BIOLOGY 321: ECOLOGY
LABORATORY & FIELD MANUAL

Instructor: C. PARADISE

DAVIDSON COLLEGE

 

TABLE OF CONTENTS

[1]Adapted with permission from Stamp, NE (1994) Ecology Lab Manual, Binghamton University.

1: Laboratory and Field Safety Agreements

Introduction

It is critical that safety rules are followed: failure to do so could cause injury. Eating and drinking in the laboratory are absolutely prohibited. In addition, if you are coming to laboratory with a drink or food, dispose of your containers and wrappers outside the laboratory.

In ecology, there won't be many times when we'll be handling chemicals, but if we do, remember to wear appropriate safety equipment. Also, please wash your hands before leaving class, and sort waste according to type. There will be designated containers for the following: glassware, sharps, and chemicals. Always know what you are handling and how to dispose of it. You have a right to know about the chemicals with which you work – just ask.

Whether we're going in the field or staying in the laboratory, wear appropriate clothing. This means no sandals or open-toed shoes, no cut-offs, or baggy clothes, and no dangling jewelry. In addition, if we're in the field, it's best to wear long pants and shirts with sleeves, especially if you're sensitive to poison ivy or insect bites.

Make sure you know where the emergency equipment is and how it works. There are flip charts in the laboratory with simple instructions. Always look out for potential hazards, keep your work area clean and free of clutter, and look out for yourself and your laboratory partners.

Davidson College Department of Biology

Laboratory Use Agreement

Read the following carefully before you sign the forms at the end of this section. In order to have access to laboratory facilities in Watson or Dana Laboratories, you must agree to the conditions. By signing this document, you agree to follow the following rules and accept the risks and responsibilities that accompany use of a scientific laboratory.

RULES

1) I will only access rooms and use equipment where I have been granted permission. Access to a room does not convey unlimited use of the facilities within a room and requires previous training in safety and emergency procedures.
2) I will only access rooms and use equipment for BIOLOGY courses. Within the permitted room, I may only use equipment on which I have been trained by a faculty or staff member and I may only use that equipment for designated assignments. Students may not grant permission or provide training for each other
3) I will only use equipment for which I have prior approval and training by the course instructor. I will follow instructor-approved protocols and safety guidelines.
4) When I am done I will clean my work area and place all equipment, reagents, and trash in designated areas. This includes placing "LABORATORY WASTE" in designated containers. I will dispose of all solutions properly and I will ask before pouring anything down a drain.
5) I will not eat or drink in the laboratory at any time. Food may not be consumed, stored, or

disposed of in any laboratory. Food includes water and gum.

6) I only qualify to ask for laboratory access outside of normally scheduled times if successful completion of my research requires my presence in the laboratory during that additional, privileged, time period. I understand that scheduled classes have priority access to laboratories and equipment.

7) I will plan my lab work so that it will be completed by 1:00 AM. Building access is prohibited 1:00 – 6:00 AM and I understand that I will be removed by security if I am in the lab during these hours. On the rare occasions that my research requires lab access during this restricted time, I will inform my instructor in advance to ask that s/he apply for an exception through the Vice President for Academic Affairs.

8) I will not prop lab doors open for any reason. If working alone in a lab, I will close and lock the door for my safety.

9) I will not perform dangerous experiments or work with hazardous chemicals alone, as per the campus chemical hygiene policy. Under these circumstances, I will make arrangements for a 'buddy system[1] with two or more people in the same room

10) I will not use the laboratory for other purposes. I understand that laboratories are specialized, technical work areas and as such are NOT available for general student access. Approved uses include course-related work such as: assigned laboratory work, data analysis, or presentation preparation and practice. I understand that access to equipment in the instructors' bench in a teaching lab requires prior arrangement with the class instructor.

11) I will use the laboratory printer to print only data analysis and other materials specifically requested by the instructor. Prohibited printing includes:
    a. lecture materials
    b. literature searches, websites or articles even if the items are course related.
    c. work, papers, or any other materials for other classes.

12) If there is any accident, to a person or to equipment, I will report the incident as soon as possible to the appropriate authority (e.g., security, fire, paramedics, etc.) and to the course instructor. Emergency phones and all exits are well marked.

13) I will not use the adjacent prep room or the equipment within without specific permission.

14) I will not borrow equipment or reagents from other laboratories or research areas without prior permission from the professor who has principle responsibility for the item/room. I will take responsibility for returning all borrowed items, clean and in good working order, within a predetermined period of time.

RISKS

I understand that working in a laboratory may expose me to risks and dangers, including but not limited to the following:

- Chemicals-- including acids, bases, salts, alcohols, corrosives, and fixatives (e.g., formaldehyde). Chemicals may be neurotoxic, caustic, carcinogenic and/or flammable.
- Equipment-- including glassware, sharps (e.g., razor blades and scalpels), high voltage sources, microwaves, and UV light sources.

- Animals-- including snakes, mice, rats and birds

DAVIDSON COLLEGE BIOLOGY DEPARTMENT
FIELD ACTIVITY AGREEMENT

ASSUMPTION OF RISK, RELEASE OF LIABILITY AND HOLD HARMLESS AGREEMENT

THIS IS A LEGAL DOCUMENT. READ IT CAREFULLY BEFORE SIGNING.

1. I understand and accept that the Davidson Biology Department activity noted above exposes me to many risks and dangers. Some of the risks, which may be present or occur include, but are not limited to:

- hazards of physical exertion associated with the activity.
- hiking in wilderness terrain, far removed from medical treatment and transportation.
- trail hazards, including steep slopes, rocks and limbs in and over the trail, slippery footing, and holes and declivities;
- using tools and gear such as, laboratory utensils, kitchen utensils, knives, power tools, trapping devices, marking and measuring devices, and camping equipment;
- chemical hazards associated with trapping, killing and preserving specimens;
- carrying a backpack and other equipment;
- injuries inflicted by animals, insects, reptiles and plants;
- the forces of nature including lightning, weather changes, extreme temperatures, sunburn, high winds, blizzards, avalanches and others not named;
- water hazards including swimming, wading, snorkeling, scuba diving, capsized boat;
- traveling in a vehicle not driven by me.

2. I understand and accept that these risks expose me to, but are not limited to, the following consequences: death, serious neck and spinal injuries which may result in complete or partial paralysis, brain damage, serious injury to my general health and well being. I also understand that the risks in participating in the field activity include not only the foregoing physical injuries, but also impairment of my future abilities to earn a living, to engage in business, social and recreational activities, and generally to enjoy life.

3. Understanding the risks mentioned above, and understanding that this activity may subject me to rigorous physical exertion, I hereby state that I am physically fit to participate in this activity.

4. In consideration of my being permitted to participate in the field activity, and as a condition of the right to participate in the field activity, I personally assume all risks incident to such activities. I also waive, release and forever discharge Davidson College and any of its employees or agents from all liabilities, losses, damages or costs of any nature that may arise in connection with my travel to or participation in such activities (including rescue activities associated with the programs). I hereby agree not to file suit against Davidson College or any of its employees. I agree to indemnify and hold the college and employees harmless from all liabilities, losses, damages or costs of any nature that may arise in connection with my travel to or participation in such activities, including rescue activities. The terms of this document shall bind me, my heirs and personal representatives.

______________Print this page, sign, and hand in to your instructor________________

Laboratory and Field Signature Page

Class: **BIO 321, Ecology** Semester: **Fall '10** Instructor: **C. Paradise**

Davidson College Department of Biology: Laboratory Use Agreement

Access to laboratory Bldg(s): **Watson Life Sciences** Room #: **243**

I have completed safety training, understand and accept the stated risks, and agree to the above stated terms of access. I understand that I am responsible for my actions while in the laboratory and that breaking the terms stated above may result in personal penalties and in the entire class having access restricted or revoked.

___________________________________ ___________________

Signature Date

____

Printed name

Davidson College Department of Biology: Field Safety Agreement

Date(s) of field activity: **Various, during Fall Semester 2010**

Prior to signing this document, I have had an adequate opportunity to read and understand it, have had an opportunity to ask questions about it, and any questions I have had have been answered to my satisfaction. I further state that I am ___ years old and competent to sign this document.

___________________________________ ___________________

Signature Date

____

Printed name

2: Overview of Ecology & Developing Ecological Hypotheses

There are several approaches to studying ecology, and you will experience some in the laboratory portion of this course. In the first part of the semester, you will work with one or two partners to conduct an independent ecological study at the Davidson College Lake Campus.

Observational ecology, sometimes also called descriptive ecology, involves the study of patterns in nature. These patterns could be of a single individual's behavior, a population inhabiting a single place at a single point in time, a population observed over a long period of time, or an entire community over time. Observational ecology is not manipulative – we study through observation and describe patterns based on those observations. We might go farther and test hypotheses regarding the observations, but the system is not manipulated.

