

Earth Science Enterprise  
**Night Lights**

This investigation for grades 5–8 is reprinted from the NASA-funded Mission Geography curriculum. The entire K–12 curriculum can be downloaded from <http://www.missiongeography.org>



# Module 2 Educator's Guide Investigation 1

## Where do we choose to live and why?



### Investigation Overview

In this investigation, students use a nighttime image to observe areas of light across the United States and to identify patterns and spatial distributions of human settlements. They explain the reasons for these patterns by answering questions and making inferences about what they observe. Then this knowledge is applied to identify similar patterns and spatial distributions on an unidentified region of the world using a color topographic map and nighttime image.

Time required: One or two 45-minute sessions

### Materials/Resources

Briefing and Logs 1, 2, and 2.2 (one copy for each student)

Figure 2: United States at night puzzle (one per student or student group)

Figure 5: United States relief map (one per student or student group)

U.S. road/travel map or atlas

World map or globe

Overhead transparency sheet

Overhead markers (light colors)

Clear cellophane tape

Scissors

### Content Preview

The spatial concepts of pattern, dispersion, and density help to analyze geographic distributions. Maps and images of the United States and other areas of the world provide the information needed to describe and explain the spatial distribution of settlements.

### Classroom Procedures

#### *Beginning the Investigation*

1. To begin the investigation, have students examine a U.S. road map and discuss the distribution of the population and human settlement features such as cities, highways, transportation hubs, and other areas. A classroom atlas can be used, or U.S. road maps can be purchased at most stores or local travel agencies.
2. Have students identify and list any patterns they see. Some pattern examples are large concentrations of settlements separated by what appears to be unoccupied space, lines of settlement near water, and settlements located with respect to landforms, such as at the foot of mountains.

## Geography Standards

### *Standard 1:*

#### *The World in Spatial Terms*

How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective

- Use geographic tools and technologies to pose and answer questions about spatial distributions and patterns on Earth.

### *Standard 3:*

#### *The World in Spatial Terms*

How to analyze the spatial organization of people, places, and environments on Earth's surface

- Analyze and explain distributions of physical and human phenomena with respect to spatial patterns, arrangements, and associations.

## Geography Skills

### *Skill Set 4:*

#### *Analyzing Geographic Information*

- Interpret information obtained from maps, aerial photographs, satellite-produced images, and geographic information systems.
- Interpret and synthesize information obtained from a variety of sources—graphs, charts, tables, diagrams, texts, photographs, documents, and interviews.

### *Skill Set 5:*

#### *Answering Geographic Questions*

- Make generalizations and assess their validity.
- Develop and present combinations of geographic information to answer geographic questions.

3. Allow students to discuss the following questions:
  - Why are some areas empty and some areas more densely populated? (Due to physical features such as water bodies, mountain ranges, or deserts.)
  - How are these areas connected to each other? (Via roads, rails, or air transportation.)
  - Where do most of the larger cities seem to be located? (In the eastern part of the country and along coasts.) Why? (Historical settlement pattern, rainfall, agriculture.)
4. Three important terms associated with spatial distribution are used in this investigation: pattern, dispersion, and density. Have students define these terms in a class discussion or by using a dictionary. As an example of spatial distribution, have the students apply the new terms to the classroom setup. For example, what is the pattern of desks and chairs, and how dispersed or densely arranged are they?
9. Have students cut out each segment of the U.S. image puzzle and assemble them. Ask them to use any patterns they see in each segment to guide them in the task. Students should use clear tape to attach the segments. Once the image is assembled, have students tape a clear overhead transparency over the image to allow them to use markers to label and identify the regions discussed in the questions they are to answer.
10. Instruct students to use their assembled U.S. image to answer the questions in Log 2.

