

**Objectives:** *To understand the ecological concepts of succession and microclimate*  
*To predict and quantify microclimate differences in space*  
*To associate changes in microclimate with successional change in time*  
*To observe differences in the insect community as succession progresses*  
*To predict the importance of changes in the insect community over time*

**Background:** Like all organisms, the plant species that grow in an area are determined by the availability of *resources*, their tolerances for excesses or shortages of resources, and interactions with other organisms that have a positive, negative, or neutral effect on population size. Plants are influenced by a number of factors such as the availability of light, water, and nutrients. In turn, as the base of most food chains, the type of plants that grow in an area exerts a strong influence on the presence or absence of other members of the *community*.

As *biotic* or *abiotic* conditions in the environment change due to disturbances such as fire, wind, or animal (including human) activity, plant communities show somewhat predictable responses to such changes. Some plant species are better adapted to frequently disturbed environments while others are better adapted to stable environments. In a process referred to as *succession*, plant communities gradually change after a disturbance until the locally dominant plant community has formed. The dominant community can vary by region, taking the form of coniferous forest, deciduous forest, or grassland depending on geographic location. Therefore, a progression of species occurs over time, from those adapted to quickly changing conditions immediately after a disturbance, to those adapted to more stable conditions in between disturbances.

In this lab<sup>1</sup> we will study two wooded areas behind the science building. We will first look for general patterns of insolation and soil temperature in the area in order to identify microclimates, followed by a comparison of the distribution and abundance of various insects found in those microclimates.

To an ecologist, the term *succession* refers to the predictable changes that occur in the plants and animals that live in an area over time. This progression is stopped and even reset to earlier stages by *disturbances*. See how these changes affect an abandoned New Jersey farm field, which is what most of the land surrounding The Lawrenceville School was until the early-mid 1900s.

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<sup>1</sup> based in part on chapters 2 and 3 in Brower, Zar, and von Ende (1998) *Field and Laboratory Methods for General Ecology, 4th ed.*



Originally, the farm field was a deep forest filled with towering beech and oak trees.



Clearing the forest for farming evoked major changes to the kinds of plants and wildlife that could live here. Clearing the forest was a *disturbance*, and could have come about by natural causes such as wind storms or wildfires. Disturbances can remove plants but often leave their seeds undisturbed in the soil.



After several years of farming, this field was abandoned. For the next few years, annual weeds, grasses, wildflowers, and other small, short-lived plants invaded the bare soil, creating a habitat suitable for field mice, bluebirds, and other open-field wildlife. These are the *pioneer species*, which arrive early after disturbance.



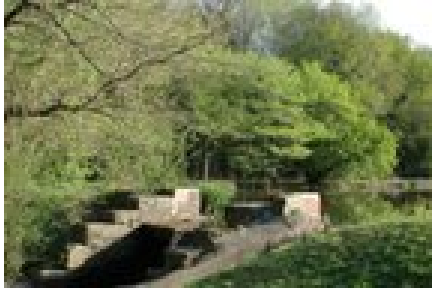
Eventually, shrubs, blackberry canes, and young maple and juniper trees emerged from seeds that entered the field. As these new light-loving plants grew, their leaves and branches shaded out and killed off the shorter pioneer plants below, creating a different kind of habitat. Chipmunks and robins were among the animals attracted to this new habitat.



Over time, maple and hickory trees grew tall and shaded out most of the canes and shrubs, creating forest habitat once again. Squirrels and wild turkey replaced chipmunks and robins. Beech and oak seedlings in the *understory* grew (slowly because of the shade) and eventually rose above the other trees. As the shaded maple and hickory trees died and fell, the spaces they left in the forest *canopy* were filled by beeches and oaks growing up from below.



More than 100 years after this forest was first cleared for farming, it returned to beech-oak forest again through the process of succession. For this location, beech-oak forest is the *climax community* – the association of plants and animals that will remain stable until disturbed by a force such as fire, wind, disease, or human activity.