Manipulation of variables is the purview of experimental ecology. Here, ecologists attempt to test the direct effects of one or several variables on some dependent variable, be it an individual organism, a population, or a community. In a well-designed experiment, other independent variables are controlled, or held constant, so that only the manipulated factor has the potential to affect a change in the dependent variable(s). Additionally, good experiments offer rigorous tests of hypotheses. The hypotheses are often generated from observations and also from a third major branch of ecological pursuit: theoretical ecology.

Theoretical ecology typically involves the use of models that are used to test fundamental ideas about ecological systems. Ecological hypotheses arise from observational and experimental ecology. Experiments are then devised to test hypotheses. Sometimes those experiments are thought-experiments, which use graphical or mathematical models to simulate the real world and examine how a system responds to particular independent variables given a variety of assumptions about the system. Theoretical considerations should drive any ecological study, even if models are not explicitly used or developed.

We will discuss in the field how ecologists develop testable hypotheses, as well as how manipulative experiments are designed and carried out. Most organisms exhibit patterns in their distributions, their interactions with other organisms, or their growth, survival, and reproduction. Through observation, ecologists discern these patterns and then attempt to determine the mechanisms that cause the patterns. Manipulative experiments and theoretical models can be used to test mechanisms.

To understand ecological systems, we must first be able to describe them, both qualitatively and quantitatively. We must describe the patterns that we observe in a quantitative fashion in order to hypothesize about the processes that cause the patterns observed. For instance, we might observe a pattern where individuals of a prey species are rarely found where predators are found and commonly found in predator-free areas. There are alternative mechanisms that may lead to such a pattern: prey may be able to detect the presence of a predator, and avoid such areas, or prey densities may be lowered by predation. A model or an experiment may be used to discriminate between these two alternatives.

3: Forest Succession

Introduction

In this exercise you will describe vegetative patterns of the forest at DCEP and learn some basics of ecological study and experimentation. We will use these data to determine if this forest is a mature community or if successional change is occurring.

If you plan to study or manage a population, you need information on characteristics of abundance and dispersion, as well as the community in which the population lives. Different methods have been developed to gather data on populations of different types of organisms. Obviously, mobile species require different methods than sessile species. For example, because they are not mobile, and are relatively easy to identify, trees make excellent subjects for studies of abundance, dispersion, and community composition. We can easily estimate the density and describe the dispersion for populations of trees living in the forest in the Davidson College Ecological Preserve.

Sampling considerations

Generally, if you are interested in community structure or function in a forest, it is not practical to sample every tree. In addition, various attributes of the members of the population, such as size and age must be estimated by sampling. Time and financial constraints often require that we estimate these values, since complete censuses of populations require considerable time and effort (just ask the US Census Bureau!). This is where **random sampling** comes in, which allows scientists to obtain a practical amount of information and yet still make conclusions about the entire population in an objective manner. We cannot actively select individuals to sample, as that biases our experiment, so we must randomly select individuals or plots to include.

The most straightforward approach is to select as objectively as possible a series of sample plots within a community, which are representative of the community as a whole. Historically, these plots are called **quadrats** by ecologists, although they are not always square. From these samples we extrapolate a description of the entire community, which of course may be subject to sampling error. Quadrat sampling is often used to study plant communities, but may also be used for animal communities, such as in the study of stream invertebrates.

The shape and size of the quadrat used affects the sampling characteristics of the data collected. The shape that is fastest and easiest to use is a circle, but a square is often used when the total habitat is divided into numbered sampling units sampled randomly. To use a circular quadrat, randomly select a point and sample all the organisms of interest within a given radius of that point. In sampling the woods at DCEP, we will use quadrats of 100 m^2 (radius = 5.64 m). Why do we use such a large quadrat? If it is too small, more than one individual of the species in question may not fit in the quadrat; if too large, counting all the individuals may be time-consuming. Reproducibility is also higher when taking many small samples rather than a few large ones.

There are several sampling patterns typically employed by ecologists. To determine an unbiased estimate of the population, the sampling data should be collected at random. The simplest such scheme is the **unrestricted random sample** – our region or habitat can be mapped on a Cartesian coordinate grid, and we could select two random numbers from a random numbers table (Table 2.1) that will be our X and Y coordinates on the map. We would continue to do this until we selected as many pairs of coordinates as we need for our study. A random selection implies that every point in a study area has an equal probability of being selected and that the location of one sample does not influence the location of any other sample. The element of chance makes it possible that some areas of the community will be missed and other areas may be oversampled, but the reliability of one's sample is at least testable, and the data are more amenable to statistical analysis.

A **systematic sample** is one where samples are obtained at fixed intervals in time or space. Samples are placed at regular intervals along a line or at intersecting points of a line grid. This method has certain advantages in speed of selection and in spreading the samples throughout the entire area (or forest). The data, however, are not satisfactory for probability tests because the sampling locations are not independent of one another, and cannot be analyzed statistically.

Because many samples in an unrestricted random sample may, just by chance, come from the same part of the habitat or field, and because of the statistical problems associated with systematic samples, we will actually employ a hybrid of the two methods, the **stratified random sample**. In this method every point in the study area has an equal probability of being sampled (as in the random method), but this method also spreads the samples throughout the study area (as in the systematic sample method). Our equal sized subdivisions will take the form of a grid, and in each square of the grid a quadrat is located at random. Thus every point in the field has an equal chance of being sampled, and the method provides us with testable data.

Objectives

- To learn to identify common trees in the Davidson College Ecological Preserve.
- To apply standard forestry sampling methods to a forest.
- To become familiar with standard vegetative analysis.
- To use statistical procedures to test hypotheses.
- To describe vegetative patterns of the woods at DCEP, and to determine if this forest is a mature community or if succession is occurring.

Week 1 – Materials

random numbers table (Ex. 1)	flagged stakes	compasses
tree field guides	measuring tapes	clipboard/data sheets

Week 1 – Methods

a. The class will divide into groups of three to four. If you are usually paired up with someone else, your pair will merge with another pair. If you usually work in a group of three, stay with that group. One person in each group will record data, while the others will locate points, identify trees, and measure distances and basal areas of those trees. Rotate these tasks occasionally. Construct a data sheet to use for the group with five columns for the following information: quadrat #, tree species, and tree diameter at breast height.

b. Each group will select 5 pairs of two-digit random numbers from the random numbers table. The technique will be explained by your instructor. The random numbers should each be divided by 5 and recorded on the data sheet **before** going into the field.

c. To locate sample sites, each group will start at a different stake along the border of a gridded area that has been staked out by Dr. Peroni, near Erwin Lodge. Use this first stake as a starting point. Then locate a random point from this stake using your first pair of random numbers, measuring out a distance in meters equal to the first number and, perpendicular to that direction, a distance equal to the second number. Place a stake at that point.

d. Record the following information for all trees within 5.64 m of your sampling point (your quadrat is 100 m^2, which is equal to 1/100 hectare): 1) species and diameter at 1.35 m above ground (breast height). You can read diameter directly from the dbh tapes. If a tree is on the border of your quadrat, make sure you measure to the center of the tree to determine if it is in your quadrat or not (it must be more than half in). We'll call a plant a tree if the trunk has a basal area of at least 81 cm^2 (10 cm diameter at breast height). Anything smaller is a sapling (or a shrub). If you have saplings, record the species and the canopy species above each sapling.

e. After sampling is complete, remove the second stake and go back to the first one. From there move to the next stake in the grid. Use the new stake as your first stake to define the corner of your second grid square. Locate the second quadrat as you did the first, using the pair of random numbers. Continue with this procedure until you have collected data on five quadrats.