### *Concluding the Investigation*

11. In concluding the investigation, have students develop new questions that can be asked about the image. They must also be prepared to answer their new questions.
12. Guide students into discussions of possible future settlement patterns and influences of future population growth in the United States. An example may be that cities and urban areas continue to spread out using more and more land. Future settlement patterns may be influenced by road development, development of automated, computer-controlled autos, high-speed rail travel, and information technology such as computers and other electronic devices which allow people to work away from a specific factory or office and thus avoid commuting to work.

### *Developing the Investigation*

5. The investigation is divided into three sections that build upon each other. Each section has a series of questions that students answer. Students answer the questions on their own, in small groups, or in an educator-guided class discussion. The answers are based on what students observe in the images and the maps provided. A U.S. road map is needed. A shaded relief map of the United States (Figure 5) will be needed.
6. Distribute and have students read the Briefing.
7. Distribute Log 1. It guides students to a basic understanding of spatial concepts associated with human settlement patterns by using an image of the northeast region of the United States. The image shows the nighttime lights in this region. Discuss the information about spatial concepts with the students to assure their understanding before proceeding with the questions.
8. Distribute and read copies of the student pages for Log 2 of this investigation. Log 2 builds upon what the students learned in Log 1. It uses a different image. The students must first assemble the puzzle made from pieces of an image of the nighttime lights of the United States and then answer questions about what they observe in the assembled image. This allows them to develop a better understanding of human settlement patterns. The questions are divided into three sections. Each level builds to a higher level of skills.

### **Background**

#### *Settlement Patterns*

Why do you live where you live? Where do people choose to live? Why do they choose to live there? People have lived on Earth for thousands of years. Throughout history they have chosen particular settlement locations for many practical reasons. For just as many reasons they have packed up and moved to settle in other areas. Sometimes bloody wars have been fought over the right to settle in a particular region. Also, natural hazards such as floods, earthquakes, and climate changes have influenced people to change the locations of their settlements. Cities, highways, roads, agricultural areas, industrial regions, and transportation hubs around the world are factors that contribute to the formation of human systems. When the United States was settled, early settlements began in the east and gradually moved westward. Could this be the reason the eastern United States is more densely populated than the west? What if the settlements began in the west and moved eastward instead? How would the United States look today?

NASA has been observing and studying Earth since 1958 with aircraft, spacecraft, satellites, and humans. These observations have generated millions of images and tremendous amounts of data. NASA Earth observations help geographers worldwide to study and answer many questions about human migration and settlement patterns. Where will human settlements be 10 years, 20 years, or even 100 years from now? Can humans build settlements on other worlds like Mars or our Moon? Will settlements of other planets become a necessity?

### *Nighttime Image*

This map is a compilation of satellite images from the National Oceanic and Atmospheric Administration (NOAA), the National Geographical Data Center (NGDC), and the Defense Meteorological Satellite Program (DMSP) that show the continental United States at night. The image of the U.S. nighttime lights was derived from cloud-free portions of 231 orbits (October 1994 to March 1995) of DMSP Operational Linescan System (OLS) data. The majority of the detected features are lights from cities and towns. The arrangement of lights on this map is called a spatial distribution.

### *Spatial Distribution Concepts*

There are three important concepts in locating items in space. They are pattern, dispersion, and density. Pattern refers to the arrangement of items within a distribution in terms of density, clustering, alignment, and orientation. Dispersion refers to whether items are clustered or spread out. Density means the number of items within a defined area. Examining the distribution of lights across the United States will help students understand these three concepts.

### Evaluation

#### Log 1

1. Night
2. Space
3. Population
4. Absence of population
5. No
6. Students should see population clusters, linear arrangements of population, and even distribution and spacing between clusters.

#### Log 2

1. Answers may vary.
2. They are lakes.
3. Gulf of Mexico; offshore platforms
4. Rugged, arid terrain discourages population.
5. Answers will vary.
6. Answers will vary.
7. More people live along the coast.
8. Answers will vary.
9. Answers will vary.
10. Students may see that population densities are greater in the eastern portion of the United States than in the western portion.
11. Students may see linear patterns running east-west and north-south in the west and trending southwest to northeast in the east following the Appalachians. Answers will vary.
12. Students may observe that population is least dense in the drier regions of the United States.
13. Answers will vary, but there is a relationship between population and elevation and relief.

