# USING MICROCLIMATE TO PREDICT SCHOOLYARD PLANT DISTRIBUTION

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## Abstract

The influence of climate on plant distribution is well established, yet generally unknown by students. Here, we examine microclimate preferences of plants using outdoor inquirgy.

## Introduction

One of the most difficult concepts for K-12 students to grasp is how much variation exists in the natural world, particularly for vague concepts like climate. Some students fail to comprehend broad climatic differences because they have never experienced them, and local climatic variation is commonplace. The natural world exhibits substantial variation in climate that influences the distribution, reproductive success, and survival of plants and animals. Microclimate, for example, can influence where birds place their nests (e.g. Lloyd and Martin 2004), where insects reside (e.g. Lorenzo and Lazzari 1999), and where plants successfully germinate (e.g. Tomimatsu and Ohara 2004). Thus, microclimate can have a profound effect on local community structure and biodiversity. This is particularly true for plants, because they are unable to move and thus often limited by local environmental conditions. For students to understand the structure and function of their local environments they must gain an appreciation for the potential impacts of small changes in local microclimate on plant distribution.

Students have an innate interest in understanding the natural world, yet unfortunately, few have had the opportunity to use scientific approaches to discover the underlying reasons behind the patterns they observe in nature. Microclimate is something that is easy for students to comprehend, easy to measure, exists in any schoolyard, and has important and tangible ecological implications. By teaching students about microclimate, we enrich their understanding of the natural world and empower their comprehension of why it appears as it does.

Although students are aware of local weather, their understanding of climate is typically less clear, especially the notion that climate can vary at small spatial scales. Our goal is for students to learn the differences between weather and climate as well as the degree of natural variation in climate that exists across spatial scales. Once students understand climate, and how it varies, they can explore the natural variation in microclimate throughout the schoolyard. Finally, students learn to make associations between the microclimates they measure and the plant life they find.

This investigation is designed to address National Science Education Standards (NRC 1996) A (Science as Inquiry) and C (Life Sciences) by examining how variation in abiotic factors can lead to variation in the distribution of the plants. Students observe and measure variation in microclimate and plant distribution and use this information to identify correlations between the two. Ultimately, students will use this information to generate predictions about the distribution of different plant types beyond where they sampled.

**Preparing for a Microclimate Investigation**

Successful completion of this inquiry requires roughly two 1-hour class periods. One to establish the ecological foundation of this exercise, introduce students to the vocabulary, and gather measurements, and one to compile data, make maps, and develop predictions about plant distributions.

Although detailed, this investigation requires relatively few items (Table 1). Basic items include clipboards, pencils, and colored pencils or markers. Beyond these items, students will require a map of the outdoor classroom. A simple hand-drawn map will work, but ideally, all students should have the same map. Using the same map is easier when the students combine their data.

Secondly, students need a data sheet (Figure 1) that includes a column for plant type, temperature, relative humidity, wind speed, light availability, or any additional variables of interest. The exact parameters depend on the equipment available and the interest of the class. If students are interested in looking at the influence of microclimate on specific plant species, a book of local flora is useful. To measure microclimate conditions, students will require specific equipment such as a thermometer (temperature), hygrometer (relative humidity), anemometer (wind speed), or photometer (light intensity). Instruments that give instantaneous digital readings are the best because they take less time, and are easier for students to use. Any instrument that measures relative humidity also measures temperature and is therefore ideal for this inquiry (i.e. Testo 625, by GmbH & Co.).

Before heading out into the schoolyard, introduce students to the basic concepts needed to successfully understand and measure microclimate. Introducing the vocabulary (Table 2) is important because much of it will be new. Because the interest of this lesson is in teaching students through inquiry, introducing concepts through open questioning may be the best approach. Starting with simple concepts such as weather can facilitate this process. For example, have students describe current weather conditions, the components of weather (i.e. temperature, rain, wind, or snow), and trends in weather at different locations around the world (i.e. tropics versus polar). Because students often have difficulty distinguishing between weather and climate, sports can be a useful analogy to help them understand the differences. For example, if a basketball team wins twelve games then loses a game, is it a poor team? In this analogy, each game is like a day's weather event, and the team's win-loss record is like an area's climate. A team can lose a game but still be a winning team. In the same way, rain can fall in a desert (weather) but a desert is still a dry place (climate).

