WARD'S™
DataHub
The Power of Twelve
The Convenience of One

City Microclimate:
Measuring Environmental Temperature and Humidity in Green Areas and around Urban Areas
(Teacher's Guide)

OVERVIEW

Students will measure and study the temperature and humidity variations in different environments (open and closed spaces) as they approach green areas, starting from their classroom. They will recognize quantitative qualities that allow them to explain the positive effect of city vegetation.

MATERIALS NEEDED

Ward's DataHub
USB connector cable*
Ward's DataHub external temperature probe

** – The USB connector cable is not needed if you are using a Bluetooth enabled device.*

NUMBER OF USES

This demonstration can be performed repeatedly.

FRAMEWORK FOR K-12 SCIENCE EDUCATION © 2012

* The Dimension I practices listed below are called out as **bold** words throughout the activity.

Dimension 1 Science and Engineering Practices				
	✓	Asking questions (for science) and defining problems (for engineering)	✓	Use mathematics and computational thinking
	✓	Developing and using models	✓	Constructing explanations (for science) and designing solutions (for engineering)
	✓	Planning and carrying out investigations	✓	Engaging in argument from evidence
	✓	Analyzing and interpreting data	✓	Obtaining, evaluating, and communicating information

Dimension 2 Cross Cutting Concepts				
		Patterns	✓	Energy and matter: Flows, cycles, and conservation
	✓	Cause and effect: Mechanism and explanation		Structure and function
		Scale, proportion, and quantity	✓	Stability and change
	✓	Systems and system models		

Dimension 3 Core Concepts	Discipline	Core Idea Focus
	Life Science	LS2: Ecosystems: Interactions, Energy and Dynamics
		LS2.A: Interdependent Relationships in Ecosystems
		LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
	Earth and Space Science	ESS2: Earth's Systems
		ESS2.A: Earth Materials and Systems
		ESS2.C: The Role of water in Earth's Surface Processes
		ESS2.D: Weather and Climate
	Engineering, Technology, and Applications of Science	ETS2: Links Among Engineering, Technology, Science, and Society
		ETS2.B: Influence of Engineering, Technology and Science on Society and the Natural World

NGSS Standards	Middle School Standards Covered	High School Standards Covered
	MS.LS-IRE: Interdependent Relationships in Ecosystems	HS.LS-IRE: Interdependent Relationships in Ecosystems
	MS.LS-MEOE: Matter and Energy in Organisms and Ecosystems	HS.LS-MEOE: Matter and Energy in Organisms and Ecosystems
	MS.ESS-HE: The History of Earth	HS.ESS-ES: Earth Systems
	MS.ESS-EIP: Earth's Interior Processes	HS.ESS-CC: Climate Change
	MS.ESS-ESP: Earth's Surface Processes	HS.ETS-ETSS: Links Among Engineering, Technology, Science and Society
	MS.ESS-WC: Weather and Climate Systems	
	MS.ETS-ETSS: Links Among Engineering, Technology, Science and Society	

✓ Indicates Standards Covered in Activity

(Standards continued on next page)

NATIONAL SCIENCE EDUCATION STANDARDS © 2002

Content Standards (K-12)			
✓	Systems, order, and organization	✓	Evolution and equilibrium
✓	Evidence, models, and explanation	✓	Form and Function
✓	Constancy, change, and measurement		

Life Science Standards Middle School		Life Science Standards High School	
✓	Structure and Function in Living Systems	✓	The Cell
	Reproduction and Heredity	✓	Molecular Basis of Heredity
✓	Regulation and Behavior		Biological Evolution
	Populations and Ecosystems	✓	Matter, Energy, and Organization in Living Systems
	Diversity and Adaptations of Organisms		Behavior of Organisms

✓ Indicates Standards Covered in Activity

LEARNING OBJECTIVES

Core Objectives (National Standards):

- Develop the ability to refine ill-defined questions and direct to phenomena that can be described, explained, or predicted through scientific means.
- Develop the ability to observe, measure accurately, identify and control variables.
- Decide what evidence can be used to support or refute a hypothesis.
- Gather, store, retrieve, and analyze data.
- Become confident at communicating methods, instructions, observations, and results with others.

Activity Objectives:

The purpose of this activity is to study the relationship between temperature and humidity in several locations inside and outside school, creating a hypothesis and proceeding to test it using the Ward's DataHub Relative Humidity, GPS and External Temperature Sensors. The goal is to obtain the values of these variables in urban spaces and in green areas.

Time Requirement:

60-90 minutes

VOCABULARY

Air Saturation: The condition or state of air in relation to how much of a substance (ex. water) is suspended in the air. The process of condensation removes water from the air causing a decrease in humidity.

