BEYOND POPULATION – USING DIFFERENT TYPES OF DENSITY TO UNDERSTAND LAND USE

TEACHER VERSION

Subject Level:
High School Geography

Grade Level:
12

Approx. Time Required:
180 minutes

Learning Objectives:

- Students will be able to identify and explain where and why density is highest along four major U.S. interstates.
- Students will be able to calculate arithmetic (population), agricultural, and physiological densities at the state and national levels.
- Students will be able to design and create bar graphs to visualize and compare the density levels of a U.S. state with national levels.

Activity Description

Students will use images, U.S. Census Bureau data, and interactive maps to visualize and calculate arithmetic (population), agricultural, and physiological densities at local, regional, and national scales. They will also transfer their calculations to bar graphs.

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Topics:

- Agricultural density
- Arithmetic (population) density
- Human population characteristics
- Physiological density

Skills Taught:

- Calculating density
- Creating a bar graph
- Reading and interpreting maps

Materials Required

- The student version of this activity, 19 pages; it contains images that should be printed in color.
- Calculators
- Colored pencils
- Teacher computer with Internet access and a projector to display web sites

A computer with Internet access for each student is preferred but optional.

Activity Items

The following items are part of this activity. Items, their sources, and any relevant instructions for viewing them online appear at the end of this teacher version.

- Item 1: Beyond Population: Definitions
- Item 2: Density Analysis Images

This activity also uses the following online tools:

- U.S. Census Interactive Map – "I-95 Population Density Profile, 2010"
  www.census.gov/library/visualizations/2012/comm/pop-density-I95-2010_012.html
- U.S. Census Interactive Map – "I-5 Population Density Profile, 2010"
  www.census.gov/library/visualizations/2012/comm/pop-density-I5-2010_025.html
- U.S. Census Interactive Map – "I-10 Population Density Profile, 2010"
  www.census.gov/library/visualizations/2012/comm/pop-density-I10-2010_030.html
- U.S. Census Interactive Map – "I-90 Population Density Profile, 2010"
  www.census.gov/library/visualizations/2012/comm/pop-density-I90-2010_031.html

For more information to help you introduce your students to the U.S. Census Bureau, read "***Census Bureau 101 for Students***." This information sheet can be printed and passed out to your students as well.

Standards Addressed

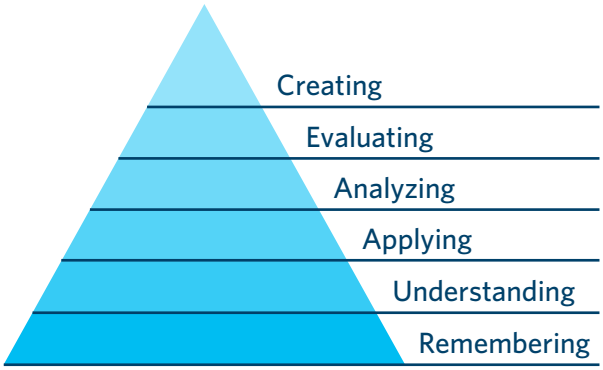
See chart on the following page. For more information, read "***Overview of Education Standards and Guidelines Addressed in Statistics in Schools Activities***."

National Geography Standards

Standard	Grade	The student knows and understands:
9 – The characteristics, distribution, and migration of human populations on Earth's surface	12	Characteristics of Population. Culture, economics, and politics influence the changing demographic structure of different populations.

Bloom's Taxonomy

Students will ***apply*** their understanding of density and ***create*** bar graphs that show the population density at state and national levels.



Teacher Notes

Before the Activity

Students must understand the following key terms:

- **Arable land** – land suitable for agriculture
- **Arithmetic (population) density** – the number of people per unit of area
- **Ecumene** – inhabitable land, where people have made their homes and work areas
- **Large-scale map** – a map with a relatively small ratio between its map and ground units, usually with higher resolution and covering a smaller region (e.g., city maps), such as one inch measured on a map that equals one mile on the ground.
- **Small-scale map** – a map with a relatively large ratio between its map and ground units, usually lower resolution and covering a larger region (e.g., state and national maps), such as one inch measured on a map equals 20 miles on the ground.
- **Population** – the number of people living in an area
- **Density** – the measure of some type of mass per unit of area
- **Urban** – a type of location with high population density and many human-built features compared with the surrounding area
- **Rural** – all population, housing, and territory not included within an urban area, typically with very low population density
- **Urban sprawl** – the uncontrolled expansion of urban areas
- **Urbanization** – the act of taking on the general characteristics of a city

