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# PART 1

# Ecological Principles

To understand the actions and reactions that occur in the environment, we must begin by studying organisms and their interactions with the environment. From this knowledge, we will increase our understanding of nature and human impacts on it. During the past several decades, it has become increasingly clear that any trespasses we commit against nature are also committed against ourselves. With increasing rates of species extinctions and habitat destruction, it is imperative that we learn all we can about the natural world, and the species that inhabit it. As we increase our knowledge, we humans must be willing to make some hard decisions regarding the species and ecosystems that share this planet with us.

Part I introduces some basic concepts of ecological communities, with each lab building upon the knowledge gained from previous ones. Exercise 1 introduces the student to the scientific method and helps develop scientific thought processes. Exercise 2 describes the diversity of community structure and function. Exercise 3 provides techniques for estimating a species' population size, while exercise 4 discusses species diversity. Exercise 5 examines concepts of habitat and niche. Exercise 6 analyzes competition between organisms for shared or limited resources. Finally, exercise 7 addresses whether your own campus provides the necessary resources for survival of wildlife.

# EXERCISE 1
# Introduction and Lab Format

## I. Objectives

After completing this introduction the student will be able to:

1. Understand the nature of environmental studies and laboratory techniques.
2. Apply scientific methods to experimentation in this course.
3. Write a scientific laboratory report.

## II. Introduction

### The Problem:

Human beings (and all living things) are a product of their environment. We depend completely upon the various systems in nature that provide, clean, and cycle the very air, water, and soil upon which survival balances. Humans have a critical interest in ensuring the sustainable condition of these systems comprising the various environmental compartments. Without air, water, and soil, a person can survive only for minutes, days, or weeks, respectively. Without sufficiently clean air, water, and soil, the quality of life deteriorates to unacceptable levels at some point. Beyond the pragmatics of survival is a moral obligation humans have toward the environment. For the first time in the history of the earth, a single species has acquired the ability, through invention and voluntary actions, to change the global environment. Through these actions, humanity threatens to alter or destroy the balance achieved over millions of years, which created the very conditions allowing not only human evolution, but that of all life as we know it. This acquired ability makes humankind responsible for our actions and requires that we seek a sustainable social presence and a balance between human and ecological needs.

### The Solution:

Because we are a part of the problem, we must be a part of the solution. By buying and using products that are not produced with the environment in mind, we are contributing to the problem. By mindlessly allowing harsh chemicals to be flushed down the drain, by burning petroleum products in your car, and by not reducing your household wastes and allowing them to be buried in a landfill, you are contributing to environmental problems. Solutions require first an awareness of the problem, then a determination of the extent of the problem, and finally action to solve the problem. It is the intent of this manual to continually make you, the student, aware of what the problems are in environmental issues and of actions that can be taken to solve these problems. You, through your actions, are the solution, like it or not, to future environmental sustainability. You can help by:

Rethinking your role

Reducing what you use

Reusing what you use

Recycling what you use

Refusing to accept a lesser quality of life for future generations

### Environmental Studies

Environmental studies is the interdisciplinary study of the interaction between human beings and their environments. It examines the effects of humanity on other living organisms and on the nonliving physical environment, the sustainability of natural resources, and the environmental impact on human quality of life. Environmental studies is considered to be interdisciplinary because it takes into consideration information not just from classical sciences such as biology and chemistry, but also disciplines such as anthropology, sociology, law, and economics. In this course, you will apply techniques developed in the physical, natural, and social sciences to real-world environmental problems and relate them to humanities' interactions with nature. Many of the methods taught are used throughout the world to analyze and solve environmental problems and will allow you to compare your results to those obtained by professionals in the field.

### Scientific Investigation

Science is a methodical and precise way to study the natural world. Science is one tool for solving problems; it simply discovers facts and relationships based on observation. Scientific investigation typically consists of these steps:

1. Make observations.
2. Formulate questions or hypotheses.
3. Design a study or controlled experiment.
4. Collect data.

5. Interpret data.
6. Draw conclusions.

It is often crucial to review the literature in the field to determine if the same or related experimentation has already been done. This prior knowledge, if any, can corroborate or confound data and conclusions from your study. Once step six has been completed, the process can then be repeated until the questions asked about a topic have been answered. Objects or events to be questioned or explained may be found in natural settings or planned as laboratory experiments. The important factor is that for objects or events to be explained, they must be directly observable.