### Resources

NASA Spacelink

<http://spacelink.nasa.gov/>

NASA Earth Science Enterprise

<http://www.earth.nasa.gov/>

National Oceanic and Atmospheric Administration (NOAA)

<http://www.noaa.gov/>

National Geophysical Data Center (NGDC)

<http://www.ngdc.noaa.gov/>

Defense Meteorological Satellite Program (DMSP)

<http://www.ngdc.noaa.gov/dmsp/dmsp.html>

U.S. Geological Survey (USGS)

<http://www.usgs.gov/>

Central Operation of Resources for Educators (CORE) was established for the national and international distribution of NASA-produced educational materials in multimedia format. Educators can obtain a catalogue and an order form via the CORE Web site at <http://core.nasa.gov>

### Educator Resource Center Network (ERCN)

To make additional information available to the education community, NASA has created the NASA Educator Resource Center (ERC) network. Educators may preview, copy, or receive NASA materials at these sites. Phone calls are welcome if you are unable to visit the ERC that serves your geographic area. A complete list of ERCs is available electronically via NASA Spacelink at <http://spacelink.nasa.gov/ercn>



# Module 2, Investigation 1: Briefing

## Where do we choose to live and why?

### Background

Why do you live where you live? Where do people choose to live? Why do they choose those places? People have lived on Earth for thousands of years. Throughout history they have chosen particular settlement locations for many practical reasons. For just as many reasons they have packed up and moved to settle in other areas. Sometimes bloody wars have been fought over the right to settle in a particular region. Also, natural hazards such as floods, earthquakes, and climate changes have caused people's decisions to change the locations of their settlements.

Cities, highways, roads, agricultural areas, industrial regions, and transportation hubs around the world are factors that contribute to forming human systems. When the United States was settled, early settlements began in the east and gradually moved westward. Could this be the reason the eastern United States is more densely populated than the west? How does this historical migration affect current population patterns in the United States? What if the settlements had grown in the west and moved eastward instead? How would the United States look today?

NASA has been observing and studying Earth since 1958. These observations have been made with aircraft, spacecraft, satellites, and humans on the ground. These observations have generated millions of images and tremendous amounts of data. NASA Earth observations have helped geographers worldwide study and answer many questions about human migration and settlement patterns by providing researchers with large-area views of our planet. Where will human settlements be 10 years, 20 years, or even 100 years from now? Can humans build settlements on other planets like Mars or our Moon? Will settlements of other planets become a necessity?

In this investigation, we look at one region of Earth using some unique and interesting perspectives including: images of Earth taken from space, a relief map, and a road map. Using these views we identify where human settlements are found and why these settlement patterns exist.

### Objectives

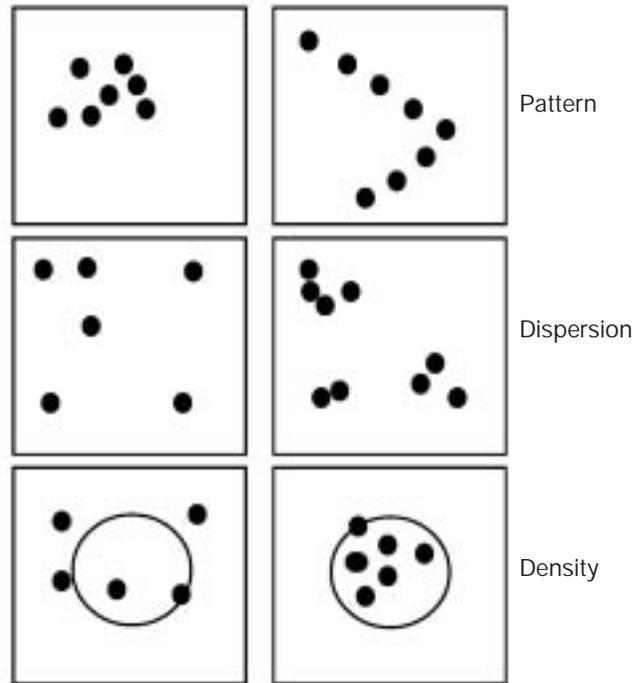
Upon completion of this investigation, you will:

- understand different ways of observing Earth,
- understand ideas of spatial distribution and how these are used to understand human settlement patterns, and
- identify human settlements and patterns using maps and images.