Different regions of the world support different kinds of climax communities, including deserts, prairies, and rainforests. Some areas are so frequently disturbed that they rarely experience their climax communities because

the march of ecological succession is so often set back. For example, shallow ponds<sup>2</sup> (such as the one on campus) rely on seasonal flooding to erode away vegetation on their banks and to wash away soil that has accumulated on the bottom. When flooding is controlled with dams or channels, the pond becomes shallower and the edges grow up with vegetation, effectively reducing the pond's size over time. Once the area of the pond fills with soil and is covered with vegetation, it will eventually become a climax forest. Only the repeated disturbance of spring flooding maintains the pond as a pond. Balancing the desire to control flooding and drainage on campus with the desire to have a campus pond presents a conflict with the natural progression of ecological succession and necessitates the periodic dredging of the pond to remove soil from its bottom and sides (such as in the spring and summer of 2007).



[The dam below The Lawrenceville School pond, before (left) and after (right) dredging, spring 2007.<sup>3</sup>]



Biologists use their understanding of succession to manage wildlife populations. The endangered Kirtland's warbler<sup>4</sup> in Michigan, for example, is reliant on frequent disturbance and will only nest in stands of young jack pine trees. Periodic wildfires once maintained this habitat, but when humans suppressed fires, Kirtland's warblers had nowhere to nest and nearly became extinct. Today, in Kirtland's warbler habitat areas, managers use disturbance such as clearcutting and prescribed burning to prevent succession from occurring—to

<sup>2</sup> [http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/P/Pine\\_Hole\\_Pond.jpg](http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/P/Pine_Hole_Pond.jpg)

<sup>3</sup> photos by Dr. Kelley Nicholson-Flynn

<sup>4</sup> <http://cahlander.com/jpeg/kwarb.html>

maintain the young jack pine habitat that the warblers and other kinds of wildlife need to survive.

Consider the woods on campus. There are always disturbances in the forest landscape, whether or not they are directly caused by humans. Forests might be cleared, burned or flooded, but eventually, if conditions become suitable once again, the bare land will begin to change back into a forest.

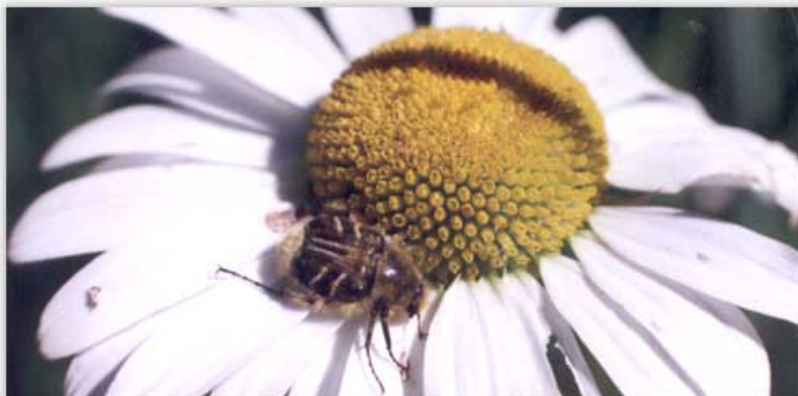
*[Grasses are the first plants that grow on bare ground, beginning the process of succession that eventually leads to the growth of trees. Photo by Maya Walters.]*



This happens very slowly and gradually, however. Before trees can move in, the area must first be colonized by grasses and shrubs. These first plants to move in are called *pioneer plants*, and they need to be tough and grow quickly in order to survive in the often harsh conditions of recently disturbed areas. Pioneer plants tend to thrive in open areas where light is abundant.

The pioneer plants are the first step in changing a disturbed area back into a forest. Gradually they are replaced by larger shrubs and trees that take longer to grow -- the process known as *ecological succession*. The patterns of succession are relatively predictable in most areas. Grasses always move in first, followed by a series of vegetation which eventually leads to the *climax forest*. Any particular region has its own set of climax species, which are the plants that are best adapted for the area and will persist after succession has finished, until another disturbance clears the area. A climax forest is characterized by plants that can withstand low light levels; these plants grow slowly with little light and eventually shade out plants that require more light.