Once students have grasped the concept of climate, have them talk about the different climates of the world and their associated plant types (i.e. cactus in a deserts, rainforests in the tropics). Introduce students to how the climate of an area can determine the plants found in that area. To ensure that students fully understand this relationship, discuss local landscape features they have experienced. Differences between plant communities on north- versus south-facing slopes, or valley floors versus mountainsides, are tangible concepts for students to visualize. After students understand that climate is variable and can explain variation in plant communities, they can begin to consider whether there is variation in climate in their schoolyard. Have them think about the best place to warm up on cold mornings or cool off on a hot afternoon. Soon students will realize that even in their schoolyard there are distinct microclimates. Finally, challenge students to consider whether they think these small differences in climate are enough to influence the plants that can live there.

**Procedure**

To begin the investigation, break students into groups to consider where different plant types grow (i.e. deciduous tree, shrub, grass) and what microclimate they might expect in those areas. Depending on the level of the class and their understanding of local plants, students can predict the microclimates for different plant types. Once students have made their predictions, give each group a data sheet, the appropriate instruments, and have them go outside. Each group should find 4-6 samples of each plant type, and take microclimate measurements at the base of each. All groups should take measurements at nearly the same height for all samples, because height can influence microclimate measurements, making patterns more difficult to assess. Each group should record the microclimate readings on their data sheet, and an associated numbered location on the map 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 all of the data gathered by the class. Therefore, each group should transfer their data to the blackboard along with the number signifying its location on their map. This enables the entire class to access all of the data and its associated locations. Next, have students calculate a class average for each of the microclimate variable, as well as averages for each plant type. Simultaneously, supply all members of the class with one map of the outdoor classroom for each microclimate variable measured. Have students record the positions of all the sampling points from each group on their individual maps.

Using the class data and their maps, students can create their own microclimate map for the outdoor classroom. For example, if students are going to create a temperature map, they must first replace the sampling point numbers on their maps with the appropriate temperature measured at that position. To simplify, round measurements to the nearest whole number or, in some cases, 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 2). An isocline map is similar to a topographic map, but shows patterns of temperature rather than elevation. To create an isocline map, draw colored lines between points with the same temperature, each temperature receiving its own color. Ultimately, students will create a map consisting of a series of circles indicating different temperatures (Figure 2). Note that some circles may be incomplete because part of the circle may lie off the map. Importantly, no lines of different colors can cross, as this would indicate that a point had two different temperatures. There are, however, few additional rules to creating an isocline maps, though students should attempt to create the simplest map possible (i.e. fewest number of circles). Students should feel free to be creative in designing their maps. Remember, there is no 'right' answer.

## Assessing What Students Learn

Through this investigation, students can demonstrate a number of scientific skills (e.g. mathematical and graphical skills, attention to detail, and creativity) that educators can assess either formally or informally. A student's understanding of the content of this exercise can be evaluated by their ability to answer simple questions about the 'preferred' habitats of different plant types or the variation in microclimates (Table 3). Ultimately, the depth of their understanding can be assessed by asking students to integrate all of the information they have gathered to make new predictions using their data and maps and then report their findings to their classmates.

**Understanding Variation in Microclimate**

By introducing climate globally, and scaling it to their local schoolyard, students 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 comparing the variation in temperature readings obtained for their schoolyard to the variation in temperatures of their respective homes. How does variation in microclimate in nature compare to the 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 (i.e. water, light availability), which can influence where they germinate and grow. Like people, different plant species have 'preferred' microclimates. Graphing the means and extremes for each plant type is an effective method of showing students the extent that different plants share the same microclimate 'preferences' (Figure 3). Depending on the area sampled, students may or may not find any differences among the different plant types in 'preferred' microclimate, but most likely, they will find some plants differ from one another. Using their maps, graphs, and even information from field guides or the web, 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 where they 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 might.

**Conclusion**

Understanding the distribution of plants and animals is a central theme of ecology. By examining climate in their own schoolyard, students become acutely aware of a one of the major ecological factors determining the distribution of plants and animals globally, and locally. From this foundation, students are better 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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**Table 1: List of Materials**

| | |
|---|---|
| Basic Materials | paper, pencils, clipboards, colored pencils or markers |
| Measuring Equipment* | thermometer, hygrometer, anemometer, photometer |
| Additional Materials | hand drawn map, data sheet |

* maybe available from local universities, government agencies, or television stations

**Table 2: Vocabulary**

| | |
|---|---|
| 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 small, 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 |
| 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 |

**Table 3: Possible Discussion Questions**

1. What were the highest and lowest temperatures (humidity, wind speed, light availability, etc.) for each plant type?

2. Which plant type, on average, lived in the coldest/warmest area (wettest, windiest, etc.)?

3. Do plants appear to differ in the microclimate they inhabit? If so, why do you think different plants might occur where they do (think about the biology of the plants)? If not, why not?

