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Schoolyard Microclimate

Students learn the differences between weather and climate as well as the degree of natural variation in climate

Joseph J. Fontaine, Samuel C. Stier, Melissa L. Maggio, and Karie L. Decker

The natural world exhibits substantial variation in climate, which influences the distribution, reproductive success, and survival of plants and animals. Although students are aware of weather, their understanding of climate is typically less clear, especially the concept of *microclimate*—the climate of a specific place within an area as contrasted with the climate of the entire area. Microclimate can influence where birds place their nests (Lloyd and Martin 2004), where insects reside (Lorenzo and Lazzari 1999), and where plants successfully germinate (Tomimatsu and Ohara 2004). Therefore, microclimate can have a profound effect on local community structure and biodiversity, particularly on plants, which are unable to move and thus often limited by local environmental conditions.

Students can gain an appreciation for the structure and function of local environments by studying the potential impacts of small changes in local microclimate on plant distribution. The concept of microclimate is easy for students to comprehend, simple to measure, exists in all schoolyards, and has important and tangible ecological implications. This article discusses an inquiry in which students learn the differences between weather and climate as well as the degree of natural variation in climate that exists across spatial scales. In this activity, students are introduced to the concept of climate and how climate varies. Students also observe and measure variation in microclimate and plant distribution throughout the schoolyard and learn to make associations between the microclimate and plant life.

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Preparing for a microclimate investigation

This investigation is designed to address National Science Education Standards A (Science as Inquiry) and C (Life Sciences) by examining how variation in abiotic factors can lead to variation in the distribution of plants (NRC 1996, pp. 30, 37). Successful completion of this inquiry requires roughly two one-hour class periods: the first to establish the ecological foundation of this exercise, introduce students to the vocabulary, and gather measurements; the second to compile data, make maps, and discuss findings.

The activity requires a few basic materials (Figure 1), a map of the schoolyard (Figure 2a, p. 40), and a datasheet (Figure 3, p. 40). If students are interested in looking at the influence of microclimate on specific plant species, a book of local flora is also useful. A simple hand-drawn map of the schoolyard is sufficient, but all students should work with the same map to make combining and comparing data among groups easier.

The datasheet (Figure 3) should include columns for the sample number, plant type, and microclimate variables such as temperature, relative humidity, wind speed, and light availability. To measure microclimate conditions, students can use any of the following instruments: a thermometer (temperature), hygrometer (relative humidity), anemometer (wind speed), or photometer (light intensity). The exact variables measured depend on the equipment available and the interest of the class. Instruments that give instantaneous digital readings are ideal. Any instrument that measures relative humidity also measures temperature and is therefore well suited for this activity.

FIGURE 1

List of materials.

(Measuring equipment may be available from local universities, government agencies, or television stations.)

Basic materials	paper, pencils, clipboards, colored pencils or markers
Measuring equipment	thermometer, hygrometer, anemometer, photometer
Additional materials	hand-drawn map, datasheet

Introducing basic concepts

Before heading out to the schoolyard, introduce students to the basic concepts needed to successfully understand and measure microclimate. Open discussion is a good method for introducing the related vocabulary (Figure 4, p. 41), which includes terms that may be new to students. For example, have students describe simple concepts such as current weather conditions, the components of weather (e.g., temperature, rain, wind, or snow), and trends in weather at different locations around the world (e.g., tropics versus polar). Students should discuss the important distinction between *weather* (the state of the atmosphere at a given time) and *climate* (the average or prevailing weather conditions). For example, rain can fall in a desert (weather) but a desert is still a dry place (climate).

Once students have grasped the concept of climate, discuss different climates of the world and associated plant types (e.g., cactus in deserts, bamboo in rain forests). Discuss how the climate of an area can determine the plants found in that area. To ensure that students fully understand this relationship, discuss local, familiar landscape features. Tangible concepts for students to visualize include differences between plant communities on north- versus south-facing slopes, or valley floors versus mountainsides.

After students understand that climate is variable and are able to explain variation in plant communities, students can begin to consider climate variation in their schoolyard. Students should think about the best place in the schoolyard to warm up on cold mornings or cool off on hot afternoons. Soon students will realize that distinct microclimates exist even in their schoolyard. Finally, challenge students to consider whether they think these small differences in climate are enough to influence the plants that can live there.