Pioneer species grow quickly when an area is disturbed. Each square meter of healthy soil could contain as many as 1,000 dormant seeds. When the vegetation is cleared, many of these seeds sprout immediately. If the vegetation is cleared and the topsoil is also disturbed or relocated, the area remains bare and is susceptible to severe erosion.



*[Wildflowers, which provide food for insects, are common in early stages of succession. Photo by Maya Walters.]*

The grasses that move in as pioneer species are often thought of as weeds, the subsequent growth of shrubs are considered undesirable "brush." But without these intermediate stages, the disturbed habitat can't return to a natural forest. For example, in *temperate forests*, if the shrubs are not allowed to grow, insect pests turn to feed on young trees instead. This has happened in many places where trees are replanted after an area is clearcut. Large quantities of pesticides are then brought in, polluting the soil and water and altering the natural ecosystem even further.

By now, it is a well-known fact that forests everywhere are facing a range of threats. The forests that remain today cover a fraction of the area that was forested even a few hundred years ago. And the speed of destruction is only increasing. Everything from the direct and obvious effects of over-cutting to the more subtle effects of climate change is threatening to destroy the last of the remaining natural forests.

Threatened forests are more than just threatened trees. When the trees disappear, so does everything that depends on them, from fungi and micro-organisms to tigers and bald eagles. Each species has its own particular requirements for habitat, and therefore preserving only certain forest ecosystems does not protect the habitat of all forest species.

Trees are, of course, also threatened by more "natural" causes, such as pests and diseases. However, pests and diseases have been around for as long as the forests themselves, and the forests didn't begin to seriously decline until threatened by humans. In large numbers, insects can kill trees, often by eating their leaves. Diseases can wipe out entire populations of tree species. For example, in eastern forests, all the large American chestnut trees were killed back to the roots. However, the blight that killed them did not naturally occur in North America; it was brought from Asia, accidentally, by humans.

Species that are brought from their natural habitat and introduced into a new area by humans can be amazingly destructive. Sometimes these *introduced species* are types of grasses or shrubs that were transported accidentally as seeds, and upon arriving in a new habitat, managed to replace the native species. Other times, insects are introduced accidentally. With no natural enemies, they quickly multiply and become *invasive* in their new habitat, feeding heavily on the leaves of trees and other plants. When mammals are introduced, the native animal populations can suffer greatly. This has been repeated many times on small islands where humans intentionally brought familiar food and companion animals when first moving to the islands. Many native island animals evolved without any serious predators, and were quickly driven to extinction by the introduced livestock. Introduced animals such as goats also cause extensive damage to the land itself, by feeding on all the grasses and small plants, leaving the ground bare and very susceptible to erosion.<sup>5</sup>

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<sup>5</sup> Walters, M, Schultz, J, and Degenhardt, D. 1998. "Shades of Green: Earth's Forests." <http://library.thinkquest.org/17456/menu.html> access dates 9/17/2005, 7/16/2007.

**Before completing Exercise A in lab: Define the bold terms in the passage above. Be sure your definition is appropriate for the context of the term.**

