Identifying Urban Heat Islands

Overview

Students are introduced to two geographers who study urban heat islands and work with cities across the country to help reduce the impact of urban heat on residents—especially the young, the old, and those with lower socioeconomic status. Then students will analyze GIS maps to examine for themselves how urban heat can impact people's lives.

Estimated Time

100 minutes

Materials

Worksheet 1: Studying Urban Heat Islands

Worksheet 2: Interpreting Urban Heat Island Maps

Worksheet 3: Making Comparisons

Video: Studying Urban Heat Islands (5:50)

Map: Land Surface Temperature Modeling

Map: Median Household Income Modeling

Map: Extreme Heat Vulnerability Index Modeling

Map: Map of Marion County

Computer and internet access

Overhead projector and/or document

Ruler

Learning Objectives

After completing the lesson, students will be able to:

- Use a three-step procedure to interpret maps

- Systematically compare maps

- Explain how land surface temperature and socio-economic level affect heat vulnerability

Vocabulary

Census Block Group: A statistical division of a census tract, used to present data, generally containing 600- 3,000 people.

Census Tracts: Small, relatively permanent statistical subdivisions of a county or equivalent entity that provide a stable set of geographic units for the presentation of statistical data. Census tracts generally have a population size between 1,200 and 8,000 people, with an optimum size of 4,000 people.

Median Household Income: The amount which divides the income distribution into two equal groups, half having income above that amount, and half having income below that amount.

Vulnerability: Open to physical harm or damage.

GIS Tools and Functions

- Use GIS paper maps to read a map (symbols, scale, direction)
- Use GIS maps to interpret patterns

Additional Resources

Eric Klinenberg, Heat Wave: A Social Autopsy of Disaster in Chicago. University of Chicago Press, 2002. This book focuses on the aftermath of the Chicago heat wave of 1995, mentioned in the video for this lesson.

Opening the Lesson

"You are now about to be introduced to two geographers who study urban heat islands using geospatial technologies and use what they learn to help cities deal with the effects of urban heat."

1. Distribute a copy of the **Studying Urban Heat Islands** handout to each student.

2. Show the *Studying Urban Heat Islands* video. Ask students to find and record answers to the questions contained in the handout, as they watch the video.

3. After showing the video, give students an opportunity to comment, express opinions, or ask questions about what they have seen.

4. Then, have students work in small groups of three or four to discuss their answers to the questions on the handout. Encourage students to modify their answers to the questions, based on their small group discussion.

5. Then have students share what they have learned with the class. Again, encourage students to modify their answers based on the class discussion.

Developing the Lesson

6. Indicate to students that they are now going to use three maps generated by the two geographers they just saw in the video to examine for themselves how urban heat impacts people's lives.

7. Distribute a copy of the **Interpreting Urban Heat Island Maps** handout to each student.

8. As a class interpret the Land Surface Temperature (LST) Map that appears in the handout. Follow the three-step map interpretation procedure outlined in the handout.

9. At the front of the class, you should have the map and worksheet projected on an overhead projector and /or a document camera. As you go through the worksheet, write answers in the correct spaces, so that students know how to complete the worksheet.

10. Begin by reading the worksheet from the top. "Important information about urban heat islands can be obtained from maps. Before the information on a map can be described and analyzed, it is necessary to have a clear understanding of what the map is about. This is the first step in obtaining information from a map.

    "Question One, **what is the map about?** This involves previewing the map. So we are going to look at these five items: title, symbols, map scale, compass direction, and footnotes, and identify them in a way to understand what the map is about.

    "What is the title of this map?"

    "Titles are usually found at the top of a map (point to an example in the classroom if you have a map hanging). However, this map does not have a title at the top. What else do we know about titles? They are usually bold and larger than the rest of the text. Where on this map do I find that type of text? This text, Land Surface Temperature (LST) Modeling, is a different color, uppercased and larger than the text below, so this is the title.

    "Based upon this title, what is this map about?"

    "The title suggests that this map is about the temperature of the surface of the land.

    "The next step is decoding the symbols. In order to decode symbols, I must look at the legend or key.

    "Where is the legend on this map? And what does it mean?

    "The section on the right looks like a legend. The legend shows land surface temperature measured in degrees Fahrenheit. The **dark red** is 87 degrees to 93 degrees; **orange** in 85 to 87 degrees; **yellow** represents 84 to 85 degrees; **green** is 83 to 84 degrees; light blue is 81 to 83 degrees; and **dark blue** represents 73-81 degrees. Notice how each color is represented by different ranges

of temperature, also called interval data. The legend shows the data being classified. The attribute of temperature is being classified into 6 classes.

"So what does this mean? The dark red represents hot land surface temperatures and the dark blue represents the coolest land surface temperatures.

"Next, we are going to check the map scale. Everybody take out your ruler and let's figure out the relationship between the distances on the map to the actual distance on the ground for this map.

1 inch is equal to about 3.4 miles

1 inch is equal to about 5.6 kilometers

8 miles is equal to 2 $\frac{9}{16}$ inches

10 kilometers is equal to 1 $\frac{13}{16}$ inches

"Let's expand on this and measure the area of this map. In order to get the area of the map we need to figure out the length and the width and then multiply the two. For this map, we are going to leave out the little sliver of area in the top right section of the map. And make sure that when we are measuring the width and length we put our ruler through the middle of the map.

- Width = 5 ¾ inches

$$\frac{1 \text{ inch}}{5 \text{ ¾ inches}} = \frac{3.4 \text{ miles}}{? \text{ miles}} = 19.55 \text{ or } 19 \text{ ½ miles}$$

- Length = 5 $\frac{13}{16}$ inches

$$\frac{1 \text{ inch}}{5 \text{ } \frac{13}{16} \text{ inches}} = \frac{3.4 \text{ miles}}{? \text{ miles}} = 19.7625 \text{ or } 19 \text{ ¾ miles}$$

- Area of the map = 19.55 miles X 19.7625 miles = 386.36 square miles

"Do our calculations seem correct? How can we test that based upon given information. Would you say our map is a small-scale map or a large-scale map?

"Next, we are going to use the compass to find north. This way when you are describing locations and features you can use cardinal directions to describe spatial relationships. For example, north of the hottest cluster are low temperature clusters.

"Lastly, let's look to see if there are any footnotes. Footnotes contain the source of information, or in other words, where the data came from. Here we can see it is from Marion County Census Blockgroups from 2010. This data is 6 years old.

"Let's move on to Question Two. **What does the map say?** The second step in obtaining information from a map involves asking and answering questions about how things are arranged on the map.

