New Jersey School of Conservation
One Wapalanne Road • Branchville, NJ 07826-5115
http://friendsofnjsoc.org • info@friendsofnjsoc.org

# Cool Schools: Designing for Climate Change

In this activity, students will observe how different types of surfaces have an effect on temperature and learn how albedo and the concept of Urban Heat Islands relate to those surfaces. Students will collect data from the NJSOC campus and use the information that they collect to make suggestions on how to reduce the Urban Heat Island effect around a typical school.

**OBJECTIVES:**

1. Students will understand the concept of albedo and how it relates to the 'Urban Heat Island' effect.
2. Students will collect data and compare and contrast a variety of different surfaces.
3. Students will apply what they have learned to make suggestions for modifying a typical school environment to reduce the Urban Heat Island effect.

**BACKGROUND INFORMATION:**

See information on climate fact sheet, albedo worksheets, and the directions for care, use, and safety of the infrared thermometers.

**MATERIALS:**

- Laminated Terms (Albedo, Urban Heat Island, Glaciers, Sea Ice, Positive Feedback Loop)
- Laminated Pictures of Different Surfaces (Ice, Water- Ocean & Lake, Desert, Green Forest, Asphalt, Cement, Snow, Crops, Soil/Exposed Rock, Grass)
- Infrared Thermometers and Data Collection Sheets
- Schoolyard Drawings
- Schoolyard Model

**PROCEDURE:**

This activity will be divided into 3 parts:

1. Introduction to terms and concepts in the classroom
2. Walking the NJSOC campu to collect data using infrared thermometers
3. Back in the classroom where students will make suggestions for modifications to the landscape and design of a 'sample school yard'.

**Part A: (15-20 min)**

1. Post the Laminated terms: **Glacier and Sea Ice** Ask: *Do any of you know these terms? Elicit student responses*

   If students seem stumped, a good place to begin is to **ask what the difference is between glaciers (ice that is on land) and sea ice (ice that is on the water)**. Then ask: I*n terms of climate change, why do we care about ice? Responses should lead to as the earth warms glaciers melt causing sea levels to rise. Additionally as the earth warms water expands causing sea levels to rise- like a ring getting tighter on your finger that expands on a hot day. But what about Sea Ice- that is already in the water so if it melts it won't make the sea levels rise, so why do we care about that? As the ice melts it adds more fresh water to the sea water which changes ocean currents and can change food supplies etc. but also sea ice is REALLY shiny and that is what we are going to talk about today.*

2. *Does anyone know how we measure the shininess or reflectivity of an object?* We measure it on what is called the ALBEDO scale. **Put the laminated term albedo up.** *Think about going outside on a really hot day wearing a black t-shirt versus a white t-shirt- which one absorbs more solar radiation?* **The albedo of an object is a measure of its reflectiveness. We measure albedo on a scale of 0 to 1. So the Black t-shirt would have a low albedo close to 0 and the white one would have a higher albedo, closer to 1.**

   **When the sun hits our Earth a number of things can happen, but let's just think about these two:**
   **1) it can get absorbed by things like your black t-shirt or**
   **2) it can bounce off of surfaces and go back out of our atmosphere.**

   Ask students: *Can you tell me some of the colors found on the surface of the Earth and where those colors are found? And ask them where those colors are found. As students respond- hand them one of the Earth's Surface Cards that corresponds to what they say- Blue (Ocean), White (Snowy Mountain top), Green (rainforest) etc.*

3. Now post the Albedo Scale have students make their way to the front of the room and position themselves (with their cards) in the order of albedo of the surface that they are holding. Encourage students to discuss with each other the potential order. *Discuss their placements- see fact sheet and place cards in the correct order on the shelf. Students should return to their seats.*

4. **Now post the term: Urban Heat Island**

   Ask students if they know this term? Ask: *What do you think the surfaces in a (urban area) city have to do with Albedo? There is a lot of asphalt and cement that absorb heat and drive up the temperature.*

   ***This leads into the idea of a positive feedback loop- the hotter it is the more people use air conditioning, the more greenhouse gasses that get emitted and the planet gets hotter. When the planet gets hotter- more reflective snow and ice melt and the planet gets less 'shiny' and more solar radiation is absorbed and the planet gets hotter.***

This is what is called a positive feedback loop- even though there is nothing positive about it. ***Post the term: Positive Feedback Loop***

**Part B: (30-35 min)**

In this part of the lesson you will be going outside using the infrared thermometers to see how different surfaces absorb heat.

