Opposing Slopes Lab – Part I
Comparison of Plant Communities Across Topographic Gradients at Richard Nixon County Park

"...in one sense, the distinction between a theoretician, laboratory worker, and field worker is that the theoretician deals with all conceivable worlds while the laboratory worker deals with all possible worlds and the field worker is confined to the real world. The laboratory ecologist must ask the theoretician if the possible world is an interesting one and must ask the field worker if it is at all related to the real one." -- Slobodkin in Ricklefs. 1979. The Economy of nature.

INTRODUCTION

The final arbiter of good science in ecology is the field. Much progress in ecology occurs in the lab and greenhouse and through conceptual and mathematical modeling. But these ideas contribute to the science of ecology only insofar as they are relevant to patterns and processes in the field. Just as a cell biologist's context is the body of the cell, the ecologist's context is nature -- not only pristine nature but nature ranging from polluted wastelands to untrammeled wilderness.

Recall from lecture, that ecological studies generally progress from description of pattern, to hypotheses to explain those patterns, and finally to the tests of alternative hypotheses. Eventually, these hypotheses are coalesced into theory that seeks general explanations for many patterns in nature.

Your focus here will be twofold. The first part (week 1) of this lab will introduce you to two of the crucial elements of description: (1) recognizing patterns in nature and (2) documenting or testing those patterns. The second part (week 2) of the lab will be mechanistic. What factors in the environment could be responsible for the patterns that you have documented?

PART I: DOCUMENTING VEGETATION PATTERNS ON A NORTHEAST AND A SOUTHWEST FACING SLOPE.

The study site: Richard Nixon County Park

Richard Nixon Park is located in an area known as the Southeastern Upland. The underlying rocks at this site are schists and quartzites, which are largely erosion resistant compared to the limestone found just to the north in the City of York. This region is dominated by Harpers phyllite, a dark-greenish-gray argillaceous (containing clay minerals) rock, with intrusions of quartz. The soils derived from quartzite rocks are relatively infertile compared to rich, limestone based soils.

Nixon Park and the adjoining Kain County Park are excellent places to explore relationships between topography, direct environmental variables (light, water, nutrients, etc.), and species composition. The park supports forests on a wide diversity of what I will call topographic elements. We will concentrate our efforts on two of these: (1) a southwest-facing slope of a small tributary to the east branch of Codorus creek and (2) a northeast-facing slope just opposite of (1) above.
What do I mean by vegetation patterns?

Plant communities show remarkable change from one place to another in the landscape, such as on a global scale. There can be impressive changes in vegetation, however, even over small parts of the landscape. The first question that probably comes into your mind is "change in what?" In examining communities, ecologists usually look for change in at least three parameters: (1) the growth forms or types of species (morphology, physiology, life history type), (2) the species composition or the identity of the species, and (3) the species diversity (roughly, the number of species).

Major causes of vegetation patterns in nature.

What are the main factors responsible for changes in vegetation across the landscape? Two of the main factors causing such variation are physical environmental gradients and interactions with other species.

Environmental gradients. We sometimes like to think of the world as falling into discrete categories, such as moist vs. dry or rich vs. poor soil. In fact, most of the environment varies in a continuous manner, that is, physical factors (e.g. soil moisture) change gradually across physical space. It is along these gradients of conditions that plant communities exhibit substantial change -- change in the plant species in the community, the number of species, and the types of species. In class, we will cover how global and regional gradients of temperature and moisture influence vegetation. These same two variables plus others such as soils also operate on a more local scale (scale over which you could walk) to influence the character of the vegetation.

Where should you look for such change? Except for extremes, humans are not very good at directly detecting gradients of the factors (light, water, minerals) that directly affect plants. But we are good at detecting changes in landscape variables such as topography, soil type, and proximity to water. These factors of course do not directly influence plant success or failure -- plant growth is not causally a function of a factor such as slope steepness. But these "indirect" factors are generally the key determinants of levels of moisture, nutrients, light, competitors, and herbivores -- the variables that "directly" affect plant success or failure.