GPS: Global Positioning System, an accurate worldwide navigational and surveying facility based on the reception of signals from an array of orbiting satellites.

Green Space: An area of grass, trees, or other vegetation set apart for recreational or aesthetic purposes in an otherwise urban environment.

Humidity: A quantity representing the amount of water vapor in the atmosphere or a gas.

Microclimate: The climate of a very small or restricted area.

Stomata: Any of the minute pores in the epidermis of the leaf or stem of a plant, forming a slit of variable width that allows the movement of gases in and out of the intercellular spaces.

Temperature: The degree or intensity of heat present in a substance or object.

Transpiration: The process in plants where water moves through the vascular system into the environment.

Urban: Referring to a city or town area.

Teacher Notes

INTRODUCTION

Trees and green areas generally have a positive influence on our atmosphere in relation to the Sun's radiation, temperature, winds, environmental humidity, evapotranspiration and precipitations. This is why people usually agree on the importance of taking care of such places, especially in city centers where we mostly find buildings and industrial parks.

- **When do you use green areas? Tell us several outdoor activities you like to take part in.**
- **Have you ever entered a park after walking for a long time in the sun? Describe your experience.**

Carry out the experiment with your class so that at the end, students will be able to answer the following question:

- **How do green areas affect environmental temperature and humidity?**

BACKGROUND

The population of cities grows around two to three times faster than the population of country areas. This means, an increasing number of buildings, industries and roads, while the number of trees and green places in the city can be observed to decrease. This makes for microclimate change, and often affects the quality of life for the city's inhabitants.

There are several possibilities for green areas in a city: gardens, waterfronts, linear corridors, community gardens, wild areas and traditional parks. In particular, parks significantly change their environment - improving the air quality ventilation, and filtering large amounts of rain water. Depending on the size of the park, it may also provide a habitat for a variety of fish, birds, insects and other animals, along with protecting the diversity of the flora. In addition, green areas are great places to practice sports and rest, or to just go and have fun with your friends and family.

We can find a great variety of plants and flowers, crawling herbs, tall and short plants, vines, shrubs and trees. We may find varieties of evergreen or deciduous plants, with branches forming foliage. Some of them will be endemic (local wild species) and others will be introduced from other countries. One of the most important plant processes is water transpiration, which contributes to maintaining ground moisture. This way, plants - most importantly trees - decrease the air temperature.

At this point, encourage students to formulate a hypothesis to test as part of this activity. Students may find it helpful to formulate their hypothesis as an answer to the following questions:

- **In an open space, how would you expect temperature and humidity levels to change as you approach a wide green area? Why do you think this happens?**

DID YOU KNOW?

London England has often been referred to when speaking of urban open space, or green space. In the early 17th and 18th centuries, paved squares were developed to be open areas, open to all citizens and in the 19th century royal parks began to be open to the public.

CONNECTING THE WARD'S DATAHUB TO A COMPUTER

If you are using a Bluetooth communication device:

Right click on the Bluetooth icon in the lower right corner of the screen and select the Ward's DataHub you are using. The icon will change from gray to blue, as shown at right, indicating that the Ward's DataHub and the computer are now connected.

If you are using a USB communication device:

In order to use USB communication, connect the Ward's DataHub and the computer with the USB cable supplied. Click on the USB icon at the lower right corner of the screen. This icon will change from gray to blue, as shown at right, indicating that the Ward's DataHub is connected to the computer via USB.

USING THE WARD'S DATAHUB

= Select key = On/Off and Escape key = Scroll key

To collect measurements with the Ward's DataHub, it must first be configured as follows:

1. Turn on the Ward's DataHub by pressing the On/Off/Esc key.	
2. Press the Scroll key Twice to go to **Configuration** then press the Select key to select the Configuration menu	x 2 then
3. Press the Scroll key to go to the **GPS Configuration Menu** then press the Select key	then
4. Press the Select key for **GPS Enabled**	
5. Press the On/Off/Esc key Twice to return to the main menu.	x 2
6. Go to Setup by pressing the Scroll key then select Setup by pressing the Select key	then
7. Select the **Set Sensors** option by pressing the Select key	
8. If any sensor(s) appear on the screen, press the key representing that sensor to deactivate it. Press the Relative Humidity/GPS Sensor key **Once for the Relative Humidity Sensor**	
9. Press the Relative Humidity/GPS Sensor key **Twice for the GPS Sensor**	x 2
10. Press the **Temperature Sensor** key Twice for the External Temperature Sensor (screen will say "Ext. temper.")	x 2
11. Press the On/Off/Esc key Three times to return to the main operating screen.	x 3
12. **Press the Select key to start measuring.** (You are collecting data when there is an icon of a Runner in the upper left hand corner of the screen.)	
13. Once you have finished measuring, stop the Ward's DataHub by pressing the Select key, followed by the Scroll key.	then

DID YOU KNOW?