- Please instruct students on the proper use and SAFETY for using the thermometers (NEVER POINT THE LASER AT ANYONE'S EYES).
- Try to measure the temperature the same distance away from every object.

1. Depending on how many students are in a group-pair them up or put them in groups. **Give them a thermometer to share and a data sheet.**

2. Walk around the campus and be sure the students are testing many different surfaces and recording the temperatures. They should **note the outside temperature at the start** and whether or not the object they are testing is in direct sunlight or not.

3. **Test the asphalt, gravel, grass, cement, dark wood/roofs, lighter wood, metal, water etc.**

4. As you walk around campus try to point out things related to climate mitigation and general environmental issues such as
   - the native plant pond (Frog Hollow)
   - the temperature difference in the shade of a tree versus in direct sunlight
   - permeable, semi permeable and non-permeable surfaces and how they
   - affect runoff
   - Invasive species that may be better adapted to the changing climate etc.

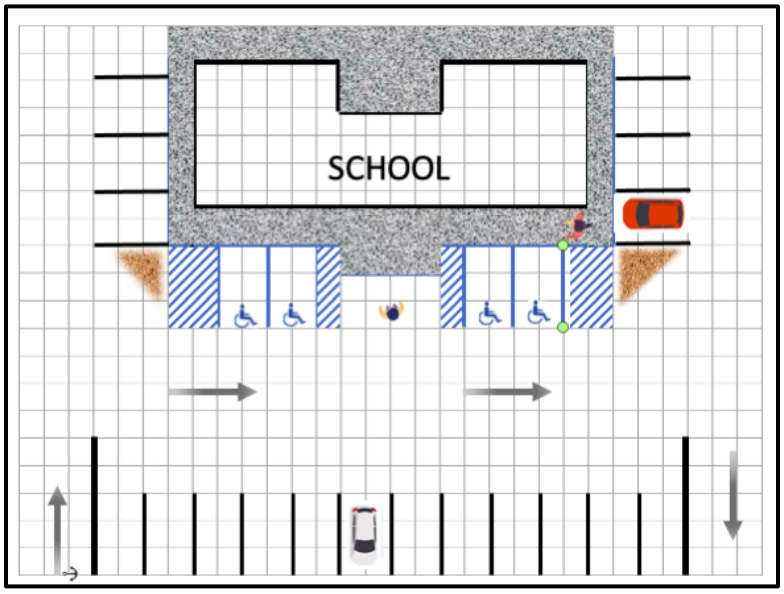
**Part C: (30-35 min)**

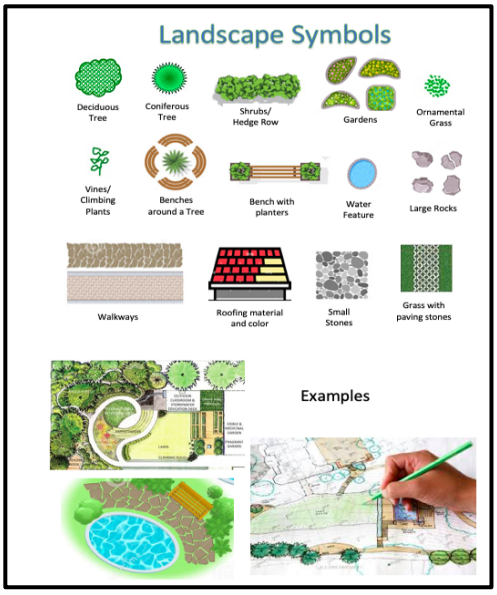
1. Return to the classroom.

2. Tell students: Think about a typical school- often made from cement or bricks, has lots of parking spaces, may have a flat roof, sidewalks etc. **You are going to use the data you have collected to modify a sample schoolyard to help decrease the Urban Heat Island effect and increase the Albedo.**

3. Show students the model of "a typical school" and hand out the associated diagrams.

4. **Using the data that they collected from their walk, ask students to 'mark up' their diagrams using the landscape symbols and colored pencils to make suggestions for this schoolyard and what can be done to limit the urban heat island effect. The administration of this school has agreed to 'give up' no more than 1⁄3 of the parking spaces to assist your climate mitigation strategies**. (7 or less parking spaces)




5. Circulate to make sure the students are making their suggestions based on data and the things you have previously talked about.

