Raystown Field Station
Juniata College
Huntingdon, PA

Outreach Program in Environmental Science

Forest Productivity Module

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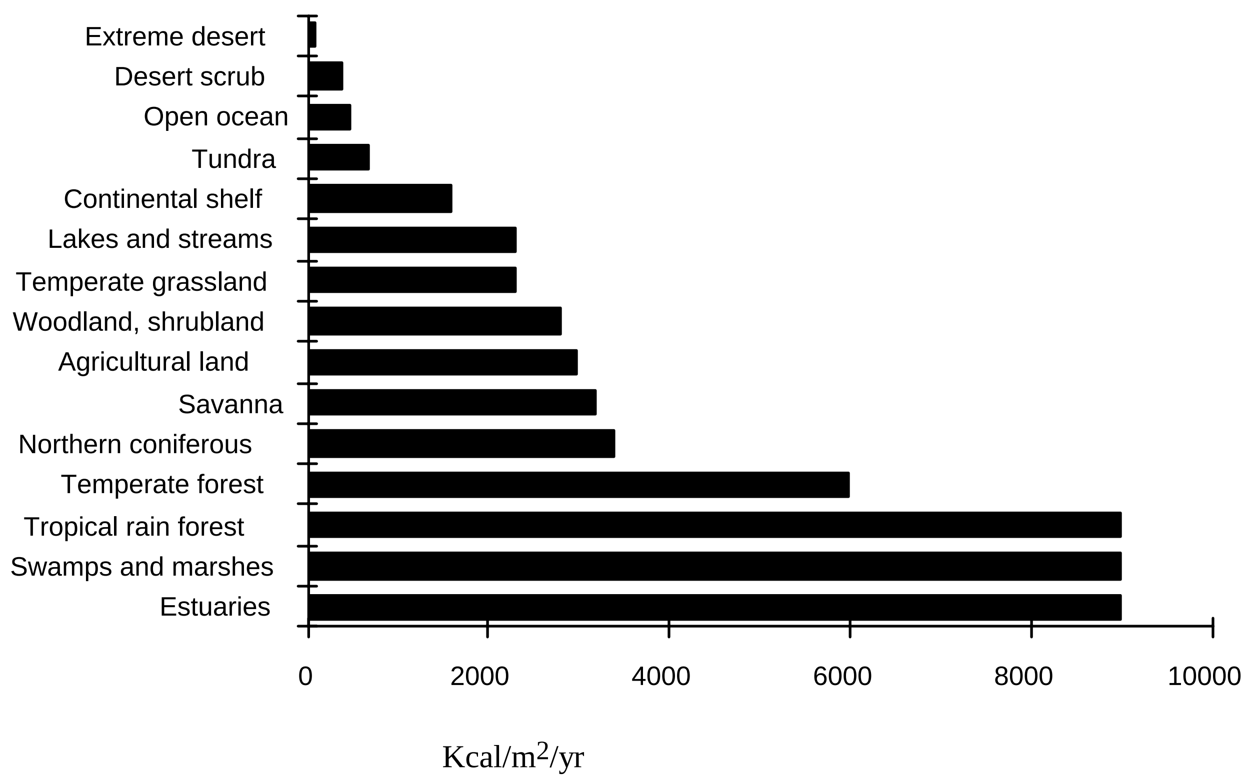
This program is made possible by
grants from the Whitaker Foundation
the WestVaCo Corporation and
the Knight Foundation

I. Introduction

One of the foundation concepts in ecology is that of **primary productivity**. Primary productivity is the rate at which plants in an ecosystem produce biomass or plant matter such as roots, leaves and stems.. Some ecosystems provide conditions that are more conducive to producing high biomass, i.e. those having adequate **moisture, temperature** and **nutrients**. Wetlands and coral reefs have the highest productivity of any ecosystem while tropical forests have the highest productivity of any terrestrial ecosystem because neither are limited by any of these three factors (see graph below). Deserts have a very low primary productivity because the environment is limited in water and usually experiences extreme temperatures, causing plants to have slow growth rates. Grasslands have a moderate productivity (see graph below). This module will focus on the relatively high primary productivity of a deciduous forest.