"Ask and answer 'fact finder' questions. Some questions are asked to find facts that are important. Answering 'fact finders' supplies you with basic information about the features on the map.

"Ask and answer 'pattern finder' questions. Pattern finders ask how things are arranged over the map. A basic distinction is made among clustered, random, and uniform arrangements. With clustered arrangements, objects are located close together. With uniform arrangement, objects are evenly spread over an area. With random arrangements, there is no pattern to how objects are arranged. Answering pattern finders supplies you with information about the arrangement of features on the map.

"We are going to examine the LST map and determine how the features on the map are arranged by answering the following questions.

"Are there areas of high land surface temperature shown on the map of Marion County?

"Is the arrangement of areas experiencing high land surface temperatures clustered, random, or uniform? What makes you say so?

"Is the arrangement of areas experiencing low land surface temperatures clustered, random or uniform? What makes you say so?

"Where on the map are the areas of high land surface temperature clustered?"

"Question Three asks **what the map means.** We need to take the information we gathered in Questions One and Two, analyze it and combine it into a brief, well- organized summary. This summary should consist of five to six sentences that draw together the information obtained from the map.

Have students write a short paragraph summarizing the information obtained from the LST map. Have some of the students share their responses to the class.

11. Have students work in groups of two or three, to complete Part 2 of the **Interpreting Urban Heat Island Maps** worksheet and answer questions about the Median Household Income (MHI) Modeling map. Students will follow the same three-step process.

12. Once students finish their work on the MHI map, have them share their responses with the class. Encourage students to modify their interpretations of the MHI map, based on their classroom discussion.

13. Tell students that Part 3 of **Interpreting Urban Heat Island Maps** will be homework.

14. Distribute a copy of the **Making Comparisons** handout to each student. Have students work in their small groups to compare the patterns on the LST and the MHI maps, using the two-step procedure that appears in the **Comparing Maps** handout.

15. When the small groups have completed their work on comparing the two maps, have students share what they learned about the maps, as a class. Encourage students to modify their comparisons of the maps, based on their classroom discussion.

Marion County Map Activity

16. Indicate to students that they are going to examine some other maps of Marion County, Indiana to get some further insights into urban heat islands. Using a computer, go to Google Maps and search for Marion County, IN. Project the image onto a screen. Zoom in so that the county fills the screen.
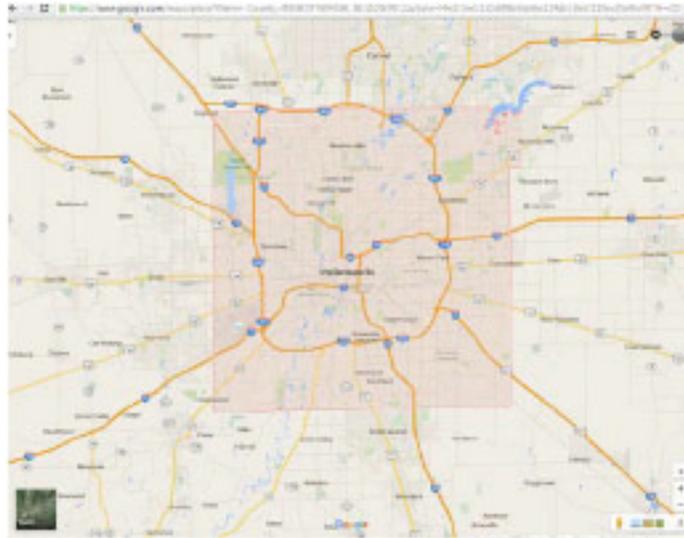
17. Ask students, "Does this map represent the same area as the maps we were working with in this lesson? What makes you say so?

18. Ask students to examine the Google map of Marion County and identify features that could affect the land surface temperature variations that they observed on the maps earlier in the lesson? (Students might identify the following features: two lakes (one on the west side and one on the Northeast corner of the county), the White River flowing through the county from the Northeast to the Southwest, the City of Indianapolis in the center of the county, and less urban concentrations around the edges of the county.)

19. Then ask students how these features are reflected in patterns seen on the LST and EHVI maps. (Students might respond that in the center of the county, where Indianapolis is located, there is a large cluster of high land surface temperatures. As one moves away from the city center, the land surface temperatures decrease, areas along the river seem to have lower surface temperatures outside of Indianapolis, and if we look at the two lakes in the county, we see that those align with the lowest land surface temperatures.)

20. Indicate to students that the next map they are going to see will show the actual landscape of Marion County. This map can also be compared with the

maps that they have been working with. Click on Satellite in the bottom left corner of the Marion County map.
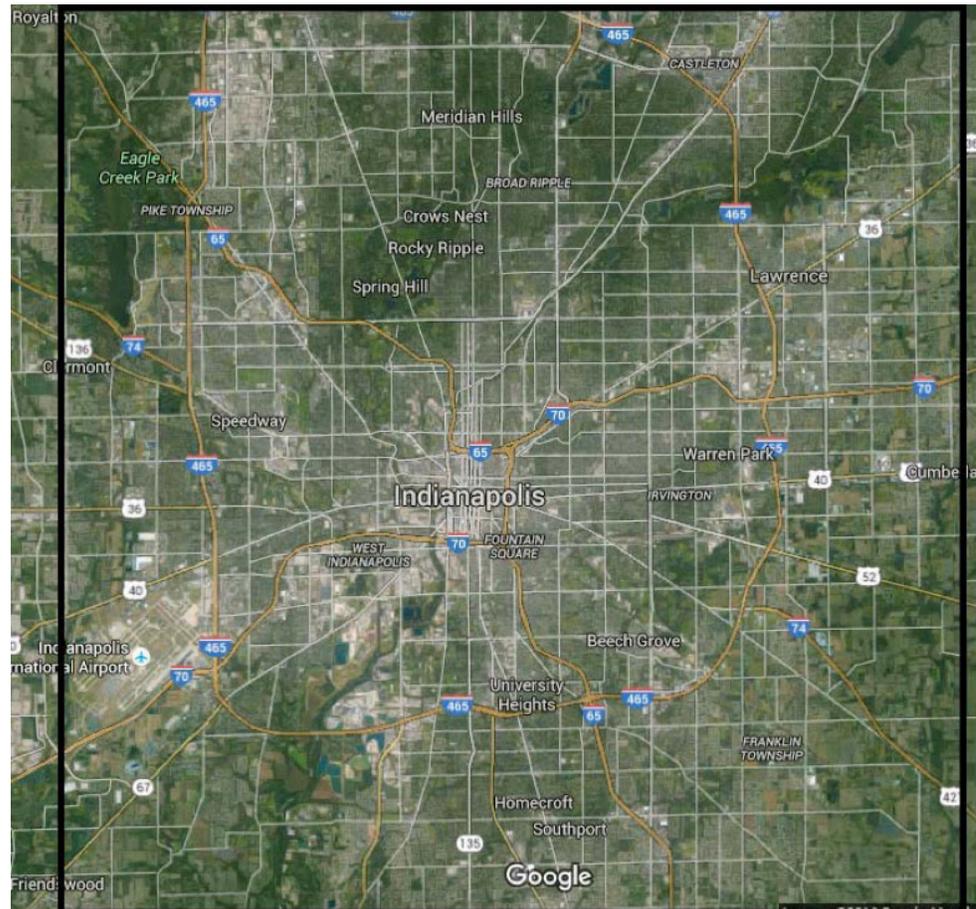
21. Ask students what they think each of the colors on the map represents. (They should respond that the gray represents built up areas, while the green represents areas covered with vegetation.)