4. What are the potential sources of bias and/or 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 (think about 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?

## Figure Legends

**Figure 1 | Sample data sheet and example measurements.** Data sheets 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.

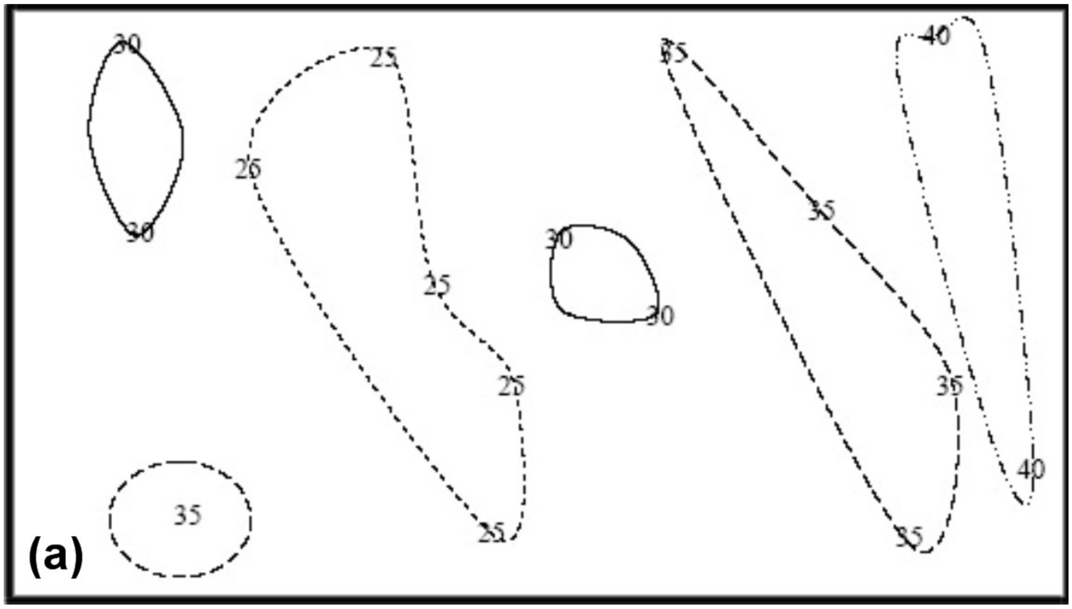
**Figure 2 | Examples of two isocline maps based on the same data.** Students should be encouraged to be creative when interpreting the data as there is no 'correct' answer. However, for these examples map **(a)** is less parsimonious than map **(b)** because it requires more circles. Students should consider this when developing their maps and attempt to make the simplest map possible.

**Figure 3 | Example plot of temperature extremes for different plant types.** By plotting the extreme values for the different plant types, students can quickly see the extent to which different plants are found in the same microclimate. Students can also see the extent to which different plant types are generalists or specialists. 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.

**Figure 1**

| Sample # | Plant Form | Temperature | Humidity | Wind |
|---|---|---|---|---|
| Example 1 | Coniferous Tree | 7ºC | 22% | 5 km/hr |
| Example 2 | Grass | 12ºC | 20% | 6 km/hr |
| Example 3 | Deciduous Tree | 3ºC | 45% | 1 km/hr |