Week 2 – Vegetative sampling analysis

We'll start with a descriptive analysis of the canopy species (trees with dbh $\geq$ 10 cm). The standard measures that summarize the raw data in a convenient manner for describing forest community composition are:

a. Frequency: the percentage of quadrats containing a given species. If 15 out of 30 quadrats (each 0.01 hectare) contain red oak, its frequency is 50%

b. Density: the number of individuals per unit area. If our total sample contained 20 red oak, and our total sample area was 30 quadrats, then our density estimate is $20/(30 \bullet 0.01) = 66.7$ trees / ha.

c. Dominance: basal area (or any other measure of cover or size) per unit area. If the total basal area of red oaks in $30 \bullet 0.01 = 0.3$ ha was 90 dm^2, then its dominance is $90/0.3 = 300$ dm^2/ha. Basal area is calculated by dividing dbh by 2, squaring it, and multiplying that by pi (π).

d. Average size: the mean basal area of a species for the entire sample. Divide the total basal area for a species by the total number of trees of that species. For red oaks, 90 dm^2/20 = 4.5 dm^2. Size of trees is correlated with age, and the comparison of different species may provide evidence about the dynamics of the community.

e. Relative frequency: this, and the other "relative" measures are closely related to the corresponding ones above, but the data are made relative, so that the sum for all species adds up to 100% in each case. This may be advantageous if several forests are being compared. Relative frequency is the number of quadrats containing a species divided by the sum of that number for all species. If red oak occurred in 5 quadrats, sugar maple in 10, and american elm in 10, the sum of the quadrats of occurrence for all species is 25, and the relative frequencies are 20%, 40%, and 40% for the three species.

f. Relative density: the proportion of all individuals sampled belonging to a given species. If a total of 95 trees were sampled and 20 were red oak, the relative density is $20/95(\bullet 100) = 21\%$.

g. Relative dominance: the proportion of total basal area sampled belonging to a given species. If the sum for all species is 800 dm^2, and that for red oak alone is 90, the relative dominance is $90/800(\bullet 100) = 11.25\%$.

h. Relative importance value: the average of relative frequency, relative density, and relative dominance for each species. This value is used as a single-value index of the overall importance of a species in a community. In the present example, the relative importance of red oak is (20 + 21 + 11.25)/3 = 17.4%.

i. Tree Density: the total density of trees per hectare, regardless of species (# trees / (total number of quadrats • 0.01)).

j. Dominance per hectare: total sum of basal area / (total number of quadrats • 0.01).

k. Basal area per tree: total sum of basal areas / # trees.

Table 3.1. Sample data sheet for group quadrat calculations (also refer to Excel spreadsheet supplied by instructor).

	Trees				
Species:					
Frequency					
Density					
Dominance					
Average size					
Relative frequency					
Relative density					
Rel. dominance					
Importance value					
Dominance/ ha.					
Overall					
Total tree density					
Basal area per tree					
Total sapling density					

Week 2 – Statistical analysis

1. Patterns of population dispersion

Typically, ecologists consider three broad categories of dispersion: random, clumped, and uniform. Determine the dispersion, or distribution, pattern of three common species in the DCEP forest by comparing it to a well-known theoretical random distribution. In a random distribution, the presence of an organism does not change the probability of the presence of another one of that species in the vicinity. In an aggregated, or clumped, distribution, the probability of finding another is increased, and in a regular one, the probability is decreased. Specifically, you want to know the spatial pattern or dispersion of the species you sampled.

For a random distribution, there is a set relationship between frequency and density per quadrat (or per unit area). This relationship is based on the Poisson distribution, which is

$$P_x = e^{-\mu}(\mu^x/x!)$$

where P_x = the probability of observing x individuals in a quadrat,

x = an integer count, the number of individuals observed,

μ = true mean of the distribution (unkown to us)

$x! = (x) \bullet (x - 1) \bullet (x-2) \ldots (1)$; the factorial of x

To fit the Poisson distribution to observed data, we need only calculate the mean, which is our estimate of μ, the true mean. We could calculate the expected frequency distribution and compare it to our observed frequency, but a simpler test is to use the "index of dispersion." This calculation is based on the Poisson distribution, and is simply defined as

$$I = \text{observed variance/observed mean} = s^2/x$$

A property of the Poisson distribution is that the true variance is equal to the true mean ($\sigma^2 = \mu$), and so I would be equal to 1 in a random distribution. For aggregated distributions, variance increases relative to the mean, so I>>1. For uniform distributions, variance decreases relative to the mean density, so I<1.

Calculate the index of dispersion, I, for both species. For this you will have to calculate the sample variance and the mean (use formulas in Excel).

2. Statistical test of dispersion

The index of dispersion **describes** the dispersion of the **sample**. We are using the samples we collected as a proxy for the population we studied. We need to use inferential statistics to determine the probability that any deviation from a random pattern in our sample represents an artifact of sampling rather than a deviation of the population from a random dispersion pattern. Inferential statistics allow us to test hypotheses, which are predictions about the variables we study. We will test the hypothesis that the distribution is not random, which means we are actually testing the null hypothesis that the distribution is random. Most groups will be able to follow this procedure to test hypotheses about distribution for your species:

a. For each species, sort the data by number of stems (or plants) per quadrat, using the Data – Sort command.

b. Determine the number of quadrats that contained 0, 1, 2, …, m individuals and record in a separate column on the data sheet. These data provide a frequency distribution for the variable "# of individuals per quadrat."

c. Calculate the number of quadrats you would expect to find in each category if the dispersion pattern is random. To obtain these predictions, first use the mean number of individuals per quadrat and Poisson distribution to calculate the proportion of quadrats that we expect to fall into each category if the pattern is random. Excel will perform these calculations. In the column next to the column containing the frequency distribution, locate a free cell and type

=poisson(#seedlings/quadrat,mean density,false)

For example, if you wanted to calculate the proportion of quadrats expected to contain 0 goldenrod stems from a sample with a mean of 6.45 stems/m^2, you would type

=poisson(0,6.45,false)

"False" indicates that you want Excel to calculate the probability associated with the specified outcome only. "True" instructs Excel to return the cumulative probability of all outcomes less than or equal to the one specified.

d. In the next column calculate the actual **number** of quadrats you would predict in each category with the random dispersion pattern you just calculated. Simply multiply the proportion of quadrats predicted by the Poisson distribution by the total number of quadrats sampled.

e. We'll use a Chi-square, χ^2, test to compare the observed frequency distribution of # of individuals / quadrat with the one predicted for a random dispersion pattern by the Poisson distribution. The χ^2 test requires that all categories have predicted numbers ≥ 5. If some categories do not meet this criterion, lump several adjacent categories until their predicted values sum to ≥ 5. You might establish categories such as 0-3, 4-5, etc.

f. For each category, calculate the value [(observed # - expected #)^2 / expected #], and sum across all categories. That sum is our χ^2 value. If all observed and expected # are equal, $\chi^2 = 0$, and as the differences increase, so does the χ^2 value.

g. Calculate the probability, P, that you would obtain a sample with a χ^2 value this large or larger from a population with a random dispersion pattern (i.e., that adhered to the null hypothesis).

=chidist(χ^2 value,degrees of freedom)

Degrees of freedom are calculated by taking the number of categories you used to calculate the χ^2 value and subtracting the number of pieces of information you used in order to obtain your predicted values. In this case, we used the mean number of plants per quadrat and the total number of quadrats sampled to obtain those predicted values. Degrees of freedom are thus = the number of categories – 2. Reject your null hypothesis of a random distribution if $P \leq 0.05$. In that situation there is very little chance you would obtain a sample with a χ^2 value as large or larger than the one you calculated from another population with a truly random dispersion pattern. If the P value is > 0.05, you cannot reject the null hypothesis, and you conclude that the pattern does not deviate significantly from random.

h. If you rejected your null hypothesis, you have concluded you don't have a random distribution, but you still don't know if you have an aggregated or uniform distribution. Here, simply use the index of dispersion you calculated earlier. If it's non-random and greater than 1, conclude a clumped distribution, and if it's less than 1, conclude a uniform distribution.

3. Community succession

a. A very simple, and non-statistical, way we can determine if our forest is in a mature state, and predict the future composition of the forest, is to compare the present frequencies of trees in different DBH size classes. For the three tree species you worked with in Part 1 determine the frequencies of individual tree in each 5 cm DBH size class. Prepare graphs illustrating the frequencies, densities, and dominance of each of three tree species across DBH size classes.

Exercise 4: Community-based Project in Ecology

Goals of the project

The idea of this project is to tackle an ecological or environmental problem posed by a local non-profit organization. The interdisciplinary character of ecology allows us to understand the role that humans play in changing, managing, and interacting with nature. In this course, we explore environmental concerns addressed by ecology. This project will help you to more deeply understand connections between humans and their environment and the importance of ecological thinking to an educated citizenry. This project will also help you learn to think like an ecologist (i.e., holistically), to apply concepts to solve ecological problems, to think critically about environmental issues, and to communicate ecological ideas to non-scientists.

Assignment

You and your partner will develop a community-based research project that meets the needs of one of our community partners. The project you develop should have three components: 1) library and/or literature research, 2) data collection/empirical research, and 3) education and dissemination of your research. At the end of the project each group will present their findings to the class and the community partners and each individual student will turn in a paper. Details on those assignments will come later.

Early in the semester each pair of students will brainstorm and discuss project ideas and plans with me. Each group, in consultation with me and the community partner, will develop a strategy to complete the project. A short proposal (instructions below) will formalize the strategy.