## Hypotheses

Once a person has made a series of observations, he or she must do something with the resulting data. Some sort of general statements or hypotheses must be made about the data. One type of generalization summarizes and makes a statement about a set of data. For instance, a person may notice that the sycamore tree in his or her yard begins to lose its leaves in late October. After observing other sycamore trees in neighboring yards losing leaves at the same time, the observer concludes that all sycamore trees begin to lose their leaves in late October. This conclusion is an example of a generalization based on inductive reasoning, or induction. Induction involves reasoning logically from the specific to the general, from isolated observations to a general statement. Generalizations can be drawn confidently only if a large number of observations has been made that reduce the distorting effects of individual differences.

The hypothesis about leaf fall can be tested by observing other sycamore trees. As more information is gathered, the observer may find it necessary to change the original hypothesis. For instance, the hypothesis may have to be changed to: All sycamore trees in the Southwest lose their leaves in late October.

A second type of hypotheses is an explanatory hypothesis. This type of hypothesis goes beyond a simple summary, and attempts to determine the cause(s) or reason(s) for certain observations. One explanatory hypothesis might propose that sycamore trees begin to lose their leaves because of a change in the photoperiod. Another may relate leaf loss to changes in plant hormone levels. These hypotheses are easily tested by setting up experiments comparing leaf loss under various photoperiod conditions, or by altering plant hormone levels. Both hypotheses meet the scientific requirement of being testable. Hypotheses may be stated in "if . . . then" form, for example:

HYPOTHESIS

***If sycamore trees begin to lose their leaves in late October because of changes in plant hormone levels, then a large artificially induced change in hormone levels at other times of the year should also result in leaf loss.***

Hypothesis testing involves the use of deductive reasoning. A person using deductive logic starts with general observations and makes a specific conclusion. The "if" portion of the statement is the hypothesis, and the "then" portion contains the predictions that are based on the assumptions made in the hypothesis. If after experimentation the predictions prove to be false, then the hypothesis is false. In science, hypotheses can never be absolutely proven. There will always be alternative explanations for why the results turned out the way they did. Through careful research design and by repeatedly disproving hypotheses, we can make stronger conclusions.

CONCLUSION

***Science does not deal with certainties, but with probabilities.***

Many false hypotheses have been accepted because they led to true predictions. To show that such a hypothesis is false, other tests must be developed. One false experimental result does not always mean the hypothesis must be totally discarded. It is more a question of the percentage of results that support the hypothesis for it to have any value. Statistical analysis is used to determine the significance of any deviations seen during prediction testing. The larger the sample size or the greater the number of observations, the more likely the hypothesis can be accepted or rejected confidently.

## Quantitative and Qualitative Data

Data may be quantitative or qualitative. Quantitative data can be expressed numerically and statistically analyzed. Qualitative data are expressed verbally and may incorporate subjective and cultural values. Both qualitative and quantitative data may be collected from experimentation and observation. Scientists prefer quantitative data. This type of data can be presented directly to the reader without subjective interpretation, which may introduce bias. Quantitative data can also be checked easily by other experimenters. Qualitative data are less easily checked and present fewer opportunities for verification than do quantitative relationships.

Data must also be organized in such a way as to give the investigator useful information. If the experiment used control groups, the easiest organization would be to compare data from each group. If similar measurements were made at various locations or under various treatment conditions, the data could be organized by group, location, or type of measurement.

## Limitations

Science has some limitations. Scientists cannot study any phenomenon that cannot be observed. Science cannot be used to make moral or value judgments. Science can predict human reactions to a given situation and it can provide information to people so they may make moral and value judgments for themselves.

All students should remember that there are no necessarily "right" answers for the exercises in this lab manual and there is nothing "wrong" with results that contradict predictions or hypotheses. Remember the statement from earlier: Science does not deal with certainties, but with probabilities.