Resources

Community

Biotic

Abiotic

Pioneer plants

Disturbance

Ecological succession

Climax forest

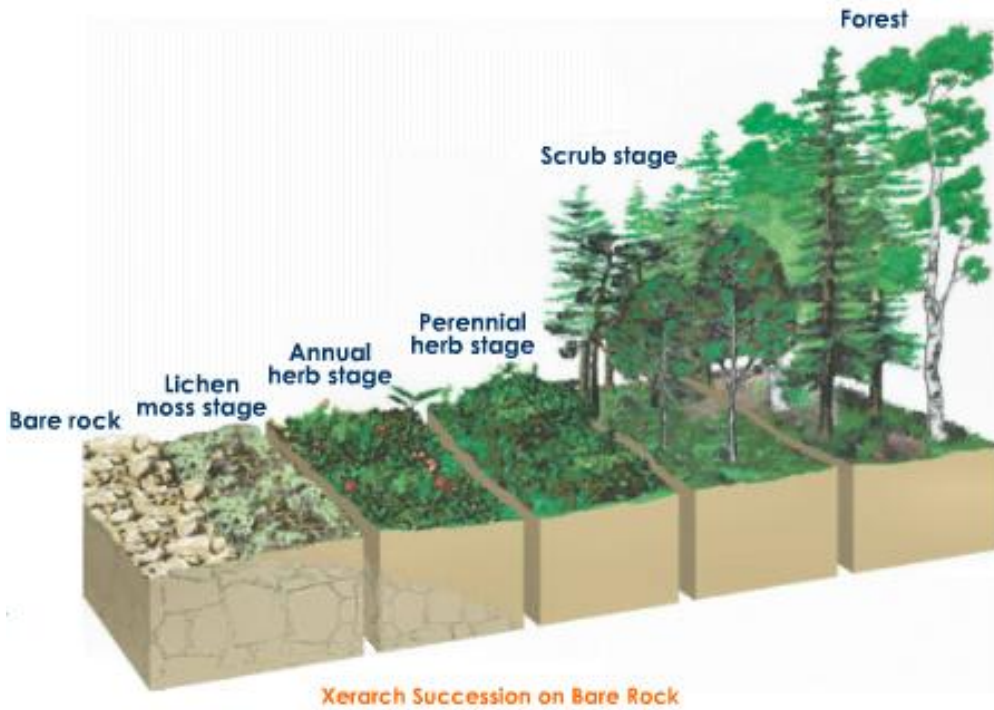
Temperate forest

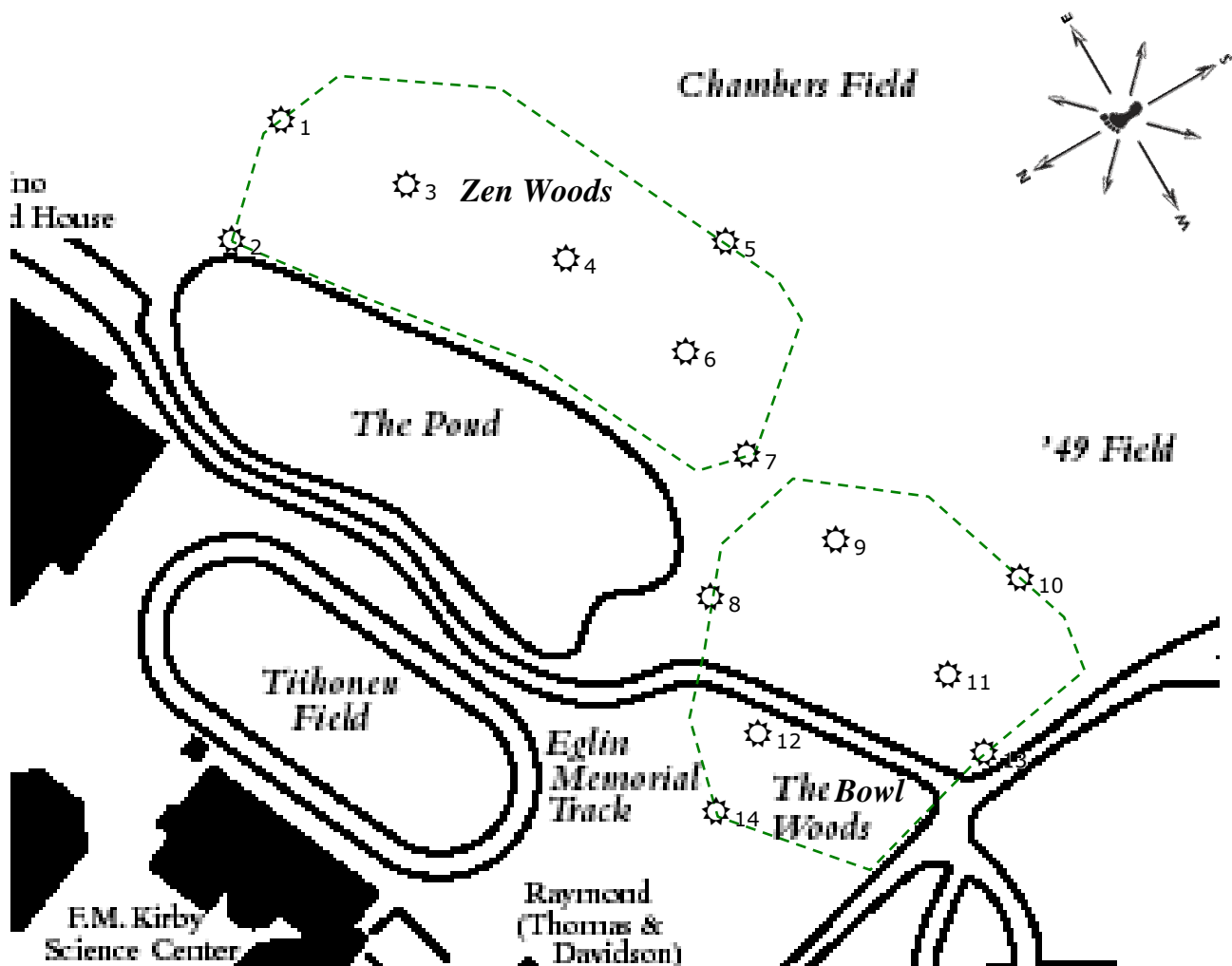
Introduced species

Invasive

Also, predict how these parameters will differ as the area pictured below goes through succession.

<i>Parameters</i>	<i>Early succession (bare rock)</i>	<i>Intermediate stages (annual herb – scrub stages)</i>	<i>Climax forest</i>
Soil moisture content			
Primary productivity			
Albedo			
Biodiversity			
Soil temperature			





**Exercise A.** Use the light meter to measure how much insolation each location within the Zen and Bowl woods receives at ground level (each woodlot is roughly outlined above on the map). As you walk around the woods, stop roughly at each of the 14 ☀s on the map and record the amount of light by holding the *back* of the meter *on* the ground. Thus, the sensor should point *up* toward the sky. Be consistent – don't angle the meter in some places and not in others. Write each light measurement next to the place on the map where that measurement was made and leave a flag at the site so you can find it again.

Divide your data into three categories by magnitude (there do *not* have to be an equal number of data points in each category). Fill in the table below with your data and calculate the three averages.

Lowest values	Middle values	Highest values
Average =	Average =	Average =

**Postlab exercise:** What *units* did you use to measure light levels? Check your light meter.

Note the compass rose on the map. Do the southern edge measurements differ from the northern edge ones *on average*? Explain.

We might expect the southern edge measurements to be greater on average than the northern edge ones. Explain what lies behind this expectation.

Explain some reasons this expectation might *not* be realized in reality.