Conducting the investigation

To begin the investigation, break students into groups and either provide a list of the different plant types in their schoolyard (e.g., deciduous tree, grass, coniferous tree, shrub, cactus, vine), or have students compile a list themselves. Ask students to consider where the different plant types might grow in their schoolyard, and what microclimates might be expected in those areas. Depending on student understanding of local plants, have students make formal predictions about the microclimates of the different plant types (e.g., conifers grow in hot, dry areas). Once students have made their predictions, provide each group with the basic materials (Figure 1), a map of the schoolyard (Figure 2a), a datasheet (Figure 3), and the appropriate instruments needed to take measurements (Figure 1). Guide students outside and use five minutes to demonstrate how to take measurements with each piece of equipment.

Once students understand how to use the equipment, instruct each group to find and observe four to six samples of each plant type listed on the datasheet and take microclimate measurements (e.g., temperature, humidity, wind speed) at the base of each plant. All groups should take measurements at nearly the same height from the ground for all samples because height can influence microclimate measurements; readings taken at varying heights make patterns more difficult to assess. Each group should record the microclimate readings on their datasheet and record the associated sampling number (Figure 3) on the map (Figure 2a) at the location for each set of measurements.

Weighing the evidence

To test students' predictions about the influence of microclimate on plants in the schoolyard, students need to map the combined data gathered by the class. Each group should transfer their microclimate data to a class spreadsheet on a blackboard, overhead, or computer, and signify the location of their data on a class map using the appropriate sampling number. This process is easier if each group is represented by a different color. The combined data enables the entire class to access all of the data and associated locations. Students should calculate a class average for each of the microclimate variables and each plant type.

Using the class data and additional copies of the maps, students can create their own microclimate maps for the schoolyard. Supply every student with one map of the schoolyard for each microclimate variable measured (e.g., a map each for temperature, humidity, and wind), and have them record the appropriate microclimate readings at each sampling point. For example, if students are going to create a temperature map, they must first record the temperature reading for each sampling point at the appropriate location on their map. To simplify, students can round measurements to the nearest whole number or to the nearest 5 or 10 place. Once all of the measurements are on the map, students can use these points to create their own *isocline* map (Figure 2b and 2c). Similar to a topographic map, which shows elevation, an isocline map shows patterns of temperature.

To create an isocline map, students should draw colored lines between points with the same temperature; each temperature receives its own color. Ultimately, students create a map consisting of a series of circles indicating different temperatures (Figure 2b and 2c). Note that some circles may be incomplete because part of the circle may lie off the map. No lines of different colors should cross, as this would indicate that one point had two different temperatures. Students should attempt to create the simplest map possible with the fewest number of circles but should feel free to be creative in designing their maps. Students should remember that there is no single right answer.

FIGURE 2

Map of the schoolyard (a) and examples of isocline maps (b and c).