Students should have the following skills:

- Calculating density
- Drawing bar graphs
- Dividing and multiplying

Teachers should review information about rural and urban classifications here:
www.census.gov/history/www/programs/geography/urban_and_rural_areas.html?cssp=SERP

During the Activity

For part 1, teachers will lead a whole-class discussion to complete the introductory questions, then play the four Census Bureau interactive map animations if students are unable to watch them on their own computers. As students complete the "explanations" column of their charts, teachers should encourage them to consider how geographic features (e.g., mountains, swamps) and other factors like climate and job opportunities affect

population density. When students are done, teachers should direct them to form pairs to compare their notes, then have the pairs share some of their findings with the rest of the class.

For part 2, teachers should talk students through the definitions and images in **Item 1** and **Item 2**, providing them with insight and guidance for each set, including that:

- **Item 2, image #1** is of an agricultural field in Germany, where there appears to only be one home off in the distance and one farmer who uses mechanized farming.
- **Item 2, image #2** is of an urban landscape in Abu Dhabi, which is a very densely populated city in the United Arab Emirates with many high-rise buildings.
- **Item 2, image #3** is of an agricultural landscape in Rwanda, where terraced gardens on hills demonstrate the value of farming wherever possible in a very densely populated area with limited arable land. Rwandans use mostly hoes and hand tools, as there is limited access to new farming technologies.

For parts 3 and 4, teachers should assign half of students to complete the Florida calculations and the other half to complete the Texas calculations. For an easier activity, teachers could choose to have the whole class work together on one calculation sheet.

Note: The farm data used in parts 3 and 4 come from Vintage 2014, an updated release of the data.

After the Activity

Ask students to reflect about what they learned.

Extension Idea

- Teachers could have students conduct research to compare a more developed and less developed country's arithmetic, agricultural, and physiological densities, to help students understand the implications of density in different countries and ecumenes.

Student Activity

Click ***here*** to download a printable version for students.

Activity Items

The following items are part of this activity and appear at the end of this student version.

- Item 1: Beyond Population, Definitions
- Item 2: Density Analysis Images

This activity also uses the following online tools:

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  www.census.gov/library/visualizations/2012/comm/pop-density-I95-2010_012.html
- U.S. Census Interactive Map – "I-5 Population Density Profile, 2010"
  www.census.gov/library/visualizations/2012/comm/pop-density-I5-2010_025.html
- U.S. Census Interactive Map – "I-10 Population Density Profile, 2010"
  www.census.gov/library/visualizations/2012/comm/pop-density-I10-2010_030.html
- U.S. Census Interactive Map – "I-90 Population Density Profile, 2010"
  www.census.gov/library/visualizations/2012/comm/pop-density-I90-2010_031.html

Student Learning Objectives

- I will be able to identify and explain where and why density is highest along four major U.S. interstates.
- I will be able to calculate arithmetic (population), agricultural, and physiological densities at the state and national levels.
- I will be able to design and create bar graphs to visualize and compare the density levels of a U.S. state with national levels.

Part 1 – Understand and Observe Density in America

Using what you know about population density, answer the questions below:

1. How would you calculate the population density of our classroom?

   The number of students divided by the area of the classroom (in square feet)

2. How would you calculate the population density of our classroom if the population of our class doubled?

   Twice the number of students divided by the area of the classroom (in square feet)

3. What issues might we face if we doubled the density of our classroom?

   Student answers will vary but could include: space limitations, physical discomfort, not enough desks, increased noise and trash, challenges with classroom management, etc.

Watch the Census Bureau interactive map animations listed in the Activity Items section to complete the table below. These maps display the population density of cities along four major U.S. interstates. When you are done, compare your table with a partner.

Student answers in the table below will vary.