Is there relatively high or low *uncertainty* in your averages? Explain.

What is the importance of relative amounts of sunlight in the process of ecological succession?

You may recall or you may observe that the Bowl Woods are an older woodlot than the Zen Woods. Do your insolation measurements reflect this difference? Explain.

**Exercise B.** Return to each flag and record the soil surface temperature using the soil temperature probe. Keep the probe tip 1-2 cm below the surface. Before collecting these data,<sup>6</sup> predict the results using the graph below. Plot all 14 points. Then add the actual data to the graph in another color once they have been collected.



At each of the 14 sites, sample the understory insect biodiversity using the beat sheet and stick provided (the method will be demonstrated before lab). Collect all insects in a Ziploc bag, numbered with the site number (1-14). Record the insect data in the table below.

Site	Number of insects	Number of types of insect	Beetles	Flies	Bees, wasps, ants	Moths, butterflies	Bugs, aphids	Grass-hoppers	Other insect types
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									

<sup>6</sup> Complete the various tasks as time allows. For example, the predictions in Exercise B may be made in the same lab period that Exercise A is completed, and then the remainder of Exercise B can be completed during the next lab session.

**Postlab Exercise:** Are there any differences in the insect community between the Zen (1-7) and Bowl (8-14) Woods? Explain.

If you omit the insects sampled at the edges of the woods, do any patterns emerge/change/disappear? Explain.

To what can you attribute any differences in the insect communities in these two woods?

How would you test any of your ideas?

What does the presence of insects indicate in a wood?

How might a change in the insect community over time affect the woodland ecosystem?