In a chemistry lab, many of the variables that might adversely affect the outcome of an experiment can be controlled (e.g., temperature, humidity, air pressure). Therefore, the student can predict results with confidence and may assume that some human or mechanical error has been made if those results differ from predictions. In this course, however, the outcome of each exercise depends on a multitude of variables that may not as yet be fully understood. Many environmental factors that cannot be controlled by the experimenter are involved. Results may be predicted only in the most general way and may be perfectly correct even if they differ significantly from those predicted. Often, the real value in an experiment is what is discovered from having a hypothesis disproved. Some of the most valuable scientific advancements have come as serendipitous discoveries.

## III. Relevance

Students taking a lab course for the first time are often intimidated about science and the process of successfully participating in a laboratory course. Some students may feel that they are not capable of doing "real science," while others simply may not be interested. There is also the lack of understanding about why you may be doing a particular lab. In fact, students in many labs merely "go through the motions" of performing the activity, with no real understanding of the relevance or meaning of what they are doing. This manual strives to make the labs interesting, informative, and relevant. It does a person no good if he or she can measure tree height without understanding the reason for this measurement. This is a particularly important factor when environmental issues are being studied, since humans are directly and indirectly affected by their environment. Citizens must become more informed about the science, and the scientific process, involved in gathering data about pollution, species extinction, population, resource depletion, energy use, and so on. On a larger scale, although environmental studies is based on gathering data by using the scientific method, on top of this are the social, economic, ethical, religious, and political realities of our society. Regardless of what the data tell us, if society is unwilling to accept the information, or to make changes based on data, we will not reach sustainability. So, in order to become better informed people, it is important to understand the process, limitations, and function of science in society.

## IV. Activity

### Information and Instructions for Lab Class

#### In General

This course is an introductory-level course that usually counts as a lab-science credit for a variety of majors. Therefore, students in this class come from a wide range of science and nonscience backgrounds. Some of you may be familiar with the concepts presented in class, while others are getting their first introduction to the material. Contribute your knowledge in class discussions, listen to your classmates, and ask questions. You may discover new viewpoints and aspects of what you thought were familiar issues. For those of you who do not have a strong science background, do not panic—you will have just as much opportunity to learn as anyone else. Feel free to participate in class discussions and to ask questions. Never hesitate to ask a question because you think it is silly. Some of the best discussions start from supposedly "silly" questions.

Some students, especially those who are not science majors, may have trouble seeing the relevance of some of the topics that are covered and the exercises that are performed. Each chapter has a section entitled "Relevance," which is designed to show you why each topic is important to environmental issues. You should read this section carefully, and you are encouraged to engage your instructor and classmates in discussions pertaining to the topic you are covering.

Some nonscience majors may dislike science in general, and not see the point of any of the labs. These students should understand that science is an integral part of all our lives. By seeing how science works, nonscientists may hopefully gain a better appreciation of the capabilities and limitations of science.

At the conclusion of an exercise, the instructor will lead the class in a discussion of what has been discovered. Pay close attention to both the written and oral instructions for answering the questions and/or writing reports. Since each unit has slightly different requirements, the instructor will explain how to write your report. Do not leave class without a complete understanding of how to complete the assignments. Be sure to address each of the questions (listed in the Questions section of each chapter) in your lab write-up.

## V. Procedure

#### In Class

Most of the activities and procedures are designed to demonstrate complex concepts in environmental science and, although not difficult to understand, can be quite detailed and involved. The lab instructor is there to guide you through the exercises, to serve as a facilitator, not to familiarize you with the procedures. If you come to class and are not familiar with the procedures to be followed for that day, you will be behind at the outset. You will impede the class if you require the instructor's time to familiarize you with the procedure.

**SAFETY CONSIDERATIONS:** Before coming to class, you should read and understand the material in the lab manual.

*This is the most important instruction you will receive for this lab class.*

Being prepared will allow you to focus on the outcome and its relevance to environmental issues. You will get more out of the class this way. There are no shortcuts to environmental solutions.