**Figure 2**



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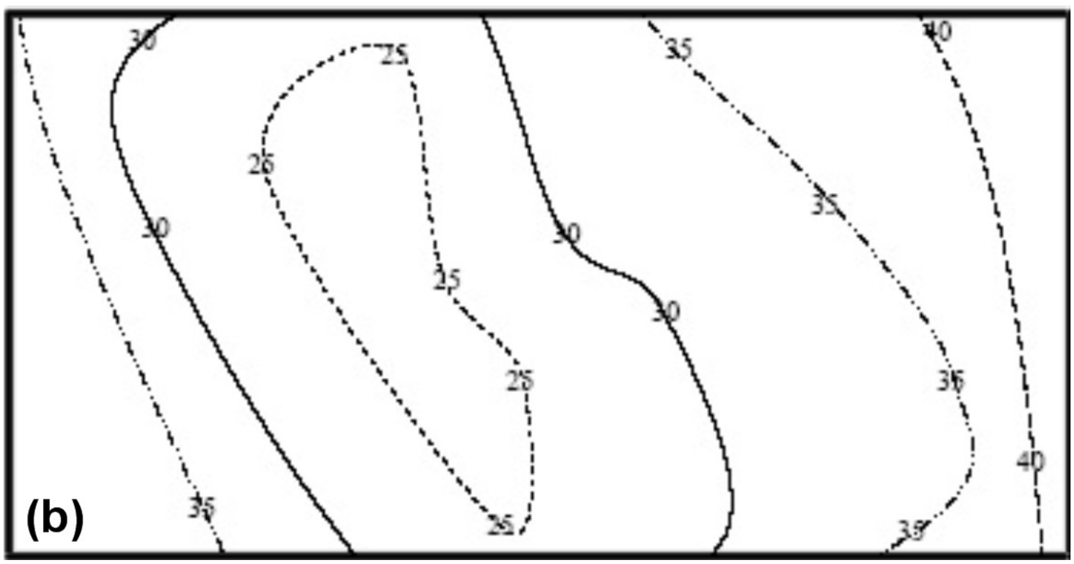

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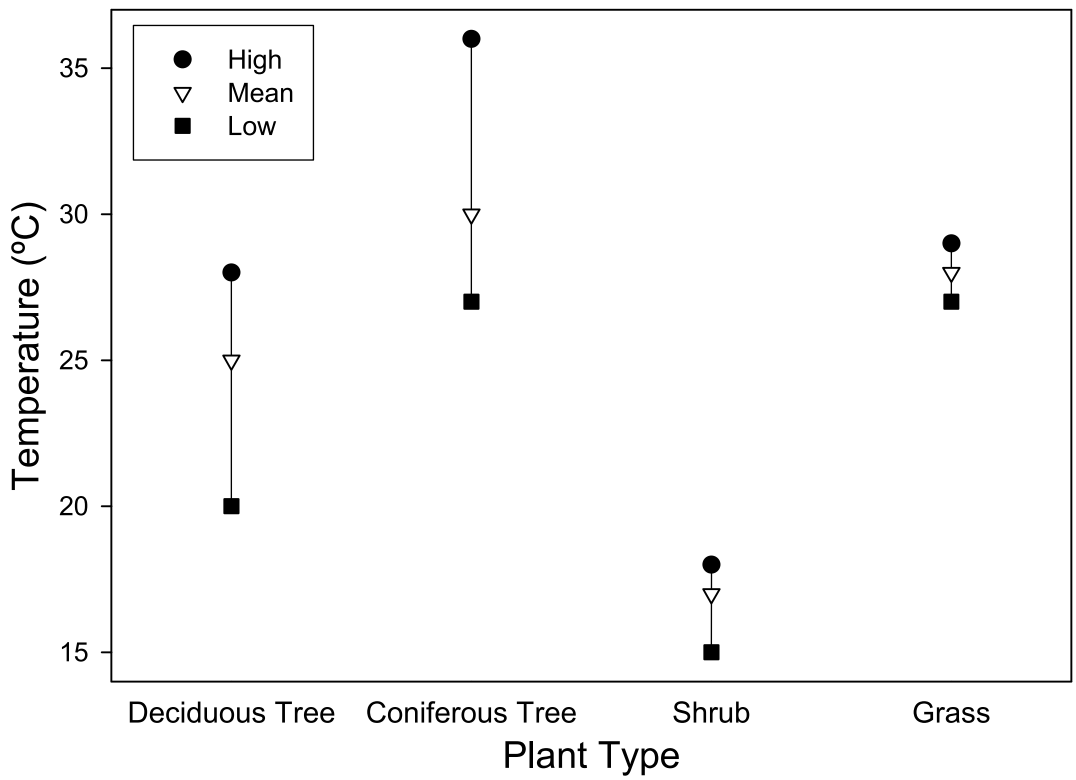
**Figure 3**


High
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Temperature (ºC)
Deciduous Tree
Coniferous Tree
Shrub
Grass
Plant Type