6. After a sufficient amount of time has been allowed, have the students come forward and use the model to explain what their suggestions are- you might also ask them to explain how any of these strategies may be used on their own school grounds. Add anything that is included in the sample remediation diagram that was not discussed or thought of by the students.

**ALBEDO SCALE:**

| Substance | Typical Albedo |
|---|---|
| Asphalt | .03 |
| Open Ocean | .06 |
| Lake | .10 |
| Green forests | .15 |
| Soil | .17 |
| Crops | .18 |
| Grass | .20 |
| Desert | .30 |
| Concrete | .40 |
| Ice | .45 |
| White Paint/Pebbles | .70 |
| Fresh Snow | .90 |

Reminder- this scale only goes from 0-1 so a small change in the number is a big difference.
*Not included in the pictures but it should be mentioned.

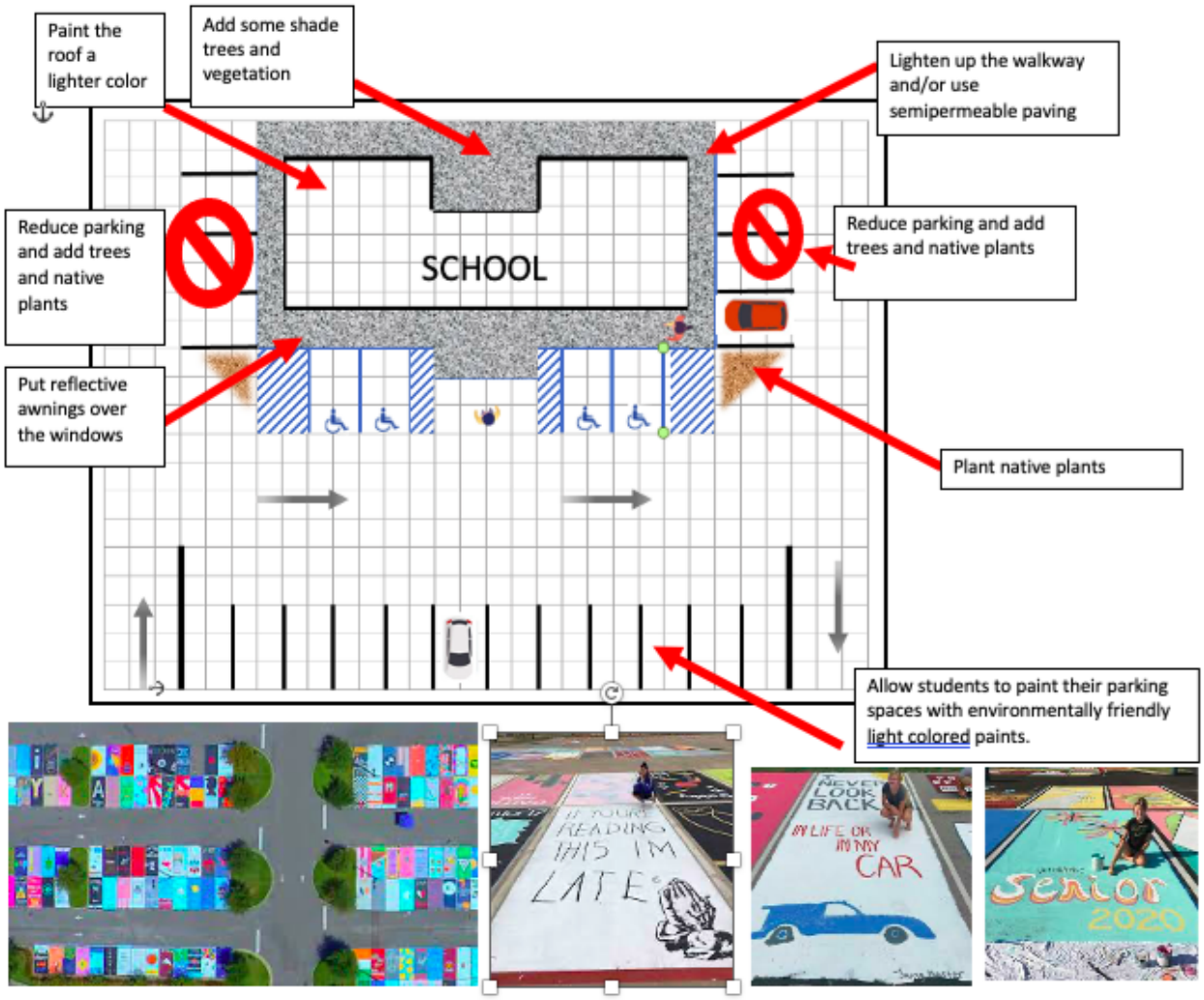
Names(s): _____

Outside Temperature _____

In the sun: _____ In the shade: _____

| Description of Surface | Temperature in the Sun (degrees F) | Temperature in the Shade (degrees F) | Notes/Ranking |
|---|---|---|---|
| **Red Paint** | | | |
| **Gravel** | | | |
| **Grass** | | | |
| **Dirt** | | | |
| **Cement** | | | |
| **Water** | | | |
| **Dock** | | | |
| **Sand** | | | |
| **Blacktop/Road** | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**Sample Remediation Ideas:**




**FOLLOW-UP ACTIVITIES:**

- Encourage the teachers and the students to conduct a similar activity back at their school. If they do not have access to infrared thermometers (they are inexpensive and can order just 1 or 2) they can look up the typical albedo of different services or use a regular thermometer to get a reading for comparison purposes. Students can make suggestions to the administration of their school.

- Students can also look into the idea of living roofs and living walls as well as algae tanks that are all used to help diminish carbon dioxide (through photosynthesis) and decrease the urban heat island effect.

- Take a field trip to a business or location that uses some of these techniques in their design concepts- such as Duke Farms.

## NJ Student Learning Standards

### MS-ESS3: Earth and Human Activity

• MS-ESS3-1 Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

• MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

• MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

• MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

## Climate Change

• MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

### Scientific and Engineering Practices / NGSS

This field lesson can be tailored to have students directly involved with

- Asking Questions and Defining Problems
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

## Comprehensive Health and Physical Education

• 2.2.8.MSC.7 Effectively manage emotions during physical activity (e.g., anger, frustration, excitement) in a safe manner to self and others.

• 2.3.8.PS.1 Assess the degree of risk in a variety of situations, and identify strategies needed to reduce deliberate and non-deliberate injuries to self and others

