

ECOLOGICAL PATTERNS IN A NORTHERN BOG

INTRODUCTION

Ecology is a multifaceted discipline involving the study of living (*biotic*) and non-living (*abiotic*) factors that affect the distribution and abundance of organisms. Ecologists investigate the interactions between organisms and their environment in order to understand how ecosystems operate. Initially an ecologist will observe nature and identify a pattern that is worthy of study. A worthy pattern is one that provokes curiosity – “Why are these organisms distributed in such a fashion?” After considerable study and thought, the ecologist makes an educated guess as to how the system works. A more appropriate term for this “educated guess” is a **hypothesis**.

The focus of this exercise is to help you develop observational skills and formulate testable hypotheses. A **testable hypothesis** is one that can be shown to be wrong. An example of a testable hypothesis might be “The difference in tree density on north and south facing slopes is associated with differences in light intensity.” A non-testable hypothesis might state that tree density differences are caused by the activity of invisible alien invaders. Since there is no way to gather evidence for the activity of invisible aliens, the latter hypothesis cannot be tested.

During this field exercise, you will visit Vestaburg Bog in Montcalm Co., Michigan. Vestaburg Bog is an excellent place to observe ecology at the individual, population and community level. You will learn some of the indigenous plant species and their adaptations for living in a bog environment. You will observe how plant species are distributed within the bog ecosystem and will be asked to speculate on the reasons for this distribution pattern.

OBJECTIVES

In today's lab you will learn to:

- Identify bog plants and successional zones.
- Identify distribution patterns for various plant and animal species.
- Develop observational skills and the ability to ask lots of questions.
- Formulate questions and testable hypotheses about patterns in nature.

KEY WORDS

Be able to define the following terms:

Abiotic	Kettle-hole lake	<i>Sphagnum</i> moss	Ombrotrophic
Biotic	Mineral soils	Organic soils	Peat
Hypothesis	Sedge zone	<i>Sarracenia</i>	Cation exchange
Testable	Tree zone	<i>Larix</i>	pH
Bog	Lagg zone	<i>Chamaedaphne</i>	Calcareous

BACKGROUND: Bog characteristics**Origin of Bogs**

Bog lakes are especially prevalent in glaciated regions of North America and Eurasia where glaciers left behind large blocks of ice buried in till. Melting ice blocks formed small, deep “kettle-hole” lakes, usually without an inlet or an outlet. Such conditions are ideal for the establishment of a bog. Some of the finest examples of bog lakes occur in Michigan, Wisconsin, Minnesota, and southern Ontario.

No one knows for sure why some **kettle-hole lakes** become bogs. Small, deep lakes are more suitable than large shallow lakes. Water tends to circulate more freely in larger lakes, thus ensuring adequate oxygen for decomposition. In kettle-hole lakes, water does not circulate freely and oxygen may become depleted at lower depths. Consequently, respiration is limited to anaerobic organisms, and decomposition is not nearly as complete as in an aerobic environment. As a result, organic matter is deposited faster than it is broken down. The accumulated organic matter is known as **peat**.

Soils and hydrology

Two major types of soils are mineral and organic. **Mineral soils** are formed from the breakdown of rock and parent material derived from rock. In regions with large limestone deposits, mineral soils are **calcareous** in nature (lots of calcium carbonate) and have a high pH. **Organic soils** are formed by the accumulation of partially decayed vegetation with little input from weathering of rock. Organic soils may contain close to 100% organic matter, whereas mineral soils may contain less than 5% organic matter.

Bogs commonly develop in lakes or depressions where most of the water comes from precipitation rather than overland runoff. Few minerals from the surrounding landscape enter the bog system. As a result, the water in a bog is extremely poor in minerals (soft) and acidic.

The Role of the Sphagnum Moss

Sphagnum moss is the dominant plant in a bog ecosystem. *Sphagnum* is the major source of peat. It also has a high water holding capacity. Consequently, it not only helps to maintain wet conditions but it also reinforces those anaerobic conditions favorable to bog development. In addition, *Sphagnum* also has a significant impact on the chemistry of a bog. *Sphagnum* has a high **cation exchange** capacity. It removes mineral cations (Ca^{++} , Mg^{++}) from the water and gives off hydrogen ions in return, thereby effectively reducing the **pH** (negative log of the hydrogen ion concentration). The pH of most bog water ranges from 3.0 to 5.0, comparable to that of acid rain. Acid conditions slow decomposition even further and encourage peat accumulation.

Bog Vegetation and Succession

In lakes where bogs do form, vegetation becomes established near the shoreline. A floating mat composed of *Sphagnum* moss, roots and other debris then begins to grow outward over the surface of the water. The mat continues to grow in thickness until it becomes grounded to the bottom of the lake. Eventually, the open water disappears.

One can see a series of vegetation zones forming concentric circles that radiate from the center of the bog. Each zone correlates with a successional sequence of bog formation, the earliest stage of succession being nearest to the center of the bog. The general sequence is as follows:

1. Open water. In the center of the bog, water lilies (*Nuphar* spp.), cattails (*Typha* spp.) and other aquatic vascular plants are evident.
2. Sedge zone. Sedges (*Carex* spp.) form a matrix of rhizomes and roots that trap debris and provide support for the bog moss (*Sphagnum* spp.) Cottongrass (*Eriophorum* spp.), actually a sedge not a grass, may also occur. These species form the floating mat.