Interstate	Relative Location	Density Patterns Observed	Implications of Density	Explanations for Density
I-95	East Coast	Southern and northeast areas have the highest densities (e.g., Philadelphia, New York City, Boston, and Miami). The New York area has 30,000–40,000 people per square mile. There is a high population density region (a "megalopolis") stretching from Boston to Washington.	Areas of impact for high-density places here include commuting, congestion, pollution, waste management, and movement of goods.	People may be drawn to the Northeast for its economic and urban amenities. People may be drawn to Florida for climate and lifestyle factors. Interstates themselves may have increased the population density because they may have lured companies to build houses nearby for the people commuting to the cities these roads connect.
I-5	West Coast	Southern California (Los Angeles and San Diego); the Bay Area (San Francisco); Portland, Oregon; and Seattle have the highest densities. Los Angeles has the peak density at nearly 14,000 people per square mile.	Areas of impact for high-density places here include commuting, congestion, pollution, and water supply.	People may be pulled to the West Coast for environmental and economic factors. Interstates themselves may have increased the population density because they may have lured companies to build houses nearby for the people commuting to the cities these roads connect.

Interstate	Relative Location	Density Patterns Observed	Implications of Density	Explanations for Density
I-10	**South**	**Los Angeles; Tucson, Arizona; Houston; and New Orleans are the highest-density areas.** **Density is high for many coastal cities.**	**Areas of impact for high-density places here include commuting, housing, and delivery of goods.**	**Major port, energy, and Gulf Coast industries may have contributed to this area's high density.** **Interstates themselves may have increased the population density because they may have lured companies to build houses nearby for the people commuting to the cities these roads connect.**
I-90	**North**	**Population density is highest in cities along the coast and near the Great Lakes, where there is greater urbanization.** **Chicago has a density of 18,000 people per square mile.** **There is low density in both the cities in middle America and the areas near them.**	**Areas of impact for high-density places here include commuting, congestion, etc.**	**Interstates themselves may have increased the population density because they may have lured companies to build houses nearby for the people commuting to the cities these roads connect.**

Part 2 – Define Density Types

Follow along as your teacher reviews the definitions and images in **Item 1: Beyond Population: Definitions** to complete the table below.

TYPES OF DENSITY

TYPE	DEFINITION	FORMULA
ARITHMETIC	**The total number of people per unit area of land (same as population density)**	**population (people) / land (square feet)**
AGRICULTURAL*	**The total number of farmers per unit of arable land**	**population of farmers (farmers) / arable land (square feet)**
PHYSIOLOGICAL	**The total number of people per unit of arable land**	**population (people) / arable land (square feet)**

Follow along as your teacher reviews the images in **Item 2: Density Analysis Images**. Complete the table below with your expectations for each area's arithmetic, agricultural, or physiological density (choose one type for each).

Student answers and choice for density type will vary but should demonstrate understanding of how arithmetic, agricultural, and physiological densities differ and are relevant to different areas of the world.

IMAGE	ANALYSIS
1	**Agricultural density – Germany has a low agricultural density, which may be due in part to mechanized farming.**
2	**Arithmetic density – Abu Dhabi has a very high population density, with high-rise buildings for its many residents, and thus a high arithmetic density.**
3	**Physiological density – This type of density is high in Rwanda due to the limited amount of arable land and the large population.**

*Agricultural density is usually calculated by dividing "population of farmers" by "arable land"; however, due to available data for this activity, "number of farms" is used in place of "population of farmers."

Reflection Question

Why do you think policymakers and the U.S. Census Bureau are concerned about arithmetic, agricultural, and physiological densities?

Student answers will vary but could include the following key topics and explanations:

Arithmetic Density

Key topics: resource pressures and urban sprawl

Arithmetic density lets us understand where urbanization is occurring and the pressures people place on land in areas that are not urban but are still very densely populated.

Agricultural and Physiological Densities

Key topics: land use, possible impact on natural resources

Understanding agricultural density lets us keep track of where domestic food sources are and how many farms are in operation. Understanding physiological density lets us understand how much food is being produced in an area for the people the land supports. These densities also allow countries and areas to understand the pressures that may occur in densely populated places and where agricultural and living spaces coincide. In some places around the world (for instance, Rwanda), the pressures of people and food are very high.

An area's interests and public policies will be affected at the local, regional, and national levels based on whether it is more rural or urban and more or less developed.