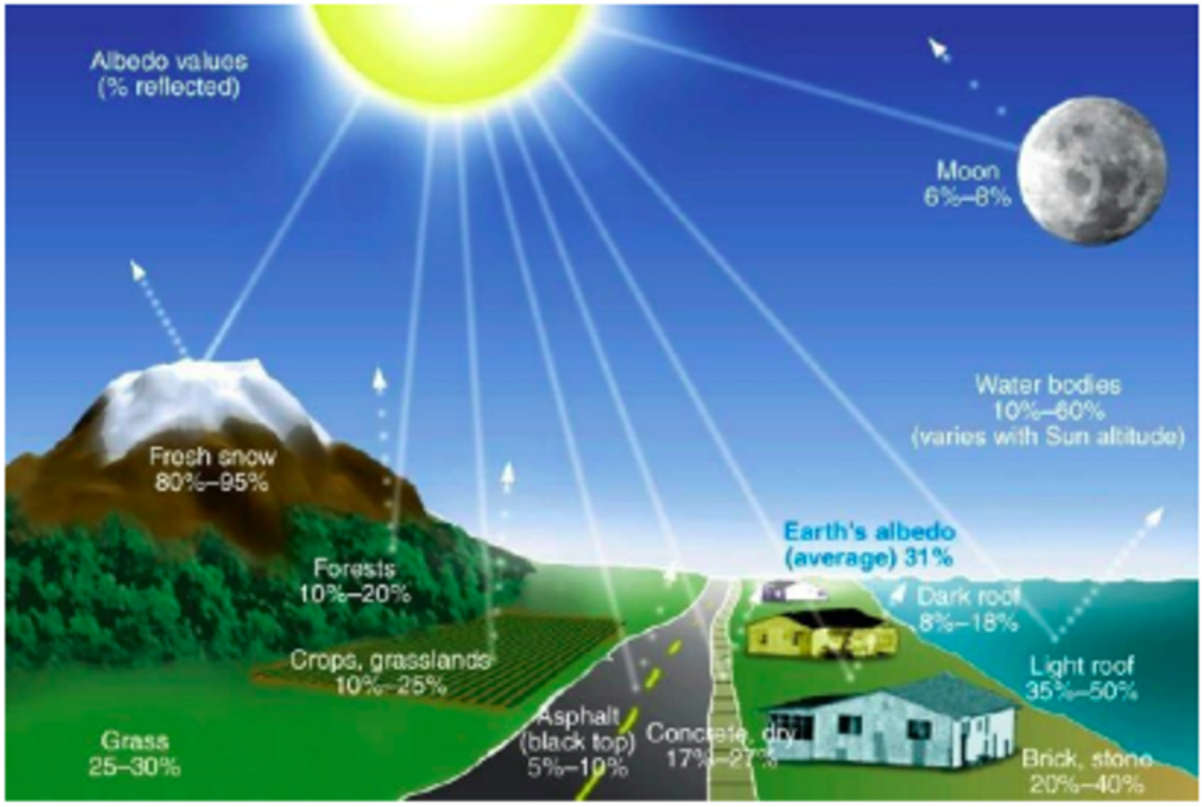
## Social and Emotional Learning

All of our field lessons integrate the concepts of self-awareness, self-management, social awareness, responsible decision-making, and relationship skills found in the New Jersey's Core Social and Emotional Learning (SEL) Competencies.

**RESOURCES AND BACKGROUND READING:**

## Albedo, Melting Ice and Climate Change

Earth's radiation budget is a concept that helps us understand how much energy Earth receives from the sun and how much it radiates back into space.




Albedo measures the percentage of light that is reflected off a surface. An object that reflects all the light would have an albedo of 1 (100%), whereas a completely opaque object would have an albedo of zero.

If Earth was completely covered in ice like a giant snowball, its albedo would be about 0.84, meaning it would reflect 84% of incoming sunlight and absorb about 16 percent. On the other hand, if Earth was completely covered by a dark green forest canopy, its albedo would be about 0.14, meaning most of the sunlight would get absorbed and our world would be significantly warmer than it is today.

Satellite measurements made since the late 1970s estimate Earth's average albedo to be about 0.30. In other words, about 30 percent of incoming solar radiation is reflected back into space, and 70 percent is absorbed. Earth's radiation budget is balanced when the amount of incoming radiation is equal to the amount of outgoing radiation. If the budget is out of balance, Earth may experience net warming or cooling. Over the past century, there has been a net warming trend which has caused the Earth's temperature to increase by about 0.8° C.

# Heat Island Background Information:

https://www.epa.gov/heatislands/learn-about-heat-islands

### What are Heat Islands?

Structures such as buildings, roads, and other infrastructure absorb and re-emit the sun's heat more than natural landscapes such as forests and water bodies. Urban areas, where these structures are highly concentrated and greenery is limited, become "islands" of higher temperatures relative to outlying areas. These pockets of heat are referred to as "heat islands." Heat islands can form under a variety of conditions, including during the day or night, in small or large cities, in suburban areas, in northern or southern climates, and in any season.