3. Shrub zone. The dominant vegetation consists of shrubs from the family Ericaceae (Heaths) growing on the *Sphagnum* mat. Representatives include: leatherleaf (*Chamaedaphne calyculata*), bog rosemary (*Andromeda glaucophylla*), bog laurel (*Kalmia polifolia*), Labrador tea (*Ledum groenlandicum*), cranberries and blueberries (*Vaccinium* spp.)

Among the shrubs, particularly where there is not too much shade one can find the insectivorous plants, sundew (*Drosera* spp.) and the pitcher plant (*Sarracenia purpurea*). Several species of orchids are also likely to occur but less commonly. They include pink ladyslipper (*Cypripedium acaule*), arethusa (*Arethusa bulbosa*), rose pogonia (*Pogonia ophioglossoides*), and grass pink (*Calopogon tuberosus*).

4. Tree zone. Tamarack, or larch, (*Larix laricina*) and black spruce (*Picea mariana*) are the dominant trees, but several shrubs in the previous zone may occur in the understory. *Sphagnum* spp. also persists, some assuming different color growth form than in open areas of the mat.
5. Lagg. Between the tree zone and the upland soil there is often a moat of open water where little vegetation is established. *Sphagnum* is less abundant and usually absent from the moat. *Sphagnum* is intolerant of high pH water that runs off from calcareous upland soils. In addition, shade kills some species of *Sphagnum*.

The above sequence represents an idealized pattern of bog succession. Often zones are absent or the zonation is irregular. In fact, the patterns of succession in some bogs show no zonation at all.

Life in the Bog

Lack of oxygen. Plant roots require oxygen for respiration. Therefore anaerobic conditions in the peat can be a serious problem for plants attempting to take up nutrients. Looking closely, however, most bog plants maintain virtually all their roots in the live *Sphagnum* and upper few centimeters of peat. Barring sudden changes in water level, *Sphagnum* maintains an aerobic zone a few centimeters above the water where most of the plant roots are found.

Low pH. pH of the bog has an impact on primary productivity especially that of higher plants. Nitrogen fixation and nitrification are inhibited by low pH, and

phosphorus and other micronutrients form insoluble compounds in an acid environment, rendering them useless to plants.

Nutrient stress. Peat represents a potential source of nutrients that are “tied up”.

Simply, peat is a nutrient sink. Because nutrients are unavailable to plants, some are introduced through precipitation. Communities that rely exclusively upon rainfall for their nutrient input are termed **ombrotrophic**.

Bog plants have evolved several strategies in response to low nutrient availability. Roots in the uppermost zone of peat and *Sphagnum* may facilitate interception of nutrients from rainfall. Other plants (*Sarracenia*, *Drosera*) have mechanisms for capturing insects, which supplement their demands for nitrogen. The predominance of evergreen plants may also be adaptive to low levels of nutrients. Holding on to their leaves may be a mechanism by which nutrients are retained longer than if the leaves were dropped.

Physiological stress. Many bog plants exhibit characteristics of desert plants even though water is everywhere. During the winter, the upper layer of *Sphagnum* freezes. The moss continues to lose water through its leaves but it can not replenish it through its roots because soil water is frozen.

Biogeographic Patterns of Bog Plants

Many bog plants are also common in the tundra and boreal forest biomes. Some ecologists have interpreted bogs as relics of boreal vegetation left behind as the boreal forest retreated northward on the heels of the receding glaciers. The deciduous forest moved northward, displacing boreal forests, as the climate became warmer and drier. Consequently, boreal vegetation persisted only in the coolest wettest microenvironments typical of the bogs we see today.

DIRECTIONS AND EXPECTATIONS OF STUDENTS

As you walk through Vestaburg Bog, carry out the following tasks:

1. Develop three specific questions concerning this ecosystem. See “Discussion Questions” below for general examples.
2. Identify the level of ecological organization relevant to each question (e.g. individual, population, community, ecosystem).
3. Create a null hypothesis and an alternative hypothesis from each question.

4. Consider ways to test your hypotheses.

This exercise is designed to provide you with an opportunity to increase your observation and quantitative skills, and more specifically, to provide you with an introduction to general habitat analysis. We have purposely given you a minimum of specific instructions. Our goal is to challenge you to be creative in the questions you will ask (hypotheses formed) about the observations made during the class field trip.

DISCUSSION QUESTIONS

Becoming a keen observer is essential if one is to ask meaningful ecological questions. Thoughtful questions regarding organism adaptations, species interactions and the movement of matter and energy establish a framework for ecological investigation. Consider the following questions.

1. How do physical and chemical factors (e.g. light, temperature, moisture, pH, minerals) affect the spatial distribution of plants in the bog ecosystem? Are there limiting factors?
2. What species adaptations permit survival and reproduction in the bog?
3. Is the pitcher plant population increasing or decreasing?
4. What is the ultimate source of energy driving this ecosystem? Can you trace the path of an energy molecule through the food web?
5. What is the role of *Sphagnum* in the bog?
6. What happens to nutrients in the bog ecosystem? Trace the path of a nitrogen molecule from decaying *Sphagnum* tissue.
7. Is there any evidence that this community will significantly change over the next 100 years?
8. Is there any evidence of disturbance to the bog?
9. How might competition, herbivory or predation influence the species composition of the bog?

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