Mean Net Primary Productivity of Selected Biomes



Even within a single ecosystem, forest stands may vary in productivity due to subtle environmental factors. For example, forests on south facing slopes receive more sunlight than forests on north facing slopes. The greater sunlight exposure could give the forest on the south facing slope a warmer climate as well as a longer growing period each day. Thus, we might predict that the forests on south facing slopes will have greater primary productivity. Furthermore, forests in valley bottoms may receive more moisture and perhaps have greater productivity than forests on ridge tops.

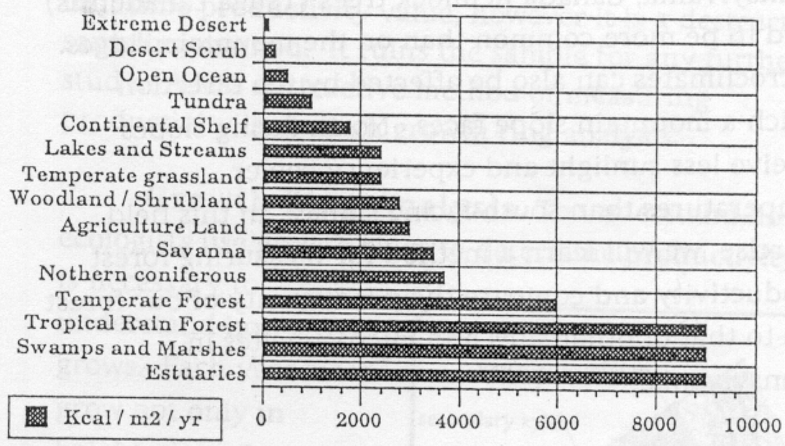


Fig 1. Mean net primary productivity of selected biomes.

There are several methods for measuring vegetative productivity. All of the methods depend on the basic idea of samples. It is not practical to measure every tree in an entire forest, especially when some forests cover hundreds of square miles, so ecologists use randomly selected samples within a forest to represent the whole forest. In this module we use a quadrant sampling method. Quadrant sampling involves selecting several random points within the stand. At each point, a square area is created of a designated size and all vegetation within the square is surveyed. The data collected from all of the sample sites can be statistically tested to see if we have done sufficient sampling.

One method to determine annual productivity is to clear-cut the sample quadrant and dry all of the vegetative matter and weigh it. This yields a mass per unit time productivity value, however it is a destructive sampling method. It fairly effectively ruins the sample for any further study. An advantage in working with forests is that annual productivity is fairly easy to determine. We will be taking a core of each tree and counting annual growth rings on each core to determine annual productivity. Core sampling is a simple non-destructive method of measuring productivity in forests.

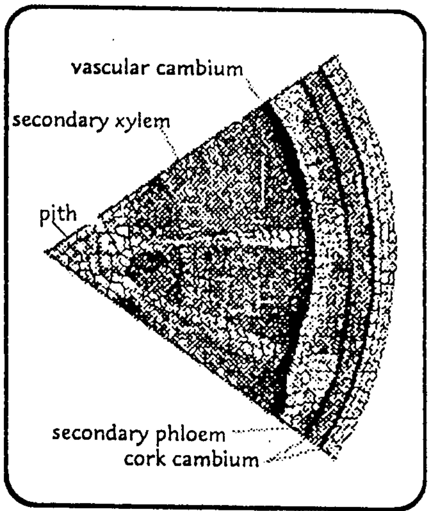
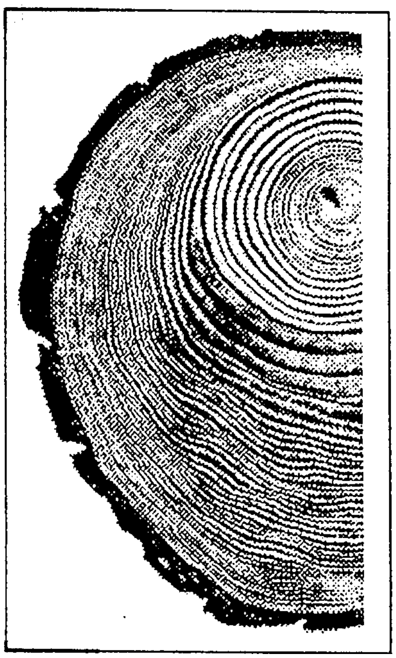


Fig. 2. Cross-section of a tree trunk showing the various types of tissues.

