

Lesson 4: Urban Heat Islands

Overview:

In this lesson, students will explore the concept of a heat island. In the first activity, students will consider temperature variations with respect to color. In the second activity, students will investigate temperature differences throughout their field sites. The third activity will guide students in synthesizing the first two activities by defining what causes heat islands and how they can be reduced. Strategies for reducing heat islands are presented.

Sub-Question

What is an urban heat island and how does it impact a city?

WAYS OF KNOWING URBAN ECOLOGY:



Students will...

Understand

- Understand the factors that contribute to heat island effects which are prevalent in urban areas. (*forces and drivers, human impact, ecosystem state and structure*)
- Understand that different surfaces impact a city's temperature. (*human impact, ecosystem state and structure*)
- Understand that there are ways in which urban areas can be planned in order to reduce the heat island effect. (*human impact, ecosystem state and structure*)

Talk

- *Discuss possible solutions for reducing the heat island effect in urban areas.*

Do

- Collect data from their field site and describe the albedo effect trends of the site.

Act

No specific goals connected with acting on urban ecology in this lesson.

Safety Guidelines

Safety precautions associated with field visits

Preparation

Time: 2 class periods

- Day 1: Activity 4.1
Activity 4.2
- Day 2: Activity 4.3

Materials

Activity 4.1

- Lights (50-75 Watt bulbs)
- Different color paper
- Thermometer

- Copies of narrative

Activity 4.2

- **SUNNY DAY:** *This activity works much better if it is sunny*
- Clipboards
- Thermometers
- Copies of student data collection sheet

Activity 4.3

- PowerPoint presentation- Urban Heat Islands
- PowerPoint presentation- Possible solutions

Instructional Sequence**Day 1****Activity 4.1: Demonstration**

This activity is designed to help students better understand the impact of color on temperature

1. Set up at least two different stations (white and black paper) with a thermometer under a piece of paper and light shining on it at the start of the class.
2. Have the students write down which setup will show the greatest temperature change and why.
3. Begin talking to the class about the next activity which will have them exploring temperature differences in their field site. After about 10 minutes check to see if there are any temperature changes associated with the demonstration. If there isn't keep checking every 10 minutes.

Teacher Content Background: How do heat islands form and how are they controlled?

The materials used in construction and the surface characteristics of the city such as the building dimensions and spacing, thermal properties, and amount of green space influence heat islands. Heat island formation is favored by

- relatively dense building materials that are slow to warm and cool and store a lot of energy
- replacement of natural surfaces by impervious or waterproofed surfaces, leading to a drier urban area, where less water is available for evaporation, which offsets heating of the air
- lower surface reflectivity to solar radiation -- dark surfaces such as asphalt roads absorb more sunlight and become much warmer than light-colored surfaces

Trees reduce heat island effects through:

1. Transpiration or the loss of water from leaves cool the surrounding air
2. Shade from canopies of trees also cools the surrounding air.

4. Discussion of demonstration
 - Tell students the temperatures from each piece of paper
 - Ask students how the results compared with their predictions?

- Have students explain the demonstration including why the black piece of paper was hotter.

Activity 5.2: Data collection

1. Before taking students outside ask students what they expect to find in terms of temperature.
 - Possible questions could be: Where do you think you will find the hottest temperatures? The coldest? How might vegetation influence temperature?
2. Break the students into small groups. Each group should have a clipboard, copies of the student sheet, something to write with, and thermometer.
3. Have the groups collect data in different areas where they can record the temperature around several different types of surfaces. A good strategy is to find an area that is shaded (under a tree for instance) and then walk in a straight line outward toward a sunny location. This approach will enable students to see how rapidly temperature can change.

Teacher Background: Bad thermometers

Sometimes your thermometers may have widely varying start temperatures. If you have a set of thermometers that disagree with one another you can get some ice water and submerge all the thermometers in the ice water and this should help to standardize them.

For this activity having thermometers that all measure temperature the same is not that critical since you want to students to notice the relative change in temperature from one point to another point. However, if you do want to compare different sites having a set of thermometers that measure temperature similarly would be important.

4. Back in the classroom have the students examine their data and see if they see any trends in their data. For example, was the temperature cooler near a certain area? Was it cooler in areas that were paved with blacktop or concrete?
5. Have students complete the data analysis questions on their student sheets

Closing activity

1. Engage students in a discussion about potential impacts of heat islands that they learned from the narrative

Day 2**Activity 5.3: Why do heat islands form?**

This activity will reinforce the meaning of a heat island and how they form by drawing together information from the data collection activity and information from the narrative

1. Opening

- Ask students to reflect on their personal experiences with these ideas. A possible question might be: You are outside in the summer time wearing nothing on your feet. Where would you want to stand? Why?
- Discuss students answers

2. PowerPoint presentation- Urban heat islands

Teaching Background: What causes a heat island and how why does the surface matter?

On hot summer days, cities can be up to 8 °F hotter than their suburban and rural surroundings. Heat islands occur because cities are made mostly of paved and dark colored surfaces like roofs, roads, and parking lots that absorb, rather than reflect, the sun's heat, causing the surface and air temperatures to rise. Darker colors absorb more light energy which means that darker objects heat up more.

To determine the amount of energy any object absorbs scientists use the concept of **albedo**. **Albedo** is a Latin word which means whiteness. The albedo of an object ranges from 0 (no light reflected) to 1 (all light reflected). So the higher the albedo the more energy that is reflected which means less energy is absorbed. The table below shows the albedo of some common surfaces that are in the city of Boston. For example, Black Pavement (Tar) only reflects about 5-10% of the energy that strikes it or another way to think about it is that Black Pavement absorbs 90 – 95% of sunlight that hits it.

Albedo (%)	Surface
5% - 10%	Black Pavement
15% - 35%	Concrete
10% - 30%	Grass
80% - 95%	Snow
5%	Black Paint
80%	White Paint

3. After the PowerPoint presentation refer back to yesterday's activities. Have students discuss other impacts of the heat island effect.
 - Ask students why do we care about cities as heat islands?
4. Role of vegetation in reducing the heat island effect
 - Have students take out their data from yesterday's activity. Ask students what the temperatures were like near vegetation? *Temperatures should be lower near vegetation than in sunlight.* Ask students to explain this phenomenon. *Students will most likely say that shading keeps temperatures lower.*
 - Explain that in addition to shade, transpiration from vegetation also helps lower temperatures and reduce the heat island effect.

Teacher Background: Making Connections – Tree transpiration

In this activity your students may notice that the temperature under a tree may only be a few degrees cooler than in the sun. Trees not only reduce the temperature through shading the area underneath them they also make it cooler by releasing moisture into the atmosphere.

Moisture transpiration from leaves has a cooling effect that exceeds the moderating effect of shade. Roughly 95% of the water in a tree is recycled into the atmosphere through *evapotranspiration* (a by-product of photosynthesis). The transpiration rate is highest during hot afternoons in the growing season.

- Ask students what might be the similarities and differences of planting a tree in an open space vs. in a paved area. Make a Venn diagram on the board of student's ideas.
5. Discuss ways to change the way that land is used to reduce the heat island effect. This can be done as a whole class or by breaking the students into groups.

Conclusion

1. Show students the Potential Solutions Powerpoint presentation. Compare student ideas to the information presented on this slide.
2. Reflection, ask students: How does the way we use land impact the heat island effect?