from previous exercises that you can left click on a column name and a menu appears that allows you to sort the data in either ascending or descending order. This menu also has other options, including a *Calculate* option. Left click on the heading *2016 POPULATION DENSITY* and select *Calculate*. Select the *SQL* option. The *Calculate Field* window appears.

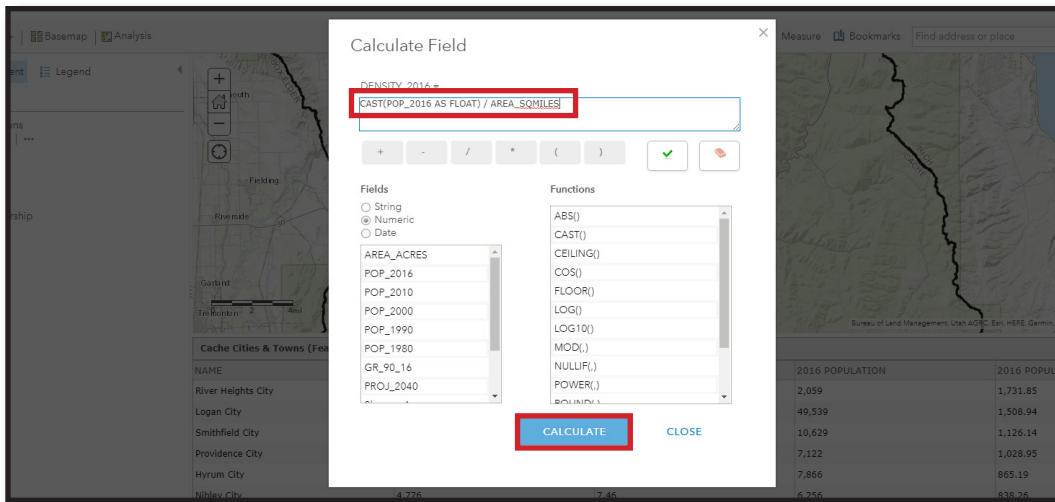
This window may appear complex, but it quite simple to use. Remember, all of the data that you need to calculate the population density is already available to you in the attribute table. The program just needs to be told the correct fields to use to calculate the population density.



Under the heading *Fields* in the *Calculate Field* window, select *POP_2016*. This is the field that represents the *2016 POPULATION*. In the input box, the program has written *CAST(POP_2016 AS FLOAT)*. There is no need to understand what this means except that it is using the attribute *POP_2016* to calculate a new field.

The next step is to tell the program that it should divide the *POP_2016* by the area of the city or town. Click on the division button (*/*). Then select *AREA_SQMILES*. Make sure you have selected the area in square miles, not acres, for this calculation. By using the area measurement of square miles, you will obtain a population density result that is more understandable.