You will spend the equivalent of your laboratory time during each of several weeks, as well as time outside of class, working on this project. We will meet at the beginning of each dedicated laboratory session so that each team can check in with me to discuss progress and problems. Some projects may require you to work in large blocks of time, and others may require meetings or field work off-campus. You will determine the project characteristics as you prepare the proposal.

The syllabus contains a schedule of activities. Please make note of due dates. It is important to plan for projects early so that support staff can gather supplies and materials, and any flaws in research design can be spotted early in the planning process. I expect your project to be well planned and carefully conducted, your presentation be professional, and your paper to be carefully written. Not everyone is detail-oriented. If you are one of these people, please be as mindful as possible and communicate with me and your partner so that details or tasks do not get overlooked. Use additional college resources, such as the staff at the Library, The Writing Center, and The Speaking Center for assistance.

Projects

The following problems have been suggested by several community partners. You will notice that each problem has the following features: 1) it is a problem in the community, 2) it requires acquisition of background knowledge and application of ecological concepts, 3) there is an opportunity for empirical research or design implementation, 4) there is a need to make decisions about what is important to consider or ignore, and 5) it offers an opportunity to educate some sector of the public about ecological concepts.

1. <u>Davidson Lands Conservancy</u>: "Managing succession in a forest for a species of special interest."

   Cypripedium acaule, Pink lady slipper, is a beautiful, native orchid species that is rare in this area of the NC Piedmont. On a privately-owned woodland tract 9 miles from Davidson College exists a population estimated at 1,500 stems. The population is thriving, with specimens of all ages represented. The species is not expected to persist with transition from the current forest successional stage. The community partner is interested in obtaining a stewardship plan for managing the habitat to sustain the population. This plan would be useful in obtaining funding and public support for management activities. The current status of the population needs to be documented, as does successional stage, estimated rate of change of forest composition, and rate of transition to soil conditions not conducive to persistence of *C. acaule*. Finally, there should be identification of management activities to promote sustainability of favorable habitat and population of *C. acaule*, including a schedule and scope of management activities and estimated cost factors.

2. <u>Davidson College Sustainability Office</u>: "Incorporation of native grasses on Davidson College campus."
   Our new Sustainability Fellow, Kristina Johnson, is interested in converting areas of grass on campus to native grasses. This project involves working with Physical Plant to research and identify spaces on campus that could be converted to a native grasses program. Research involves identifying and investigating ecology of native grasses, and feasibility of re-introducing particular species on campus. Research on similar successful programs at other institutions should be conducted and may even involve a daytrip to a regional college with a native grasses program. This project offers opportunities to conduct surveys on status of current grass diversity on campus, current grass management practices, assessment of soil conditions, and estimation of cost and carbon emissions savings. Goals include reduction of upkeep, fertilizers, mowing, pesticides and carbon dioxide emissions, and an increase in native biodiversity.
3. <u>Davidson Community Garden</u>: "Implementation of sustainability practices in an organic community garden."
   The Davidson Community Garden seeks to incorporate more sustainability practices, particularly in the areas of watering, organic pest control, and soil composition. This project involves studying and documenting current practices, researching best practices for organic gardens of similar size and budget, and implementing practices aimed at sustaining the garden and increasing produce yield in 2011. The aim of the community partner is to yield more produce in 2011 while staying within budget limitations. This might include development of education or training modules for volunteers. This project offers opportunities to conduct surveys on primary production and yield of various crops under current management practices, status of pest and predator populations, and assessment of soil conditions. Finally, there should be recommendations of management activities to promote sustainability and stewardship while keeping the goal of the community partner in mind.
4. <u>EcoTrail at Davidson Elementary School</u>: "Erosion control on the EcoTrail."
   One of the bridges to the Davidson Elementary School's Eco Trail was washed away last year due to soil erosion. Bridge replacement at the same location will cost approximately $30K. This project involves studying and documenting erosion and its impacts along the trail, devising an ecological plan to reduce erosion and reverse its impacts. The current status of erosion impacts and vegetative cover at the site needs to be documented, as does estimated rate of erosion. Recommendations are sought as to whether bridge should be rebuilt or sited elsewhere. A plan to complete the trail without having to worry about the implications of

future erosion is desired. Implementation of the plan would involve possible planting of erosion control vegetation or some other erosion control, hopefully with involvement of elementary school students.

Proposal Instructions

The main purpose of the project proposal is for each group to demonstrate a clear plan toward the problem's solution. Only one proposal is required per group. View your proposal as a strategy for what you plan to do, how and when you plan to do it, and how you plan to analyze and disseminate your findings. Each group will prepare a joint proposal. Many of the particulars of the assignment that follow apply to your research report as well. Proposals should be submitted electronically, as an e-mail attachment. Files should be named using the following convention: lastnames_cblprop.docx

Proposals should be single-spaced, with a 12 point font and 6 pt spacing between paragraphs. They should not exceed two pages in length, excluding literature cited and any figures or tables. Use subheadings where appropriate and the active voice throughout. Carefully edit for grammar, spelling, and accuracy of ideas. I suggest you employ the spelling and grammar checkers of your word processing program as well as the Writing Center. Follow a standard and consistent format for literature cited.

The proposal is due on the 27th or 29th of September, depending on which laboratory section you attend. Make sure answers to the following questions are embedded somewhere in the proposal.

- Your Names
- Proposed Title of Project
- A clear description of the environmental or ecological problem you will be addressing and how application of ecological methods and concepts will help solve the problem.
- A clearly stated goal along with a description of your overall plan of action.
- Literature resources related to your topic that will assist you and that explain details of the methods beyond the course material.
- Methods from this course you plan to use to solve your problem and how you will integrate methods and conceptual ideas.
- Materials needed for project (be specific and be complete) – if you omit something, we may not be able to acquire it later.
- Schedule of project (start date, end date, dates in the field, etc.) – give actual dates.
- A brief description of the impact on the community and a list of community contacts you have consulted and to whom you will disseminate your findings.

Submitting the revised project proposal

I will read and comment on your proposal quickly so that you can initiate and complete your project in a timely fashion. After receiving these comments you will submit a revised project proposal. Submit electronically, as you did for the initial proposal, **one week** after receiving my comments.

Requirements for the Project Paper

The lengths of project papers may vary, but expect that a substantial project will require approximately 8-10 pages of text, but no longer than 15 pages, along with supporting figures, data, and references. The format and content of your paper depends largely on the type of problem you address and how you develop the project. E-mail me a copy of your final paper and executive summary so they can be shared with your nonprofit organization for their use.

Your paper should contain the following elements (there may be some variation depending upon the project):

- Executive summary: you are expected to produce a 2-page executive summary. This summary should provide a broad overview of your project, conclusions and recommendations. It should provide an overview of your approach and describe strengths and weaknesses. The executive summary will be read by the community partners who are anticipating your results and should include technical details appropriate to the intended audience.
- Abstract: this is a short overview of the paper, in about 150 words or so. A reader should get a good idea of what problem has been tackled, what types of techniques were used to solve it, and what sort of solution was found.
- Introduction: this will include a section describing the problem, the ecological background and relevant ecological concepts and methods to be applied, and a clearly stated goal. Provide ample background, including why the solution to the problem is important, the relationship to ecological methods and concepts, and what you expected to find. Explain the questions that you would like to be able to answer. The introduction should also include an overview of the solutions, including the techniques used and other relevant studies that attempted to solve similar problems.
- Methods: Describe the methods you used for gathering data and implementing solutions, including how you devised them. Are they standard methods you adopted for your project or did you come up with them specifically for this project?
- Results: Clearly describe what you found in the literature, what data you gathered, the results you obtained, and whether your proposed solution was effective or not.
- Discussion: Interpret results and solutions in terms of the original problem and ecological theory. Did the solution help to address the problem? Compare your results and solution to published reports dealing with similar problems. Include improvements and suggestions that the community partner could implement to continue working towards a solution. Discuss what improvements are desirable to make in order to obtain better results, how easy or difficult these might be to implement, and why your original methods did not work as effectively as you thought they would. Projects such as ours have limitations, so you will increase readers' confidence by including future improvements. <u>End this section with a one-paragraph summary of what you have done and what you have learned from doing it.</u>
- Acknowledgments: be sure to thank your community partners.
- References: include both a literature cited section and a broader bibliography if you used references beyond what you have cited in the paper. If you take a description directly from another source it should be in quotes and properly acknowledged. If you paraphrase it, you still cite the reference.

Peer Analysis

Each group member is requested to submit a paragraph stating the work that each student did, including themselves. I only use this in case one student drops the ball, otherwise each student in a group will receive the same grade. In other words, this analysis will not boost your score but is simply used to check in on each group.