22. Then have students compare what they see on this map with the LST and EHVI maps. Do they see a correspondence between gray on the landscape map and red on the temperature maps? Do they see a correspondence between the green on the landscape map and blue on the temperature maps? Ask them what conclusions they can draw from these comparisons. (Students should respond that the high surface temperatures are where the concrete is, and the cooler temperatures are where the vegetation cover is located.)

Concluding the Lesson

23. For homework, have students interpret the **Extreme Heat Vulnerability Index (EHVI) Map**, completing the rest of Interpreting **Urban Heat Island Map**s handout. Remind students that extreme heat vulnerability was featured in the video they saw in this lesson. One of the questions in the Handout associated with the video focused on extreme heat vulnerability. Indicate that they will be sharing their findings in the next class period.

24. The next day in class, ask students to share what they learned from interpreting the EHVI Map.

25. Have students reassemble in their original small groups of two or three. Ask each group to determine how the "high heat risk" areas that they identified from comparing the LST and MHI Maps, compare to the most vulnerable areas identified on the EHVI Map. Have some of the student groups share their findings.

26. Ask students to try to explain how income and surface temperature contribute to heat vulnerability. (Answers will vary.)

27. As a class have students identify a list of characteristics of an urban heat island.

Worksheet 1:
Studying Urban Heat Islands

1. How did Dan Johnson get interested in studying urban heat islands?

2. What types of environmental data are used to calculate the Extreme Heat Vulnerability Index?

3. What is the source of this data?

4. What types of economic and social data are used to calculate the Extreme Heat Vulnerability Index?

5. What are some of the ways in which the Extreme Heat Vulnerability Index is used to help people living in cities?

Worksheet 2:
Interpreting Urban Heat Island Maps

Part 1: Important information about urban heat islands can be obtained from maps. Before the information on a map can be described and analyzed, it is necessary to have a clear understanding of what the map is about. This is the first step in obtaining information from a map.

1. **What is the map about?** This involves previewing the map:

   Inspect the title—by Inspecting the title, you can find out the subject of the map, the area for which information is shown, and when the information was gathered. (Some of this information may appear in the map notes—see below.)

   Decode the symbols—by decoding the map symbols in the key (legend), you can find out what the symbols on the map mean. Sometimes symbols are used that are not listed in the legend.

   Check the map scale—by checking the map scale, you can tell the relation between distance on the map and distance on the ground.

   Examine the compass to find north—by knowing where north and other cardinal directions are make it possible to find and describe the location of features on the map.

   Check the foot notes—by checking the map notes, you can tell the source of the information in the map.

   Examine the **Land Surface Temperature (LST) Map**. Determine what it is about by completing the five tasks listed below. Write your answers in the spaces below.

   a. Inspect the title

   b. Describe the symbols

   c. Examine the scale

   d. Use the compass to find north

   e. Check the footnotes

2. **What does the map say?** The second step in obtaining information from a map involves asking and answering questions about how things are arranged on the map.

Ask and answer "fact finder" questions. Some questions are asked to find facts that are important. Answering "fact finders" supplies you with basic information about the features on the map.

Ask and answer "pattern finder" questions. Pattern finders ask how things are arranged over the map. A basic distinction is made among clustered, random, and even arrangements. With clustered arrangements, things are located close together. With an uniform arrangement, things are evenly spread over the area. With random arrangements, there is no pattern to how things are arranged. Answering pattern finders supplies you with information about the arrangement of features on the map.

Examine the LST Map. Determine how the features on the map are arranged by answering the following questions. Write your answers in the spaces below.

a. Are there areas of high land surface temperature shown on the map of Marion County?

b. Is the arrangement of areas experiencing high land surface temperatures clustered, random or uniform? What makes you say so?

c. Is the arrangement of areas experiencing low land surface temperatures clustered, random or uniform? What makes you say so?

d. Where on the map are the areas of high land surface temperatures clustered?

3. **What does the map mean?** The information obtained from a map should be combined into a brief, well-organized summary paragraph. This is the final step in obtaining information from a map. The summary involves speculating about the factors that could have led to the patterns in the distribution seen on the map and/or the possible implications of the patterns observed.

This summary paragraph should be comprised of five to six sentences that draw together the information obtained from the map.

Consider the **LST Map**. In the space provided below, write a short paragraph summarizing the information obtained from the map.

Part 2: Use the same three-step procedure to gather information from the **Median Household Income (MHI) Map.**

1. Determine what the **MHI Map** is about by completing the five tasks listed below. Write your answers in the spaces below.