Part 3 – Calculate Densities in the United States and Individual States

1. Use the density formulas you recorded in part 2 and the information provided below to complete the blank calculation sheet for the United States. Round your decimals to the nearest tenth.

UNITED STATES	
TOTAL POPULATION	318,857,056
TOTAL LAND AREA	3,531,905 square miles
TOTAL ARABLE LAND AREA	1,426,563 square miles
NUMBER OF FARMS	2,084,000

LARGEST CITIES	POPULATION	LAND AREA
New York City	8,491,079	302.64 square miles
Los Angeles	3,928,864	468.67 square miles
Chicago	2,722,389	227.63 square miles

DENSITY CALCULATION SHEET

UNITED STATES

CALCULATION	Formula (plug in numbers)	Value
PERCENTAGE OF ARABLE LAND (Arable Land/Total Land*100)	1,426,563 / 3,531,905 * 100	40.4 percent arable land
ARITHMETIC DENSITY	318,857,056 / 3,531,905	90.3 people per square mile
AGRICULTURAL DENSITY	2,084,000 / 1,426,563	1.5 farms per square mile of arable land
PHYSIOLOGICAL DENSITY	318,857,056 / 1,426,563	223.5 people per square mile of arable land
ARITHMETIC DENSITY FOR New York City	8,491,079 / 302.64	28,056.7 people per square mile
ARITHMETIC DENSITY FOR Los Angeles	3,928,864 / 468.67	8,383.0 people per square mile
ARITHMETIC DENSITY FOR Chicago	2,722,389 / 227.63	11,959.7 people per square mile

2. Use the density formulas you recorded in part 2 and the information provided below to complete the calculation sheet for either Florida or Texas. Round your decimals to the nearest tenth.

FLORIDA	
TOTAL POPULATION	19,893,297
TOTAL LAND AREA	53,625 square miles
TOTAL ARABLE LAND AREA	14,844 square miles
NUMBER OF FARMS	47,600

LARGEST CITIES	POPULATION	LAND AREA
Jacksonville	853,382	747.00 square miles
Miami	430,332	35.87 square miles
Tampa	358,699	113.41 square miles

DENSITY CALCULATION SHEET

STATE: FLORIDA

CALCULATION	Formula (plug in numbers)	Value
PERCENTAGE OF ARABLE LAND (Arable Land/Total Land*100)	$\frac{14,844}{53,625} * 100$	**27.7 percent arable land**
ARITHMETIC DENSITY	$\frac{19,893,297}{53,625}$	**371.0 people per square mile**
AGRICULTURAL DENSITY	$\frac{47,600}{14,844}$	**3.2 farms per square mile of arable land**
PHYSIOLOGICAL DENSITY	$\frac{19,893,297}{14,844}$	**1,340.2 people per square mile of arable land**
ARITHMETIC DENSITY FOR LARGEST CITY	$\frac{853,382}{747.00}$	**1,142.4 people per square mile**
ARITHMETIC DENSITY FOR SECOND-LARGEST CITY	$\frac{430,332}{35.87}$	**11,997.0 people per square mile**
ARITHMETIC DENSITY FOR THIRD-LARGEST CITY	$\frac{358,699}{113.41}$	**3,162.9 people per square mile**

TEXAS	
TOTAL POPULATION	26,956,958
TOTAL LAND AREA	261,232 square miles
TOTAL ARABLE LAND AREA	203,125 square miles
NUMBER OF FARMS	245,500

LARGEST CITIES	POPULATION	LAND AREA
Houston	2,239,558	747.00 square miles
San Antonio	1,436,697	35.87 square miles
Dallas	1,281,047	113.41 square miles