A review of research studies and data found that in the United States, the heat island effect results in daytime temperatures in urban areas about 1–7°F higher than temperatures in outlying areas and nighttime temperatures about 2–5°F higher. Humid regions (primarily in the eastern United States) and cities with larger and denser populations experience the greatest temperature differences. Research predicts that the heat island effect will strengthen in the future as the structure, spatial extent, and population density of urban areas change and grow.

### Causes of Heat Islands

Heat islands form as a result of several factors:

- **Reduced Natural Landscapes in Urban Areas.** Trees, vegetation, and water bodies tend to cool the air by providing shade, transpiring water from plant leaves, and evaporating surface water, respectively. Hard, dry surfaces in urban areas – such as roofs, sidewalks, roads, buildings, and parking lots – provide less shade and moisture than natural landscapes and therefore contribute to higher temperatures.

- **Urban Material Properties.** Conventional human-made materials used in urban environments such as pavements or roofing tend to reflect less solar energy, and absorb and emit more of the sun's heat compared to trees, vegetation, and other natural surfaces. Often, heat islands build throughout the day and become more pronounced after sunset due to the slow release of heat from urban materials.

- **Urban Geometry.** The dimensions and spacing of buildings within a city influence wind flow and urban materials' ability to absorb and release solar energy. In heavily developed areas, surfaces and structures obstructed by neighboring buildings become large thermal masses that cannot release their heat readily. Cities with many narrow streets and tall buildings become urban canyons, which can block natural wind flow that would bring cooling effects.

- **Heat Generated from Human Activities**. Vehicles, air-conditioning units, buildings, and industrial facilities all emit heat into the urban environment. These sources of human-generated, or anthropogenic, waste heat can contribute to heat island effects.