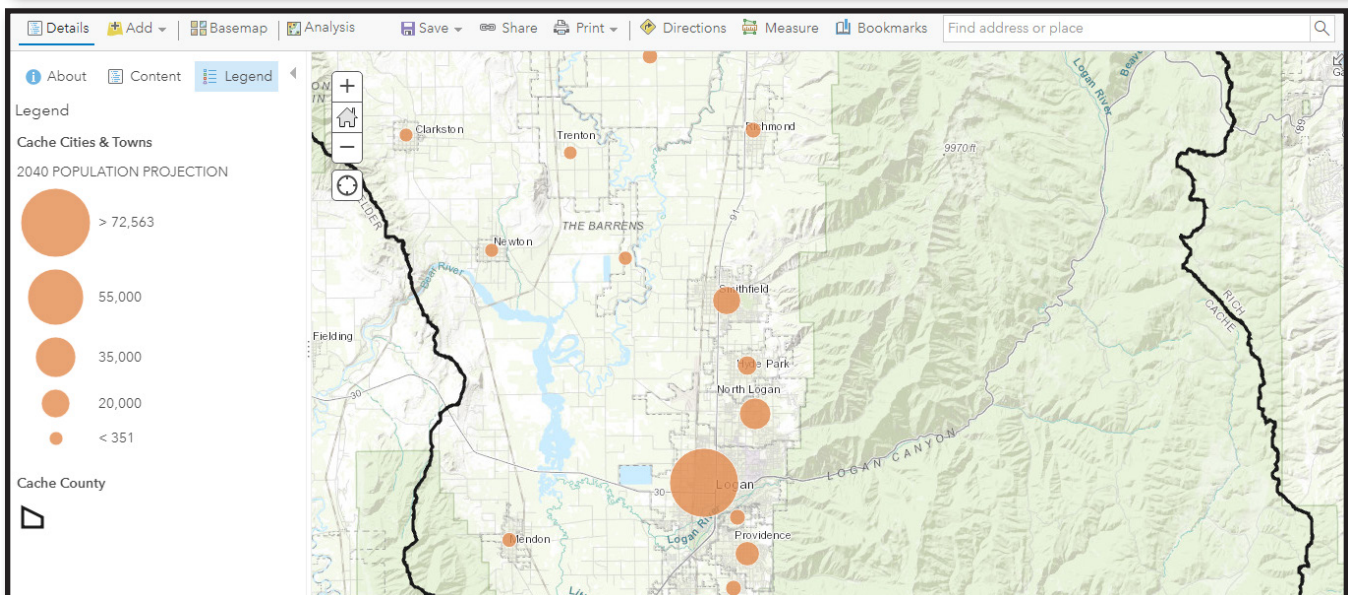
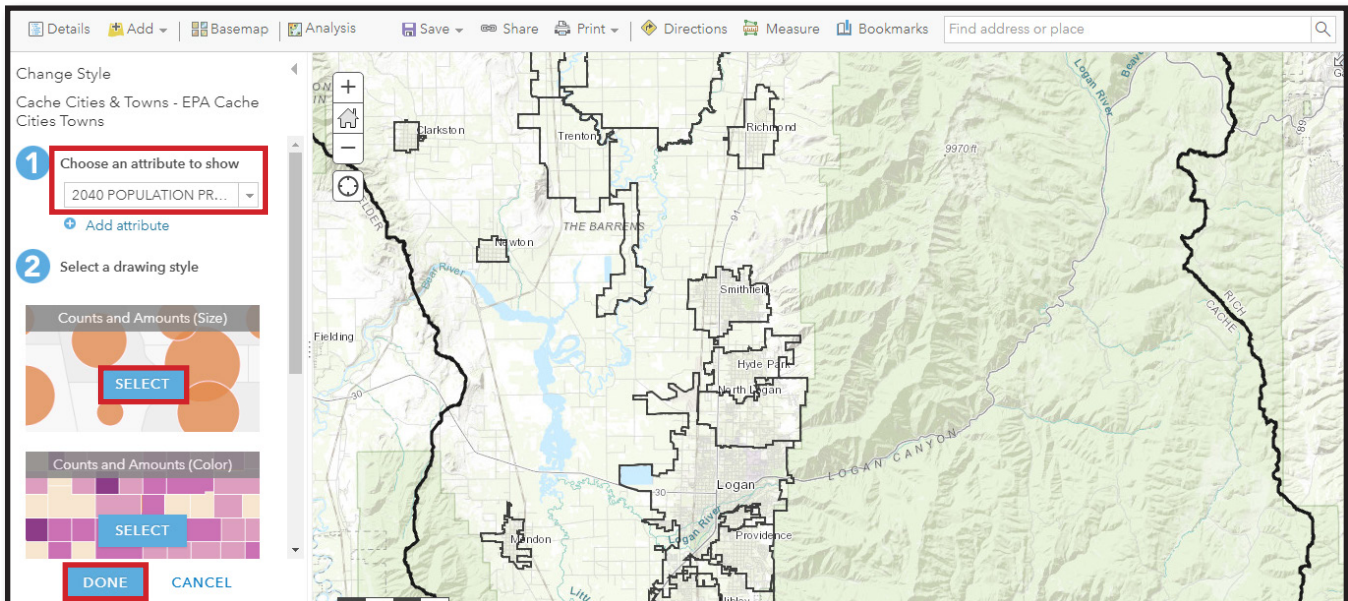
The final equation should be: *CAST(POP_2016 AS FLOAT) / AREA_SQMILES*. To execute the calculation and to populate the new field, click *CALCULATE*.



The new attribute *2016 POPULATION DENSITY* has been created and it represents the number of persons per square mile within each city and town within Cache County. This field can be sorted to identify the cities and towns with the highest and lowest population densities.