Interactions with other species. Other factors can also be important in imposing changes on vegetation. For example, interactions with other species, both mutualists (e.g., seed dispersers, pollinators, etc.) and enemies (e.g., herbivores, competitors). A good example of this in Pennsylvania is herbivory by deer. In PA, as in much of the northeastern and midwestern U.S., deer are much more common now than in presettlement times. The result: lots of deer that are eating plants. To some plant species, this doesn't matter because deer find them unpalatable. But for the species that deer choose to eat, the abundance of deer can strongly affect the abundance of that plant species.

Another strong component that influences where in the environment that we might expect to find a particular species is competition. It is easy to quickly conclude that just because we find a given species in a particular environment, that the species grows well there. That is, we assume that the species is growing in its optimal range (or occupying all of its fundamental niche). However, given an optimum set of resources, some species grow better than others. Consequently, some species may be relegated to living on less than optimum sites, not because they do well there, but because they can tolerate those conditions (and they cannot compete with other species on better sites). Hence, we often find that the realized niche of a species does not equal its fundamental niche.
What to look for in the field.

Look for physical gradients. How would you describe them? What "direct" environmental variables do you think might change along these "indirect" gradients? Do you notice changes in vegetation along these gradients: changes in the identity of species, the density of trees, the size of trees?

HYPOTHESES

Recall that many studies in ecology involve two steps: documentation of patterns and then, tests of explanations for these patterns. Today's lab will focus on documenting patterns in nature. The hypotheses will focus on a comparison of the vegetation on a northeast-facing and a southwest-facing slope.

Documentation. Because of the tilt of the earth, south-facing slopes in the Northern Hemisphere receive more solar energy than north-facing slopes. Midday solar insolation on a 20° south-facing slope at latitude 41° N (about central NJ and southern PA) is on the average, 40% greater than a north-facing slope during all seasons (Smith 1996). This leads to a long chain of interacting events that result in differences between the slopes in the many environmental variables important to the success or failure of plants. It will be up to you to read the associated literature on reserve in the library, collect the data and make the crucial connections that explain the pattern that you will document in lab. The point is that we generally expect that the species composition of these two areas will differ. Our first question, then, is "Does species composition differ between the north-facing and south-facing slopes at Nixon Park?" The null hypothesis or H₀ (essentially, the hypothesis of no difference) is that the two slopes do not differ; the alternative hypothesis (Hₐ) is that there is a difference.

Documenting patterns in nature: vegetation sampling.

The next step in any ecological study would be to quantify, document, or test these patterns. The patterns seem obvious, but human perception can be very biased. Therefore we want to begin to gather some data to 1) document our observations and 2) to generate some plausible explanations for the patterns we document. For example, are some species present at some sites but not others because of changes in soils or light between those two sites? Our goal today is not to carry out a thorough study, but to become more familiar with some basic techniques in field plant ecology as follows.

Quantifying plant communities: There are many methods for sampling plant communities. Today, we will use the quadrat method to estimate plant density, which is a variant of the method that is frequently used by foresters (USDA 1985). At 25 meter intervals along a transect, a round quadrat with a radius of 5.65 meters will be defined by using a tape measure. The quadrat size will be 1/100 of a hectare. Within each quadrat, 1) all the trees are identified and the DBH measured (DBH= diameter at breast height or 1.37 meters from the ground). If the trunk is divided into two or more stems, measure all the stems and note that there were multiple stems. 2) The number of mountain laurel and spicebush plants (do not count individual stems unless they are solitary. If many stems originate from the same point in the ground, consider that 1 plant.) 3) The number of Christmas ferns.
**What you will do today:**

We will establish a 100 meter long transect up the southwest facing slope. I will divide the class groups. Each group will sample one round quadrat along this transect. The quadrats will be established at intervals as determined by the instructor and the center marked with a small piece of flagging so that we can return to it the following week. At each quadrat you will:

1) Measure and identify trees (I will help with identification)
   a) Diameter of each tree species > 5 cm in diameter.
   b) If the trunk is divided into two or more stems, measure all the stems and note that there were multiple stems. (You will calculate the basal area of each stem separately, then add them together.)

2) Measure of shrubs
   a) The number of individual mountain laurel and spicebush.

3) Count the number of Christmas fern clumps.

After you have collected the data in your quadrat, measure 25 meters to the North and establish a second quadrat.

After each group has sampled two quadrats on the south-west facing slope, we will repeat the procedures on the north-east facing slope.

At the end of lab, I will collect the data sheets from each group and make them available on my web page.