Each class will begin with a lecture by your instructor, which includes additional information and an explanation of the procedure. It will be helpful if you have read newspapers, magazines, etc. Your participation in all discussions is encouraged and expected. Take careful notes because information presented in the lecture may be necessary to complete the exercise and may be required in your lab write-up.

Take notes during the procedure on anything you observe that could have an impact on the results of the exercise. Record this information on the data sheets. Follow the procedure exactly so that experimental results will be valid. Record your data in a neat and logical format. Come to lab prepared for the activity in which you will be involved. Bring a calculator, lab notebook, and lab manual to each lab. In some labs (water and soil labs), you will handle chemicals, some of which are corrosive. You will be issued safety glasses and gloves, and you should dress in clothing on which you won't mind possibly getting stains and holes. Please leave the laboratories and equipment as you found them when you entered the lab.

### In the Field

Field trips are an opportunity to examine up-close the relationships explored in this class. They are designed to better help you understand the interrelationships between humans and ecology by directly observing interactions of plants, trees, animals, conditions, soils, and activities. Depending upon the time of year of your class, the weather may be hot, cold, wet, or windy. Biting insects, poison ivy, and temperature extremes are all likely to be encountered. Dress and prepare accordingly. We suggest that you do not wear expensive or dress clothing, short pants, sandals, open-toe shoes, etc., for participation in outdoor lab sessions.

## The Laboratory Report

One of the most important things you will do in this class (and possibly your career) is write laboratory reports. Your report is your tool for expressing what you did, why you did it, and what you learned in the process. Even if your understanding of the procedure, techniques, and results is perfect, and your results error-free, a poorly-written report will not indicate that you really understand what you have done. Writing reports is not difficult if you remember a few guidelines. Normally, scientific reports are divided into the following sections:

1. Abstract

   The abstract should contain a brief summary of purpose, methods, results, and conclusions of the whole experiment. It is generally no longer than three or four sentences. It may be easier after you have written the rest of the report to write the abstract.

2. Introduction

   Write your introduction in such a way that the reader will be interested in reading the rest of your report. The introduction consists of two parts:

   a. An introduction to the topic and its importance to the environment and society. Cite at least one reference [e.g., (Marcum 1991, p. 32)].

   b. A connection between the introduction and why you performed the exercises (this is your hypothesis). End the introduction with specific questions you intend to answer while testing your hypothesis.

   The first item that should be addressed in the introduction is the importance or relevance of what you've undertaken.

   Examples:

   What is ecological competition?
   What is the difference between intraspecific and interspecific competition?
   Why is information about competition useful?
   Why is it important to look at intraspecific and interspecific competition?

   The second item that should be addressed are the hypotheses being investigated in the report. For example, you might state:

   "I (or "We") hypothesize that intraspecific competition is more intense than interspecific competition in species X."

   The part of the introduction preceding your hypothesis should let the reader know why you think your hypothesis is true. After your hypothesis, you may want to state any predictions you have. For example:

   "I/We predict that if intraspecific competition is more intense in species X than interspecific competition, then the distance between individuals of species X should be greater between each other than the distance between individuals of species X and species Y."

3. Materials and Methods

   This section should include a description of the characteristics of the study area (when applicable) and a summary of what was done and what equipment was used. The procedure should be presented in chronological order and in past tense. You should use the scientific names the first time you mention a species (e.g., "The study area was dominated by sycamore trees, *Platanus occidentalis.*"). Thereafter, you only need to use the common name.

   Your methods section should be complete enough so that anyone reading it would be able to reproduce your experiment with nothing but your report to follow.

4. Results

   Tear out your data sheets and include them with this section. The results section consists of two parts:

   a. Original data obtained from using the procedure.

   b. Data derived or calculated from the information obtained during the lab exercise.

The results section contains nothing more than results. It is not a discussion of what you found (this comes next), it is not a conclusion about what you found (this comes after the discussion), but is only the bare-bones reporting of the facts. State the results of the experiment without opinion, interpretation, or explanation. This is the first time, other than in the abstract, that results have been mentioned. All tables and graphs should follow immediately behind this section. Every table and figure should be numbered and referenced in the text. If you include tables or figures that you do not reference, then they are unnecessary. All tables and figures must be labeled with a one-sentence description or title that tells what is being shown. The reader should not have to refer back to the text to understand the information they are looking at. Descriptions of tables go above the table, whereas descriptions of figures are placed at the bottom of the figure.