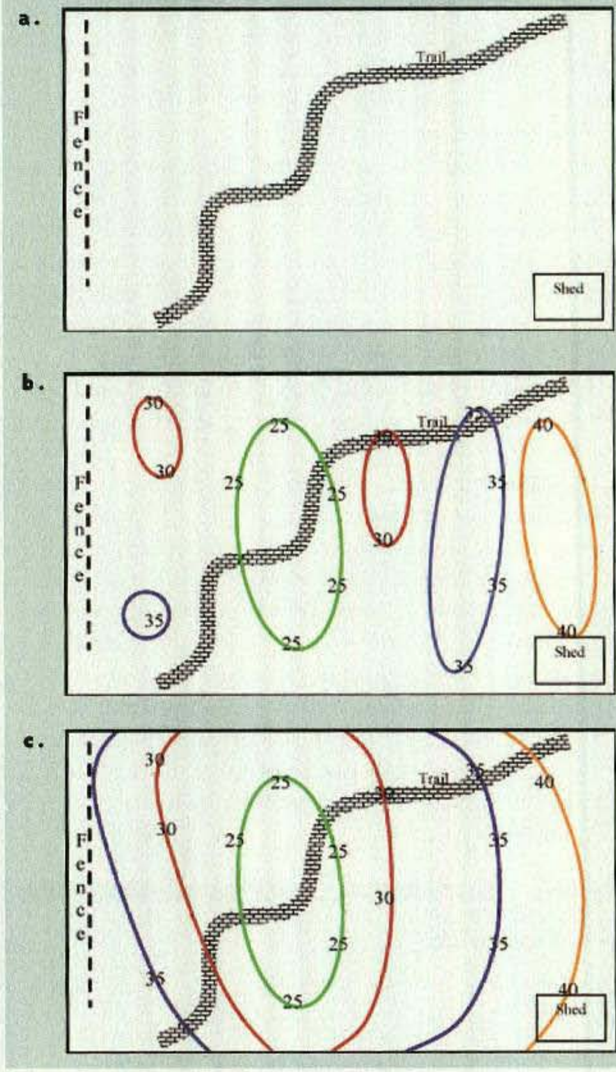

FIGURE 3

Sample datasheet and example measurements.

Datasheets should include columns for each microclimate variable measured as well as for the sample number. Students should take care to label all measurements with appropriate units.

Sample #	Plant type	Temperature (°C)	Humidity (%)	Wind speed (km/hr)
Example 1	Coniferous tree	7	22	5
Example 2	Grass	12	20	6
Example 3	Deciduous tree	3	45	1

Assessing what students learn

Throughout this investigation, students demonstrate a number of skills such as mathematical and graphical skills, attention to detail, and creativity that can be assessed either formally or informally. A student's understanding of the content of this exercise can be evaluated by his or her ability to answer simple questions about the "preferred" habitats of different plant types or the degree of variation in microclimates in the schoolyard (Figure 5, p. 42). Ultimately, the depth of understanding can be assessed by asking students to integrate all of the information they have gathered to make new predictions (discussed in the following section) using their data and maps and then report their findings to classmates through a poster or PowerPoint presentation.

FIGURE 4

Vocabulary. (Adapted from Campbell and Reece 2005; Merriam-Webster 2007.)

Weather	The state of the atmosphere at a given time and place, with respect to variables such as temperature, moisture, wind velocity, and barometric pressure.
Climate	The weather conditions, including temperature, precipitation, and wind, that prevail in a particular region.
Microclimate	The climate of a specific place within an area as contrasted with the climate of the entire area.
Temperature	The degree of hotness or coldness of a body or environment. Specifically, temperature measures the average kinetic energy of molecules.
Relative humidity	The ratio of water vapor in the air at a specific temperature to the maximum amount that the air could hold at that temperature, expressed as a percentage.
Biodiversity	The number and variety of organisms found within a specified geographic region.
Generalist	A species that can exploit a wide range of resources.
Specialist	A species with specific resource requirements.
Biotic	Produced or caused by living organisms.
Abiotic	Factors affecting the environment produced or caused by nonliving influences, such as light, temperature, and wind.

Understanding variation in microclimate

After being introduced to climate globally, and scaling climate to their local schoolyard, students should become acutely aware of the degree of variation in the natural world. To check their understanding of climatic variability, ask students to extend the investigation by considering how the microclimate measurements taken in the schoolyard may change throughout the year. Do students expect the relative microclimate of different sampling points to be the same as seasons change (e.g., the coolest site is always the coolest)? How might biotic factors, such as trees losing their leaves, influence measurements? Students can make predictions and then test those predictions by measuring and comparing the relative microclimates of different sampling points throughout the year.

To help students understand the influence of microclimate on plant distribution, ask students to compare the temperature readings obtained from their schoolyard to the temperatures inside their homes. How does microclimate in nature compare to students' habitats? A few temperature readings from home will show students that the microclimate they occupy is not readily available across the landscape, especially on a cold winter day. Plants are also limited in the areas they occupy based on the microclimates that exist across the landscape. Different plants have different requirements (e.g., water, light availability), which can influence where they germinate and grow. For example, species such as cottonwood and willow only grow in wet areas, while cacti thrive at drier sites. Some species such as corn require sunny locations, while others such as maple do well in shaded areas. Like people, different plants have preferred microclimates.