In this investigation, you will learn spatial distribution concepts: pattern, dispersion, and density. You will accomplish this using an image of an unidentified location on Earth and answering questions about what you observe in that image.

### Spatial Concepts

The arrangement of things on Earth's surface is called spatial distribution. Observe these six sets of dots. Each square represents an equal area. Each one illustrates an important concept in the location of items in space. They are pattern, dispersion, and density. Pattern is the arrangement and design in the distribution. Dispersion relates to whether items are clustered or spread out. Density refers to the number of items or observations within a defined area.





### To Observe, Characterize, Predict and Respond to Global and Regional Changes

#### Earth System Science:

NASA's Earth Science Enterprise researches the Earth as a group of global interactive systems. Based on this research informed decisions are made about environmental trends, protecting our planet, and future quality of life.

Farmers, geologists, economists, and city planners interpret remote sensing imagery in order to monitor local and regional changes. Scientists interpret imagery for broad geographic understanding of global ecosystems, and to study the relationship between human activities and the impact upon social, economic, and political issues.

#### Information about this composite satellite image:

The city night lights in this picture connect you to people living in an urban community. Each point of light represents 2,500 people or 427 family units per  $\text{km}^2 \pm 5$  percent. Light from moving trains, planes, cars, boats, and water and full moon reflections were removed.

The satellite data used to make this image were collected by the Westinghouse broad-band visible to near infrared (0.4 to 1.1 microns) optical sensor with a spatial resolution of  $2.7 \text{ km}^2$ . Between fall 1994 and spring 1995, the sensor collected data during 231 ascending polar orbital paths using 3,000 km swaths, with a whisk-broom oscillating pendulum motion at a rate of 101 minutes per orbital period, at an average altitude of 830 km.

### Classroom Purpose, Education Level 9–12

Technology is used to access, process, visualize, and communicate data about Earth Science. Viewing urban lights from the vantage point of satellites enables us to see patterns of urbanization. Urbanization interests the science community because of the way it influences global climate change, and economic and biological sustainability.

#### Objectives:

1. The student will be able to interpret Earth System Science satellite imagery and explain the relationship between urban development, geography, and the global ecosystem.
2. The student will be able to apply knowledge of satellite urban imagery to additional interdisciplinary learning activities within science, math, geography, social studies, and technology.

*Materials needed:* World Atlas Map

#### Procedures for Discussing Real-Life Applications:

1. Place students into eight geographical small groups:
  - a) Africa and Egypt
  - b) Australia, Fiji, and New Zealand
  - c) Cambodia, Laos, Malaysia, and Vietnam
  - d) China, Japan, Korea, and Taiwan
  - e) Europe, Iceland, and Netherlands
  - f) India, Middle East, and Tibet
  - g) Central and South America
  - h) Kazakhstan, Russia, and Uzbekistan
2. **Measure:** Direct each group to determine the number of satellite paths required in compiling the image of their geographic region. (Formula is width of the geographical area in km, divided by the swath width of 3,000 km.)
3. **Interpret:** Have each small group use the satellite image to locate, within their region, the major cities, landforms such as water bodies, mountains, and plains, and transportation routes. Use additional maps or an atlas to verify the cities, landforms, and transportation routes they identified.
4. **Explore:** Have student groups use a map or an atlas to identify vegetation, food crops, grazing areas, and trade routes that may have contributed to the urbanization in their region.