The last element that urban planners and city managers need to understand is **population projections**, or educated assessments of the population at some future point in time. By combining the information about population growth rates, population density, and population projections, urban planners, city managers, and county officials can develop short- and long-term urban and transportation plans that sustain robust economic foundations and promote environmental sustainability. Population projections have been calculated for the 19 cities and towns in Cache County. These projections, which were calculated using a compounding population growth formula, represent the estimated future populations for each city and town in the year 2040.

To review these 2040 population projections, hover over the *Cache Cities & Towns* data layer and click the *Change Style* button. Below (1) Choose an attribute to show, click the dropdown arrow, scroll down, and select *2040 POPULATION PROJECTION*. Below (2) Select a drawing style, select *Counts and Amount (Size)*, and then select *DONE*.



By displaying the *2040 POPULATION PROJECTION* with different sized symbols, you can identify what cities and towns will be largest or smallest populations in 2040, and by referencing the legend and attribute table, you can determine what these populations are estimated to be in 2040.

Before proceeding to the next section, remember to save a copy of the map to your ArcGIS Online account. You can name it *Module 3 Map*.

INVESTIGATION

In this module, you learned about the importance of population as it relates to urban planning and environmental sustainability. You learned how certain measures of population dynamics, such as total population and population growth rates, can assist urban planners and city managers in making more informed decisions. You learned how to symbolize data layers using color ramps and different size symbols. You began to explore attribute tables in greater detail, and you learned how to add a new field to an attribute table to discover additional information.

Using the skills that you learned in the previous module (*Module 2 - Exploring ArcGIS Online* - <https://arcg.is/CWKKO>) and in this module, please answer the following questions:

1. The population of cities and towns within a region is an important dynamic to understand because it influences the environment through the use of natural resources, through impacts to water and air quality, and through the production of garbage and sewage. Population is also important to understand because it allows city and county administrators to assess taxes that support the development of infrastructure and public utilities. Using the *Cache Cities & Towns* data layer, identify the two cities with the highest 2016 population and the two cities with the lowest 2016 population. You will need to open the attribute table and sort the attribute *2016 POPULATION* in either ascending or descending order.

What two cities or towns have the highest population in 2016? Include the names of the cities/towns and the population counts.

What two cities or towns have the lowest population in 2016? Include the names of the cities/towns and the population counts.

2. Using the *Cache CDPs* data layer, open the attribute table, and explore the data to identify the number of CDPs in Cache County and the area (in acres) and population of Benson CDP.

How many CDPs are there in Cache County, Utah?

What is the area (in acres) and the 2016 population of Benson CDP?

3. Land ownership is an important factor in determining where future population growth and urban development may occur. Private lands are more likely to be sold to developers and municipalities for urban expansion and development. Using the *Cache Land Ownership* data layer, click on any polygon that represents private land. Evaluate the pop-up window and attribute table to identify how many acres of private land there is in Cache County.

How much private land (in acres) is there Cache County?

4. The area of a city, town, or municipality frequently influences the impact on the local environment. The area can impact how and where urban development occurs and it can affect transportation networks, water supplies, sewer treatment, and open space. Using the *Cache Cities & Towns* data layer, evaluate the attribute table to determine which city or town has the greatest area and which city has the smallest area in Cache County, Utah.

What city or town has the greatest area (in acres)? Identify the name of the city or town and the area (in acres).

What city or town has the smallest area (in acres)? Identify the name of city or town and the area (in acres).

Does this correspond to the size of the population? Use your answers from Question 1 to make a comparison and note any observations.

5. Annual growth rates are important indicators of population change. High growth rates suggest that the population is growing quickly and that urban development needs to expand to accommodate that growth. Using the *Cache Cities & Towns* data layer, identify the top three cities with the highest growth rates. You will need to make sure that the attribute *ANNUAL GROWTH RATE (%)* has been added to the attribute table and you will need to sort the column in either ascending or descending order.

What three cities or towns have the highest annual growth rates? Identify the names of the cities/towns and the growth rates.

6. The population density of cities and towns can have differing impacts on environmental resources. In Cache County, cities and cities with low population densities generally occupy greater areas. With greater areas and more diffuse populations, the infrastructure and environmental costs may be higher. Using the *Cache Cities & Towns* data layer, identify the cities or towns with the lowest and highest population densities. You will need to make sure that you have created and calculated the new attribute *2016 POPULATION DENSITY*.

What city or town in Cache County has the lowest population density in 2016? Identify the name of the city or town and the population density.

What city or town in Cache County has the highest population density in 2016? Identify the name of the city or town and the population density.