Our main objective in this module is to determine from our forest samples whether there is a relationship between forest location and primary productivity. Therefore, we shall divided the forest into several specific areas and then choose our random samples from within these designated areas.



II. Research Question

What is the relationship between the location of a forest stand and it's net primary productivity?

III. Research Design

A. Summary

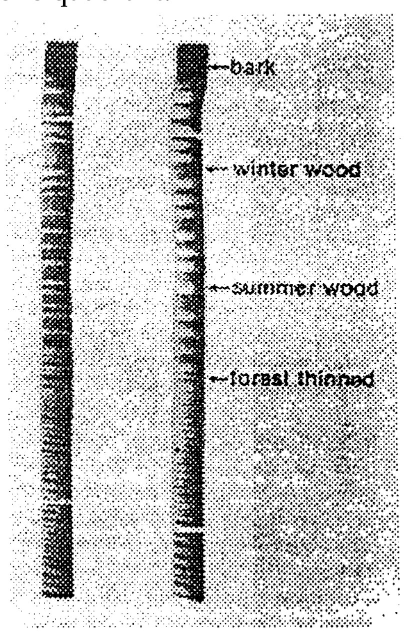
To address the research question, we will visit four forest stands at different locations on the field station property. The locations are ridge top, north facing slope, south facing slope, and valley bottom. At each stand we will divide up into teams to collect the data necessary to calculate the productivity. Each team will establish a study plot and locate all of the trees within the plot. From each tree in the plot your team will collect the following data:

1. Diameter of the tree at breast height.

2. Estimated height of the tree.

3. The species of the tree.

We will also extract a core sample from each tree to determine its annual growth rate. In order to make the sampling fairly accurate, we will require data from at least five plots at each study site therefore some groups may need to record data from more than one quadrant.



From this data, as well as leaf fall data that we collect each year, we will be able to calculate the annual productivity of each tree and therefore, for each forest plot.

Questions:

1. What are the <u>treatments</u> for this experiment ?
2. What are the <u>variables</u> for this experiment ?

3. Do we have true replicates in this experiment ?
4. How many replicates do we have ?
5. What predictions would you make about our results ?

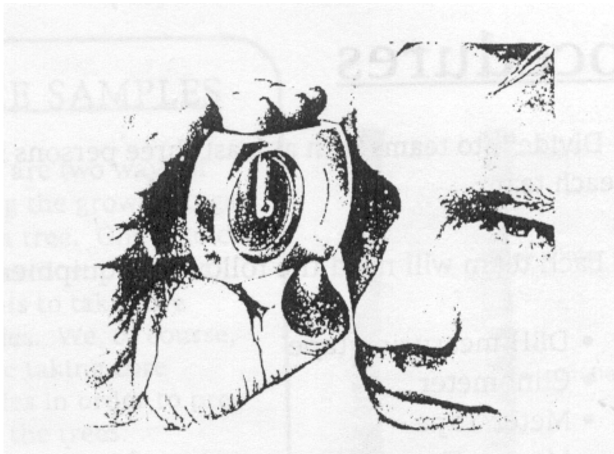
IV. Procedure:

1. Divide into teams with at least three persons in each team.

2. Each team will need the following pieces of equipment:
   a. DBH measuring tape
   b. Altimeter
   c. Meter Tape
   d. Marker Flags
   e. Tree core borer
   f. Plastic tubes for tree cores
   g. A marking pen for labeling samples
   h. Clipboard
   i. Data sheet (from the back of the module)
   j. A pen or pencil for recording data.
   k. A tree identification guide.

3. We will travel together to each study site. At each study site, randomly locate a point in the forest stand and use the marker flags and and tape measure to establish a 10 meter by 10 meter study plot.

4. Locate each tree within the boundaries of the study plot. Indentify the species of tree and assign each tree a number. Then measure its diameter at breast height using the DBH tape, and its height using the altimeter and the measuring tape. From each tree, extract a core sample using the core borer. Put the core into a sample bag and label it with the tree number. We will demonstrate the correct procedure for all sampling equipment but it is up to you and your team to collect and record the data. Try to collect data from at least 5 plots for all teams from each study site (If there are 5 teams, then only 1 plot each).