The National Ocean and Atmospheric Administration's National Geophysical Data Center and the Defense Meteorological Satellite Program's Operational Linescan System provided data to NASA Goddard Space Flight Center and Bowie State University in order to render this image of global urban lights. Dr. Marc Imhoff is the Principal Investigator for this project at NASA.

#### Related References and Resources:

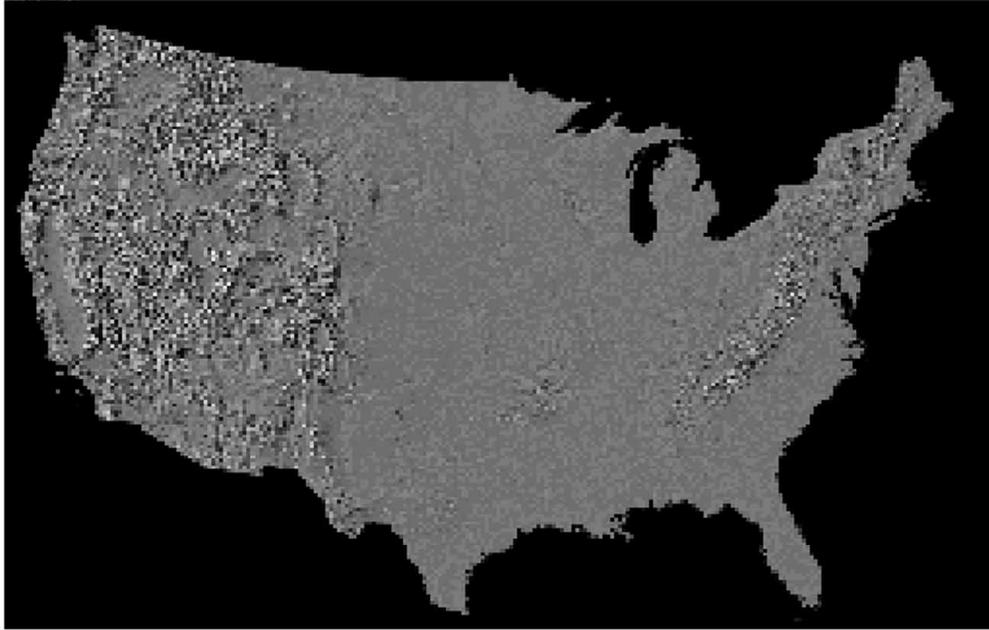
- "Remote Sensing Environment" Feb. 1997, Pub. Elsevier Science, Inc. NY, NY.  
<http://www.elsevier.nl/locate/rse>  
[http://www.ngdc.noaa.gov/dmsp/descriptions/doc\\_ols.html](http://www.ngdc.noaa.gov/dmsp/descriptions/doc_ols.html)  
<http://www.missiongeography.org>  
<http://earth.nasa.gov>  
<http://www.usgs.gov>  
<http://www.cet.edu/essea>  
<http://www.eoscenter.com>  
<http://pumas.jpl.nasa.gov>  
<http://eosps.gsf.nasa.gov>  
<http://pumas.jpl.nasa.gov>  
<http://www.globe.gov>  
[http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img\\_id=4333](http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=4333)  
<http://esto.nasa.gov>