    a. Inspect the title

    b. Describe the symbols

    c. Examine the scale

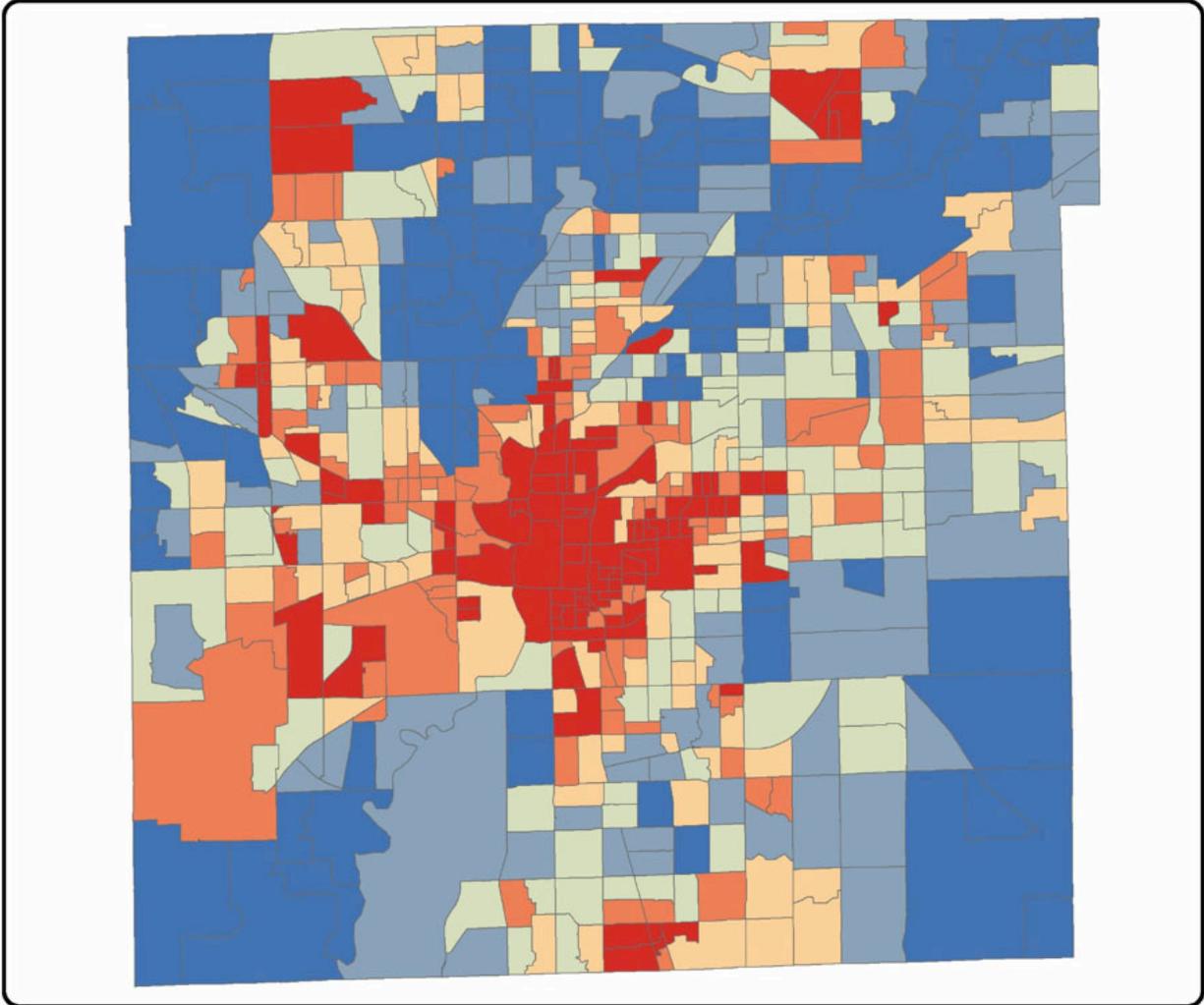   d. Use the compass to find north

    e. Check the footnotes

2. Examine the **MHI Map**. Determine how the features on the map are arranged by answering the following questions. Write your answers in the spaces below

    a. Are there areas of low median household income shown on the map of Marion County?

    b. Is the arrangement of areas experiencing low median household income clustered, random or uniform? What makes you say so?
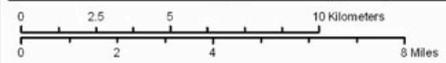
    c. Where are high median household incomes located?

    d. Where on the map are the areas of low median household incomes clustered?

3. Consider the **MHI Map**. In the space provided below, write a short paragraph summarizing the information obtained from the map.

Part 3: Use the same three-step procedure to gather information from the **Extreme Heat Vulnerability Index (EHVI) Map**.

1. Determine what the **EHVI Map** is about by completing the five tasks listed below. Write your answers in the spaces below.

    a. Inspect the title

    b. Describe the symbols

    c. Examine the scale

    d. Use the compass to find north

    e. Check the footnotes

2. Examine the EHVI Map. Determine how the features on the map are arranged by answering the following questions. Write your answers in the spaces below

    a. Are there areas of high heat risk shown on the map of Marion County?

    b. Is the arrangement of areas experiencing high heat risk levels clustered, random or uniform? What makes you say so?

    c. Is the arrangement of areas experiencing low heat risk levels clustered, random or uniform? What makes you say so?

    d. Where on the map are the areas of high heat risk clustered?

3. Consider the **EHVI Map**. In the space provided below, write a short paragraph summarizing the information obtained from the map.

Land Surface Temperature (LST) Modeling

0   2.5   5   10 Kilometers
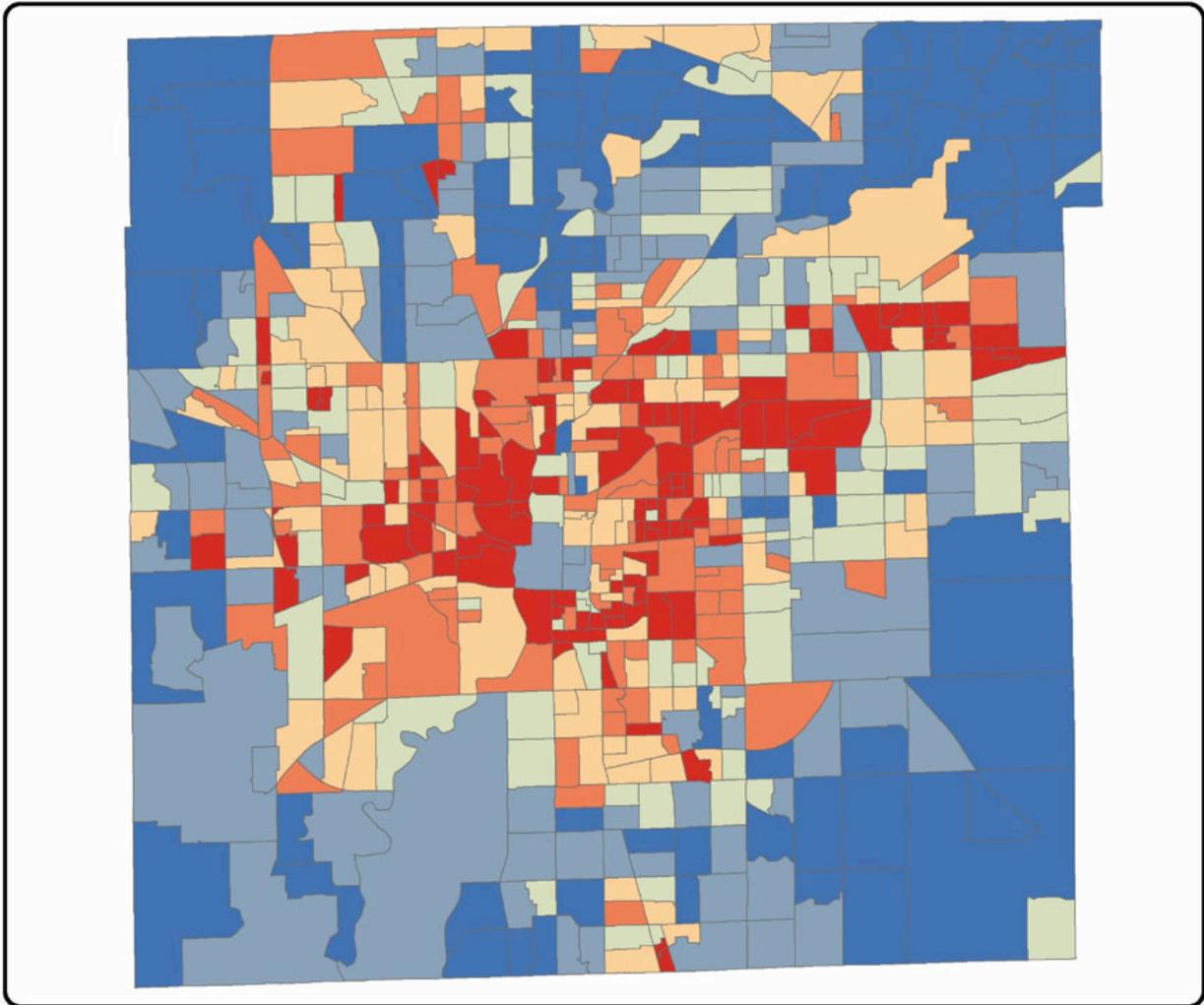
0   2   4   8 Miles