Absolute humidity is a measure of the actual amount of water vapor present in a particular sample of air. Warm air has the ability to hold up to 25 grams of water vapor. This is why the air in the tropics feels so damp and heavy. The air in the cold polar regions can not hold any water vapor.

ACTIVITY

1. Take the Ward's DataHub and connect the external temperature probe. Start measuring from the classroom door, as you move to a nearby green area.
2. After registering the data in the green area, approach an area of asphalt.
3. Register your observations and the exact location in your notebook.
4. Once you have finished measuring, turn the Ward's DataHub off.

RESULTS AND ANALYSIS

The following steps explain how to analyze the experiment results.

1. Connect the Ward's DataHub to the computer using the Bluetooth wireless communication channel or USB connector.
2. In the top menu, click on the  button and select the  button.
3. Select the last experiment on the list.
4. Observe the graph displayed on the screen.
5. Press the  button and write notes on the graph specifying your observations according to the moment you registered the data.
6. Click the  button and select points on the graph. Pick one representative point for each location.
7. Fit the graph range according to your measurements, setting the y-axis scale.
8. Right click on the y-axis and set the minimum and maximum value according to your measurements. Round your minimum value down and your maximum value up, and enter these numbers into "minimum" and "maximum".
9. To see the map, click on the  button which is in the top-right corner of the software screen and then click on the  button.

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RESULTS AND ANALYSIS

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10. In the top-right corner of the map, you'll see the words "map" and "satellite".
    - If you click on the map, you'll see only the name of the streets.
    - If you click on the satellite, you'll see only the satellite image.
    - If you click on satellite/label, you'll see the satellite image with the name of the streets.
11. If you want to see the exact value of each point, put the mouse's arrow on the point of the map and a label with the values will appear.
12. In the top-left corner of the map, you'll see the zoom and the cardinal points.
13. On the right side of the map, you'll see the scale, you can adjust the values (minimum and maximum) with the button shown at right, and change them by clicking on the y-axis of the map and selecting "set range".

14. To change the variables of the graph, right click on the y-axis and select the variable that you want to see.
15. To move the map, click on it and move the mouse's arrow.
    - **Did you find differences between what you expected and your actual results? Explain.**
    - **Did the humidity values at the different locations vary? Explain the differences.**
    - **Which place presented the maximum humidity value? Describe it.**
    - **Was the temperature recorded constant or variable? Explain.**

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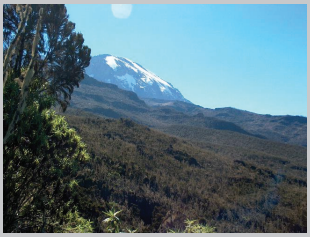
DID YOU KNOW?

In the summer months, trees have many leaves on them. This means that there are millions of stomatas open to the environment transpiring water to cool the tree. A large maple tree can transpire 50-60 gallons of water per hour into the atmosphere. This greatly increases the humidity, and can often create super-saturated clouds. These clouds result in snow or rain. If the trees were not present to produce this water vapor, precipitation would not occur. On Mt. Kilimanjaro, in Tanzania, the snows have disappeared due to the deforestation that has taken place in the area. It has resulted in a net loss of local transpiration and thus less (or no) snowfall.



RESULTS AND ANALYSIS

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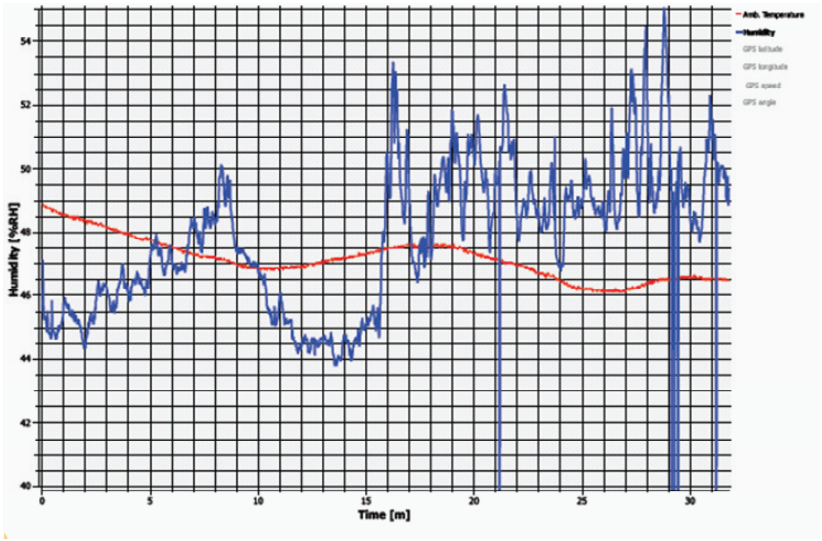
The graphs below should be similar to the ones the students obtained.