5. Discussion

This is the most important portion of the report. In this section, you will discuss your data and any trends or relationships that appeared in the data. The first item that should be addressed here is the interpretation of the results. For example, which type of competition is most intense, and which species compete most intensely? Provide insight as to why such trends may have occurred. Secondly, in this section you should discuss why your results support or disprove your hypothesis (was the field technique appropriate; were the counts accurate; what do these results mean for the future of the species in the area; how does this relate to succession, etc.?). Are your results consistent with what you expect? Why or why not? Are your results above or below accepted environmental quality standards? Why or why not? Answer the questions you asked in the introduction section. Any problems encountered during the procedure that may have caused errors should be discussed. Pay close attention to both human error and equipment error.

Whenever necessary, suggest other experiments that should be done, or additional data that should be collected to answer your initial questions (in your introduction) more thoroughly.

6. Conclusion

Conclusions are to be based on data, and they should follow from your discussion. All conclusions drawn should relate to the statement of the problem (your hypothesis). Did your results confirm or deny your hypothesis? Were your results above or below accepted standards? This section can be a brief, three- to four-sentence paragraph, in which you summarize very clearly your conclusions.

7. References, Literature Cited

Use the format employed in your lab manual. Your lab manual should be cited, of course, as well as any other source you have used. In the text of your report, if you cite specific information, or quote data or persons, cite references using the author's surname, year of publication, and page number [e.g., (Enger and Smith 1997, p. 32)]. If referencing other work in general, no page number is required. In the bibliography, use the following citation format:

Enger, E. D. and B. F. Smith. 2000. *Environmental Science: A Study of Interrelationships,* 7th ed. McGraw-Hill, Dubuque, IA. 456 pages.

Helpful Hints:

When writing your report, the following hints may be helpful:

- Do not put off writing your lab report until the night before it is due. Write it as soon as possible after completing the exercise.
- Write in active voice. For example: "I shook the solution until it was thoroughly mixed," rather than "The solution was shaken until it was thoroughly mixed." The pronouns we, he, and she may also be used where applicable; for instance, "As a group, we compiled data from two sources."; "We laid out a 100-meter transect, using a tape measure and string, then . . . "; or "Our results indicate that . . . ". In some cases, it may be necessary to use the passive voice, but it is not a preferred usage.
- Write in past tense unless it is ridiculous to do so, or unless past tense makes the meaning unclear. The use of past tense is a convention of technical writing.
- Put section headings in your report. These make the report easier to grade and will give it a professional appearance.
- Put your data into graphs or tables whenever possible. Be sure to carefully title all graphs and tables. Refer to these by number in the text of your report.
- Strive for a professional appearance in your work. Write as though you are being paid to do so. Neatness, clarity, style, and appearance of lab reports are important.
- Even though you may have worked in groups, write your own lab report.
- Be sure that you have a separate cover sheet, or title page, showing the title, name and number of the lab, your name, and the date.
- Each section of the report (abstract, introduction, etc.) should begin on a new page.
- The report must be typewritten, double-spaced, 12-point Times Roman font, and margins of approximately one inch.
- Charts, tables, figures, and/or graphs should be referred to in the text, not just included, have a legend, and be on a separate sheet of paper. They should be placed as close to their reference as possible.
- Length should be sufficient to fully address all issues and requirements, but no longer than necessary.

## VI. Questions

1. What actions do you do that harm the environment? That help preserve the environment?

2. Have you ever had an environmental studies course? What do you expect to get from this course? What are three of the most important issues you would like to learn about in this class?

3. Take any three observations you have made today (it can be about your friends, nature, studying, or anything else), and formulate three hypotheses that attempt to explain your observations.

4. In your own words, summarize the seven parts of a good lab report. Write down any questions you may have about writing a report, so that your instructor may provide written answers to them.