EHVI Analysis of Indianapolis, IN; Department of Geography ~ IUPUI

Analysis: Johnson et al. (2012)
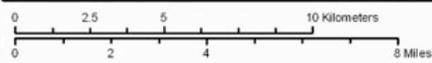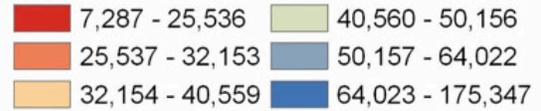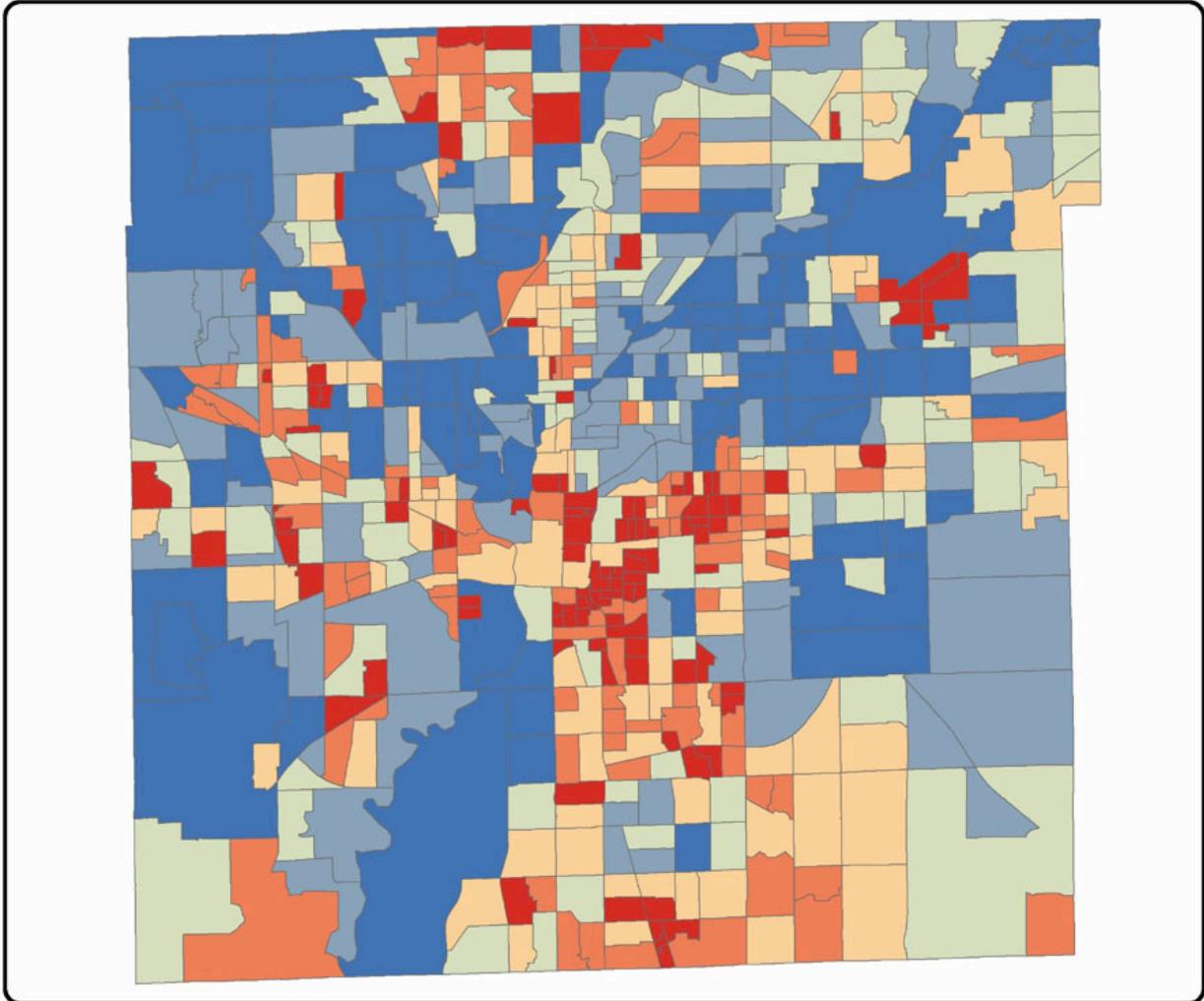Source: Marion County Census Blockgroups (2010), LST (Landsat5, 07.15.11)

Land Surface Temperature (Fahrenheit)

87 - 93	83 - 84
85 - 87	81 - 83
84 - 85	73 - 81

Median Household Income (MHI) Modeling

0   2.5   5   10 Kilometers

0   2   4   8 Miles

EHVI Analysis of Indianapolis, IN; Department of Geography ~ IUPUI

Analysis: Johnson et al. (2012)
Source: Marion County Census Blockgroups (2010), LST (Landsat5, 07.15.11)

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Median Household Income (US Currency)