5. Upon returning to the lab, we will stain each tree core sample to reveal the annual growth rings.   Once stained, measure a 3 cm segment of each tree core and count the annual growth rings. A dissecting microscope will be useful for counting faint rings. Dividing three by the number of growth rings will give you the average annual growth of the tree in cm.

Using a forest productivity computer program, we will calculate the productivity of each study plot.

V. Data Analysis

We will evaluate the differences in productivity among the different study sites by using a statistical procedure called analysis of variance (ANOVA). In this procedure, the productivity values from the five plots at each study site are pooled and a mean value is generated. ANOVA compares the means and their variance among the different study sites to determine if there is a significant difference between the means.

VI. Discussion Questions

1. Were there significant differences between the study sites? How do you explain the differences or lack of them ?

2. What were weaknesses of the research design ? Were there variables that we should have considered that we didn't ?

3. Can you rearrange the data to find out if growth rates vary be tree species ? If so conduct the analysis. What are the results?

4. What are some human impacts which might affect forest stand productivity in Pennsylvania ?

5. Choose a particular factor that might affect forest productivity (natural or human induced). How would you design an experiment to examine the effect of that impact?

Data Sheet

Name:_________________________________ Date:_____________

Study Site Location:_____________________ Plot #:____________

#	Tree Species	DBH (cm)	Height (m)	Annual Growth Rate (cm)
1				
2				
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Data Sheet

Name:__________________________________ Date:______________

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Appendix A:

How to take an increment core:

1. Remove borer bit and extractor from inside the handle. Place the extractor your pocket for convenience and protection of the extractor.

2. Assemble the handle and borer bit by:
   a. pushing the locking latch away from the handle with your thumb,
   b. inserting the square end of the borer bit into the handle, and then
   c. returning the locking latch completely around the borer bit "collar." You're now ready to start boring; however, we suggest you apply beeswax to the threads and shank before you do.

3. Align the borer bit and the handle so that the bit will penetrate through or towards the center of the tree and at right angles to the tree. In any other alignment, the annual growth rings seen in the extracted core will be distorted and could result in erroneous growth rate analysis.

4. Place the borer bit threads against the tree, preferably in a bark fissure where the bark is thinnest. Hold the threads in place with one hand. With your other hand push forward on the handle and simultaneously turn it to the right until the bit threads penetrate the wood enough to hold the bit firmly in place.

5. Then place both hands, palms open, on the ends of the handle and turn the handle to the right until the bit reaches the desired depth.

6. With the bit at the desired depth inset the full length of the extractor, concave side up. Then turn the handle one-half turn to the left to break the core from the tree and also to turn the extractor concave side down.

7. Pull the extractor from the borer bit. The core will be resting in the channel and held in place by the small "teeth" at the tip of the extractor. Before examining the core sample, promptly remove the borer bit from teh tree, clean it with WD-40 and place it and the extractor back in the handle.

Red Maple *(Acer rubrum)* A

Appendix B:

Tree identification guide:

medium sized tree with smooth gray young trunk bark and broken darker older bark. Leaves 3 to 5 lobed, much whitened and hairless or hairy beneath. Notches between leaf lobes relatively shallow, base of terminal lobe wide. Leaves 2"-8". Height 20'- 40'; diameter 1' -2'. Flowers red, rarely yellow, in short clusters, March- May. Fruits reddish, May - July.

Sugar Maple *(Acer saccharum)* A large tree with dark brown trunk bark marked with rough vertical grooves and ridges. Leaves mostly 5-lobed with moderately deep notches between lobes. Foliage pale green beneath. Leaves usually hairless. Leaf edges firm and not drooping. Leafstalk bases not much enlarged, no stipules, or small ones that do not cover buds. Buds slender, sharp-pointed, brown. Twigs glossy and reddish brown. Leaves 2" - 10". Height 40' - 60'. Diameter 1'- 2'. Flowers yellowish, April - June. Fruits June - September.

Striped Maple *(Acer pensylvanicum)* A small slender northern tree with green bark vertically marked with white stripes. Leaves 3-lobed, sometimes with 2 additional small lobes near base, lobes somewhat long-pointed. Foliage double-toothed, hairless, green on both sides, paler beneath. Twigs hairless, mostly greenish. Leaves 2" - 10". Height 5'- 15'. Diameter 1"-2". Flowers in long clusters, May- June. Fruits June- Sept.