Presentations

Your community partners have been invited. You may wish to invite friends and/or family to this celebration of your hard work. You will turn in your PPT presentation to me several days prior to presentation day. This is when I will begin grading them, and I may also send it back for editing if that is appropriate. I will be evaluating your visual aids and your actual presentation as effective communication tools. I will be looking for a clear concise statement of the problem, an accessible description of the ecological concepts behind the project, visual aids that help to evaluate the recommendations gained by your study, how your problem connects to the community, and how it might be disseminated to other partners with similar problems. You should plan to stay after class if possible to discuss with your community partner.

The presentation should run about 15-20 minutes, with all group members participating equally in preparation and presentation. Consider the following points as you prepare:

- Design - Good visual presentation, attractive, interesting, and viewable. Avoid large amounts of text. Use bullets with short points, and then discuss those at greater length. Use large fonts and high contrast for ease of viewing. Add pictures of organisms, study site, or setups. You can borrow a camera, use your own, or search the internet. If you include downloaded pictures, include the URL or source where the picture was obtained.
- Overall clarity - Clear organization of your topic that identifies important ideas (concepts, principles, and methods) with presentation that flows well. After a brief introduction the audience should be able to grasp the basics of your topic and accurately summarize your message and the study’s significance. Emphasize two or three major points throughout.
- **Read Section 7 for more tips on preparing oral presentation.**
- Grades will be based on: 1) organization and delivery, 2) visual aids, 3) ability to convey how your study contributes to ecology, 4) correctness of ecological examples, explanations and concepts, 5) ability to focus on 2-3 three major points, 6) ability to stay within the time limit, 7) ability to answer questions at the end, and 8) discussion of broader significance of the research.

5: Patterns, Processes, and Observational Ecology

Introduction

The definition of ecology is the "study of distribution and abundance of organisms." More than that, ecologists attempt to determine the mechanisms that cause the observed pattern of abundance and distribution. As your first independent foray into ecological research, we ought to begin with observational ecology. Observational ecology is primarily descriptive, although as you'll see there are hypotheses we can test about the underlying patterns of distribution and abundance observed. In addition, manipulation of independent variables in an experimental ecology context will be useful to further test hypotheses and eliminate other possible alternatives.

Goals of the project

Research in ecology can occur in a wide variety of settings, using a variety of methods. You and a partner will develop a question, design and execute an observational study and manipulative experiment, and analyze and present the results of the experiment in the form of a laboratory report. My objective is for you to develop a better understanding of the way in which ecologists conduct research by conducting an original project in ecology.

Objectives

- To plan and execute, with one to two partners, an observational study and manipulative experiment in ecology.
- To learn standard data collection techniques for estimating and describing ecological patterns.
- To collect data on the ecology of an organism of your choice.
- To become familiar with simple standard methods for analysis of ecological data, including use of inferential statistics to test hypotheses.
- To hone your writing skills by writing a short proposal and a research report.
- To study particular species, populations, or communities in depth.

Assignment

You and your partner(s) will design a short-term study to address your question. Decide on a topic, discuss that topic and proposed methods with me, and then write a short two page proposal. In an early meeting, each pair of students will brainstorm and discuss project ideas and plans with me. There is a form at the end of this chapter that you can cut and paste into an e-mail and send to me so that I have a record of your needs.

You will spend the equivalent of your laboratory time during each of several weeks gathering and analyzing your data. The amount of time you spend should be about 3 hours each week, although it may not occur during scheduled laboratory time. However, we will meet at the beginning of each laboratory session so that each team can check in with me to discuss progress and problems. Whatever you come up with as your project, it will at least take up the bulk the equivalent of four to five laboratory periods. Some experiments may require you to check something daily (e.g., take a temperature measurement every day); most will require field excursions.

Several project ideas are listed below, but you are encouraged to develop your own question and experiment. Be creative and ambitious. The syllabus contains a schedule of activities and you will see that projects ideas and designs are due early in the semester. This is for several reasons: 1) animal activity wanes as the semester proceeds for many species, 2) it is important to plan for projects early so that support staff can gather supplies and materials – there will be multiple projects for this class and others, and 3) any flaws in research design can be spotted early in the process.

There are several things to keep in mind when choosing subjects and planning your project. First, there may be constraints on accessing equipment. Even if we have it, if it is used by another class or research group, your access may be limited. Next, you must be able to complete your project within 4-5 weeks, so do not design a project that will take longer than that. Finally, plan your experiment so that you have sufficient ability to reject your null hypothesis if it is, in fact, false. Lack of replication will result in low statistical power and the inability to correctly reject the null if false. Replication is balanced by resources, such as time, energy, equipment, availability of specimens, and cost. See section below for more information on experimental design and analysis.

You will write up the results in the form of a primary literature research report. I expect your project to be well planned, carefully conducted, and your paper to be carefully written. Attention to detail is vital. Not everyone is detail-oriented. If you are one of these people, please be as mindful as possible and communicate with me and your partner so that details or tasks do not get overlooked. I will be happy to help you with writing, including providing comments on short sections of your paper (I will not review drafts of the entire report) before it is due. The Davidson College Writing Center is also available for writing help. When writing in the sciences, preciseness is extremely important. Your work should have a logical sequence and should not be vague.

Week 1 – Coming up with the plan and developing a protocol

We will take a trip out to one field site (the Lake Campus), where I will introduce you to a variety of organisms available for study, as well as some examples of how density and dispersion patterns have been studied in other organisms. You will then form groups of 2 or 3, brainstorm methods, study previous research methods, choose a study organism, and **devise a protocol** that can be carried out in the time available to you. You should attempt to address ecological questions pertaining to two levels of the biological hierarchy (e.g., individual and population, or population and community).

Your consideration of methods should include sampling method, randomization techniques, sample size, and creation of a data sheet. In addition, you will need to advise me of a list of materials that you will require. We have measuring tapes, compasses, quadrats of several sizes, field guides, binoculars, and other common materials used for field ecology.

Questions to consider

- How might choice of methods or size of quadrats affect the outcome of a study?
- What other method besides a quadrat method might be used to study patterns of density and dispersion for your chosen organism?
- How might choice of organism affect the choice of method?
- How might the chosen method have to be altered to design an unbiased sampling scheme for your chosen organism?

Weeks 2-4 – Executing the protocol

You and your partner will have to coordinate field trips and data collection carefully. Your protocol must be approved by me prior to beginning the experiment. Be sure to follow your protocol. All equipment used must be signed out from the ecology laboratory and returned in original condition (that means clean it if it gets dirty!).

Record all your data on paper and tabulate in an Excel spreadsheet for later analysis. If you are designated as the data entry person, you will e-mail the resulting spreadsheet to your partners.

Week 4 or 5 – Analysis of data

I will meet with each group to discuss analysis of data. The quantitative data we collected can be used to estimate population densities or describe patterns of dispersions. Any estimate based on sampling of a population will be subject to some degree of uncertainty, also known as sampling error. In order to help other ecologists interpret your data, you must provide an estimate of error or variation when displaying estimates of means. The mean is a descriptive statistic. Other descriptive statistics that describe error or natural variation include variance, standard deviation, and standard error, which are all measures of variation or uncertainty in a data set. The median and range are other descriptive statistics. Inferential statistics will be used to test hypotheses, and I will work closely with each group to conduct statistical analyses.

Proposal Instructions

View your proposal as a justification for what you plan to do, how you plan to do it, and how you plan to analyze your data. I will discuss analysis with each group prior to proposal submission, and we have a variety of statistical procedures written up by Dr. Peroni and available to us. Justification (i.e., why your project is important and how it relates to previous studies) for your project should be supported by citing primary literature.

Each pair of students will prepare one proposal. Many of the particulars of the assignment that follow apply to your research report as well. Proposals should be submitted electronically, as an e-mail attachment. Files should be named using the following convention: lastnames_proposal.docx

Proposals should be single-spaced, with a 12 point font and 6 pt spacing between paragraphs. They should not exceed two pages in length, excluding literature cited and any figures or tables. Use subheadings where appropriate and the active voice throughout. There should be no title page, but at the top of the first page include the title, authors and date. Carefully edit for grammar, spelling, and accuracy of ideas. I suggest you employ the spelling and grammar checkers of your word processing program as well as the Writing Center. You may ask a colleague to review your proposal. Follow a standard and consistent format for literature cited.

The proposal is due on the 4^{th} or 6^{th} of October, depending on which section you attend.