7,287 - 25,536	40,560 - 50,156
25,537 - 32,153	50,157 - 64,022
32,154 - 40,559	64,023 - 175,347

Extreme Heat Vulnerability   Index (EHVI) Modeling

0   2.5   5   10 Kilometers

0   2   4   8 Miles

N
W — E
S

EHVI Analysis of Indianapolis, IN; Department of Geography ~ IUPUI
Analysis: Johnson et al. (2012)
Source: Marion County Census Blockgroups (2010), LST (Landsat5, 07.15.11)

Indianapolis 2010 EHVI Risk Level

High High   Medium Low
High Low   Low High
Medium High   Low Low

Worksheet 3:
Making Comparisons

It would be interesting to compare the median family income (MFI) map (an indicator of poverty levels) and the land surface temperature (LST) map (an indicator of environmental conditions) that we have already examined to get an idea of where the people most at risk from urban heat live in Marion County.(It is important to realize that there are many other measures of social-economic status aside from median income). There are also environmental factors other than surface temperature that influence vulnerability. But this comparison of temperature and income would be a good start on investigating more about the problem of urban heat problems.

Once we have decided what to compare—in this case the arrangement of income and temperature—there are two steps involved in making a comparison of maps.

Step One: Use comparable maps

1. Information contained on the maps must be for the same *study area*. For example, a map that has information for a state cannot be compared with a map that has information for the entire country.

2. Maps of the same study area must contain information for the same *unit areas*. For example, a state map that has information by counties cannot be compared with a map that has information by townships.

Question: Are the LST and the MHI Maps comparable? What makes you say so? Enter your answer in the space below:
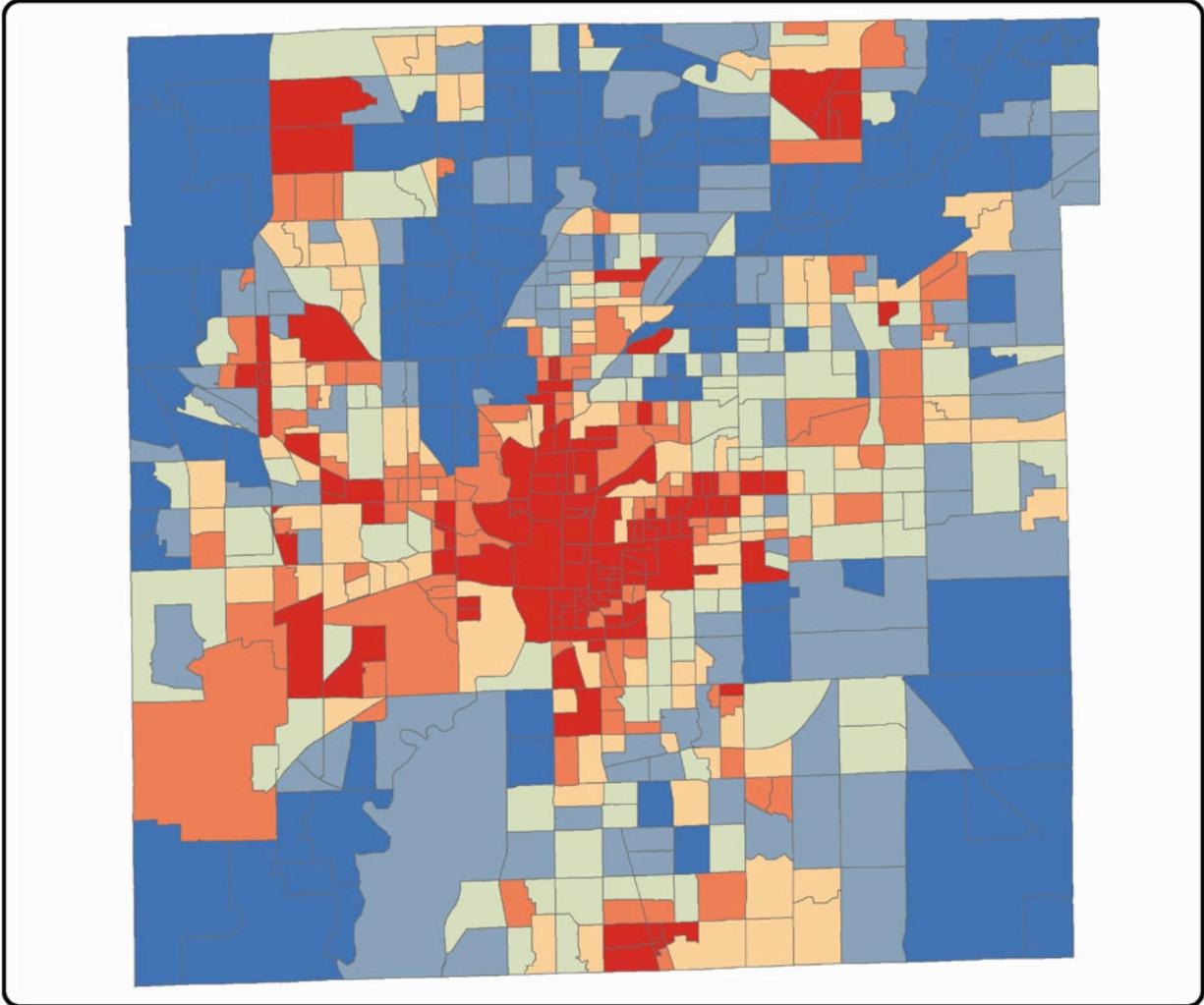
Step Two: Compare the arrangements

Once the arrangements to be compared have been determined, and comparable maps showing these arrangements have been secured, the actual comparison can be made. To do this, similarities and differences between the arrangements on the maps must be described.

Task 1: Use a marker to place circles on the MHI Map where there are clusters of low income. Are there areas in the county where both low income and high temperature are clustered? Mark these areas as A, B, C…on the MHI map.
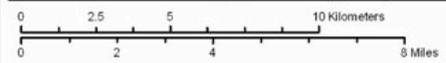
Task 2: Use a marker to place an X on the MHI Map where high income households are clustered. Are there areas in the county where both high income and high temperature are clustered? Mark these areas with a 1, 2, 3…on the MHI map.

Task 3: Are there areas in the city where both low income and low temperature are clustered? Use a marker to place check marks on the MHI Map where those areas are located.

Task 4: Write a short paragraph (5 to 6 sentences) summarizing the information obtained from comparing the two maps.