Temperature versus time

Humidity versus time

DID YOU KNOW?

Environmental factors that affect the rate of transpiration:

1. Light: Plants transpire more rapidly in the light than in the dark. This is because the stomata are open during the daylight hours. A warm leaf also will transpire more water.

2. Temperature: Plants transpire more rapidly at higher temperatures because water evaporates more at higher temperatures.

3. Humidity: When the surrounding air is dry, diffusion of water through the stomata occurs more rapidly.

4. Wind: When there is no air movement, the area around the leaf becomes more and more humid thus reducing the amount of transpiration.

5. Soil Moisture: A plant cannot transpire water through its leaves if water is not being replaced by the absorption of water by the roots.

CONCLUSIONS AND ASSESSMENTS

1. According to your results, how do green areas affect humidity? **Explain.**

   Students should understand the conservation of humidity due to foliage. The leaf surface maintains a certain humidity level, intercepting the moist air coming from the evaporation of water from the ground. It also provides a condensation surface and transpires water as part of the life process of the tree.

2. What kind of green area is most effective in maintaining humidity? **Argue** your answer in terms of the experiment.

   The results should show that wider green areas with more percentage of tall trees are damper and so best maintain humidity.

3. Did you observe a relationship between the type of vegetation and the humidity values? **Describe.**

   Students should find a relationship between the data obtained in the experiment and the type of vegetation in each place by analyzing the map.

4. What relationship can be identified between humidity and temperature by analyzing the graph? **Explain.**

   Students should find an inverse relationship between humidity and temperature by analyzing the slopes of the graph and the observations made during the measurement. They should also compare the color scales of the maps.

5. Write a concluding paragraph describing what you observed during the experiment.

   Students should reach the following conclusions:

   They should conclude that humidity levels are very different between certain locations in the same area, depending on the vegetation: the more trees, bushes, and plants growing in a place, the more humidity and the lower the temperature.

ACTIVITIES FOR FURTHER APPLICATION

DID YOU KNOW?

Dew point is the temperature to which air must be cooled to become saturated with water vapor. The closer the temperature gets to the dew point, the more likely it is for clouds to form, and precipitation to occur, which occurs at 100% humidity.

The aim of this section is for students to extrapolate the knowledge acquired during this class and apply it to different contexts and situations. Furthermore, it is intended that students question and present possible explanations for the experimentally observed phenomena.

1. Do you think green areas and trees are somehow related to energy consumption during the summer? **Describe** and **explain.**

   Due to the temperature decrease caused by trees, the shadows cast on buildings and the ability to halt the wind - green areas contribute to a reduction in energy consumption. Therefore, they reduce pollution caused by the process of energy generation. Students should think of other ways in which these elements can reduce energy consumption, then discuss and reflect upon the topic of energy saving.

2. What are the benefits of green spaces. **Describe** and **explain.**

   Students may point out many positive qualities of green spaces. For example, they provide habitat for fauna, cooling in summer, environmental teaching space, aesthetics, recreational activities, control of pollution, oxygen generation, protect from erosion, and of course temperature and humidity regulation.

3. How would you improve the humidity and temperature conditions in your classroom? **Explain.**

   Students should discuss possible ways to improve their daily environment. Some possibilities are growing indoor plants, improving the means of ventilation, using curtains that prevent the transfer of heat but let the light pass and more.

4. How could you increase the amount of green space in your school? **Explain.**

   Students should make suggestions to improve their school facilities. For example, they may think how to take care of or preserve the existing green areas, grow plants inside the classrooms, organize and regularly take care of a school garden and plant some deciduous trees (they cast shadows in the summer and let the sunlight pass in the winter). In addition, endemic trees and bushes can be planted (that don't consume too much water) to act as a windbreak; replace some asphalt areas with green places; or design vertical gardens and plant walls.

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After carrying out this experiment, you should be able to answer the following question:

- **How do green areas affect environmental temperature and humidity?**

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RESULTS AND ANALYSIS

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- **Did you find differences between what you expected and your actual results? Explain.**

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3. Did you observe a relationship between the type of vegetation and the humidity values? **Describe.**

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4. What relationship can be identified between humidity and temperature by analyzing the graph? **Explain.**

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5. Write a **concluding** paragraph describing what you observed during the experiment.

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