Some equipment we have:

- Standard ecological field measuring equipment
- Standard entomological collecting equipment
- Standard biological laboratory equipment (balances, water baths, dissecting equipment, pH meters, etc.)
- Aquaria, pumps, and other materials for aquatic organisms
- Small cages of many types
- Other – ask and we will see what we can do

A non-inclusive list of project ideas for independent research project:

- impacts of urbanization on plant or insect biodiversity

- density and dispersion of plant species in different habitats
- species interactions or habitat use of particular species
- some aspect of stream ecology as it relates to greenways or water quality
- biodiversity on local farms or soils of different type
- behavioral studies of a particular species or comparative behavioral studies
- pollination studies or ecology of honeybees
- successional studies in plant communities
- human ecology or behavior

Experimental design and analysis

You will require a detailed experimental design. There are seven aspects to keep in mind whenever designing an experiment:

- Factors: what are the independent variables you will observe, control or manipulate? These are the factors of your experiment.
- Treatments: the levels of the factors are the treatments you apply. For instance, if you choose to study predation on a population of herbivorous insects, predation is the factor, and presence or absence could be two treatments of the factor.
- Subjects: the individual species, populations, or communities you choose to study are the subjects. The choice should be made carefully, as poor choices may prevent you from accurately testing your hypothesis.
- Replication of experimental unit: the sample size, or how many subjects per treatment, is essential for statistical analysis. Statistics can rarely be applied when sample size is one, and larger sample sizes allow for more powerful detection of biological and statistical significance. The experimental unit is a physical entity that is exposed to a treatment. It could be an individual organism, or it could be an entire ecosystem; it depends on your question, but be careful not to inaccurately apply sample size estimates to individuals when you are testing an entire community. Each experimental unit must be independent of other units.
- Constraints: cost, time (both weekly and the entire time-frame), and energy are all constraints that will limit the number of factors, treatments, and samples you use.
- Control/blocking: you must control extraneous variables to be sure that you do not confound your factor with other factors. You may wish to use some kind of blocking design, which is a way to reduce the experimental error by making treatment comparisons solely within blocks, thereby taking advantage of the homogeneity of each block. The effect is similar to that obtained by controlling for a variable. A block may be a set of trials performed at a particular time, a particular researcher running a set of trials (used to determine any experimenter effects), or a set of repeated measurements made on the same experimental unit. Blocking isolates a systematic effect and prevents it from obscuring main effects.
- Statistical analysis: we will discuss this in more detail, and I will guide you in designing your experiment so that we can apply statistical analysis appropriately to your experiment. Most experiments will be able to employ a regression or analysis of variance approach, and these will be discussed in class.

Form to be sent along with Proposal: Copy this table to an email, fill it out carefully and completely, and email it to me ASAP.

Ecology Research Project Needs

Your Names:	
Proposed Title of Project:	
Species, populations, or communities with which you will be working:	
Number of subjects needed and number that must be acquired by the biology department:	
Particular characteristics of subjects you require (e.g., age, sex, etc.):	
Materials needed for project (be specific and be complete) – if you omit something, we may not be able to acquire it later.	
Will you need to use temperature controlled environmental chambers or any other laboratory space (list type of space and environmental requirements)?	
Schedule of project (start date, end date, dates you need chambers, dates in the field, etc.) – give actual dates and estimated times.	
Other things I should know about your project?	

6. Preparing and Writing Scientific Research Reports

Basic Guidelines for Writing

Writing a paper on your observations, experiments, and conclusions is a critical part of a laboratory course in ecology. You should set aside whatever notions you may have about "scientific writing" and prepare reports that are composed of straightforward English-language sentences. Remember that the point of the report is to effectively convey a message to the reader. Decide what you want to say and then translate your mental notions into symbols that will have specific meaning for the reader. In this context, writing sentences that sound right is not merely a matter of aesthetics, but a way of promoting effective communication. Follow the organization suggestions below, and use the guidelines for each section to organize your paper.

1. Prepare your summary tables and figures. **Identify the key points that you wish to make and structure your paper around them.**
2. Prepare an outline on a computer. The outline is the design of your paper. The more time you take to construct it carefully, the more logical your paper will be and the easier it will be to turn the outline into text. Save your outline and first draft on disk, and save any early hardcopies you prepare. Be sure to save your work on more than one disk.
3. Prepare at least two drafts of text. First, prepare a rough draft that can be checked, read aloud, altered, and rewritten. The second draft may be ready for your instructor.
4. Avoid jargon as much as possible. State your meaning in a simple and concise manner. Whenever possible, remove unnecessary words from your sentences. Reading aloud helps identify unnecessary words and awkward phrases. Unnecessarily long sentences are ineffective because they dilute the writer's meaning. Economical sentences drive their messages home forcefully.
5. Use the “spell check” feature of your word processor! Use the “grammar check” too, if you feel inclined. By removing errors, you help the reader focus on your message, rather than by distracting them with your errors.

The Form of a Scientific Report

Both tradition and common sense support the fundamental structure of scientific report consisting of an introduction, materials and methods, results, discussion, and references cited. In preparing your reports, you may work together in your groups to compare and compute results, but each individual must write their own section of the report. See Exercise 1 to help you decide how to prepare tables and graphs.

1. Introduction:

This is a statement of the purpose of the study. Introduce the problems and questions you addressed in your experiment (i.e., why did you do it?). You must also make a statement of your hypothesis or question. In a formal scientific paper, the author will usually review previous publications related to the hypothesis or question, in order to put their work in a larger contect. For our purposes, an introduction of 1-2 paragraphs should be sufficient. Use information from the lecture and your text to provide background (add a literature review if instructed to do so).

2. Methods and Materials:

The purpose of this section is to allow the reader to critique or repeat the experiment performed. Usually you would address the following questions: What did we do? How did we do it? Where did we do it? What organisms did we study? What equipment did we use? How did we analyze the data? How did you set up your experiment? How many experimental groups did you have? How did you measure the effect you studied? For most exercises, however, the methods will be presented in this manual or by the instructor. To repeat them in your report would only be busy work. I will ask you only to describe materials and methods **not** included above or in another handout. Anything that is different from methods stated in the manual must be **explicitly** stated. Ask me if you have questions about any specifics. Sometimes materials and methods will not be required at all.

3. Results:

This section presents the key findings of the study, the results of experiments and field observation, and/or the data gathered during the project. Here you want to show data, in tables or graphs that relate to your stated hypotheses and questions and **make specific points**. Each finding should be briefly discussed and perhaps related to other results, although you should save discussion of the truly significant conclusions for the next section. The object here is to describe in a clear and logical way what you discovered.

Whenever we perform experiments with multiple replicates, condense your data into averages and standard deviations across replicates. Do not show all raw data in this section unless I specifically ask you to.

Presenting Your Data

Numerical results are useful because they help answer a question or test a hypothesis. The task of scientists is to make certain that their readers understand why certain data do or do not answer a given question. Presenting data in tabular or graphic form are two methods that scientists use to assist their readers (and themselves) in the interpretation of their results. Presentation of results, for maximum effectiveness, requires condensation and summarization of raw data. There are very rare occasions when it is desirable to present raw data, and those occasions are exceptions to the rule. The processing of raw data usually leads to presentation of average values for treatments, estimated from the replicates of each treatment, along with some measure of the variability around those estimates, either standard deviation or standard error of the mean.

In a laboratory report, tables and figures should **always** be labeled with a table or figure number, such as "Table 1" or "Figure 3." Always refer to the table or figure in the text, either to point out a trend in the data or to discuss the significance of the data. Never put tables or figures into a report without discussing them or referring to them in the text!

Tables are generally used to show the relationships between treatments and controls when it is necessary to present information on several different dependent variables for each treatment or subject. However, this method can become cumbersome when large data sets are displayed or when there are many dependent variables. Alternatively, graphs are often used to demonstrate relationships without burdening the reader with large quantities of numbers. There are advantages and disadvantages to both styles of presentation.

Tables are useful when one wants the reader to see the actual numbers (the processed, condensed numbers, rarely the raw data). They are also useful to show frequency counts of categorical variables or results of statistical tests. As previously mentioned, tables can be a disadvantage when one has to present large data sets, because it forces the reader to visualize the relationships among many numbers and the complex interactions between many variables.

That's where graphs come in. When a reader looks at a graph, they should be able to quickly grasp the point being made. The graph should effectively show a trend (e.g., an increase in the measured variable over time) or a relationship (e.g., the difference between a control and treatments). However, if there are many variables on which one needs to present data, it could overwhelm the reader, and to present different variables for each treatment on the same graph may require special graphing programs.

Graphs generally consist of an independent and a dependent variable. The independent variable is generally displayed on the abscissa (the x-axis) and can be a measured quantity, such as time, or a category, and may be set by the investigator. This variable should be unaffected, or as the name implies, **independent,** of the factor that is being studied. The **dependent** variable, on the other hand, is affected by the factor under investigation (or at least one hypothesizes that it is before the experiment is conducted). The dependent variable is graphed against the independent variable so that one can see how the dependent variable changes with changes in the independent variable.