Land Surface Temperature (LST) Modeling

0   2.5   5   10 Kilometers

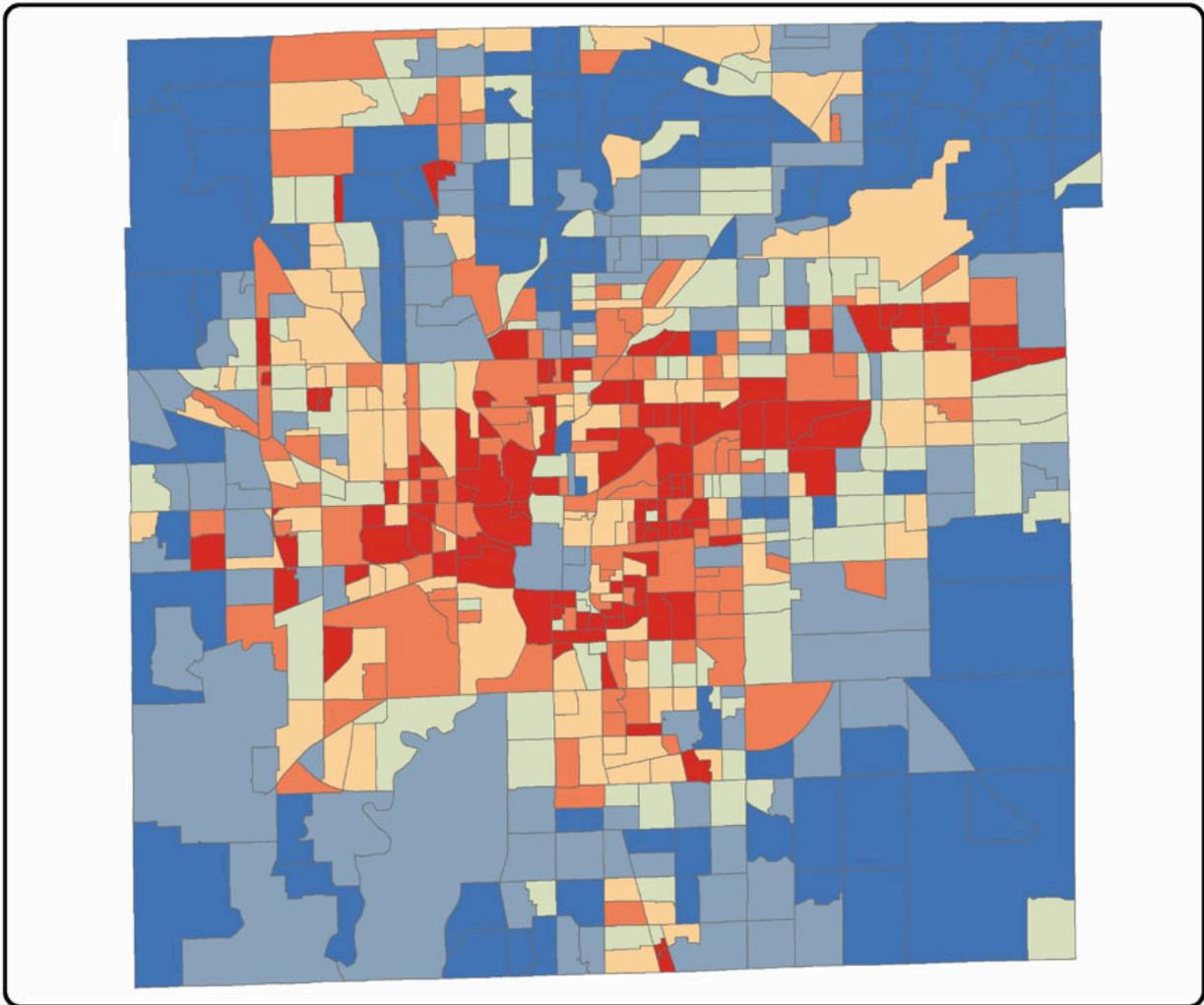0   2   4   8 Miles

EHVI Analysis of Indianapolis, IN; Department of Geography ~ IUPUI

Analysis: Johnson et al. (2012)
Source: Marion County Census Blockgroups (2010), LST (Landsat5, 07.15.11)
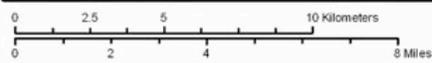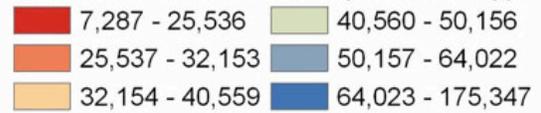
Land Surface Temperature (Fahrenheit)

87 - 93		83 - 84
85 - 87		81 - 83
84 - 85		73 - 81

Median Household Income (MHI) Modeling

0   2.5   5   10 Kilometers
0   2   4   8 Miles
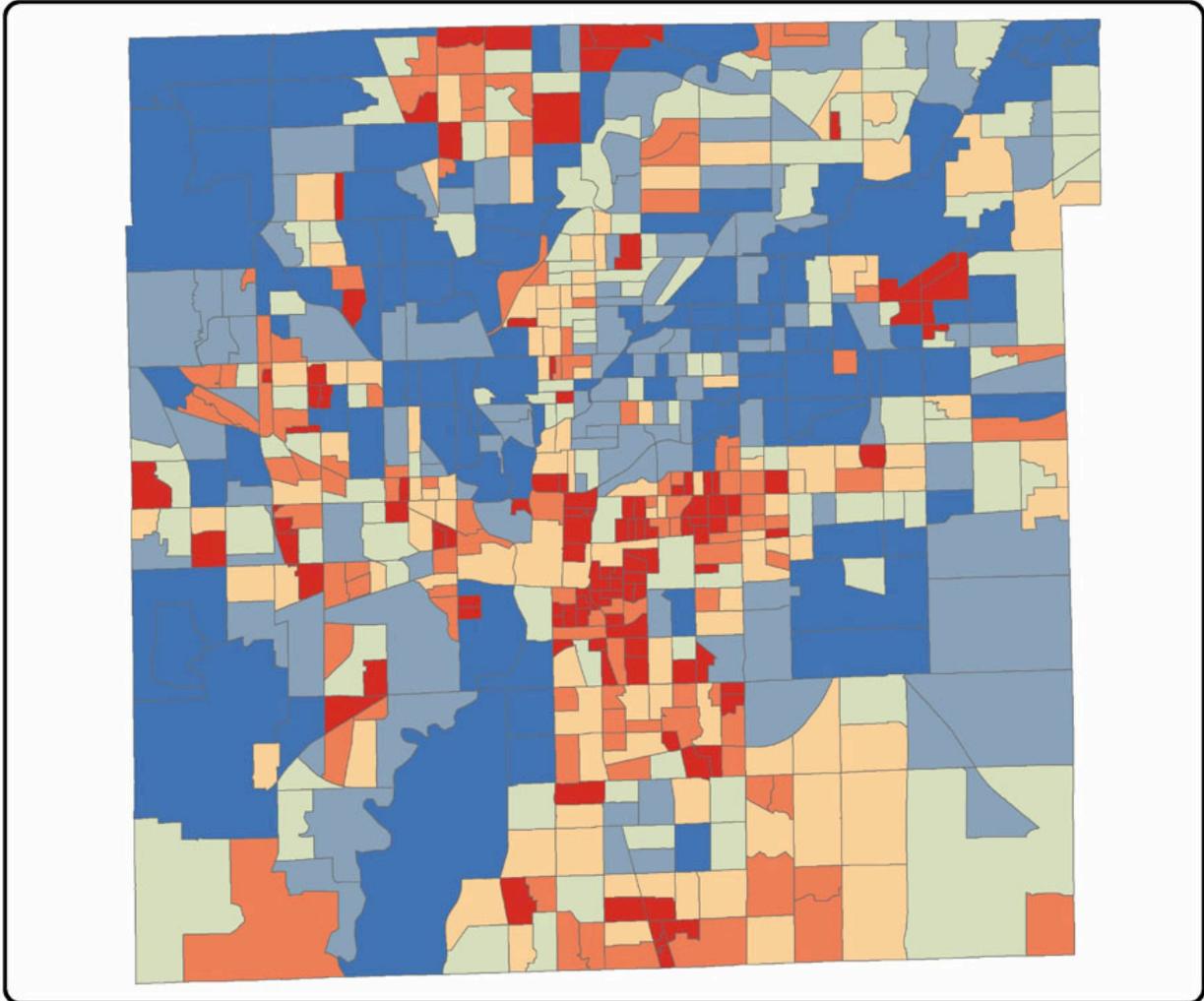
EHVI Analysis of Indianapolis, IN; Department of Geography ~ IUPUI
Analysis: Johnson et al. (2012)
Source: Marion County Census Blockgroups (2010), LST (Landsat5, 07.15.11)