5. **Earth Science:** Explain the processing skills within Earth System Science of observing, characterizing, understanding, predicting and responding to changes in the relationship between the ecosystem and urban development. **Q.** What would happen if the average regional temperature increased or decreased by  $10^\circ\text{F}$  ( $5.6^\circ\text{C}$ )? Using logical progressions, analyze the risks and benefits of human (urban) induced changes on the environment. Use a sequence of assumptions that moves your thought process from implementation, to consequences, to conclusion, and then to predicting future outcomes.
6. **Physical Science:** Explain and apply the four key concepts that guide most scientific investigations: balance of energy, system feedback, life interactions, and change over time. Encourage each geographic group to use intuitive problem solving skills, to present a concept map predicting cause and effect, about motion and forces, and interaction of matter within ecosystems. **Q.** How is urban development a "force of change" on the balance of the regional and global ecosystem?
7. **Life Science:** Explain the interdependence of organisms within living systems. Living things need water for survival. **Q.** What would happen if the average annual regional rainfall increased or decreased by 10 centimeters? How does converting a rain forest or a desert to agricultural land change that ecosystem?
8. **Application:** Direct the group's attention to the United States urban lights image. Apply skills to identify, analyze, and classify the similarities and differences between global and North American urban development patterns. **Q.** What variables would government managers use in remote sensing imagery to plan for new highways, shopping centers, and industry?
9. **Self-Assessment:** Brainstorm, construct, and present your hypothesis about regional ecosystem changes on human populations. **Q.** As you listened to other group presentations, did any of your assumptions change about humans' role in affecting the Earth system? If you were an Earth system scientist, what technological tools would you recommend for the economic and societal benefit to your community?
10. <http://esto.nasa.gov> Download in JPEG or PDF, print, and tape onto the wall or ink-board, 18 color pages of  $8.5 \times 11$ -inch panels of this lithograph in poster form for further interdisciplinary discussions of the relationship between urban growth and our "Home Planet." The enlarged print forms a  $4 \times 8$ -foot wall mural for the students to assemble. Answers to the questions are provided on the Web page.



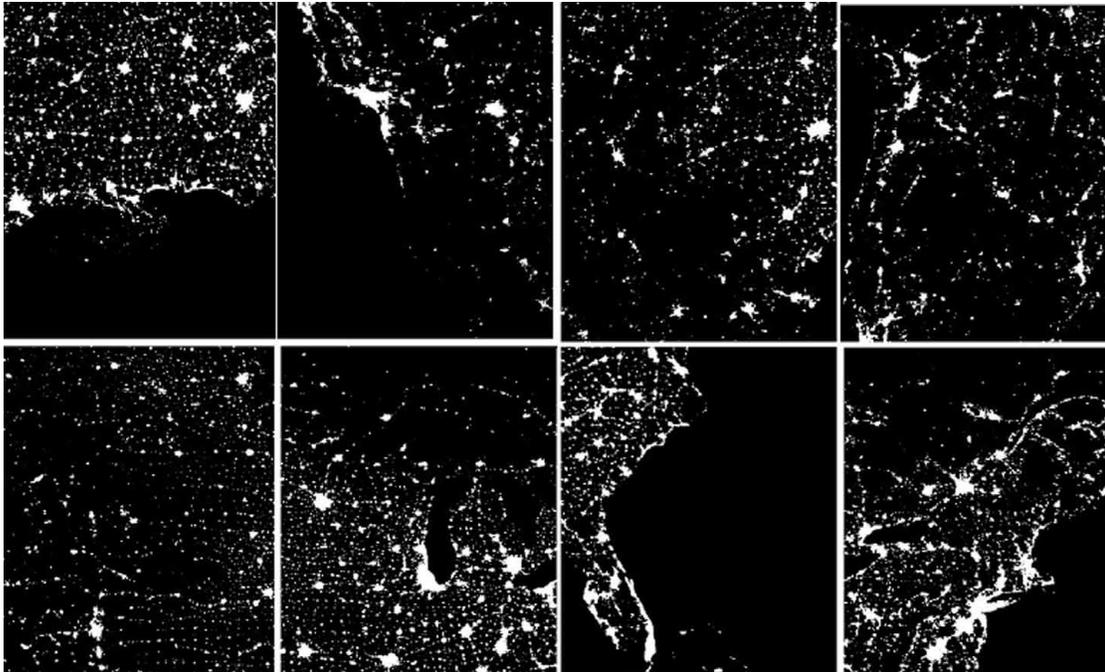
## Module 2, Investigation 1: Figure 5

### United States relief map



## Module 2, Investigation 1: Figure 2

### United States at night map





# Module 2, Investigation 1: Log 1

## Where do we choose to live and why?

### Directions

Apply the spatial distribution concepts to Figure 1 to answer the following questions.