There are many different ways to graph data. **Line graphs, scatter plots,** and **histograms** are probably the most popular and will be the types that you will use most frequently. Line graphs show the relationship of a dependent variable to an independent variable when the independent variable is a continuous measurement, such as time (Figure 6.1). A scatter plot would be simply a plot of Y vs. X, with no lines connecting the points (Figure 6.2). Finally, a histogram is a bar graph, and is the best way to show **averages (± standard deviations)** and **frequency distributions** of either **categorical or continuous variables** (Figure 6.3). The frequency is the number or proportion and is the dependent variable, while the various categories or scale on the x-axis make up the independent variable.

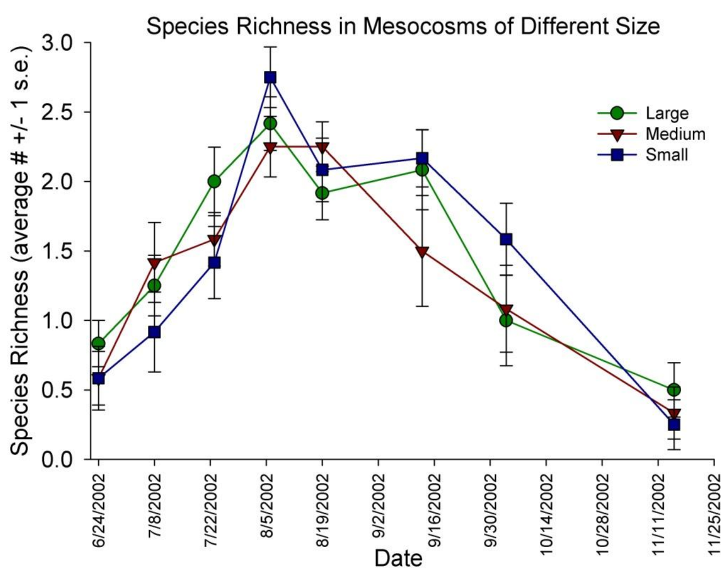

Figure 6.1. Example of a line graph, with time as the independent variable.

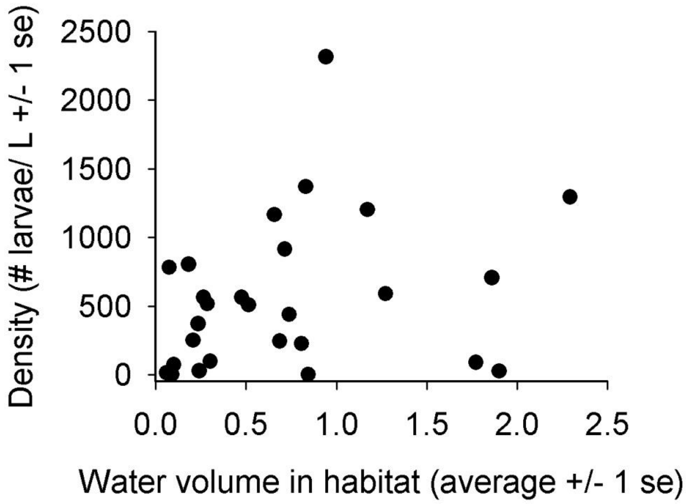

Figure 6.2. Example of a scatterplot.

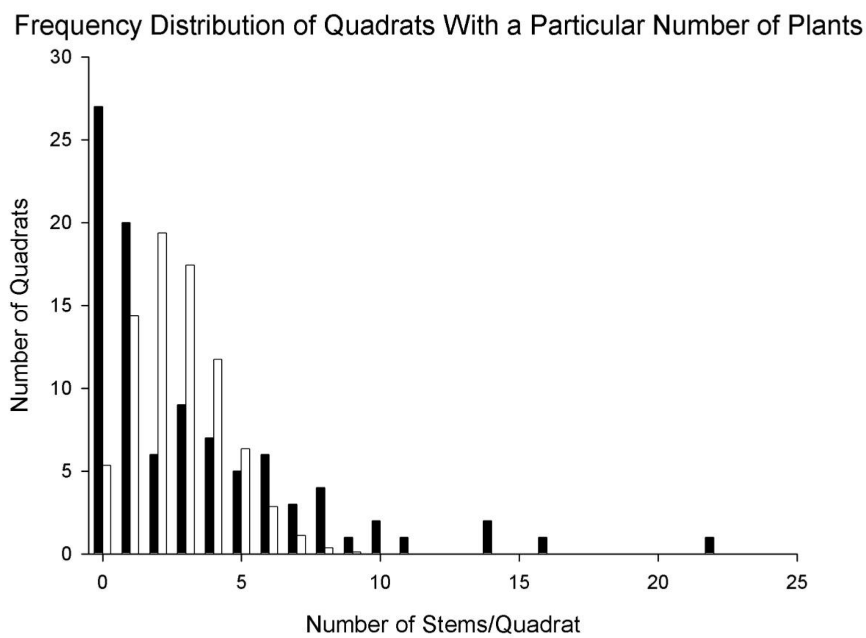

Figure 6.3. Example of a frequency distribution. There are no error bars because each point represents a frequency, not an average.

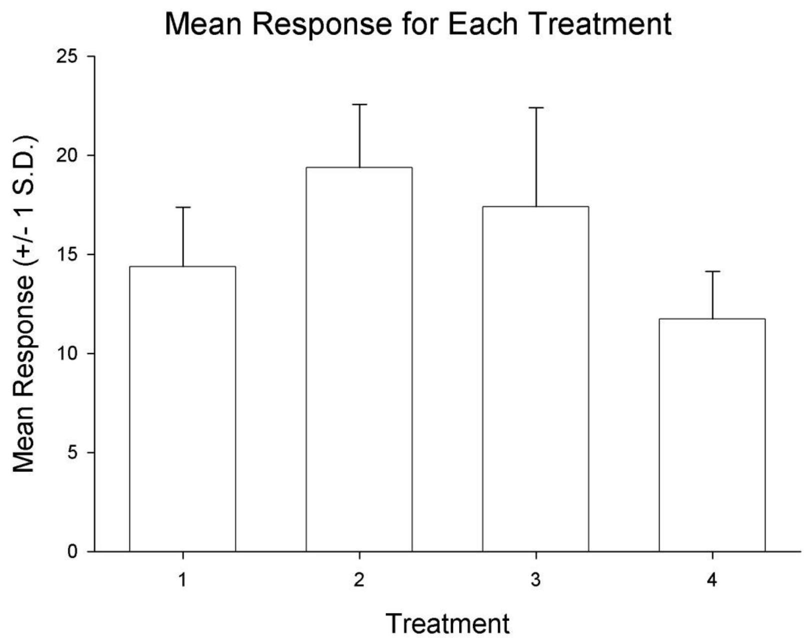

Figure 6.4. Example of a histogram with error bars added. Here the error bars are calculated standard deviations.

4. Discussion:

This section should contain a detailed examination for the few (usually two to three) major issues illustrated by the study. You should also point out why the research was significant, what general conclusions can be drawn, and the relation between your findings and basic scientific principles and concepts. Consider the following questions: How do your results support our hypotheses? Or do they? What sources of error and/or bias were present? How would you perform the experiment differently to help eliminate error? What new questions come to mind after examining the results?

5. References: Include complete citations of any works you cite. Use the standard format below (find the example that best fits your source).

Anonymous (2001) Davidson College Department of Biology Homepage. http://www.bio.davidson.edu/index.html

Carpenter, SR, & Kitchell, JF (1993) The Trophic Cascade In Lakes. Cambridge University Press, London, England.

Merritt, RW, Dadd, RH, & Walker, ED (1992) Feeding behavior, natural food, and nutritional relationships of larval mosquitoes. Annual Review of Entomology 37:349-376.

Paradise, CJ (2003) Patterns and processes, density and dispersion. Pages 6-12 *in* CJ Paradise (ed.), Biology 321: Ecology Laboratory and Field Manual. Davidson College, Davidson, NC.

Power, ME, Parker, MS, & Wootton, JT (1995) Disturbance and food chain length in rivers. Pages 286-297 *in* GA Polis and KO Winemiller (eds.), Food Webs: Integration of Patterns and Dynamics. Chapman and Hall, New York, New York, USA.

Rith, J (1988) Plant succession on abandoned railways in rural New York State. Proceedings of the 73rd Annual Meeting of the Ecological Society of America, Davis, CA.

7. Preparing Oral Presentations

Introduction

For your report you will present background on your study system, a detailed explanation of your questions, methods, and results, a discussion of your conclusions and recommendations, and references you used. Use PowerPoint for your presentation. For Discussion, put your results into the big picture of ecology as well as how ecology has been applied to help solve a community problem. Integrate your content with course content when the opportunity arises. There should be several major concepts illustrated by your project. Explain why the research was significant, what general conclusions can be drawn, and the relation between your findings and basic scientific principles and concepts. Use information from class, the handout, and the text to provide background.