Median Household Income (US Currency)

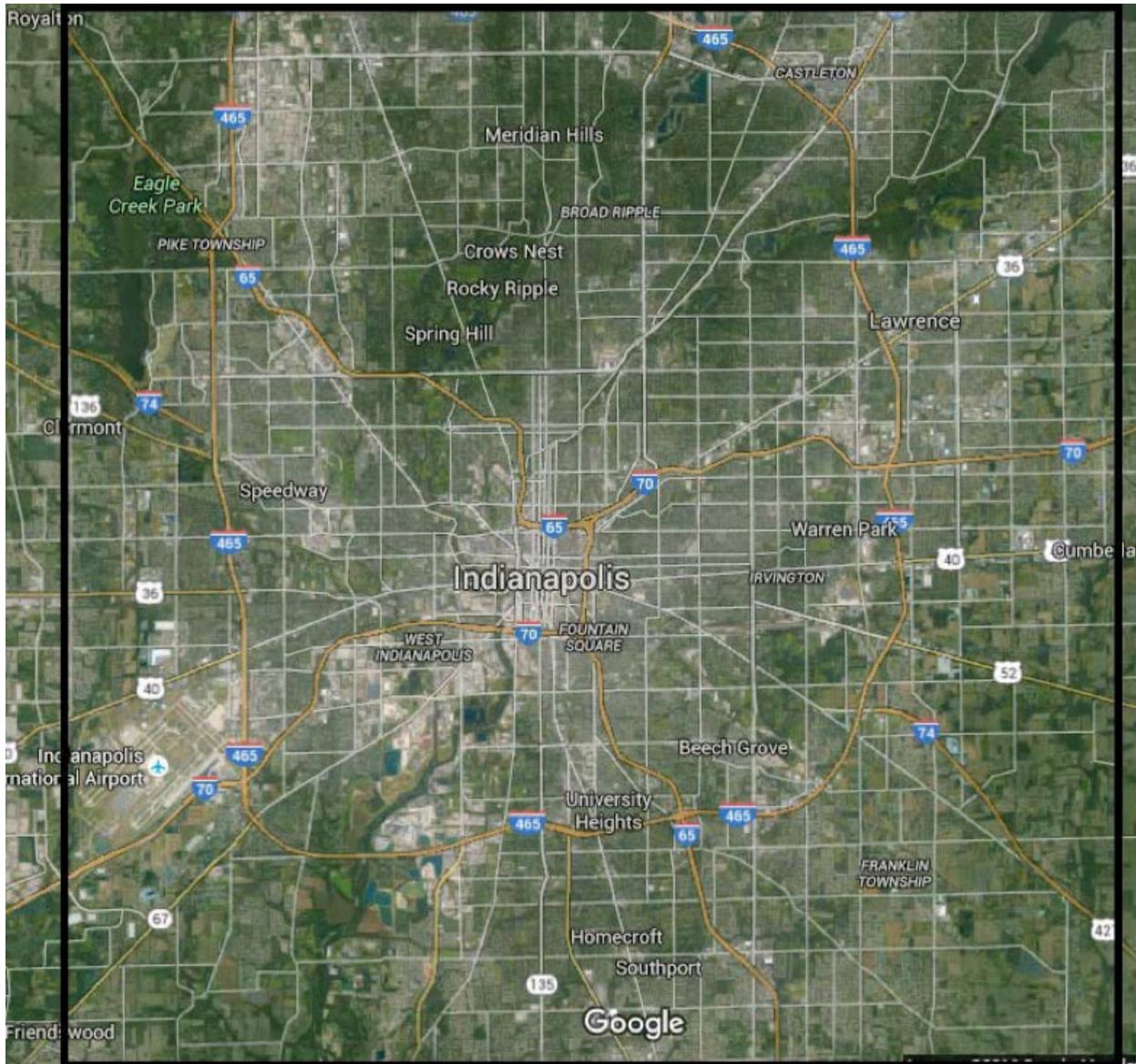|	
7,287 - 25,536	40,560 - 50,156
25,537 - 32,153	50,157 - 64,022
32,154 - 40,559	64,023 - 175,347

Extreme Heat Vulnerability Index (EHVI) Modeling

Indianapolis 2010 EHVI Risk Level

High High		Medium Low
High Low		Low High
Medium High		Low Low

0 2.5 5 10 Kilometers

0 2 4 8 Miles

N W E S

EHVI Analysis of Indianapolis, IN; Department of Geography ~ IUPUI
Analysis: Johnson et al. (2012)
Source: Marion County Census Blockgroups (2010), LST (Landsat5, 07.15.11)

Map of Marion County