The major tree species you will encounter are white oak (*Quercus alba*), black oak (*Q. velutina*), red oak (*Q. rubra*), chestnut oak (*Q. prinus*), black birch (*Betula lenta*), sassafras (*Sassafras albidum*), hickory (*Carya* spp.), red maple (*Acer rubrum*), blackgum (*Nyssa sylvatica*), white ash (*Fraxinus americanum*), tulip tree (*Liriodendron tulipifera*), and black cherry (*Prunus serotina*).

**Shrubs and ferns.** Spicebush (*Lindera benzoin*), mountain laurel (*Kalmia latifolia*) and one fern dominant fern, Christmas fern (*Polystichum acrostichoides*).

**One more important item!!** Be observant. Examine the each of the slopes and think about what factors might explain the difference in the appearance of the two slopes.
Here are ways to report the density of trees and shrubs (by species) and Christmas fern in your tables.

**a) density of each species** = sum of individuals of each species found in all 10 quadrats x 10

= # individuals/hectare.

Recall that each circular plot was 1/100 of a hectare. Instead of averaging the 10 samples, we will add them together. Since you sampled 10 plots, the total area sampled was 1/10 of a hectare. However, expressing the density based on 1/10 of a hectare is awkward, so we will scale up to 1 hectare by multiplying the data by 10 (Note! This only applies if the class has sampled 10 quadrats per slope. If the number of quadrats is not 10, then you must determine a different multiplier to use.) We assume that if we continued to sample another 90 plots (for a total of one hectare) that the composition of the forest would be the same. That is, we are assuming that our sample of 10 plots adequately represents the forest.

**b) basal area (BA) per hectare** of the tree data (by species).

Basal area for 1 tree = \((\pi) \times (\text{diameter})^2 / 4\)

BA per hectare = sum of BA of species A per quadrat for 10 quadrats x 10 =

basal area of species A /hectare. Report basal area as meters^2/hectare

Note: If your tree had multiple stems, calculate the basal area of each stem separately, then add them together for the actual basal area of that individual. For the purpose of density, multiple-stemmed individuals = 1 tree.

**Literature cited**


**References**


The following articles are linked (by number) to the Opposing slopes data page.


**Lament of a field biologist**

My former choice collecting spots  
Are shopping center parking lots  
The meadow, once abuzz with bee,  
Is still now, thanks to DDT.  
Shades of Rachel Carson,  
Whatever will become of me.

The glen where trilliums lolled in shade  
And toadlets hopped, and chipmunks played,  
In a watery grave has lain for years  
Drowned by the Corps of Engineers.  
My wild world is sinking fast,  
Whatever will become of me.

The marsh, a haunt of coots and rails,  
Where *Typha* waved and wagged its tails,  
Succumbed to an ignominious fate,  
It's a cloverleaf on the Interstate.  
Nature heaves a dying breath,  
Whatever will become of me.

Clear birch-edged stream with fauna rank,  
With iris blue upon your bank,  
Your poisoned pools I now scan,  
My seine haul yields one Falstaff can.  
Everything I love is gone,  
Whatever will become of me.

The fields are being, with great precision transformed into a subdivision,  
The eagle falls, the lily dies,  
And on the road a 'possum lies.  
No doubt what will become of me,  
Molecular Biology.

George W. Folkerts
DATA SHEET FOR NIXON PARK SAMPLING

NAME OF SAMPLERS___________________________________________  DATE________

SLOPE ASPECT____________________       DISTANCE UP TRANSECT ___________________

PLOT 1

TREES

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# of Mountain Laurel __________  # of Mountain Laurel __________

# of Spicebush __________

# of Christmas Ferns __________

Air Temperature __________

Soil Temperature __________

Light Intensity __________

PLOT 2

TREES

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# of Spicebush __________

# of Christmas Ferns __________

Air Temperature __________

Soil Temperature __________

Light Intensity __________
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NAME OF SAMPLERS___________________________________________  DATE__________

SLOPE ASPECT____________________   DISTANCE UP TRANSECT ____________________

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# of Mountain Laurel ________  # of Mountain Laurel ________
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# of Christmas Ferns _________  # of Christmas Ferns _________

Air Temperature ____________  Air Temperature ____________
Soil Temperature ____________  Soil Temperature ____________
Light Intensity _____________  Light Intensity _____________