### Questions

1. During what time of the day was this image taken?

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2. Do you think this image was taken from the ground, airplane, or space?

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3. What do the areas of light on the image indicate?

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4. What do the areas of dark on the image indicate?

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5. Are the areas of light equally dispersed?

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6. Do you see any patterns? If so, identify them.

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7. Use a U.S. road map or atlas to:

- identify and label specific cities, water bodies, roads, or other specific features; and
- identify which part of the United States this image represents.

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Figure 1



# Module 2, Investigation 1: Log 2

## Where do we choose to live and why?

### Background

In Part B of this investigation, you will apply what you learned in Part A to assemble the segments of a “United States at night” image and answer questions regarding spatial distribution. Figure 1, in Log 1, shows the northeast section of the United States as seen at night from space. The image is a compilation of satellite images taken over several months (231 Earth orbits from October 1994 to March 1995) to avoid cloud cover. The white areas are lights, and the black areas are either an absence of lights over land or over bodies of water. Where there are lots of lights, there are lots of people. People choose to live where they do because of many factors. People tend to live where it is easy to make a living, is easy to get resources, it is not too wet or dry, it is not too cold or hot, and the land is not too rugged.

### Procedures

1. Figure 2 is a complete “United States at night” image separated into eight random segments creating a puzzle. Following the directions below, assemble these segments to make an accurate image of the 48 contiguous states of the United States.
2. Assemble the segments of the image into the complete map of the United States by connecting features and patterns. Rely on your mental map of the United States to complete this task.
3. Lay an overhead transparency over the assembled image. Use this transparency and overhead markers to trace the map and complete the questions below.
4. Use a U.S. shaded relief map (Figure 5) and a U.S. road map or atlas to help answer the questions below.

### Section One

1. What region(s) has/have the highest concentration of light? Why? Label these areas.

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2. Identify and label the fingerlike areas of dark in the northeast section of the image. Why are they dark?

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3. Identify and label the black region in the southern section. What are the smaller light areas located within this region?

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4. Identify and label the area in the western region that is mostly dark. Why is it that way?

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5. Locate and label where you live on the image. Is it in an area of light or dark?

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# Module 2, Investigation 1: Log 2.2

## Where do we choose to live and why?

### Section Two

6. Identify and label the 10 areas with the highest density of light. Use a road map to identify them.

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7. Why do areas along coastlines, rivers, and lakes appear to have a relatively higher density of light?

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8. Identify and label any major highways you can observe on the image.

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9. Identify and label any major water bodies you can observe on the image.

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### Section Three

10. Describe the dispersion of population in the United States.

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11. Identify and label any patterns you observe on the image.

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12. Does the climate have any effect on the settlement patterns observed in the image? How?