Graphing the means and extremes for each plant type studied in the schoolyard is an effective method of showing students the extent that different plants share the same microclimate preferences (Figure 6, p. 42). Using their maps, graphs, and even information from field guides or the internet, students can consider why some plants occur in a variety of microclimates (generalists) while others appear more limited in where they occur (specialists).

Once students have assessed the variation in microclimate and which microclimates different plants prefer, challenge students to use what they know to make predictions about the distribution of different plant types beyond the areas sampled. Having students make predictions beyond where they sampled gives them the opportunity to assimilate all the information they have gathered and to use it in much the same way a research scientist would.

Understanding the distribution of plants and animals is a central theme of ecology. By examining climate in their own schoolyard, students become aware of a major ecological factor that determines the distribution of plants and animals both globally and locally. From this foundation, students are better

FIGURE 5

Possible discussion questions.

1. What were the highest and lowest temperatures (or humidity, wind speed, light availability) for each plant type?
2. Which plant type, on average, lived in the coldest/warmest area (or wettest, windiest)?
3. Do plants appear to differ in the microclimate they inhabit? If so, why do you think different plants might occur where they do (consider the biology of the plants)? If not, why not?
4. What are the potential sources of bias and error in the microclimate measurements that we measured?
5. We said that microclimate is an abiotic factor that can influence where a plant grows. Can biotic factors influence microclimate? For example, can plants or animals influence their local microclimate or the microclimate of other organisms (consider shade)?
6. Based on the graphs we made showing the mean and extreme microclimates for each plant type, which plant type do you think might be a generalist or a specialist?
7. Using the available data and the microclimate maps, how could you predict the distribution of plants in the outdoor classroom beyond where we measured?
8. Based on what we know about the different plant types and looking at your microclimate maps, which plant types would you expect to be the most common or rare?

able to understand the world around them and are prepared to face future challenges about the processes determining the composition of their own environment. ■

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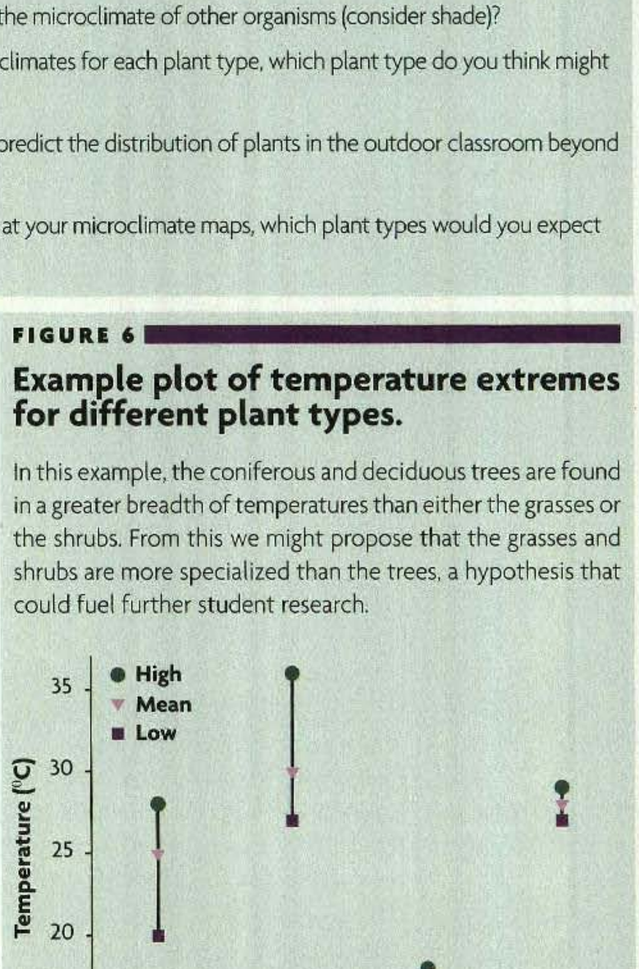
FIGURE 6

Example plot of temperature extremes for different plant types.

In this example, the coniferous and deciduous trees are found in a greater breadth of temperatures than either the grasses or the shrubs. From this we might propose that the grasses and shrubs are more specialized than the trees, a hypothesis that could fuel further student research.



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