DENSITY CALCULATION SHEET

STATE: TEXAS

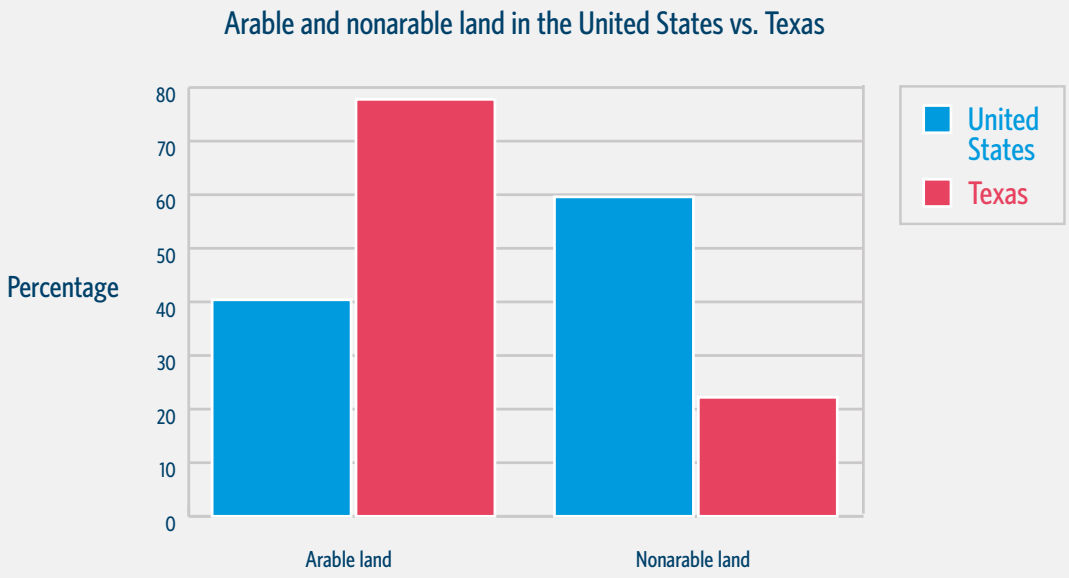
CALCULATION	Formula (plug in numbers)	Value
PERCENTAGE OF ARABLE LAND (Arable Land/Total Land*100)	$\frac{203{,}125}{261{,}232} * 100$	**77.8 percent arable land**
ARITHMETIC DENSITY	$\frac{26{,}956{,}958}{261{,}232}$	**103.2 people per square mile**
AGRICULTURAL DENSITY	$\frac{245{,}500}{203{,}125}$	**1.2 farms per square mile of arable land**
PHYSIOLOGICAL DENSITY	$\frac{26{,}956{,}958}{203{,}125}$	**132.7 people per square mile of arable land**
ARITHMETIC DENSITY FOR LARGEST CITY	$\frac{2{,}239{,}558}{599.59}$	**3,735.1 people per square mile**
ARITHMETIC DENSITY FOR SECOND-LARGEST CITY	$\frac{1{,}436{,}697}{460.93}$	**3,117.0 people per square mile**
ARITHMETIC DENSITY FOR THIRD-LARGEST CITY	$\frac{1{,}281{,}047}{340.52}$	**3,762.0 people per square mile**

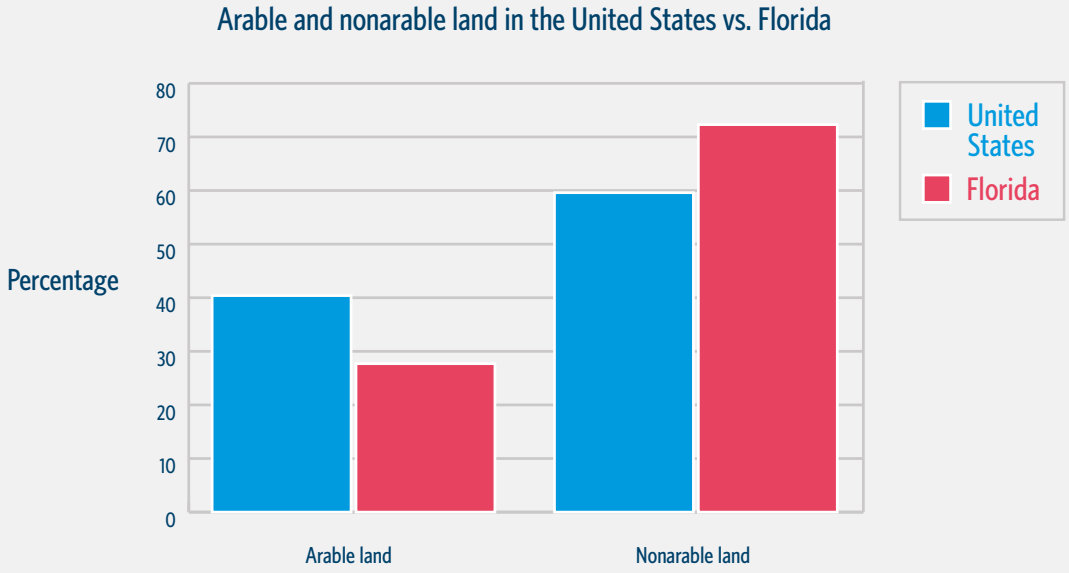
Part 4 – Graph Densities in the United States and Individual States