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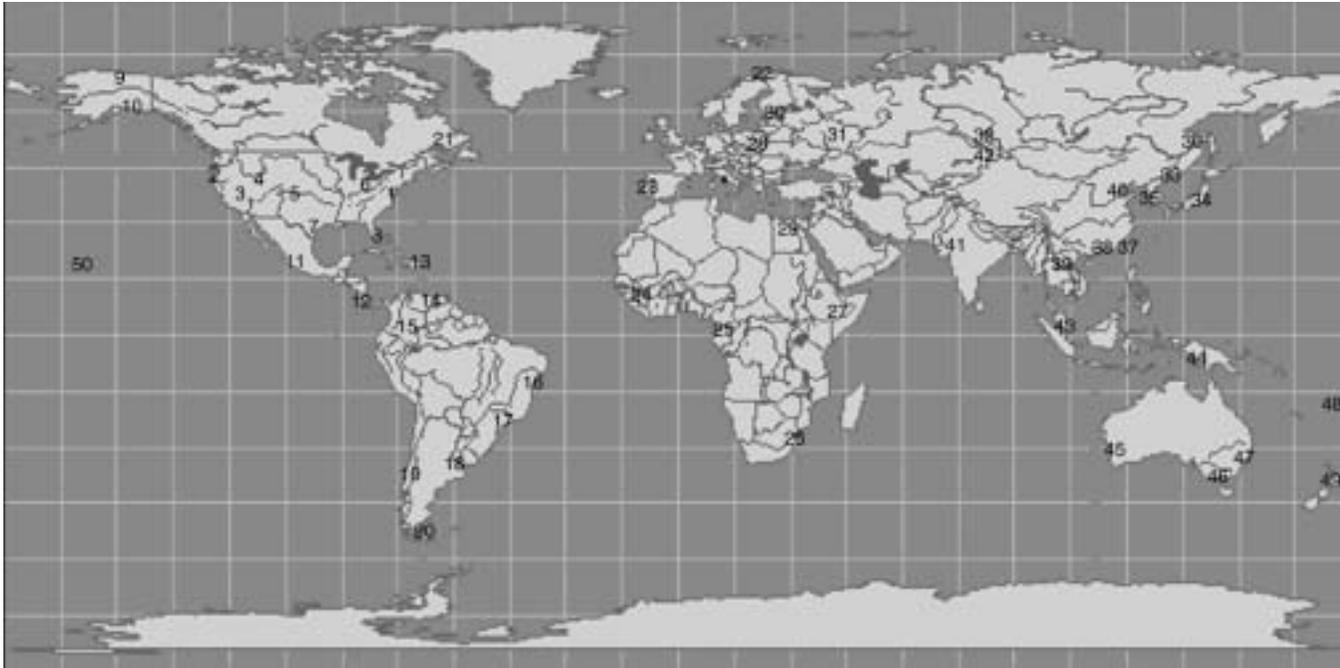
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13. Do elevation and relief have any effect on the settlement patterns observed in the image? How?

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# Night Lights of Urban City Development



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|----------------------------------|--------------------------------|-----------------------------|
| 1. Washington, DC                | 18. Buenos Aires, Argentina    | 35. Seoul, South Korea      |
| 2. Seattle, Washington           | 19. Santiago, Chile            | 36. Nikolayevsk, Russia     |
| 3. Reno, Nevada                  | 20. Punta Arenas, Chile        | 37. Taipei, Taiwan          |
| 4. Denver, Colorado              | 21. Montreal, Quebec           | 38. Hong Kong, China        |
| 5. Kansas City, Kansas           | 22. Hammerfest, Norway         | 39. Hanoi, Vietnam          |
| 6. Detroit, Michigan             | 23. Lisbon, Portugal           | 40. Beijing, China          |
| 7. San Antonio, Texas            | 24. Freetown, Sierra Leone     | 41. Ahmadabad, India        |
| 8. Miami, Florida                | 25. Molabo, Cameroon           | 42. Almaty, Kazakhstan      |
| 9. Fairbanks, Alaska             | 26. Johannesburg, South Africa | 43. Singapore, Malasia      |
| 10. Anchorage, Alaska            | 27. Harer, Ethiopia            | 44. Paupau New Guinea       |
| 11. Mexico City, Mexico          | 28. Warsaw, Poland             | 45. Perth, Australia        |
| 12. Panama City, Panama          | 29. Cairo, Egypt               | 46. Melborne, Australia     |
| 13. San Juan, Dominican Republic | 30. Helsinki, Finland          | 47. Sydney, Australia       |
| 14. Caracas, Venezuela           | 31. Moscow, Russia             | 48. Suva, Fiji              |
| 15. Bogata, Columbia             | 32. Novosibirsk, Russia        | 49. Wellington, New Zealand |
| 16. Salvador, Brazil             | 33. Vladivostok, Russia        | 50. Honolulu, Hawaii        |
| 17. Rio de Janeiro, Brazil       | 34. Tokyo, Japan               |                             |

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