Requirements:

- You will use PowerPoint for your presentation.
- Gear your entire presentation for no more than 20 minutes in length, including time at the end for discussion or questions and answers. I will be firm in the length of the each presentation. The best advice I can give is to practice your timing multiple times beforehand.

Organization

- You should include an **introduction** or overview to the topic. The introduction should tell your audience what you are going to say. The Introduction should be a succinct description that prepares your audience for what follows. Introduce the question, the hypotheses, the motivation, the justification, and the study system. This is where you have the chance to motivate and interest your audience. Why did we do this exercise? What is the larger context in which we can place this study? Be brief, but thorough.
- Develop a smooth transition to the **methods** section your talk. Describe your protocol in detail, using the instructions above and my lecture on sampling to guide you in what to include. What biases or flaws did you discover in your protocol? What else should or could you have done to enhance the quality of your study?
- The **results** section is where you tell the audience what you found. The beginning of your main results should be smoothly entered, having prepared the audience adequately. The body should take its cue from the introduction and should expand on each of your major points, in the same order as you outlined in the introduction. If not stated previously, state your hypotheses. Show the data that relate to your hypotheses, predictions, and questions. The objective here is to describe in a clear and logical way what you discovered and what you have done to assist the community partner.
- Present data in the form of line graphs or histograms, whichever is most appropriate. Calculate measures of variation (e.g., standard deviation) as appropriate and include them. Tables and figures should always be labeled with a number, such as "Table 1" or "Figure 3." Title and label your graphs and tables so the reader knows what they are examining. Include the results of statistical analyses, using tables or figures.
- For each point you should provide **discussion** based on analysis, a link to the original question or point, and supportive examples. There should then be a smooth transition as you begin to present your conclusions.

- The **conclusions** tell the audience what you just said. It should take about 2-3 minutes. The conclusion should summarize your main findings and reiterate how you have addressed the original question or task. You should use the conclusion to further motivate the audience and to ask for feedback or initiate question time.
- **Acknowledge** any assistance you received.
- **References** can be cited during the presentation, but put full citations on slides at the end of the presentation.
- You may wish to use some of your time for questions and discussion. If so, prepare ahead of time a list of questions and discussion points to provide the group. Think about the questions below, as some of them might help you prepare your presentation. Not all questions will fit every situation, and don't feel that you need to ask these questions at all. Develop the best questions and discussion points you can that will get a discussion rolling. Be prepared to answer every question you ask.
    - What are your reactions to…?
    - What aspects were of greatest interest to you?
    - What are your conclusions to…? And what evidence supports your conclusions?
    - What alternative hypotheses might explain…?
    - What are the next steps that need to be taken…?
    - Take a devil's advocate role and argue a counterpoint.
    - What implications to your conclusions are there?
    - What do you consider to be the major forces that affect…?
    - How can you integrate past material with…?

Tips for Giving an Oral Presentation

Oral communication is a valuable skill. As well as encouraging you to develop this skill that can be used beyond college, this skill also fully tests your knowledge of an area. In order to explain an issue or argument to others, you must have fully considered it yourself, and figured out how to best present it. Think about the different types of presentations you have done previously. How do these experiences will compare with an oral presentation in a science seminar? What feedback did you receive from previous presentations, and how will this impact on your preparation and delivery this time?

There are two well-known models to communicate effectively. The first is to K.I.S.S. (keep it simple, stupid). Focus on conveying one to three key points. Second, repeat key insights: tell them what you're going to tell them (forecast), tell them, and tell them what you told them (summary). Consider your audience and keep in mind what they already know as you develop your presentation.

Here are a presentation few tips. You must decide what is appropriate for you and your topic, then go with it. What is important is that you plan!

- KNOW your task: Think very clearly about your purpose and how you are going to achieve it. Ask yourself if your main points and arguments relate to my original topic and objective?

- KNOW your stuff: You will need to formulate a clear plan for arguing your case or presenting your explanation. You will need to have examples and expert opinions on hand to support your points.
- KNOW what to expect: Try to anticipate the kinds of questions that the students and instructor might ask. Prepare some answers for these questions in advance.
- Make a good first impression by looking at the people around the room, not just at your notes or the screen. Omit distracting gestures (like stray hand movements) but use enhancing gestures. For example, if you make a sweeping statement, a sweeping hand gesture will seem appropriate.
- Monitor the volume and pace of your voice. Speak slowly and project your voice – a slow pace allows the audience to process information. Be sure to enunciate so that you are easy to understand. Remember that you can convey emotion through your voice. The use of silence and repetition can emphasize important points. Pause from time to time to catch your breath. Be enthusiastic about your topic and avoid monotone – remember this is your topic that you worked hard on so be proud and express yourself! **Do not read your presentation!**
- Avoid filling pauses with "uhm", "like" and "you know".
- Talk your audience through the organization. "We will discuss three issues, first X, then Y, and end with a discussion of Z." At the end of each section, tell the audience that you are now moving on to the next section. If you use overheads or PowerPoint, use these as aides to what you say. Use them to show organization, define your terms, show pictures, figures, and tables. Don't overload the audience's eyes with distracting information.
- Make each slide clear and uncluttered. Use the visual aid quite literally and do not spend space on words. Your aim is to highlight, reinforce, focus and illustrate a point. You could overburden your audience if you require them to see too much at one time, or if you require that they remember too many terms from earlier overheads.
- At the end of your presentation, thank your audience for their attention. Then ask if there are any questions. That clues in the audience that you're done – I've seen many speakers that have just stopped and the audience doesn't know if it's a long pause or the end.
- Given your time budget, think about each statement and ask if it informs the audience, if it fits with what you've said and are about to say, and if it makes a relevant point?

How to control your nervousness!

Feeling nervous before a presentation is normal, but there are ways to control nervousness. The best way to overcome shyness and gain confidence is to prepare. Rehearse and time yourself. Work with your group and the Speaking Center to hear you and give you feedback. Before presenting, take some time to calm yourself. Instead of frantically re-reading your notes and working yourself up, go for a walk and breathe deeply or meditate. Most importantly, be sure that you are fully prepared and that you are confident with your topic. The surer you are of your topic and your mastery of it, the less nervous you will feel on the day. Think how far you have come and that you have something to say that no one else in the room knows. Exert your expertise with confidence!

Answering questions at the end of your presentation

As part of your presentation, you will need to answer questions from your peers, instructor, and community partners. Remember that because you have already researched the topic in depth, you will be the expert in the subject area. The audience is showing interest if it asks questions; do not consider this to be threatening. Consider the following tips when answering questions.

- Try to anticipate questions the audience might ask and prepare responses. When planning your answers be sure to have examples ready that illustrate major points. Be concise by stating your answer clearly and illustrating it with a single example.
- Repeat and/or paraphrase the question. Here you can buy yourself time to fully consider your answer, help the audience by ensuring that everyone has heard the question, and demonstrate that you understand the question. If you don't understand the question, ask the audience member to repeat it in a different way.
- Never guess an answer or "make up" an answer. If you don't know the answer to someone's question, you're going to have to admit it.
- Remember that question/answer time is part of the assessment process. Summarize each of your responses and check that the audience understands.
- If someone in the audience begins a commentary, but doesn't ask a question, gently remind them that, while comments are valuable, at this point you are only answering questions. Offer to discuss the comments after class.
- If someone asks a really complex question that will take too long to answer and will eat up all the remaining time, acknowledge the complexity of the question and offer as simple an answer as possible. Offer to discuss the topic in greater depth outside of class.

Assessment:

Grades will be based on the following:

- Thoroughness of Introduction: How well was it developed and how well did it set up the body of your presentation?
- Methods/Protocol/Results: Were all aspects of assignment covered in sufficient detail? Did you appear to understand the topic of the presentation? Provide an understandable explanation of results and recommendations?
- Discussion / Conclusions: Was the discussion focused on the results? Were results put into a larger context? Were major points reiterated? Was it clear what the take-home message was?
- Organization: Were ideas presented logically? Did you follow an obvious and memorable structure for the presentation?
- Synthesis: Was material from the text integrated with the presentation?
- Transitions: Were they smooth?
- Presentation: Did you use technology effectively? Did you appear to have practiced using this technology beforehand?
- Answering Questions: Did you answer questions thoroughly and correctly?
- Speaking Skills: Did you use clear and concise language? Did you speak loudly enough to be heard? Vary the pitch of your voice and pace of speaking? Refrain from using "er," "ah," "um," and slang too frequently? Did you move easily from point to point during the presentation? Did you make eye contact with the audience?
- Directions: Have you followed the directions above and in the syllabus?