Now use your calculations from part 3 to create three bar graphs using the blank grids below. Label your axes appropriately, give each graph a title, and choose a different color for each variable (i.e., each location) in a set.

1. Create a bar graph that compares the percentages of arable land and nonarable land in the United States and in either Florida or Texas.

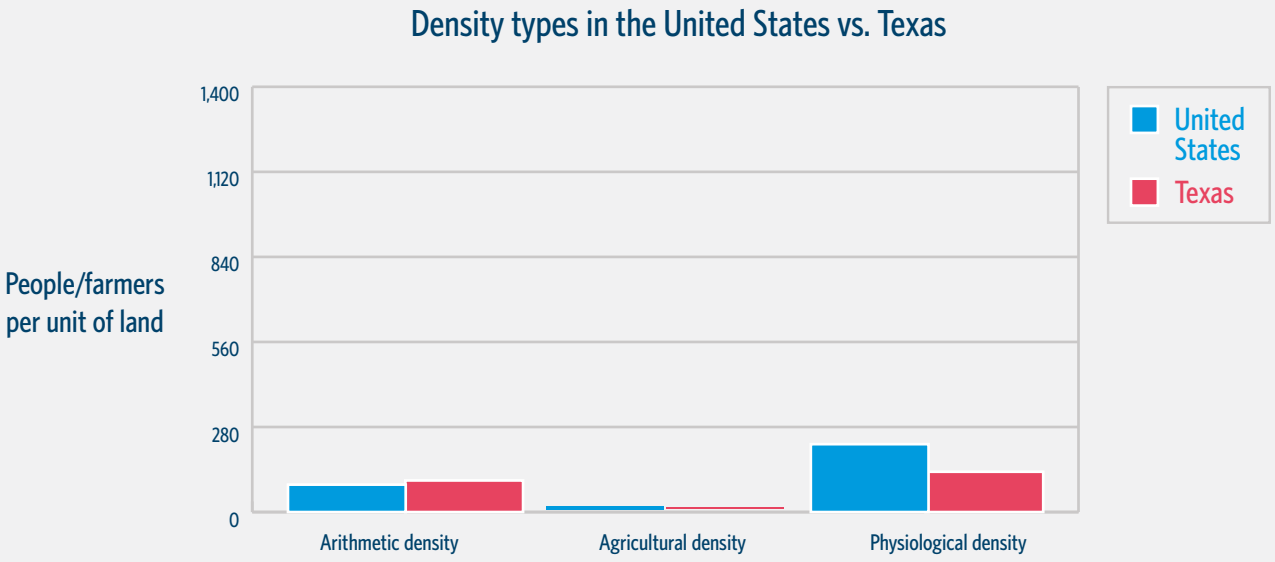
   Student bar graphs should look similar to this:

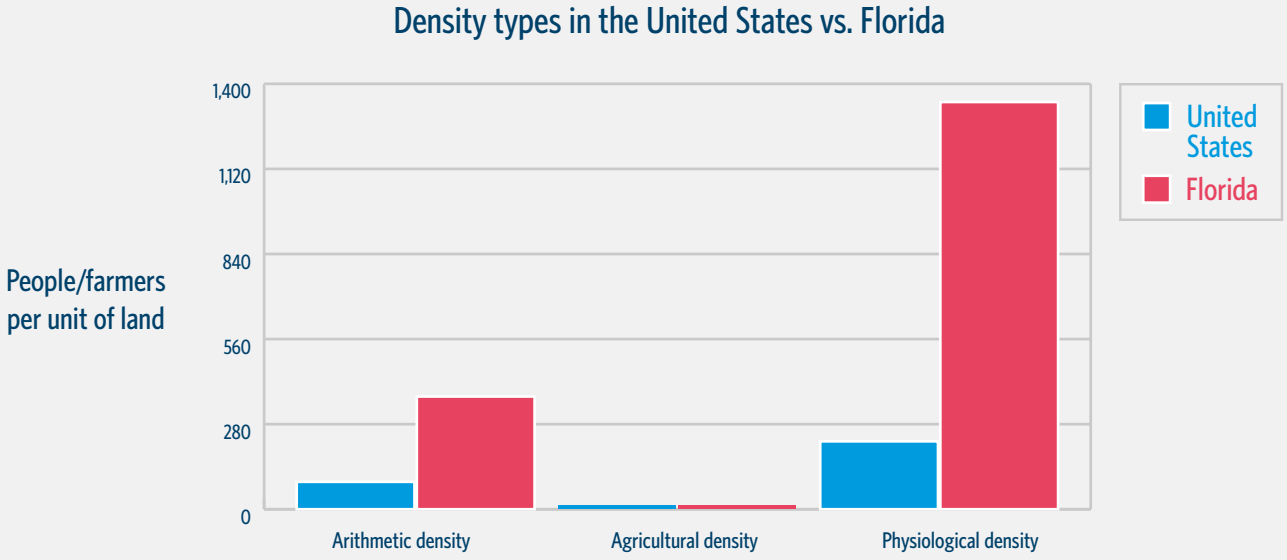




2. Create a bar graph that compares arithmetic, agricultural, and physiological densities in the United States and in either Florida or Texas.

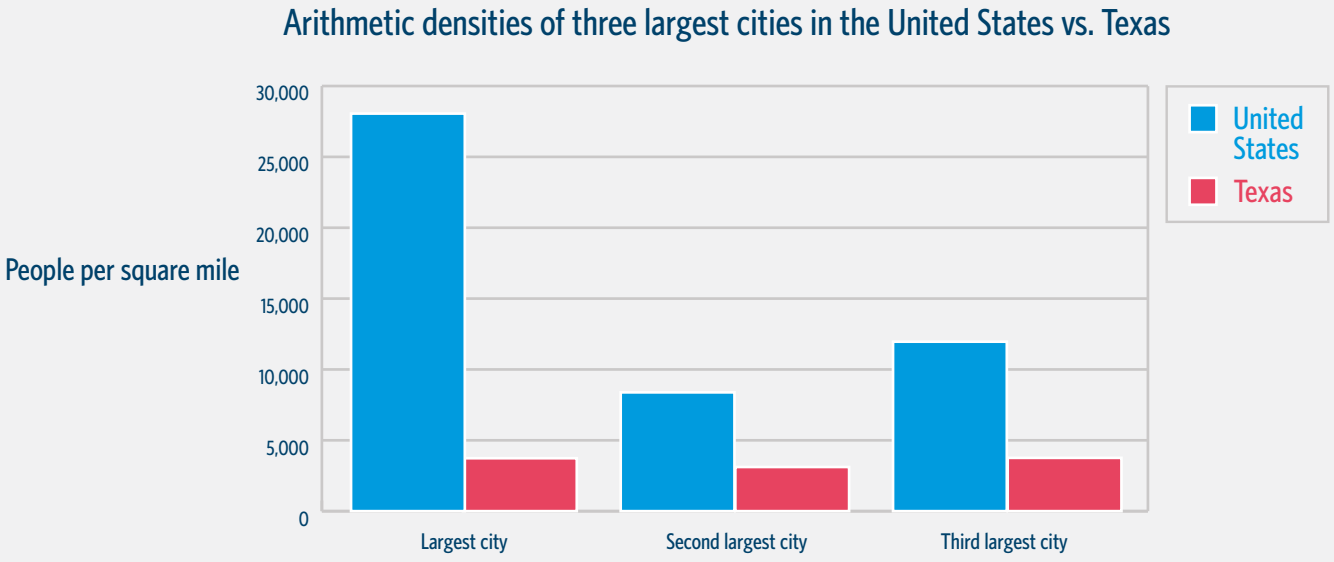
Student bar graphs should look similar to this:

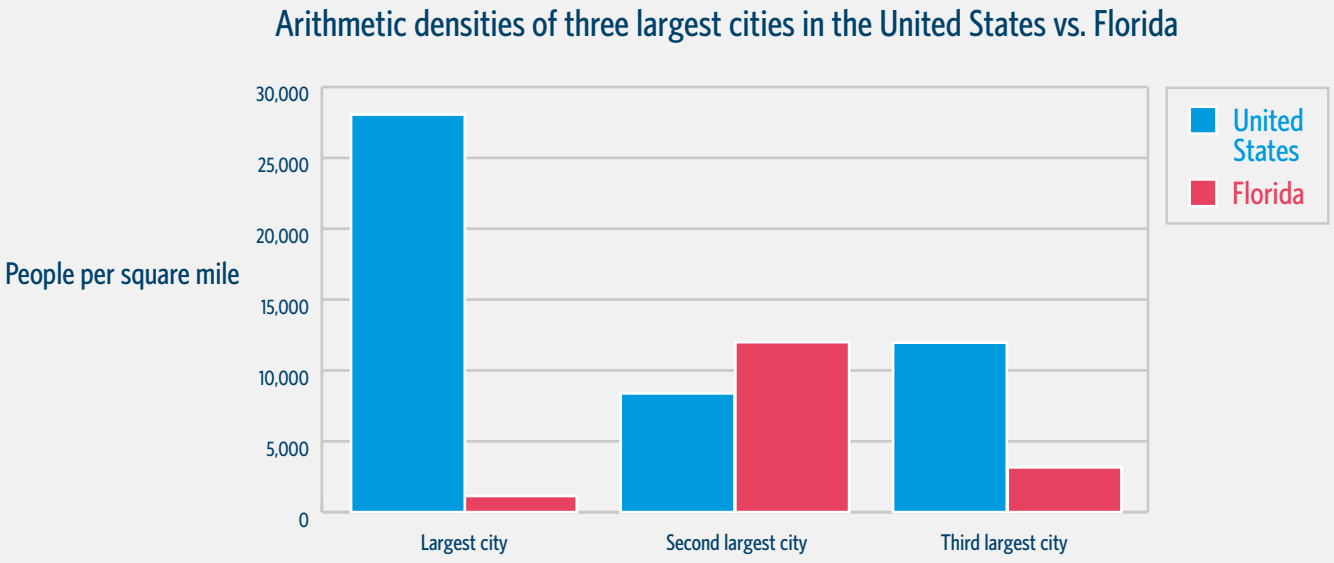




3. Create a bar graph that compares the arithmetic densities of the three largest cities in the United States with the density of either Florida or Texas.

Student bar graphs should look similar to this:





Reflection Questions

Partner with a classmate who used data from the other state to answer the following questions:

1. How are the densities and arable land percentages in your states and their cities similar? How are they different?

   Student answers will vary.

2. Based on the data provided, are both of your states more rural, urban, or mixed? How do you know?

   Student answers will vary but should focus on the densities.

3. How do the densities for both of your states compare with the densities for the United States?

   Student answers will vary.

Item 1: Beyond Population: Definitions

Ecumene – inhabitable land, where people have made their homes and work areas

Image #1: Ecumene in Rwanda. Notice the human-environment interactions for housing and agriculture.

Arithmetic density – the number of people per unit of area (i.e., the same as population density)

Image #2: Village in Germany with a high arithmetic density. Notice the closeness of the homes, businesses, churches, and agricultural lands.

Item 1: Beyond Population: Definitions (Continued)

Agricultural density – total number of farmers per unit of arable land.

Image #3: Farming in the Netherlands where urban and agricultural landscapes interact closely but agricultural density is low due to heavy-use mechanization, greenhouses, and industrial high-tech cropping of high-value crops, such as flowers.

Physiological density – total population per unit of arable land.

Image #4: Refugee camp in Rwanda. Known as the "land of a thousand hillls", Rwanda has one of the highest physiological densities in the world.

All images are courtesy of Dr. Robert Ford, who helped create this activity. They are intended for noncommercial use only.

Item 2: Density Analysis Images

Image #1

Image #2

Item 2: Density Analysis Images (Continued)

Image #3

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